Science Update

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Mark T. Peters
Los Alamos National Laboratory
U.S. Department of Energy

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Overview

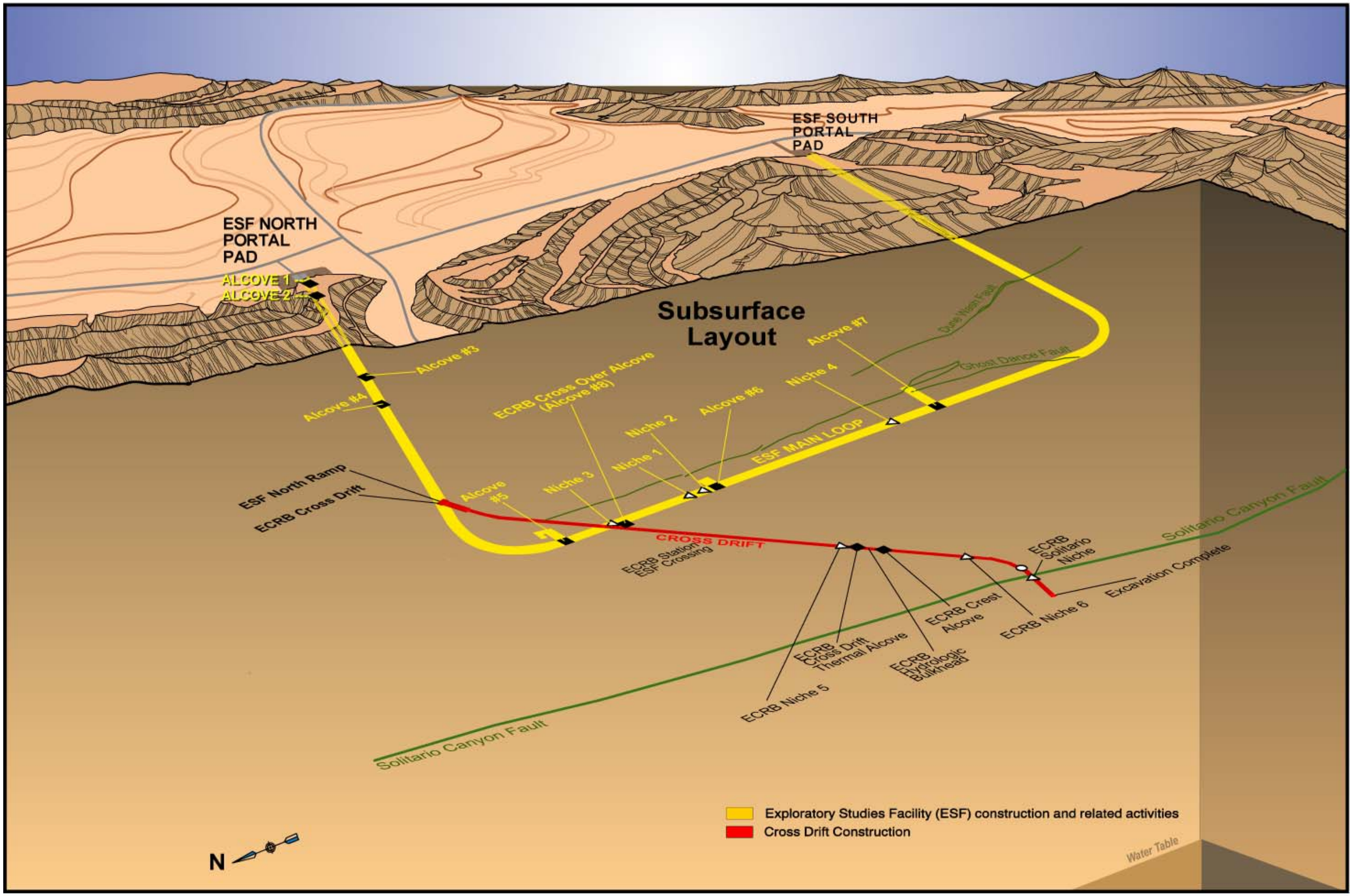
- Objective is to provide status on scientific and engineering data collection and testing program in support of natural and engineered systems process models and design
- Unsaturated Zone (UZ)
  - Exploratory Studies Facility (ESF) Studies
    - Drift Scale Test
    - ^{36}Cl Validation
    - Secondary Fracture Minerals
    - Hydrochemistry
  - Cross Drift Studies
    - Lithophysal / Fracture Studies
    - Alcove 8 / Niche 3 (Crossover Alcove)
    - Bulkhead Investigations

Overview
(Continued)

- **Cross Drift Studies (continued)**
  - Thermal Properties Investigations
  - Thermal-Mechanical Rock Properties Investigations
- **Saturated Zone**
  - Hydrochemistry
- **Igneous Events Studies**
- **Summary**

The data and conclusions presented are preliminary, in various stages of Project review, and not yet all in controlled databases/reports.

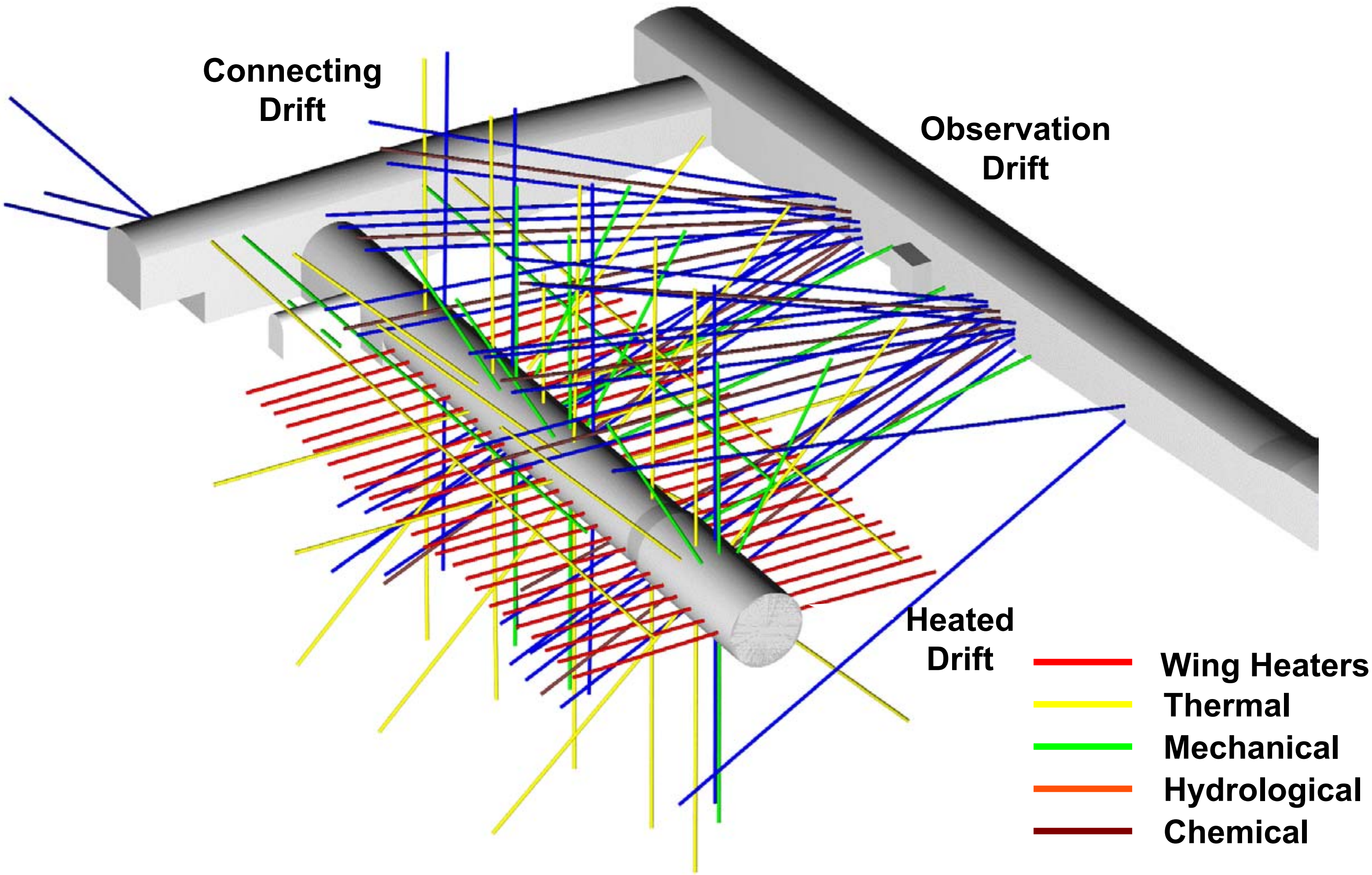
Exploratory Studies Facility and Alcoves



ESF_subsurface_01_03a.ai

Drift Scale Test

Evaluate thermally-coupled processes in proposed repository horizon rocks at the field-scale in support of Coupled Process Models, Near-Field Environment Models, and Design



Probing THMC Processes – Drift Scale Test

Pre-Test Characterization

Laboratory	Field
T-Properties	Rock Classification
H-Properties	Fracture Mapping
M-Properties	Borehole Videos
MIN/PET	Air Permeability
Pore water	

Periodic Active Testing during Heating and Cooling

GPR, Neutron log, ERT } Matrix Liquid Saturation

Air Permeability : Fracture saturation and fracture aperture changes

Gas Sampling

Water sampling

Passive Monitoring during Heating and Cooling

- Temperature
- Displacement
- Strain
- Humidity
- Pressure
- Acoustic Emission (microfracturing)

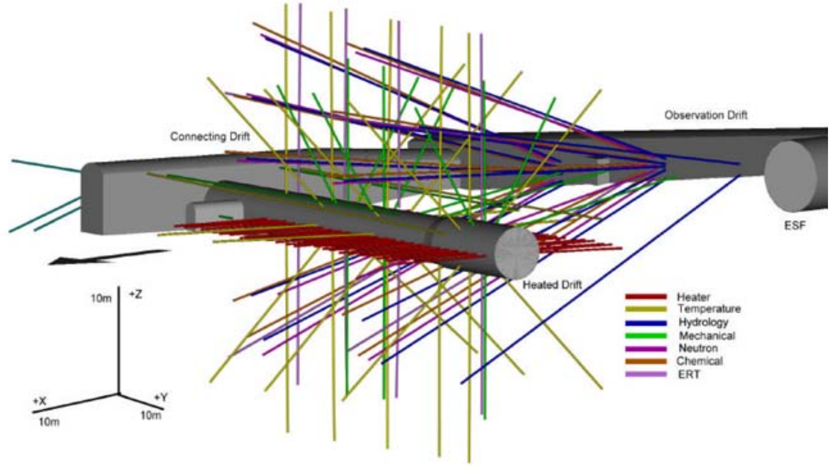
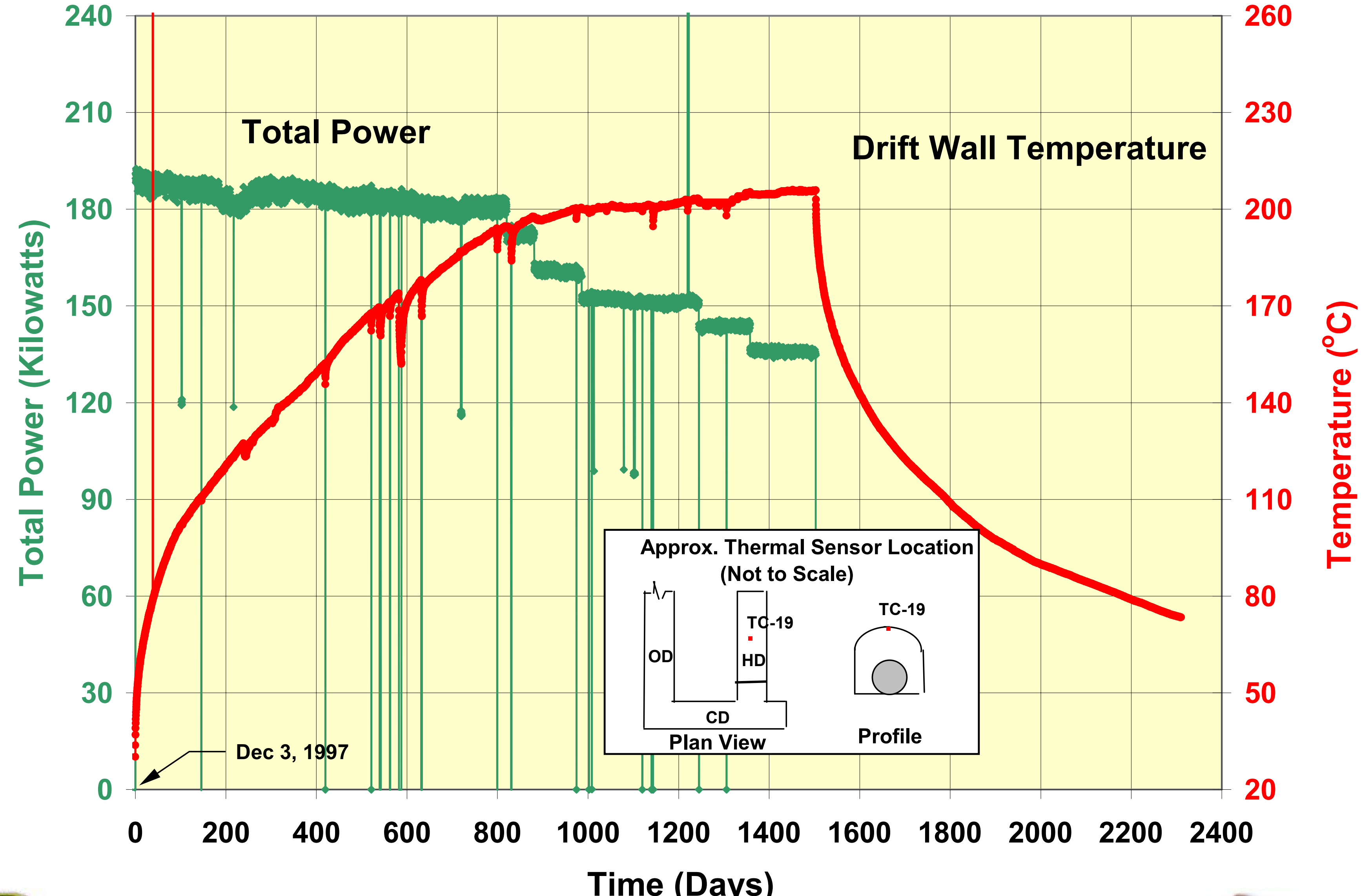


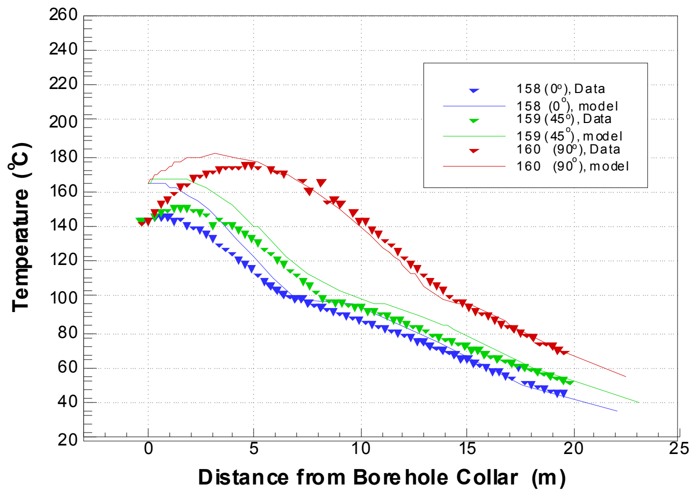
Figure A-1. Perspective View Showing Drifts and Boreholes of the Drift Scale Test.

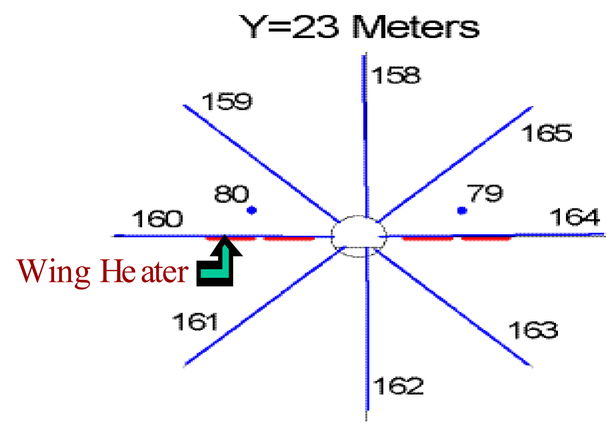
Drift Scale Test (Continued)



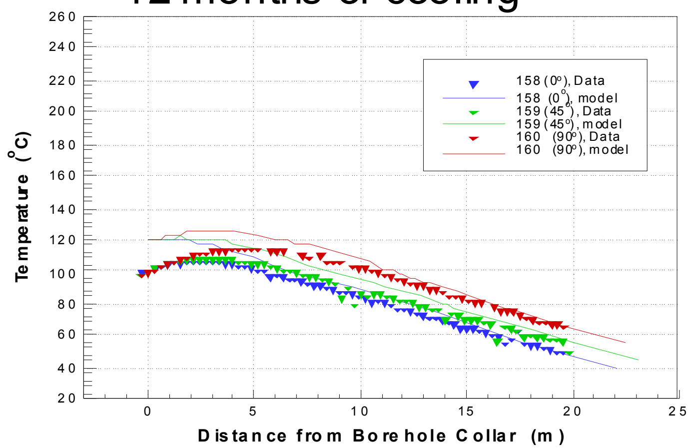
Drift Scale Test (Continued)
Temperature Profiles: Measured vs. Simulated

