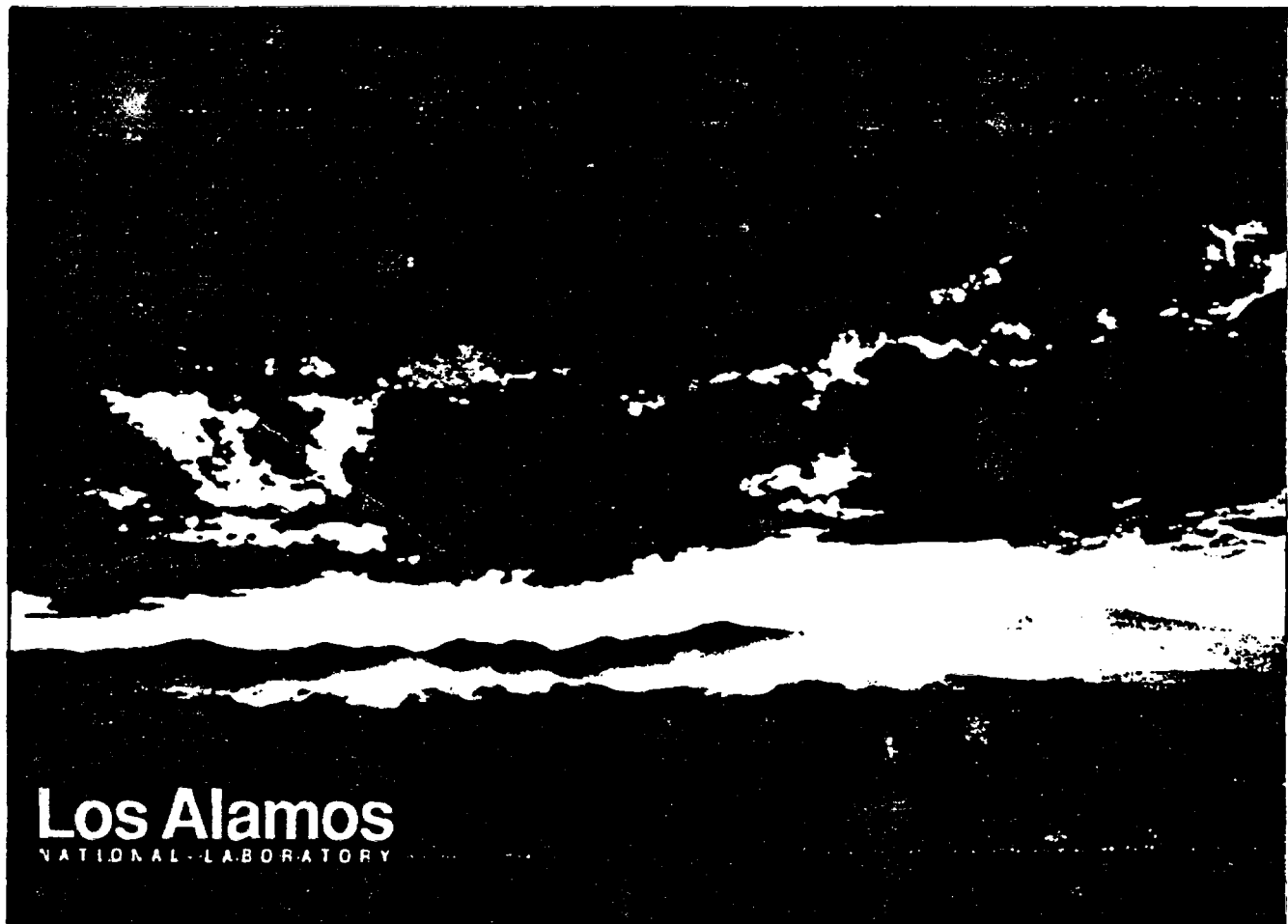


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# Yucca Mountain Site Characterization Project

## Monthly Activity Report

October 1991



Attachment to TWS-EES-13-12-91-041

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# LOS ALAMOS NATIONAL LABORATORY YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

## Monthly Activity Report October 1991

### WBS 1.2.1 SYSTEMS

The objective of this task is to integrate systems with the Geologic Repository Program, to describe the Yucca Mountain Site Characterization Project Mined Geologic Disposal System, and to evaluate the performance of the natural, engineered barrier, and total systems for meeting regulatory standards.

#### TECHNICAL DATA (WBS 1.2.1.3.5)

##### ACTIVITIES AND ACCOMPLISHMENTS

L. Lopez attended a TDAG Meeting in Las Vegas on 17 November.

A revised draft of the technical data procedure is being prepared for review.

We now have immediate access to the Automated Technical Data Tracking (ATDT) system in Las Vegas, and the first edition of the YMP Technical Data Catalog has been released.

##### PLANNED ACTIVITIES

Become more familiar with the ATDT system. Submit *Preliminary Geologic Map of the Sleeping Butte Volcanic Centers*, by B. Crowe, to Genesis and RIB.

#### CAISSON EXPERIMENT (WBS 1.2.1.4.6)

##### ACTIVITIES AND ACCOMPLISHMENTS

A meeting was held with S. Pahwa and W. Nelson of INTERA (M&O) on 23 October to discuss work plans for 1.2.1.4.1 activities at Los Alamos in FY92. The caisson experiment was discussed, and both parties agreed on the proposed work plan.

Laboratory experiments being conducted by Sandia National Laboratories (M. Siegel and B. Glass) neared completion. These experiments will be used to support the selection of the porous media fill to be used in the caisson experiment. A meeting has been scheduled for 7 November at SNL to select the porous fill material.

##### PLANNED ACTIVITIES

Meet with SNL personnel to discuss caisson experimental design. Continue to obtain instrumentation and sampling equipment for the experiment.

#### PERFORMANCE ASSESSMENT CALCULATIONAL SUPPORT (WBS 1.2.1.4.7)

No progress during the reporting period.

#### WBS 1.2.3.2.1.1.1

### MINERALOGY, PETROLOGY, AND ROCK CHEMISTRY OF TRANSPORT PATHWAYS

The purpose of this activity is to define the important mineralogic and geochemical variables along transport pathways at Yucca Mountain in support of performance assessment and to evaluate the impact of repository construction on natural waste-transport barriers.

#### ACTIVITIES AND ACCOMPLISHMENTS

Calcites from Yucca Mountain tuffs are being studied to evaluate their role in past transport. Cathodoluminescence is being used to distinguish growth cycles, particularly within calcite spar that occurs in fractures above the static water level (SWL). Chemical data collected so far indicate major differences between calcites formed above and below the water table, with strong negative Ce anomalies in those above the SWL; calcite below the SWL appears to have no Ce anomaly and a larger rhodochrosite component.

The manganese-oxide mineral lithiophorite has been confirmed to be present in fractures of the upper Prow Pass Member of the Crater Flat tuff in drill core USW G-2. It occurs primarily as abundant blocky crystals up to 50 micrometers in diameter. Lithiophorite had previously been identified only in the Topopah Spring Member of the Paintbrush tuff, where the crystals are less than 3 micrometers in diameter.

B. Carlos presented a poster session entitled *Fracture-Lining Manganese Oxide Minerals in Silicic Tuff at Yucca Mountain, Nevada* on 22 October at the annual Geological Society of America (GSA) meeting in San Diego. She also attended a short course on the use of the SUPCRT 92 program for description and analysis of fluid-mineral equilibria; this course was given prior to the GSA meeting in San Diego.

D. Broxton obtained 29 samples of cuttings from drill hole USW H-5. Samples were collected at intervals of approximately 80 feet, down to a 2270-foot depth. Further sampling will be extended beneath the water table to include the transmissive interval that occurs just beneath the SWL. These samples will be used to extend our knowledge of mineral distributions within and beneath the exploration block. D. Broxton also began preparing a paper for the 7<sup>th</sup> Water-Rock Interaction meeting (July 1992). This paper will describe the chemical differences between vitric and zeolitized outcrops of the tuff of Calico Hills.

The DOE Tiger Team visit that began on 23 September completed most of its surveillance activities in October.

#### PLANNED ACTIVITIES

Work planned within the next few months includes the following activities: (1) continue analysis of Mn-oxide fracture fillings in the Crater Flat and Paintbrush tuffs to determine their distribution and factors controlling that distribution; (2) complete paper on Mn-oxides for publication in a refereed journal; (3) continue analysis of calcites to understand transport and precipitation mechanisms; and (4) complete sampling of cuttings from USW H-5.

#### PROBLEM AREAS

Many studies require approval of software for quantitative x-ray diffraction (XRD) analysis (e.g., milestone 3137). Approval of software for quantitative XRD analysis will take longer than the electron microbeam software to gain approval.

## MILESTONE PROGRESS

3120

29 May 1992

*Calcite in the Upper Paintbrush Tuff*

3123

2 March 1992

*Mn Minerals in the Crater Flat Tuff*

Undergoing extensive revision.

3130

17 August 1992

*Fracture Mineralogy of the Paintbrush Tuff*

3137

30 September 1992

*Mineralogy of Calico Hills for Adit Development*

Writing 66% complete; will be completed six months after XRD software approval.

## PUBLICATIONS

B. Carlos, D. Bish, and S. Chipera

*Fracture-Lining Manganese Oxide Minerals in a Silicic Tuff*

Journal article, *Chemical Geology*

Undergoing extensive revision.

D. Bish and S. Chipera

*Detection of Trace Clays and Clay Minerals Amounts of Erionite Using X-ray Powder Diffraction: Erionite in Tuffs of Yucca Mountain, Nevada, and Central Turkey*

Journal article, *Clay and Clay Minerals*

In press.

D. Vaniman, D. Bish, D. Broxton, B. Carlos, S. Chipera, and S. Levy

*Mineralogy as a Factor in Radioactive Waste Transport Through Pyroclastic Rocks at Yucca Mountain, Nevada*

Journal article, *J. Geophys. Res.*

Draft complete; may be revised for a different journal.

## WBS 1.2.3.2.1.1.2

## MINERALOGIC AND GEOCHEMICAL ALTERATION

The objective of this task is to characterize past and present natural alteration processes that have affected the potential geologic repository and to predict future effects of natural and repository-induced alteration.

## ACTIVITIES AND ACCOMPLISHMENTS

D. Bish, S. Chipera, and D. Vaniman presented papers at the 1991 annual Clay Minerals Society meeting. Bish gave an invited presentation about the determination of paleogeothermal and paleohydrologic conditions in Yucca Mountain tuffs from illite/smectite mineralogy. Chipera presented the results of experiments on the rehydration behavior of a natural analcime; he found that analcimes at room temperature would probably take years to reach their initial

predehydration state. With increasing temperature, the analcime structure expands to facilitate the entry of water molecules, leading to an increased rate of rehydration. Vaniman proposed that authigenic sepiolite in laminae within faults and slope-parallel carbonate soil horizons formed by desiccation of high-CO<sub>2</sub> soil-zone water equilibrated with siliceous igneous rocks at low temperature.

D. Bish gave a presentation about repository thermal effects on minerals to the Nuclear Waste Technical Review Board. S. Levy also attended the three-day meeting.

#### PLANNED ACTIVITIES

S. Levy will attend the MRS meeting in Strasbourg in early November. The symposium on the scientific basis for nuclear waste management will include a session on clays and hydrosilicate gels in the nuclear field, in which Levy will present a paper on natural gels in the Yucca Mountain area.

#### PROBLEM AREAS

X-ray diffraction data-reduction software has not received quality assurance (QA) approval. As a result of the last QA audit, we no longer have an approved vendor to calibrate our ovens.

#### MILESTONE PROGRESS

3138

30 October 1992

*Chemical Transport in Zeolitic Alteration*

3141

31 March 1992

*Laminated Zone in Trench 14*

3142

3 April 1992

*K/Ar Dating of Clays and Zeolites*

Research continuing; new draft in preparation.

3143

30 September 1991

*Experimental Dehydration of Volcanic Glasses*

Interim draft complete.

#### PUBLICATIONS

S. Levy and C. Naeser

*Bedrock Breccias Along Fault Zones near Yucca Mountain, Nevada*

Chapter in USGS Bulletin on Yucca Mountain studies

In USGS editorial review.

D. Vaniman, D. Bish, and S. Chipera

*Rehydration of a Tuff Vitrophyre*

Journal article, *J. Geophys. Res.*

Interim draft complete.

**WBS 1.2.3.2.1.2****STABILITY OF MINERALS AND GLASSES**

The objective of this activity is to produce a model for past and future mineral alteration in Yucca Mountain. The model is intended to explain the natural mineral evolution resulting from the transformation of metastable mineral assemblages to more stable assemblages and the effects of a repository emplacement.

**ACTIVITIES AND ACCOMPLISHMENTS**

This activity has been deferred.

**WBS 1.2.3.2.5****POSTCLOSURE TECTONICS**

The objective of these volcanism studies is to determine the hazards of future volcanic activities with respect to siting a high-level radioactive waste repository at Yucca Mountain.

**ACTIVITIES AND ACCOMPLISHMENTS**

Field work was conducted in the Nellis Bombing range on the Thirsty shield, a sequence of mafic lavas located south of Black Mountain caldera. We have previously sampled and analyzed these lavas (Crowe *et al.*, 1986) and used field relations from published maps which show that the lavas underlie the Thirsty Canyon tuff (8.5 Ma). Recent examination of satellite and aerial photographs showed that the lavas may overlie the Thirsty Canyon tuff. We conducted the field work to examine the stratigraphic relations.

Field work confirmed that the basalt of the Thirsty shield overlies the Thirsty Canyon shield. The basalt units do not form a shield; they drape the topography-filling surface formed on the Thirsty Canyon tuff and form a lava mesa. The eruptive vents for the lava mesa consist of a north/south-trending cluster of scoria-spatter cones that uphold the high point of the mesa (Thirsty benchmark). The estimated volume of the lava mesa is about 5 km<sup>3</sup>. The mesa is significantly modified by erosion but still retains higher-standing topography of scoria vents. This degree of preservation suggests the age of the center could be late Miocene or Pliocene. It is definitely younger than previously assumed. The lava mesa may mark the location of an additional Pliocene volcanic center in the Crater Flat volcanic zone. However, testing of this idea will require age determinations of the lava mesa and field examination of other basalts that overlie the Thirsty Canyon tuff on the north side of the Black Mountain caldera. Two samples were collected for dating using the <sup>40</sup>Ar/<sup>39</sup>Ar-dating method.

An audit of activities at the University of New Mexico (UNM) was successfully completed.

The annual review meeting for the volcanism project was held on 8 October in Berkeley, California. All participants from the volcanism project presented summaries of work progress for FY91 and planned activities for FY92.

A drill hole sample was collected from a private drilling site at the aeromagnetic anomaly south of the town of Amargosa Valley. Basalt was encountered in the drill hole at an approximate depth of 300 to 500 feet below the surface.

Two participants from the volcanism task attended a special short course on *Fractals and Their Use in Earth Sciences* associated with the National Geological Society of America meeting in San Diego. This course responds to a recent paper in the *Journal of Geophysical Research*, where repose periods of volcanic activity at oceanic islands were modeled as deterministically chaotic.



The annual report covering the activities at UNM in support of the volcanism task was completed and submitted to the principal investigator(see Appendix for full report).

Thermoluminescence (TL) dating of soil samples was completed for a suite of samples from the Snake River Plains. The results of the TL dating for all samples except one were in close agreement with previously obtained  $^{14}\text{C}$  age determinations; the one date yielded an anomalously old age in comparison with the  $^{14}\text{C}$  age. This sample will be rechecked, but the age discrepancy may have resulted from incomplete resetting of an inherited TL signal. The soil sample was covered by a thin pahoehoe flow. We will resample the same site and collect samples located progressively closer to the lava flow contact.

A talk was presented at the Department of Geological Sciences of the University of California, Riverside, on the *Volcanic Hazard Studies for the Yucca Mountain Project*. A talk on volcanoes was also presented to local teachers at the Yucca Mountain Information Office.

#### Work In Progress

Four summary papers were submitted and accepted for presentation at the International High-Level Radioactive Waste Management conference (IHLRPMC) in Las Vegas in April 1992.

Land access clearances are being processed for further trenching work at the Lathrop Wells volcanic center.

Scheduled work for the volcanism task (task descriptions and milestones) for FY92 and FY93 was revised and submitted to Los Alamos.

Work on the Issue Resolution Report has been halted until January so that topical reports could be prepared for Waste92 and the IHLRPMC.

Revisions are continuing on the study plan on effects of magmatic disruption of the site. The study plan has now been divided into three activities: eruption effects and eruption modeling, subsurface effects of magmatic activity, and magma dynamics.

We are continuing prototype modeling studies of the eruption dynamics of basaltic pyroclastic eruption.

#### PLANNED ACTIVITIES

Additional trenching will be conducted at the Lathrop Wells volcanic center as soon as the second phase of environmental surveying has been completed.

Participants from the volcanism program will present talks on geochronology at the ACNW meeting in November.

#### MILESTONE PROGRESS

3174

8 January 1992

*Effects of Magmatic Disruption on the Repository (study plan, R0)*

3108

30 September 1992

*Status of Geochronology Studies at the Lathrop Wells Volcanic Center*

3129

10 July 1992

*Petrology of Lathrop Wells Eruptive Sequences*

## **PUBLICATIONS**

B. Crowe et al.

*Multiple Eruptive Events at Small Volume Basaltic Centers: Evidence From the Cima and Crater Flat Volcanic Fields*

Journal article

In preparation.

B. Crowe et al.

*Methods for Assessing the Risk of Volcanism at the Yucca Mountain Site*

Journal article

Revised draft in preparation.

B. Crowe et al.

*Status of Geochronology Studies of the Lathrop Wells Volcanic Center*

LA-series report

In preparation.

## **WBS 1.2.3.3.1.2.2**

### **WATER MOVEMENT TRACER TESTS**

The objective of the water movement tracer tests is to obtain measurements of chlorine isotope distributions to help quantify the percolation of precipitation in the unsaturated zone.

### **ACTIVITIES AND ACCOMPLISHMENTS**

Study Plan 8.3.1.2.2.2 was revised to incorporate NRC and State of Nevada comments and was submitted to YMPO on 16 October.

The contractor, Hydro Geo Chem, underwent an internal audit on 24–25 October. The only finding was concerned with documentation on purchase requests, and a few observations were made by the auditors. The audit report is being prepared.

Detailed technical procedure (DP) LANL-INC-DP-87, *Identification, Storage, and Handling of Samples at Hydro Geo Chem*, was issued, clearing the way for Hydro Geo Chem to receive samples at its Tucson facility. Ten other DPs are in draft form and at various stages of review. Technical and QA reviews have been completed on six of them; however, because the DPs are highly interdependent, the full set was submitted to G. Gainer (Quality Assurance) for advice on minimizing conflicts and overlaps.

