Sandia National Laboratories
Albuquerque, New Mexico 87185

March 11, 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 February 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
Supervisor
Waste Management Systems
Division 6431

RMC:6431:jm

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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

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PRINCIPAL INVESTIGATOR: E. J. Bonano

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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 FEBRUARY 1984

Activities and Accomplishments

The main activities during February consisted of attending a short course on rock mechanics in St. Louis, Missouri, a workshop on coupled thermal, hydrological, mechanical, and chemical interactions, and a technical review meeting of the NRC high-level waste research programs at Lawrence Berkeley Laboratory in Berkeley, California. A small effort was also devoted to the reviews of the draft EA's. Trip reports for the travel activities during the month are attached.

Travel

Krishan Wahi attended a rock mechanics course in St. Louis, Missouri, the workshop on coupled thermal, hydrological, mechanical, and chemical interactions, and the technical review meeting on NRC's high-level waste research programs in Berkeley, California.

Problems Encountered

None.

A-1755
1628.010
February 1985

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

	Month	Current Year-to-Date
I. Direct Manpower (man-months of charged effort)	0.5	3.8
II. Direct Loaded Labor Costs	4.0	36.0
Materials and Services	0.0	0.0
ADP Support (computer)	0.0	1.0
Subcontracts	24.0	89.0
Travel	1.0	1.0
Other	0.0	0.0
TOTAL COSTS	29.0	127.0

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

TRIP REPORT: SHORT COURSE ON ROCK MECHANICS

Based on NRC's letter dated October 31, 1984, SNLA instructed K. Wahi to participate in a short course titled "Rock Mechanics for Engineering - Theory and Practice" held in St. Louis, Missouri during February 11-15, 1985. The following is a summary description of the material presented in that course. In addition, the applicability of the concepts and case histories in the course to the technical problems of underground disposal of nuclear waste is discussed.

The course was designed to provide the theoretical basis of rock mechanics and its application to practical problems in civil, mining and geotechnical engineering. The course instructors were Dr. Evert Hoek and Dr. Dougal McCreath, both of Golder Associates. A comprehensive set of notes was provided which also contained copies of several relevant technical papers.

On Monday (February 11), the topics included triaxial testing of intact rock, shear testing of discontinuities, surface roughness, interlocking and dilation, strength of jointed rock masses, non-linear failure criteria for jointed rock masses, and estimation of rock mass strength using rock mass classifications. These strength properties are relevant to mine design and operation of a repository. It is expected that DOE will furnish strength data for the host rock as part of its overall supporting data package. Although the effect of temperature on rock strength was not addressed in this course, the general trend is a degradation of strength at elevated temperatures. Use has been made of the rock-mass classification systems in the basalt draft EA document.

Application of structural geology to rock mechanics was discussed on Tuesday. The use of spherical projections for the presentation and analysis of geologic data, and for the analysis of structural instability problems in slopes, foundations, and excavations was illustrated and discussed in detail. Also discussed on Tuesday were sub-surface groundwater problems and design of drainage systems for groundwater control. Several examples of actual projects were given. This is highly relevant to repository design where one of the objectives is to minimize contact between waste packages and ground water, especially during the operational (or retrievability) period.

On Wednesday morning, stress measurement techniques were described and their theoretical bases noted. Measurement of in-situ stress by hydrofracturing and overcoring were discussed. It was pointed out that hydrofracturing was the only technique that allowed in-situ stress measurement from surface; all other techniques require underground access. However, two significant problems with hydrofracturing are determining the direction of the fracture and establishing

