CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: 2006 Fall Meeting of the American Geophysical Union
(20.06002.01.191; 212; 252; 262; 272; 292; 302; and 312)
AI 06002.01.302.701

DATE AND PLACE: December 11–15, 2006
San Francisco, California

AUTHOR: N. Adams, C. Dinwiddie, D. Hooper, C. Manepally, L. McKague, P. Shukla, S. Stothoff, and A. Sun

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PERSONS PRESENT:

The annual fall meeting of the American Geophysical Union is a venue for researchers, academics, exhibitors, consultants, and students of the Earth and space sciences to present the latest trends and findings in an array of disciplines; it is unique in its size and international presence. N. Adams, D. Hooper, C. Manepally, L. McKague, P. Shukla, S. Stothoff, and A. Sun of the Center for Nuclear Waste Regulatory Analyses (CNWRA) and C. Dinwiddie and R. Green of the Department of Earth, Material, and Planetary Sciences (DEMPS) participated in the fall meeting of the American Geophysical Union held in San Francisco, California, December 11–15, 2006. More than 13,000 geoscientists attended the meeting, including representatives from the private sector; universities; U.S. Nuclear Regulatory Commission (NRC); U.S. Department of Energy (DOE) Office of Civilian Radioactive Waste Management in Las Vegas, Nevada; several DOE national laboratories; U.S. Bureau of Reclamation; U.S. Geological Survey; and other federal and state agencies.

BACKGROUND AND PURPOSES OF TRIP:

The American Geophysical Union 2006 Fall Meeting provided an opportunity for NRC, CNWRA, and DEMPS staff to present the results of technical work in the areas of hydrology, geochemistry, geology, geophysics, and volcanology to the broader scientific community. Attendance at the meeting also acquainted staff with other technical work relevant to preparations for review of a potential DOE license application for Yucca Mountain. Attendance at the meeting supports NRC principles of good regulation, including openness, efficiency, and reliability.

MEETING SUMMARY:

Significant presentations are discussed in the following paragraphs.

<u>CNWRA/DEMPS presentations</u>:

S. Stothoff (CNWRA) and R. Fedors (NRC) presented a poster called Mountain-Front Distributed Recharge in Nevada. The poster summarized approaches used to evaluate estimates of mean annual infiltration in NRC performance assessments. The poster also provided preliminary estimates of the change in infiltration due to different precipitation seasonality patterns across western North America, indicating the order of magnitude response to climate change over a glacial cycle.

R. Fedors (NRC) and S. Stothoff (CNWRA) presented a poster called Relationship of Short-Term Precipitation Records at Yucca Mountain to Long-Term Climate Records. The poster summarized available records that may be used to evaluate DOE estimates of mean annual precipitation over the past 8,000 years. The poster indicated that precipitation patterns near Yucca Mountain show a strong indication of wet and dry cycles at several different scales ranging from decadal to multicentury.

C. Manepally (CNWRA) and others presented a poster titled Model for the Evolution of Thermohydrology and Its Effects on Chemistry and Corrosion of Engineered Barrier Materials, which summarized a phased study that involves experimental and numerical models to (i) simulate the in-drift conditions by controlling the heat load, infiltration flux, and initial water compositions, and (ii) measure the changes in temperature, relative humidity, and chemistry of the water contacting the surfaces of the engineered barrier materials. This ongoing study is a collaborative effort that integrates the unsaturated flow processes occurring during the thermal period with geochemical and corrosion processes. Relationships between evolution of the water chemistry as a function of temperature, relative humidity, infiltration flux, and corrosion of the waste package and drip shield materials are evaluated. Analytical and experimental studies to determine the composition of the salts forming due to evaporation from a wide range of initial pore water compositions were completed in the first phase. The second phase, now underway, considers the evolution of coupled thermohydrological-chemical conditions and their impact on corrosion processes using experimental and numerical models. Effects of drift degradation will be included in the third phase of this study.

