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SUBJECT: Trip rept of 971208-12 visit to American Geophysical Union Fall Meeting & Field Testing & Assocaited Modeling Workshop. Each author presented at least one poster,as well as attended several sessions relevant to technical area.

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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Trip to American Geophysical Union Fall Meeting and Field Testing and Associated Modeling Workshop (20-1402-861)

DATE/PLACE: December 8–12, 1997
San Francisco, CA
December 15–16, 1997
Berkeley, CA

AUTHOR: S. Stothoff and J. Winterle

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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: American Geophysical Union Fall Meeting and
Field Testing and Associated Modeling Workshop
(20-1402-861)

DATE/PLACE: December 8-12, 1997
San Francisco, CA
December 15-16, 1997
Berkeley, CA

AUTHOR: S. Stothoff and J. Winterle

PERSONS PRESENT:

The American Geophysical Union (AGU) meeting was attended by S. Stothoff and J. Winterle (CNWRA), N. Coleman (NRC), and D. Woolhiser (CNWRA consultant) as well as more than seven thousand earth and planetary scientists, including many representatives of universities, the national laboratories and the United States Geological Survey (USGS). The Field Testing and Associated Modeling (FTAM) Workshop was attended by Jim Winterle, John Bradbury (NRC), and approximately 50 other attendees from national laboratories, USGS, and several representatives from European and Eastern European repository programs.

SUMMARY OF PERTINENT POINTS:

The authors each have a copy of the Fall Meeting Program and abstracts from the Fall Meeting, which may be examined upon request. J. Winterle has a copy of the proceedings of the FTAM Workshop which contains summaries of most of the presentations given and a list of attendees.

SUMMARY OF ACTIVITIES:

Each of the authors presented at least one poster, as well as attended several sessions relevant to his technical area. J. Winterle gave an oral presentation at the FTAM Workshop.

IMPRESSIONS/CONCLUSIONS:

Part 1: AGU Fall Meeting

The following are highlights of an intensive meeting.

CNWRA staff and contractors presented three posters. **S. Stothoff** (CNWRA) et al., discussed field and modeling work related to infiltration studies at Yucca Mountain (YM), particularly regarding the interplay between soil properties, climate, and vegetation in shallow soils overlying fractured bedrock. **D. Woolhiser** (CNWRA consultant) et al., discussed field and modeling work related to runoff and channel infiltration in the Solitario Canyon watershed. **J. Winterle** and **S. Stothoff** discussed the evidence for hysteretic moisture retention in YM core samples implied by discrepancies between wetting experiments and drying experiments performed by the USGS. In addition, **N. Coleman** (NRC) et al., presented a poster outlining efforts towards climate issue resolution.

L. Flint and **J. Winterle** discussed Winterle's poster presentation, which was largely based on laboratory data measured by Flint et al., and agreed that additional laboratory measurements are necessary to resolve discrepancies between modeled and observed flow in unsaturated rocks. In particular, it is necessary to quantify and distinguish between the effects of hysteretic moisture retention and entrapped air during imbibition. **L. Flint** indicated that plans are being made to perform additional laboratory measurements and experiments on YM rock and expressed a desire for input from **J. Winterle** on design of laboratory tests to resolve these discrepancies.

V. Tidwell et al., presented work related to visualizing and measuring diffusion of brines into matrix blocks using x-ray techniques. This work was originally intended for use at YM, but has found application at the WIPP site through the vagaries of funding. Diffusion coefficients are on the order of 10^{-6} to 10^{-5} cm^2/s, resulting in the penetration of brines 5 cm into the matrix in roughly 1 month. The matrix has permeability and porosity comparable to the TSw unit.

J. Whelan et al., discussed evidence, based on analysis of strontium isotopic ratios in secondary mineral deposits, for large-scale water table fluctuations at YM. In addition to the 100-m rise often discussed, Whelan suggests that the water table may have dropped as much as 300 m from the current elevation at least twice in the past. Whelan noted that waters sufficiently rich in carbonate to enable deposition must have made their way past zeolites undersaturated in carbonate, under drier conditions than present.

J. Wang et al., discussed ESF-based testing approaches and observations related to moisture, showing pictures of unsaturated damp spots found in the niches constructed to date (niches 1 and 2). Wang noted that the niche studies are designed to identify whether fractures will conduct water into the niche, by injecting dyed water from horizontal boreholes above the niche both before and after niche excavation. Two types of fracture flow were observed, localized and widely spread. Even though water was injected into the most permeable portions of the overlying horizontal boreholes, dye traces were not always observed in the niche. It was understood by the authors that dye traces were observed less frequently for tests subsequent to niche construction, implying that niche construction fostered lateral diversion. Photographs of dye profiles normal to the fracture plane seem to indicate limited imbibition of the fracture flow into rock matrix: dye penetration into matrix at the top of the niche, where exposure time would have been much longer, was not discernibly greater than near the termination point of the fracture flow.