which of the fractures responded to the hydraulic pressurization. Several different devices - USBM deformation gauge, "doorstopper" strain gauge, photoelastic cell, and CSIR triaxial cell - were briefly described that are utilized with the overcoring technique. In all these devices, the properties of the glue for affixing the gauge are very important. Dr. Hoek remarked that measurements from all over the world show a tendency for high horizontal stresses at shallow depth. This could be significant when boundary stress assumptions are made in the numerical analyses. He also said that overcoring measurements are relatively expensive (~$5000 per measurement) and have a practical limitation on depth of roughly 200 ft. Photoelasticity, closed form solutions, and numerical techniques were all discussed in some detail as they apply to stress analysis. Before numerical techniques became so popular and economically feasible, many of the stress analyses relied on experimental techniques such as photoelasticity. Using circularly polarized light, contours of principal stress difference ($\sigma_1-\sigma_3$) can be obtained in a photoelastic material such as glass or plastics. Contours of stress sum ($\sigma_1+\sigma_3$) can be obtained with electrical analogs. A combination of centrifuge and photoelastic models has also been used in the past for stress analysis. Reference was made to a recent paper by Lorig and Brady (1984) that describes an application of the coupled boundary element and block model in generating support interaction curves. The technique should be applicable to other analyses involving underground excavations. The factors that influence the magnitude of induced stresses around an opening are: in-situ stress, cavity shape and orientation, proximity to other cavities, and geological features (bedding planes, joints etc.). Two numerical codes that were recommended for mine and pillar safety calculations are MINSIM and NFOLD.

The afternoon lectures on Wednesday were on the topics of failure around a circular tunnel, influence of discontinuities on stress and failure, rock-support interaction analysis, and an illustrated review of types of support used in civil and mining tunnels. A paper by Brown et al. (ASCE J. Geotech. Eng., v. 109, no. 1, January, 1983, pp. 15-39) that contains ground response curves for rock tunnels was recommended for reading. A number of "rules of thumb" were provided that can be useful in design, analysis, or construction. When using the Hoek-Brown Criterion, plasticity will occur if $p_o \geq 1/2\ \sqrt{s}\ \sigma_c$ in the absence of support, where: s is a material constant and σ_c the compressive strength. For a failed rock mass, Hoek recommends dropping down the classification by one category compared to the unfailed case. The adequacy of steel sets as tunnel support depends on how well the blocks are placed. For analysis purposes, shotcrete can be modeled as a ring of concrete; ungrouted bolts are relatively easy to model but grouted ones are not.

On Thursday morning, basic equations for rock stability problems were developed. Slope stability analyses for various conditions such as tension cracks, water seepage etc., were formulated. Reference was made to a paper by Sarma (ASCE J. Geotech. Engg., vol 105, no. GT 12, 1979, pp. 1511-1523) that uses the limit equilibrium approach for stability analysis of embankments and slopes. The method developed by Sarma allows for the possibility of shear failures inside the sliding mass and is, therefore, suitable for back analysis of strength parameters from actual slip.

Thursday afternoon, the discussions centered on differences between factor of safety and probability of failure. Advantages and limitations of each technique in rock slopes and underground excavations were mentioned. When using the probabilistic approach it is instructive to know that friction angle, dip and dip angle, compressive strength, and rock mass rating typically have a normal distribution. Cohesion generally has a log-normal distribution and fracture-length has an exponential distribution. Hoek showed the example of a hydro project in Quebec where he used the probability approach in calculating a "factor of safety." Qualitatively, a higher factor of safety can be viewed as lowering the probability of failure. Monte Carlo techniques can be applied to compute, for instance, what fraction of a number of slopes would have a factor of safety less than one. The role of physical models in geomechanics was discussed briefly. Scaled models, centrifuge techniques, photoelasticity, and electrical analogs were mentioned. In designing underground structures the investment per cubic yard of material should be a big factor. Based on his experience, Hoek feels that cavern design should be very conservative. The advice is, "get it right the first time; save your money on the tunnel." A rule of thumb for support in a jointed rock mass is that the rock bolt spacing should be less than three times the joint spacing, and the bolt length should be roughly 1/3 of the cavern span.

Excavation techniques were described in the Friday morning presentations. Drill and blast versus tunneling machines were compared. Cost of bench blasting is significantly lower than tunneling. However, in sequential blasting, the accuracy of detonation-timing is a problem area. Inclined holes are suggested as one way of controlling breakage. Some details were provided on the design of burn cuts. Pre-splitting was recommended for near surface blasting and post-splitting (i.e., smooth blasting) for underground. Case histories where salt dissolution resulted in or contributed to disaster were mentioned. Several years ago, a mill was lost in South Africa as a result of salt dissolution. More recently, dissolution

was a contributing factor in a mine in Sasketchewan. Events such as these are important for NRC and DOE in postulating potentially adverse scenarios and estimating their probabilities.

