CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Twelfth Thermal Workshop (20.01402.661)

DATE/PLACE: June 7–8, 2001; Summerlin, Nevada

AUTHOR: D. Hughson

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PERSONS PRESENT:

Photocopies of the sign-up sheets for the two days of the workshop listing persons present, their affiliations, and contact information are attached as Appendix A. D. Hughson from CNWRA attended as an observer.

BACKGROUND AND PURPOSES OF TRIP:

The purpose of this trip was to attend the Twelfth Thermal Workshop and observe the U.S. Department of Energy (DOE) approach to testing and modeling of coupled thermal-hydrologic processes and to gather information to assist in issue resolution. These thermal workshops are the primary forum for dissemination of information and integration of activities regarding the DOE thermal testing program at Yucca Mountain, Nevada. The meeting itinerary is included as Appendix B.

MEETING SUMMARY:

The Twelfth Thermal Test Workshop was held in Building 9 of the DOE office complex in Summerlin, Nevada, June 7–8, 2001.

There were two notable changes in personnel since the previous Thermal Test Workshop. Robert Jones from Sandia National Laboratories has taken over Robin Datta's project management duties and Sandy Ballard is no longer working on the Yucca Mountain Project.

June 7, 2001

After a brief introduction, reiterating that the purpose of the thermal testing program at Yucca Mountain is to improve understanding of thermally-driven coupled processes, Ralph Wagner turned the floor over to Yvonne Tsang who led a discussion of thermohydrologic model validation. Y. Tsang stated that the data for tracking thermohydrologic processes in the thermal tests are mainly temperatures, continuously monitored using Resistivity Temperature Detectors (RTD) at approximately 30 cm spacings in 36 boreholes. In addition, air permeabilities are measured in the boreholes equipped with packers and also geophysical measurements of Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), and neutron probe logging are collected on a periodic interval of a few months. All of these methods are used to track mobilization and redistribution of pore water in the fractures and matrix of the Topopah Spring welded tuff. A plot of the volume of rock having a matrix saturation less than 50 percent is nearly a straight line function of time, indicating a nearly constant rate of drying.

Steve Sobolik presented the latest power and temperature data received from S. Ballard prior to her departure. The Drift Scale Heater Test (DST) is now midway through its fourth year of heating. Power reductions to the heaters began about a year ago, with the most recent power reduction made about a month ago. These power reductions are to maintain drift wall temperatures near 200 °C. Hottest areas of the drift wall occur about midway down the heated drift near the wing heaters at the drift springline, where temperatures are about 209 °C, while the ends of the heated drift near the bulkhead and at the concrete-lined far end are cooler. Anomalous temperature signals are seen in the horizontal boreholes 79 and 80 which run lengthwise parallel to the heated drift above the wing heaters. Anomalous temperature signals at locations of about y=12m and y=35-40m are interpreted as evidence of preferential vapor and liquid water flow following a vertical discrete fracture. The zone at y=12m also correlates with a region of recent rockfall observed in the heated drift. S. Sobolik asked the workshop participants how one might go about incorporating anomalies, such as those observed at y=12m and y=35-40m, into process models supporting performance assessment (PA). A discussion ensued regarding the importance of volume-averaged processes versus the smaller-scale anomalies. Debbie Barr held the opinion that the small-scale anomalies could not be neglected unless it was demonstrated that they would not affect performance. All acknowledged the importance of heterogeneity but Tom Buscheck thought that heterogeneity is more of a concern for fracture flow away from the drifts rather than close to the drift. T. Buscheck believes that thermal radiation inside the drift has the effect of preventing the kind of fracture flow into drifts that appears to be occurring in horizontal borehole 80.

Wunan Lin presented an analysis of thermally driven refluxing and water vapor movement as indicated by temperature data. W. Lin suggested that spatial variation in the boiling temperature of a few degrees was an indication of water/rock interaction. His hypothesis was reactions with the rock resulted in higher concentrations and an increased boiling temperature. W. Lin showed several examples of bilateral asymmetry in moisture distribution. For example, there appears to be more water in the fracture zone at y=12m on the side opposite the Observation Drift, whereas more water appears on the side of the heated drift adjacent to the Observation Drift in the fracture zone at y=23m. Also boiling occurred earlier in borehole 159 (adjacent to the Observation Drift) and lasted longer than in borehole 165 (opposite the Observation Drift). Earlier and longer boiling was also observed in borehole 175 (opposite the Observation Drift) than in borehole 171 (adjacent to the Observation Drift). A satisfactory explanation of this asymmetry in moisture distribution was not given but fracture heterogeneity and/or matrix block size were suggested as probable causes.

Y. Tsang continued the discussion of thermohydrologic model validation with a summary of conceptual model development. Early data from the DST had led to favoring the Dual Continuum (DKM) over the Equivalent Continuum (ECM) conceptual model. At around 30 months of heating, the model of the DST was modified to give the boreholes containing the wing heaters a high-permeability. This modification reduced modeling over-prediction of temperatures as compared to the RTD sensors, but the current model still overpredicts temperature data from the DST system. Modeling the wingheater boreholes as high-permeability conduits (3 orders of magnitude larger than the mean fracture permeability of $10^{-13}m^2$) allows water vapor to escape and consequently reduces the two-phase heat pipe signature and shedding of condensate around the ends of the wingheaters. Also it was found that the invert has a significant effect on modeled temperatures below the heated drift.

Air permeabilities are measured quarterly in the packer-equipped hydrology boreholes. A large decrease in air permeability was observed in borehole 60 (below the heated drift) after about four months of heating.

By January 1998, after more than one year of heating, 2L of water had been collected in borehole interval 60-3 and the air permeability had begun to increase. Similarly a large decrease was observed in borehole interval 60-2, where 5.7L of water was collected by January 1998. The lowest air permeabilities were measured in borehole intervals 59-2 and 59-3 (above the heated drift) in December 1999. By November 1999, borehole interval 59-2 had collected 2.6L of water and by December 1999, borehole interval 59-3 had collected 2.3L of water. Decreases in air permeabilities are interpreted as indicating an increase in fracture saturation from condensation of thermally mobilized water vapor. However some air permeabilities show an increase over the pre-test baseline. These increased air permeabilities are interpreted by Y. Tsang to be caused by thermomechanical (TM) effects.

Y. Tsang briefly summarized the findings from the Single Heater Test (SHT) as indicating that heat transport in that test was primarily by conduction, water collected during the test was condensate, and air permeabilities showed small thermomechanical changes. During a discussion of model aspects important to performance, Y. Tsang said that fracture heterogeneity was obviously important to seepage into drifts. Mike Itamura asked about the accuracy of model-predicted fracture saturations. Y. Tsang replied that predicted fracture saturations depend on conceptual model assumptions and that the actual saturation of fractures in the test was unmeasurable. Y. Tsang felt, however, that trends in fracture saturation, from drying to rewetting, were well-represented by the present model.