R. Green (DEMPS) and others presented a poster called Model for Understanding Flow Processes and Distribution in Rock Rubble, which described a multiphase assessment study undertaken to evaluate the potential effect of rubble on infiltration in an emplacement drift. The initial phase of the project is to estimate the size and shape distributions of fragments of the lower lithophysal unit of the Topopah Spring (Tptpll—potential host rock unit) using the size and shape of fragments in a talus slope and in the dislodged rubble in the Exploratory Studies Facility and the Drift-scale Heater Test. The next phase of the project will assess the effect of rubble shape and size distributions on infiltration using laboratory-scale testing. The laboratory-scale infiltration tests will evaluate the effect of rubble shape and size distribution at different infiltration rates using rubble from the Tptpll unit mined from the Enhanced Characterization of the Repository Block. This effort is expected to provide additional realism in the corresponding process models and performance assessment of the potential repository at Yucca Mountain and to help evaluate the chemistry of water contacting the waste as well as conditions affecting waste package corrosion in the presence of rubble.

A. Sun (CNWRA) and others presented preliminary results on representing uncertainty in the alluvial architecture within the site-scale, saturated zone models in a poster titled Characterization and Modeling of the Alluvium Beneath Fortymile Wash, Nevada. The valley-fill alluvial aquifer beneath Fortymile Wash constitutes an important component of the natural barrier system. The alluvium is currently modeled as a homogenous hydrogeologic unit in the DOE saturated zone site-scale model. Geological and geophysical surveys conducted in the area, however, have indicated strong spatial variability in the alluvium resulting in a significant amount of model uncertainty. Facies distributions, when modeled under a probabilistic framework, can be used to generate images of subsurface heterogeneity and to link geology to hydraulic parameters, which in turn can be used for stochastic flow and transport simulations. Lithology logs, outcrop studies, and resistivity survey data were analyzed to define quantitative models for the proportions, geometry, and spatial distribution of geologic materials that have distinctive hydraulic properties (i.e., hydrofacies). A transition probability/Markov chain geostatistical approach was taken to represent the geometry and juxtapositioning tendencies of facies and to generate conditional realizations of facies distributions. The results show that interconnected facies form preferential flow paths, and large variability exists in the flow path pattern.

P. Shukla (CNWRA) and others presented a poster called Flow of In-Drift Water Through Stress Corrosion Cracks. This work presented theoretical and experimental studies conducted at CNWRA to determine conditions when water would leak in the waste packages through stress corrosion cracks. Theoretical work was performed using the Rayleigh-Taylor method. Results indicate that capillarity will be dominant in the stress corrosion cracks; therefore, if cracks are oriented parallel to gravity, in-drift water may seep through the cracks. Complementary experimental studies were also conducted to determine when in-drift water would seep through the crack. The experimental results show that the contact angle between in-drift water and the waste package surface would affect the in-drift water flow through stress corrosion cracks. This work was conducted to evaluate a DOE assumption that no water will flow through stress corrosion cracks during the postclosure period.

D. Hooper (CNWRA) and others presented a poster called Modeling Potential Tephra Dispersal at Yucca Mountain, Nevada. This poster describes realistic modeling of volcanic eruption plumes with the TEPHRA code. TEPHRA uses an advection-diffusion approach to translate complex volcanological, meteorological, and field data into a reasonable contour map of tephra (ash) and uranium (fuel) accumulation deposited at distances from the volcano by sedimentary transport from the volcanic plume. Ash accumulation is calculated using measured eruption data as input parameters and incorporates the effects of stratified wind layers on ash dispersion. This presentation summarized technical work being conducted as part of the Airborne Transport of Radionuclides Integrated Subissue.

L. McKague (CNWRA) and others presented a poster titled Evidence for Active Westward Tilting of Fortymile Wash, Nye County, Nevada. Active westward tilting between Fortymile Wash and the Bare Mountain fault is indicated by (i) topographic profiles across Fortymile Wash, (ii) geologic mapping of the Fortymile Wash channel, and (iii) level line data along US 95, between the northward projection of the Gravity Fault across US 95 and the Bare Mountain fault. The area of westward tilting adds another factor to be considered in evaluating the tectonic models of the Yucca Mountain Region and their control of natural hazards within the region and at the repository site.

