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Yucca Mountain Site Characterization Project

Monthly Activity Report

January 1994

Photograph: by Chris J. Lindberg

Attachment to LA-EES-13-05-94-001

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LOS ALAMOS NATIONAL LABORATORY

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Monthly Activity Report

January 1994

WBS 1.2.1 Systems Engineering

Objective

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.

Activities and Accomplishments

S. Levy submitted the final Los Alamos input on geochemical effects to Steve Saterlie of the M&O; he will incorporate this information in the thermal loading systems study he is preparing. This version includes references to Los Alamos YMP research relevant to the thermal loading issue.

Planned Activities

No planned activities reported.

WBS 1.2.3.1.1 Site Investigation Coordination and Planning/Site Management

Objective

The objective of this task is to manage and coordinate site characterization activities.

Activities and Accomplishments

Principal investigators (PI's) and management staff spent considerable time preparing for the upcoming 14-18 February Technical Program Review. Most PI's will have spent approximately one person-month on this review, which included the following activities: attending planning meetings; preparing view graphs, questions, answers, and matrices; preparing and presenting dry runs; and participating in the week-long review.

I. Triay, A. Meijer, and J. Mercer-Smith attended a meeting at YMPO to resolve comments on the study plan titled "Batch Sorption Studies and the Development of Sorption Models." All comments were resolved in a satisfactory manner.

Staff revised FY94 milestones and criteria statements and incorporated this information into the Planning and Control System.

Staff developed an estimate of the cost of inputting backlog data into the Technical Data Base.

Staff supported revision of the study plan titled "Kinetics and Thermodynamics of Mineral Evolution at Yucca Mountain, Nevada," SP 8.3.1.3.3.2.

Staff participated in a Geochemistry Integration Team teleconference to plan for the following upcoming events: February 1994 Technical Program Review, geochemistry white paper titled "The Essential Role of Geochemistry in Site Characterization and Performance Assessment at Yucca Mountain, Nevada," and model validation workshop titled "Validation of Geochemical Models for Performance Assessment.

Planned Activities

Staff will asses how milestones for FY94 were impacted by the time required to prepare for the Technical Program Review in the February upload of costs and schedules, which will be submitted on 15 March.

WBS 1.2.3.1.2/3 Site Investigation Coordination and Planning/ Test Management and Integration

Objective

The objective of this task is to manage and integrate Exploratory Studies Facility (ESF) and Los Alamos site characterization test activities and to provide coordination for Los Alamos surface-based test planning and package development.

Activities and Accomplishments

Surface-Based Testing. Staff represented the Test Coordination Office at weekly surface-based testing meetings and M&O work scope coordination meetings.

Staff continued to support activities pertaining to the use of tracers, fluids, and material at Yucca Mountain to the M&O and EG&G.

B. Carlos and A. Mitchell represented the principal investigators at the January Sample Overview Committee meeting.

Staff submitted technical and QA input for NRG-7A sampling requirements to support the Water Movement study (WBS 1.2.3.3.1.2.2) in the event that water is encountered during drilling operations.

ESF Testing. Staff provided day-shift field coordination and PI support for ESF north-ramp starter tunnel tests. Planning on the Phase III ESF tests was continued including the M&O test-to-test, test-to-construction, and waste-isolation evaluations. Staff continued to finalize planning packages for the radial borehole test.

Construction of the ESF starter tunnel alcove was almost complete. This activity is fully supported by geologic mapping, consolidated sampling, hydrochemistry, and construction monitoring test activities. No perched water was identified in the ESF.

Staff continued to finalize record packages that document the development of controlled documents that govern Phase II ESF field testing activities.

Planned Activities

Staff will continue to support Los Alamos surface-based site characterization and ESF test coordination activities in response to Project programmatic requirements.

Problem Areas

None

WBS 1.2.3.2.1.1.1 Mineralogy, Petrology, and Rock Chemistry of Transport Pathways

Objective

The purpose of this activity is to define the important mineralogical and geochemical variables along fracture and rock-matrix 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

Effective 1 January, D. Bish assumed the position of technical coordinator for Mineralogy-Petrology activities, and D. Vaniman assumed the position of principal investigator for the Transport Pathways study.