Ken Lee reported on ongoing modeling studies of the completed Large Block Test (LBT) using the NUFT code. The LBT was conducted on a free-standing 3m×3m×4.5m block excavated in the Topopah Spring formation on Fran Ridge. The LBT was heated for 375 days, starting in February 1997, by 5 horizontal heaters about 2.75m from the top of the block. Problems were encountered in characterizing heat flux through the insulation surrounding the block and additional insulation was added to the test block at 125 days after commencement of heating. K. Lee presented model results comparing results obtained using the drift-scale and mountain-scale property sets from the Calibrated Properties Analysis and Models Report (AMR). These property sets differ only in showing a higher fracture permeability for the mountain-scale property set. Simulated temperatures from both property sets compare reasonable well with temperature data from the LBT. Temperatures near the heaters simulated using the mountain-scale property set are slightly higher. Modeled liquid saturation in the matrix, however, lagged substantially behind the neutron probe data up to about 365 days of heating using the drift-scale property set. Simulated matrix saturations using the mountain-scale property set did not lag behind the neutron probe data as much but tended to over-predict imbibition.

R. Wagner mentioned an AMR on thermal testing recently completed that compared results from the SHT, DST, and LBT to model simulations using various calibrated property sets. The statistical measures used for these comparisons were Mean Difference (MD), Root Mean Squared Difference (RMSD), and Normalized Absolute Mean Difference (NAMD) of measured versus model-predicted temperatures. This comparison for the DST showed that the model results had at most a 13 percent error. A similar effort is underway to make statistical comparisons of model saturations to Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), and neutron probe data. Preliminary indications are that this error is closer to 25 percent. Dave Dobson pointed out that it would be useful to have some measure of uncertainty as a function of temperature as that is a focus of the Supplemental Science and Performance Assessment (SSPA) Report.

Eric Sonnenthal described the validation of the coupled thermo-hydrologic-chemical (THC) model as an "iterative process." Mark Conrad presented isotopic data obtained from water and gas sampling in the DST. From isotopic compositions of water vapor in gas samples collected in borehole intervals 59-3 (directly above the heated drift) and 58-3 (about 4m above borehole interval 59-3), M. Conrad deduced that vapor transport is limited to a few meters, the isotopic composition of pore water remains near ambient until boiling, and that condensation drains primarily through fractures. Gas sampling shows low CO_2 concentrations in the dryout zone and a halo of higher CO_2 concentrations around the dryout zone of about 1000ppm. In borehole intervals 59-3 and 57-3 above the heated drift, CO_2 concentrations increase steadily with heating to about 1.5 orders of magnitude above ambient. In borehole interval 78-3 (farthest below the heated drift and about midway along its length), CO_2 concentrations increase rapidly with heating then drop off as available CO_2 is depleted. Radiocarbon data from borehole interval 78-3 show a drop from the 50 percent modern carbon background down to 10 percent modern carbon indicating that CO_2 is coming from dissolution of calcite. Spatial variation in CO_2 concentrations can be seen in the data from adjacent borehole intervals 185-2 and 185-3, above the heated drift, which are at the same temperature but show significant differences in CO_2 concentration. M. Conrad speculated that this difference may be due to differences in permeability even though the isotopic compositions of the CO_2 gases were nearly identical. In general, M. Conrad finds that permeability and CO_2 concentration are positively correlated.

Brian Marshall had few new water samples for analysis of Sr and U isotopes to report since very little water had been collecting in the boreholes. Comparisons of Sr and U isotope data collected from the DST with a more extensive database of Sr and U isotopes from the Yucca Mountain (YM) area are being used to determine which minerals and phases in the rock are reacting with thermally mobilized water. Concentrations of Sr and U in boreholes that collect water start out close to original pore water concentrations then decrease with time. There is a narrow range of the Sr isotope ratio in calcite at YM from about 0.7095 to 0.713. Grout is a significant reservoir of Sr in the DST with an isotope ratio of about 0.7085. Ratios of Sr isotopes from horizontal borehole 80 indicate contamination from grout while lower ratios from borehole 60-3 (below the heated drift) indicate dissolution of calcite. Ratios of Sr isotopes from all other water samples are close to the original pore water ratio. B. Marshall reported that procedures were in place for extracting pore water out of cores from the ECRB and analyzing for the trace elements Hg, As, and Pb. However, they were not able to extract water from the only core processed by this procedure so far. B. Marshall said the lower lithophysal zone of the Topopah Spring tuff tends to have a lower matrix saturation (about 80-85 percent) than the middle nonlithophysal zone (which is closer to 90 percent saturation). Cores from the ECRB were preserved by two different methods. Pore water analyses of major chemical species obtained from one set of cores show more chemical variability ("highly variable" according to B. Marshall) in the lower lithophysal unit than in the middle nonlithophysal unit.

Schön Levy reported on the latest round of sidewall samples collected, in December 2000, from borehole 54 above the heated drift. The locations of these sidewall samples were in the boiling zone above the heated drift when they were taken but previously they had been in a region of condensation and drainage. Electron microscopy images of fracture coatings from recent sidewall samples were compared with pre-test core from the borehole. This comparison showed lobes and cascades of amorphous silica coating the original fracture surfaces. S. Levy observed evidence for multiple episodes of condensate drainage and silica deposition. This observation brought up discussion of a crushed tuff column experiment underway in Albuquerque, New Mexico, that is showing silica deposition in the boiling zone. In this experiment the column is filled with crushed tuff from the lower lithophysal unit of about 0.5cm particle size. The base of the column is heated to just above boiling and condensation drains from the top. S. Levy reported that "major" deposition of amorphous silica was observed after about one month of operation. However, evidence from the DST sidewall samples, and also from overcoring the SHT, suggests that evaporation rather than complete boiling is responsible for the observed multiple layers of amorphous silica. S. Levy interpreted a final thin (~400nm) film of amorphous silica in the image, with some overlying carbonates, as indicating arrival of the boiling zone and cessation of reflux. Another sample showed calcium sulfate (gypsum) on a surface with no previous coatings and no other deposits. S. Levy interpreted this as a tight fracture where no condensation had occurred, underscoring the spatially variability of condensate drainage in the fractured tuff. According to this interpretation, the gypsum was deposited as pore water exited the matrix and evaporated.