Presentations by others relevant to program objectives:

Hydrology-related presentations:

R. Salve (Lawrence Berkeley National Laboratory) and others presented a study related to the *in-situ* field experiment in the underground Exploratory Studies Facility in the fractured Topopah Spring tuff at Yucca Mountain, Nevada. Ponded water {with a ~0.04-m [0.13-ft] head} was released onto a 12-m^2 [129.2-ft^2] infiltration plot (divided into 12 square subplots) over a period of ~800 days. As water was released, spatial and temporal variability in infiltration rates was continuously monitored. In addition, changes in moisture content were monitored along horizontal boreholes located in the formation ~19–22 m [62–72 ft] below. In particular, it was observed that in some of the subplots, the infiltration rate abruptly increased a few weeks into the infiltration tests before gradually decreasing, while in others, a relatively low infiltration rate persisted for the duration of the experiment. Distinct flow zones, varying in flow velocity, wetted cross-sectional area, and extent of lateral movement, intercepted the monitoring boreholes. There was also evidence of water being diverted above the ceiling of a cavity in the immediate vicinity of the monitoring boreholes. Observations from this field experiment suggest that isolated conduits, each encompassing a large number of fractures, develop within the fractured rock formation to form preferential flow paths that persist if there is a continuous supply of water. An overriding conclusion is that field investigations at spatial scales of tens of meters provide data critical to the fundamental understanding of preferential flow in fractured rock. The related journal article is currently under peer review.

B. Freifeld (Lawrence Berkeley National Laboratory) and others reported on evidence of rapid localized groundwater transport in volcanic tuffs southeast of Yucca Mountain, Nevada. Nye County borehole EWDP-24PB is located 15 km [9.3 mi] south of Yucca Mountain, and it is screened in the Tram and Bullfrog tuffs. Current model-based basecase estimates of specific discharge in this vicinity have a mean of 2.3 m/yr [7.5 ft/yr]; direct measurements of groundwater flow velocities or specific discharge are not traditionally collected. These authors used two new measurement techniques to independently quantify the vertical distribution of horizontal fluid flux: (i) Fluid Electrical Conductivity (FEC) logging, and (ii) a distributed fiber optic thermal perturbation sensor with a continuous heater. The FEC logging was conducted first and was plagued by intraborehole flow; then the thermal perturbation sensor instrumentation was installed in EWDP-24PB and the well backfilled with sand and bentonite to eliminate the vertical intraborehole flow observed during FEC logging. The continuous heater provides a thermal pulse to the wellbore, and the resulting thermal transient is used to estimate groundwater flux. These different measurement techniques yielded consistent results, leading workers to conclude that there are two high flow zones. They are located at 135 and 231 m [443 and 758 ft] below ground surface and have groundwater flow velocities of 15.7 and 21.0 km/yr [9.8 and 13.0 mi/yr] (assuming fracture porosity of 1 percent), respectively. More than half of the groundwater flow through this well occurs in these two 20-m [65.6-ft]-thick flow intervals. The authors suggest that additional work will be needed to determine the lateral extent of these flow conditions and to arrive at implications for radionuclide transport in this vicinity. The presentation provides additional information on the higher-than-expected flow rate reported by the DOE Office of Science and Technology during a recent drilling event.

E. Al-Aziz (Los Alamos National Laboratory) and others contributed to a poster presented by S. James (Sandia National Laboratories) describing a revised Yucca Mountain site-scale saturated zone flow model. The results were based on a numerical model of a site-scale saturated zone beneath Yucca Mountain, which is used for performance assessment predictions of radionuclide transport and to guide future data collection and modeling activities. This effort started from the ground up with a revised and updated hydrogeologic framework model, which incorporates the latest lithology data and increased grid resolution from 500 by 500 m^2 to 250 by 250 m^2 [1,640 by 1,640 ft^2 to 820 by 820 ft^2]. Data collected since the previous model calibration effort have been included, and they comprise all Nye County water-level data through Phase IV of their Early Warning Drilling Program. Target boundary fluxes were derived from the newest (2004) Death Valley Regional Flow System model from the U.S. Geologic