Drilling of the first of twelve neutron-access boreholes for USGS study *Characterization of Unsaturated-Zone Infiltration* was completed this month, providing approximately forty QA-traceable ream-cutting samples for chlorine-36 analysis.

### **PLANNED ACTIVITIES**

Submit criteria letter and cutting requests for prototype hole UZP-6; revise DPs for processing samples for chlorine-36 analysis; process cuttings samples from neutron-access boreholes; and process USGS water samples.

## **MILESTONE PROGRESS**

3191

*Procedure for Chlorine-36 Analysis of Unsaturated Zone Samples*

3192

20 December 1991

*Water Movement Tracer Test (study plan)*

Completed.

## **WBS 1.2.3.3.1.2.5**

### **DIFFUSION TESTS IN THE ESF**

The objective of this task is to determine *in situ* the extent to which the nonsorbing tracers diffuse into the water-filled pores of the Topopah Spring welded unit.

### **ACTIVITIES AND ACCOMPLISHMENTS**

No significant activity in this study.

## **MILESTONE PROGRESS**

No level II milestones are planned this fiscal year.

## **WBS 1.2.3.3.1.3.1**

### **SITE SATURATED ZONE GROUND-WATER FLOW SYSTEM**

Experiments will be conducted at the C-Well complex (holes UE25c#1, UE25c#2, and UE25c#3) and in other wells near Yucca Mountain. Reactive tracers will be used to characterize retardation and transport properties on a scale larger than that currently used in laboratory experiments.

### **ACTIVITIES AND ACCOMPLISHMENTS**

Extensive characterization of the C-Well rock samples to be used in the lithium batch sorption experiments has been carried out. X-ray diffraction (XRD) analyses by EES-1 personnel yielded results similar to those performed on the Prow Pass samples used in the preliminary lithium sorption experiments already performed, with only minor differences detected (slightly more feldspars and less quartz in the C-Wells samples). Therefore, we expect the behavior of the sorption experiments to be similar to those performed earlier. Samples have been sent to MST personnel for BET surface area and particle size analysis. Ion chromatograph methods are being refined to improve the resolution of lithium concentration measurements by reducing the interference of sodium.

### **Software Qualification**

The implementation phase (coding, verification, etc.) of the SORBEQ application is nearly complete and ready for review. The software design document for the FRACNET application has been written, and the Model and Methods Summary is being prepared. These are the two main documents required in the design phase of this life cycle. The Software Requirements Specification for the FEHMN application is being written. The implementation baseline for the interface table tools is currently under review. A general-purpose plotting routine that reads data from interface tables

and uses the DISSPLA graphics package for plotting is under development and is nearly ready for review. An updated version of the data-acquisition software for the Dionex ion chromatograph has been installed and is operating as expected.

## PLANNED ACTIVITIES

Continue the effort to bring the computer codes FRACNET, FEHMN, and SORBEQ and other software into compliance with the Los Alamos Software Quality Assurance Plan (SQAP). This consists of compiling existing documentation on these codes and writing new material required by the SQAP.

Continue activities necessary for the batch sorption experiments with lithium bromide, including completing the development of analytical techniques for measuring lithium concentration, compiling error statistics on the measurements, and the determining cation exchange capacity of the samples. Continue to development techniques for measuring the concentration of polystyrene microspheres in solution.

## PROBLEM AREAS

The XRD analyses cannot be used as quality-affecting data because the data-acquisition software has not been certified. If we need these data to interpret the sorption results, we will have to repeat these analyses.

## MILESTONE PROGRESS

3193

30 November 1991

*Batch Sorption Experiments with Boron Using Single Crystals*

3188

16 January 1992

*Documentation for SORBEQ*

3194

1 April 1992

*Batch Sorption Experiments with Lithium*

T112

22 June 1992

*Final Documentation for FEHMN*

3196

27 July 1992

*FRACNET Documentation*

## PUBLICATIONS

W.L. Polzer and H.R. Fuentes

*The Use of the Modified Estimate Thermodynamic Equilibrium Properties of Ion Exchange Adsorption of Radionuclides on Volcanic Tuff. Part II. Experimental*

Journal article, *Environmental Science and Technology*

Submitted to Project Office 7 August 1990; resubmitted 22 March 1991 under AP-1.3.

B.A. Robinson  
*FRACNET—Fracture Network Model for Water Flow and Solute Transport*  
LA-series report  
In preparation.

B.A. Robinson  
*SORBEQ—A One-Dimensional Model for Simulating Column Transport Experiments*  
LA-series report  
In preparation.

### **WBS 1.2.3.4.1.1**

## **GROUND-WATER CHEMISTRY MODEL**

The goal of this investigation is to provide conceptual and mathematical models of the groundwater chemistry at Yucca Mountain. These models will explain the present groundwater composition in relation to interactions of minerals and groundwater and will be used to predict groundwater compositions as a result of anticipated and unanticipated environments.

### **ACTIVITIES AND ACCOMPLISHMENTS**

An abstract entitled *Water-Rock Interaction and the pH of Yucca Mountain Ground Water* was submitted to the 7<sup>th</sup> International Symposium on Water-Rock Interactions for presentation at the July 1992 meeting. M. Ebinger also co-authored a second abstract entitled *Calcite-Sepiolite Associations in Waters Evaporated from Carbonate and Tuffaceous Aquifers of Southern Nevada* with D. Vanniman, D. Bish, and S. Chipera for the same symposium.

M. Ebinger attended a short course on use of the computer code SUPCRT for geochemical modeling on 18–19 October. The code will be translated for use on IBM/PC-format microcomputers.

### **PLANNED ACTIVITIES**

Track Study Plan 8.3.1.3.1.1 during YMPO review.

Continue the USGS collaboration. We will arrange to sample and analyze dissolved gases from USGS water samples. These data will be used to ascertain Eh conditions independently from Pt electrode measurements. Sampling of additional redox couples is under consideration.

### **MILESTONE PROGRESS**

3006  
31 March 1992  
*Eh and pH Buffering Capacity*

3415  
30 September 1992  
*Letter Report: Most Active Groundwater Chemistry*

## **WBS 1.2.3.4.1.2.1 and 1.2.3.4.1.2.3 BATCH SORPTION STUDIES AND SORPTION MODELS**

The objective of this task is to provide sorption coefficients for elements of interest to predict radionuclide movements from the repository to the accessible environment.

### **ACTIVITIES AND ACCOMPLISHMENTS**

Experiments designed to evaluate the effects of crushing on the sorption coefficients obtained by batch techniques were completed. We are awaiting mineralogic analyses from D. Bish before all the data can be properly interpreted. Surface area determinations have been completed on approximately one half of the samples; surface area does not seem to be a major determinant of the variations in sorption coefficients observed for Cs, Sr, and Np in these samples.

Preliminary atomic-scale images were obtained for goethite using the new atomic force microscope. However, to obtain images with the highest possible resolution, better vibration isolation is required, particularly in the acoustic range. A vibration isolation booth has been designed, and materials have been ordered. This instrument will be used to image substrates before and after sorption reactions involving the important radionuclides.

The Stanford contract has lapsed. P. Rogers is working on placing a new contract and should be completed by the end of November.

Environment, safety, and health issues have taken a significant effort this month during the Tiger Team's visit.

### **PLANNED ACTIVITIES**

Continue study of radionuclide sorption on pure mineral phases, complete paper for Sorption Workshop proceedings, and complete study plan revisions.

### **MILESTONE PROGRESS**

3216

30 September 1992

*Mass Spectrometry as Applied to Americium Sorption*

3009

20 February 1992

*Variation of Water-Rock Ratio Sorption Coefficients on Zeolitic Tuff*

3212

*Progress Report on Single Mineral Experiments*

### **PUBLICATIONS**

A. Meijer

*Sorption Studies Review and Strategy*

Conference paper, *Proceedings of the Radionuclide Adsorption Workshop*, Los Alamos, NM, 11-12 September 1990

In preparation.

## WBS 1.2.3.4.1.2.2

### BIOLOGICAL SORPTION AND TRANSPORT

The purpose of this research is to determine whether microbial activity can influence the movement of plutonium in tuff. Because fluids are used extensively in the exploration of locations for a nuclear repository, those microorganisms capable of utilizing drilling fluids as growth substrates are of special interest.

#### ACTIVITIES AND ACCOMPLISHMENTS

Environment, safety, and health topics were addressed in preparation for the Tiger Team visit, which began on 23 September.

During 16–19 October, L. Hersman presented an invited paper at the Northern California branch meetings of the American Society for Microbiology. On 25–26 October, L. Hersman hosted the New Mexico branch meetings of the American Society for Microbiology.

In the past, we identified that the siderophore contains four major amino acids, two of which are serine and L-ornithine. Recent analysis confirmed that one of the two unidentified amino acids is B-hydroxy aspartic acid; the identity of the fourth amino acid is still unknown.

#### PLANNED ACTIVITIES

Continue plutonium  $K_d$  and colloidal agglomeration experiments.

#### MILESTONE PROGRESS

3080

30 September 1992

*Report on Chelation*

3092

30 September 1992

*Report on Colloidal Agglomeration*

3176

30 September 1992

*Procedure for Determination of Formation Constants*

In progress.

3177

30 September 1992

*Procedure for Determination of Effects on Colloidal Agglomeration*

#### PUBLICATIONS

L. R. Hersman, D. E. Hobart, and T. W. Newton

*Preliminary Evidence of Siderophore/Plutonium Complexation*

Journal article, *Journal of Applied and Environmental Microbiology*

Undergoing revision.

## WBS 1.2.3.4.1.3

**RADIONUCLIDE RETARDATION BY PRECIPITATION PROCESSES**

The objective of the solubility determination task is to determine the solubilities and speciation of important waste elements under conditions characteristic of the repository and along flow paths from the repository into the accessible environment.

**ACTIVITIES AND ACCOMPLISHMENTS**

Preparation and auditing of our facilities by the DOE Tiger Team is complete. While we have many areas in which we must respond to audit findings, no serious findings were noted that will have a prolonged adverse impact on our work.

Planning and scheduling activities for the Dissolved Species Concentration Limits Studies and the Colloid Behavior Studies were completed. All ongoing activities have been planned for FY92. Detailed descriptions were prepared for all FY92 activities as well as activities in out-years. Most Project personnel assigned to this task have also been undergoing an annual update of training requirements and responding to new training requirements as a result of recently revised procedures.

D. Hobart and D. Clark recently represented Los Alamos Geochemistry Site Characterization Efforts at the 15<sup>th</sup> Open House Tour of the Yucca Mountain Site.

**Solubility and Speciation Studies**

H. Nitsche prepared and submitted a technical paper for QA review entitled *Dependence of Actinide Solubility and Speciation on Carbonate Concentration and Ionic Strength in Groundwater*. This paper will be published in a special issue of *Radiochimica Acta*, containing the proceedings of the 3<sup>rd</sup> International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere that was held in Jerez de la Frontera, Spain, on 21-25 October.

The Berkeley group has experienced some difficulty with their pH electrodes in 60° C solutions. They are from a new supplier and need more attention than the electrodes previously used—in particular, they need to be refilled and calibrated more frequently. After solving this problem, staff started the neptunium and americium/neodymium solubility experiments at pH 6, 7, and 8.5 in UE25p#1 water. They are currently working up the data from the initial filtration experiments for both radionuclides and will be starting the plutonium solubility experiments in early November.

H. Nitsche's team completed the draft of the Mettler H6T balance operating and calibration procedure, TWS-LBL-DP-14, R0; this procedure is now ready for review. They continued to work on the new draft for *Concentration Determination of Soluble Radionuclides from Data Provided by Low Energy Gamma Counting System* (TWS-LBL-DP-01, R0) and the revised version of *Operation and Calibration of Low Energy Gamma Counters* (TWS-LBL-DP-02, R1).

**Photoacoustic Spectroscopy (PAS)**

The coding standards for Microsoft QuickBASIC were completed and forwarded to Software Quality Assurance for preliminary review. Once approved, these standards will serve as guiding documentation for all software development activities related to the PAS effort in this task. Work on developing PAS software in compliance with these standards has begun in anticipation of the approval of the standards.

Review comments on milestone report *Pu(IV) Complexation by Carbonate, EDTA, and Siderophore Ligands: A Progress Report* were addressed. The manuscript was revised and resubmitted to YMPO for further review.



## MILESTONE PROGRESS

3120

30 September 1991

*Progress Report on PAS*

In preparation.

3031

30 September 1992

*Speciation Measurements*

3329

30 September 1992

*Report on Neptunium, Plutonium, and Americium Solubility Experiments from Oversaturation*

## PUBLICATIONS

*Report on Measured Solubilities of Pu, Am, and Np in J-13 Groundwater from Oversaturation Conditions*

LA-series report

In preparation.

*Carbonate Complexation of Pu(IV)*

LA-series report

In preparation.

## WBS 1.2.3.4.1.4

### RADIONUCLIDE RETARDATION BY DISPERSIVE, DIFFUSIVE, AND ADVECTIVE PROCESSES

The objectives of this task are to determine the rate of radionuclide movement along the potential flow paths to the accessible environment and to examine the effect of diffusion, adsorption, dispersion, anion exclusion, sorption kinetics, and colloid movements in the flow geometries and hydrologic conditions expected to exist along the flow path to the accessible environment in the scenarios used for performance assessment.

## ACTIVITIES AND ACCOMPLISHMENTS

I. Triay attended Migration '91 (the Third International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere) and presented a paper entitled *Radionuclide Migration in Tuff under Diffusive Conditions*, describing diffusion as an important retardation mechanism for radionuclides in a potential high-level nuclear waste repository at Yucca Mountain, Nevada.

Migration is an international conference solely devoted to the chemistry and migration behavior of actinides and fission products in the geosphere, and Migration '91 was held in Jerez de la Frontera, Spain, on 21–25 October. The conference was organized by CIEMAT, Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas, Madrid. It was cosponsored by CEC (the Commission of the European Communities, Brussels) and by ENRESA (Empresa Nacional de Residuos Radioactivos, S.A., Madrid). Over 257 scientists from 20 countries attended: half of the attendants were from Spain, France, and Germany; other European countries were well represented (e.g., Sweden had 27 representatives); and there were representatives from Asia (mainly Japan), Australia, Africa, and North and South America.

The presentations in Migration '91 were categorized in terms of actinide and fission products; solubilities, speciation, and complexation in natural aquatic systems; interactions between radionuclides and geologic media; transport mechanisms; and application and validation of models. Different topics were introduced by an invited presentation (approximately 40 minutes long) followed by 20-minute presentations on the subject. The conference had two evening sessions; each of these sessions consisted of the presentation of over 50 posters. The oral and poster presentations will be published in *Radiochimica Acta* and the *Journal of Contaminant Hydrology*.

Several topics deserve special attention due to their potential impact on current and future investigations within YMP. The complexation of actinides by organics in natural systems could be dominant in actinide speciation studies. It is not clear what is the amount or the nature of organics present in the groundwaters at Yucca Mountain; this issue may become extremely important in future studies. Models to describe the transport behavior of soluble and colloidal species in heterogeneous geologic media were presented. It became evident that laboratory and field data need to be collected for validation purposes before the available models can be utilized as predictive tools. The formation of colloids and its role in radionuclide transport was discussed. The data presented were hard to interpret and a lot of the seemingly conflicting results were probably due to experimental artifacts. Clear conclusions on colloid transport could not be drawn from presentations at this conference. However, it became evident that colloid transport cannot be ignored and this issue needs to be addressed within the context of YMP investigations.

Surface complexation clearly emerged as the most important sorption mechanism for actinides in geologic media. Even though the speaker of the inaugural lecture (W. Stumm) said that the field of surface complexation "has come of age," it was not clear from the following lectures that surface complexation models have predictive capabilities. Other lecturers and conference attendants (including myself) are of the opinion that distribution coefficients (which are empirical in nature) will have to be utilized in assessing the performance of nuclear waste repositories; surface complexation modeling will be valuable to support the choice of distribution coefficients made.

Los Alamos is responsible for the radionuclide transport work performed within YMP. It is imperative that our staff attend Migration conferences, the most respected international forums for discussions on radionuclide migration. My opinion is that DOE has been under-represented at Migration conferences when they are held in Europe. The healthy attendance of the European scientific community at this conference when it is held in the US testifies to that. I do not know of a more appropriate forum than the one provided by Migration conferences to develop consensus on issues related to radionuclide migration. Clearly stating the needs of YMP with respect to issues that have not been resolved in the area of migration will ensure that the international community in the nuclear waste management area will work towards a common goal.

The final program and the list of participants of Migration '91 were distributed at the conference and are available from the PI.

This month, A. Mitchell and I. Triay completed an exhibit of the Los Alamos transport work (within YMP).

## MILESTONE PROGRESS

3040

30 September 1992

*Kinetics of Sorption on Columns of Pure Minerals*

## PUBLICATIONS

I.R. Triay, A.J. Mitchell, and M.A. Ott

*Radionuclide Migration Studies for Validating Sorption Data—Past, Present, and Future*

Conference paper, *Proceedings of the Radionuclide Adsorption Workshop*, Los Alamos, NM, 11–12 September 1990

In internal review.

I.R. Triay

*Radionuclide Migration in Tuff under Diffusive Conditions*

Conference Paper, Migration '91, Jerez de la Frontera, Spain, 14-18 October 1991

In preparation.

#### WBS 1.2.3.4.1.5.1

### RETARDATION SENSITIVITY ANALYSIS

The objectives of this task are to construct a geochemical/geophysical model of Yucca Mountain and to use this model to examine the physical and chemical controls on radionuclide transport along flow paths to the accessible environment.

#### ACTIVITIES AND ACCOMPLISHMENTS

##### Analysis of Physical/Chemical Processes

Calculations were run to model rock beaker diffusion experiments (W.B.S. 1.2.3.4.1.4.2). Modeled results compared well with experimental results for nonsorbing tracers. A kinetic sorption model may be required to model experiments with sorbing tracers.

*Update Report on Coupled Phenomena* (milestone 3049) by G. Zyvoloski was completed (see Appendix for full report). The report gives a description of the dual porosity/dual permeability model used to calculate flow in unsaturated fractured porous media. It also discusses calculations of flow in a discretely fractured medium that butts up against a fault zone. This problem was run as part of early site suitability.

##### QA and Programmatic

Certification of TRACRN continued, and the Software Requirements Specification document is nearly finished. Calculated results for several verification examples (1-d transport and 1- and 2-d saturated flow) compare favorably with analytic solutions. Work on the user's manual continued.

Since it was recently discovered that the dynamic memory management system that was being added to TRACRN was outside the scope of activity allowed for the reverse engineering approach, an SCM variance was presented to the CCB to allow this work. Adding dynamic memory allocation involves relatively few code changes, allows more efficient implementation of interface tables, and will allow a more diverse set of problems to be run. The CCB consensus was to accept the variance with the condition that the new software modules conform to the Fortran standards. Code modifications are being made to include the memory management system.