E. Sonnenthal introduced his coupled THC model with a conceptual discussion of mineral deposition taking place where evaporation is occurring, especially in the reflux zone above the heated drift, and dissolution occuring where condensation is draining, along the sides and below the dryout region, perhaps followed by precipitation as the draining condensate cools. E. Sonnenthal's model from about 12 to 20 months of heating shows a halo of CO_2 moving out with a peak concentration occurring at about the 60 °C temperature contour. E. Sonnenthal has two geochemical models. One, which he calls the base case, consists of calcite, silica polymorphs, and gypsum. The other, which he calls the extended case, includes minerals such as mordenite, stellerite, various clays, zeolites, and other aluminosilicates. He showed comparisons of model results at single nodes with sample analyses obtained from borehole intervals and commented that the base case model seemed to fit the data better. Some error in the chemical analyses, according to E. Sonnenthal, could be attributed to concentrations made artificially high in samples by a high water vapor content. Modeled Cl concentrations over time compared with water samples from borehole 63 suggest very little fracture-matrix interaction. E. Sonnenthal thought that model underprediction of silica mobilization could be attributed to the omission of opal in the model. The model predicts at most 0.04 volume percent dissolution of calcite in the condensation zone and precipitation primarily at the base of the refluxing zone. The base of the refluxing zone, where boiling occurs, is where the model predicts most of the calcite, amorphous silica, and gypsum are deposited. In summary, E. Sonnenthal said his model represents CO_2 and pH fairly well and fracture-matrix interaction is limited, although there is some mixing of fracture and pore water. Amorphous silica, calcite, and K-feldspar are dissolved and amorphous silica, calcite, and gypsum are the major minerals precipitated.

Nicolas Spycher presented the use of THC models and test results as providing water and gas compositions for use in performance assessments and as technical bases for porosity and permeability changes. He alluded to iterative and on-going modeling work to calibrate thermodynamic and reaction rate parameters and use of ambient data to constrain model uncertainty. Calibrated model comparisons with thermal test results 'validated' the model, according to N. Spycher, and he thought the planned Cross Drift Thermal Test (CDTT) would be very useful to fill in 'data gaps'. For performance assessments, predictions are made using the so-called "chimney" models which are half of one drift spacing in lateral extent and have no-flow boundaries from ground surface to the water table along the sides. Gas and water compositions calculated in these "chimney" models near and within the drift are input to corrosion and waste package chemistry models. Chloride concentrations were predicted to be fairly similar for models with and without fracture heterogeneity. N. Spycher said that kinetic and thermodynamic parameters, the geochemical system, and initial water compositions are the greatest sources of uncertainty in THC predictions. There is a wide range of pore water compositions at Yucca Mountain and THC models use variously: pore water extracts from Alcove 5, perched water from UZ-14, and J-13 ground water as initial compositions. N. Spycher said that formation of a Ca-Mg brine, which he thought was potentially corrosive, depended on assumptions about initial water composition.

Steve Sobolik said that thermomechanical data were used for primarily two purposes. One deals with structural stability of the design, e.g. what are the thermomechanical rock properties of the rock unit and will thermal processes reduce rock integrity. The other concerns effects on flow of long-term thermomechanical changes in permeability. S. Sobolik presented data from the most recent plate-loading test in October, 2000. In the Plate-loading Niche of the DST, Multi-point Borehole Extensiometer (MPBX) rods are connected from the hot side to the cold side of the heated drift with three anchors on each side. Up to 32 MPa of pressure is applied to metal plates with the "flat jack" and then the pressure is released and the rock mass allowed to relax. S. Sobolik said that the results of this most recent plate-loading test gave a higher rock modulus of elasticity than the test in 1998. This led to some speculation about whether the difference represented a dependence on temperature or just a better, more accurate test.

The three arrays of 4 boreholes equipped with MPBX anchors at 1, 2, 4, and 15m from the driftwall were the next topic of S. Sobolik's presentation. Although most of the data indicate steady expansion and elastic behavior, S. Sobolik interpreted a change of direction in MPBX borehole 3, anchor 4, (located 15m from the collar at y=12m) around October 2000 as possible evidence of fracture closure. A 2mm decrease in the MPBX borehole 7 anchor closest to the collar at y=23m, with no change in displacement at the adjacent anchor, provides possible evidence of rockfall. S. Sobolik talked about ongoing efforts to interpret the very noisy MPBX data. Oscillations in these data are believed to result from water refluxing in the vertical boreholes and attempts to filter the data include omitting any change greater than 0.3mm within a 6 hour period.

S. Sobolik could find no correlation between Acoustic Emissions and the MPBX data and no correlation to rockfall. Apparently the most recent spalling observed in the heated drift did not create a signal significant enough to register on the detectors. One aspect of the Acoustic Emissions data S. Sobolik mentioned was the prevalence of signals ("pops") in the vicinity of the drift crown during the first two years of heating.

Wunan Lin presented an analysis normalizing MPBX displacement by distance between anchors. From this he concluded that deformation was less in the region between the Observation Drift and the heated drift than on the side of the heated drift opposite the Observation Drift and that deformation was greater above the heated drift than below. Also he found that fractures affected rock deformation although overall the deformation of the rock mass agreed reasonably well with a conceptual model of matrix thermal expansion.

S. Blair presented thermomechanical modeling done for an upcoming AMR. Temperatures in S. Blair's model were taken from the NUFT thermohydrologic model simulations and used in a discrete element and a continuum deformation model. Comparing calculated deformations at ambient temperature with data from a "mine-by" at boreholes 42 and 43 show the model over-predicting deformation. Large parts of the thermally perturbed rock mass were modeled fairly well by the continuum model but some parts were not. S. Blair attributed some of the errors in modeled displacements to errors in temperatures from the NUFT model. S. Blair's thermomechanical models agreed with W. Lin's analysis that more deformation had occurred on the side of the heated drift opposite the Observation Drift but showed more variability in deformation below the heated drift.

Results from the LBT indicated that incorporating the major fractures in the thermomechanical model improved the model fit to data. Of models incorporating 0, 6, 7, and 28 mapped fractures, the model incorporating 7 fractures had the best fit to MBPX data from the LBT. S. Blair said the model incorporating 28 fractures was similar to the continuum model but that including a few, not all, but just the major fractures improved the model's match to the data. He also said that the LBT acted more like a continuum below the heaters and more like a discontinuum above the heaters. It was suggested that the lack of confining stress on the block may account for this behavior.