Survey. A commonly used weighting scheme in which target locations near probable flow pathways are given higher weights was used to assign importance to each measured water-level datum and boundary flux extracted from the regional model. The numerical model was calibrated by matching these weighted water level measurements and boundary fluxes using parameter estimation techniques, along with more qualitative comparisons of the model to hydrologic and geochemical information. Analyses evaluated the impact of these updates and additional data on the modeled potentiometric surface and the flow paths emanating from below the repository. The authors presented particle pathways from the proposed repository and compare them to those from the previous model calibration. The results showed that the updated model yields a calibration with smaller residuals than the previous model revision while ensuring that flow paths follow measured gradients and paths derived from hydrochemical analyses. The poster summarized the latest DOE efforts in updating the site-scale saturated zone flow model and previews the upcoming revised DOE report on site-scale saturated zone flow.

S. Kelkar (Los Alamos National Laboratory) and others presented an updated site-scale transport model, which is based on the refined site-scale flow model. It incorporates updated Kd distributions for radionuclides of interest and updated retardation factor distributions for colloid filtration. The resulting numerical transport model is used for performance assessment predictions of radionuclide transport and to guide future data collection and modeling activities. The transport model results are validated by comparing the model transport pathways with those derived from geochemical data and by comparing the transit times from the repository footprint to the compliance boundary at the accessible environment with those derived from 14C-based age estimates. The colloid-facilitated transport of radionuclides is modeled using two approaches: the colloids with irreversibly embedded radionuclides undergo reversible filtration only, while the migration of radionuclides that reversibly sorb to colloids is modeled with modified values for sorption coefficient and matrix diffusion coefficients. The poster summarizes the latest DOE efforts in updating the site-scale saturated zone transport model and prepares the staff to review the revised DOE report on site-scale saturated zone transport.

Volcanology-related presentations:

F. Perry (Los Alamos National Laboratory) and others presented a poster titled Control of Basaltic Feeder Dike Orientation by Fault Capture Near Yucca Mountain, Nevada, USA. Using high resolution aeromagnetic data, they infer a north-northwest trend for basaltic dikes that fed the centers of igneous complexes located southwest of Yucca Mountain. This orientation differs from the northeast azimuth(s) predicted from the present-day stress field, suggesting these feeder dikes were captured by faults whose orientations were established in a mid-Miocene regional stress field. These faults seem to be subsidiary intrablock faults that are steeply dipping (near vertical) and that may act as preferential pathways to the surface because, at a given magma pressure, the magma will have to overcome lower normal stresses to dilate the fault plane. These results could affect calculations for the probability of a future basaltic dike intersecting the proposed Yucca Mountain high-level waste repository.

J. Reisner and G. Valentine (Los Alamos National Laboratory) gave an oral presentation titled Transition From Unsteady to Steady Jet Behavior in Pulsing Explosive Eruptions concerning the transition between Strombolian and violent Strombolian eruptive behavior during basaltic eruptions. They suggest that the explosion frequency during such eruptions acts as a control, and as such, these processes can be quantified and delineated; below a certain value, the eruption is characterized by separate, distinct explosions, and above a certain value, explosion signals are mixed to essentially produce a steady jet. The middle range between these two values represents a transitional regime in which a steady jet occurs, but at some height above the vent, and might also mark the boundary between Strombolian and violent Strombolian behavior. A better understanding of explosive eruptive behavior and the transition between eruptive regimes is important for assessing risks associated with possible extrusive igneous activity in the Yucca Mountain region.

S. Dartevelle (Los Alamos National Laboratory) presented a poster titled Verification and Validation (V&V) Methodologies for Multiphase Turbulent and Explosive Flows: V&V Case Studies of Computer Simulations from Los Alamos National Laboratory GMFIX Codes describing a new approach to code validation that concentrates on the controlling physics of volcanic clouds. Using GMFIX (Geophysical Multiphase Flow with Interphase eXchange Version 1.62), numerical results were obtained and compared to analog experiments. GMFIX accurately described the position of the first Mach disk with regard to the pressure ratio, K, and the particle mass fraction, ϕ, and the velocity profiles and turbulence quantities generated by GMFIX compared well with results from analog experiments. Thus, validation of real-world physics describing explosive volcanism is nearly impossible, but new approaches test the capture of specific eruption processes by GMFIX and show it provides numerical data that can be used towards the mitigation of hazards.