L. Trease reviewed interface table software.

Corrective actions to clear deficiency reports (DRs) resulting from Audit No. LANL-AR-91-05 were completed. Verification of some DRs has also been completed.

Activity descriptions, scheduling, and resource allocation were updated in the FY92 PACS.

## **MILESTONE PROGRESS**

3049

27 June 1991

*Update Report on Coupled Phenomena*  
Completed (see Appendix).

3052

30 March 1992

*Baseline Documentation for TRACRN*

## **WBS 1.2.3.4.1.5.2**

### **DEMONSTRATION OF APPLICABILITY OF LABORATORY DATA**

The purpose of this study is to design and conduct experiments to evaluate the applicability of laboratory data and to test models used in the Radionuclide Transport Program to determine far field radionuclide transport. Both intermediate- and field-scale experiments and natural analogs will be assessed for their potential to provide the required data.

### **ACTIVITIES AND ACCOMPLISHMENTS**

An abstract was prepared, submitted, and approved by YMPO for an invited presentation at the 13<sup>th</sup> Annual Low-Level Waste Management Conference.

Work scope and schedules for PACS were input.

### **PLANNED ACTIVITIES**

Continue to support the change request and to develop the study plan.

### **PUBLICATIONS**

C. Woloshun

*A Summary and Discussion of Hydrologic Data from the Calico Hills Nonwelded Hydrogeologic Unit at Yucca Mountain, Nevada*

LA-series report

Received YMPO approval on 16 October 1991.

E. Springer

*The Use of Anthropogenic Analogues in Site Characterization for Low-Level Radioactive Waste Sites*

Abstract, 13<sup>th</sup> Annual Low-Level Waste Management Conference

Received YMPO approval on 29 October 1991.

## **WBS 1.2.5**

### **REGULATORY AND INSTITUTIONAL**

The purpose of this task is to coordinate the regulatory and institutional Project requirements within the Los Alamos programmatic structure. The focus of this coordination effort is on the integration of the technical work within the regulatory and institutional framework.

## ACTIVITIES AND ACCOMPLISHMENTS

J. Canepa attended the International Workshop on Radionuclide Sorption, 14–18 October, in Interlaken, Switzerland, and the Migration '91 conference in Jerez de la Frontera, Spain. A trip report is included in the Appendix.

## PUBLICATIONS

J. Canepa

*Strategy for Testing the Applicability and Validity of Radionuclide Transport Models for Yucca Mountain, Nevada*  
Conference Paper, Migration '91, Jerez de la Frontera, Spain, 14–18 October 1991  
In preparation.

### Study Plans

Water Movement Test, R3 (8.3.1.2.2.2). A revision incorporating NRC and State of Nevada comments was submitted on 16 October 1991.

Diffusion Test in the Exploratory Studies Facility, R0 (8.3.1.2.2.5). A revision incorporating DOE/HQ and Project Office comments was submitted on 11 June 1991.

Testing of the C-Hole Sites With Reactive Tracers, R1 (8.3.1.2.3.1.7). Issued by DOE/HQ as a controlled document, and sent to the NRC on 10 April 1990.

Mineralogy, Petrology, and Chemistry of Transport Pathways, R3 (8.3.1.3.2.1). Accepted by the NRC on 4 September 1990. Responses to NRC comments were submitted on 19 August 1991.

History of Mineralogy and Geochemical Alteration at Yucca Mountain, R0 (8.3.1.3.2.2). A revision incorporating SAIC comments was submitted on 13 June 1991.

Kinetics and Thermodynamics of Mineral Evolution and Conceptual Model of Mineral Evolution, R0 (8.3.1.3.3.2; 8.3.1.3.3.3). Comment resolution meeting for DOE/HQ and Project Office comments was held on 14–15 March 1990; revision activity has been deferred.

Sorption Studies and Sorption Modeling, R0 (8.3.1.3.4.1; 8.3.1.3.4.3). Comment resolution meeting for DOE/HQ and Project Office comments was held in February 1990; revision is in progress.

Biological Sorption and Transport, R1 (8.3.1.3.4.2). Revision, incorporating DOE/HQ and Project Office comments, was submitted to Project Office on 20 May 1991. Additional revised text was submitted to the Project Office on 28 August 1991.

Dissolved Species Concentration Limits, and Colloid Formation and Stability, R0 (8.3.1.3.5.1; 8.3.1.3.5.2). Submitted to Project Office on 17 August 1990.

Dynamic Transport Column Experiments, R0 (8.3.1.3.6.1). Comment resolution meeting for DOE/HQ and Project Office comments was held on 28–30 August 1990; revision is in progress.

Diffusion, R0 (8.3.1.6.2). Comment resolution meeting for DOE/HQ and Project Office comments was held on 28–30 August 1990.

Probability of Magmatic Disruption of the Repository, R0 (8.3.1.8.1.1). Revision incorporating DOE/HQ and Project Office comments was submitted on 19 June 1990.

Effects of Magmatic Disruption of the Repository, R0 (8.3.1.8.1.2). In preparation.

Characterization of Volcanic Features, R0 (8.3.1.8.5.1). Accepted by NRC on 4 September 1990.

Retardation Sensitivity Analysis, R0 (8.3.1.3.7.1). A revision incorporating DOE/HQ and Project Office comments was submitted on 18 June 1991.

Ground Water Chemistry Modeling, R0 (8.3.1.3.1.1). Submitted to Project Office on 15 March 1991.

## **WBS 1.2.6**

### **EXPLORATORY STUDIES FACILITY**

These exploratory studies (ES) will address the issues and information needs associated with the feasibility of storing high-level nuclear waste in a geologic repository at Yucca Mountain.

#### **ACTIVITIES AND ACCOMPLISHMENTS**

The management plan for control of fluids, materials, and tracers was finalized and submitted to YMPO for acceptance.

Staff participated in meetings to develop criteria for the excavation of ramps. This team was constituted in response to comments at the 11 October TPO meeting on the Construction Implementation Plan (CIP) developed by the M&O. The team is to report back to the TPOs on 5 November at a planning meeting on ramp location.

#### **PLANNED ACTIVITIES**

We will implement the concepts proposed in the Fluids, Materials, and Tracers Management Plan. Work will be initiated to update ESF Test Support Requirements Document. Work will be initiated to prepare Title II Test Planning Packages (TPP) and to develop new networks for ESF testing. Staff will prepare SCPB changes (Sections 8.3 and 8.4) to incorporate new ESF configuration and tests descriptions as developed through TPP 91-5.

The following work will continue: support ramp location initiative, work with the M&O to finalize the CIP, and replan the Los Alamos effort and assist others in developing FY92 and FY93 plans.

## **WBS 1.2.6.8.4**

### **INTEGRATED DATA SYSTEM**

The integrated data system (IDS) supports the Exploratory Studies Facility (ESF) test program by providing a central facility to automatically measure and control aspects of the ESF tests. The primary purposes of the IDS are to assist the principal investigators (PI's) in acquiring high-quality test data in a uniform, controlled fashion and to transfer those data to the PI's organizations for data management and analysis.

#### **ACTIVITIES AND ACCOMPLISHMENTS**

All activities to close-out RSN IDS work have been completed. The draft IDS Design Summary Report was received from RSN and sent to YMPO.

A plan is being drafted that will direct the phase-in of a new IDS design contractor. This work will contain a list of key documents to be given to the contractor for study, an outline of a memorandum of understanding to define the

interface between Los Alamos and the contractor, a list of first tasks needed to acquaint a new contractor to the IDS project, a suggested progress reporting scheme, suggestions on the content of the core design team, a high-level design schedule with task descriptions for the design of the IDS, and some comments on the RSN draft IDS Design Summary Report.

## PLANNED ACTIVITIES

Complete the new contractor phase-in plan.

### WBS 1.2.9.1.2.4

## TECHNICAL SOFTWARE MANAGEMENT

The purpose of this activity is to manage the development, implementation, and use of all software employed on activities that will support a license application; to manage the configurations of all software and computational data; and to provide tools and procedures that support these activities.

## ACTIVITIES AND ACCOMPLISHMENTS

### Software Engineering

The review committee for the INTERFACE\_TABLES application met to establish the set of Review Item Dispositions (RIDs) to be submitted to the Configuration Control Board (CCB) for the implementation baseline. Issues established in the RIDs must be addressed before approval of the implementation baseline. Certification of the INTERFACE\_TABLES application is expected in mid-November.

A Software Change Request was submitted for the DOCGEN application, and the application's overall structure is being hammered out. A draft Software Requirements Specification (SRS) for the pseudocode-formatting and syntax-checking portion of DOCGEN has been completed, and a draft SRS for the application is near completion. Work has also been started on a draft SRS for the data dictionary portion of DOCGEN.

Lex and yacc, two Unix-based facilities, are being studied as potential aids for portions of the DOCGEN-development effort. It is possible that proper use of these tools could accelerate development and enhance maintenance of the relevant portions of DOCGEN. Prototype work has been performed to investigate fast hashing functions suitable for use within DOCGEN, which will be used to facilitate and improve searching (potentially large) lists of identifier descriptions.

A prototype version of an error-reporting facility for Ada software was developed. This facility will help to give a common look and feel to errors reported by our software. Another prototype Ada package has been developed to enhance our ability to work with the types of character strings provided with the Booch components. This package consists of nearly 40 procedures.

Work continued on developing a command-line parser, and an SRS has been submitted for review.

The section is evaluating Ada compilers produced by Alsys, Verdix, and Meridian to determine the most suitable one for our development environment.

The first in our fall series of software engineering seminars took place on 30 October; Dr. M. Jamshidi of the University of New Mexico presented *Fuzzy Logic and Control: Past, Present, and Future*.

### **Software Configuration Management (SCM)**

During October, staff continued to process submitted baselines, to hold CCB meetings, and to sanction software applications for YMP use. Three Software Implementation Notices were issued regarding development policies and procedures. The SRS for the Configuration Accounting Database upgrade is progressing, albeit slowly. Staff also conducted self-appraisal audits of the SCM effort, with special emphasis on the configuration status accounting system to ensure completeness and correctness and to improve procedures.

Staff processed six baseline submissions—storing the submitted material in the Certification Environment, generating the attendant SCM documentation, performing the Physical and Functional Configuration Audits on each, and generating software review packets to support CCB review of each. The SCM effort sanctioned seven software applications and updated the Computer Program Library for each.

Two CCB meetings were held during October at which fourteen reviews were approved, three Software Change Requests were accepted (with their attendant Engineering Change Directives and Life Cycle Specifications), and one SCM Variance Authorization was issued.

### **WBS 1.2.9.1.4 RECORDS MANAGEMENT**

The objective of this task is to manage records and documents related to the licensing of a geologic repository for the disposal of high-level radioactive waste by developing, implementing, and maintaining a comprehensive, automated, and integrated information management system.

#### **ACTIVITIES AND ACCOMPLISHMENTS**

The Records Processing Center rejected 7 records and accepted 41 records in October; however, records will not be transmitted to the Central Records Facility until the stop work order is lifted.

The following quality administrative procedures (QPs) were issued:

- LANL-YMP-QP-02.5, R1, Selection of Personnel
- LANL-YMP-QP-04.5, R1, Procurement of Non Commercial-Grade Items and Services
- LANL-YMP-QP-06.1, R3, Document Control
- LANL-YMP-QP-06.2, R1, Preparation, Review and Approval of Quality Administrative Procedures

The following detailed technical procedures (DPs) were issued:

- LANL-EES-DP-126, R1, Heavy-Liquid Mineral Separation Procedure
- LANL-EES15-DP-317, R2, Calibration and Use of Analytical and Top-Loading Balances
- LANL-INC-DP-63, R2, Preparation of NTS Core Samples for Crushed Rock Experiments
- LANL-INC-DP-86, R0, Sorption and Desorption Determinations by a Batch Sample Technique for the Dynamic Transport Task
- LANL-INC-DP-87, R0, Identification, Storage, and Handling of Samples at Hydro Geo Chem



### WBS 1.2.9.3 QUALITY ASSURANCE

The Quality Assurance (QA) Program supports Los Alamos Yucca Mountain Site Characterization Project participants and ensures that their efforts provide data and evidence admissible for the repository-licensing process.

#### ACTIVITIES AND ACCOMPLISHMENTS

##### Grading

Of the 32 Los Alamos grading packages being prepared, 27 are approved, 3 have been withdrawn, and 2 are in YMPO review.

##### Training

Training classes for QP-3.5 (notebooks) and QP-8.1 (samples) were held. Efforts continue on redesigning the training program. The new training orientation class will be available in early January.

##### Program Development

Reviews of QP-16.3 (reporting concerns), QP-4.4 (commercial-grade procurement), and QP-4.5 (noncommercial-grade procurement) were completed. Six other procedures are nearly ready for review.

S. Bolivar, J. Day and T. Morgan attended the 18<sup>th</sup> Annual National Energy Division ASQC conference. Bolivar and M. Clevenger also attended a seminar on Managing Priorities. S. Bolivar provided presentations on the *Status of QA* and *How to Survive an Audit* to University of New Mexico (UNM) subcontractors.

Fifteen Los Alamos YMP personnel visited the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM. The trip provided a good perspective on what a waste repository might look like.

##### Deficiencies

Stop Work Order SWO-LA-05 (bid evaluations) was lifted. At YMP's request, an amended response to SDR 497 was submitted and accepted.

##### Audits

Audit report LANL-AR-91-07 was approved and distributed. The internal audit of UNM subcontractor was completed; UNM has shown steady improvement in implementing QA. The first DOE mini-audit of FY92 was held. Although three corrective action requests (CARs) were issued, Los Alamos was found to have a strong quality program. One vendor was evaluated and qualified for calibration services.

#### PLANNED ACTIVITIES

Grading package revisions will continue. Internal audits of group LS-2 and Ohio State University will be undertaken. Revisions to several QPs will continue. There will be a concerted effort to close any open CARs before January.

#### PROBLEM AREAS

The new QARD will affect some of our QPs, and the revisions will take time. We have submitted a request to YMP to hold a records workshop to resolve problems with records.

**APPENDIX**

**ATTACHMENTS AND LEVEL III MILESTONE REPORTS**

Los Alamos

Los Alamos National Laboratory  
P.O. Box O Mercury, Nev. 89023

WBS 1.2.3  
"QA"

## memorandum

TWS-EES-13-LV-10-91-15  
Page 1 of 4

October 30, 1991  
702/794-7096  
FTS/544-7096  
M/S 527

TO: Julie Canepa, EES-13

FROM: Bruce Crowe, EES-13/LV

*Bruce Crowe*

SUBJECT: TRANSMITTAL OF ANNUAL REPORT, UNIVERSITY OF NEW MEXICO

Attached with this memorandum is the summary of research activities at the University of New Mexico for the Fiscal Year 1991. I have reviewed the report for conformity to programmatic responsibilities for the Yucca Mountain Project. I find their work to be satisfactory in all areas. I have listed below major highlights of accomplishments for the fiscal year.

To summarize briefly, significant progress was made in three areas that have positive impact on the goals of the volcanism program. First, the petrologic and isotopic studies of the Lathrop Wells volcanic center show conclusively that the center was produced from multiple, time-separate, batches of magma. The level of detail of these studies, both geochemically and isotopically, is unprecedented. Second, the initial success in obtaining numerical ages from pedogenic calcite combining <sup>14</sup>C dating and analysis of carbon and isotopic ratios is most encouraging. It offers the important potential of applying the well tested radiocarbon time scale to geochronology studies at the Lathrop Wells center. Third, the trenching results at the Lathrop Wells center have confirmed that systematic studies of soil pits at this center using our 4 x 4-mounted backhoe should successfully resolve the conflicting stratigraphic and geochronologic models. This work will be more time consuming than anticipated but initial results have been exciting and discriminatory.

### HIGHLIGHTS OF FY91 PROGRESS

1. Geochemical Studies of the Lathrop Wells Volcano. New trace element and isotopic data indicate that the Lathrop Wells volcanic center was formed from multiple, time-distinct magma batches. This interpretation supports the polycyclic model. It is probably the most detailed trace element and isotopic study of a small volume basalt center ever attempted.

2. Computer Modeling. The initial coding has been completed for a computer model (CONERAND) that simulates a random spatial distribution of basaltic centers. This code allows establishment of baseline data for the likelihood of intersection of existing vents from subsequent volcanic activity for volcanic fields of variable dimensions (size, number of events).
3. Strategy Planning: Magma Dynamics. The basic strategy for generation, storage, ascent, and eruption processes of basaltic eruptions have been developed (with Greg Valentine, EES-5). This strategy begins implementation of one of the review recommendations from Don DePaolo.
4. Radiocarbon Dating of Soil Calcite: Preliminary experiments show that it may be possible to obtain numerical ages from  $^{14}\text{C}$  dating and environmental data from C and O isotopic analysis of soil calcite. This would allow application of the well calibrated  $^{14}\text{C}$  radiocarbon dating method to chronology studies of late Pleistocene and Holocene basaltic centers. It also may allow direct comparison of ages determined using the  $^{14}\text{C}$  and thermoluminescence (TL) methods.
5. Initiation of Paleomagnetic Studies at UNM: We have established a contract with John Geissman at UNM to take over paleomagnetic studies for the volcanism project. John sampled sites in Paiute Ridge, the Lathrop Wells volcanic center and the Cima volcanic field. Studies are in progress on core from those sites. This work should lead to resolution of long standing controversies concerning interpretation of results of paleomagnetic studies by the USGS.
6. Collaboration of Cosmogenic  $^3\text{He}$  and Geomorphic Studies: We have established a productive relationship between UNM workers (now U.C. Riverside) and Los Alamos researchers. Cooperative work has established the versatility of using the  $^3\text{He}$  cosmogenic dating method for determining the minimum ages of desert pavement surfaces. Using field and geomorphic data, minimum ages of pavement surfaces can be correlated with volcanic events.