Friday afternoon, case histories of tunnel and cavern design from a variety of projects around the world were presented in the form of slides and commentary. Most of the material presented in this short course has direct applications to performing or assessing analyses of design and rock mechanics aspects of underground repositories.

ROCK MECHANICS FOR ENGINEERING - THEORY AND PRACTICE

2/11 thru 2/15 (1985)

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Trip Report

(Lawrence Berkeley Laboratory, Berkeley, California)

The following is a trip report based on Krishan Wahi's attendance at two meetings in Berkeley, California. The first meeting was a workshop on coupled thermal, hydrological, mechanical, and chemical interactions in high-level waste repositories, held on February 25 and 26, 1985. The second meeting, on February 27 and 28, was for a technical review of the NRC-funded high-level waste research programs. Both meetings were held at the Lawrence Berkeley Laboratory (LBL) in Berkeley.

The workshop commenced at 1 p.m. on February 25 with introductory remarks by John Randall (NRC). C. F. Tsang (LBL) made the first presentation on "Investigation of Coupled Thermal, Hydrological, Mechanical, and Chemical (THMC) Phenomena in HLW Repositories," FIN B-3046. After a brief statement on the first panel report on coupled THMC processes associated with a nuclear waste repository (LBL-18250, July 1984), the speaker summarized the main points of the second panel meeting that took place in January 85. Apparently, the panel feels that the bottleneck to a repository design is the chemical containment problem and not the mechanical design. Other points, as paraphrased by Tsang, are that: the maximum temperature around the canister could be limited to below 100°C so that many of the poorly understood phenomena could be eliminated; the key parameters are temperature gradient, groundwater (g.w.) flux, and chemical environment; the backfill should be designed to permit minimum g.w. flux, maximum attenuation, and high stability; evaporation/condensation will change composition of fluid near backfill with unpredictable results; assumption of low corrosion potential for copper might be erroneous if evaporation occurs; vapor transport is poorly understood; analog studies (e.g., petroleum engineering, geothermal, hard dry rock literature) can be very useful; possible relationships between porosity and permeability need investigation; hydrochemical modeling needs to include boiling; not enough geochemical input is being provided to site characterization studies and activities; need to perform worst case studies, sensitivity studies, and establish limits; the consensus of the panel is that we will learn as we develop the repository and that site characterization is never complete; during repository development an emphasis should be on sealing the worst fractures, the design should be flexible enough to permit a change of direction, and there should be a willingness to abandon a site if necessary; and finally, field tests should be conducted to assist the site characterization efforts.

E. Bonano (SNLA) described the development of Sandia's methodology for repository performance assessment under FIN A-1266. In addition to the methodology for repository project (FIN A-1266) funded by the NRC research branch, he indicated how two of the NMSS-funded projects (FIN A-1755 and A-1766) provide a valuable feedback to the research project. Brief descriptions of SWIFT II, NWFT/DVM and DNET were given. Demonstrations of the Sandia methodology for candidate media have been (or will be) performed using these codes. The geochemical sensitivity project (FIN A-1756) is supposed to analyze the potential influence of geochemical parameters on repository performance. The parameters considered are: sorption, solubility, speciation, substrate mineralogy, g.w. chemistry, colloid formation, presence of organics and reaction kinetics. The results of an analysis on transport and capture of colloidal particles in single fractures were shown. Two main conclusions were that capture rate was dependent on particle size and that fluid velocity had a negligible effect on capture rate.

Next, H. Wollenberg (LBL) briefly described the site geochemistry work being performed under FIN B-3040. Preliminary indications of a near-field hydrothermal rock-water interactions study are that solubilities do not change significantly with temperature if a reducing environment is maintained.

Valence effects on sorption were discussed by R. Meyer (ORNL) based on the work performed under FIN B-0462. The objective of this research is to assess methods of valence control used now or proposed for use in the future. The experiments to measure sorption and desorption ratios (R_d) focused on Np and Tc. Effective R_d of Np is 10 - 20 greater under reducing conditions. Sorption was found to depend strongly on pH. The solution isotherms were linear until reaching capacity.