The session titled *Trends in Numerical Simulation of Flow and Transport in Heterogeneous Subsurface Systems* featured several interesting presentations. **A. Guadagnini** discussed ongoing work in collaboration with **S. Neuman** regarding nonlocal simulation of conditional mean flow in randomly heterogeneous porous media, indicating that results are similar to Monte Carlo simulation when using the same grid, while computational effort might be reduced from that required for Monte Carlo simulation when using the coarser grid allowed by the relatively smooth solutions. **D. Oliver** discussed work using

kriging for finite-element weighting functions, rather than standard interpolators, claiming that this procedure provides improved capturing of subgrid variability. **T. Russell** and **R. Healy** presented work in mixed and eulerian-lagrangian localized adjoint finite volume methods, respectively, providing formulations that result in improved computational efficiency for these accurate, but expensive approaches. **E. Sudicky** discussed 2D and 3D simulation results of dense nonaqueous phase liquids (DNAPL) migration in fractured porous media, emphasizing the extreme importance of local grid refinement of the fractures near fracture intersections; too-coarse meshes can provide qualitatively different results (predominantly vertical flow as opposed to predominantly horizontal flow). **A. Tompson** presented 3 vignettes of hydrologic interpretations using extremely large grids (up to 35 million grid blocks) with complex permeability fields; interestingly, hydrologic interpretations appeared to be most sensitive to the low-permeability units rather than the high-permeability units.

The session entitled *Alternative Approaches for Modeling Unsaturated Flow and Transport in Fractured Rocks* had several pertinent presentations. **D. Chesnut** discussed the simple lognormal model for transport velocity distributions that was presented in detail in the 1994 Conference on High-Level Radioactive Waste Management. **K. Pruess** used imbibition characteristics to estimate the number of seeps per unit area, calculating a rough value of about 5 seeps per 100-m grid block. **S. Wheatcraft** discussed the state-space regimes that are chaotic for water flowing vertically down a rough surface, using a numerical Navier-Stokes simulator for the calculations. **W. Illman** discussed ongoing air-permeability characterization work at the Apache Leap Research Site, generally showing good matches with theory as long as borehole storage is accounted for, and further finding that permeability increases with scale from single-hole to cross-hole tests. While discussing her poster, **S. Levy** suggested that the Sundance Fault (which is not aligned north-south) appears to have uniquely large alteration and may exhibit much larger fluxes than other faults, perhaps due to the diffuse nature of the fault zone.

The set of three sessions titled *Nuclear Waste Disposal Issues: Hydrologic Field Testing and Site Evaluation* featured numerous presentations and posters relevant to YM and provided opportunity for informal interaction. In the first session, two posters examining potential fluxes into drifts at YM were presented, by **A. James** and **J. Birkholzer** (both with coauthors). Both posters presented studies that treated matrix as impermeable and fractures as a heterogeneous continuum, with correlation lengths of 0.2 or 2 m in the horizontal and 3 or 12 m in the vertical. The 2D study by A. James examined sensitivities from a drip borehole above the drift, simulating a planned field test. The 3D study by J. Birkholzer attempted to quantify the number and quantity of drips for TPA purposes. Interestingly, 2 of the 3 realizations indicated that dripping required at least 10 mm/yr of flux before dripping occurred, and dripping was more prevalent where fractures were less permeable and therefore unable to divert laterally around the drift. Other posters by **G. Zyvoloski** et al., (saturated zone transport at YM), **J. Czarnecki** et al. (first cut at using the 3D geologic model for saturated zone modeling), **B. Robinson** et al., (development of models for radionuclide transport at YM), and **G. Bodvarsson** et al. (development of the 3D UZ model at YM) all reprised for a general audience information previously **obtained. C. Fridrich** et al., presented a coupled flow and heat analysis of the large hydraulic gradient, eliminating a conceptual model incorporating deep flow and proposing additional boreholes to resolve significant differences posed by another pair of conceptual models. **D. Diodato** presented FracMan96 simulations of barometric forcings at YM.