The poster by D. Hooper and others was one presentation in a large three-part session (two oral and one poster) titled Description of Tephra Dispersal and Sedimentation: Field Studies, Modeling, and Hazard Assessment. This session was conceived to bring together scientists with active research interests and expertise in the application of tephra studies to develop numerical models of tephra dispersion and sedimentation. Tephra produced by volcanic eruptions poses a substantial risk to the aviation industry and tephra fallout represents a significant public health and societal hazard. Accurate forecasts of particle dispersal and fallout are critical during volcanic crises and are important components of volcano hazard assessments where both short- and long-term volcanic risk must be estimated. This session highlighted recent work on the analysis of tephra hazards and the integration of field studies and numerical modeling of particle transport and fallout. Topics that were addressed included (i) strengths and weaknesses of existing numerical models for tephra transport and sedimentation, (ii) new techniques for collection and monitoring of tephra during eruptions, (iii) critical assessments of existing techniques for the study of tephra deposits, (iv) environmental and societal impacts of tephra fallout, and (v) risk mitigation. Insights gained from these presentations help staff prepare a technical basis to review DOE models that address volcanological issues. The session was chaired by C. Bonadonna (University of Geneva), C. Waythomas (U.S. Geological Survey), and P. Webley (Alaska Volcano Observatory).

Another poster in this session was by C. Bonadonna (University of Geneva) and others titled Validation of Sedimentation Models: The Case Study of Pululagua Volcano, Ecuador. An inversion technique combined with the advection-diffusion model TEPHRA was applied on the Pululagua Plinian deposit and generated eruption parameters in good agreement with field data (e.g., column height and volume). Different techniques for determining the deposit volume were also considered and analyzed (i.e., exponential and power-law methods), confirming that curve fitting can be problematic above all when the proximal and/or distal data are missing (power-law coefficient <2). In addition, the TEPHRA model reproduces a concentric isopach map with good agreement between computed and observed data in medial and distal area {>6 km [3.7 mi] from the inferred vent}, with about 60 percent of computed data showing a percentage error less than 20 percent. Although C. Bonadonna and others are using the TEPHRA code model, this is a revised version of the code developed at the University of South Florida, and it is being applied to a larger and more violent volcanic eruption than the violent Strombolian eruptions recognized in the Yucca Mountain region.

L. Costantini (University of Geneva) and others presented a poster called New Approaches for the Characterization of Poorly-Exposed Tephra deposits: The Case Study of Fontana Lapilli Eruption, Nicaragua. They note that even though a few well-preserved outcrops in the medial area allowed the temporal evolution of the eruption to be well constrained, the lack of deposit exposure in the proximal and distal areas prevents the determination of crucial eruption parameters by standard techniques. As a result, they applied an inversion technique in combination with the forward model TEPHRA to achieve column height and total erupted mass of the main units of Fontana Lapilli eruption. The strength of this technique is that input parameters are not estimated *a priori* as in forward modeling, but are automated as part of the process of searching for optimal parameters by employing a mathematical algorithm to guide the search for the best-fit parameter set. Results for column height show a close agreement with field data, whereas estimation of the total erupted mass shows a significant discrepancy with values obtained using standard techniques. Such a discrepancy significantly affects the estimate of other important parameters, including mass discharge rate and eruption duration. They conclude that the application of inversion techniques confirms the problematic nature of uncertainties associated with field data often used as input factors in numerical models, suggesting that numerical solutions should be preferred to curve-fitting techniques for determining eruption parameters above all in cases of poor deposit exposure.