F. Kulacki (U. of Delaware) presented a talk on heat transfer experiments designed to provide an understanding of the very-near field and near-field thermohydraulic phenomena and to provide a data base for validation of numerical models. The laboratory experiments are, in a sense, scaled repository models. A cylindrical heat source which simulates a canister is surrounded by small glass beads packed in an annulus between the source and a larger cylinder. In another experiment, a tank has strips of heat sources at the bottom which can be selectively activated. The tank is to be filled with either glass beads to represent a semi-porous medium or with blocks with small balls between them to simulate fractured media. The tank experiments are scaled representations of the near field.

The last presentation on February 25 was made by M. Seitz (ANL) on backfill modification experiments performed under FIN A-2239. The goal was to determine the capability of the backfill material to retard flow and transport. Experiments were carried out to measure permeability at elevated temperatures, swelling behavior at room temperature, radiolysis of repository air at elevated temperatures and of saturated backfill at 90°C. Elevated temperatures up to 260°C by themselves (i.e., without vapor formation) did not change substantially the permeability of the backfill material. For the vapor-contacted case, the clays lose their swelling capacity and a large change in permeability (from ~10^{-10} to ~10^{-13}) occurs. The mineralogic composition, however, did not change with exposure to steam. Radiolysis of backfill and water resulted in an increased permeability. An integrated dose of 10^8 rads (10^5 rads/hr over 40 days) was used. High swelling clay converted to low swelling clay with the mineralogy changing from dioctahederal to trioctahederal. An increase was seen in Mg and Ca in bentonite with a decrease in Na. These results "integrate with the metal corrosion and leaching studies" funded by the NRC.

Tuesday morning (February 26), the session consisted of five presentations. The talk on long-term performance of waste packages was presented by S. Nicolosi of Battelle Columbus Laboratories (BCL). The work is being funded under FIN B-6764. The objectives are to understand and quantify containment degradation processes by means of corrosion experiments and modeling, and by integral (coupled?) experiments. In addition, release rates after waste-package breaching will be characterized by experimental studies on the effects and degradation of remaining containment surfaces and on the waste-form degradation and solubility of HLW glass and spent fuel.

Laboratory analog of leaching and migration was discussed next by M. Seitz (ANL), FIN A-2230. A series of experiments was conducted to reproduce some of the conditions expected in a repository. Leach tests and adsorption tests were described. Materials, flow path and flow rate, glass type and g.w. composition were constants of the experiments; whereas the overpack metal, radiation, and states of radioactive waste and basalt were variables. Contact with backfill did not change the g.w. composition. Np concentration dropped rapidly with distance in basalt rock sample in the experiment. Exposure to radiation caused a 50% increase in Pu and a 50% decrease in Np. No effects were seen on radioelement migration. Little difference was found between the transmission through as-cut and leached (120 days) waste forms, but the hydrated waste showed a more pronounced transmission of radioelements. For altered basalt, progressively higher transmission through basalt was observed in going from as-cored to leached to

hydrated basalt. It was claimed that this work will help in evaluating DOE's conclusions, in the performance assessment of proposed repositories for licensing, and in the geochemical model development.

C. Byers (ANL) described plans for studying natural glass analogues with applications to nuclear waste glass alteration. The total project (FIN A-2254) has five tasks: natural analog studies, characterization studies, mechanistic (laboratory) studies, development/verification of correlation with waste glass, and model development. A typical finding from the work to date is that glass devitrifies to some clay mineral. Accelerated experiments will be carried out to simulate long-term behavior.

Field and theoretical assessments of fracture flow were reported by S. Newman (U. of Arizona) for the work carried out under FIN B-5753. A site near Tucson in granite rock matrix with very low permeability was chosen for the field test. The project is termed "Oracle Project" because of its location adjacent to Oracle. The g.w. flow at the site is dominated by fractures. Three types of models - equivalent porous, parallel plate, and dual porosity - were considered for fitting the measured flow response. Three primary, near-orthogonal sets of fractures were found in the rock. The number of fractures as a function of fracture spacing fit an exponential curve. A log-normal distribution for the hydraulic conductivity was found to be a better fit than others that were tried. A correlation between fracture density and hydraulic conductivity could not be established. It was concluded that for the Oracle site, detailed measurements of fracture geometry would be of little use. Tracer tests have been conducted at the site. Newman feels that cross-hole tests need to be conducted to measure the magnitude and direction of hydraulic conductivity. The data appear to fit an anisotropic (ellipsoidal) hydraulic conductivity model, which corresponds well with the three orthogonal sets of fractures. Direct hydraulic conductivity tests are recommended for meaningful data. Then geostatistical theories may be used to derive equivalent porosity. Longitudinal and transverse dispersivities were also predicted in the above analysis.