3 months of cooling

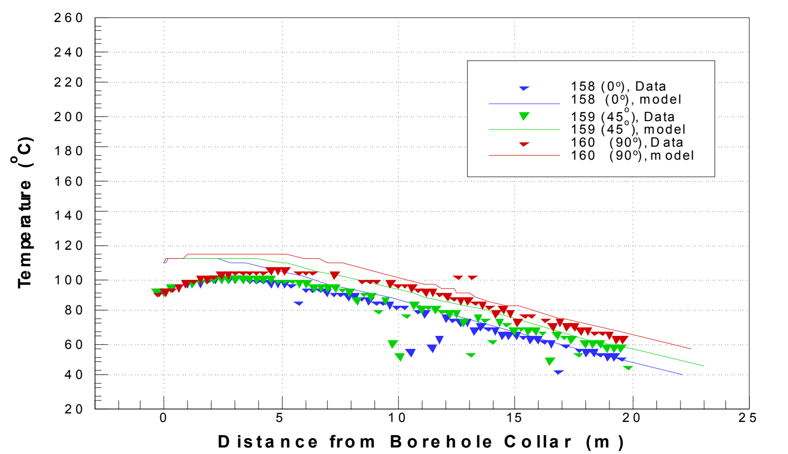




12 months of cooling



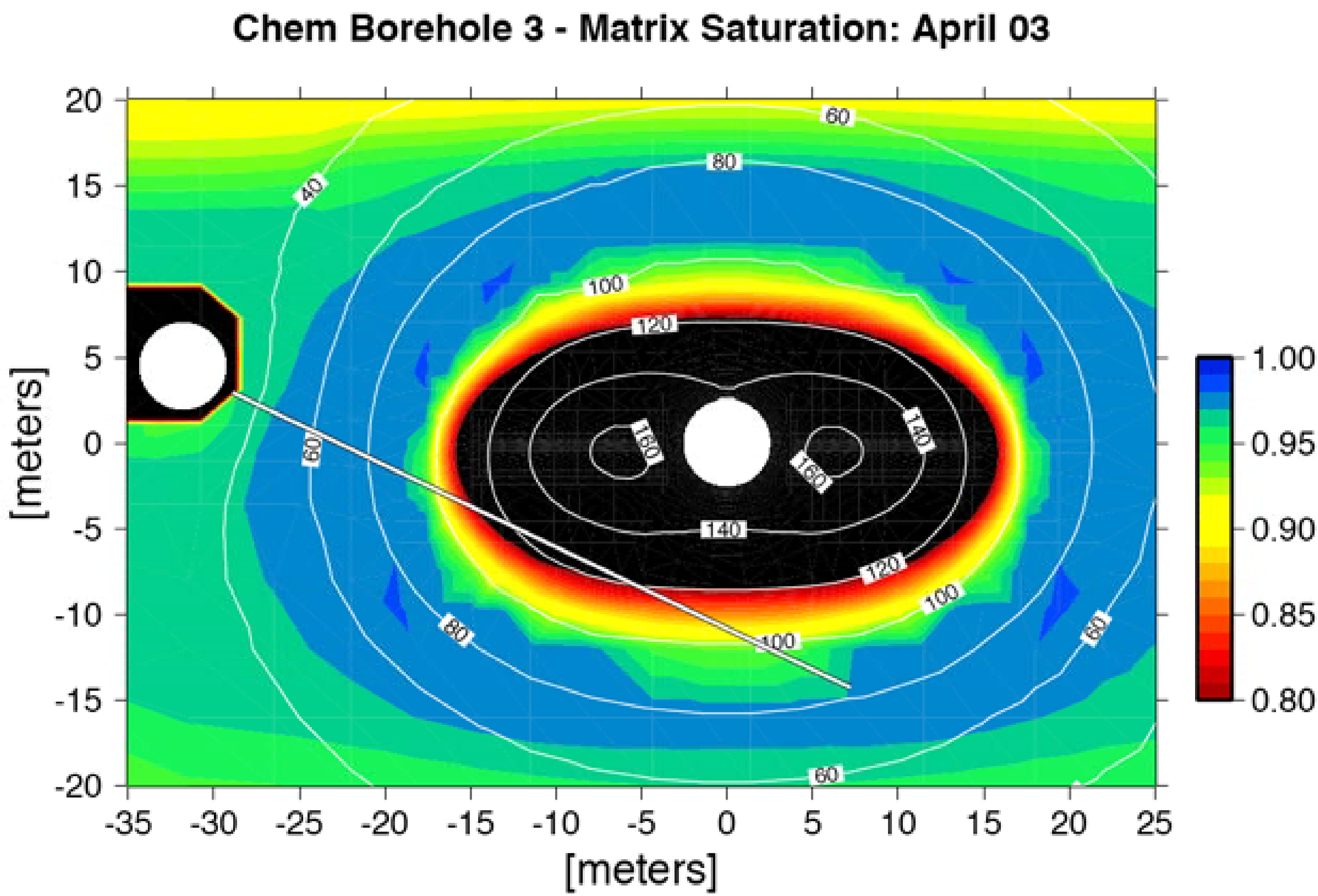
18 months of cooling



Drift Scale Test
(Continued)

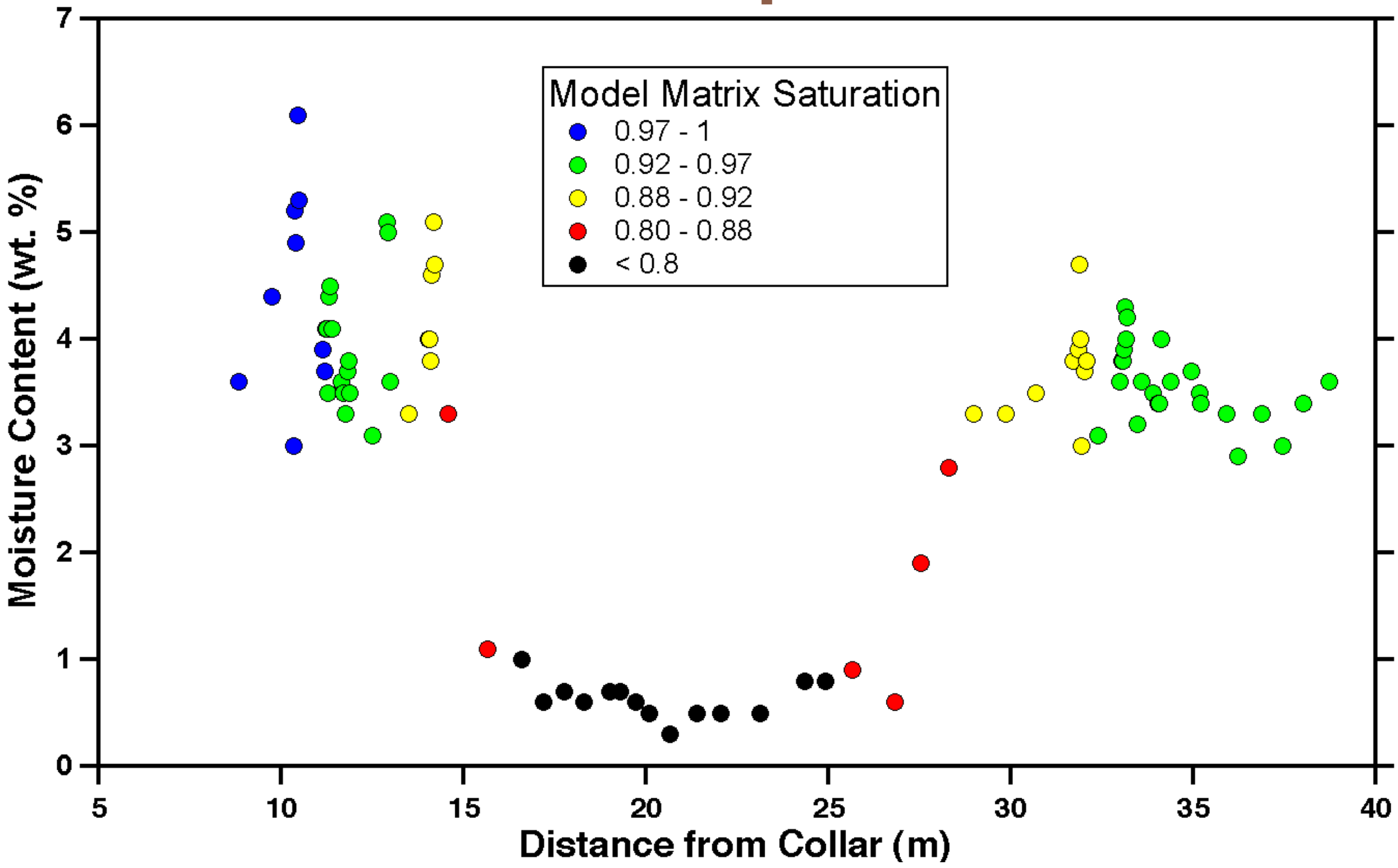
- **Borehole ChemSamp-3 drilled about a year ago**
  - Half of the core intervals were preserved for water extraction and chemical analyses
  - Water content of pieces of preserved core was determined by weighing both before and after oven-drying
  - The results reveal a pattern of moisture content from near ambient to very dry
  - These results match the detailed prediction of water movement based on thermal-hydrologic modeling

Drift Scale Test (Continued)
DST Model Matrix Saturation



Contours for temperature

Drift Scale Test (Continued)
Measured Moisture Content in ChemSamp-3 Core



^{36}Cl Validation

- Validate occurrence of "bomb-pulse" ^{36}Cl at two locations in the ESF (Sundance Fault Zone and Drillhole Wash Fault Zone)
- Update
  - DOE is conducting an independent study of $^{36}Cl/Cl$ systematics – led by completely independent experts from UNLV and New Mexico Tech
    - Scientific Investigation Plan in place
    - ESF sampling ongoing
    - Quarterly meetings will be held

Secondary Fracture Minerals

- Ongoing studies of fracture minerals
- Confirm slow mineral growth rates throughout the Quaternary
- Establish a linkage between climate variations and UZ percolation flux
- Add confidence to the UZ flow and transport models by integration of climate records

Micro-Analyses of UZ Minerals

- Calcite and opal deposited in the last million years are useful for testing models of percolation flux response to climate change
- Micro-analytical methods used to evaluate UZ climate signal
  - Mineral growth rates calculated by U-series dating of opal
  - Profiles of stable C and O isotope variation in calcite
- Implications from initial work (now published)
  - Growth rates under drier Quaternary conditions may be slightly lower than those under wetter Tertiary conditions
  - Finest sampling resolution implies variable growth rates that may correlate with climate change

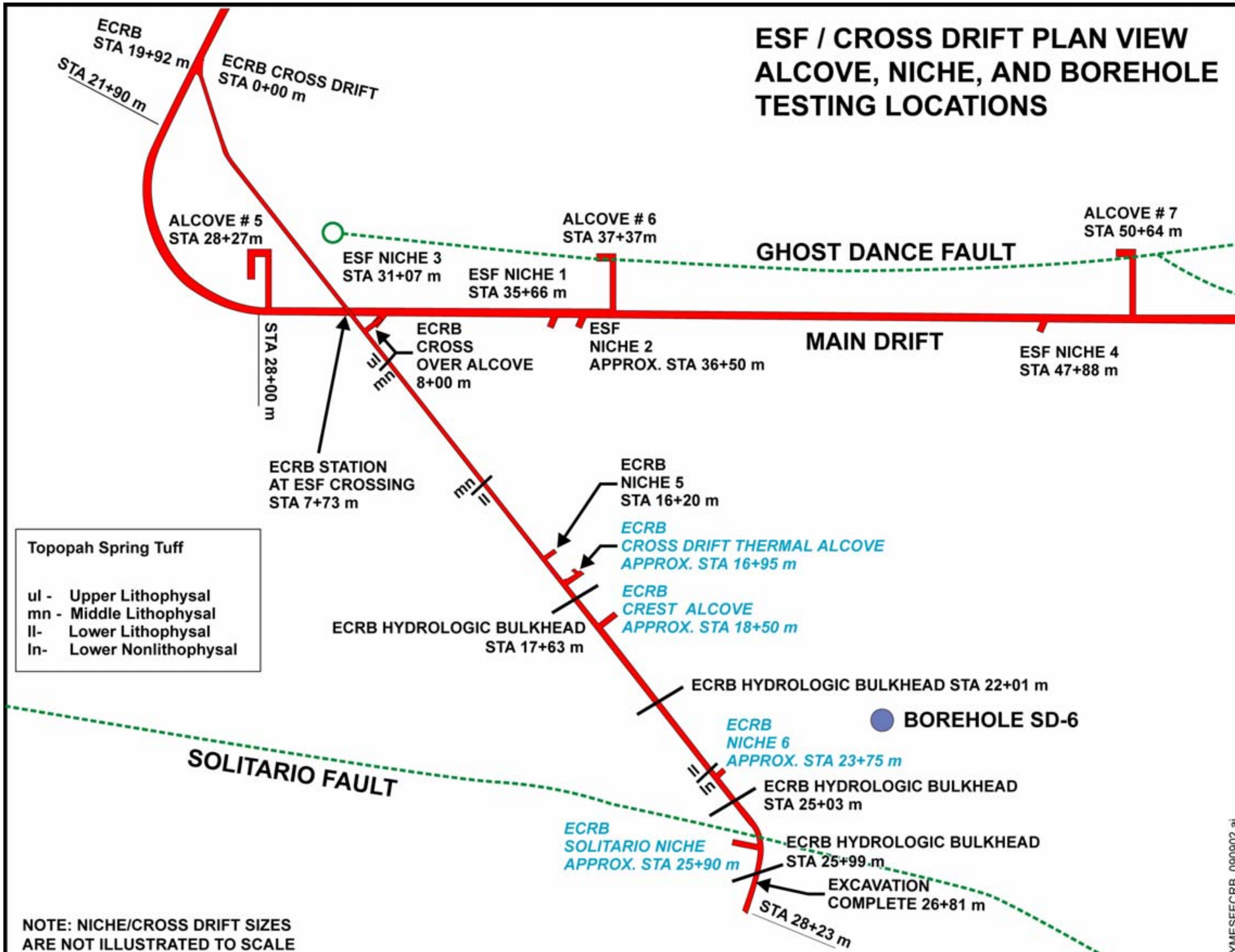
Micro-Analyses of UZ Minerals
(Continued)

- New work on late-stage calcite and opal
  - First calcite oxygen isotope data by ion microprobe
    - Several profiles in calcite show a 3 to 4 per mil range in $\delta^{18}O$ values
    - Observed $\delta^{18}O$ oscillations may reflect variable climate signal but requires age framework
  - Additional U-series dating by ion microprobe
    - Opal adjacent to calcite $\delta^{18}O$ profiles varies from 50 ka to 1,200 ka
    - Calculation of growth rates and age framework for calcite $\delta^{18}O$ data are underway
  - Additional U-series dating by sequential *in situ* microdigestion
    - Age profiles for several more opal samples are underway
    - Acquired new instrumentation (mass spectrometer and micro-mill) that will allow more precise determinations of growth rates

Delineation of UZ Flow at the Repository Horizon

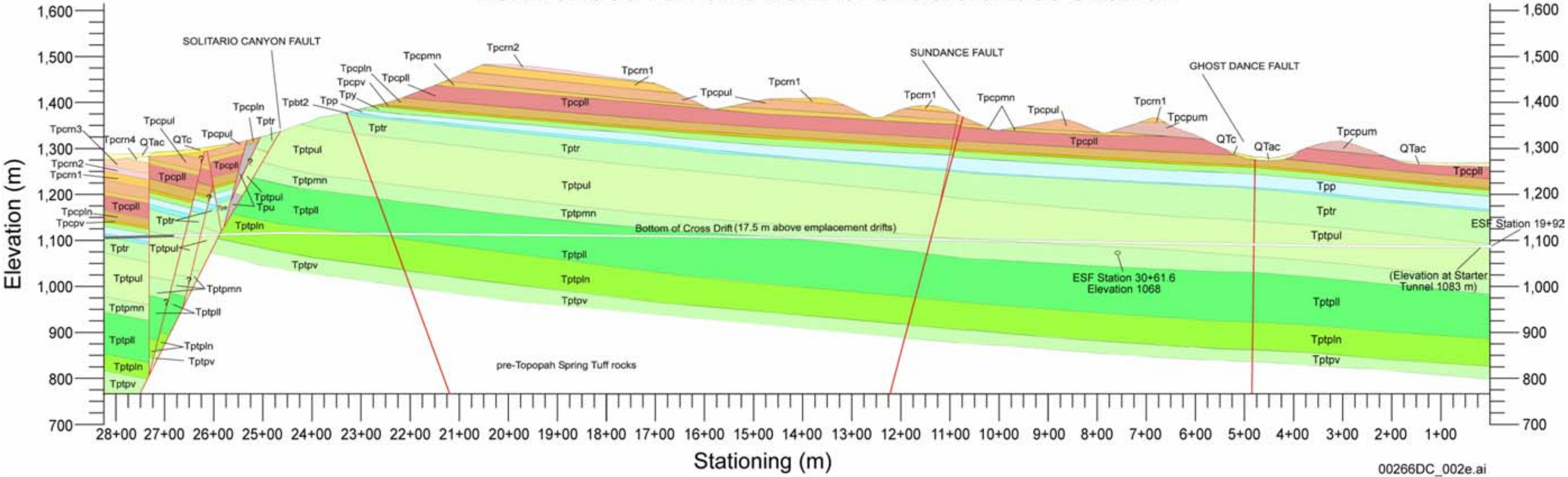
- U-series radioactive disequilibrium in repository rocks can help test conceptual and numerical UZ flow models including
  - Focusing of UZ flow in fault zones
  - Differences in fracture versus matrix flux
- Whole-rock $^{234}U/^{238}U$ and $^{230}Th/^{238}U$ compositions are affected by water/rock interaction
  - Degree of disequilibrium related to differing amounts of UZ flow
- Implications from previous U-series data
  - Disequilibrium in most rock samples reflects pervasive UZ percolation
  - No significant differences in disequilibrium yet seen between samples from fracture surfaces and adjacent rock interiors
  - Greatest disequilibrium at Bow Ridge fault in ESF is present on footwall surface implying greater UZ flow down fault plane

Exploratory Studies Facility and Cross Drift



Cross Drift Studies

ECRB CROSS-DRIFT AS-BUILT GEOLOGIC CROSS SECTION



LEGEND

Quaternary

- QTac Alluvial and colluvial deposits
- QTc Colluvial deposits

Tiva Canyon Tuff
Crystal-rich member

- Tpcrn4 Subvitric transition subzone
- Tpcrn3 Pumice-poor subzone
- Tpcrn2 Mixed-pumice subzone (Tpcrn2, Tpcrl2)
- Tpcrn1 Crystal transition subzone (Tpcrn1, Tpcrl1)

Crystal-poor member

- Tpcpul Upper lithophysal zone
- Tpcpum Upper lithophysal zone and middle nonlithophysal zone undivided
- Tpcpmn Middle nonlithophysal zone
- Tpcpll Lower lithophysal zone
- Tpcpln Lower nonlithophysal zone
- Tpcpv Vitric zone

- Tpy Yucca Mountain Tuff, includes pre-Tiva Canyon Tuff bedded tuff (Tpbt4)
- Tpp Pah Canyon Tuff, non- to moderately welded, includes pre-Yucca Mountain Tuff bedded tuff (Tpbt3)
- Tpbt2 Pre-Pah Canyon bedded tuff
- Tpu Undifferentiated Paintbrush Tuff

