# CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

## TRIP REPORT

**SUBJECT:** American Geophysical Union Spring 2001 Meeting (20.01402.861)

**DATE/PLACE:** May 29–June 2, 2001
Boston, Massachusetts

**AUTHORS:** W. Illman

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**PERSONS PRESENT:**

The 2001 Spring Meeting of the American Geophysical Union (AGU) was held in Boston, Massachusetts, May 29–June 2, 2001. The conference was attended by W. Illman and J. Russell from the CNWRA.

**BACKGROUND AND PURPOSE OF TRIP:**

The semiannual AGU meetings provide an excellent opportunity for exchange of information and exposure to new technologies among earth and physical scientists, many of whom are conducting research pertinent to the geological disposal of high-level waste (HLW) and other CNWRA activities. This trip afforded CNWRA attendees opportunities to present ongoing research activities, receive constructive feedback regarding methods and assumptions, and discuss new methods and technologies with other researchers. Presentations in several of the meeting sessions were directly relevant to ongoing investigations of the suitability of Yucca Mountain (YM) as a geologic repository for HLW.

**SUMMARY OF ACTIVITIES:**

Numerous talks and posters were presented over five days. There were many presentations of interest to CNWRA work for the NRC.

W. Illman (CNWRA) presented a poster co-authored with D. Hughson on numerical modeling of unsaturated flow in thick vadose zones of fractured rocks. This work was undertaken as an activity under the Unsaturated and Saturated Flow Under Isothermal Conditions Key Technical Issue. The primary objective of this study was to evaluate the assumption in the DOE's model that unsaturated flow can be adequately represented using average properties for each hydrostratigraphic unit. This assumption was tested by examining the effects of varying hydrostratigraphic strata properties on unsaturated flow through thick vadose zones. Monte Carlo simulations revealed the development of preferential pathways and focusing of flow, both of which can have significant consequences on the performance of waste facilities constructed in unsaturated, fractured rocks.

J. Russell (CNWRA) gave a presentation on employment of geoscientists in the private sector. The main theme of the session was career choices for students in the geosciences. J. Russell's presentation highlighted the qualities of a geoscientist seeking employment in the private sector. In the private sector, major employers of geoscientists engage in diverse activities ranging from resource exploration and extraction,

assessment of geologic hazards, and determination of environmental impacts. These firms actively recruit, from the breadth of geoscience disciplines, technically qualified individuals with the ability to make pragmatic decisions in the context of multidisciplinary teams that commonly include nonscientists. He noted that employers expect applicants to communicate effectively verbally and in writing, as well as demonstrate skills and experience in integrating field investigations, conducting laboratory studies, and conducting computer modeling.

Other presentations of interest to CNWRA work for the NRC included a presentation by R. Neupauer (University Of Virginia) and J. Wilson (New Mexico Tech) on travel time probabilities of groundwater tracers and contaminants. They presented an overview of the use of the travel time approach for chemical transport in groundwater, focusing on techniques used to obtain source characteristics. They considered both forward and backward travel time probabilities. A forward travel time probability represents possible arrival times of the contamination at a downgradient position, while backward travel time probabilities represent possible times in the past when observed contamination was at an upgradient location.

R. Pawar and D. Zhang (Los Alamos National Laboratory) displayed a poster on the use of depleted oil reservoirs for carbon dioxide sequestration. They highlighted how the safe, long-term sequestration of carbon dioxide ($CO_2$) is fast becoming a need because of the environmental impact of increased amounts of greenhouse gases in the atmosphere. Injection of $CO_2$ in depleted oil and gas reservoirs is one of the options where technology already exists because $CO_2$ is routinely used in enhanced oil recovery operations. They explored the total capacity of the reservoir for long-term sequestration.

B. Berkowitz (Weizmann Institute of Science) and S. Silliman (University of Notre Dame) displayed a poster on fluid flow and chemical migration within the capillary fringe. The authors demonstrated through laboratory experiments that flow and transport in the capillary fringe are vastly more complicated than represented in the vertical flow conceptualization. This complexity is likely to lead, near the water table, to complicated mixing phenomena, high levels of biological activity and diversity, and complex geochemistry.

M. Dragila (Oregon State Univeristy) and G. Su (U. S. Geological Survey) presented a talk that discussed the physics of seepage into unsaturated fractures. The authors presented an innovative porous media model, the Aggregated Materials Model, that predicts seepage will occur even while the matrix is partially-saturated. This model establishes specific conditions for the physical properties of the matrix and the fracture surface. The authors emphasized the significance of their model as it improves the understanding of fluid behavior in the vadose zone, and it may explain some of the early arrival data from contaminated vadose sites.