7. Stratigraphic Relations of Volcanic Units of the Cima Volcanic Field: Revised stratigraphy of the A, I, and G cones has been established using combined methods of field mapping, geomorphic analysis, soils studies, and petrologic studies. These data combined with new chronology results (TL,  $^3\text{He}$ ) provide support for the concepts of evolution of volcanic centers described in Wells et al. (1990).
8. Trenching Program at the Lathrop Wells Center: Trenching studies were started in July at the Lathrop Wells center using the 4 x 4 backhoe truck. Fifteen soil pits have been constructed. Two lava flow sequences separated by primary and reworked tephra with an intercalated soil unit having horizon development have been recognized in the units that occur north of the main cone. The erosional/soil surface on the lower lava flow (buried flow) appears correlative with an erosional surface we have traced, from detailed field mapping, beneath the cone slopes of the main scoria cone.
9. Theodolite Survey: Topographic surveying of volcanic centers has been successfully tested using a laser theodolite surveying system. The trial data set has been contoured using a surface display computer system.
10. Successful Completion of OA Audits

The attached report by the contractors at the University of New Mexico meets a level three milestone for the volcanism studies. It is my intent to continue cooperative studies with the University of New Mexico. There will be several changes, however, in FY92. First, Steve Wells is now at U.C. Riverside. His consultant contract has been modified to continue his work. He may need some administrative support to cover quality assurance responsibilities at U.C. Riverside. John Geissman has been converted from a consultant to a contract participant on the University of New Mexico contract. I will increase the University of New Mexico contract amount and decrease the money budgeted for the consultant work.

Please call me if you have any questions about the report or my summary memorandum. I will be in Los Alamos on the 8th of

J. Canepa, EES-13  
ANNUAL REPORT UNM  
October 30, 1991

TWS-EES-13-LV-10-91-15  
Page 4 of 4

November. We should probably review at that time, the budget allocated to contract work for the volcanism studies.

BMC:kq29

Attachment: (Appendices 1-4 "Limited Value Material")

Cy: S. Wells, U.C. Riverside, Riverside, CA, w/o att.  
J. Geissman, UNM, Albuquerque, NM, w/o att.  
L. McFadden, UNM, Albuquerque, NM, w/o att.  
F. Perry, UNM, Albuquerque, NM, w/o att.  
J. Stuckless, USGS, Denver, CO, w/o att.  
J. Whitney, USGS, Denver, CO, w/o att.  
EES-13/LV, LANL, MS 527  
RPC Files, LATA, MS M321 (2), w/o appendices 1-4.  
CRM-4, LANL, MS A150, w/o att.



**The University of New Mexico**

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Telephone (505) 277-4204  
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OCT 15 2 24 PM '91

October 10, 1991

Dr. Bruce M. Crowe  
Los Alamos National Laboratory  
101 Convention Center Drive, Suite 820  
Valley Bank Center  
Las Vegas, NV 89109

Dear Bruce,

The attached report summarizes activities carried on at the University of New Mexico during fiscal year 1991 in support of the volcanism task for the Yucca Mountain Project. This report fulfills a level III milestone, "Consultant's Progress Reports", and the reporting requirements of Ordering Agreement No. 9-X60-D1200-1, Task order No. 7. If you find this report satisfactory, please forward it to the Program Office.

Sincerely,

Frank V. Perry

**ACTIVITIES AT THE UNIVERSITY OF NEW MEXICO IN  
SUPPORT OF VOLCANISM STUDIES FOR THE YUCCA  
MOUNTAIN PROJECT, FISCAL YEAR 1991**

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This report provides a summary of the progress during fiscal year 1991 for studies at the Department of Geology of the University of New Mexico in support of the volcanism task for the Yucca Mountain Project. This task is attempting to determine the hazards of future volcanism with respect to location of a facility for geologic disposal of high-level radioactive waste at Yucca Mountain. Los Alamos National Laboratory has the primary responsibility for the volcanism work (B.M. Crowe, Principal Investigator).

Work for the volcanism task is supported through studies by F.V. Perry and J. W. Geissman of the University of New Mexico (Ordering Agreement No. 9-X60-D1200-1, Task Order No. 7), and by Neotec, Inc., and Geoprofile, Inc. Activities for this work include:

1. Petrologic and geochemical studies of volcanic centers of the Yucca Mountain region (F. V. Perry).
2. Field and laboratory studies of soil formation of volcanic features (L. D. McFadden).
3. Paleomagnetic studies of volcanic centers of the Yucca Mountain region (J. W. Geissman)
4. Field studies of geomorphic parameters of volcanic features (S. G. Wells)
5. Compliance with the Quality Assurance requirements of the Yucca Mountain project.

**PETROLOGIC AND GEOCHEMICAL STUDIES OF QUATERNARY VOLCANIC  
CENTERS OF THE YUCCA MOUNTAIN REGION (F. V. PERRY)**

The goal of the petrologic and geochemical studies is to understand the configuration, processes, and evolution of magmatic systems in the Yucca Mountain region. Petrologic and geochemical data will provide constraints to model physical processes of magma generation, storage, ascent, and eruption. An understanding of these magmatic processes will aid in forecasting future eruptive activity in the Yucca Mountain region.



### Sampling and Analytical Progress

Thirty additional geochemical and geochronologic samples were collected from Quaternary volcanic centers of the Yucca Mountain region. Geochemical samples were collected at the Cima volcanic field (19 flow samples), and at the Lathrop Wells center (5 scoria, ash, and bomb samples), from pyroclastic units uncovered during trenching in July and August. Six samples from volcanic centers in Crater Flat were collected for dating by the  $^{40}\text{Ar}/^{39}\text{Ar}$  method. These dates will be obtained in FY92 from Lehigh University in Pennsylvania.

A continuing and major impediment to the geochemistry studies is the inability to obtain major-element data for samples submitted to the XRF facility at Los Alamos, due to delays caused by the Software Quality Assurance program.

Fifty INAA trace-element analyses of flows, scoria, and bombs from the Lathrop Wells center were received from Washington University (Appendix 1). In the absence of major-element data, these analyses provide the most comprehensive geochemical characterization of eruptive units at Lathrop Wells.

Preliminary Sr and Nd isotopic analyses of eleven lava and scoria samples from Lathrop Wells were received from the University of Colorado. Pb isotope analyses of these samples will be completed soon.

### Geochemistry of the Lathrop Wells Volcanic Center

A fundamental question regarding the Lathrop Wells volcano is whether it is monogenetic, formed during one eruptive episode, or polygenetic (polycyclic), formed by a series of eruptive episodes separated by significant time periods. The formation of a monogenetic volcano represents the formation, ascent, and eruption of a single batch of magma, and takes place over a period of days to several years. Polygenetic volcanoes are formed by the eruption of multiple magma batches over periods of thousands to millions of years.

Geochemical variations at monogenetic and polygenetic volcanoes reflect the petrogenetic processes operating at each type of volcano. Generally, more complex geochemical variations can be expected among lava flows that comprise a polygenetic volcano. Geochemical variations among different eruptive pulses at monogenetic volcanoes have been documented, and attributed to fractionation of a single magma batch (Luhr and Carmichael, 1985; McBirney et al., 1987). An important test of monogenetic versus polygenetic volcanism at Lathrop Wells is whether geochemical variations can be related to evolution of a single magma batch, or require multiple magma batches. Trace element and isotopic analyses of eruptive units at Lathrop Wells acquired during FY 91 indicate that eruption of several magma batches formed the Lathrop Wells center.

#### *Trace elements*

Two approaches can be used to determine whether trace-element variations are produced by fractionation of a single magma or represent different magmas produced by

separate mantle melting or segregation events:

1. A "process identification diagram" (Allegre and Minster, 1978) can discriminate variations produced by different degrees of partial melting from those produced by fractionation.
2. If trace-element variations among eruptive units represent different points during the evolution of a single magma, any particular eruptive unit should occupy the same relative position (e.g., least evolved or most evolved) on different trace element plots.

Process identification diagrams rely on the relative behaviors of highly incompatible and moderately incompatible elements during batch partial melting and fractional crystallization to discriminate between the two processes. During fractional crystallization involving a basaltic mineral assemblage, the ratio of a highly incompatible to moderately incompatible element will remain constant or increase slightly; during batch partial melting, this ratio will increase as the degree of partial melting decreases. A plot of La vs. La/Sm (Fig. 1) shows that eruptive units at Lathrop Wells have a range of La/Sm ratios, even at similar La contents (compare the Quarry unit and unit QL). These differences in La/Sm at the same La content cannot be produced within a single magma batch undergoing fractional crystallization.

The increase in La/Sm with increasing La content *could* be produced by fractionation of clinopyroxene (as indicated by the fractionation vectors on figure 1), in which case unit QL would represent the *least* evolved magma sampled from a continuously fractionating magma batch. On a plot of Sr vs. Sc, however, unit QL would represent the *most* evolved magma produced by fractionation of clinopyroxene (Fig. 2). This inconsistency among trace-element plots rules out derivation of all the eruptive units from a single fractionating magma.

#### *Sr and Nd isotopes*

Nd and Sr isotopic data (Fig. 3) indicate that unit QL, and possibly the Quarry units, are distinct from the rest of the analyzed eruptive units. The isotopic variations could have been produced in a single magma batch undergoing a complex evolution involving fractionation, assimilation, and recharge, and sampled at different stages of its evolution. From consideration of trace-element variations, however, it is more likely that the isotopic variations represent slightly different evolutionary paths of different magma batches. The isotopic variations may be due to slightly different interactions with crustal wallrock, or may represent heterogeneities in the mantle source.

#### *Conclusions*

Both trace element and Nd and Sr isotopic data indicate that several magma batches erupted to form the Lathrop Wells volcanic center. Considering the low magma flux in the Yucca Mountain region in the Quaternary, the probability of several magma batches, each the

product of a separate evolutionary path, erupting essentially simultaneously (monogenetically) at Lathrop Wells is considered remote. It is more likely that the presence of several separate magma batches implies a series of eruptions that took place over many thousands of years. The geochemical data from Lathrop Wells is consistent with the concept of a complex, polycyclic volcano, which was originally proposed based on geomorphic and soils data by Wells et al. (1990).

#### Computer modeling of vent distributions

The possibility of polycyclic volcanism in the Yucca Mountain region has led us to explore the mechanisms that control vent distribution in volcanic fields of high vent density (Cima volcanic field) versus at isolated centers (Lathrop Wells). The first step was to determine how many vents will overlap in a volcanic field with high vent density given a random vent distribution. We have modeled random vent distributions by developing a BASIC computer code, "CONERAND" that randomly places scaled circles (to represent cinder cones) in X-Y coordinates scaled to the dimensions of a volcanic field. Cone diameters are scaled to vary randomly from 200-1000 meters. Once a selected number of circles are randomly distributed, the program counts the number of vent overlaps. This process can be automatically iterated to generate a statistically valid set of overlap counts and the results saved to a file for input into a statistical software package. An example of the screen output using the dimensions and cone count of the Quaternary part of the Cima volcanic field is shown in Figure 4. Figure 5 is a histogram of overlap counts produced by 500 iterations of random distribution, each with 35 eruptive events. The distribution of overlap counts is approximately normal with a range of 0 to 14 and an average of about 5. This approach can be used to assess whether the actual number of polycyclic centers in a volcanic field is due to random or non-random processes. Structural control of magma ascent would be expected to increase the number of vent overlaps by concentrating eruptions into certain structural zones.

#### Magmatic processes

An understanding of magma generation, storage, ascent, and eruption processes is critical to understanding the potential of further basaltic eruptions in the Yucca Mountain region. Greg Valentine (EES-5) and I have begun formalizing a strategy for understanding magmatic processes using existing studies in the geologic literature, additional modeling where necessary, and geologic constraints from a variety of geologic disciplines. The following processes will be considered:

##### I. Magma generation/segregation

1. Continuous or discontinuous (triggering events)
2. Length and time scales

## **II. Magma transport in mantle**

- 1. Porous flow vs. fracture flow**
- 2. Flux rates**

## **III. Magma storage**

- 1. Location**
- 2. Dimension**
- 3. Mass budget (recharge and venting)**
- 4. Time scale**

## **IV. Magma ascent in crust**

- 1. Dike initiation**
- 2. Transport time**
- 3. Cooling time**

## **V. Eruptive processes**

**Geologic constraints on magmatic processes include the following:**

### **I. Petrology and geochemistry**

- 1. Phenocryst assemblages and characteristics**
- 2. Degree of magma evolution**
- 3. Geochemical variations**
- 4. Xenoliths**

### **II. Geophysical data**

### **III. Geochronology**

- 1. Timing or Periodicity of eruptions**

### **IV. Volcanology**

- 1. Eruption Volumes**
- 2. Eruption dynamics (volatile content, flux rates)**
- 3. Dike dimensions**

## **SOILS STUDIES OF QUATERNARY VOLCANIC CENTERS OF THE YUCCA MOUNTAIN REGION (L. D. McFADDEN)**

Five field trips were conducted to carry out research relevant to geochronologic and field geologic studies concerning the age of volcanic flows, cones, and related surfaces and deposits:

- Three trips to Cima volcanic field, southern California, to evaluate soils and geomorphologic feature of Late Quaternary cinder cones and tephra.
- One trip to Snake River Plain to evaluate well dated Late Quaternary cinder cones and flows.
- One trip to Cima volcanic field with biologists and archeologist to identify evidence of desert tortoise activity and cultural features as part of an effort to acquire formal approval to conduct soil excavations.

Until July, problems with the state of Nevada precluded excavation of soil pits in the Lathrop Wells/Crater Flat area. The desert tortoise remains officially classified as an endangered species, and formal permission to excavate pits in the Cima area has not been attained.

Collaborative research, involving Dr. Ron Amundson (University of California, Berkeley) and Oliver Chadwick (Jet Propulsion Laboratory, Pasadena), was continued to analyze pedogenic calcite in desert soils in order to attain numerical ages from  $^{14}\text{C}$  and environmental data from carbon and oxygen isotopic ratios in the calcite. Preliminary data from an area in which extensive studies have provided calibration for experimental age-dating of soils (the Silver Lake playa area, 10 km north of the Cima volcanic field) are very encouraging, indicating that isotopic and radiocarbon dating of soil calcite in volcanic materials have the potential to provide important independent age constraints on volcanic tephra. Isotopic data indicate precipitation of soil calcite in isotopic equilibrium with the soil atmosphere, which provides (1) important data regarding the influence of plant-produced  $\text{CO}_2$  on calcite precipitation; and (2) significant information regarding the interpretation of the accelerator dates on soil calcite.

Research continued in the area of genesis of soils in volcanic parent materials influenced by incorporation of eolian dust. Laboratory preparation of splits and powders from soil samples from the Cima area was initiated in anticipation of analytical investigation of soils.

A Geological Society of America Penrose Conference concerning cosmogenic dating and other methods of dating surface landforms was attended (with S. Wells). The ongoing investigations at Lathrop Wells by the volcanism group were vigorously debated by those present.

## **PALEOMAGNETIC STUDIES OF VOLCANIC CENTERS OF THE YUCCA MOUNTAIN REGION (J. GEISSMAN)**

In May and June, 1991, samples for paleomagnetic and rock magnetic analyses were collected from the southern portion of the Cima Volcanic Field, Paiute Ridge (Nevada Test Site), and portions of the Lathrop Wells volcanic center.

In the Cima Volcanic Field, sampling was conducted with the assistance of Bruce Crowe, Frank Perry, and Stephen Wells, and focussed on the youngest basaltic eruptions (flows and pyroclastic deposits of the F, A, and I cones). Twenty seven sites were occupied; at each site at least ten independent samples were obtained as an independently oriented core with portable field drilling equipment. All sample orientations were made with both magnetic and sun compasses.

At Paiute Ridge, Nevada Test Site, a total of twenty sites were occupied in basalts and contact rocks of an approximately 8 million year old eroded volcanic center. Bruce Crowe assisted with field sampling. Again, at each site about ten independent samples were collected as independently oriented core with portable field drilling equipment. For most sites, all sample orientations were made with both magnetic and sun compasses.

At Lathrop Wells, ten sites were occupied: four in Q<sub>L</sub>, four in Q<sub>L</sub>, on the south side of the cone, and two in the buried basalt flow on the north side of the cone. Again, at each site at least ten independently oriented (both magnetic and sun compasses) samples were collected as cores with portable field drilling equipment.

All sun compass orientation data have been reduced in the laboratory and compared with magnetic compass orientation results. Where the solar and magnetic orientation measurements differ by more than two degrees, the solar measurement has been used in the preparation of specimen (multiple specimens having been prepared from each sample) data files. To date, specimens from all Lathrop Wells samples have been prepared for measurement. To assess the possibility of a strong magnetic fabric influencing the overall remanence at a sampling site, measurements of the anisotropy of magnetic susceptibility are currently being performed on at least one specimen per sample prior to remanence studies. It has been demonstrated that alternating field demagnetization at high peak inductions can significantly affect the anisotropy of magnetic susceptibility fabric acquired during magma flow.

## **GEOMORPHIC STUDIES OF QUATERNARY VOLCANIC CENTERS OF THE YUCCA MOUNTAIN REGION (S. G. WELLS)**

A study was initiated at the Cima volcanic field to investigate the utility of cosmogenic age dating (<sup>3</sup>He) of volcanic flow surfaces and associated stone pavements (with Dr. Chad Ollinger, LANL, and L. M. McFadden). Preliminary results are very encouraging and support previous studies of McFadden and Wells concerning the origin of pavements and soils on volcanic landforms, which have played a key role in the interpretations of the timing and nature of late Quaternary volcanism in the Lathrop Wells/Crater Flat area.

Detailed field observations were made along the Black Tank ("A") volcanic center lava

flows and along the "I" volcanic center lava flows in order to delineate areas for thermoluminescence dating of soils and sediments buried by lava flows in the Cima volcanic field.

Field observations were made concerning soil-stratigraphic and geomorphic relations during backhoe excavations along the northern periphery of the Lathrop Wells Volcanic Center with B. Crowe, F. Perry, and R. Morley.

A field excursion to Neogene and Quaternary volcanic fields in northern Arizona and southern Utah was conducted in order to assess the geomorphology and soils on volcanic cones and flows of differing ages and in differing climatic regimes with B. Crowe, F. Perry, and G. Valentine.

Field practice surveys were conducted at the Black Tank center in the Cima volcanic field with the Wild Heerburg Total Station EDM in order to establish field procedures for DP preparation and to assess need for supplemental equipment. A field nomenclature for entering volcanic and geomorphic features into the Wild Heerburg data collector during surveys was established. These surveys resulted in a topographic profile of the east side of the youngest Black Tank cinder cone (Fig. 6).

## **COMPLIANCE WITH THE QUALITY ASSURANCE REQUIREMENTS OF THE YUCCA MOUNTAIN PROJECT**

An internal audit of activities at UNM was conducted on November 5-6, 1990, by LATA personnel. Implementation of Quality Assurance requirements at UNM was considered to be excellent. The audit report is included in Appendix 1.

A detailed procedure "Procedure for preparation of splits and powders from soil samples" was prepared and submitted, and is in the process of review. A detailed procedure for use of the Wild Heerburg Total Station EDM is being prepared.

Project participants from UNM met all training requirements of the Project.