A paper for the 1994 International High-Level Radioactive Waste Management Conference titled "Inferences of Paleoenvironment from Petrographic, Chemical and Stable-Isotope Studies of Calcretes and Fracture Calcites," by D. Vaniman and J. Whelan (USGS) was submitted to YMP for review on 12 January.

B. Carlos performed SEM examination of oxide and silicate phases (hematite + a calcic amphibole) from lithophysal cavities in the Paintbrush Tuff.

Staff met in Los Alamos with A. Simmons (YMPO) and S. Nelson (M&O) to discuss the upcoming Technical Program Review. Staff prepared view graphs and wrote supporting material.

D. Vaniman and D. Bish met with A. Simmons on 12 January to discuss and modify the Geochemistry White Paper.

Twenty-four core samples to be used in geochemistry/sorption studies were prepared and x-rayed. A Rietveld refinement was conducted on a sample of the zeolite stellerite separated from sample UZ-16 1029.2/1029.5 to obtain an appropriate reference intensity ratio for use in quantitative x-ray diffraction analyses of the UZ-16 drill core samples, some of which contain stellerite.

Min-pet staff attended a presentation on the computer code FEHM given by B. Robinson of WBS 1.2.3.3.1.3.1. Subsequent discussion focused on the types of mineralogy-petrology data required for modeling the site and how best to provide the data to modelers.

Staff attended the annual Los Alamos YMP QA review and began training to all new QA procedures.

Planned Activities

Work planned for the coming months includes the following activities: (1) continue analysis of calcites to understand transport and precipitation mechanisms; (2) examine drill core from USW UZ-14 and USW UZ-7a as it becomes available at SMF; (3) complete analysis of XRD data on UE-25 UZ-16 drill core; (4) continue analysis of background dust mineralogy around Yucca Mountain, with possible additional sampling near drill sites; (5) continue characterization of trace minerals and continue microautoradiography experiments; (6) begin analysis of fracture coatings in UE 25 UZ-16 and USW UZ-14 core; (7) begin examination of fracture-coating samples from the starter tunnel; and (8) prepare preliminary report on fracture-lining minerals in USW UZ-14 when that hole is completed.

Problem Areas

None

Milestone Progress

3255
30 September 1994
Trace Mineral Study

3370
31 August 1994
Los Alamos report on Fracture Mineralogy of UZ-16

3371
30 June 1994
Los Alamos report Summarizing Fracture Mineralogy from Old Core

3372
29 April 1994
Los Alamos report on Quantitative Mineralogy in UZ-16

3373
14 January 1994
Paper on Paleohydrological Implications of Calcite Chemistry

4005
31 March 1994
Letter report on Fracture Mineralogy of UZ-14

4006
31 March 1994
Letter report on Quantitative Analysis of Hydrous Minerals

4007
23 December 93
Letter report on Temperature Calibration for Hazardous Minerals at Yucca Mountain
Completed.

4008
29 October 93
Convene Short Course on Health Hazards Fibrous Minerals
Completed.

4031
31 August 1994
Letter report on Silica Leaching and Porosity

Publications

B. Carlos, S. Chipera, and D. Bish
Distribution of Fracture-Lining Zeolites at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

B. Carlos
Field Guide to Fracture-lining Minerals
Addressing YMPO comments.

S. J. Chipera, D. L. Bish, and B. A. Carlos
Equilibrium Modeling of the Formation of Zeolites in Fractures at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

Publications (cont.)

G. D. Guthrie, D. L. Bish, and B. T. Mossman
Quantitative Analysis of Zeolite-Bearing Dusts Using the Rietveld Method
Journal article, *Science*
Submitted.

G. Guthrie, D. Bish, S. Chipera, and R. Raymond
Distribution of potentially hazardous phases in the subsurface at Yucca Mountain, Nevada
Los Alamos report
Addressing YMPO comments.

D. T. 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, *Clay and Clay Minerals*
In revision.

D. T. Vaniman
Calcite Deposits in Drill Cores USW G-2 and USW GU-3/G-3 at Yucca Mountain, Nevada
Los Alamos report
In Los Alamos publication process.

D.T. Vaniman and D. L. Bish
The Importance of Zeolites in a Potential High-Level Waste Repository at Yucca Mountain, Nevada
Proceedings paper, *Zeolite '93*
Approved by YMPO; addressing reviewers' comments.

