CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Field Examination of Fractures and Talus from Lithophysal Tuffs at a Rubble Analog Site, South End of Fran Ridge, Yucca Mountain, Nevada (AI 20.06002.01.262.706) and (AI 20.06002.01.342.704)

DATE/PLACE: February 5–8, 2007
Yucca Mountain, Nevada

AUTHOR(S): Danielle Wyrick, Geosciences and Engineering Division (GED); Randy Fedors, U.S. Nuclear Regulatory Commission (NRC); Kevin Smart (GED); and Ron McGinnis (GED)

PERSONS PRESENT:

Staff from NRC and GED visited the surface exposures of the Topopah Springs welded (TSw)[1] Lower Lithophysal unit at Yucca Mountain, Nevada, on February 5–8, 2007. The staff present were Randy Fedors (NRC), Jack Parrott (NRC), Danielle Wyrick (GED), Kevin Smart (GED), and Ron McGinnis (GED). In addition, Alan Mitchell (Yucca Mountain Project Technical Coordination Office), Ezra Wasson (Yucca Mountain Project Technical Coordination Office), and various other Yucca Mountain Project operations staff were present.

BACKGROUND AND PURPOSE OF MEETING/TRIP:

Little is known on the nature and characterization of rubble piles that may result from degradation of drifts in welded lithophysal rocks. Spalling of rock during the Drift Scale Heater Test and fragments found in the mesh and on the invert in the Exploratory Studies Facility (ESF)[2] tunnel and Enhanced Characterization of Repository Block (ECRB)[3] drift provide qualitative information. More detailed and quantitative information is not available at these locations. The nature of the fragments and their packing in rubble piles, however, may be needed to conceptualize and quantify the water flow (liquid and gas phase) and heat transfer (conduction, convection, and radiation) for performance assessments. In addition, an understanding of the fragment sizes and shapes and their packing could help constrain estimates of bulking factors, which influence the extent that degradation will propagate vertically.

---

[1]Topopah Springs welded (TSw) is referenced throughout this report. Consequently, the acronym will be used.

[2]Exploratory Studies Facility (ESF) is referenced throughout this report. Consequently, the acronym will be used.

[3]Enhanced Characterization of Repository Block (ECRB) is referenced throughout this report. Consequently, the acronym will be used.

A previous visit to Yucca Mountain[4] identified surface exposures at which further analyses could be performed to help understand how the TSw Lower Lithophysal unit breaks apart; the Lower Lithophysal unit is the primary lithologic interval for the potential Yucca Mountain repository footprint. Staff concluded that a semiquantitative understanding of rubble size distributions could be achieved by examining fractured outcrops of lower lithophysal rock and nearby talus piles on the southern end of Fran Ridge. The processes driving the breakup of the rock are assumed to be less important than the preexisting rock fabric and, therefore, it is assumed that drift degradation will proceed along existing fractures. Once analyses are complete, this information can be used to support the characterization of rubble. The surface exposures and talus provide a link between fracture patterns and rubble fragment size and shape distribution.

The purpose of this field work was to characterize surface exposures of TSw Lower Lithophysal unit rocks on the southern end of Fran Ridge as a collaborative effort of UZ2[5] and ENG2[6] Integrated Sub-Issues (ISIs). A focused investigation on the size and shape distributions of rubble resulting from fractured lower lithophysal rock, along with detailed fracture data collection, was performed to provide a stronger technical basis for an outcrop-scale rubble characterization for use in subsequent modeling efforts. Samples were collected for three laboratory experiments. One experiment will assess flow properties through the rubble. A second experiment is a drift analog intended to evaluate corrosion under an appropriate thermal-chemical-hydrological environment (UZ2, ENG1[7],and ENG3)[8]. A third experiment will assess the range of bulking factors that different packing arrangements produce using the collected samples (UZ2 and ENG2).

SUMMARY OF PERTINENT POINTS:

- Rubble size and shape properties, along with fracture network information, was collected from three outcrop areas located on the southern end of Fran Ridge.

- Approximately 1,500 rubble clasts were measured, photographed, and collected for shipment back to the Center for Nuclear Waste Regulatory Analyses (CNWRA).