Topopah Spring Tuff
Crystal-rich member

- Tptr Crystal-rich zone

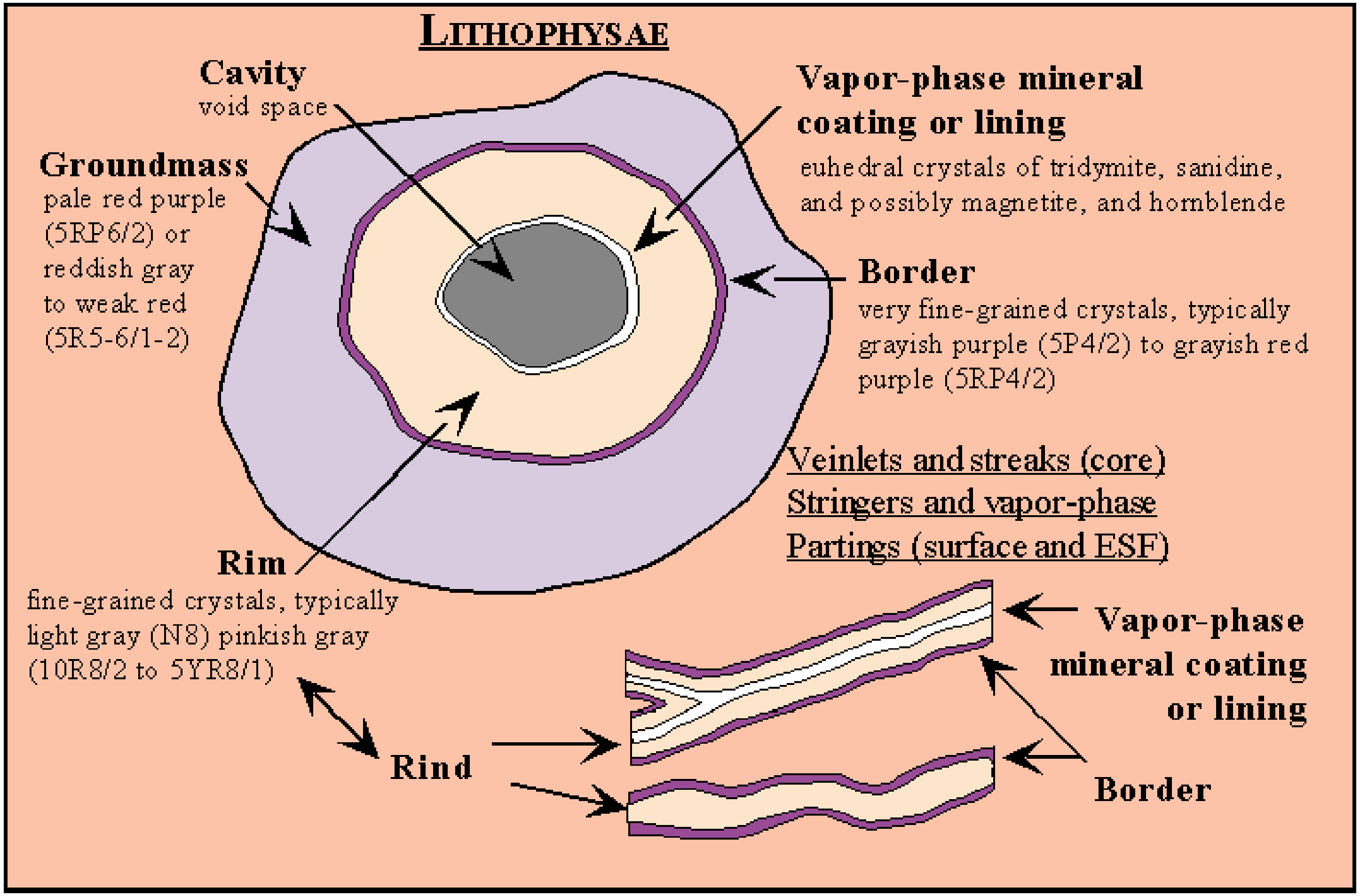
Crystal-poor member

- Tptpul Upper lithophysal zone
- Tptpmn Middle nonlithophysal zone
- Tptpll Lower lithophysal zone
- Tptpln Lower nonlithophysal zone
- Tptpv Vitric zone

Lithophysal / Fracture Studies

- **Objective is enhanced understanding of fracture geometry and relations to lithophysae – important link to thermal and mechanical properties investigations and drift degradation modeling**
- **Methods of Lithophysal Data Collection**
  - **Visual estimates – entire Cross Drift (1998)**
  - **Panel Maps – 1 X 3 m photomosaics - Topopah Spring Lower Lithophysal (Tptpll)**
  - **Tape Traverses – Physically measured "line" traverses on 5m centers throughout the Tptpll**
  - **Angular Traverses – Laser traverses at selected locations in the Tptpll**
  - **Large Lithophysae Survey – Locating only lithophysae >50 cm in size in upper Tptpll**

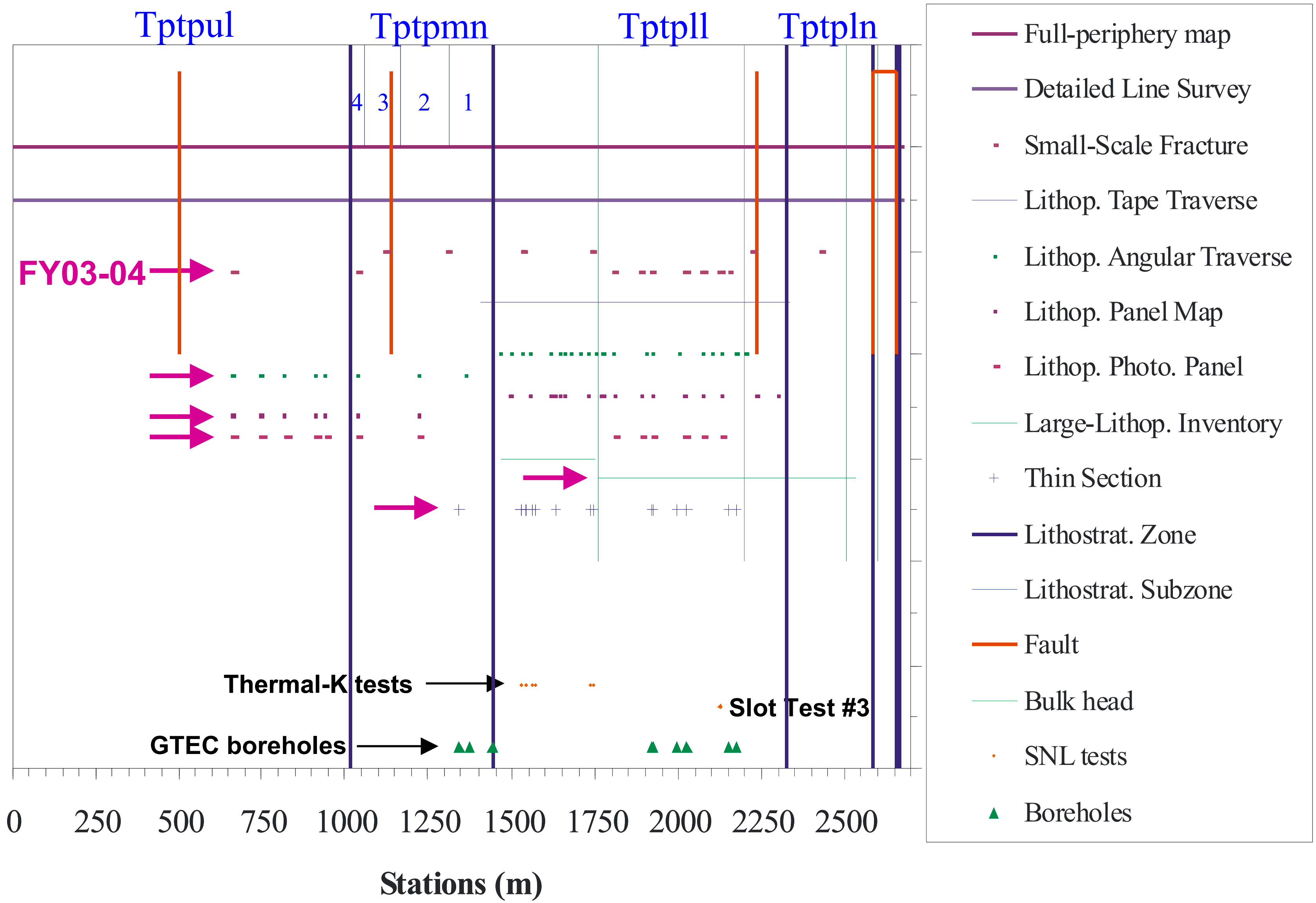
Lithophysal / Fracture Studies (Continued)
Lithophysae, Spots, and Vapor Pathways
(spots are the same as lithophysae, but do not have cavities and vapor-phase mineral coatings)



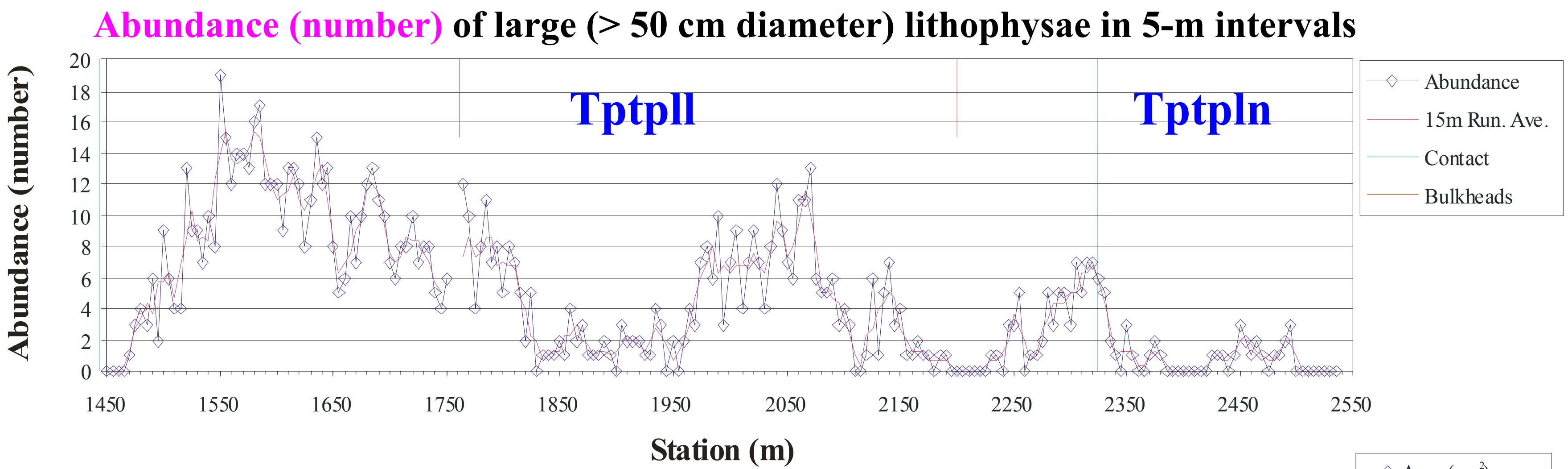
Lithophysal / Fracture Studies
(Continued)

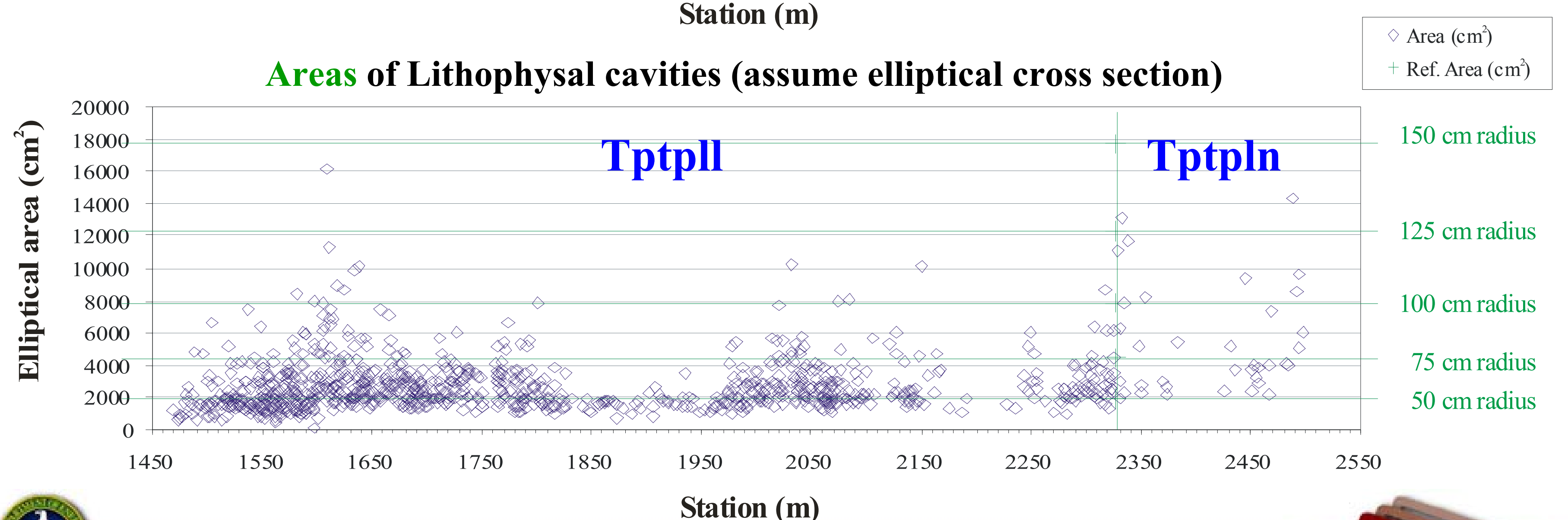
- **Data collected from Cross Drift**
  - **Panel Maps (5) and Angular Traverses (8) from 6+50 to 13+55**
    - **Data in the upper lithophysal and middle nonlithophysal zones**
    - **Provide size and distribution of features (lithophysae, rims, and spots)**
  - **Large-Lithophysae Inventory (17+62 to 25+35)**
    - **Completion of the lithophysal porosity in the lower lithophysal zone along the cross drift**
- **Video analysis of lithophysae in the Repository Host Horizon from the surface-based borehole USW WT-2**
  - **Provides "in situ" sizes and distributions of lithophysae**
  - **Results are consistent with data from the lower lithophysal zone of the Cross Drift**
  - **Results can be used to enhance understanding of borehole geophysical log data**

Locations of Geologic Data in the Cross Drift



Large-Lithophysae Inventory in the Cross Drift from Stations 1450 to 2550





Lithophysal / Fracture Studies

(Continued)

- **Fracture characteristics in the repository host horizon-equivalent rocks**
  - Core samples from surface- and subsurface-based boreholes
  - Fractures identified as "Cooling" (70%) versus "Indeterminate" (30%)
    - "Indeterminate" have no features to constrain timing of when they formed; although, they might also be late-stage cooling
  - Results are consistent with the Detailed Line Survey data in the Cross Drift when re-examined for "cooling" versus "indeterminate" criteria
- **Small-Scale Fracture (SSF) Studies in the Cross Drift (8)**
  - 1 SSF area in the upper lithophysal zone (Tptpul)
  - 1 SSF area in the middle nonlithophysal zone (Tptpmn)
  - 6 SSF areas in the lower lithophysal zone (Tptpll)
  - 6 SSF areas from previous mapping (Tptpmn [2], Tptpll [3], and Tptpln [1])
- **Supplemental Fracture Study from surface exposures**
  - Exposures of the Topopah Spring Tuff located in Yucca Wash, Prow Pass, and Windy Wash

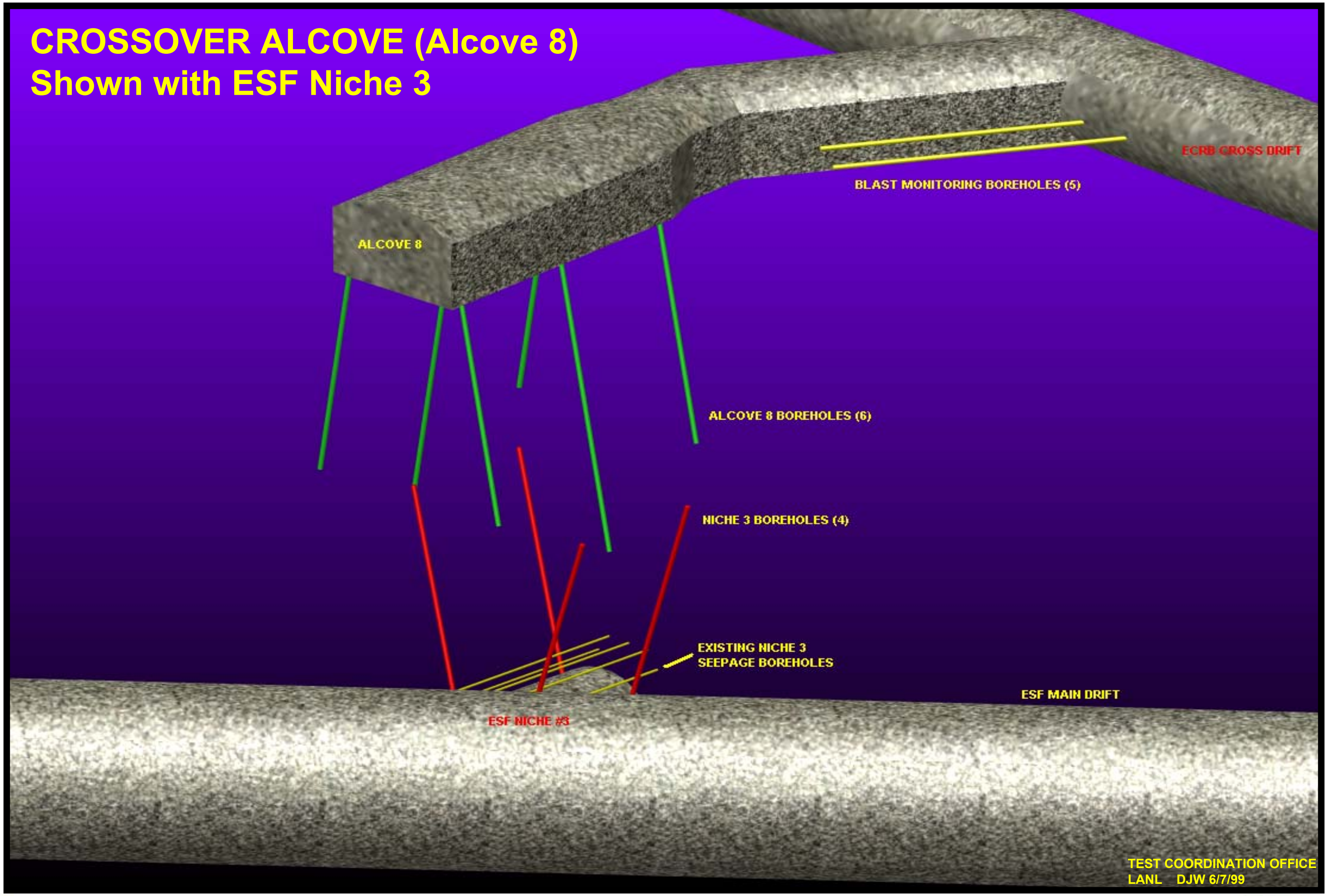
Cross Drift Studies

(Continued)