WBS 1.2.3.2.1.1.2 Mineralogical and Geochemical Alteration

Objective

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

Staff spent considerable effort preparing for the upcoming DOE Technical Program Review in February. Camera-ready summaries of Alteration History research and examples of research results were supplied to the WBS element manager.

Additional sampling criteria for drill hole UE 25 NRG-7/7A were transmitted to the TCO to address special sampling needs if perched water is encountered in the hole. If gels are found in the recovered core, they have requested that samples be bagged and held for rapid pick up by the PI.

A paper titled "Dehydration and Rehydration of a Tuff Vitrophyre" by D. Vaniman, D. Bish, and S. Chipera was published in the *Journal of Geophysical Research* and was being distributed. In this paper, the dehydration of powders prepared from Topopah Spring lower vitrophyre glass was studied using thermogravimetric analysis (TGA) and isothermal heating at 50°, 100°, 200°, and 400°C for 3.4 years followed by 1.1 years of rehydration at high controlled humidity. The TGA studies showed a two-stage dehydration of the vitrophyre, with 67 to 75 percent weight loss occurring most rapidly at temperatures ranging from 278° to 346°C. The remaining water, about 1 percent, was lost only on second-stage heating to temperatures above 650°C. These dry-heating experiments provided an end-member characterization of glass transformations for comparison with water-saturated heating experiments in which glass alteration is prominent.

A fragment of Tiva Canyon tuff from the box cut at the ESF north ramp portal was examined using SEM to identify the tiny golden needle-like crystals in the cavities. B. Carlos identified the crystals as probable amphiboles based on energy-dispersive x-ray spectra. The study was part of a search for examples of the mineral rutile in Yucca Mountain samples.

W. Carey began separation and purification of clinoptilolite-rich tuff for thermodynamic experiments. The separates were then characterized using x-ray diffraction (XRD). He began cation exchange experiments of clinoptilolite separates with the goal of producing Na, K, and Ca end-members. After installing, testing, and calibrating the necessary apparatus, Carey began thermodynamic equilibration studies of clinoptilolite in controlled-humidity experiments on the TGA.

G. WoldeGabriel revised several papers this month in response to informal and formal review comments. Revisions in response to external review comments on his Zeolite '93 paper will require some additional XRD work.

Planned Activities

Staff will be training to the new QA procedures. They will attend the DOE Technical Program Review in Las Vegas on 14-18 February, at which PI will participate in a panel discussion at the program review. Characterization of materials utilized in the steam-atmosphere heating experiments, delayed by preparations for the program review, will begin. K/Ar studies and studies of alteration in the Paintbrush tuff, near-surface deposits, and ESF north ramp samples will continue.

Problem Areas

None

Milestone Progress

3022
30 September 1994
Letter report on Zeolite Synthesis

3150
30 April 1994
Final report on Bedrock

3223
30 September 1994
Letter report on Cristobalite Dissolution Kinetics

3376
31 March 1994
Los Alamos report on Mineralogy and Chemistry of Calcite-Silica

3377
30 September 1994
Report on Microscopic-Scale Chemical Transport in Zeolitic Alteration

3379
30 June 1994
Paper on Evaluating Use of K-Ar Dating on Zeolites

3380
30 September 1994
Paper on Effects of Saturation and Temperature on Ion Exchange

4010
30 September 1994
Letter report on Long-Term Heating of Zeolites and Glasses

4015
30 September 1994
Letter report on Zeolite System Model

Publications

D. L. Bish
Thermal Behavior of Natural Zeolites
Proceedings paper, Zeolites '93
Approved by YMPO.

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.

S. Levy and G. Valentine
Natural Alteration in the Cooling Topopah Spring Tuff, Yucca Mountain, Nevada, as an Analog to a Waste-Repository Hydrothermal Regime
Approved by YMPO.

D. Vaniman, D. Bish, and S. Chipera
Dehydration and Rehydration of a Tuff Vitrophyre
Journal article, *Journal of Geophysical Research*
Published.

Publications (cont.)

D. Vaniman, S. Chipera, and D. Bish
Pedogenesis of Siliceous Calcretes at Yucca Mountain, Nevada
Journal article, *Geoderma*
Accepted for publication.

WBS 1.2.3.2.1.2 Stability of Minerals and Glasses

Objective

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

Staff submitted requests for contracts with Penn State and Yale Universities to the Los Alamos procurement department, which is in the process of letting the contracts.