- Staff observed that the outcrop fractures were a primary control on the outcrop rubble shape and size. Correlation of fracture characteristics with rubble properties at the outcrop scale may provide insight into rubble characterization at the drift scale based on

---

[4]Smart, K. and R. Fedors. “Trip Report: Field Examination of Lithophysal Rocks at Yucca Mountain.” San Antonio, Texas: CNWRA. 2006.

[5]Support Prelicensing Transition to License Application Review—Flow Paths in the Unsaturated Zone (UZ2 ISI) is referenced throughout this report. Consequently, the acronym will be used.

[6] Support Prelicensing Transition to License Application Review—Mechanical Disruption of Engineered Barriers (ENG2 ISI) is referenced throughout this report. Consequently, the acronym will be used.

[7]Support Prelicensing Transition to License Application Review —Degradation of Engineered Barriers (ENG1 ISI) is referenced throughout this report. Consequently, the acronym will be used.

[8]Support Prelicensing Transition to License Application Review—Quantity and Chemistry of Water Contacting Engineered Barriers and Wasteforms (ENG3 ISI) is referenced throughout this report. Consequently, the acronym will be used.

drift-scale fracture data.

- Most clasts were bladed, rod, or platy in shape, rather than equidimensional. This observation may affect results of analyses where rubble has been modeled as spherical particles.

- Additional fracture information was collected from the TSw Middle Nonlithophysal unit at the Large Block Test excavation site at Fran Ridge.

SUMMARY OF ACTIVITIES:

The south end of Fran Ridge at Yucca Mountain has outcrop exposures of the TSw Lower Lithophysal unit that are easily accessible (Figure 1). Field conditions were sunny and dry. Three outcrop areas were delineated in the field, designated as Plot 1, Plot 2, and Plot 3. Plot 2 was further subdivided for rubble collection and characterization with Subareas A, B, and C. For all three plots, information was collected on fracture orientation, spacing, and length. Talus was collected from directly beneath Plots 1 and 3; care was taken to ensure that the rubble collected resulted directly from the outcrop and was not transported from adjacent areas. Known limitations to the field collection data include secondary alteration to the rubble (e.g., weathering and erosion effects). To minimize these effects, rubble from Plot 2 was removed directly from the outcrop with minimal force to provide the most “pristine” collection possible in the field.

Rubble data collection was recorded with the following methodology: (i) clasts were photographed on a 2 by 2-cm [0.79 by 0.79-in] grid, (ii) the longest orthogonal dimensions (length, width, height) were measured, and (iii) all measurements were rounded to the nearest 0.5-cm increment. Size limitations on the collection include truncations at the smallest and largest scale. The largest rock clasts collected were limited to the outcrop scale. The smallest clasts {~3–10 cm [1.18–3.94 in] in longest dimension} were too small to practically measure in the field. These clasts were binned by average size, laid out on the grid as close together as possible, and photographed as a group, with the largest and average heights recorded. Volumes may be averaged for these groups by calculating the overall length, width, and height of the collection and dividing by the number of clasts in the group. The smallest material in the talus piles (i.e., fine grained particles) was not included in the collection or analysis because it was not possible to distinguish particles that originated from the outcrop from those introduced by eolian transport or other means.

Approximately 1,500 rubble clasts were photographed and measured during the field examination. Four [0.24-m^3] 55-gal drums of rubble were collected for shipment back to CNWRA for further analyses (Figure 2). Each drum contained rubble from a single characterization site (i.e., Sample drum #1 contained rubble collected and characterized from Plot 1). For Plot 2, only two of the three characterization sites were sampled. The largest clasts measured were not necessarily included in the sample drums due to size limitations; where possible, these larger clasts were wrapped separately on a pallet and tagged for sample identification.

Following completion of the rubble characterization effort, staff collected fracture data from the excavation walls of the Large Block Test site on Fran Ridge. Although detailed fracture maps are available for the Large Block itself, no fracture mapping has been published on the excavation walls. Two fracture surveys were performed: one on the north wall and one on the south wall of the excavation. Scanline surveys of the fractures recorded fracture orientation, spacing, tracelength, and observations of mineralization in the fractures. These surveys on the excavation walls will support extension of the three-dimensional fracture information from the Large Block to larger scales more relevant for drift scale analysis.