The second session featured numerous interesting and relevant posters. **E. Weeks** et al., discussed matches and discrepancies between modeling and field observations for gas exchange processes in the Tiva Canyon and adjacent units, noting the good match to extremely high Tiva Canyon permeabilities

but physically-implausible large porosity values. **T. Kneafsey** and **K. Pruess** discussed laboratory observations of boiling processes in fractures, using an analog fluid with a boiling point of about 36 °C, in which all of the potential processes (e.g., fingering, channeling) were observed. **B. Marshall** et al., presented strontium isotope data from several YM boreholes, indicating that pore waters are in disequilibrium with perched waters. **T. Tokunaga** and **J. Wan** presented laboratory results of film flow on natural and artificial fracture surfaces, including TSw blocks. It was noted that the sorptivity of fracture coatings was 5 to 6 times larger than the TSw matrix, which would translate into transmissivities within the coatings about 3 orders of magnitude larger than the matrix. **I. Yang** discussed previously published stable isotope and carbon-14 data that he interprets as suggesting that significant infiltration is coming from Solitario Canyon.

The third session also featured several interesting presentations. **R. Beauheim** listed his opinions of correctable mistakes made by various high-level nuclear waste programs, emphasizing the neglect of hydraulic testing technology developed by the petroleum industry. **M. Peters** et al., provided an overview of the drift-scale heater test design. **Y. Tsang** et al., discussed the design of the single-heater test, provided some preliminary results, and implied that the dual-permeability approach may provide a better match to the experimental results. Presentations in this session by **J. Wang** et al., and **J. Whelan** et al., are discussed above.

Recruiting for the CNWRA's two open hydrogeologist positions was facilitated at the meeting by the AGU Jobs Center. The Jobs Center posted our position announcement on a bulletin board, and maintained copies of the announcement for distribution to interested personnel. This service was free of charge. As yet, it is unknown how much interest in the positions was generated by this recruiting tactic.

Part 2: FTAM Workshop

The FTAM Workshop was hosted at LBNL by **B. Bodvarsson** and **P. Witherspoon**. Most of the presentations given at the workshop were taken directly from the *Nuclear Waste Disposal Issues: Hydrologic Field Testing and Site Evaluation* session of the AGU meeting, however several additional presentations were given.

J. Wang, J. Birkholzer, and **A. James** gave successive presentations on the topic of predicting seepage into drifts. **J. Wang** expressed the goal of developing a zero-threshold concept for drift seepage: that is, a rate of infiltration reaching the drift, below which, zero seepage will occur in the drift. **S. Blair** discussed the prediction of changes in rock permeability due to thermal-mechanical effects. **T. Tokunaga** presented an interesting talk on the need to consider fracture surface properties in fracture flow models: imbibition experiments using a dye tracer showed preferential flow along microfractures near fracture surfaces. This work suggests that unsaturated fracture flow does not occur entirely within fractures, but rather, much, if not most, of fracture flow occurs in fracture surface zones that extend up to several millimeters into the matrix. **G. Bussod** presented results of 2D and 3D unsaturated zone flow and transport models of YM, In this work, the chemistry of pore waters and perched waters was used to place bounds on the response of the hydrologic system to past and present climate scenarios. **C. Yang** discussed how the isotopic composition of groundwater can be used to infer origins of water, flow paths and velocities, and transport properties of water-rock interaction. **B. Marshall** used strontium isotope data to conclude that fracture water and pore water are mixed in the Ptn prior to infiltrating into the TSw.

The December 16th afternoon session on YM modeling was not attended by either of the authors due to travel schedules. However, summaries of the presentations given during this session are included in the workshop proceedings, available from J. Winterle.

PROBLEMS ENCOUNTERED:

None

PENDING ACTIONS:

None

RECOMMENDATIONS:

The AGU Fall and Spring meetings are the leading national meetings for hydrology research and provide a high-quality forum to present the results of CNWRA research for informal peer review. Discussions with meeting participants consistently have resulted in useful insights into CNWRA research topics, updates on the latest developments in leading-edge research, and areas of potential collaboration. AGU meetings provide a remarkably objective forum to discuss scientific issues surrounding the proposed repository at YM. AGU meetings also provide an excellent opportunity to inform attendees of what the CNWRA does, significantly enhancing the CNWRA reputation as a research institution. Future participation in AGU meetings is strongly recommended.

REFERENCES:

None

SIGNATURES:

E.C. Pearcy for SAS — 1/6/98

Stuart A. Stothoff
Senior Research Scientist — Date

12/30/97

James Winterle
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David K. Leung for E.C. Pearcy — 12/31/97

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1/6/98

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