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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Chapman Conference on Aqueous Phase and Multiphase Transport in Fractured Rock
20-5704-023

DATE/PLACE: September 12–15, 1994
Burlington, Vermont

AUTHOR(S): R.T. Green

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PERSONS PRESENT:

R.T. Green (CNWRA). A total of about 80 participants from various academic, government or research organizations.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of the conference was to bring together theoretical and experimental scientists from a variety of disciplines related to the study of transport in fractured rock. The objective of the conference was to review the state of knowledge and to identify significant knowledge gaps. The timing of the conference comes at a critical point in the Thermohydrology Research Project. The final analyses in the research project are nearing completion, and presentation of the findings of the project to knowledgeable peers provided a good opportunity to scrutinize the findings of the Thermohydrology Project and to ascertain if other recent developments on topics relating to transport through fractured rock may have relevance to the Thermohydrology Project.

SUMMARY OF PERTINENT POINTS:

C. Barton presented an invited paper on the role of fracture geometry on flow and transport in fractured rock. C. Barton stressed the difficulty of characterizing fractures in physical settings as compared to synthetic or artificial representations. He relies on fractals as a characterization or analytical measure of existing fracture systems.

L. Pyrak-Nolte presented a paper on relationships among fractures. Woods metal injected into rock cores was analyzed to provide insight into the interconnectivity of fractures.

I. Neretnieks presented an invited paper on general observations based on past studies of fracture flow and transport at several different sites in Sweden. Work at Stripa was concluded two years ago. Work has been initiated at a new site, Äsprö, which has been excavated and an integrated set of flow and transport tests have been planned and are underway. All sites of study in the Swedish projects are in

saturated fractured media. Tracer injection studies have been conducted in which the tracers were injected into the subsurface via boreholes. The amount of tracer that has been accounted for as compared to predicted values is low. The effects of matrix tracer imbibition, referred to as matrix diffusion, are incorporated into the models.

B. Andei presented an analytical model of fracture flow for different levels of contact between fracture surfaces; greater contact causes a greater degree of channel flow from which an apparent dispersion can be determined. The effects of turbulent channel flow have been investigated. Turbulence appears to retard transport of a solute. Continuous functions (e.g., Fourier transforms) were used to formulate the analytical solutions.

J. Houseworth presented a paper on a higher-order model for shear dispersion in a saturated fracture/matrix model. The analytical solution started with an asymptotic limit for late times which was then worked backward toward earlier times. They were able to approximate earlier times by incorporating higher-order terms in the analytical solution. The solution was applied to high velocity fluids through a fracture located in a matrix with low velocity fluids.

M. Bai presented a paper on concepts related to linear and nonlinear dual porosity models for flow and transport to be used to inspect matrix diffusion/replenishment. This talk was a philosophical and conceptual talk.

T. Vandergraaf presented a paper on laboratory experiments designed to investigate radionuclide migration in natural fractures. In these studies, they have recognized and addressed the difficulty of conducting laboratory-scale retardation/sorption experiments at the Canadian Underground Laboratory A one m^3 block has been used to study retardation in a fracture (granite) extracted from a surface quarry. The block is fully-saturated and the block surface has been coated with silicon to retain moisture. A single fracture dipole flow test has been conducted to monitor the migration of a host of radionuclides: ^{85}Sr, ^{95}Tc, ^{131}I, ^{137}Cs, ^{152}Eu, ^{237}Np, ^{238}Pu, and ^{241}Am. Migration was monitored using gamma and alpha counts taken in a series of boreholes placed in the block. After the flow test, the block was opened and the fracture surface was inspected. ^{237}Np and ^{238}Pu did not move. Insufficient information was available to predict elution profiles.

T. Doe presented a paper on the use of FRACMAN in the simulation of transport through discrete fracture networks. A random walk procedure is used to account for matrix diffusion. Additional features of FRACMAN were presented and discussed.

B. Kueper presented a paper on laboratory-scale fracture flow experiments. The experiments investigated two-phase flow. A capillary barrier was place at the end of the fracture to measure flow under suction. The tests were conducted under a range of different normal loads. The hydraulic characteristics of the fracture were best fit with a Brooks-Corey relationship, which is typically appropriate for media with a distinct air-entry value. The hydraulic fracture measurements did not provide a good estimate for air-entry values. They also made direct relative permeability measurements for a single fracture using a DNAPL as the permeant.

C. Mendoza presented a paper on the use of fractal analysis to discern processes within a single fracture. A Monte Carlo approach was used to generate a distribution of fractures.

M. Nicholl presented a paper on gravity-driven flow in air/water filled fractures. A laboratory experiment was conducted with R. Glass in which a synthetic fracture was constructed with roughened glass. Flow was observed in the fracture surface oriented at different inclinations. A confirmation experiment was conducted on a real fracture in Bandolier Tuff. After seven minutes of flow, the fracture surfaces were opened and the distribution of observed solute was similar to that observed with the synthetic fractures.

J. Long presented a paper on analyzing flow and transport in fractured rock and the difficulties resulting from improper conceptual models. Long contends that responses from tests (i.e., field scale) cannot be readily scaled up. Long did not have a solution to provide a prediction for large scale applications.

W. Lanyon presented a paper on advective transport in fractured media using discrete fracture network models. Lanyon used a code called NAPSAC which has capabilities similar to FRACMAN. An example model with 10,000 fractures was presented. Property assignments were log-normally distributed. Lanyon was also able to conduct simulations with effective property assignments.

C. Wels presented a paper on the proportional relationship between retardation and surface area. Surface area was found to be a function of fracture orientation. This suggests that retardation is a second rank tensor. No functional relationship between orientation and retardation has yet been identified.

B. Parney presented a paper on a statistical continuum model currently under development. The model will incorporate fracture networks and channeling. The model theory will be extended to incorporate nonorthogonal fractures.

SUMMARY OF ACTIVITIES:

The author attended the presentations and participated in formal and informal discussions. A description of the proposed percolation test for the Peña Blanca Natural Analog Site was provided to I. Neretienks during an informal discussion. Neretienks has completed several similar percolation tests at saturated sites in Sweden.

IMPRESSION/CONCLUSIONS:

The informal nature of the conference successfully encouraged open and relevant discussions concerning transport through fractured rock.

PROBLEMS ENCOUNTERED:

A family medical emergency required the author to leave the conference on Tuesday, September 13 prior to presentation of "Characterization of Fluid Flow Regimes in Heated Partially-saturated Porous Media" by F.T. Dodge and R.T. Green.

PENDING ACTIONS:

Proceedings from the conference will be published in AGU's Geophysical Research Letters. A paper containing the subject matter that would have been presented at the conference, "Characterization of Fluid Flow Regimes in Heated Partially-saturated Porous Media", will be submitted for inclusion in the peer-reviewed proceedings.

RECOMMENDATIONS:

The subject matter of this Chapman Conference was highly relevant to technical issues associated with the Yucca Mountain project. Discussions during the sessions and informal discussions at other times were extremely useful. Participation of CNWRA/NRC staff at technical conferences of this nature is highly recommended.

SIGNATURES:

Ronald T. Green
Senior Research Scientist

11/1/94
Date

CONCURRENCE SIGNATURES AND DATE:

Robert Baca - Manager
Performance Assessment &
Hydrologic Transport

11/16/94
Date

Budhi Sagar
Technical Director

11/29/94
Date

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