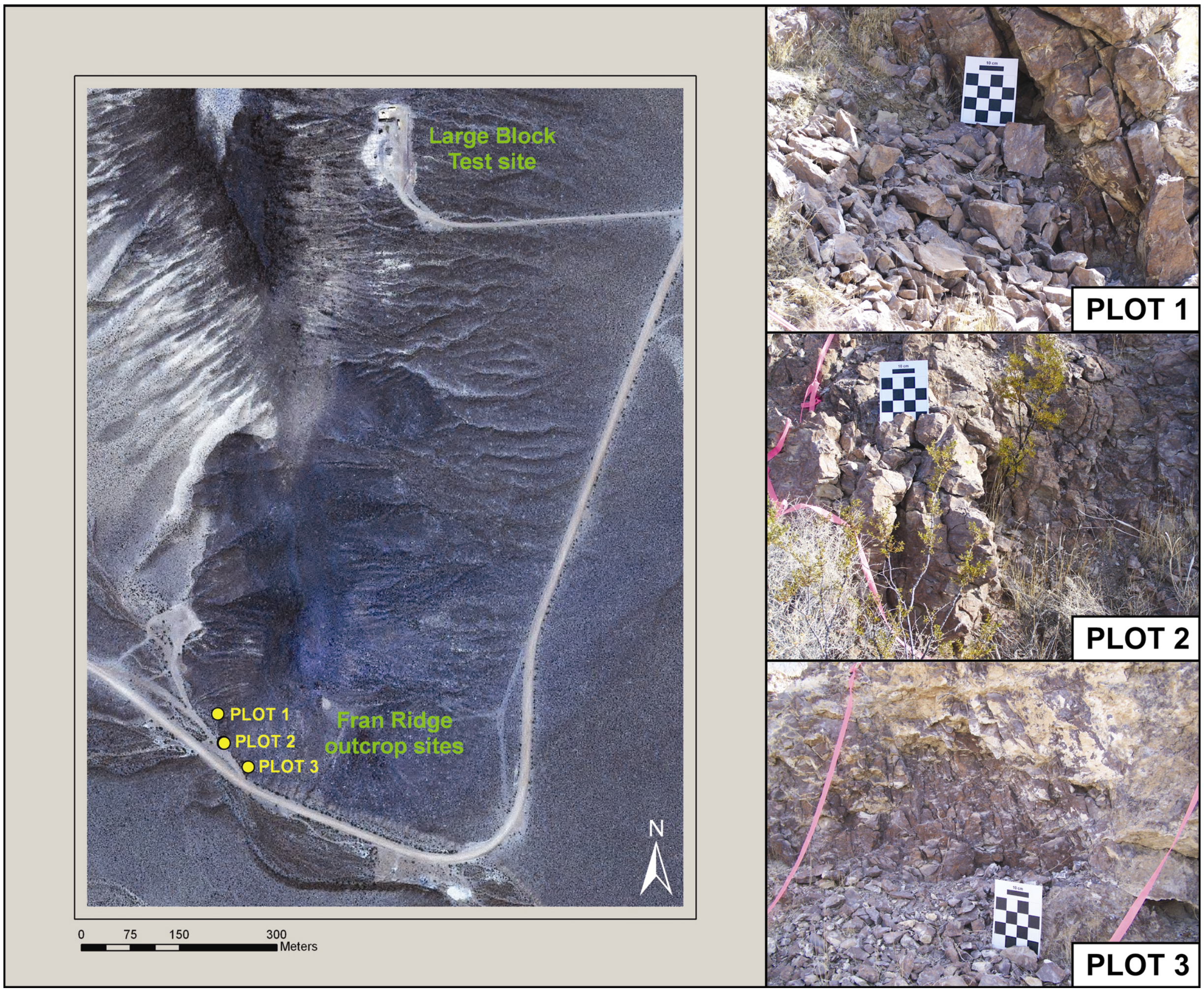

Figure 1. Location Map of Fran Ridge Outcrop Sites

Figure 2. Example Rubble Pile Collected From Plot 2 Outcrop at Fran Ridge

IMPRESSIONS/CONCLUSIONS:

- Field observations note that the rubble produced was primarily a result of the outcrop fractures. Observations include a positive correlation between higher fracture intensity and smaller clast sizes. Also, fracture set orientations contributed to the formation of prismatic (i.e., bladed) rock fragments.

- Observations of the rubble in the field noted that most rock clasts appeared to be bladed, rod, or platy in shape (Figure 3). The least frequently encountered shape was cubic (equidimensional).