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Wells, S. G., L. D. MaFadden, C. E. Renault, and B. M. Crowe, Comment and Reply on "Geomorphic assessment of late Quaternary volcanism in the Yucca Mountain area, southern Nevada: implications for the proposed high-level radioactive waste repository", *Geology*, 19, 661-662, 1991. (Appendix 2)

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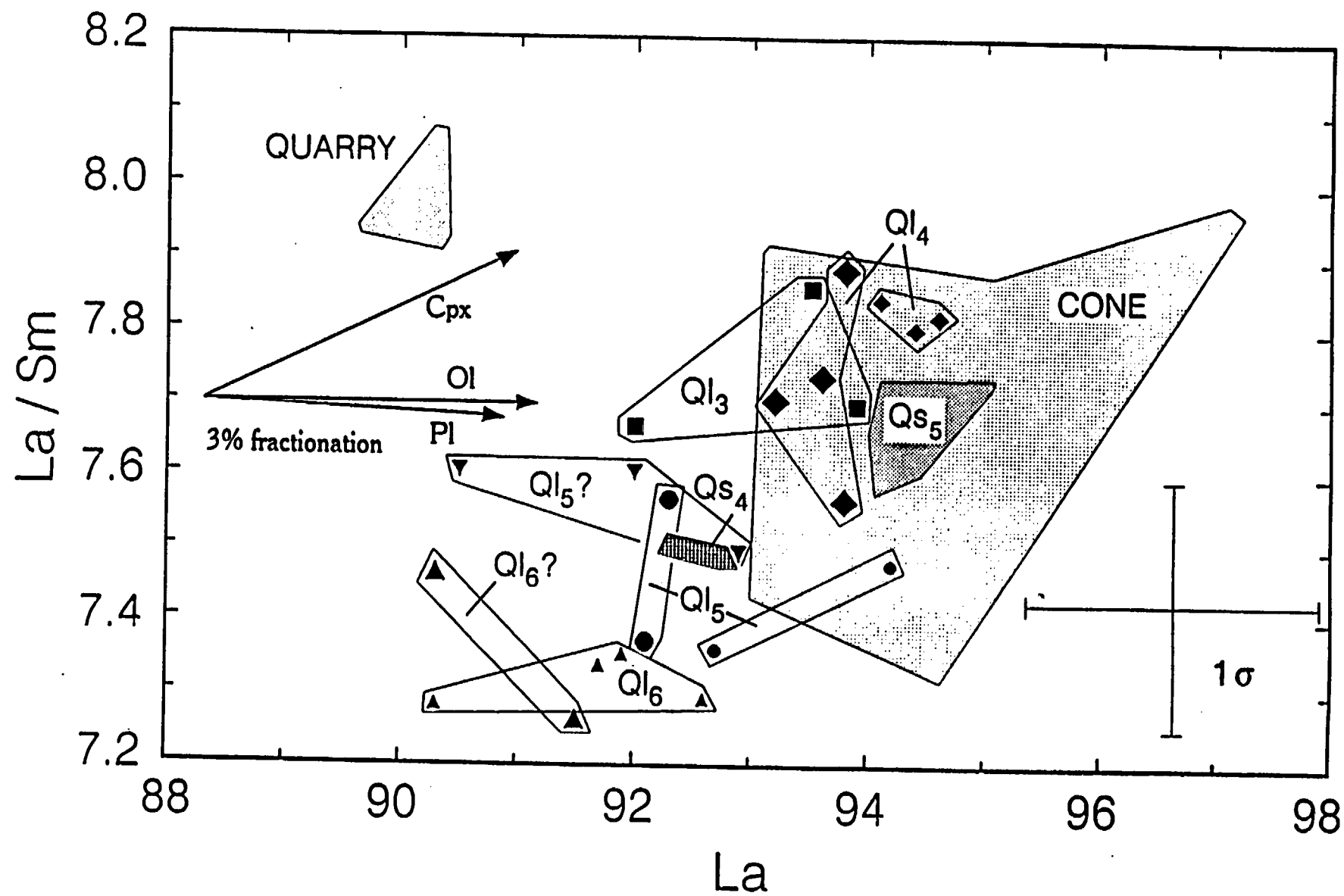


Fig. 1

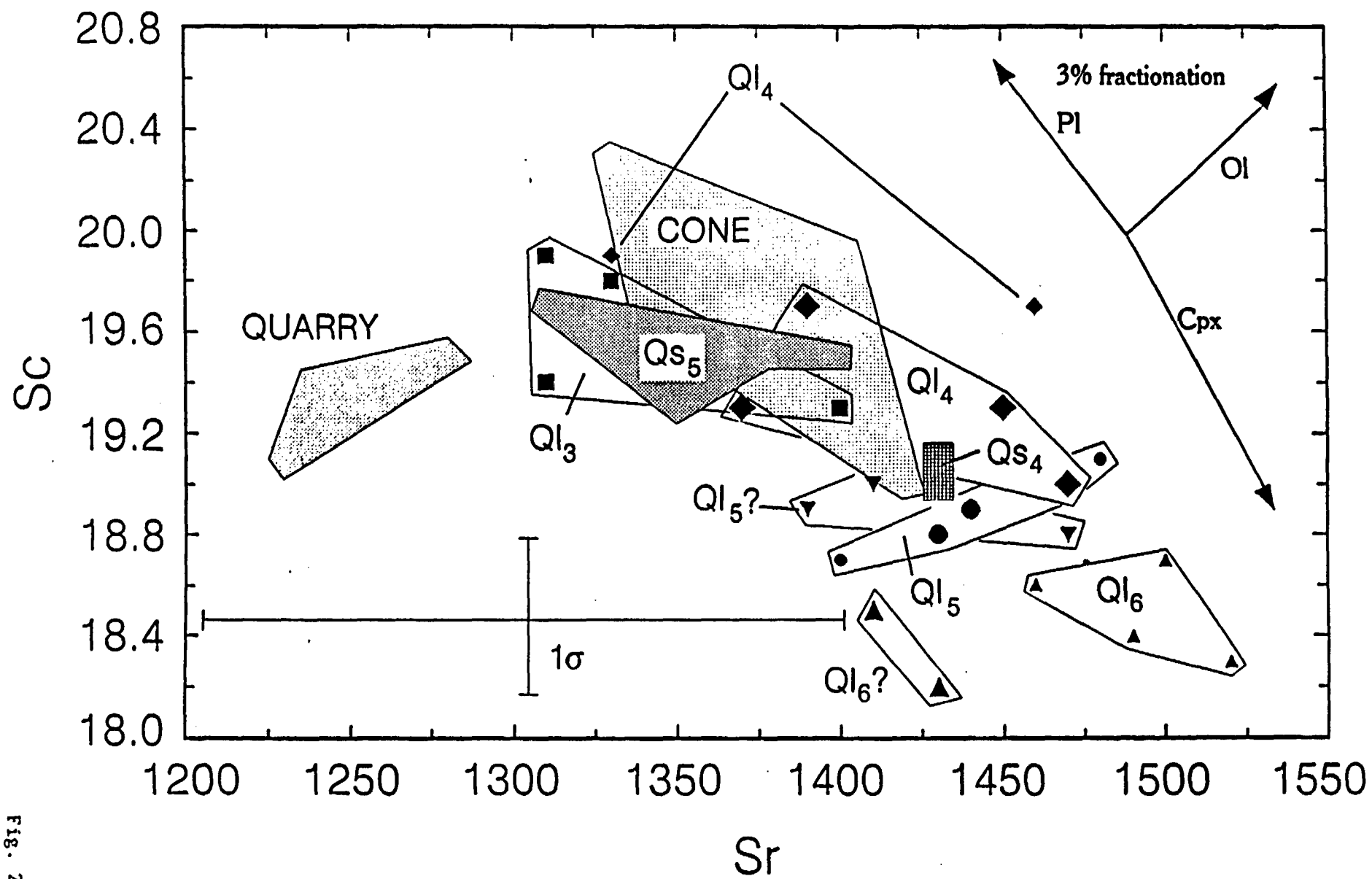


Fig. 2

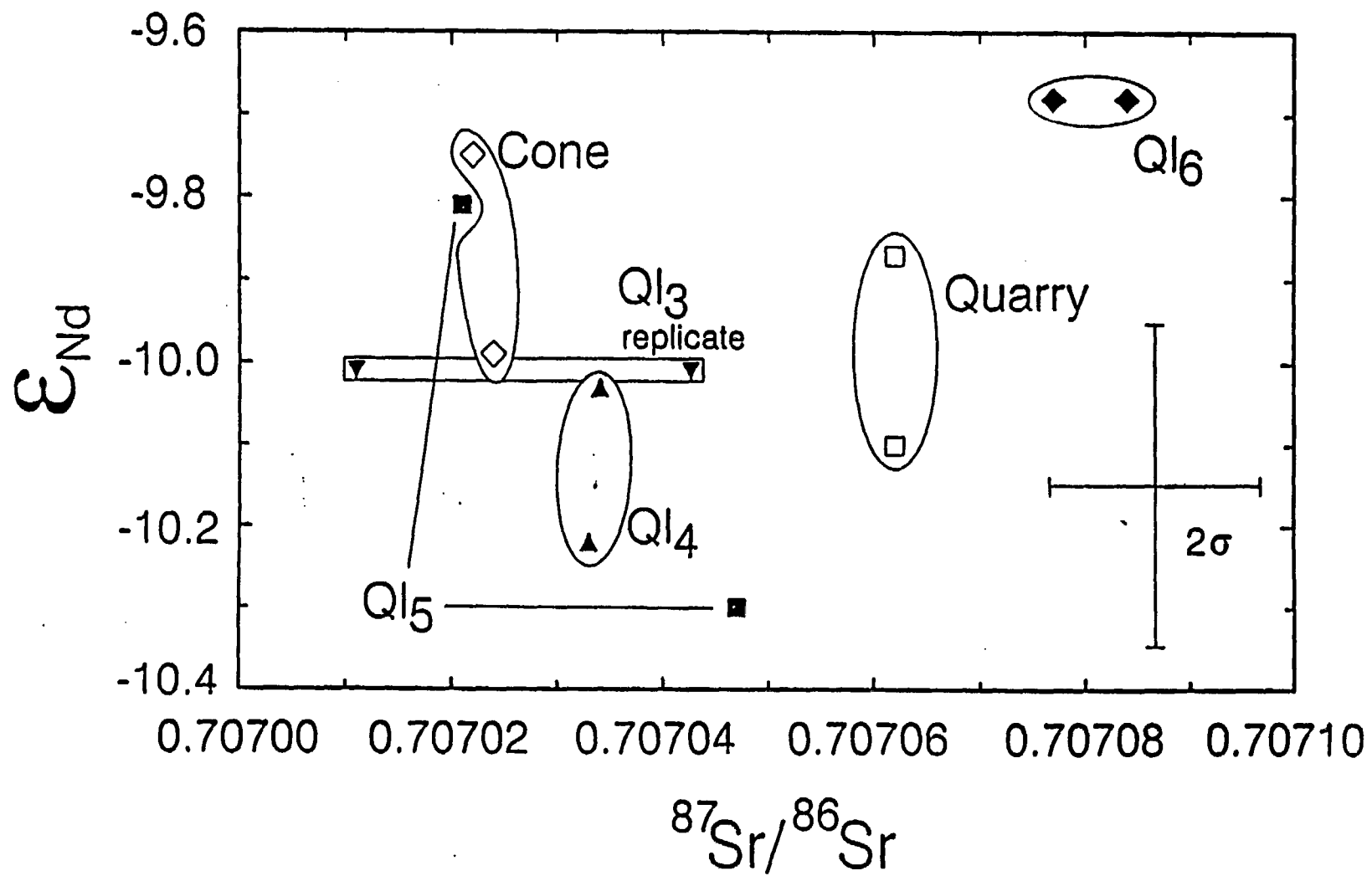
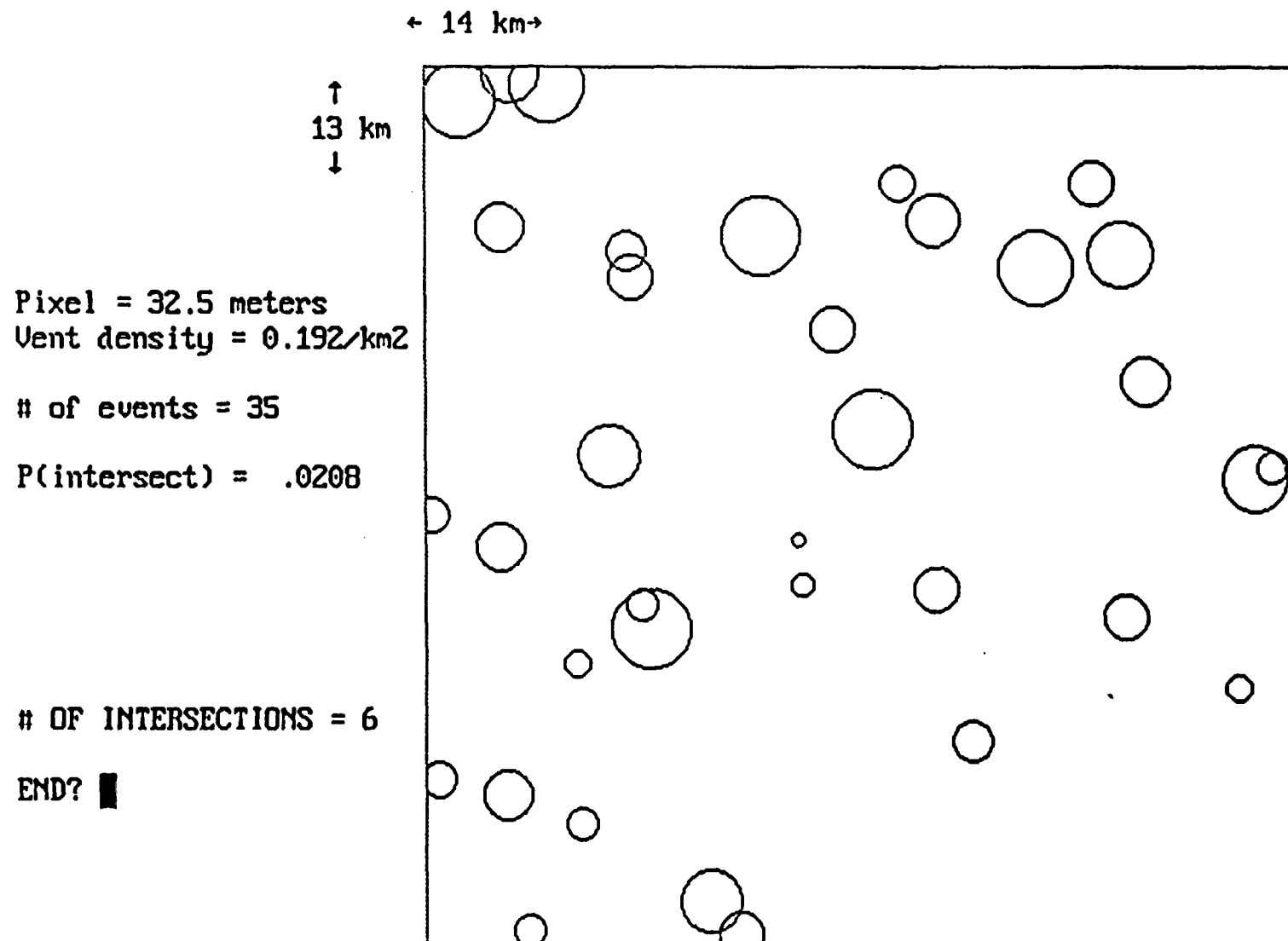


Fig. 3

# SCREEN PLOT OF RANDOMLY DISTRIBUTED VOLCANIC CENTERS (TO SCALE)



Cima. 35 events. 500 iterations

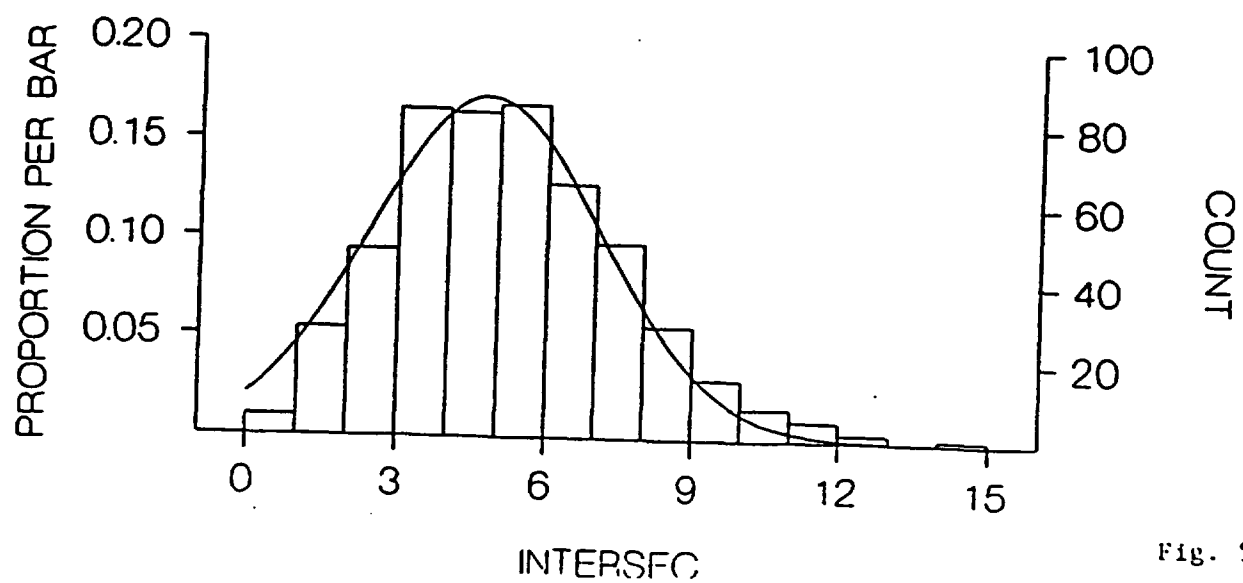


Fig. 5

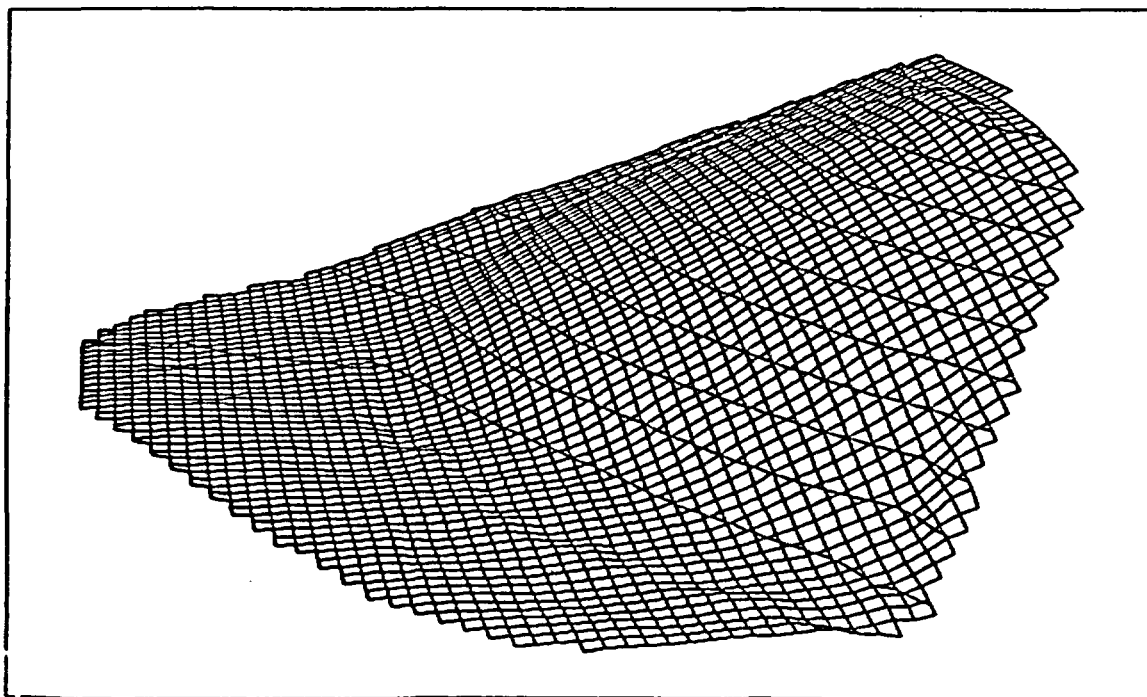


Fig. 6

## MILESTONE 3049

# UPDATE REPORT ON COUPLED PROCESSES AND APPLICATIONS IN THE UNSATURATED ZONE

By George A. Zyvoloski, EES-5

The work reported here includes: (1) development of a new isothermal air-water, multi-phase module for FEHM; (2) Site Suitability calculations of flow affected by the Ghost Dance Fault; (3) the beginning of development of double porosity/double permeability models for air-water transport; and (4) new research into development of methods for fast steady state solutions. These techniques are being investigated using rapid prototyping to determine their applicability to Yucca Mountain applications; in this report *development* is synonymous with *rapid prototyping* as described in the SQAP.