S. Blair presented thermomechanical modeling predictions for a Low Temperature Operating Mode (LTOM) and a high temperature (EDA II) repository design using 3 different fracture sets and the Discrete Element Model (DEM) of the DST. Fracture permeability was related to aperture and the thermomechanical model by the so-called cubic law. At 50 years, near the end of ventilation, this model showed quasi-concentric changes in permeability around the heated drift from a zone of high permeability near the drift to a zone of lower permeability farther out and then back to pre-existing permeabilities beyond. In this model, with zero displacement boundary conditions along the sides, a big proportion of the vertical fractures closed but the horizontal fractures did not change. The maximum increase in permeability was about 3 orders of magnitude although most permeability changes were in the range of one or two orders of magnitude. In the model of the LTOM repository design, S. Blair saw almost no changes in fracture permeability. In summary he said that themomechanical model predictions compared well with measurements, the comparisons confirmed the modulus of deformation and coefficient of thermal expansion parameters, and that including important discrete fractures improved the model's match with data.

R. Wagner concluded the first day of the Twelfth Thermal Test Workshop with a short discussion of the statistical measures used for comparison of the mechanical measurements with model predictions. These statistical measures are similar to the RMSD, MD, and NAMD of the temperature comparisons but were done only on about one third of the 70 MPBX anchors in the DST. The RMSD statistic steadily increases, indicating increasing prediction error, and the MD shows that the error is an under-prediction of displacement.

June 8, 2001

At the beginning of his presentation Robert Jones mentioned the White Paper recently submitted by the DOE, in accordance with an agreement made at the NRC/DOE Technical Exchange on January 9, 2001, regarding the significance of losses through the thermal bulkhead of the DST. NRC Staff's first impression of that White Paper was that the DOE thought measuring those losses was unnecessary. But R. Jones went on to talk about plans for making measurements of those losses. In July 2001, midway through the fourth and last year of heating, the DOE plans to hang 40 or so relative humidity (RH) and temperature sensors in strings of four from the roof of the connecting drift at about 1m spacing. The ventilation will then be temporarily halted and the response of RH and temperature at the sensors recorded. These data will help to characterize leaks which are believed to be primarily around the periphery and viewports of the thermal bulkhead. In response to a question, R. Jones replied that fans in the diagram were intended to prevent the formation of convection cells and mixing with outside air. During a preliminary 'proof of concept' field trip, he said the formation of a convection cell was observed shortly after the ventilation was stopped. Y. Tsang reminded us, during a discussion, that the concept in this proposed plan is at least two years old and that the heating of the DST, now in its fourth year, has stabilized. Besides, someone else pointed out, they're not even sure this idea will work. R. Jones recalled that there are barometric and humidity sensors on the bulkhead now. Y. Tsang commented that she thought ventilation from the duct in the access drift near the thermal bulkhead is not a significant driving force compared to the slight pressure differential on either side of the bulkhead.

Dave Dobson spoke about what was going on in the Yucca Mountain project as it affected the Thermal Testing Program over the next six to nine months. First, the DOE released the formerly titled Site Recommendation Consideration Report as the Science and Engineering Report (S&ER). Second, he said the DOE will release a SSPA addressing concerns of the Nuclear Waste Technical Review Board (NWTRB) such as uncertainty, new characterization data, and safety evaluations of lower temperature designs. He said that both the SSPA and a Preliminary Site Suitability Evaluation were to be released within the next few weeks and comments will be received through the summer. Public hearings could be held in the August 2001 time frame. He said that the Secretary of Energy could be making a decision by December of this year. He implied that only a few public hearings required by law would be held, one in Las Vegas, another in Amargosa Valley or Pahrump, and possibly one in Reno. He informed us that the DOE intended to respond to all comments received and revealed Ralph Wagner as the lead on comment response for the near field, responsible for coordinating input from Principal Investigators. Both the S&ER and the SSPA commit the

DOE to continue evaluating alternative designs and to come up with a preferred design for License Application (LA). D. Dobson challenged the Thermal Test Team to come up with experimental designs that would support a preferred repository design and reiterated that post-closure was not necessarily a repository design discriminator . He then went on to mention a "window of susceptibility" in temperature and RH conditions where alloy C-22 is more susceptible to crevice corrosion. He said that conditions in the current higher temperature design (EDA II) go right through where some people think that "window of susceptibility" lies. A concern, he said, is evolution of corrosive Ca-Mg brines. Tom Buscheck gave the opinion that dripping inside emplacement drifts and salt buildup is more likely with the low temperature operating mode (LTOM). Also, he said, the trajectory of RH and temperature predictions depends on assumptions about seepage into drifts. D. Sassani interjected that stability of liquid Ca-Mg brines in temperatures as high as 145-170C is a concern. R. Jones repeated his statement that an important task facing the Thermal Test Team was designing experiments to discriminate between various repository design options. He said that Bob Andrews at the planning level wanted them not to feel constrained by the current plans. R. Jones wrapped up with an announcement that the Near Field Environment (NFE) PMR would be combined with the Unsaturated Zone PMR and he also mentioned the impact on PA of the recently released EPA rule. As for the schedule of things to do before LA he said that list was getting longer each time they "met with NRC".

Mark Peters asked if everyone had seen the June 6, 2001, letter from Ken Hess ordering a "stand down" on all software development or modification and if they were aware of the issue. The letter from K. Hess ordered immediate cessation of all software development or modification, with the exemptions for data collection software and development specifically for SSPA. Only Nancy Williams or Ken Hess could grant any exemption to this rule. M. Peters said this action was in response to two new Corrective Action Reports on software and model validation. He said the new management at BSC felt there was a "culture problem" and wanted to "send a message". D. Dobson added that part of the motivation had come from an NRC letter critical of errors in a sampling of supporting documents. M. Peters said they should start thinking about putting codes for something like the cross drift thermal test (CDTT) into the system now in case the stand down is still in effect this fall or next year.

Dave Sassani gave an overview of the effort of the management technical support (MTS) to quantify, as much as possible, uncertainties in PA. This effort consisted of essentially two parts. The first was to go through all of the AMRs and PMRs, revision 00, to see how uncertainties and variability were treated and quantified. The end result of this was a document with synthesis of uncertainty quantification and recommendations to improve the quantification of uncertainty treatment for PA. For each AMR/PMR they looked at how discussions of uncertainty were actually implemented and how uncertainty was carried through the model abstractions to PA. Recommendations contained in this document are that a systematic procedure needs to be developed for identification and quantification of uncertainties, bases need to be provided for probabilistic parameter distributions, and there should be an AMR describing specifically the development of conceptual models. The second aspect of this effort was to identify major unquantified uncertainties, determine if these uncertainties were bounded or addressed by conservative assumptions, and can these be replaced by quantified uncertainties. Goals of this effort ultimately were to evaluate the degree of conservatism in the TSPA-SR.