Staff received contractor reports, which are included in the Appendix, that will support development of the study plan. The study plan for this task was received by the TPO in December, and the milestones are being reconsidered to reflect recent planning. An update to the Project baseline is planned.

Planned Activities

Appropriate QA procedures will be delivered to Penn State and Yale and audit personnel will then visit both universities before quality-affecting work begins.

Problem Areas

None

WBS 1.2.3.2.5 Postclosure Tectonics

Objective

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

A talk titled "Identification and age of distal ashes from the Lathrop Wells volcanic center in fault exposures near Yucca Mountain" was presented by F. Perry at the Yucca Mountain Tectonics Workshop in Estes Park, Colorado. Perry introduced methods of identifying basaltic ashes in fault trenches near Yucca Mountain. He also discussed recent field, geochemical, and geochronological studies at the Lathrop Wells volcanic center in which the Volcanism group identified four major eruptive episodes, separated from each other by erosional unconformities or soil development.

A revised map of the Lathrop Wells center, showing four main eruptive episodes, was produced for inclusion in the *Volcanism Status Report.*

Field work at Scarp Canyon consisted of studying dike geometry and effects of dikes on wall rocks as part of subsurface effects studies. Staff collected samples from dikes and wall rock.

Staff spent one day at Lathrop Wells verifying field relationships.

Staff continued to analyze data obtained during field work at the Alkali Buttes analog centers in New Mexico.

Staff studied eruption accounts of the Paricutin volcano, located near Guadalajara, Mexico, to gain insight into eruptive processes from energetic scoria cones.

Work in Progress. Revision of the *Volcanism Status Report* continued. Work focused on revision of Chapters 2, 4, and 7. Completion of the report has been delayed until February so that new stratigraphic data on the Lathrop Wells center can be interpreted and modeling of the recurrence rate of volcanic events and simulation modeling of the probability of magmatic disruption of the proposed repository can be expanded.

Planned Activities

Continue work in all areas discussed above.

Problem Areas

None.

Milestone Progress

3075
30 November 1993
Preliminary Geologic Mapping of Pliocene Volcanic Centers of Crater Flat
Delayed to Spring 1994.

3238
30 September 1993
Frequency of the Occurrence of Quaternary Basalt in the Central Great Basin by Structural SET
Delayed; now part of Milestone 3422

3245
30 September 1994
Review of Geophysics Data for YM Region (M3)

Milestone Progress (cont.)

3396
31 March 1994
Revised Geologic Map Lathrop Wells Volcanic Center

3398
30 September 1994
Structural Controls of Sites of Basaltic Volcanism

3422
11 February 1994
Volcanism Status Report
Revised date because of an unanticipated number of NRC comments.

3395
29 July 1994
Preliminary Geologic Map of Quaternary Volcanic Centers of Crater Flat

3397
30 September 1994
Report on Geochemistry of Lathrop Wells Eruptive Sequence

4016
30 September 1994
Letter report on Lithic Fragment Studies (M4)

4017
30 September 1994
Progress report on Geochronology Studies (M4)

4018
30 September 1994
Letter report on evolving patterns of Volcanic Fields in the southwest USA

4020
30 September 1994
Letter report on Magma System Dynamics

4033
30 September 1994
Letter report on Spatial Scales of Hydrothermal Processes

T055
30 September 1994
Revised Probability Calculations

Publications

B. M. Crowe et al.
Volcanism Status Report
First draft in technical review; resolving NRC comments.

B. M. Crowe et al.
Simulation Modeling of the Probability of Magmatic Disruption of the Potential Yucca Mountain Site
Conference paper, *Focus '93 proceedings*
Approved by YMPO.

Publications (cont.)

G. Valentine et al.
Effects of Magmatic Processes on the Potential Yucca Mountain Repository: Field and Computational Studies
Conference paper, *Focus '93 proceedings*
Approved by YMPO.

WBS 1.2.3.2.8.1 Rock-Varnish Dating Support for USGS Neotectonic Studies

Objective

This activity will provide rock-varnish dating support in various areas of surface site characterization activities including erosion, neotectonics, and paleoclimate.

Activities and Accomplishments

C. Harrington made a presentation titled "Analysis of Erosionally Enhanced Scarps Associated With Faults in Crater Flat, Nevada" at the Tectonic Workshop in Estes Park, Colorado, sponsored by the USGS.