### Isothermal Air-Water Code.

Transient response of fractures to infiltration events may be severely affected by air flow. If this process is to be understood, then the flow of air must be studied as well as the flow of water. An additional important benefit of the coupled air-water flow is lower computer costs. This formulation is more continuous throughout the regions of full liquid saturation, unsaturated flow, and full vapor saturation, allowing larger time steps and hence faster steady state solutions to be obtained (even with the added expense of the extra equations; Forsythe, 1989). This steady state solution may then be used with a transport code like TRACRN or FEHMN to calculate radionuclide transport times in the mountain.

The formulation of the isothermal air water problem follows that given in Zyvoloski et al. (1991) for the general nonisothermal air-water flow. Here the energy equation is neglected and a simplified thermodynamics package is supplied. The thermodynamics assumes that the density of water (liquid and vapor) is a function of pressure only and the viscosities of air and water are constant. In contrast to the nonisothermal case, the isothermal formulation is run entirely in 2-phase mode. This means no phase changes and no underrelaxation is required in the Newton-Raphson solution of the nonlinear equations, resulting in much faster steady state solutions.

## Site Suitability Calculations Using Air/Water Isothermal Formulation

An issue that has been identified for early site suitability studies is the possibility of fast transport paths through fracture/fault systems. To address this issue, calculations have been carried out for a fractured system that is thought to represent the Ghost Dance Fault. The above mathematical formulation proved ideal for calculating the flow field near the Ghost Dance Fault. Figure 1 shows the geometry of the model problem. The section is 10 m wide and approximately 400 m high. The matrix and fracture hydrogeological properties are shown in Tables 1 and 2, respectively. Following the instructions given by Kaplan et al.

Table 1: Matrix hydrogeologic properties at Well G-4.

Layer	Porosity (total)	Bulk Density (g/cm <sup>3</sup> )	$k_{sat}$ (m/s)	Van Genuchten Coefficients			Grain Density (g/cm <sup>3</sup> )	Elevation at top of unit G-4 (m)
				$\alpha$ (m <sup>-1</sup> )	$\beta$	$S_r$		
1	0.10	2.30	$2.0 \times 10^{-11}$	0.005	1.9	0.10	2.53	1080
2	0.04	2.25	$3.0 \times 10^{-12}$	0.002	1.7	0.00	2.38	870
3	0.36	1.54	$1.0 \times 10^{-11}$	0.004	1.5	0.15	2.28	860
4	0.23	1.79	$2.0 \times 10^{-11}$	0.002	1.6	0.10	2.32	780
water table								730

$S_r$  = residual saturation,  $k_{sat}$  = saturated conductivity

Table 2: Fracture hydrogeologic properties.

$\alpha$	14.5 m <sup>-1</sup>
$\beta$	2.86
$S_r$	0.045
$k_{sat}$	$8.25 \times 10^{-5}$ m/s
aperture	210 $\mu$ m

(1991), the units were assigned weighted values of saturated permeabilities, porosities, and relative permeabilities based on the fracture densities given in Table 3. The boundary conditions were taken as no flow on the horizontal boundaries and the water table level of 730 m. Different inflow rates were applied at the top boundary. These were 0.05, 0.1,



Table 3: Fracture densities within Layer 1

Layer Number	Fracture Density (fractures/meter)
1	28.3
2	35.6
3	1.6
4	1.1

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and 0.5 mm/year. The mesh used for the FEHMN calculations is shown in Figure 2. Eight hundred nodes were employed to model the problem. The number of nodes was dictated primarily by computing resources at the University of Auckland, and is admittedly quite crude. The vitrophyre is represented by the two thin element layers at 860 meters on the y-axis. The Ghost Dance Fault is modelled between 7 and 8 meters on the x-axis. Four node bilinear elements were used with node point integration. This gives a solution which is equivalent to a finite difference solution on rectangular grids, but will differ here because on the sloping mesh. Full upwinding was used. To obtain a steady state solution a transient solution with automatic time stepping was employed. The steady state solution for the 0.05 mm/yr water flux is shown in Figure 3. The high saturation of the vitrophyre is the result of water piling up in this layer due to its slow transmission properties relative to the welded tuff above it. The dip in the saturations in the fault zone is due to the lower capillary forces present there. It should be stressed that this dip is the averaged saturation in the fault zone and the fractures themselves contain almost no water.

The calculation shown in Figure 3 serves to point out the weakness in the composite formulation of matrix and fracture flow. In this simulation the fault zone was modelled as having a fracture density of ten times the corresponding material removed from the fault zone. With the capillary pressure of the fracture being insignificant relative to the matrix capillary pressure, a change in the fracture porosity from  $10^{-3}$  to  $10^{-2}$  will change the capillary pressure by at most one percent. The permeability however is dominated by fracture permeability and the factor of ten difference in the fault zone translates into a factor of ten increase in permeability in the fault zone. This gives the additional fluid velocity in the fault zone shown in Figure 3 by the dip in the saturations in the fault. This would give the erroneous impression that the fault zone is more conductive in such an environment. In

reality, there would be no water in the fracture due to the very small capillary pressures (at least until very high matrix saturations occur).

To get a true picture, a dual porosity/dual permeability model is needed.

### Dual Porosity/Dual Permeability Model

Dual Porosity Models (DP) have been used successfully in petroleum, geothermal and groundwater applications for a number of years. In the DP models, fractures are assumed to connect a model reservoir globally. In each computational zone (or node) the fracture is assumed to connect locally to matrix material surrounding it. This is shown graphically in Figure 4. Two parameters characterize a dual porosity volume element. The first is the volume fraction,  $V_f$  of the fractures in the volume element. In Figure 4 this fraction is  $a/b$ . The second is a length scale which quantifies the average distance from the fracture to the matrix material. This is shown as  $L_f$  in Figure 4. While the matrix material cannot communicate with matrix material in other computational zones, it does provide storage capacity for the matrix/fracture system. Numerically the local nature of the matrix material allows a one dimensional solution to be formulated for the matrix material. This solution can easily be 'factored' in the solution for the fracture system with the net result that the  $2N$  system of fractures and matrix material can be simulated for almost the same computer cost as the  $N$  system of fractures.

This procedure works well in fully saturated problems where capillary effects are not important and the fractures are much more conductive than the matrix material. In unsaturated problems, the matrix material with greater capillary forces is often the dominant path for moisture movement. Episodic behavior may make fractures important in parts of the flow zone as well. Double Porosity/Double Permeability models (DPDP) are designed to model this problem. The description of the DPDP method is the same as the DP method except that the matrix material can now communicate with other matrix material as well as with its local fracture. Mathematically this gives a  $2N$  system rather than an  $N$  system to solve. The trick here is to solve that  $2N$  system by noting which material provides the fast flow path in a particular location and using that information to break down the problem into simpler systems that are easier to solve. Work is proceeding on this task and solution algorithms are being designed by myself and my collaborators at the University of Auckland. When completed this formulation will have benefits for both flow and transport problems. The formulation will require input of separate matrix and fracture properties and give velocities in each material. This will allow transport and exchange of radionuclides between

each material. Adsorption models should be improved by allowing  $K_d$ 's for fractures and matrix to be used.

### **Steady State Solution Algorithms**

Most of us are aware of the expense involved in obtaining steady state flow solutions necessary for transport calculations. In a collaborative effort with Mike Osullivan and Yang Zhangke of the University of Auckland, I have been investigating grid interpolating schemes. In this technique a sequence of solutions is generated on successively finer grids. The final solution of each grid is interpolated to the next finer grid. Initial results are encouraging, with speedups of several times achieved for the small test problems. Because of the strongly nonlinear nature of the equations, the interpolation of the phase state has a great influence on the efficiency of calculations, and several interpolation algorithms are being investigated.

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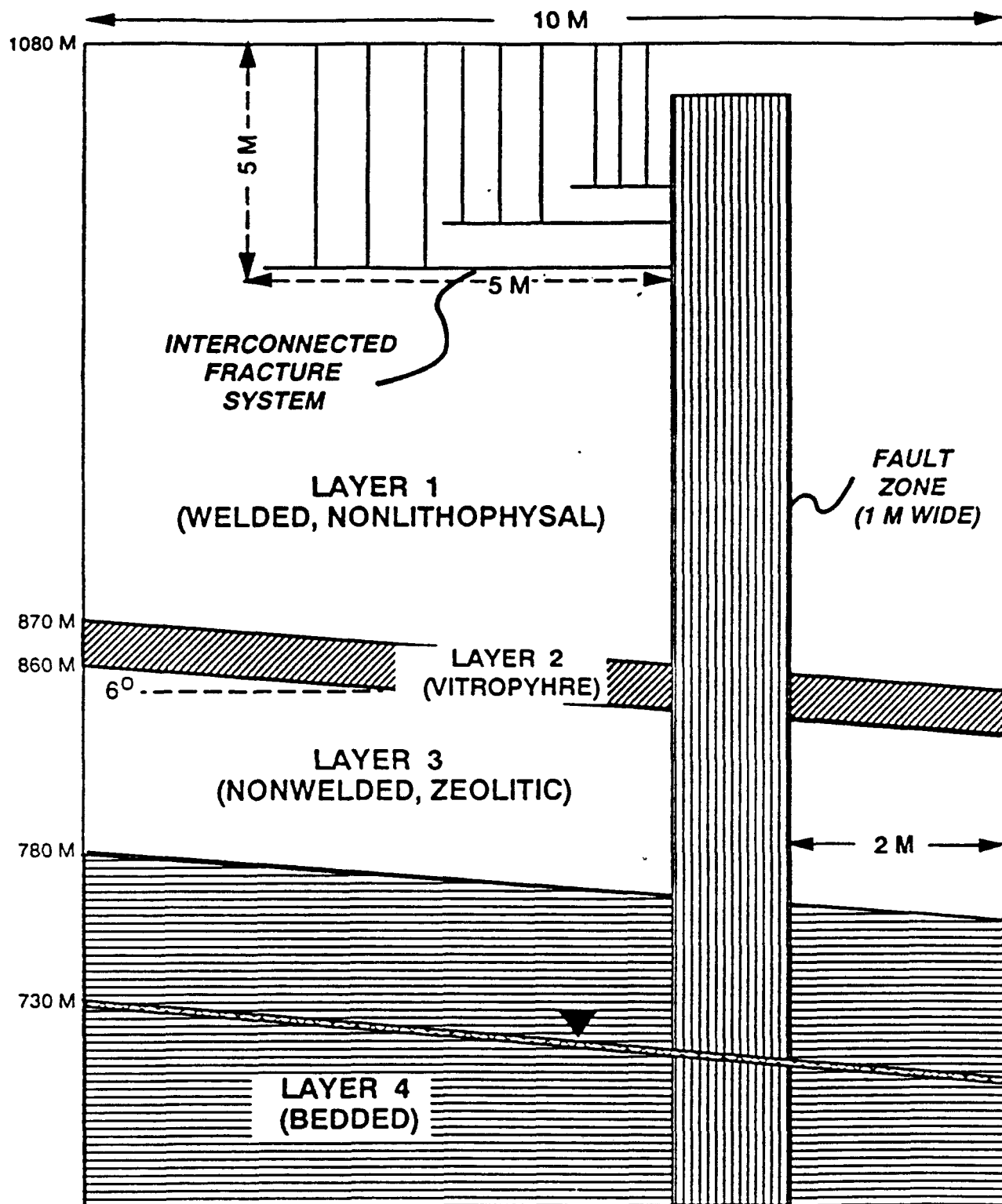
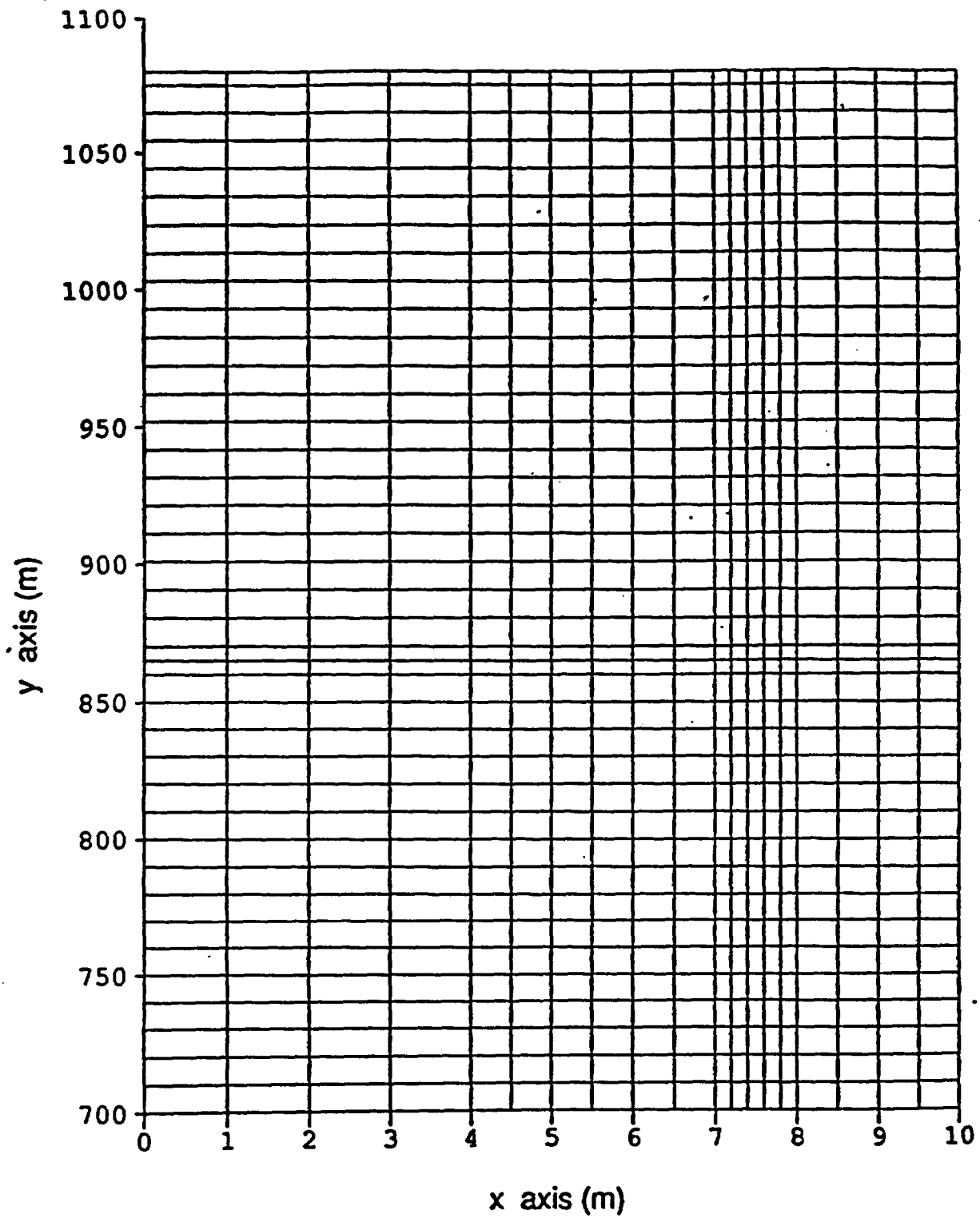


Figure 1  
Cross-section of fast paths problem domain.