- **Alcove 8 / Niche 3 (Crossover Alcove) (Station 8+00 meters)**
  - Evaluate flow and seepage processes in potential repository horizon rocks at scale of tens of meters
  - Supports UZ Seepage and Transport models

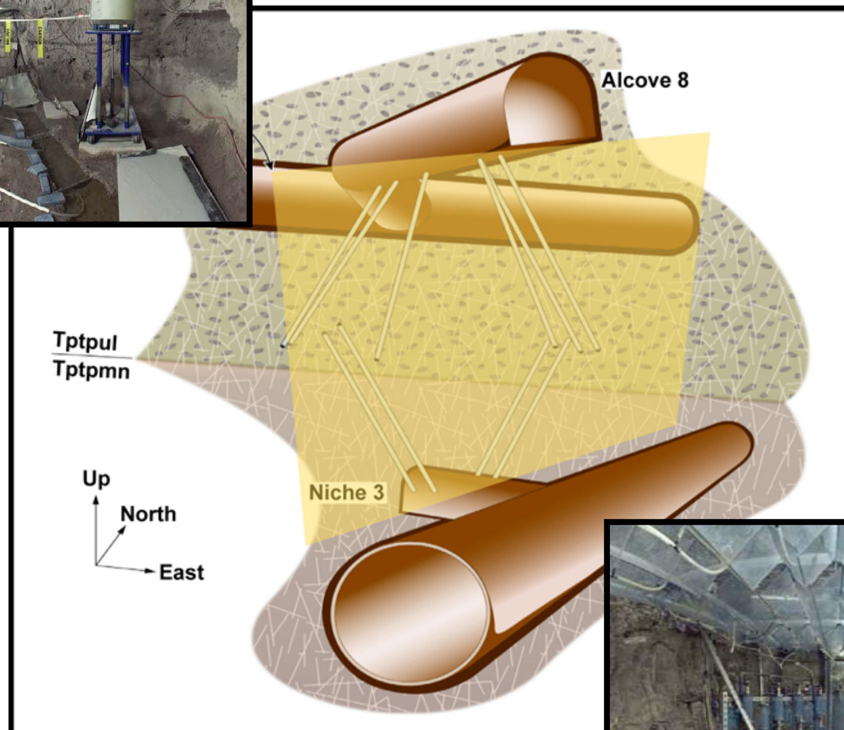
Cross Drift Studies

(Continued)

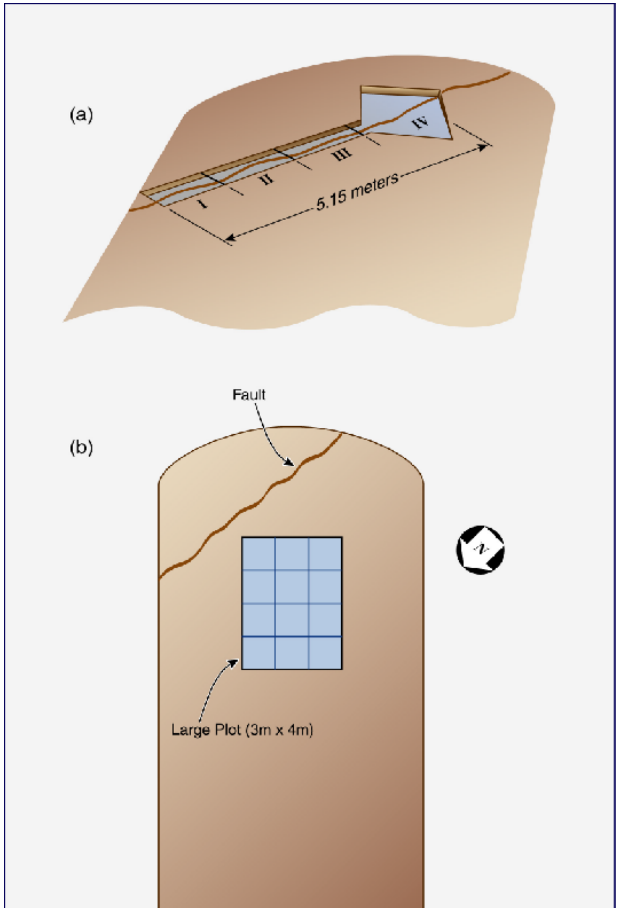


Alcove 8 / Niche 3 Fault Test

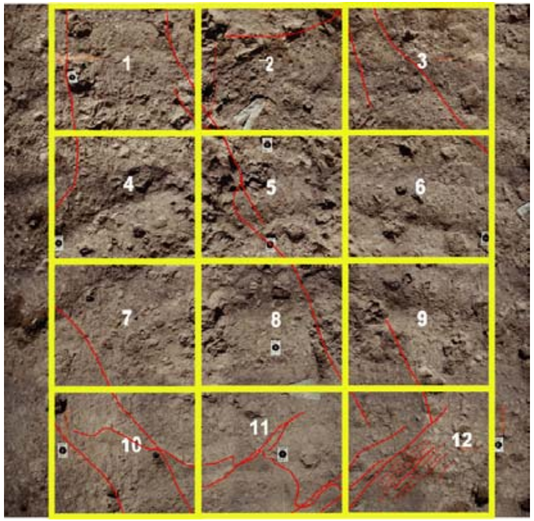
The Testbed



Alcove 8 / Niche 3 (Continued)
Methods



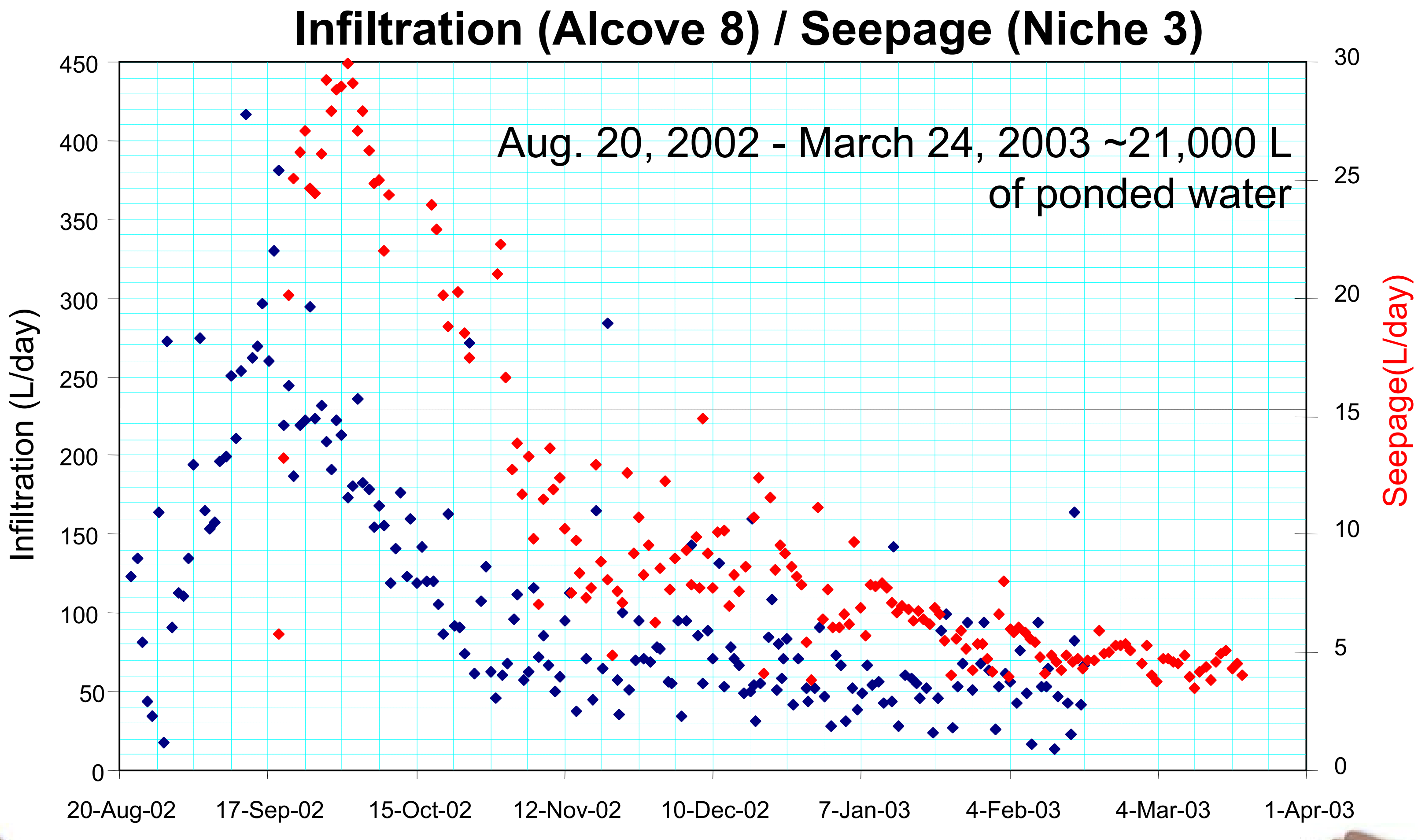
Location of Fault Along Alcove 8 Floor with Large Plot



Infiltration zone
Alcove 8

Alcove 8 / Niche 3 (Continued)

- **Spatial/temporal variability in infiltration and seepage rates**
- **Development of distinct flow paths**
- **Tracer test ongoing**



Cross Drift Studies
Bulkhead Investigations

- Evaluate flow and seepage processes in potential repository horizon rocks and Solitario Canyon Fault Zone in support of UZ Flow and Seepage Models
- Terminal 918 m of the Cross Drift isolated from ventilation to observe in situ drift conditions and re-wetting after closing bulkheads
- Monitor for free liquid water from either seepage or condensation

Bulkhead Investigations (Continued)

Water on Plastic Tray Below Wet Vent-Line (25+40)

Observations from February 3, 2003

Bulkhead Investigations (Continued)
Summary of Observations from Recent Entries

- Station 22+01 to 25+00 generally dry with water droplets observed on cables and in sections of vent line and conveyor belt
- Section between 25+01 and 25+40 wet with large density water droplets on vent line and large damp area close to bulkhead
- Section from 26+00 to TBM dry; Small area of cables with mold and water droplets
- Small pools of water in sections on conveyor belt and plastic sheet indicate collected condensate

Bulkhead Investigations (Continued)
Current Understanding

- Rapid rise in relative humidity when bulkheads closed indicates surrounding wet rock communicates efficiently with drift

- Spatial variability in temperature in non-ventilated drift partly caused by electrical power

- Multiple lines of evidence (e.g., water chemistry, moisture distribution) show that observed moisture is from condensation resulting from temperature differences within drift, and between drift and surrounding rock

Cross Drift Studies (Continued)
Thermal Properties Investigations

- **Supports coupled process models, engineered barrier system (EBS) process models, and design**
- **Laboratory Testing Program on Tptpll; Status: 144 tests completed; results presented previously**
  - Saturated and Oven-Dried Specimens
  - Specimens containing both Natural and Artificial Porosity
- **Field Tests**
  - Three tests completed - results presented previously
  - Two additional tests are ongoing: Tptpll and Tptpul
    - Phase I Nearing Completion, Heater Setting ≈ 2750 Watts, intersection temperatures approximately ≈ 100°C
    - Neutron Logging Incorporated in Test
    - Remaining Two Tests Complete by Aug 04

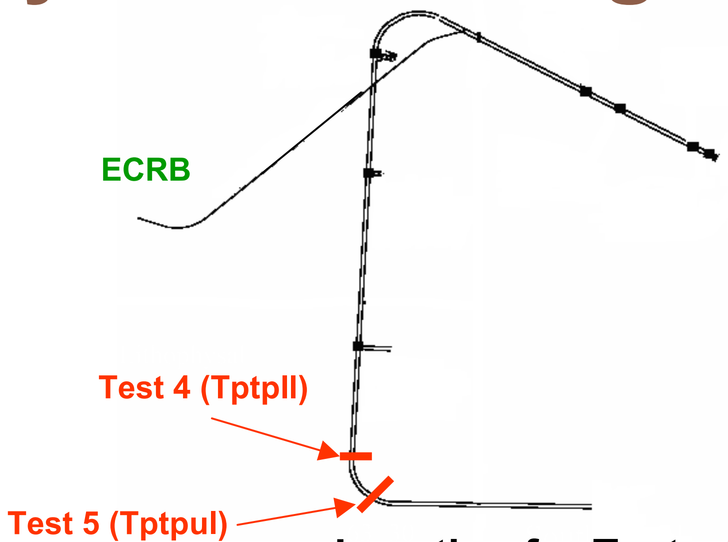
Thermal Conductivity Field Testing

- **Test 1, 2 and 3**: Two Hole, Six-Hole, and Three-Hole tests completed in FY03

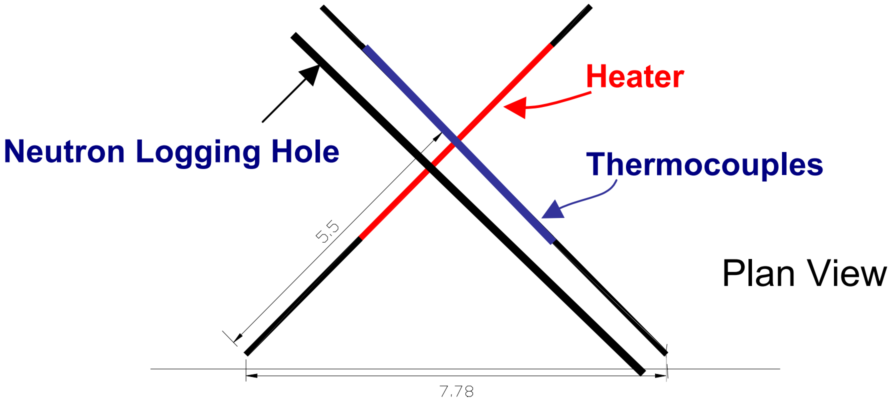
  Status: Completed

- **Test 4 and 5**: Single heater with instrumentation holes both above and below it to measure effects of convection on temperature distribution. Measure thermal properties below 100°C (phase 1), and also after the test area dries out (phase 2)

