CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Trip to the University of Manitoba (20.01402.861.042)

DATE/PLACE: October 1–5, 2001
Winnipeg, Canada

AUTHOR: Ronald T. Green

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PERSONS PRESENT: Ronald T. Green

BACKGROUND AND PURPOSE OF TRIP:

Present an invited paper titled "Heat and Mass Transfer in Porous Media" to the Geotechnical Research Group at the University of Manitoba.

SUMMARY OF PERTINENT POINTS AND ACTIVITIES:

I spent four days at the University of Manitoba in Winnipeg, Manitoba, Canada (October 1–3, 5, 2001) and one day touring the Atomic Energy of Canada Limited Underground Rock Laboratory in Pinawa Manitoba, Canada (October 4, 2001) which is located about two hours from the University of Manitoba. Time spent at the University of Manitoba was with faculty and students in their Geotechnical Research Group. The visit was arranged by and at the invitation of Dr. A. Woodbury, a professor in the Civil Engineering Department. Dr. Woodbury is collaborating the with CNWRA on Bayesian inversion techniques applied to a nonisothermal saturated groundwater flow model being developed for the Unsaturated and Saturated Flow Under Isothermal Conditions Key Technical Issue.

I gave an invited seminar titled "Heat and Mass Transfer through Unsaturated Media" to the Geotechnical Research Group at the University of Manitoba. Results of modeling heat and mass transfer through fractured porous media at the Exploratory Studies Facility Drift-Scale Heater Tests were presented at the seminar. Numerical modeling for this work was performed using the CNWRA-developed code MULTIFLO. The Geotechnical Research Group is aware of the multi-phase capabilities of MULTIFLO and has interest in using the code for other applications.

Additional time at the University of Manitoba was spent continuing development of the site-scale, nonisothermal saturated-zone flow model of Yucca Mountain and the full Bayesian inversion of the forward model. The saturated-zone flow model will employ both hydraulic head and temperature data to help constrain the physical problem. Of particular interest is the hydraulic connection between the underlying Paleozoic carbonate aquifer and the surficial alluvial/volcanic aquifer. Insufficient information is available to constrain the problem using only hydraulic head data.

A. Woodbury has made good progress evaluating the use of Latin Hypercube Sampling to expedite Monte Carlo sampling in the Bayesian inversion process. MULTIFLO is used to generate forward solutions. Key output from each MULTIFLO run is compared with known data. The input files are conditioned and MULTIFLO is rerun. The process is continued until the objective function criteria are met. We explored the possibility of sampling early MULTIFLO run output to determine whether the conditioned input data improve the solution. For cases in which a less desirable solution is attained, the MULTIFLO runs could be aborted, thereby reducing the computational effort.

Four data types will be used to effect the inversion: hydraulic head data, temperature measurements, and two hyperparameters, the variance of the hydraulic head and temperature data. The current number of layers (three) in the heat and mass transfer model may need to be increased to take full advantage of borehole temperature data from the Nye County Early Warning Drilling program.

A one-day trip was arranged to visit the Atomic Energy of Canada Limited Underground Rock Laboratory. Prior to the tour, I was given a one hour presentation of the Underground Rock Laboratory by G. Kusiak, chief-of-operations at the Underground Rock Laboratory. E. Kosak, head hydrogeologist, also attended the presentation and offered additional insight and detail. The history of the Underground Rock Laboratory, major investigative initiatives, programmatic background, and technological advances were discussed during the presentation. I provided relevant observations of the United States high-level waste program to E. Kozak and G. Kusiak.

The Underground Rock Laboratory is basically a single shaft facility with two major levels of activity, one at the 240-m [787.40-ft] level and one at the 420-m [1,377.95-ft] level. Development of the 240-m [787.40-ft] level was mostly funded by the Atomic Energy of Canada Limited. The DOE provided funding of the 420-m [1,377.95-ft] level in the early 1980s, at which time granite was being investigated by the United States program as a possible geologic high-level waste repository host medium. DOE discontinued most participation in the Underground Rock Laboratory at the time they abandoned interest in granite as a potential repository host medium. There is still some involvement by the DOE at the Underground Rock Laboratory. D. Onagi, an Underground Rock Laboratory engineer, has a joint project with J. Wang and T. Kneafsley of Lawrence Berkeley National Laboratory. Other collaborators with experiments at the Underground Rock Laboratory include the Japanese high-level waste program.

I was given a tour of both the 240-m [787.40-ft] and 420-m [1,377.95-ft] levels by Kozak and Kusiak. All major *in situ* experiments addressing hydrological-geochemical-mechanical-thermal couplings were visited during the tour. There are three major fault zones identified in the granite at the Underground Rock Laboratory. There is no fault zone identified in the 420-m [1,377.95-ft] level of the facility.

The Atomic Energy of Canada Limited is investigating two waste emplacement orientations, vertical emplacement in vertical boreholes placed in the floors of drifts and horizontal emplacement in larger chambers. A sand/bentonite mixture is planned as buffer material for both emplacement schemes. The host medium is to be granite and the repository is to be placed below the water table in a reducing chemical environment. High-level waste bundles from the CANDU reactors are about 0.50 m [1.64 ft] long and about 0.12 m [.39 ft] in diameter. There are to be 72 bundles contained in each titanium canister.

E. Kozak, G. Kusiak, and I were joined by D. Onagi after the tour for additional discussion of the Underground Rock Laboratory and comparisons between the Canadian and United States high-level waste geologic disposal programs. The Canadian government has diminished activities in their high-level waste program relative to earlier levels. Activity in the high-level waste program was reduced in 1998, with most programmatic decisions indefinitely deferred. This action was in response to comments of the Environmental Impact Statement of the Underground Rock Laboratory provided by a review panel that the Environmental Impact Statement did not adequately address the potential social impact of the proposed repository. The review panel did not identify technical problems with the Environmental Impact Statement.

CONCLUSIONS:

The visit with Dr. Woodbury and the Geotechnical Research Group at the University of Manitoba provided an excellent opportunity to develop the saturated-zone, nonisothermal groundwater flow model for Yucca Mountain and to discuss other related multi-phase and coupled-process hydrogeological problems. The visit provided an excellent opportunity to review the current approaches and to gain fresh perspectives on the remaining challenges to our modeling tasks.

PROBLEMS ENCOUNTERED: None

PENDING ACTIONS:

Continue development of the saturated zone, nonisothermal groundwater flow model for Yucca Mountain.

RECOMMENDATIONS:

Dr. Woodbury expressed an interest to have Dr. S. Painter also visit the University of Manitoba at some future date. I strongly recommend that Dr. Painter take advantage of visiting their Geotechnical Research Group.

SIGNATURES:

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10/26/01
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