**Figure 2. Numerical grid for site suitability computations of Ghost Dance Fault.**

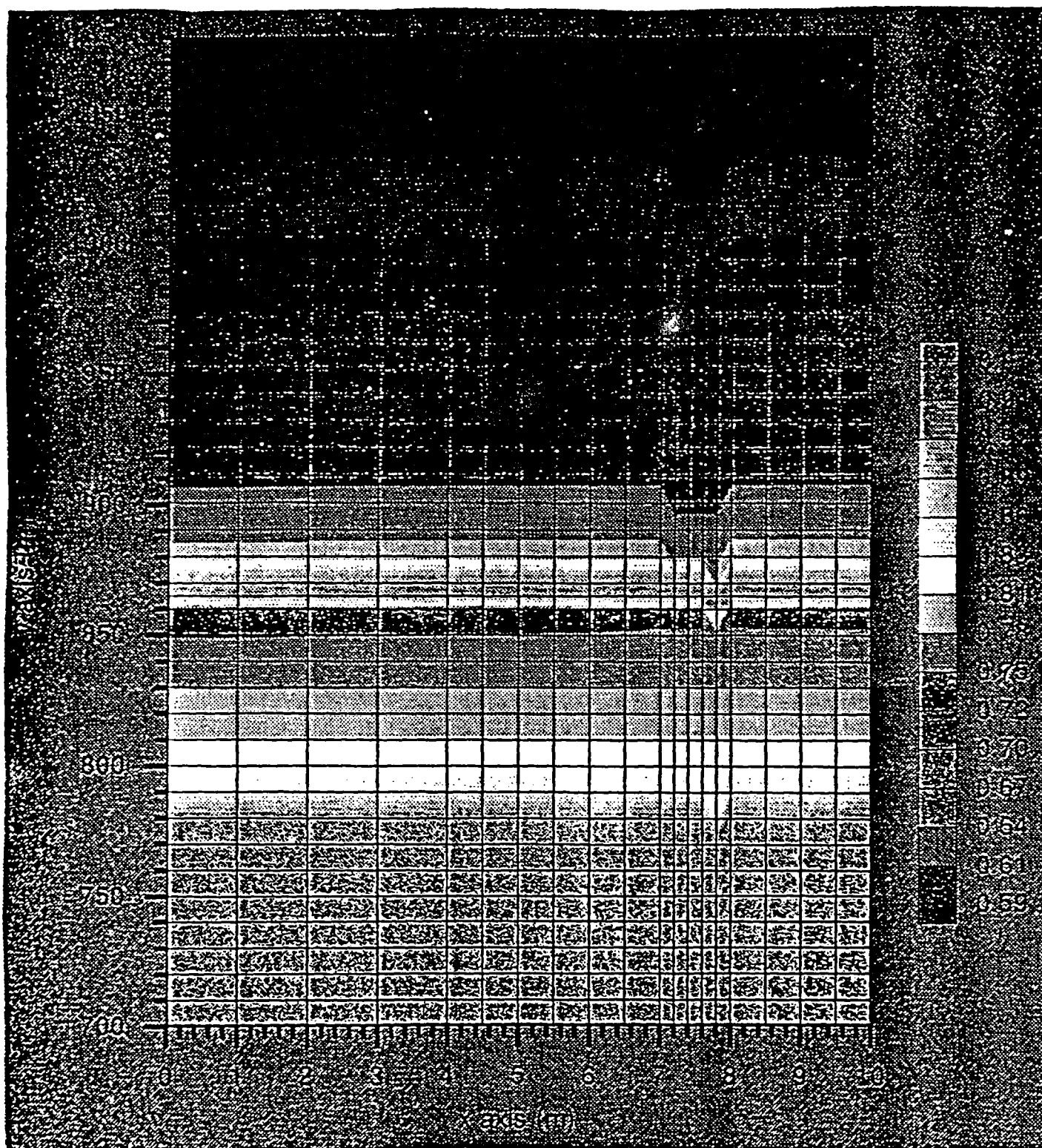
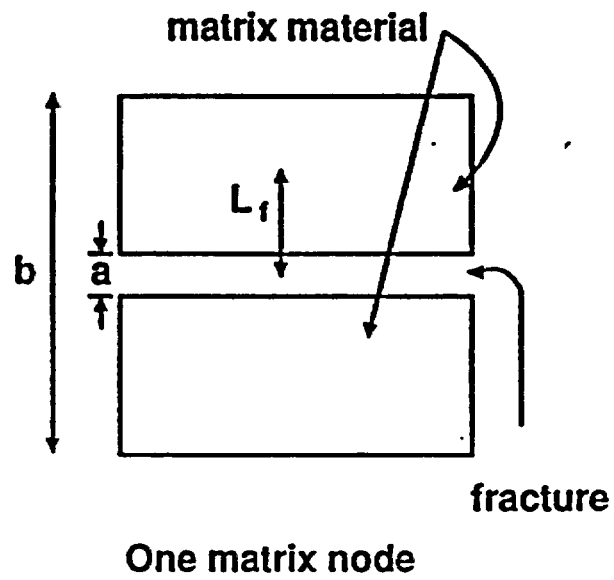


Figure 3. Saturation contours for steady state solution with downward flux of 0.5 mm/yr.



**Figure 4. Computational volume element showing dual porosity parameters.**

**FOREIGN TRIP REPORT  
INTERNATIONAL WORKSHOP ON SORPTION,  
OCTOBER 14-18, INTERLAKEN, SWITZERLAND  
AND  
MIGRATION '91 CONFERENCE,  
OCTOBER 21-25, JEREZ DE LA FRONTERA, SPAIN**

## **Introduction**

The International workshop on sorption was sponsored by the Nuclear Energy Agency (NEA) of the Office of Economic Cooperation and Development (OECD). The workshop was hosted by NAGRA (National Cooperative for the Storage of Radioactive Waste) at Interlaken, Switzerland. The purpose of the workshop was to exchange results from the Sorption Intercalibration exercise and evaluate the use of sorption in Performance or Safety assessments, evaluate methods used to develop sorption databases and discuss experimental methodology such as exploring sorption mechanisms, and establish position papers on sorption.

The Conference on the Chemistry and Migration of Fission Products in the Geosphere, known as Migration '91, was sponsored by the CEC and hosted by ENRESA and CIEMAT of Spain in Jerez de la Frontera, Spain. The conference is held biannually and allows researchers supporting high-level radioactive waste programs a forum for exchange of the chemistry and transport of actinides.

## **Reason for United States (US) Participation**

The US was asked to participate in the International Workshop on Sorption because of the studies in radionuclide sorption as a retardation mechanism for the Yucca Mountain Site Characterization Project (YMP). The US participated in the organization of the workshop and several researchers were identified as experts and invited to attend. I attended as a workshop organizer, session chair and coauthor of 1 position paper.

The Migration '91 conference is the international forum for technical exchange on the chemistry and transport of actinides. For researchers supporting the YMP in radionuclide solubility/speciation, sorption, diffusion, and transport, this is the premiere conference. I attended as a speaker and conference attendee. As the Project Leader of the Radionuclide Transport program in support of the YMP at Los Alamos, I attended in order to learn and gauge the technical progress of the Los Alamos program.

## **Workshop Activity**

The sorption workshop consisted of two parts. Part I, scheduled for the first two days, focussed on the results of the Sorption Intercalibration Exercise lead by researchers from Finland. Seven countries participated in the exercise which took



several years. The US had declined to participate at the original invitation in 1989. Reasons for not participating included changing priorities of the YMP, declining budget and retirement of key sorption personnel at Los Alamos. At that time the YMP characterization work was under a Quality Assurance Stop Work Order and I felt that allocation of staff time away from the development of a Quality program to meet YMP requirements was not justified. Part II (Days 3, 4, and 5) consisted of several sessions, 1) evaluation of data bases used to support recent performance or safety assessments, 2) evaluation of experimental methodologies determining sorption Kds and 3) development of sorption models.

Part I: Part I agenda can be found in Attachment 1. All countries presented the results of the intercalibration exercise. Finland was responsible for providing a homogeneous mineral sample (for this exercise a K-feldspar was used) and providing an experimental protocol. In most instances the protocol of Finland was followed; however, many countries also conducted the sorption experiments using their internal procedural protocol. Data for Cs and U compared quite well between the laboratories. Any differences were discussed with great interest due to researchers natural curiosity but the accuracy between labs wasn't bad (within 20%). These results are probably acceptable to Performance Assessment (PA). This intercalibration exercise should be considered a success if one compares the results to an effort in the earlier WYSAP effort. This means that the major parametric influences on sorption have been identified and experimental protocols for producing sorption values are sound. One of the goals of the NEA was to discover whether laboratories with similar nuclide and substrate concerns (granite) could share the sorption workload if everyone could have confidence in the methodologies used. Consensus was not reached on this matter but given limited research monies in all countries this issue will probably continue to surface.

The Los Alamos sorption methodologies are similar to methodologies being used by other countries. The Los Alamos methodologies haven't changed significantly over the last 10 years, and therefore, I believe that participation would have only corroborated our methods rather than shown us deficiencies in our methods. This is a significant result in of itself and gives me confidence in our experimental methods and data.

A position paper summarizing Part I and making recommendations was drafted and presented to the attendees. Comments were received and revisions were made. The paper will be part of the workshop proceedings.

Discrepancies could not be identified with any one variable. Identification could have been made; however, only 2 of the 7 labs completed all the analyses required. For example, some labs didn't analyze the water chemistry before and after while other labs ran experiments at a different pH. Still with all the "slop", 20% isn't bad. It wasn't apparent whether the lack of following

directions was a human nature problem or problems with funding. The participation was volunteer and had to be funded by each country. Regardless, any future joint or shared work could run into the same problem.

Part II: Session 1 consisted of two presentations of 1) database comparisons used in recent performance assessments and 2) the NEA sorption database. Discussions centered on whether the databases used for performances assessments were documented well enough that others might use them. The same discussion was held for the NEA databases. McKinley commented that the documentation ranged from ok to atrocious and believes that the present data is alright for scoping studies or process understanding. He felt that the validation of the sorption data bases should have equal emphasis as validation of the PA codes. The NEA database presented by Ruegger was said to be huge and its size deterred users. The consensus of the group was that the NEA data base is of value and rather than put influencing experimental parameters in the data base, it was better to show the sorption values and reference the literature.

Session 2 focussed on Database Development. Three papers were presented. The AECL (Canadian) program relies on a PA model that is capable of importing sorption data that is mineral specific. The model embodies the proposed mineralogy along the fracture flow paths and applies a  $K_d$ . I presume applicability lies in how well the flow path is known. Single mineral sorption values are obtained to build the sorption database. The second paper presented a discussion of a mechanistic approach to the generation of sorption databases. This talk focussed on the study of surface sorption phenomena. The author premised his talk on the question 'to what extent PA should use the existing data base without validating the underlying mechanisms'. He never answered the question but certainly pushed for the need to model surface complexation. The talk was interesting but no effort was made to show the tie to Performance Assessment. Discussions of validation ensued with no clear resolution as to what should be validated; accounting for all processes in transport or validating that models predict experiments. The third talk was given by the AEA of the United Kingdom. The paper given outlined the use of assessment models, their limitations and how mechanistic models are used to guide assessment development but are not incorporated into PA models. It is my opinion that the US approach to sorption most closely resembles the UK approach both of which I would characterize as a healthy respect for the underlying mechanism but a pragmatic approach in their application.

Session 3: Session 3 consisted of a combined talk 1 & 2 by Sandia on the WIPP performance assessment process for acquiring and using sorption data. The third talk was a paper by the Environmental Evaluation Group (EEG), comments on the WIPP performance assessment. The session was poor.

Session 4: Experimental Techniques were discussed in Session

4. The first paper by Allard, although interesting, was a tutorial on identifying key parameters affecting sorption and how to interpret experiments with knowledge of these parameters. The second paper by Rundberg (Los Alamos) was on approaches towards measuring sorption and application to performance assessment. This talk pulled from the YMP experimental experience in obtaining sorption data and was the only talk addressing the applicability of sorption in a dynamic system. Experimental validation of the batch sorption  $K_d$  in a flowing system was discussed. This step to validate at the laboratory scale did not impress some participants. The third paper focussed on Laboratory Eh simulations. Wikberg presented excellent laboratory work; however, the uncertainty of controlling Eh (reducing conditions) remains. This topic was of considerable interest to those countries needing to work in reducing conditions. This is not a concern of the YMP.

Session 5: The final technical paper was given by Serne (PNL) on conceptual adsorption models and open issues pertaining to performance assessment. Serne presented a similar talk to the one presented at the sorption workshop held in Los Alamos in 1990. He gave a nice overview of the types of models using  $K_d$ s and reiterated the need for properly run, well characterized and systematic batch sorption experiments. He provided a bit of a reality check in that regardless of how sophisticated our models get we still have to come back to the same measurement (a  $K_d$ ).

Session 5 ended with quite a bit of discussion. Some participants felt that a significant effort should be put into developing a data base for surface complexation modeling. Parameter needs were listed and a proposal for labs to split the work was made. It was obvious that raw data were needed but others questioned the viability of putting these data into the NEA data base. Neretnieks challenged the application of surface complexation models and felt these models were not applicable to dense crystalline rocks.

Sessions 6 and 7: The final sessions consisted of presentation of the draft position papers developed during the workshop. Major points were discussed and agreed to. The organizing committee ended the workshop by finalizing the position papers and submitting them to the NEA for inclusion in the workshop proceedings. A list of participants is provided in Attachment 2.

#### Migration '91 Conference Activity

The Migration '91 conference is a major biannual event that draws scientists from every country dealing with the issue of high-level radioactive waste disposal. The content of the conference follows the technical study efforts directly related to the work that Los Alamos provides to the Yucca Mountain Project, namely radionuclide sorption, solubility, speciation and transport. The program is provided in Attachment 3. Nearly 400 people attended the conference and the attendance list is provided in Attachment 4.

As the Project Leader for the Los Alamos effort, I focussed on trying to gauge our progress and technical expertise. In general, I am most pleased with the Los Alamos program. I believe we have the right combination of in depth scientific basis focus and a pragmatic approach to applying our understanding of radionuclide transport to assess suitability for a high-level waste repository at Yucca Mountain.

I learned that there is great interest in understanding the chemistry and transport of actinides at the molecular level. This is appropriate to providing the scientific basis for understanding transport; however, such work should be prioritized and focussed for relevance. An example is the current trend to explicitly collect data and model surface complexation. For some nuclides this information may be needed but in general the parametric complexity (enormous experimental program needed to generate necessary data for models) may not be warranted. Other countries are struggling with this issue as well as the US. I believe we have prioritized properly.

I have the same concern for the development of the thermodynamic data base for radionuclide solubility and speciation. The international community is making progress in generating "good" data and applying state of the art techniques. I believe the US is making similar contributions (Nitsche, Lawrence Berkeley Laboratory [LBL] talk on solubility of actinides) and is staying current with spectroscopic techniques such as Photoacoustic and Photothermal Spectroscopy for speciation determination. The US program at present is utilizing modeling efforts to test the thermodynamic data base but is not trying to couple such modeling with transport. This is consistent with the international perspective.

Colloid formation, characterization and transport was of great interest to the community. I would characterize the colloid concern in two categories. (1) Colloids as they affect experimental methodology. Many talks discussed colloids forming or confounding experiments. Sometimes the formation was natural or was an artifact of the experimental methodology. 2) Other talks focussed on the effect of colloids (radio-, natural (mineral) or organics) on sorption/speciation and transport. Whenever data was presented that was difficult to interpret, without fail, colloids were offered as a possible explanation. In some instances discussion of colloids were bordering on the absurd especially when the discussion tended toward having to determine if colloids are present or significantly affect transport at the 1 nanometer size. As Heino Nitsche (LBL) so elegantly exclaimed, "enough is enough".

The Los Alamos program was extremely interested in work presented describing silica colloids. Some of the work presented will help in elucidating some experimental artifacts we have observed in our column experiments and give us an insight into sorption onto silica colloids which in our estimation, if any are present at Yucca Mountain, would be the dominant form. No work was presented on how one collects or measures natural colloids in the

field. This is a key aspect for the US program in designing any colloid study strategies. I was interested to learn that the UK is fielding colloid pump tests at the field scale. These tests are similar to the tests proposed at the C-well complex near Yucca Mountain. It seems the UK is using similar artificial colloids and will probably field their test before Los Alamos is allowed to have access at Yucca Mountain. I will plan on following the UK progress.

Many European sites have significant quantities of organics, and therefore, have great concern over the presence of organics that may complex the actinides and dominate over other physical or chemical processes that might retard their transport. This could be serious from a transport perspective as well as give insight to experimentalists who think the sorption experiments show surface complexation to a mineral but may really be complexation onto an organically coated mineral surface. The Los Alamos program has not prioritized organic complexation as a great concern because of extremely low and not explicitly identified organic carbon in the saturated zone waters; however, we realize that eventually this issues must be addressed. Greg Choppin of Florida State University gave an invited lecture on the topic. It was extremely informative and I expect to involve Dr. Choppin in any future discussions with YMP staff on the effect of organics.

The conference closed with some general thoughts by J.I. Kim. He recognized that the conference did not have contributions from field tests. He recognized that the conference topics are at a crossroad with a larger migration community. Kim stated that he heard the modelers are more sensitive to the data or lack thereof. How will pragmatic models integrate with the more mechanistic approaches? A pure scientific approach can be quite large- too large for one country to pursue alone. What is the application approach and what is the passage between the two?

My comment on these questions are that the YMP Los Alamos program is exploring this "passage" with the development of testing strategies that prioritize and identify application and validation steps. I expect great participation by Los Alamos staff at the next Migration conference in the United States, Migration '93.

#### Key Issues

No key issues were brought up. The US scientists presenting talks and posters distinguished themselves and their institutions. The European scientists are concerned that not enough US scientists make the foreign trip. No changes will be made to the Los Alamos Radionuclide Transport program as a result of the technical work presented at the Workshop and the Conference. I am even more confident and pleased with the direction of the program as a result of the trip. I believe my sentiments are shared by my colleagues Ines Triay and Heino Nitsche who attend the Conference as OCRWM/YMP participants and by John Bradbury of the NRC who attended the

workshop and the conference.

#### **Actions planned**

Workshop and conference technical work will be shared with the Principal Investigators at Los Alamos who were not able to attend. I expect to maintain correspondence with P. Zuidema of NAGRA as US /Swiss cooperative agreements are implemented. During FY 93 a technical work session will be planned on the effects of organics on transport. I expect to assist the NEA in the production of the workshop proceedings as needed. I offered Los Alamos assistance to Greg Choppin (Florida State Univ.) in support of the planning and technical review needs for Migration '93.

#### **Attachments**

- Attachment 1 Sorption workshop agenda
- Attachment 2 Sorption workshop attendance list
- Attachment 3 Migration '91 agenda
- Attachment 4 Migration '91 attendance list

C. P. Gertz, DOE/YMP,  
Las Vegas, NV

**Los Alamos** Los Alamos National Laboratory  
Los Alamos, New Mexico 87545

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United States Department of the Interior I-322121

GEOLOGICAL SURVEY  
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DENVER, COLORADO 80225

IN REPLY REFER TO:

December 12, 1991

Carl P. Gertz, Project Manager  
Yucca Mountain Project Office  
U.S. Department of Energy  
P.O. Box 98608  
Las Vegas, Nevada 89193-8608

SUBJECT: U.S. Geological Survey Yucca Mountain Project Monthly  
Summary for October and November 1991.

Dear Carl:

In compliance with the revised Yucca Mountain Project monthly reporting procedures, following is the YMP USGS input for the months of October and November, 1991. The months of October and November were combined because status reports are written against the schedules and schedules were in revision during October and unable to be statused. If you have any questions, please contact Raye Ritchey at FTS 776-0517.

WBS 1.2.3 - SITE INVESTIGATIONS

The following Study Plans received NRC approval:

8.3.1.17.4.6, Quaternary Faulting Within the Site Area  
8.3.1.17.4.10, Geodetic Leveling

The QA grading report for Soil and Rock Properties of Potential Locations of Surface Facilities was approved; the Criteria Letter for drilling and test pitting for the ramps and surface facilities was sent to DOE. Work continued on the siting study for four additional North Ramp Portal alignments for the ESF.