Cosmogenic dating samples continued to be analyzed at the AMS Facility at the University of Arizona. Facility staff refined the sample processing procedure before they extracted cosmogenic 14-C.

Planned Activities

No planned activities reported.

Problem Areas

A great deal of time was spent preparing for the NRC site visit, in which staff explained the technical basis for the recent topical report on extreme erosion ("Evaluation of the Potentially Adverse Condition 'Evidence of Extreme Erosion during the Quaternary Period' at Yucca Mountain"). Several days were spent laying out the trip stops and preparing discussions and illustrations to be used in field presentations. Staff also had to prepare sample location maps and have data inputted into the DOE database system so that these maps could be generated. This additional work did have an impact on the scarp study.

Milestone Progress

4035
30 September 1994
Letter report on FY94 Fault-Scarp Studies

Publications

C.D. Harrington, J.W. Whitney, A.J.T. Jull, and G.S.Burr
Preliminary Analysis of Erosionally Enhanced Scarps Associated With Faults in Crater Flat, Nevada (Abstract)
EOS Transactions of the AGU, V. 74, p. 403
Published.

S. Reneau
Maganese Accumulation in Rock Varnish in a Desert Piedmont, Mojave Desert, California, and Application to Evaluating Varnish Development
Journal article, *Quaternary Research*
(V. 40, p. 309-317, November 1993)
Published.

WBS 1.2.3.3.1.2.2 Water-Movement Tracer Tests

Objective

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

Staff continued to thoroughly reviews notebooks and logbooks containing all chlorine-36 and halide analyses obtained to date, in preparation for closing out these documents.

HydroGeoChem completed processing a suite of 17 water samples from the saturated zone, plus four samples from the alluvium at UZ-16. Five of these samples were submitted to LLNL for chlorine-36 analysis.

The PI provided input for the Technical Program Review meetings planned for the week of 14 February.

The PI trained to 13 new QA procedures.

Planned Activities

Revise existing DPs; prepare new DPs; process soil samples for Cl/Br and chlorine-36/Cl ratios; process cuttings samples from UZ-16, UZ-14 and neutron-access boreholes; participate in planning activities for sample collection from ESF; collect additional soil samples from Yucca Mountain area as opportunities arise.

Problem Areas

The ion chromatography system continued to be plagued by problems preventing the acquisition of low-level bromide analyses.

Milestone Progress

3417
30 September 1994
Progress report on Cl-36 Analysis

Publications

J. Fabryka-Martin
Distribution of Chlorine-36 in the Unsaturated Zone at Yucca Mountain: An Indicator of Fast Transport Paths
Conference paper, *Focus '93 Proceedings*
Addressing YMPO comments.

WBS 1.2.3.3.1.2.5 Diffusion Tests in the ESF

Objective

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

The task is deferred because of lack of funding.

WBS 1.2.3.3.1.3.1 Site Saturated Zone Ground-water Flow System (Reactive Tracer Testing)

Objective

Experiments will be conducted at the C-Well complex (holes UE-25c #1, UE-25c #2, and UE-25c #3) and other wells in the vicinity of Yucca Mountain using reactive tracers to characterize retardation and transport properties at a larger scale than currently used in laboratory experiments.

Activities and Accomplishments

Software QA. B. Robinson continued his duties as CCB Chair, and Z. Dash continued to serve as a member of the CCB. The current version of FEHMN, which contains all input/output routines and the new solute transport module, was placed in the Configuration Management System.

Colloid Transport. Staff completed the final microsphere tracer experiments and began modeling the results. They are now investigating methods for measuring the aperture distribution and will attempt several techniques to determine the gap width as a function of position. These techniques include: (1) measuring the two rough surfaces of the fracture using noncontact (laser) or contact (stylus) methods and (2) creating a silicone rubber casting of the void space.

B. Robinson attended various meetings and prepared a presentation for the upcoming DOE Technical Program Review.

Planned Activities

Contribute to the SQA effort by serving as CCB Chair.

Continue work on the FEHMN user's manual.

Continue modeling studies using FEHMN to support the design of the field tests.

Begin lithium column sorption experiments.

Begin aperture characterization measurements for the C-Wells fracture specimens.