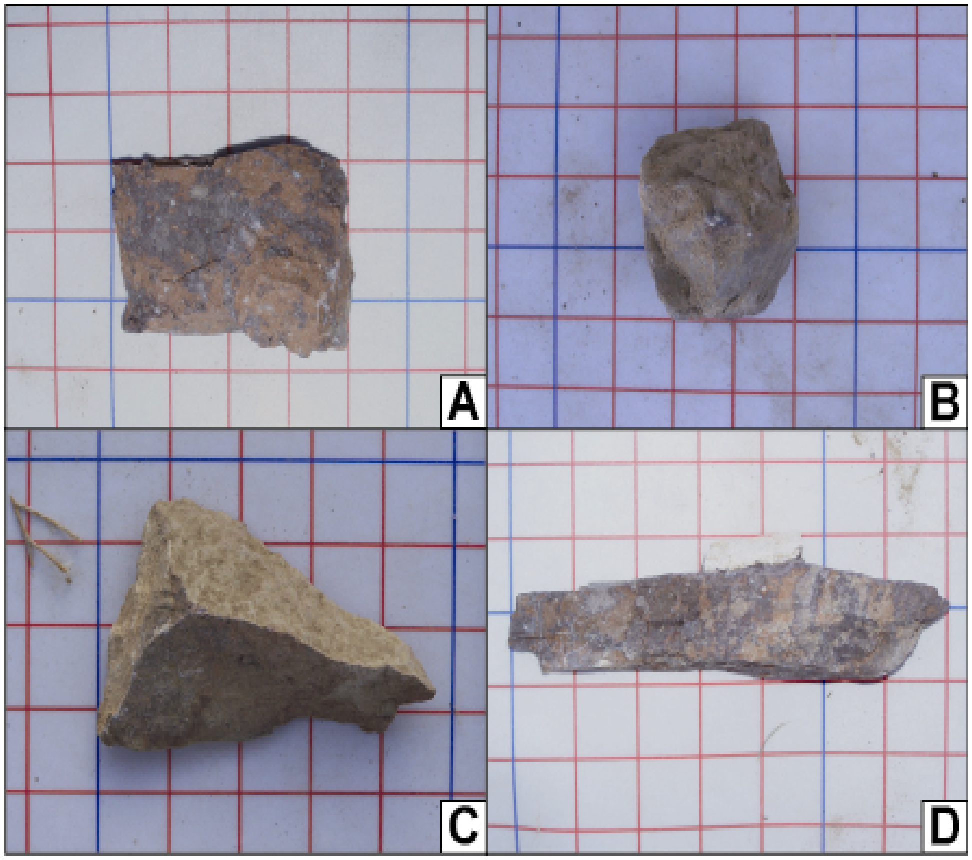

Figure 3. Examples of Basic Rubble Shapes. (A) Platy; (B) Cubic; (C) Bladed; and (D) Rod. Note That Background Grid Has 2 by 2-cm [0.79 by 0.79-in] Spacing

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

- Process the field data on rubble shape and size distributions and fracture characterization from the Fran Ridge outcrops.
- Upon receipt of samples from DOE Sample Management Facility, estimate bulking factor using various packing approaches.
- Complete a preliminary estimate of rubble characterization, focusing on the size and shapes of interfragment pore space.
- Evaluate the need for more detailed analysis, such as the use of software to better link fracture sets to rubble characteristics.

RECOMMENDATIONS:

- An understanding/characterization of clast shape distribution should accompany clast size distribution in subsequent modeling efforts.

- Observations that the fractures are a primary control on rubble shape and size suggests that follow-on analyses to correlate fracture characteristics with rubble characteristics might be warranted.

- A better analog site for rubble characterization would have been at locations inside the ECRB or ESF. DOE staff had previously questioned the feasibility of removing fragments from the drift wall for this type of analyses without the aid of a hydraulic jack hammer. In December 2005, DOE provided two barrels of rock fragments that were obtained by hydraulic jack hammer during excavation of a fire niche in the ECRB as a rubble analog, however, a significant fraction of the material was pulverized to gravel and natural fracture surfaces did not appear to be abundant. If warranted, NRC should explore the possibility of performing similar measurements in the ECRB or ESF in TSw Lower Lithophysal sections.