- ***Status:* Test *Ongoing, nearing completion of Phase I***

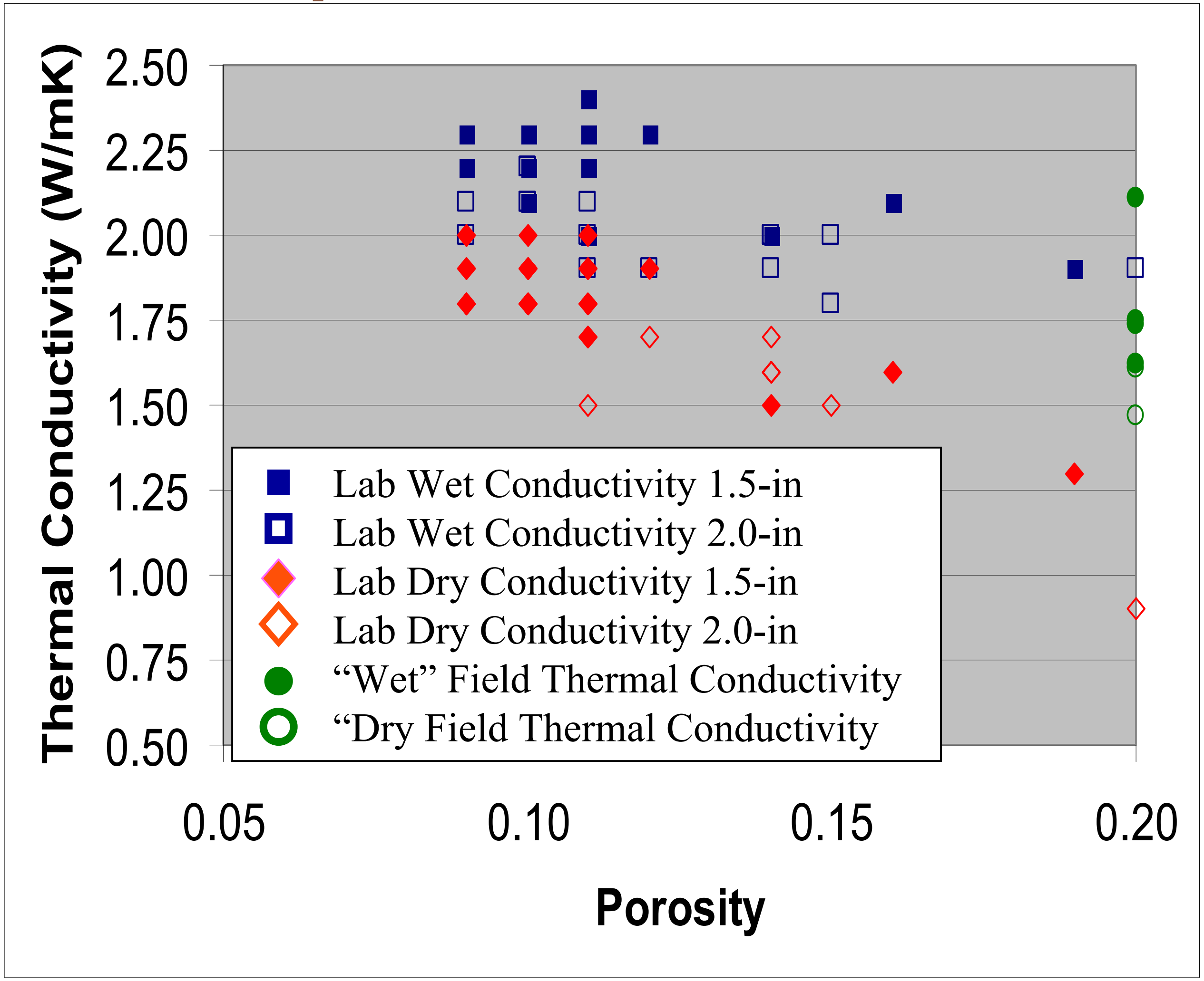


Location for Tests 4 and 5



Geometry for Tests 4 and 5

Thermal Properties Investigations
Comparison of Field and Laboratory Data



Field Thermal Conductivity

Wet: 1.7 – 2.2 W/mK

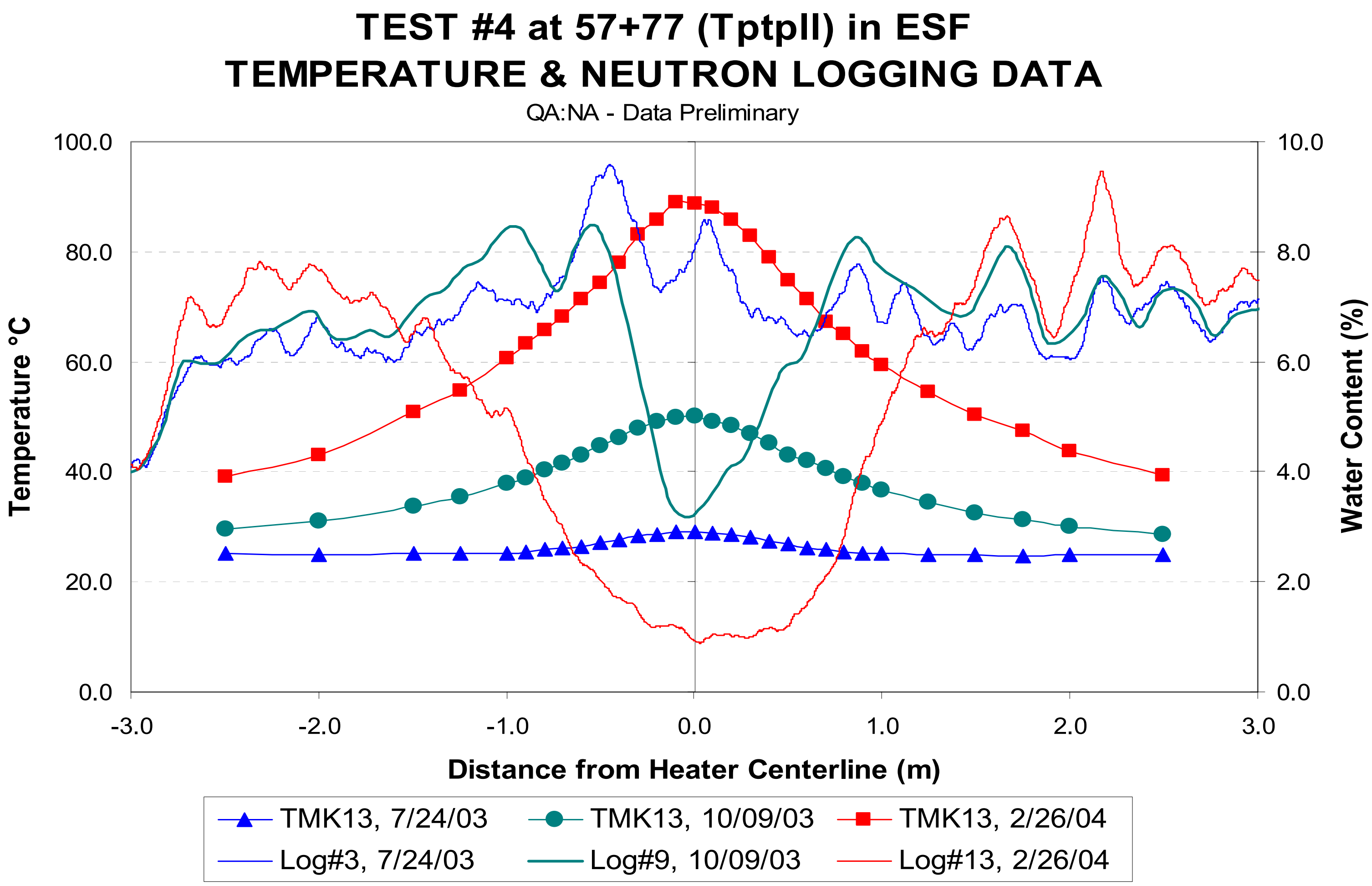
Dry: 1.5 – 1.6 W/mK

Laboratory data obtained on matrix specimens without lithophysae

Field and laboratory data are consistent

Field data are plotted at an arbitrary porosity

Field Data: Thermal Conductivity Tests



Neutron Data confirms movement of moisture away from heater as test temperature increases.

Field Data: Implications for Model

Model predictions given in: Thermal Conductivity of the Potential Repository Horizon Model Report, MDL-NBS-GS-000005. Model values account for moisture and lithophysal porosity.

	Field Thermal Conductivity		Model Report (W/mk)
	Wet (Phase I) (W/mK)	Dry (Phase II) (W/mK)	
Test 1 (2-Hole Test)	1.74	----	1.66 ± 0.25
Test 2 (6-Hole Test)	2.03 - 2.18	1.59 - 1.63	----
Test 3 (3-Hole Test)	1.73 - 1.76	1.47	1.62 ± 0.25
Test 4 (4-Hole Test, Tptpll)	1.66	----	1.90 ± 0.25 *
Test 5 (4-Hole Test, Tptpul)	1.93	----	1.77 ± 0.25 *

* These are the average values for the entire model layer (MDL-NBS-GS-000005, Table 7-10)

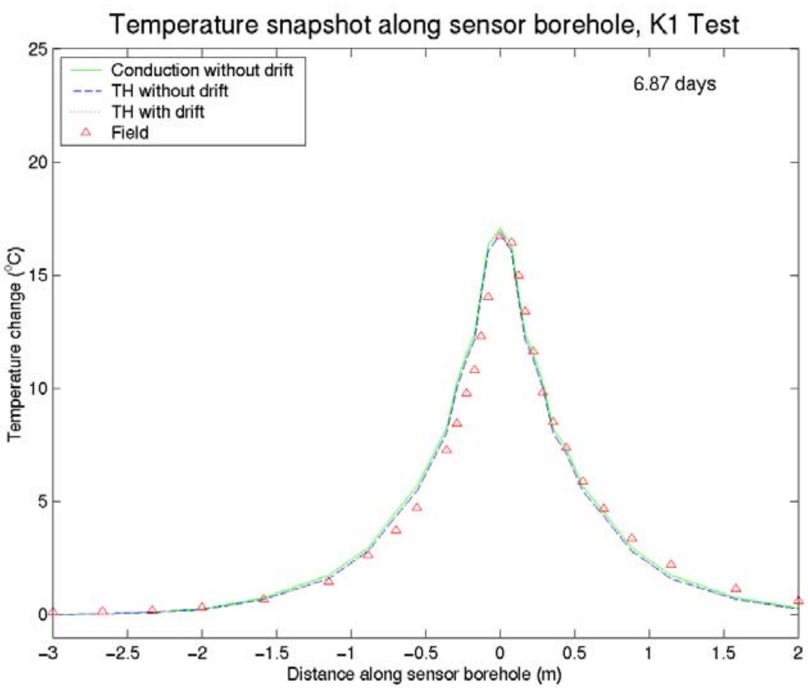
Range of values used in thermal-hydrologic models
Tptpll 2.14 W/mK (wet) to 1.03 W/mK (dry)
Tptpul 2.04 W/mK (wet) to 0.99 W/mK (dry)

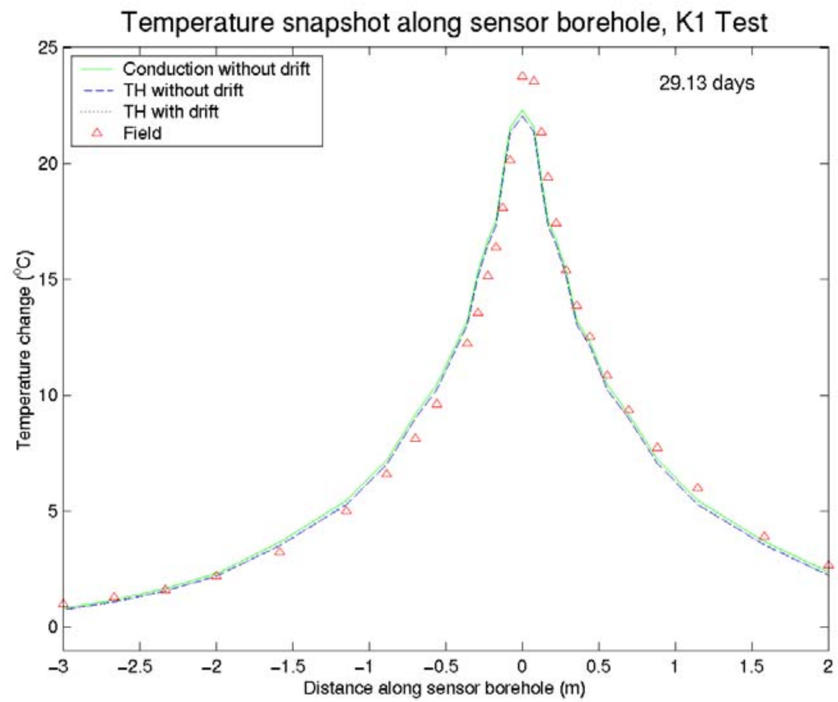
Thermal Test 1

- Thermal Test 1 was analyzed using conduction and thermohydrologic models
  - A best-fit value for thermal conductivity (1.67 W/mK) was determined
    - With a root-mean-square-error (RMSE) of 0.815 for all models
      - Conduction model with no drift
      - Conduction model with drift
      - Thermohydrologic model with no drift
      - Thermohydrologic model with drift
    - This value agrees with the value of 1.74 W/mK determined with an analytical model (Brodsky 2002)
  - Results clearly show that thermohydrologic convective-flow processes and drift boundary effects were negligible

Thermal Test 1

- **Conduction and thermohydrologic models yield close agreement with measured temperatures for a thermal conductivity of 1.67 W/mK**





Cross Drift Studies (Continued)
Thermal-Mechanical Rock Properties Investigations

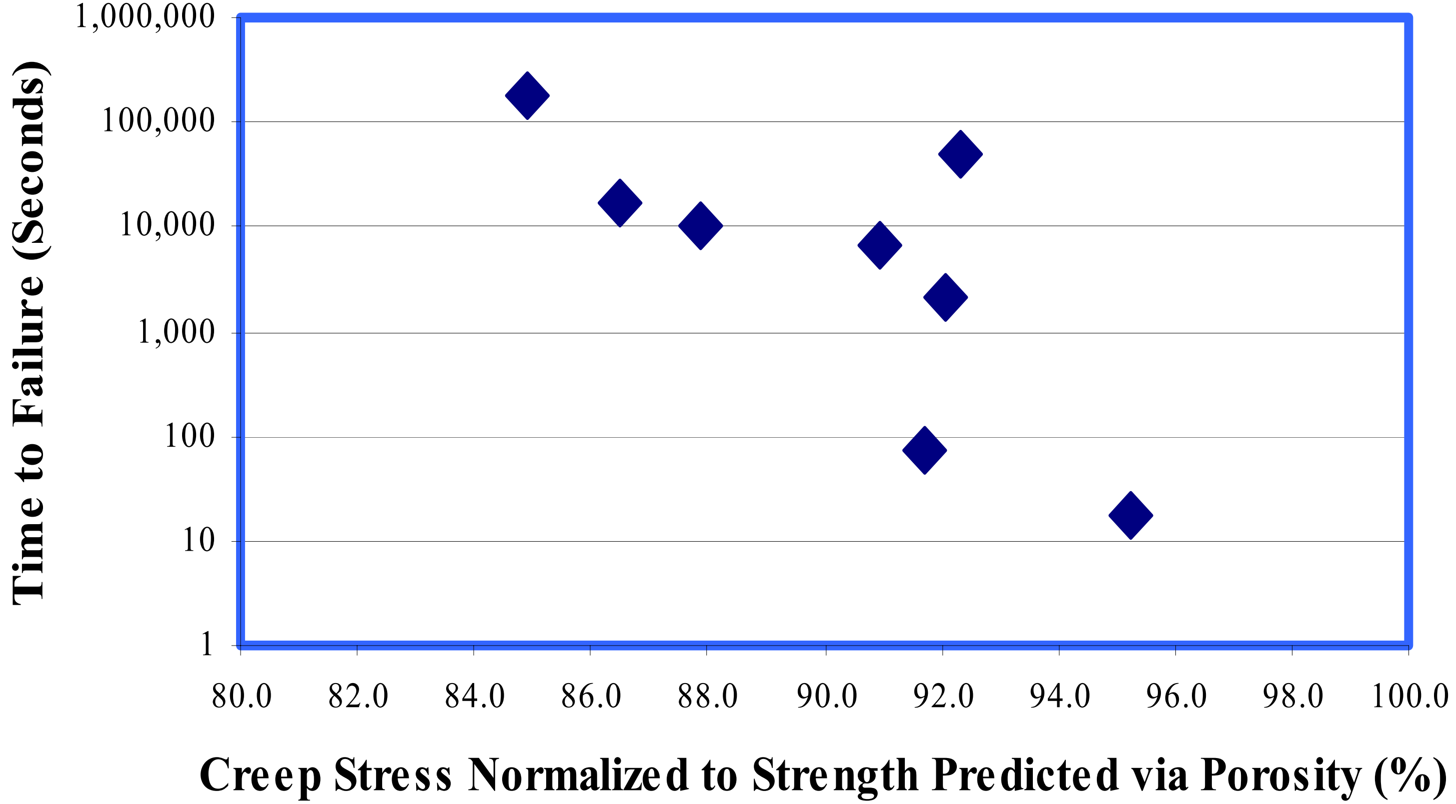
- **Objectives**
  - Provide data in support of ground support design, drift degradation models, and thermal models
- **Status**
  - Large diameter coring and sampling complete
  - In situ field tests complete
  - Laboratory measurements ongoing

Static Fatigue Experiments Long-Term Strength of Tuff

- **Sample Diameter: 50.8 mm (2 in)**
- **Sample Length to Diameter Ratio: 2:1**
- **Temperature: 125°C**
- **Confining Pressure: 5 MPa**
- **Pore Pressure: 4.5 Mpa**
- **Status: 12 samples completed to date**

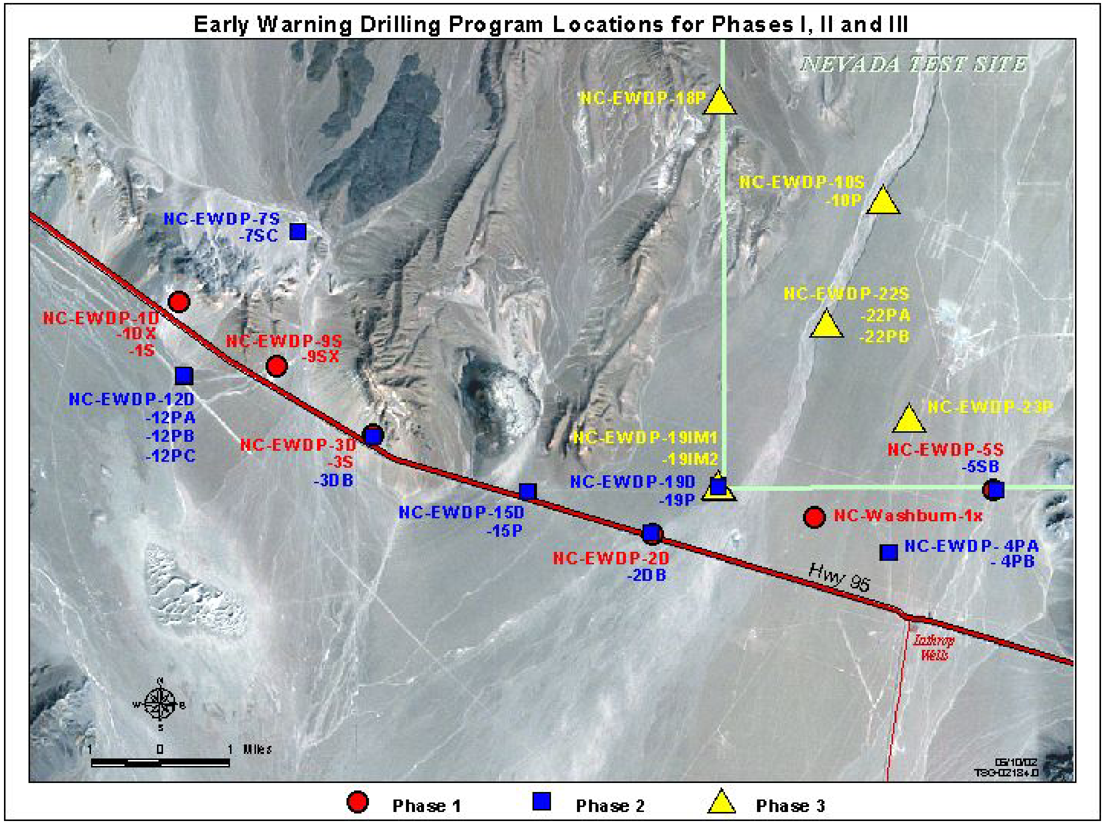
Sample Ready to Test

Static Fatigue Experiments (Continued)
Preliminary Results



Results are consistent with previous tests referenced in the Drift Degradation model.