S. Kobs and M. Bursik (State University of New York at Buffalo) presented Simulation of Near-Vent Pyroclast Deposition Using a Navier-Stokes Based Plume Model. This poster noted that the traditional advection-diffusion ash deposition models typically break down in the near-vent region because they do not sufficiently describe the eruption column. To address this, a Large Particle Module (LPM) was added to the Active Tracer High-resolution Atmospheric Model (ATHAM), a Navier-Stokes-based plume simulation. Large particles, or those in dynamic disequilibrium with the column, were tracked through a two-dimensional steady-state flow field of a large eruption generated by ATHAM. The pyroclast sizes modeled ranged from 4 to 50 cm [1.6 to 20.0 in] in diameter and were modeled as both scoria and pumice. The model results of large pyroclast deposition were consistent with field observations of deposition from plume margins, with larger particles reaching greater distances due to their increased momentum. This research is the doctoral work of S. Kobs, and staff look forward to the forthcoming publication, because this is a tephra dispersal model. Also note that M. Bursik is an Electric Power Research Institute consultant.

Performance confirmation-related presentation:

R. Versteeg (Idaho National Laboratory) and others reported on quality assurance and quality control for autonomously collected geoscience data—a topic that will be of particular importance to the DOE's Yucca Mountain Performance Confirmation program. Large amounts of data will likely be collected autonomously by robust environmental sensors and transmitted to a central server. Tens of thousands of data points per month per sensor can result. End users typically will look at voluminous data in the aggregate, rather than point by point, and perhaps will not review data for some period of time. Thus, not only will the Performance Confirmation program have to generate large volumes of monitoring data, but the program must also have an architecture that will enable staff to rapidly identify and resolve data issues, perhaps long after the data was actually collected. Anticipated data issues include complete system failure, complete sensor failure, partial sensor failure, and partial power loss. These authors recognize the need to implement data Quality Assurance/Quality Control rules and procedures that will enable autonomous analysis of new data for compliance as soon as it is transmitted to a central server so cognizant personnel can be immediately notified about any data issues. Data must be subjected to quality control tests, including timeliness, format validity, completeness, value in reference to expected range, appropriateness of time intervals, trends in data statistics, and instrument calibration. Implementation of these tests as a central part of a performance confirmation system will generate confidence in the auditability and usability of performance confirmation data.

OTHER ACTIVITIES:

Approximately 215 people seeking employment registered at the American Geophysical Union Career Center before and during the meeting. CNWRA staff interviewed seven, contacted one, and were contacted by four to seven for open positions at the CNWRA (computer geoscientist, hydrologist, and seismologist). Five people were encouraged to formally apply for the positions, and a sixth person was encouraged to apply for a summer student position.

IMPRESSIONS/CONCLUSIONS:

Because of its size and content, the fall meeting of the American Geophysical Union is a unique opportunity for technical staff to present current work and learn of latest developments in their fields of study. In particular, staff gain credibility in the scientific community by presenting research and interacting directly with national and international scientists. Presentations describing the most recent trends and technical approaches to topics both directly and indirectly related to Yucca Mountain yield insights and innovative methods that will aid staff during the review of a potential license application.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

CNWRA staff will follow-up with formal applications for the open positions as part of the normal hiring process.

RECOMMENDATIONS:

Continued participation in the American Geophysical Union Fall Meeting is recommended.

REFERENCES:

None.

SIGNATURES:

Nancy Adams Research Scientist	1/12/07 Date
Cynthia L. Dinwiddie Senior Research Engineer	1/12/07 Date
Donald Hooper Senior Research Scientist	1/12/07 Date
Chandrika Manepally Research Engineer	1/12/07 Date
H. Lawrence McKague Principal Scientist	01/12/07 Date
Pavan Shukla Research Engineer	Date
Stuart Stothoff Senior Research Scientist	1/12/07 Date
Alex Sun Senior Research Engineer	01/12/07 Date

CONCURRENCE:

John Stamatakos Manager, Geology and Geophysics	1/12/2007 Date
Gordon W. Wittmeyer Assistant Director, Earth Sciences	1/12/2007 Date
Yi-Ming Pan Principal Engineer	1/12/2007 Date