R. Jones led a discussion on planning for the cool down phase of the DST, which will have been heating for four years in December of this year. Y. Tsang presented modeling results of the DST cool down phase showing a 120°C drop in temperature and complete fracture rewetting through the first year. Even though saturation in the fractures had almost completely recovered after one year of cooling, the matrix saturation remained almost unchanged even after four years of cooling. There was some discussion about what time during the cooling would the likelihood of observing seepage into the heated drift be greatest. Y. Tsang thought that this would be most likely immediately after the heating was stopped. D. Sassani cautioned about what a failure to observe seepage would mean given the presence of ventilation immediately outside of the leaky bulkhead. E. Sonnenthal thought that additional heating time over the planned four years would be most beneficial if it resulted in more water collecting in the boreholes. He also thought that extra heating beyond four years might result in more mineral deposits. After a long discussion a consensus emerged that there were no pressing reasons to extend the heating schedule beyond the planned 4 years and that the heaters could be shut down by December 2001 or January, 2002.

Doug Weaver showed photographs of spalling and rockfall observed recently in the heated drift of the DST. A copy of D. Weaver's presentation is attached as Appendix C. The most visible area of loose rock 3m inside the heated drift from the bulkhead (third slide in Appendix C) was first observed in April 2001 and resulted in a "White Paper" referenced on the last slide in Appendix C. The major conclusions of this "White Paper" are presented on the last slide in Appendix C.

R. Wagner spoke about the need to consolidate data from the informal Thermal Test Progress Reports into a Thermal Test Measurements AMR, including analyses of data uncertainty in thermal test measurements from the DST, SHT, and LBT. The purpose of this AMR would be to centralize all the thermal testing data in one location, document anomalous data or behavior as is already being done, and provide a basis for thermal model validation. Also this document might provide a forum for discussions on the use of thermal testing data in performance assessments of a lower temperature repository.

R. Jones presented a revised schedule for the planned CDTT. Procurement will start in Fiscal Year (FY) 2002 (October 2001) with construction starting as soon as December FY02. Test block characterization and plate-loading tests will began soon after construction starts. Heating of the test block will commence in January FY03 and will continue until October FY04. Y. Tsang mentioned some additional pretest modeling with heater spacing increased from 3.25 to 4m and thermal loading from 290 to 350W/m. The basic intent of CDTT, to look at the EDA II design concept of condensate drainage between drifts and to test whether or not liquid water can enter the dryout region, has not changed. However, there was some discussion about how to make the test more relevant to the lower temperature design, such as by changing the heating schedule to simulate a low temperature regime followed by a higher temperature regime. T. Buscheck offered that thought should be given to designing an *in situ* test to explicitly test the cold-trap effect. M. Peters brought up a comment from the NRC, made at the NRC/DOE Technical Exchange on January 9, 2001, about actually detecting water moving into the dryout zone using geophysics and a related concern that small round boreholes with a high capacity for capillary diversion may confuse the meaning of the test results if water does not collect in the collection boreholes. He mentioned the use of slots instead of boreholes to capture drainage water. Y. Tsang recalled that they'd had this discussion two years ago about how the only way to get mass balance on condensate drainage is with slots or "batwings". The problem, she said, was that they were unable to actually construct these slots and "batwings". This brought up a brief discussion of how they'd originally thought to have an observation niche underneath the heater test drift but the problem with that had been cost. It appeared as though the intent of the Thermal Test Team was to go ahead with geophysics and modeling as a primarily "qualitative" evaluation of flow pathways in the CDTT.

IMPRESSIONS/CONCLUSIONS

On the subject of model validation, it's not always obvious when the DOE is using test data to calibrate a model or validate a model. For example, the DST data were used to calibrate THC model parameters for kinetic mineral reactions but DST data are also said to "validate" the THC model. It would be helpful to reviewers and other interested parties for the DOE to clearly identify and separate test data used for model calibration from data used for model validation.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

The NRC should continue evaluating the effects of small-scale heterogeneity on thermohydrologic processes, as is currently underway for pre-test predictions of the CDTT, to provide technical bases for determining importance to performance assessments.

SIGNATURES:

Debra Hughson
Sr. Research Scientist

July 9, 2001
Date

CONCURRENCE:

Asad Chowdhury
Manager, Mining, Geotechnical, and Facility Engineering

7-9-2001
Date

Budhi Sagar
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APPENDIX A

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Thermal Test Workshop
June 7, 2001

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Thermal Test Workshop
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Thermal Test Workshop
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APPENDIX B

Thermal Test Workshop

Las Vegas, Nevada
June 7-8, 2001

There will be a thermal test workshop in Las Vegas – June 7-8, 2001. The primary purpose of this workshop will be to discuss current results from the Drift Scale Test and related issues. The workshop will be held at Summerlin in three combined conference rooms (**913, 915, and 918**). The bridge number is **702-295-3689**. The agenda is as follows:

Thursday - June 7, 2001

8:30 AM	Welcome and Introductions	Ralph Wagner
8:40 AM	TH Model Validation: Integrated Assessment of Thermal and Hydrological Measurements and Agreement with Results from Numerical Analyses – Discussion led by	Yvonne Tsang
10:15 AM	Break	
10:30 AM	TH Model Validation: Integrated Assessment of Thermal and Hydrological Measurements and Agreement with Results from Numerical Analyses (continued)– Discussion led by	Yvonne Tsang
12:00 Noon	Lunch	
1:15 PM	THC Model Validation: Integrated Assessment of Chemical Measurements and Agreement with Results from Numerical Analyses - Discussion led by	Eric Sonnenthal
3:00 PM	Break	
3:15 PM	THM Model Validation: Integrated Assessment of Mechanical Measurements and Agreement with Results from Numerical Analyses - Discussion led by	Steve Blair
5:00 PM	One Hour Social / Informal Interaction	All