Saturated Zone
Nye County Early Warning Drilling Program

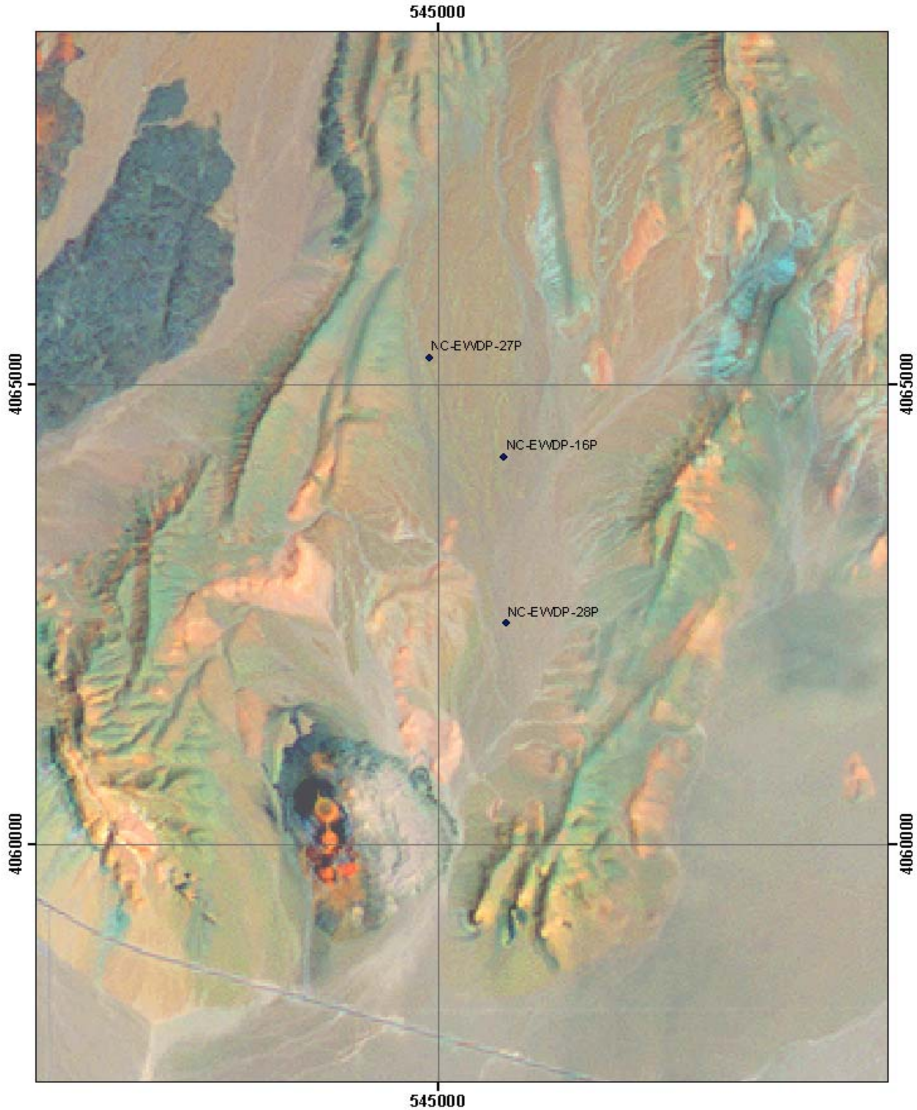


Site-Scale Data Being Collected in support of the SZ Flow and Transport Model:

(1) Lithologic data into the hydrogeologic framework model
(2) Water-level data for flow field calibration
(3) Hydraulic testing data for flow and transport models
(4) Laboratory sorption measurements (^{237}Np, ^{129}I, and ^{99}Tc) on alluvium for process models and TSPA
(5) Hydrochemistry data for flow field calibrations
(6) Eh/pH data for use in flow and transport models
(7) Hydraulic and transport testing of alluvial aquifer for flow and transport models

Saturated Zone (Continued)

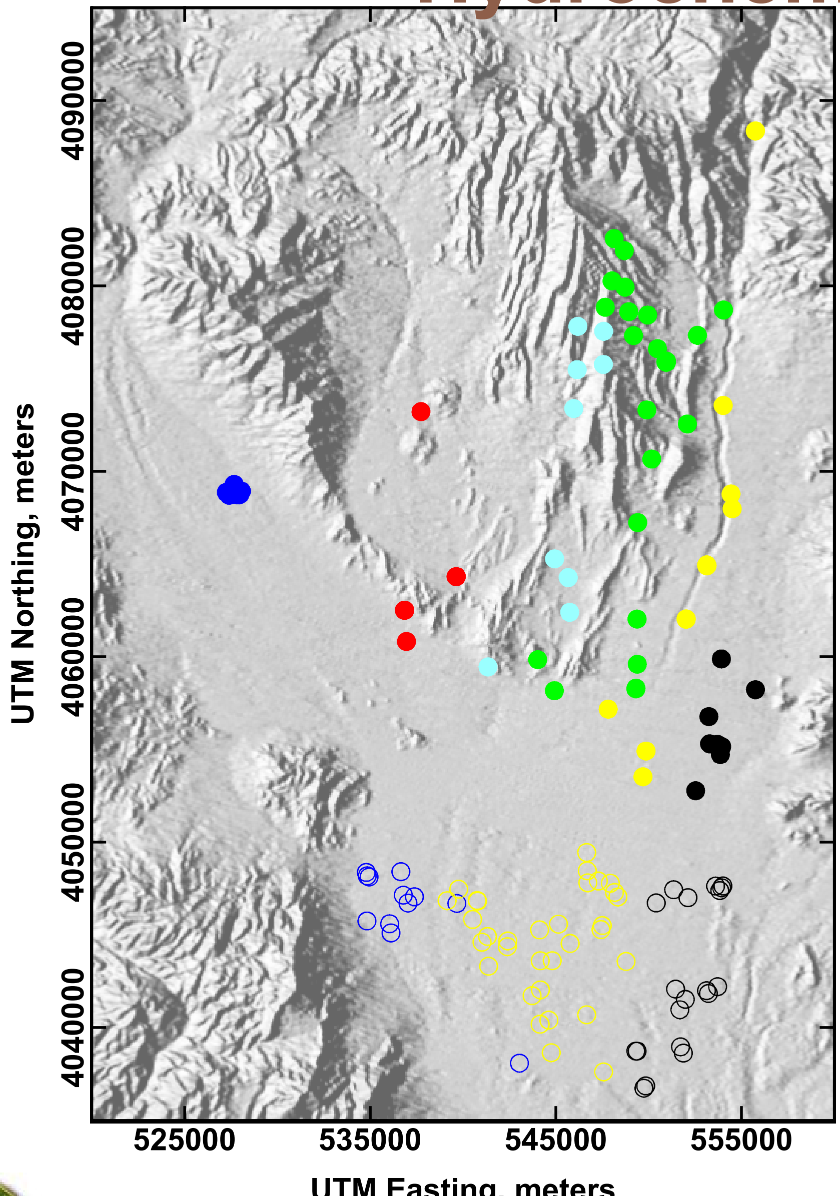
Nye County's Phase IV Drill Hole Locations



Saturated Zone (Continued) Hydrochemistry Objectives

- Identify and map hydrochemical facies in Yucca Mountain region
- Identify potential flow paths from Yucca Mountain to accessible environment
- Assess interaction and mixing among different facies, including transition from volcanic to alluvial aquifer downgradient from Yucca Mountain
- Improve understanding of compositional variability in the third dimension

Hydrochemistry (Continued)



Hydrochemical Facies and Distinguishing Analytes

- **Western Yucca Mountain Facies**
  Na, HCO_3, F, Ca
- **Eastern Yucca Mountain Facies**
  Na, HCO_3, Ca, $^{234}U/^{238}U$
- **Fortymile Wash Facies**
  Na, HCO_3
- **Bare Mountain Facies**
  HCO_3, SO_4, Cl, Ca
- **Amargosa River Facies**
  Na, Ca, SO_4, HCO_3, Ca
- **Eastern Amargosa Facies**
  SO_4, Na, Cl

Open circles represent areas where facies become less distinct due to mixing

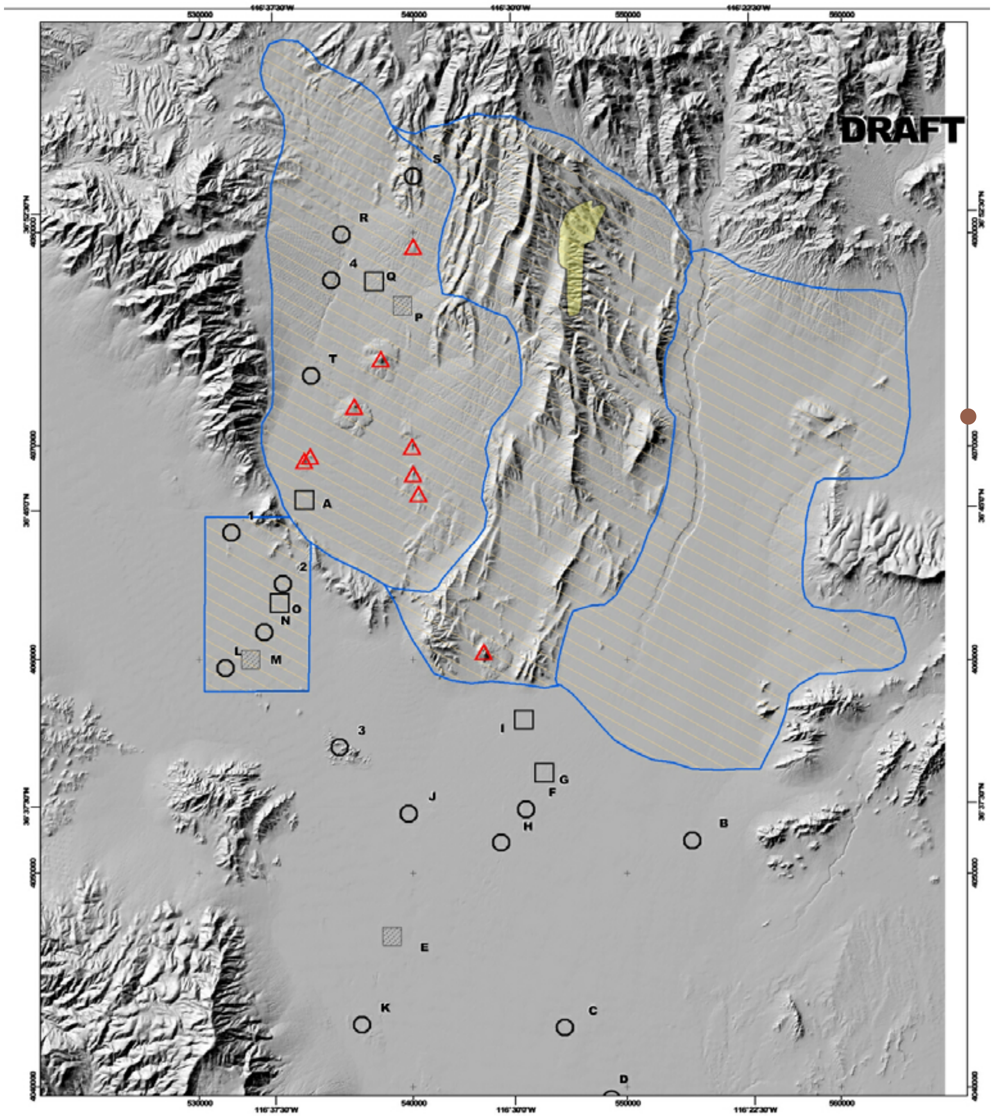
Saturated Zone (Continued)
Sonic Core from NC-EWDP-19PB

- Will provide detailed hydrochemical profiling of the saturated zone in alluvium
- Method development for water extraction
  - 225 grams of core sample centrifuged for 4 hours at 15,000 rpm yielded 9 ml of water
  - 9 ml is sufficient to analyze cations, anions, trace elements, and several isotopes
  - Experiments are underway using 0.45, 0.2, 0.1, 0.006, and 0.004 micron filters to evaluate potential colloid interference

Igneous Events Studies Support Igneous Disruptive Events Analyses and Models

- **Evaluating aeromagnetic data for identification of potential buried volcanic centers**
- **Conducting detailed aeromagnetic survey**
- **Evaluating probability of intersection based on aeromagnetic data**

Igneous Events Studies (Continued)



Design of aeromagnetic/EM survey emphasizes detection of basaltic features in magnetically noisy areas surrounding Yucca Mountain

- **Survey area used to estimate costs, actual survey area may be slightly different**
- **Diagonal flightlines are for illustration purposes only; 600 meter spacing shown, 60 meter spacing planned**

△	**Volcano**
○	**1999 USGS Survey**
□	**Planned Drill Hole**
▨	**Contingency Drill Hole**

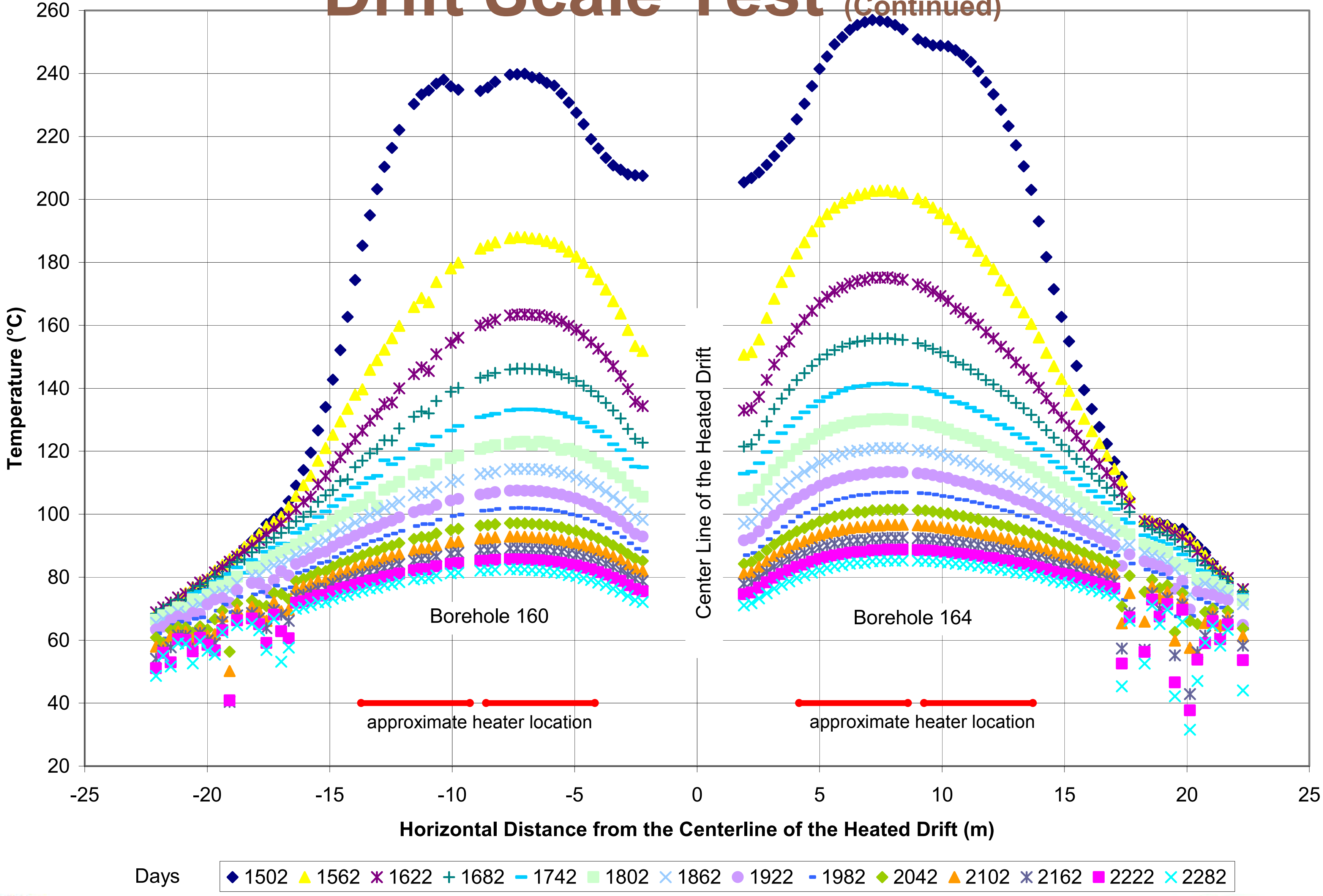
Igneous Events Studies (Continued)

Summary

- **Ongoing data collection and testing in ESF, Cross Drift, and laboratories continue to address uncertainties and provide additional confidence in natural and engineered systems analyses and models and design in support of License Application**

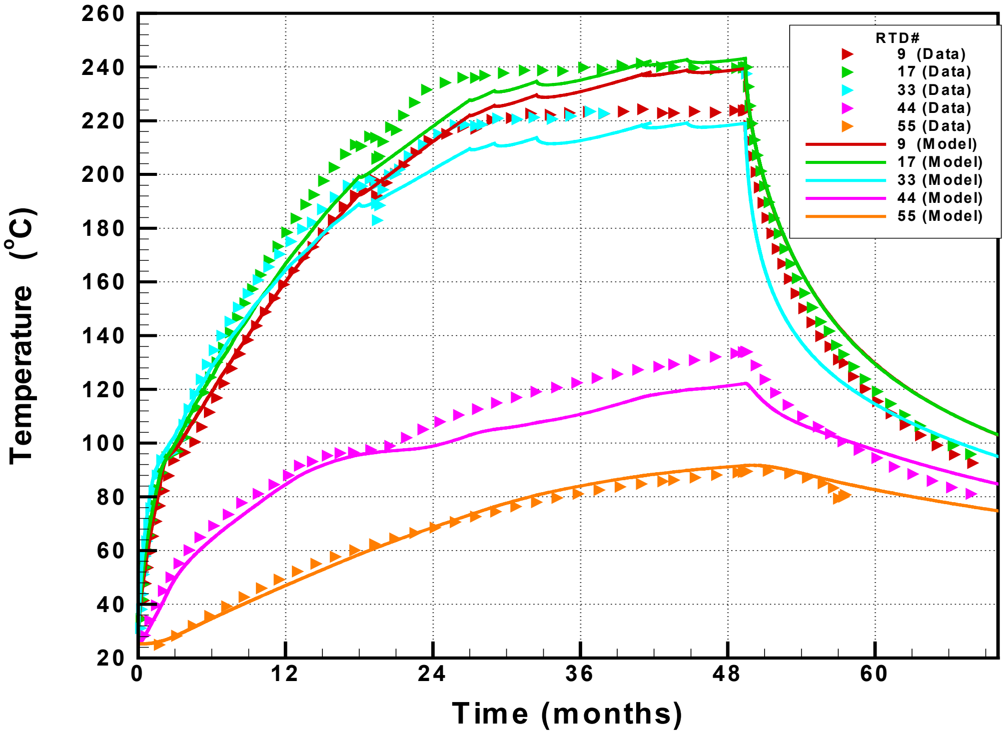
Backup

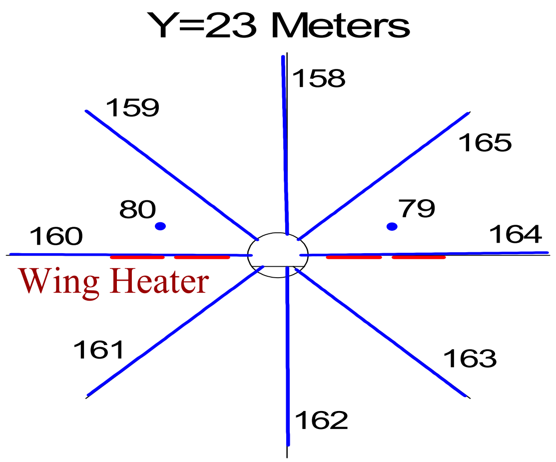
Drift Scale Test (Continued)