In support of Geologic Mapping of Zonal Features, reconnaissance began of the Ghost Dance Fault to evaluate appropriate field parameters for measurement along the faults - this supports the effort to provide detailed structural analysis of exposed fault surfaces on faults such as the Ghost Dance, Paintbrush Canyon and Yucca Wash faults.



Staff from the Eolian History of the Yucca Mountain Region collected surface sediment samples from several playas in the Mojave Desert region and in the region of Yucca Mountain. Samples were submitted for isotope and paleontology analyses.

In support of Midway Valley studies, field logging of trench ABR-B on the Bow Ridge fault was completed in October and the trench was backfilled in October. The long trench through the proposed ESF was sited and flagged and the location shown to environmental survey personnel from DRI and EG&G. Surficial geology mapping in the area of the Reference Conceptual Site on the east side of Exile Hill began in November. The work was started early because of anticipated surface disturbances to the site by construction vehicles in FY 1992.

In support of regional potentiometric studies, cuttings were collected during the construction of two oil-test wells in the Amargosa Desert in October. The first drillhole was completed to a depth of 5,020'. Cuttings from the drilling fluid were collected by USGS and/or contract personnel every 10', washed and bagged. Unwashed samples were collected every 50' for conodont fossil analyses. Paleozoic-rock cuttings (dolomite) were first encountered at 1,960' and continued to the total depth of the drillhole. Preliminary conodont analyses indicate that no conodonts were recovered from 2,960'-3,060' below land surface. Conodonts were recovered at intervals of 4,150'-4,210' and 4,210'-4,255'; preliminary analyses indicate an age of early Ordovician. Conodont indices indicated that the host rock reached a temperature of at least 300 degrees C. A second hole was constructed to a depth of 1,466' and was abandoned as a result of lost-circulation problems. Three "caverns" were indicated by lost circulation during drilling and geophysical surveys to occur at depth intervals of 1,320'-1,329'; 1,413'-1,427'; and 1,429'-1,433'. These caverns may be of some utility in obtaining travertine core for determining climatic conditions for the last 60,000 years. The holes were plugged per the request of USGS personnel by the driller of the holes with drillable cement plugs. No charge was incurred by the Project for this service. Custody of the holes will revert to the BLM, which has agreed to transfer custody to the USGS.

A saturated-zone ground-water travel time workshop, organized by the Hydrology Integration Task Force and held at the Radisson Suites Hotel in Tucson, AZ, was attended by about 50 YMP personnel. NRC and M&O representatives were present. J. Czarnecki prepared and presented a paper titled "Factors affecting ground-water flow direction and magnitude at Yucca Mountain". Czarnecki also led a wrap-up discussion at the end of the two-day meeting, and met with Hydrology Integration Task Force members afterward to coordinate the preparation of a summary paper of the meeting.

In support of past discharge studies, surficial samples were collected from 16 playa sites in Nevada and 8 playa sites in California. Twelve water analyses were completed on water samples submitted in July from Oasis Valley, Spring Mountains, and the

## Nevada Test Site.

Staff from the alternative conceptual models of the unsaturated zone project provided on-site field support for the coring of neutron borehole USW UZ-54 and coordinated field support personnel for the coring of neutron boreholes USW UZ-54 and -55.

In support of multiple well interference testing, the USBR has been assembling the monolithic "test sections" which consist of protective casing that houses the instruments needed for monitoring of pressure and temperature changes, and injection of tracers, during hydraulic and tracer testing at the C-holes. Estimates have been obtained for the cost of running a power line to the C-holes and the alternative of providing generator power during the testing, indicating that the two approaches are comparable in cost. The power line option was selected. A criteria letter will be written to initiate the process of securing the power.

The principal investigator for the hydrochemical characterization of water in the upper part of the saturated zone met with B. Lehman (Institute of Physics, University of Bern) and J. Fabryka-Martin (LANL). Bern is the site of the only laboratory currently capable of performing determinations of  $^{39}\text{Ar}$  activity. Based on YMP sampling plans, Lehman suggested that the determinations of  $^{39}\text{Ar}$  in gas-phase samples was quite feasible. He further indicated that the level of effort required for aqueous sample collection would be much higher than for gas-phase samples. Discussion also briefly touched on world-wide analytical capabilities for  $^{81}\text{Kr}$  and  $^{85}\text{Kr}$ .

The surface water runoff monitoring project reports that flow was noted on October 2, 1991, at Cane Springs Wash Trib. NR Cane Springs. It was assumed to have occurred on September 7, but the possibility that it could have been September 28 is noted. An estimate of 17.0 CFS was calculated to have passed through the culverts.

In support of prototype pore water extraction tests, staff compressed 11 cores from UZ-4; cut and prepared 15 core samples from UZ-4 and UZ-5; and received and inventoried 22 new core samples from the Sample Management Facility for UZ4, UZ5 and UZ6s. Tests of intact versus fragmented welded core indicate that fragmented core can produce almost as much water as intact core. Tests of continuous versus pressure step increase extraction method are ongoing.

Staff from the prototype dry coring of rubble report that results of rubble tests indicate that a surface-set-bit cores faster than an impregnated bit, but wears out faster. The bit penetration rate depends on fabric orientation in the welded rock - parallel to fabric is best, and the faster penetration rates are better for keeping the core cool. A moderate force applied to the drill is

best for maximum penetration and minimum heat produced. Compressed air works well for bit cooling and can be applied at the minimum pressure required to remove cuttings (~50 psi). The best rotational speed is about 250 rpm. Both hydrostone and sulfaset will produce minimum heat inside a rubble piece (5-15 degrees C) and thus either is appropriate as a blocking material for rubble.

In support of prototype tracer testing, the design of the tracer gas sorption tests has been completed. Both batch and column tests have been designed. The batch experiments utilize a glass manifold with specially designed flasks. The sample is placed in the flask, pumped to vacuum, and injected with the desired tracer gas. Analysis of samples is by gas chromatograph. The column experiments utilize a glass column connected to teflon tubing. The tubing forms a closed system that flows through an analyzer appropriate for the gas of study. A pump provides a continuous flow of the gas through the system.

In support of aqueous-phase chemical investigations, 11 nonwelded UZ4 cores were compressed. An average of 7.3 mls of water (ranging from 1.7 to 17.6 mls), and an average of 74.8 mls of gas (ranging from 49.8 to 109.8 mls) were obtained.

In support of the site vertical borehole studies, two of the three HRF boreholes were instrumented during October. Monitoring of these boreholes was begun. The third borehole is scheduled to be instrumented in February 1992. Monitoring will continue as an on-going activity indefinitely. Purchase requisitions for all sensors needed to instrument UZP-6 are in preparation. Engineering drawings to facilitate manufacture of the downhole instrument station apparatuses (DISAs) are in preparation and should be complete by mid-January. A possible device for remote access of the instrumentation cavity for water injection testing has been identified. Maximum effort will be devoted to this activity until a final resolution is made with regard to which borehole, UZP-6 or UZ 16 (a vertical seismic profiling borehole), will be drilled first.

The precipitation and meteorological monitoring project reports that a geostatistical analysis of two FY1991 storms revealed locations where additional gauges should be installed to reduce spatial variances. Work remains to pin-point locations of 20 additional gauges. Preliminary work began to correlate weather data with regional precipitation patterns, lightning strike data, and satellite data for precipitation events at Yucca Mountain in FY1991. A regional geostatistical analysis of each storm event still needs to be accomplished. The network of 97 collection gauges was monitored for a small storm on October 26; upper Fortymile Wash received the most (.25 inch).

In support of natural infiltration studies, an analysis of moisture profiles of the new neutron access boreholes N-55 and N-54 was

initiated to help investigate the effects of drilling on moisture conditions by logging the boreholes on a daily basis during the drilling process. The continued analysis of moisture profiles for these deeper neutron access boreholes will be important for investigating the influence of geologic structure, lithology, and physiography on the movement and distribution of moisture within the upper saturated zone. Installation of the first neutron access (N-55) hole was successfully completed and installation of the second new hole (N-54) is approximately 40 percent complete. The new holes have been logged on a daily basis in an effort to obtain data pertinent to meter calibration and also for investigating the effects of drilling on the hydrologic conditions of the host rock.

In support of prototype infiltration testing, the ponding test on the large block first stage started on October 28. Water with a chemical composition that is similar to that of the unsaturated zone water was used. The water front in the fractured block is being traced using thermocouple psychrometers, electrical resistance probes, and TDR. This stage will continue until the block becomes too wet where the psychrometers will not make accurate measurements.

The mineral and energy resources project reports that monitoring of exploration wells is complete. Exploratory wildcat drill holes in Amargosa Valley were monitored during drilling operations. Both drilling efforts were dry holes with no discovery of significant hydrocarbons.

Sincerely,

*Larry R. Hayes*  
for Larry R. Hayes  
Technical Project Officer  
Yucca Mountain Project  
U.S. Geological Survey

cc: D. Appel, USGS/Denver  
J. Blakey, USGS/CR  
T. Blejwas, SNL/Albuquerque  
M. Brodeur, SAIC/Las Vegas  
R. Bullock, RSN/Las Vegas  
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T. Chaney, USGS/Denver  
T. Conomos, USGS/WR  
J. Cook, USGS/SR  
R. Craig, USGS/Las Vegas  
✓ R. Dyer, DOE/YMPO/Las Vegas  
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N. Trask, USGS/Reston  
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YMP-USGS Local Records Center File 1.1.02

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REYNOLDS ELECTRICAL & ENGINEERING CO., INC.  
(REECO)

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT (YMP)

DECEMBER 1991 - STATUS REPORT

**SITE (1.2.3)**

**WBS 1.2.3.5**

**Task: LM-300 Drill Rig**

The LM-300 drill rig and pipe handling system, except the pipe handler arm, were delivered to the Area 6 Equipment Yard of the Nevada Test Site on December 18, 1991. Lang Exploratory Drilling requested and was granted an extension for the delivery of the pipe handler arm. Delivery and installation is scheduled for the week of January 13, 1992, to be completed no later than January 17, 1992.

**Task: Capital Equipment to support Drilling Programs**

Delivery of the air processing and metering system, awarded to Perry Equipment Corporation, is expected in March, 1992.

Held initial Technical Review Committee meeting to discuss the rotary all-terrain drill rig specification prepared by Raytheon Services Nevada.

**Task: USGS Hydrological Research Facility (HRF) Holes (Job Package [JP] 91-6)**

All work in support of HRF holes has been completed with the exception of instrumenting and stemming of UZP-3a, to be scheduled at a later date.

**Task: Neutron Access Holes (JP 91-9)**

UZ-N54 was completed at a total depth of 244.72 feet using the Joy 1 rig. Started rigging up on UZ-N37 utilizing the CME-550 rig on December 20, 1991. Operations were suspended on December 20, 1991 due to the holiday period and will resume on January 6, 1992.

**Task: JF-3 Water Monitoring Well (JP 92-1)**

A 13-inch hole was drilled to 523.04 feet, then opened to 15 inches and a depth of 403 feet. Operations were suspended on December 20, 1991 due to the holiday period and will resume on January 6, 1992. Casing, 13-3/8 inch, will be set at 500 feet, plus or minus 10 feet.

## **EXPLORATORY STUDIES (1.2.6)**

### **WBS 1.2.6.1**

#### **Task: Exploratory Studies Facility (ESF) Alternatives Study**

Continued to provide constructability support to activities to begin Tunnel Boring Machine operations and ESF Title I design. Received verbal comments from the Yucca Mountain Site Characterization Project Office (YMPO) on their review of the preliminary draft Request for Proposal.

## **FIELD OPERATIONS (1.2.7.4)**

### **Task: Administrative & Maintenance Support**

Continued support to W. A. Wilson, Yucca Mountain Site Manager to include: process purchase requisitions for Field Operations Center Site Office requirements; provide support services to participants and maintenance to YMP utilized facilities and roads in Area 25; and provide logistical and support services to management contractor.

Provided support for the Yucca Mountain Site Office open house and public tours. Three tours were held during this period: December 7, 1991, 350 people; December 11, 1991, 3 people; and December 17, 1991, 5 people. Support included but was not limited to: arrangements for buses, coordination of lunches/beverages, medical service, furniture, mechanical service, and grading of access road. Continued preparations for upcoming tours.

### **Task: Reactivate Well VH-1**

Continued use and maintenance of Well VH-1. Requested additional funding to provide water haulage through March 1992.

### **Task: Class III Sanitary Landfill**

Budget estimates and Title I review was completed and transmitted to the YMPO in November. No action on this task during this period.

## **PROJECT MANAGEMENT (1.2.9)**

### **WBS 1.2.9.1**

#### **Task: Site Characterization Plan (SCP) Distribution**

Distributed two SCP sets during December. Of the 196 address verification cards sent in November, the Local Records Center has received 25 responses. Individuals that do not respond will be permanently deleted from the SCP Master Distribution List.

Received 4,000 copies of Progress Report #4 and distributed over 3,000 copies.

Provided a quarterly report and SCP Master Distribution List to the YMPO.

### **Task: Long Range Planning (LRP)**

Continued support of LRP, Planning and Control System (PACS), and Performance Measurement Baseline activities to include: completion and submittal of LRP

and PACS input data sheets for Fiscal Year 1992 and outyears through license application; review of JP 92-1; completion of initiation of JP 92-2, Soil & Rock Properties; completion of data collection for input to JP 92-3; development and update of activity estimates and schedules; and completion of cost estimates as requested.

WBS 1.2.9.3

Task: Quality Assurance (QA)

Continued review, comment, and approval of various REECo implementing procedures, standard operating procedures, quality procedures (QPs), and purchase requisitions.

Continued work revising existing QPs and replacing documents with management control (MC) procedures. Distributed weekly matrix report to REECo/YMP departments for input on status of new procedures. Continued ongoing development of training sessions to be conducted as MC procedures are completed. Worked on developing a format for cross referencing QPs to MCs.

Worked on Corrective Action Response to CAR-91-001 from internal surveillance SR-REECo-022 of the Local Records Center.

Issued to controlled distribution, Quality Assurance Program Plan Change Notice, QAPPCN-91-01.

General

REECo has no reportable Level I or Level II milestone activities at this time.



**YUCCA MOUNTAIN PROJECT  
BIOLOGICAL RESOURCES PROGRAM  
MONTHLY PROGRESS REPORT  
DECEMBER 1991**

**Summary of Work Accomplished During Report Period**

EG&G Energy Measurements (EG&G/EM) conducted work for Ecology task (WBS 1.2.5.4.7) for the Project Office. Activities included conducting preactivity surveys; continuing site characterization effects studies, support studies for the radiological monitoring program, desert tortoise studies, and habitat reclamation studies; development of work instructions and study designs for new studies; and responding to requests by Project Office.

**Monitoring and Mitigation**

- Preactivity surveys were completed for the soil pits at Lathrop Wells Cinder Cone (#92-002); 15 soil test pits, one drill pad, and an access road at the North Portal Facility (#91-031d); 11 new USGS seismic stations (#1990-3228); and UZ-16 drill hole (#92-003). Survey reports were submitted to Project Office for each survey. Reclamation stipulations also were prepared and submitted to Project Office for the UZ-16 drill hole.
- A surveillance was conducted of activities at Well JF3 and the neutron boreholes. All activities were being conducted within the cleared areas as specified.
- The sites of the proposed USGS streamflow monitoring stations were visited to evaluate potential impact of construction.

**Habitat Reclamation**

- Ten EG&G/EM staff members received safety training for operating the tractor during reclamation studies.
- Native seeds were collected for use in reclamation trials.
- Disturbed habitat inventory data from 55 sites were entered into a computer database.
- A letter was sent to Project Office requesting site preparation work for two reclamation study trials.

## **Site Characterization Effects Studies**

- Traffic count data were collected at 9 locations. Counters were moved to new locations.
- Weather and soil moisture and temperature data were collected at all 48 ESPs.
- Vegetation density data continued to be entered into the computer database.
- The small mammal trapping program was reviewed, and revisions to the existing field procedures were started.

## **Radiological Monitoring Program**

- ✓ ● EG&G/EM (R. Green) met with SAIC (Kayce Prince) to discuss relocating several small mammal trapping plots for the Radiological Monitoring Program. New locations are being considered because of changes in location of the Exploratory Studies Facilities. Two relocations are being considered: moving plot 14 from the west to the east side of Exile Hill next to the north portal facility and moving plot 5 north of the sub-dock area to a site near the proposed south portal facility.
- Spotlight surveys for lagomorphs and predators were conducted at Yucca Mountain and in Crater Flats. Two jackrabbits were observed during three nights at Yucca Mountain. In Crater Flats, two jackrabbits, one cottontail rabbit, one coyote, and one kit fox were observed during three nights of surveys. This completes the winter surveys. The next spotlight survey will be conducted during summer 1992.
- Construction of the smoked (sooted) plates for recording impressions of predator tracks was completed. A preliminary test of the plates at the scent-stations was conducted. The soot withstood strong winds and light rain. Heavier rain did wash out the plates. Tracks of larger carnivores (e.g., coyotes) were relatively clear and distinct. Tracks of some smaller animals were more difficult to distinguish.
- The small mammal trapping program was reviewed, and revisions to the existing field procedures were completed.

### **Desert Tortoise Studies**

- The movements of desert tortoises that may be affected by trenching work at Exile Hill in January 1992 were summarized. This was done to identify tortoises that may need to be relocated or displaced away from this activity.
- ✓ ● Gene Ryder (YMPO) notified EG&G/EM that the Project Office will formally request that tortoise 423 be relocated away from Exile Hill in January 1992. EG&G/EM is waiting for formal notification before moving this tortoise.
- The analysis of desert tortoise movement and habitat use data collected during summer 1991 and soil samples collected at tortoise burrows was continued.
- Review and revision of procedure documents for relocating tortoises were started in preparation for trenching work at Exile Hill in January.
- Two radiomarked tortoises that had moved in late November were located twice each week during the first two weeks of December. These two tortoises have not moved since December 1. All other radiomarked tortoises have not moved since November 18 and were located once each week.
- Raven monitoring surveys were conducted twice during the second week of December and three times during the third week.

### **Support Items**

- Monthly report of November activities and accomplishments was submitted to Project Office.
- Weekly reports of activities were submitted to Project Office.
- EG&G/EM assisted with a tour of Yucca Mountain and NTS for DOE/State Representatives.
- EG&G/EM assisted with a display at Clark County Community College on opportunities in the field of Environmental Restoration.
- The results of the FY91 field work were presented to DOE/YMP.
- Preparation of the FY91 Annual Report was completed.