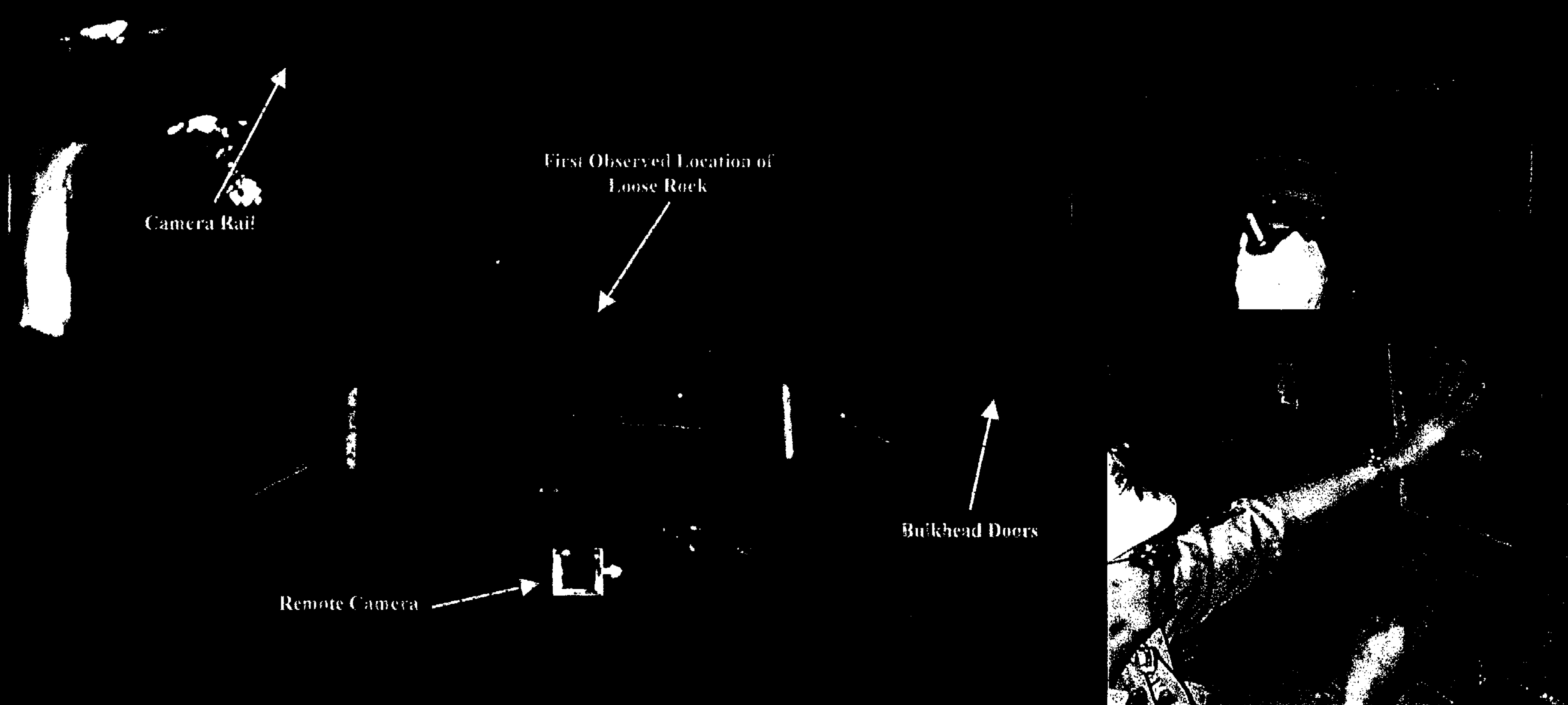
Friday - June 8, 2001

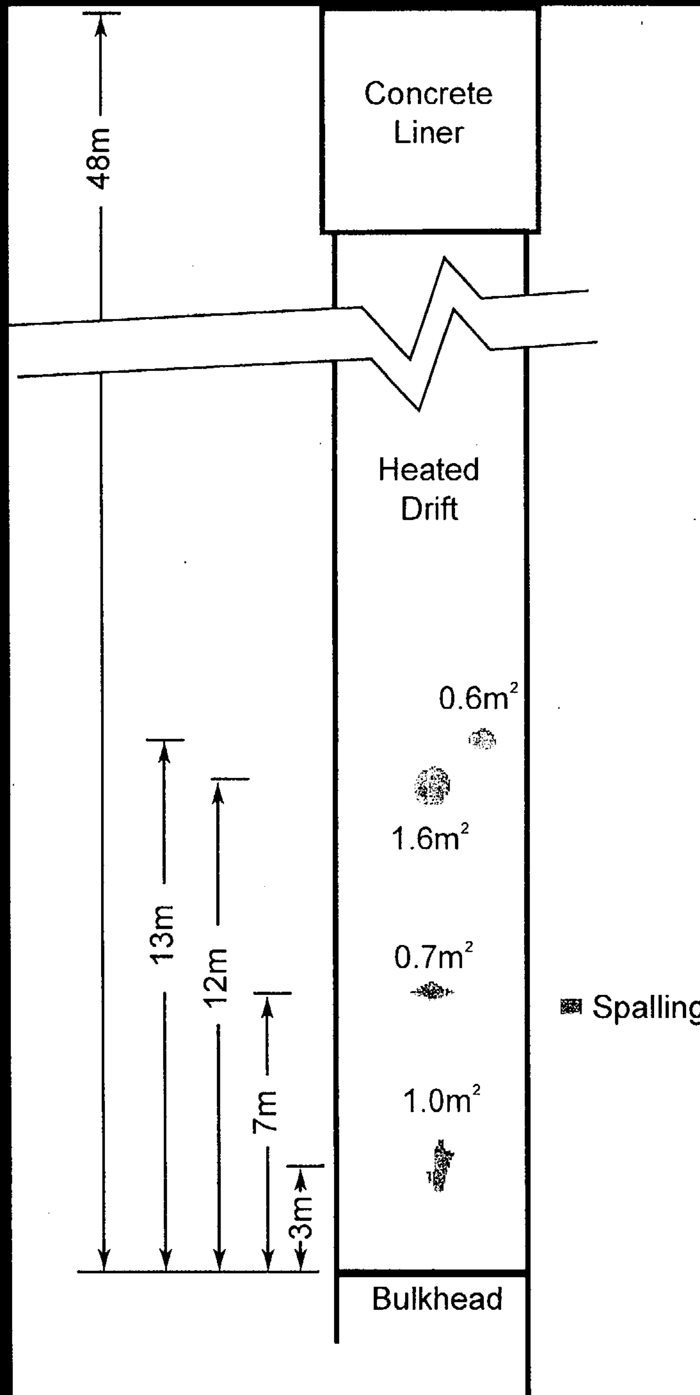
8:00 AM	Planned Measurement of Heat and Mass Loss Through the DST Bulkhead	Bob Jones
8:30 AM	Program Updates Affecting Thermal Testing Including CDTT, SR, LA, IRSR-KTIs/TEF-ENFE, & NFED	Dave Dobson
8:50 AM	YMP Uncertainty Initiative	Dave Sassani
9:15 AM	DST Heating/Cooling Schedule Revisited	Bob Jones
9:40 AM	Scaling Along Roof of Heated Drift	Doug Weaver
10:00 AM	Proposed Thermal Test Technical Report	Ralph Wagner
10:15 AM	Break	
10:30 AM	Revisit/Discussion of Cross Drift Thermal Test Discussion led by	Ralph W./Bob J.
12:00 Noon	Lunch	
1:15 PM	Revisit/Discussion of Cross Drift Thermal Test (continued) – Discussion led by	Ralph W./Bob J.
2:30 PM	Open Discussion Including Comments and Questions From Non-Thermal-Test-Team Attendees	All
3:30 PM	Adjourn	