H. Rajaram and W. Cheung (University of Colorado at Boulder) presented results of their modeling study on the dissolution of variable aperture fractures in soluble rock. The authors examined the features of dissolution channel growth in variable aperture fractures using numerical model simulations, and presented comparisons between model predictions and small-scale experimental measurements.

J. Fairley, Jr. (University of Idaho), presented his analysis of a fracture/matrix interaction test in low-permeability, welded tuff. *In-situ* liquid injection tests in the unsaturated, fractured Topapah Spring welded volcanic tuff at Yucca Mountain, Nevada, were analyzed using an numerical model for flow in a fracture/matrix system. In spite of observations and theoretical considerations indicating flow instability during the tests, field measurements indicate substantially greater flux attenuation than model predictions. This discrepancy may be attributable to matrix permeability in excess of published values, capillary water retention at asperity contacts, and/or trapping of water in dead-end fractures. If future tests confirm these

findings, the tuffs comprising the proposed repository horizon may have a larger than expected capacity to attenuate infiltration pulses, and commensurately greater waste isolation capability.

J. McCray (Colorado School of Mines) and C. Neville (SS Papadopulos & Associates) gave a presentation on quantifying the uncertainties associated with analytical-model approximations in vapor-phase pump-test analysis. For this research, hypothetical data sets were generated for idealized SVE operations in a radially symmetric aquifer using a numerical multiphase-flow model. Using a mathematical-inversion technique, they evaluated the uncertainties associated with the typical assumptions inherent in analytical models for nearly homogeneous confined and leaky vadose zones. The influences of several variables and processes that are typically not accounted for in the analytical models were assessed. These included variable water content, anisotropy, nonisothermal conditions, variable mass flow rate, gas compressibility, and linearization of the PDE used for the analytical solutions.

D. Cesano and A. Bagtzoglou (Columbia University) presented results from their research in dripping from rough multi-segmented fracture sets into unsaturated rock underground excavations. The authors presented a probabilistic analytical formulation of unsaturated flow through a single, rough multi-segmented fracture, with the ultimate goal to provide a numerical platform with which to perform calculations on the dripping initiation time and to explain the fast flow-paths detected and reported by Fabryka-Martin et al. (1996).

M. Nicholl (University of Idaho) and R. Glass (Sandia National Laboratories) presented a talk on a phase structure within a fracture network beneath a surface pond. The authors considered a simple field experiment to elucidate phase structure for the case of a fracture network dissecting an impermeable rock mass. Over a 36-minute period, dyed water was infiltrated from a surface pond into a pervasively fractured, densely welded tuff unit. The rock mass was then excavated. It was found that near the infiltration surface, flow was dominated by viscous forces, and the fracture network was fully stained. With increasing depth, flow transitioned to unsaturated conditions and the phase structure became complicated, exhibiting evidence of fragmentation, preferential flow, fingers, irregular wetting patterns, and varied behavior at fracture intersections. Limited geophysical measurements suggest that the fluid front penetrated to a depth of 3 m in less than 10 minutes, and that the network drained rapidly after infiltration was ended.

The Langbein Lecture, presented by S. Burges (University of Washington) was titled, "Hydrologic Variability and its Societal Importance." His well-attended talk emphasized the consequences of variability and the forms of persistence and the need to elucidate the causes of various forms of persistence in patterns of precipitation and resulting streamflow. Examples were presented for variable streamflow patterns that have excursions from "average" that range over time scales from years to multiple decades. The examples illustrate the critical need for sharpening all components of the water balance and making progress in conditional long-term forecasting of hydrologic extremes. The recently proposed "Water Cycle Initiative" and extensive instrumentation of natural laboratories should provide exceptional opportunities for addressing many of these issues.

**PROBLEMS ENCOUNTERED:**

None

**PENDING ACTIONS:**

None

**RECOMMENDATIONS:**

The AGU Fall and Spring meetings provide a valuable insight to hydrologic research and characterization methods and provide an invaluable forum to present results of CNWRA research for informal peer review. Discussions with meeting participants result in useful insights into modeling hydrologic processes and help staff to stay abreast of new technologies. Continued participation in AGU meetings by CNWRA hydrology staff is recommended.

**REFERENCES:**

Fabryka-Martin, J.T., H.J. Turin, A.V. Wolfsberg, D. Brenner, P.R. Dixon, J.A. Musgrave. *Summary Report of Chlorine-36 Studies*. LA–CST–TIP–96–003. YMP Milestone Report 3782M. Los Alamos, NM: Los Alamos National Laboratory. 1996.

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