A Warrick (U. of Arizona) presented the progress on the unsaturated flow project (FIN B-7291). The effort includes a three-dimensional flow and transport model of the fracture system, description of the atmospheric-earth boundary condition, radionuclide transport as vapor, and water potential/content measurements. The unsaturated conductivity was found to be inversely related to suction. A laboratory test on a soil-column was performed to study the coupled flow and heat transfer problem. In an initially uniformly unsaturated column, water movement upon heating from the hot

side to the cold side was seen. Results of the radionculide movement with vapor study will be reported at the Waste Management '85 meeting in Tucson.

M. Nataraja (NRC, NMSS) discussed the draft generic staff technical position (GTP) on in-situ testing for site characterization. A lively discussion followed the presentation. The main purpose of this presentation was to get some feedback from the NRC research contractors (LBL, ANL etc.) on the guidance included in the document. A considerable debate exists on how much coupled testing is necessary and what guidance, if any, should the NRC include in the STP. The points-of-view range from essentially no coupled testing to long-term coupled tests with large scale perimeter drifting. The site characterization data is expected to play a major role in the licensing process. The presentation by Nataraja was the last scheduled talk of the two-day workshop.

The review meeting began on Wednesday morning with introductory remarks by J. Randall followed by a brief presentation of the "Licensing Perspective" by M. Bell (NRC, Division of Waste Management). A majority of the subsequent presentations were largely a repeat of the material presented during the workshop. As such, very little is included in the remainder of this report on presentations by Tsang, Newman, Warrick, Kulacki, Seitz, Byers, Wollenberg, Meyer, and Bonano. A number of consultants were present on behalf of the NRC to evaluate the various projects and provide feedback to the NRC management.

C.F. Tsang's talk on coupled THMC phenomena was supplemented by short presentations by Carnahan, Noorishad, and Pruess from LBL. Carnahan talked about THC couplings and what processes need to be considered. The methodology used considers irreversible thermodynamics. Aside from the obvious processes such as advection, diffusion, transport etc., chemical osmosis and thermal osmosis were mentioned as potentially important mechanisms in semi-permeable materials. However, calculations of solute concentration as a function of distance from source showed only a small difference between the coupled and non-coupled cases. J. Noorishad discussed coupled TMH processes in saturated fractured/porous media. The code ROCMAS was mentioned as a tool for studying coupled TMH phenomena in a repository. It is a finite-element code that is not yet documented. An example of applying ROCMAS to analyze the Stripa data was shown. K. Pruess showed results of coupled TH analyses in the vicinity of a canister.

The material presented by S. Newman (U. of Arizona) included more slides from the experimental site and was somewhat more in-depth compared to his earlier presentation. Otherwise, the message was the same, i.e., cross-hole testing represents a new and useful approach in defining the hydraulic conductivity on a site-specific basis.

A. Warrick, in his presentation, concluded that for unsaturated flow systems, larger fractures act as barrier to flow, which is not what one would expect intuitively.

D. Stahl (BCL) described FIN B-6764, the "Long-term Performance of Waste Packages" Project. The objective is to develop a sufficient understanding of the processes which can lead to waste package containment failure and subsequent release of radionuclides (RN's). This project is a combination of analytical and experimental studies. Analyses to date include calculations of cooling rate of glass castings, development of a model to predict devitrification, collection of data for spent fuel experiments and development of a testing program, and development of a model for glass dissolution. Experiments already carried out are: autoclave pilot glass corrosion with variable temperature, pressure , surface/volume, and water chemistry; glass-water contact experiments at 90°C and 190°C; silica solubility kinetics (not complete). Future work plan calls for the development of predictive capability for basalt waste package performance, development of a source term, generation of experimental data for other media, and emphasis on the spent fuel waste form.

The pitting corrosion chemistry project (FIN A-3269) was described by H. Isaacs (BNL).