APPENDIX C

OBSERVATIONS OF LOOSE ROCK IN THE CROWN OF THE HEATED DRIFT

- Small rock chips observed on floor of Heated Drift on 11/16/99. Video run showed no evidence of large rock fragments in the mesh.
- During the cleaning and reinstallation of the bulkhead window on 4/23/01, loose rock was observed behind the mesh at several locations
- Video and still photography taken of the loose rock locations on 5/2/01

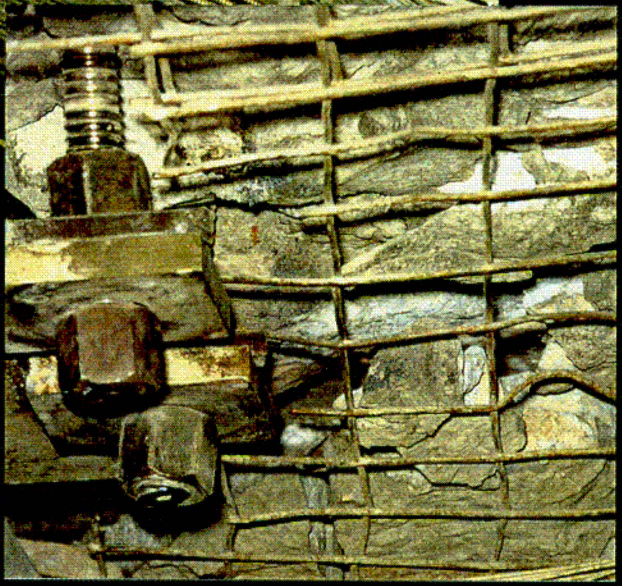




Plan view of the Heated Drift showing locations of four scaling zones. The lack of zones farther down the drift reflect limitations on clear observations.

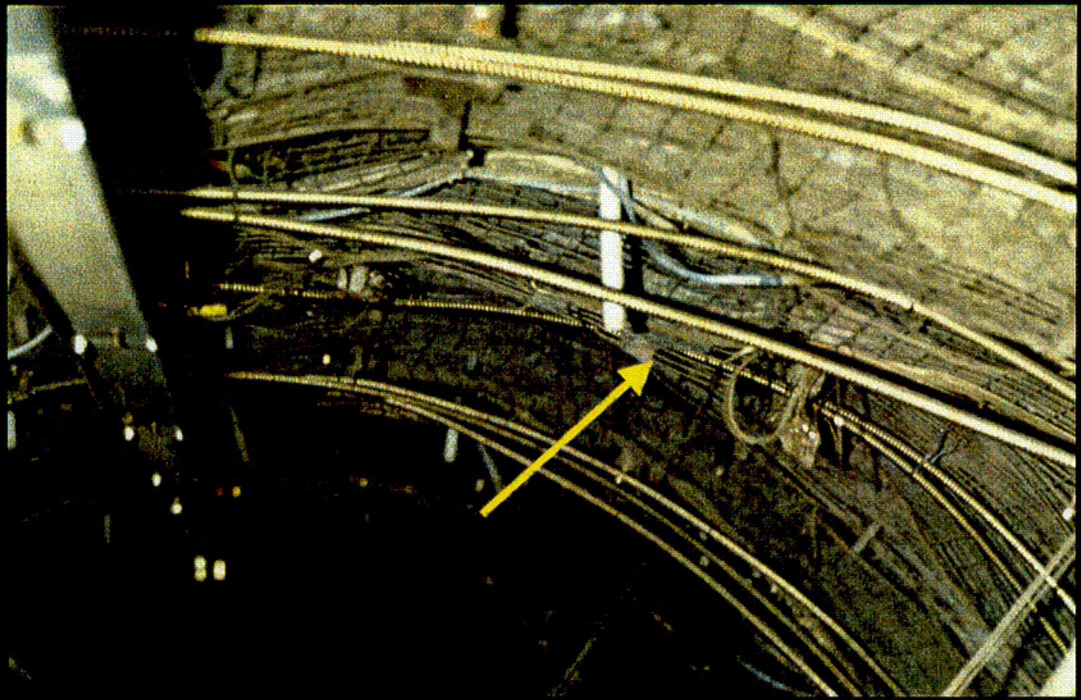
Close up of first zone approx. 3 m into drift.

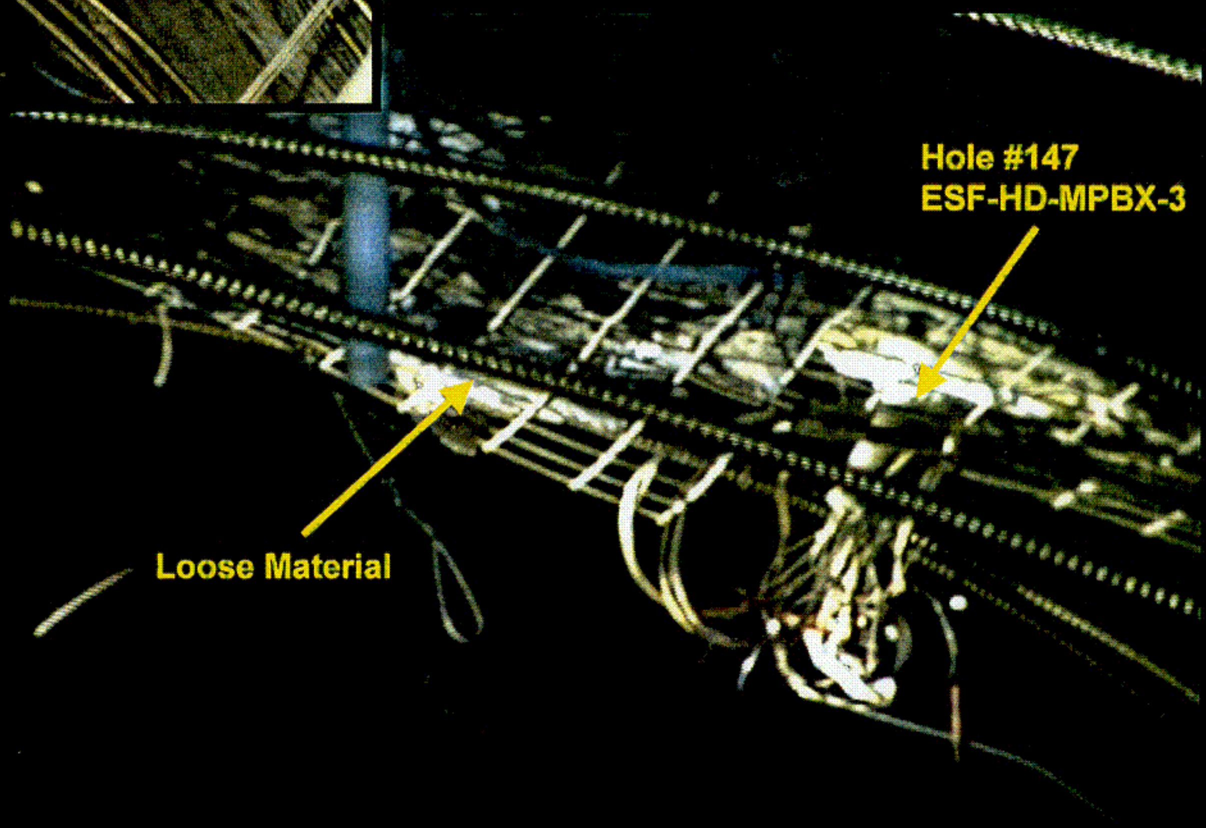
Ground support = 10' Super Swellex bolts and 3x3" WWF