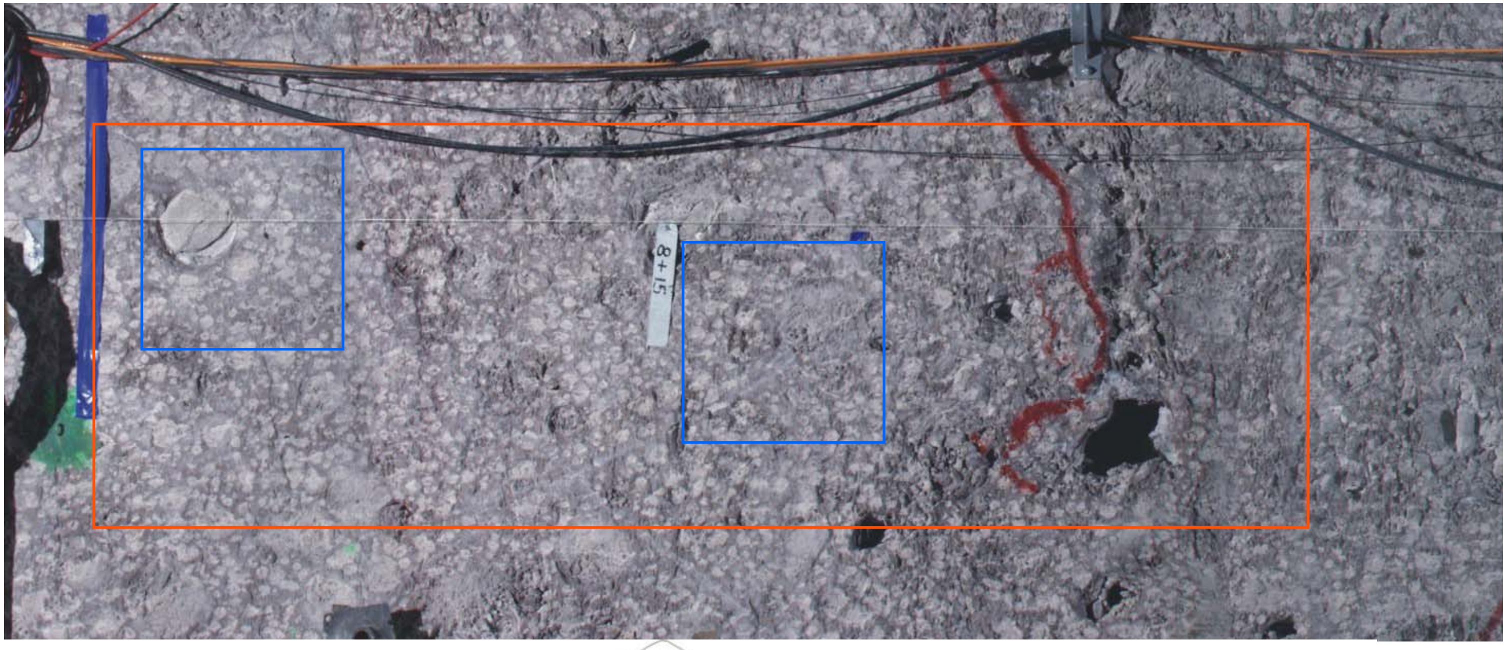
Drift Scale Test (Continued)

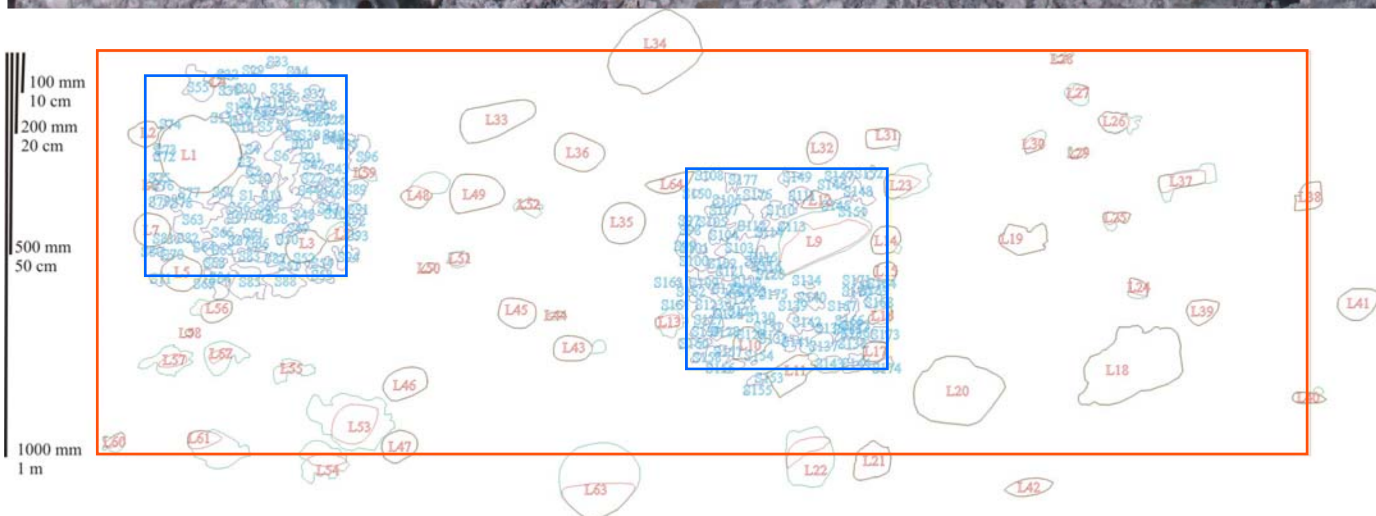
Temperature History for Selected Sensors in Borehole 160 at y = 23 m





Panel Map 08+15



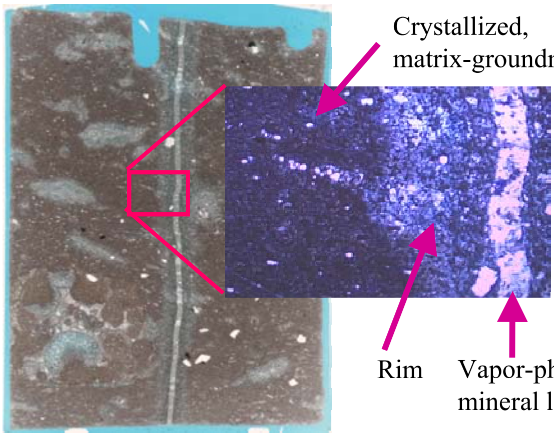


Summary

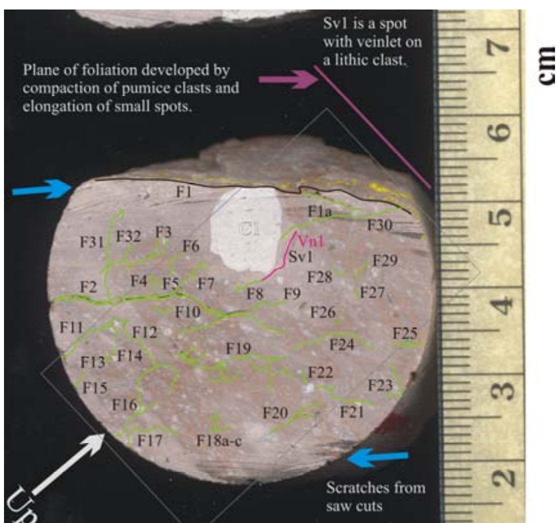
%	Feature
56.2	Matrix-groundmass
10.3	Lithophysal cavities
2.8	Rims
30.7	Spots

Lithophysae and spots of Tptpul in the 1x3-mpanel map 08+15 located on the left rib from station 08+13.6 to 08+16.6. Lithophysae have red "L" identifiers with cavities outlined in red and rims in green. Spots have blue "S" identifiers with cyan outlines, but because of the abundance of spots, they were only mapped in 50 cm squares.

Textures of Fractures Indicating They Formed During Cooling



Thin section (21x27 mm) from NRG6 730 ft, Tptpmn

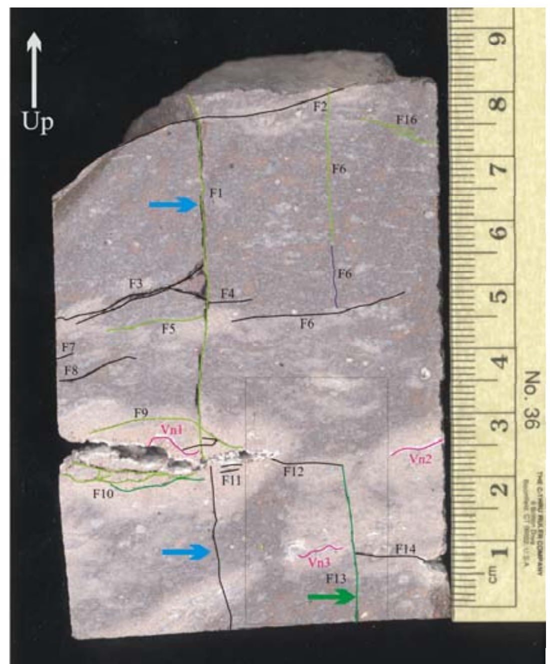


Therm-K-007 0.4 ft, Tptpll (sample number 01013319)

Small-scale textures of **cooling fractures** include

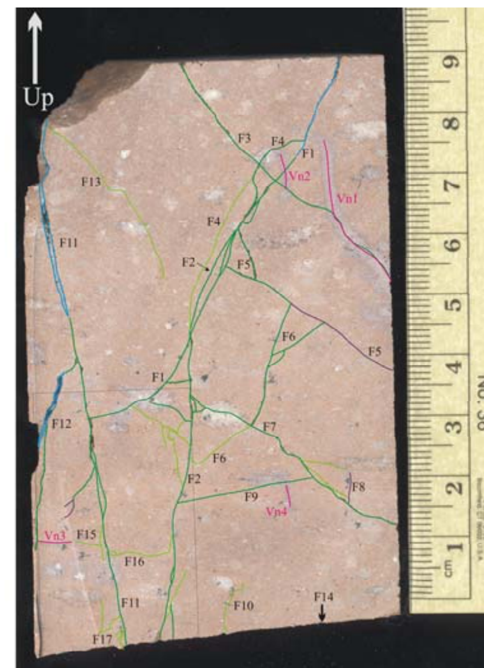
1) variably developed rims (similar to rims on lithophysae)
2) variably developed vapor-phase mineral lining
3) variably developed grayish purple or reddish purple borders
4) as many as 8 combinations of these features are depicted with colored lines

Black lines are fractures without the above features, so they have **"indeterminate"** times of formation.



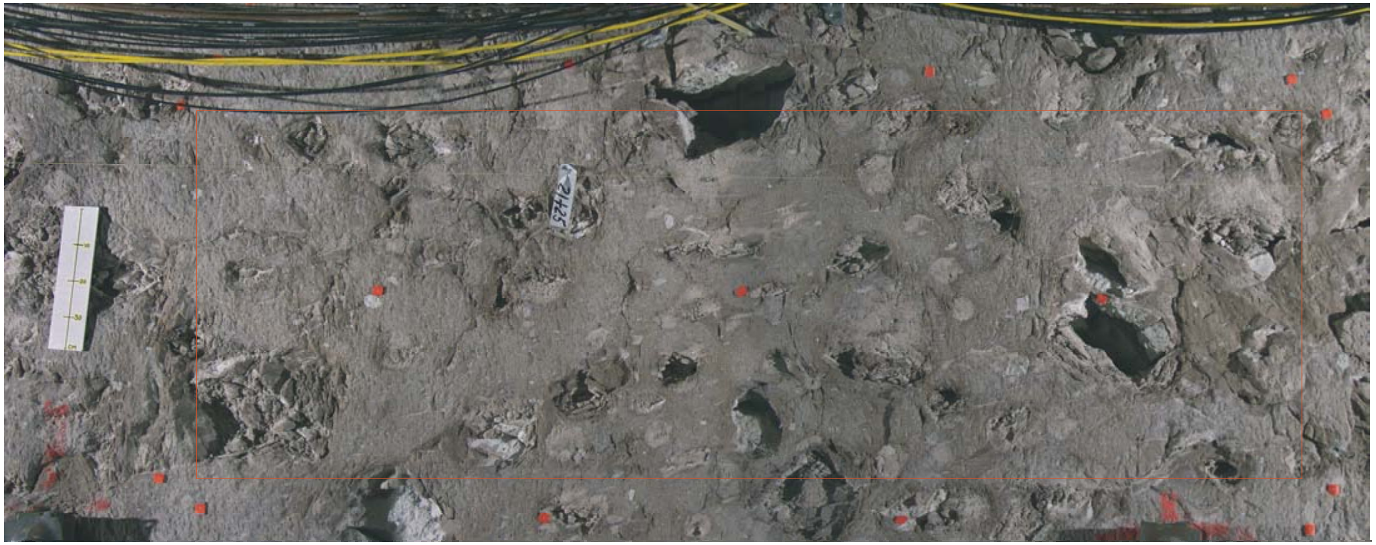
Fractures traced as "hairline" fractures to the outer wall of core are indicated with cyan and green colored arrows. Fracture (cyan line) also intersects the same lithophysal cavity on core wall with a similar "jog". The two fractures in the upper left have thin coatings of colorless euhedral (vapor-phase or zeolite) minerals. Fracture (green arrow) terminates in rock on outer wall and has a small amount of white (vapor-phase?) mineral filling at terminus.

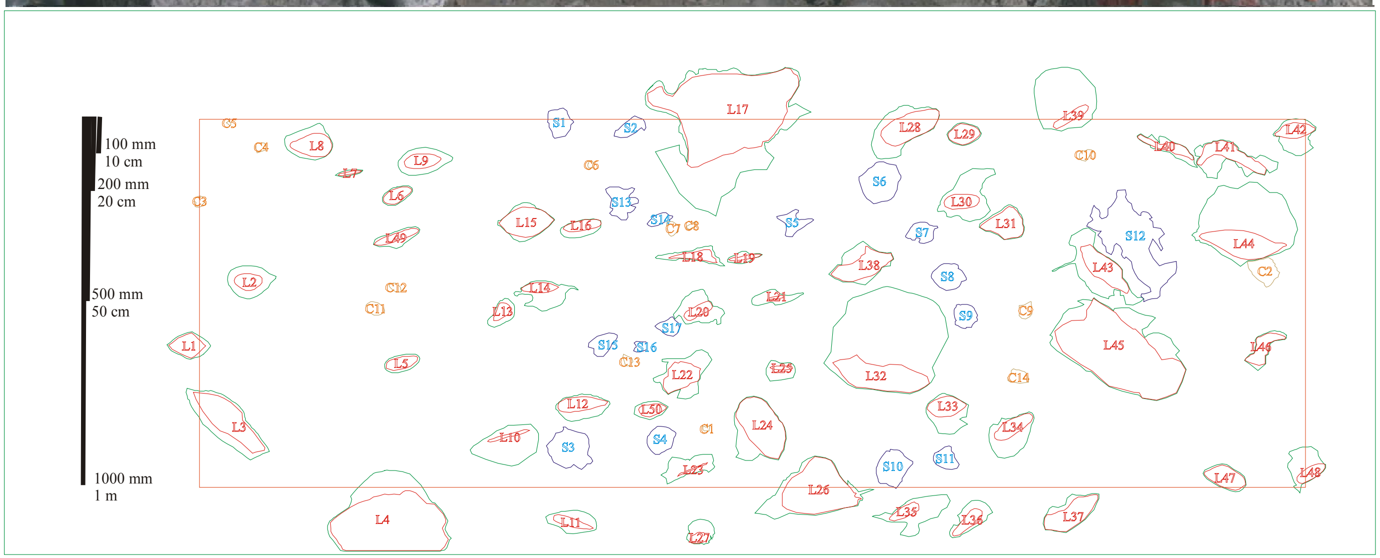
UZ-14 714.1 ft, Tptpul (sample number 0029744)



UZ-14 732.2 ft, Tptpmn3 (sample number 0029749)

Panel Map 21+25L





Summary

%	Feature
69.5	Matrix-groundmass
13.3	Lithophysal cavities
13.3	Rims
3.7	Spots
0.2	Lithic clasts

Lithophysae, spots, and clasts of Tptpll in panel map 2125 located on the left rib from station 21+25 to 21+28. Lithophysae have red "L" identifiers with cavities outlined in red and rims in green. Spots have blue "S" identifiers with cyan outlines. Lithic clasts have orange "C" identifiers with gold outlines.

Development of Discrete Fracture Networks Using FracMan

- **To further refine Drift Degradation analysis, discrete fracture networks have been developed for each Repository Host Horizon zone**
- **Networks are built by conditioning the FracMan model with observed data collected from underground excavations**
- **A hierarchal approach to defining fractures sets is used to begin defining the model**
  - **First-forming fractures are defined as either low-angle, Vapor Phase Partings, or long, high- to medium-angle fractures**
  - **After fractures are defined by length, they are further segregated into sets based on clustering of orientations**

Development of Discrete Fracture Networks Using FracMan
(Continued)

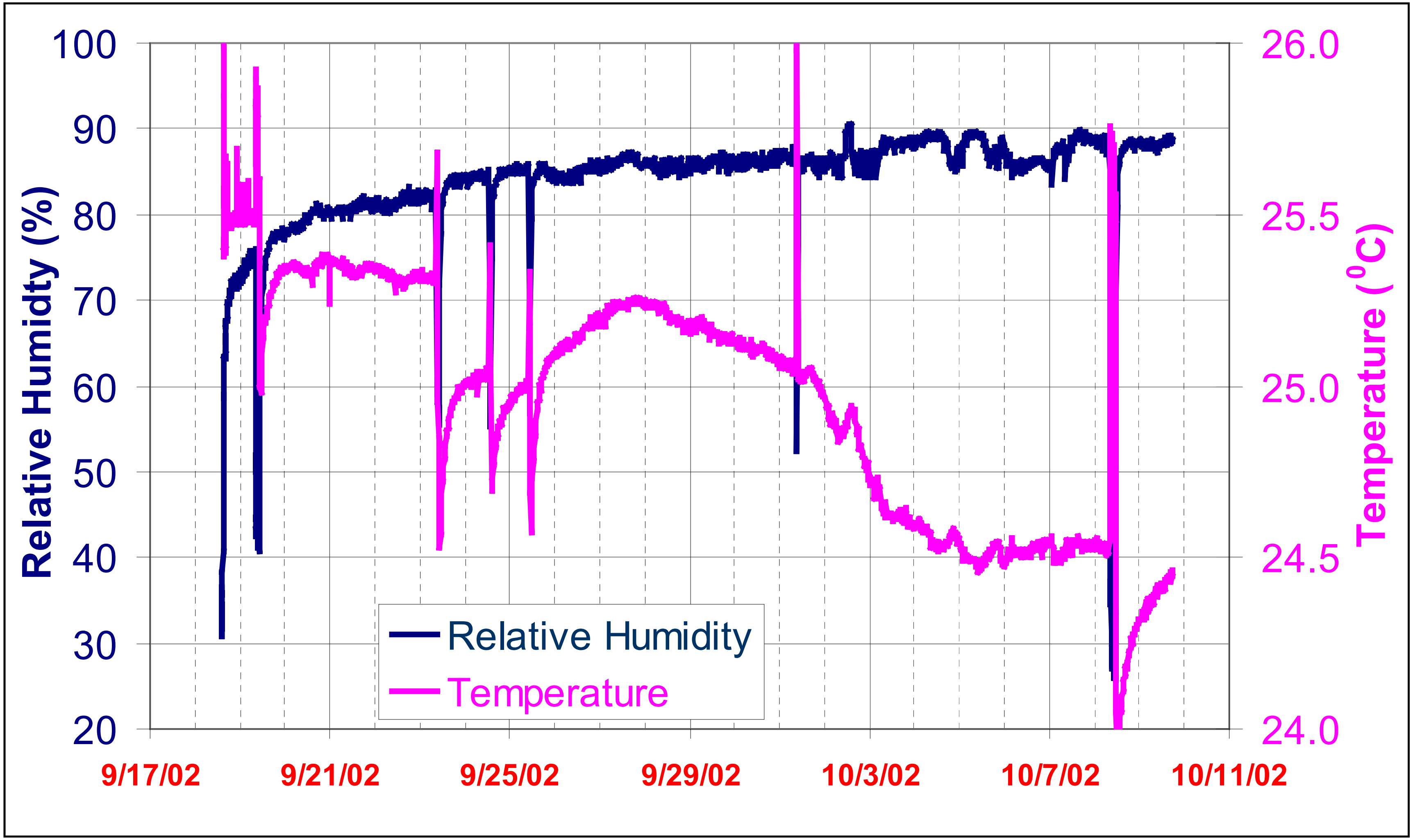
- The resulting "cube" from the FracMan model is sampled the same way the observed fractures were mapped in the underground
  - Through the direct comparison of like data, verification of the model is accomplished
    - For example: inter-fracture distance from the Detailed Line Survey can be compared to the inter-fracture distance from a synthetic survey of the FracMan "cube"
    - Trace lengths from mapping are compared to trace lengths from synthetic maps of the FracMan "cube"
    - Orientations from the underground data can be directly compared to orientations from the FracMan "cube"
    - No bias correction is necessary because the synthetic is sampled with the same biases as the underground data