Thursday morning, U. Bertocci (NBS) made a presentation of his work on the statistics of package failure by pitting. The two tasks are: 1. Analysis of pit initiation, and 2. Statistics of pitting and pit penetration, distribution of pits, and measurements of how distribution varies over time. The approach consists of exposing a large specimen (few square meters in area) to a corrosive environment and examining the surface at regular intervals over two years. The data acquisition system involves the development of computer controlled surface scanning. The objective is to detect passive film breakdown during induction (?) period and to develop a statistical model for pit initiation.

Rock mass sealing was discussed by J. Daemen (U. of Arizona) for the work carried out under FIN B-6627. Field and laboratory testing of borehole plugs and of variables that influence sealing performance has been or is being conducted on commercial sealing materials. Field testing is in progress at the McNary Dam site (basalt), Oracle Ridge mine, and Cargodera Canyon (granite). Laboratory testing consists of studying: effects of size, temperature, dynamic loading, and drying on cement-plug performance. tests were also conducted to investigate piping and fracture sealing (grouting). Plugs of bentonite and bentonite/crushed basalt are also being tested. Some positive conclusions are: wet cement plugs (in granite or basalt) have low permeability and adequate strength, no

interface flow is observed, plugs are not sensitive to substantial changes in the stress field, no measurable damage occurred under high dynamic loads, partial recovery does occur after drying damage, and the cement penetrates cracks in the borehole walls. The drilling damage is minimal for small holes in granite or basalt. The main negative conclusions are: adverse drying effects on cement and bentonite, with interface gaps and internal cracks in cement; problems in installing cement/bentonite plugs; variability in commercial bentonites and saturation problems; swelling-induced fracture opening; existing fractures in basalt; and cement/tuff interactions. Uncertainties with respect to borehole plugs are longevity, installation effects, swelling pressure, and size effects. Uncertainties for shaft/drift sealing have to do with the damaged zone in hard rock, and shaft sealing in salt repositories.

The talk by Wollenberg on site geochemistry included mini-presentations by H. Nitsche, C. Radke, D. Perry, J. Apps, and A. White. Nitsche's work included investigations of thermodynamic properties of waste RN's in solution under repository conditions. His primary conclusion was that modeling predictions are inadequate but conservative. C. Radke discussed the diffusion of ion-exchanging electrolytes in compacted montmorillonite backfills. The conclusion was that cation migration in montmorillonite is dominated by surface diffusion whereas the anion migration is limited by Donnan exclusion. Surface effects and speciation were addressed by D. Perry. The stated purpose of his work is to have experimental documentation of reactions and of species, and obtain a documentation of data bases. J. Apps discussed his work on near-field rock/water interactions. Experiments in autoclaves at high temperatures were conducted to determine solubility of RN's in simulated Hanford groundwater, and Cohassett flow rock wafers in groundwater were tested as well. Serious problems were found with the EQ3/EQ6 computer code. He commented that there is a need to calibrate the enormous amount of available data on secondary minerals. the last LBL speaker on geochemistry was A. White. He presented material on far-field radionculide interactions. The conclusions are that: water/rock systems are more reducing than previously believed (this is beneficial due to greater retardation); redox conditions of substrate may be more important in sorption and precipitation than in aqueous solution; and g.w. redox may be controlled by kinetics of cation-electron transfer rather than by aqueous speciation.

G. Birchard (NRC) discussed RN migration around uranium ore bodies. The project is in cooperation with the Austrailian Atomic Energy Commission (FIN B-6661) and makes use of a natural analogue to radioactive waste repositories. The objectives are to identify long-term processes not previously

considered, improve understanding, verify transport models, validate lab experiments by comparison with long-term field data, and to improve confidence in prediction capability.

The last presentation of the whole meeting was by E. Bonano (SNLA) on the development of a methodology for performance assessment in non-salt media. The salt methodology is presumably already in existence. Bonano summarized past efforts at Sandia and described the present research activities which include: acquisition of several flow codes for unsaturated media (TOUGH, FEMWATER, FEMWASTE, TRACR3D), selection of verification/validation problems for testing of flow codes, transport of RN's in unsaturated media, and compilation of release scenarios. Methodologies for basalt and unsaturated tuff are expected to be demonstrated in the near future.