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Albuquerque, New Mexico 87185

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July 12, 1985

Dr. M. S. Nataraja
Engineering Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Dr. Nataraja:

The enclosed monthly report summarizes the activities during the month of June for FIN A-1755.

If you have any questions, please feel free to contact either myself at FTS 844-8368 or E. J. Bonano at FTS 844-5303.

Sincerely,

R. M. Cranwell

R. M. Cranwell
Supervisor
Waste Management Systems
Division 6431

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PROGRAM: Coupled Thermal-Hydrological-Mechanical Assessments and Site Characterization Activities for Geologic Repositories

FIN#: A-1755

CONTRACTOR: Sandia National Laboratories

BUDGET PERIOD 10/84-9/85

DRA PROGRAM MANAGER: M. S. Nataraja

BUDGET AMOUNT: 365K

CONTRACT PROGRAM MANAGER: R. M. Cranwell

FTS PHONE: 844-8368

PRINCIPAL INVESTIGATOR: E. J. Bonano

FTS PHONE: 844-5303

PROJECT OBJECTIVES

To provide technical assistance to NRC in the assessment of coupled thermal-hydrological-mechanical phenomena and site characterization activities for high-level waste repositories.

ACTIVITIES DURING JUNE 1984

Activities and Accomplishments

The primary activities during the month of June were the SNLA review of the BORHOL Document (ONWI-547) and attendance at the 26th U.S. Symposium on Rock Mechanics in Rapid City, South Dakota. A review of NRC's Generic Technical Position on In-Situ Testing was also performed.

Review comments on the BORHOL Document are attached with this report. A trip report on the Rock Mechanics Symposium will be forwarded by the end of July.

Travel

K. Wahi attended the 26th U.S. Symposium on Rock Mechanics in Rapid City, SD from June 25-29.

Problems Encountered

None.

June, 1985

SNLA REVIEW OF ONWI-547

The following are general and specific comments based on SNLA's review of ONWI-547, "BORHOL: A Computer Code to Evaluate Dissolution, Precipitation, Creep, and Temperature Effects in Boreholes in Salt."

The BORHOL Code has been developed under the SCEPTER Program as part of a performance assessment package for repositories in salt. The code simulates the flow response in a vertical borehole that passes through salt units. Processes of salt dissolution, precipitation, creep deformation and heat transfer are taken into consideration in calculating time- and position- dependent borehole radius and flow. The flow rate and amount of dissolution can be related to repository performance.

A one-dimensional implicit finite-difference formulation is used to calculate density and temperature from transient non-linear partial differential equations. The utility of the solution does not seem to justify the complexity of the model or the number of parameters and assumptions. Since only vertical flow is modeled, the effects on the repository can only be estimated indirectly with additional simplifying assumptions. By comparison, the DNET code (Ref. 1) permits horizontal and vertical flow legs such that ambient as well as modified flow through the repository can be calculated.

The size of a borehole in salt is controlled primarily by: (1) flow volume, (2) dissolution rate, and (3) creep. All three processes are represented with gross approximations in BORHOL. The major component of the flow at any location in the borehole is the boundary (induced) flow rate, which in BORHOL is an input parameter. The equation for the dissolution rate is empirical and includes user input parameters. These parameters are not precise because they are empirical constants. To obtain a better agreement the initial input value was changed during code validation. The creep closure is governed by a steady-state formulation in which the driving force is the stress deviator. The deviatoric stress is highly approximate and does not consider the thermal stress.

Some important limitations are as follows:

- Flow is evaluated in terms of a fixed potentiometric head difference and a single resistance parameter for each aquifer. Thus, the effects of changing borehole properties on the pressure distribution in the transmitting and receiving aquifers are ignored.

- Mass and energy transport transverse to the vertical flow are highly approximate due to the one-dimensionality of the model and assumptions of instant mixing and heat dissipation to fluid from the rock.

- Temperature-dependence of thermal conductivity of salt cannot be considered; only a constant thermal conductivity is allowed.

- Multiple-borehole scenarios (e.g., a U-tube) cannot be analyzed. It is significant to note that the U-tube scenario is one of the few scenarios that results in any appreciable consequence with respect to radionuclide releases.

- Thermoelastic deformation of the borehole is neglected. At early times, elastic strains are comparable to creep strains.

Specific Comments

- On p.11, the units (dimensions) of Q_M' are given as $[M/L^3\ t]$. The correct units, to be consistent with other terms in Equations (2-6) and (2-7), are [M/Lt].

- On p.11, the units (dimensions) of Q_H' are given as $[M/Lt^3]$. The correct units, to be consistent with other terms in Equations (2-8) and (2-9) are $[ML/t^3]$.

- The stress deviator term, $\Delta\sigma$, in Equation (2-38) on p.19 is merely the difference between the lithostatic stress and the borehole pressure. A more appropriate stress deviator term would be one that includes the thermal stress, even if one assumes Equations (2-38) to be a valid representation of the borehole creep.

- On p. 19 reference to Equation (2-51) appears out of context, unless the equation is in the Chabannes (1981) reference document.

- On p.20, an analytical solution for temperature is given for a finite rectangular heat source. The solution is obtained by "examination"; no reference is provided that could be used to determine the basis or authenticity of this solution. To the best of our knowledge, an analytical solution to the problem of a finite, rectangular heat-source does not exist. However, the comparisons with HEATING-5 shown on p.43 (Table 4-2)and p.44 (Figure 4-3) suggest that the temperature response in BORHOL is reasonable.

- The convergence criteria on p.33, Equations (3-15) thru (3-17), appear to be mis-stated. For example,

  $| \rho_i^{m+1}/\rho_i^{m} | \leq c$ should be

  $| \rho_i^{m+1}/\rho_i^{m} -1 | \leq c$

- On p. 43 in Table 4-2, "Radial Displacement" should read: "Radial Distance".

- The heading notations of the output (pp. 94-101) are not defined. Moreover, the output list does not include all the variables that have been identified as output in the User's Manual. In particular, the manual claims (on p. 87) that at every time-step the potentiometric flow rate and the total flow rate (TOT F-RAT) are given; the output given on pp. 94-101 does not include these two important results.

- On page 103 it is stated that a microfiche Fortran code listing is enclosed. No such listing accompanied the document.

In conclusion, the BORHOL Code can predict approximate response due to the effects of dissolution, precipitation, salt creep and temperature change on a borehole through a bedded salt formation. In the application of this model the physical presence of the repository, aside from the temperature increase due to the thermal output, has no effect on the flow response of the borehole and vice-versa.

The careful use of the mass and energy conservation are somewhat of an overkill, given the imprecision of the rest of the model. Just as good or perhaps better results could be obtained by adding salt dissolution and creep models to an existing flow code.

References:

1. Cranwell, R. M., J. C. Campbell, and S. E. Stuckwisch, 1982. Risk Methodology for Geologic Disposal of Radioactive Waste: The DNET Computer Code User's Manual, NUREG/CR-2343 or SAND81-1663, Sandia National Laboratories, Albuquerque, NM.

A-1755
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June 1985

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year-to-Date
I.	Direct Manpower (man-months of charged effort)	0.7	6.0
II.	Direct Loaded Labor Costs	7.0	60.0
	Materials and Services	0.0	1.0
	ADP Support (computer)	0.0	2.0
	Subcontracts	38.0	202.0
	Travel	0.0	1.0
	Other	0.0	-1.0
	TOTAL COSTS	45.0	265.0

Other = rounding approximation by computer

III. Funding Status

Prior FY Carryover	FY85 Projected Funding Level	FY85 Funds Received to Date	FY85 Funding Balance Needed
115K	365K	250K	None