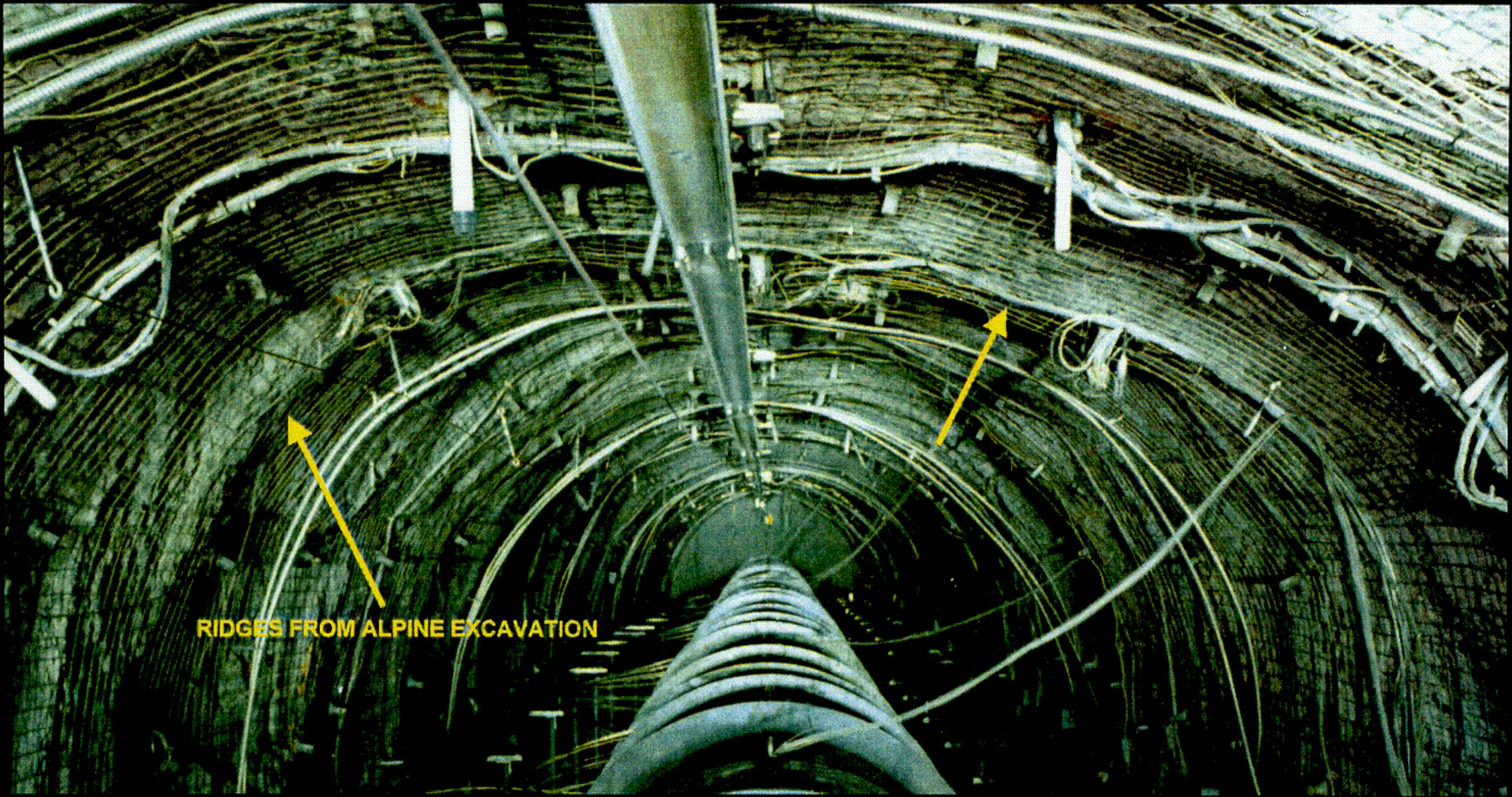
C01

Close up of a zone approx.
13 m into drift.





HEATED DRIFT PRIOR TO HEATING (11/20/97)



Most of the observed zones are associated with uneven surfaces or ridges as a result of the alpine miner. These irregular ridges should experience higher stress concentration and thus more failure than smoother surfaces along the drift periphery.

C03

ANALYSIS/CONCLUSIONS

<u>WHITE PAPER:</u>

Letter, Williams to Mellington, "CONTRACT #:DE-AC08-01NV12101 - DRIFT SCALE TEST (DST) WHITE PAPER: SCALING ALONG THE ROOF OF THE HEATED DRIFT," PROJ.05/01.033, DATED MAY 15, 2001

Occurrence of limited scaling along the roof is non surprising in that the middle nonlith is highly fractured and additional fractures were likely created during mining. This altered zone is exacerbated by:

- aggressive heating schedule
- potential for transient thermal stresses
- proximity of instrumentation and rockbolt holes

Loose rock is determined to be a surface effect involving only a relatively small volume of rock.

Ground support is performing as designed.

Conclusions based on an analysis of:

- Pre-Test Fracture Mapping
- Aggressive Heating
- Potential for Stress Failure in the Heated Rock
- MPBX Data