Development of Discrete Fracture Networks Using FracMan

(Continued)

- **Although not a replicate, the representative fracture network data is handed off to the 3DEC modelers for analysis of rock fall and tunnel degradation**

Alcove 8 / Niche 3 Observations Plot Test



Cross Drift Bulkhead Chronology

Date	Activity
5/10/99	Begin construction/fabrication of bulkheads @ 17+63 and 25+03
5/26/99	Doors @ 25+03 slam shut causing collapse of ventline
6/23/99	Closed bulkhead doors @ 17+63 and 25+03
9/1/99	USGS Neutron logged 2 meter boreholes
1/29/00	Refuge chamber established @ 17+63
2/15/00	LLNL collected microbiological samples inside bulkhead @ 17+63
6/28/00	Bulkhead doors opened, photos taken and water samples collected
6/29/00	Materials taken in to install new bulkhead @ 25+99
8/1/00	Insulated bulkhead @ 25+99
8/2/00	Closed bulkhead doors @ 25+99, 25+03, and 17+63
1/22/01	Re-entry behind bulkheads @ 25+99, 25+03, and 17+63 for observation, photos, and sample collection
5/22/01	Quick re-entry to check out 4160 volt electrical problem
10/01/01	Re-entry to locate and construct new bulkhead @ 22+01
11/14/01	Close bulkheads @ 25+99, 25+03, and 22+01
12/20/01	Close bulkhead @ 17+63
6/24/02	Re-entry to bulkhead @ 22+01
6/27/02	Closed bulkhead @ 17+63 due to mold issues
7/17/02	Bulkhead at 17+63 opene to allow for Geotechnical drilling
1/13/03	Electrical incident occurred behind bulkhead @ 22+01
1/15/03	Mine rescue opened bulkhead @ 22+01 to investigate incident, then closed door

Date	Activity
2/3/03	Re-entry behind blkhead @ 22+01 to allow testing to perform observations and crafts to stabilize incident situation
2/4/03	Closed door on bulkhead @ 22+01
7/7/03	Planned re-entry through all 4 bulkheaded areas to perform observations, collect samples, photograph locations, and perform instrument calibrations
7/9/03	Closed bulkhead doors @ 25+99, 25+03, and 22+01
9/8/03	Opened doors up to TBM to relocate refuge chamber supplies
10/29/03	Closed bulkheads @ 25+99, 25+03, and 22+01
10/30/03	Closed bulkhead at 17+63, but not sealed, waiting on sealing supplies
11/06/03	Opened bulkhead @ 17+63 to restock and check refuge chamber supplies and begin sealing bulkhead door
11/12/03	Complete sealing of bulkhead door @ 17+63
08/04	Planned re-entry to perform observations, collect samples, photograph areas, and remove instruments in need of annual calibration. Doors will be closed, but not sealed
09/04	Re-install calibrated instruments. Close and seal all bulkhead doors

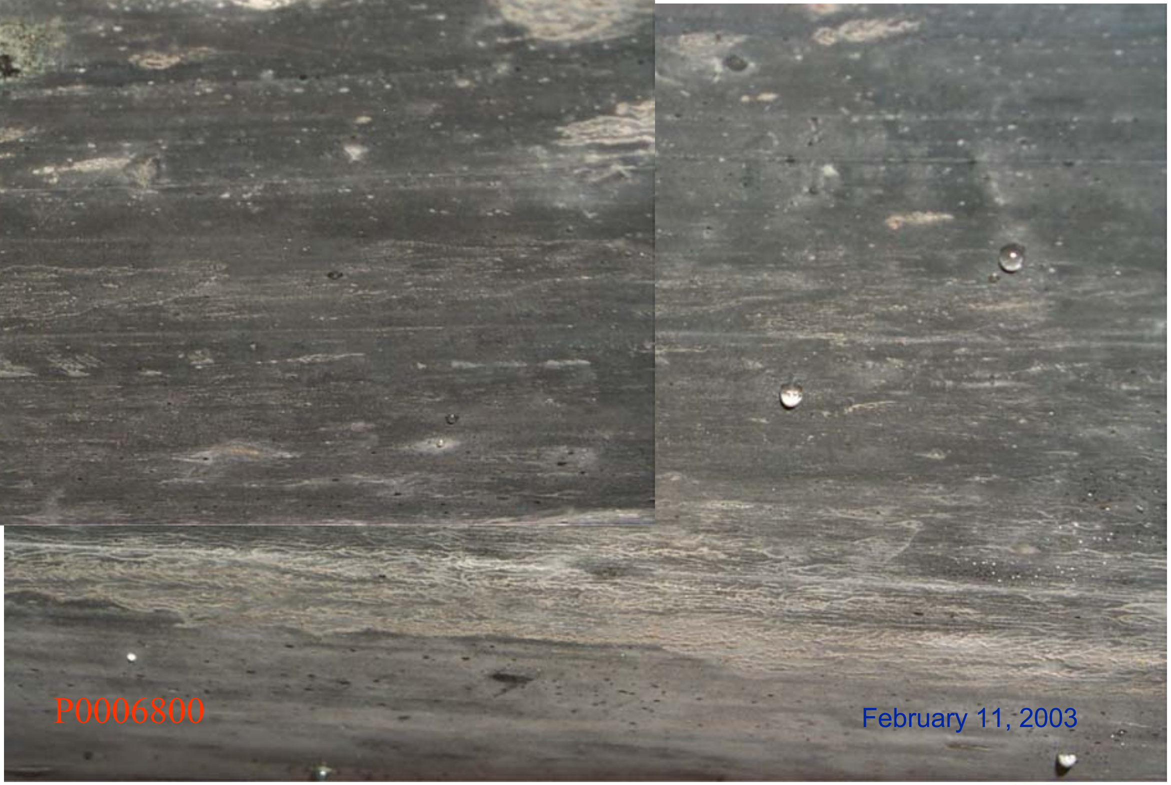
Bulkhead Investigations

Saturation Changes Along Canvas at Station 20+00 on June 2002

Observations from June 23, 2002

Bulkhead Investigations
Water Droplets on Upper and Lower Surface of Conveyor Belt (22+90)

Observations from February 3, 2003



Bulkhead Investigations

Wet Bulkhead Area at 25+01 (Facing Towards 25+00)

Observations from February 3, 2003

Bulkhead Investigations

Pool of Water at 25+40 on Lower Conveyor Belt

Observations from February 3, 2003

Bulkhead Investigations

Empty Sampling Bottle with Droplet Forming (25+40)

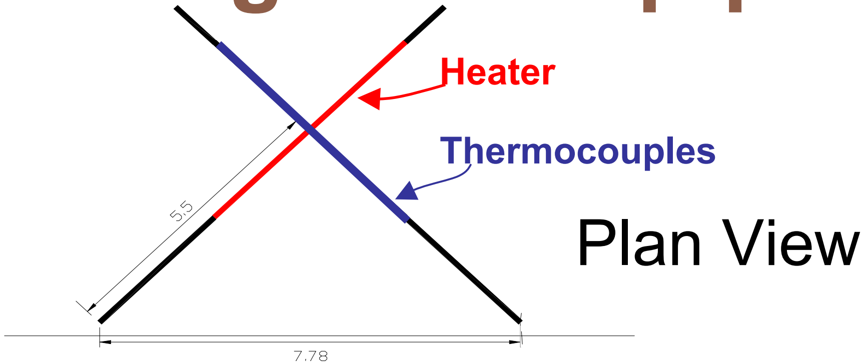
Observations from February 3, 2003

Thermal Properties Investigations Overview of Field Test Program in Tptpll

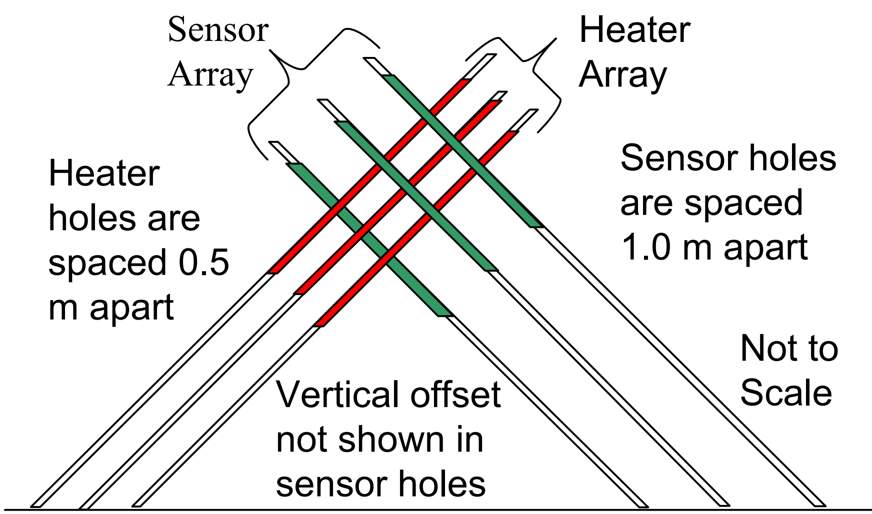
- **Test 1**: Single heater and single instrumentation borehole, run at temperatures below 100°C. ***Status: Completed***.

- **Test 2**: Three heaters and 3 instrumentation boreholes sample larger test volume, provide control of temperature distribution. Measure thermal properties at temperatures below 100°C (phase 1), and also after the test area has been dried out (phase 2). ***Status: Completed.***

- **Test 3**: Sample 3rd location. Single heater with instrumentation holes both above and below it to measure effects of convection on temperature distribution. Measure thermal properties at temperatures below 100°C (phase 1), and also after the test area has been dried out (phase 2). ***Status: Completed.***

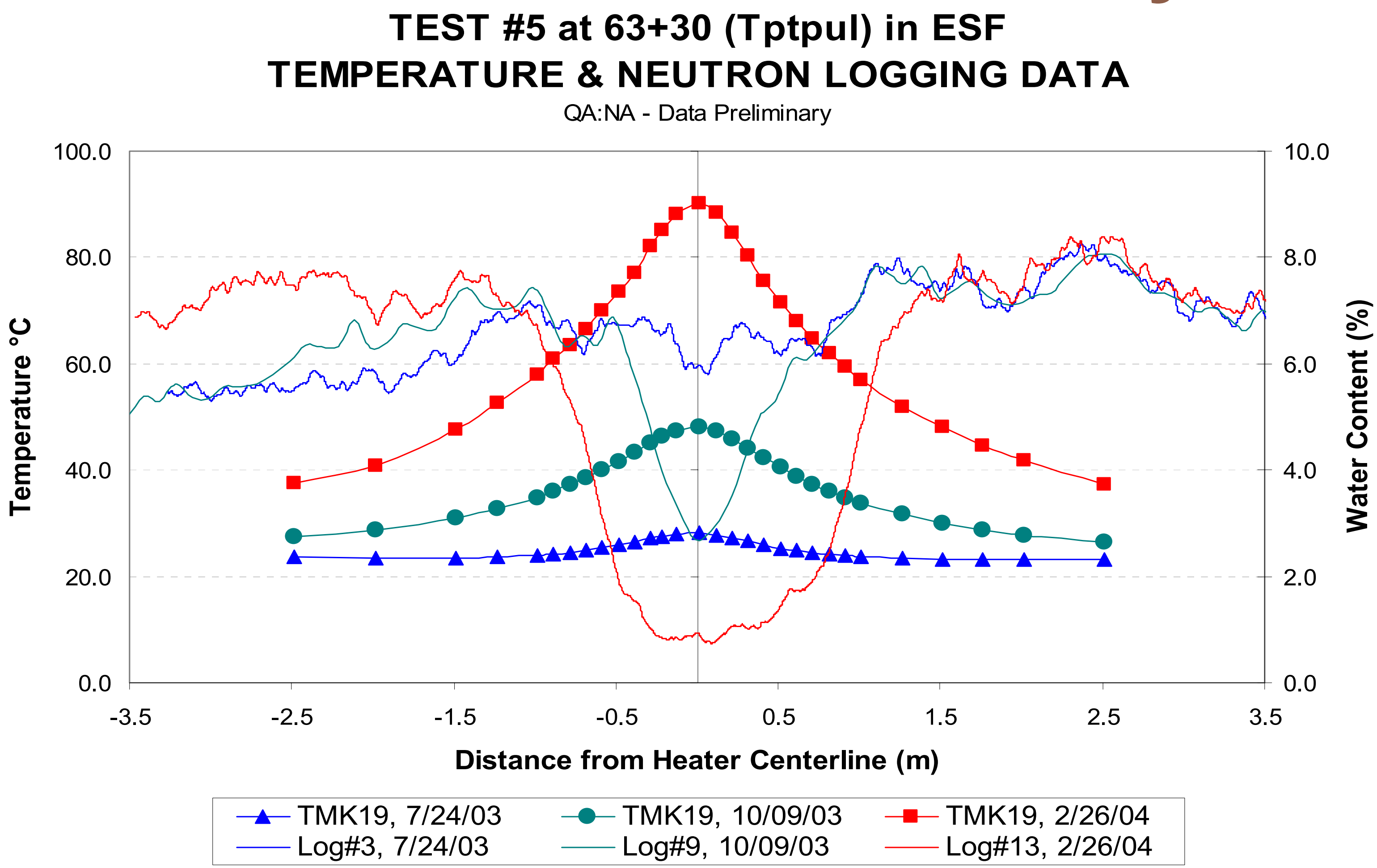


Geometry for Tests 1 and 3

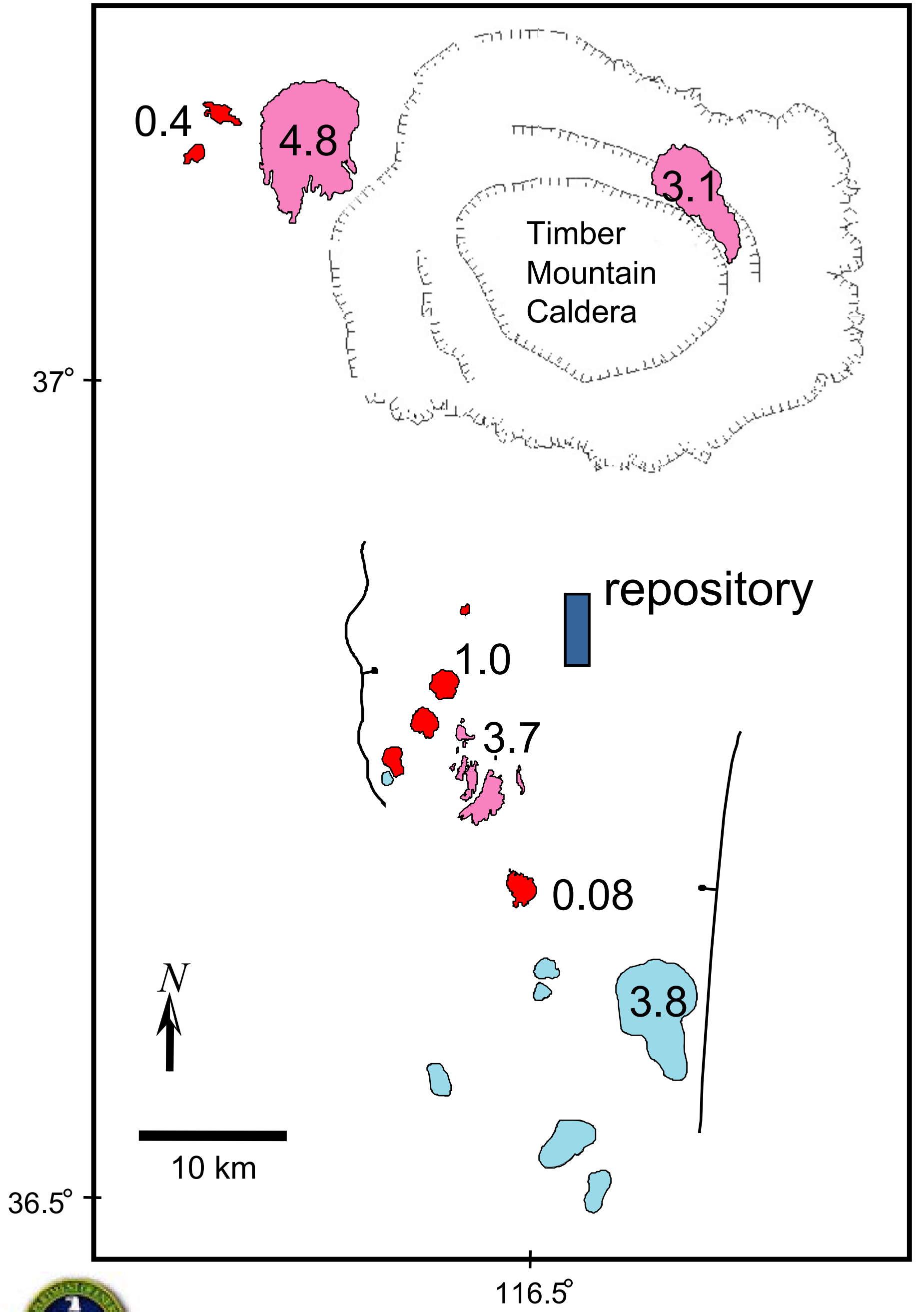


Geometry for Test 2

Field Data: Thermal Conductivity Tests



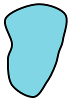
Neutron Values of »1% (m3/m3) is equivalent to dried out rock.
Phase II is initiated when dried out zone is >1 meter.



Igneous Events Studies

Buried Volcanoes are Part of the Geologic Record

- Buried volcanoes are potentially a factor contributing to the uncertainty in the recurrence rate
- At time of Probabilistic Volcanic Hazard Assessment (PVHA), known geologic record included presence of seven inferred (from geophysics) or known (from drilling) buried basalt centers



Aeromagnatic anomaly