Problem Areas

None

Milestone Progress

3247
30 September 1994
Characteristics of Reactive Tracers Polystyrene Micro (M3)

3249
3 January 1994
Column Sorption Experiments with Li (M3)

4029
30 September 1994
Letter report, *Input to Tpp/Jp*

Publications

B. A. Robinson
FRACNET—Fracture Network Model for Water Flow and Solute Transport
Los Alamos report
In preparation.

B. A. Robinson
SORBEQ—A One-Dimensional Model for Simulating Column Transport Experiments
Los Alamos report
Approved by YMPO; in Los Alamos publication process.

B. A. Robinson
A Strategy for Validating a Conceptual Model for Radionuclide Migration in the Saturated Zone Beneath Yucca Mountain (3201)
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

P. Reimus
Transport of Synthetic Colloids through Single Saturated Fractures: A Literature Review
Los Alamos report
Approved by YMPO.

P. Reimus
Transport of Synthetic Colloids and a Nonsorbing Solute through a Saturated Natural Fracture
Conference abstract, ACS Symposium
Approved by YMPO.

W. L. Polzer and E. H. Essington
The Use of Selectivity Coefficients to Estimate Modified Langmuir Isotherm Parameters as a Function of Experimental Conditions
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

WBS 1.2.3.4.1.1 Ground-water Chemistry Model

Objective

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

Activities and Accomplishments

No significant activities reported this month.

Planned Activities

No planned activities reported.

Problem Areas

None

Milestone Progress

3006
31 May 1994
pH and Eh Buffering at Yucca Mountain

4014
31 May 1994
Letter report on Most-active Ground-water Chemistry
(input to Milestone 3349 [Dynamic Transport])

4032
30 September 1994
Letter report on Most Critical Groundwater Parameters and Sorption Studies

Publications

None

WBS 1.2.3.4.1.2.1 Batch Sorption Studies

Objective

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

Staff completed a set of batch sorption experiments (under atmospheric conditions) to study the sorption of Np onto surface-based materials obtained from Yucca Mountain. They pretreated the solid phase (ground and dry-sieved to obtain particles in the 75–500 μm range) with the groundwater from Well J-13 and separated the pretreated solid phase using centrifugation. The solids were then equilibrated with a solution of Np and J-13 water; the initial concentration was 7×10^{-7} M. Following sorption, the phases were again separated using centrifugation, and the amount of ^{237}Np in each phase was determined using liquid scintillation counting. (The liquid scintillation counting technique used is capable of discriminating alpha from beta activity; consequently no interference from the ^{237}Np daughter [^{233}Pa] was expected.) The results of these experiments may be seen in Table I.

Table I. Np Sorption onto Surface-Based Materials

Solid Phase	Origin	Kd (ml/g)	Surface area, m^2/g
T-14.1	Near survey marker 315 North (white layer)	3×10^3	2.5×10^1
TO-14.2	Near survey marker 315 North (brown layer)	7×10^2	4.5×10^0
T-14.3	Near surface (white layer)	2×10^3	8.9×10^0
TO-14.4	Near surface (brown layer)	3×10^2	3.2×10^0
T-14.5	At survey marker 295 South (white layer)	6×10^3	2.8×10^1
TO-14.6	At survey marker 295 South (brown layer)	4×10^2	1.1×10^1
ESFM-1	Material in rubble pile from ESF main tunnel.	2×10^1	4.2×10^1
NRT-2.1	White and black material from North wall at survey 5/0	2×10^1	2.7×10^0
NRT-2.2	White layer from South wall	2×10^3	5.3×10^0
NRT-2.3	Fracture coating from South wall, Near survey marker West, (10 feet from center)	2×10^3	3.2×10^1
NRT-2.4	From South wall	3×10^1	4.1×10^1
NRT-2.5	At survey marker 12 (~ 20 feet deep)	2×10^1	9.0×10^0
NRT-2.6	Layer of fracture (15 feet from center of trench)	3×10^3	4.0×10^1
NRT-2.7	From lower bedding plain, Near survey marker 0/0	2×10^1	1.5×10^1
NRT-2.8	From upper bedding plain, (~ 30 feet deep), near survey marker 0/0	2×10^1	2.3×10^0

The samples designated by T-14 or TO-14 are from Trench 14; the samples designated by NRT-2 are from the North Ramp Trench, and the sample designated by ESFM originates from the ESF muck pile (material from the excavation activities at the ESF main tunnel). The samples from Trench 14 were separated into two parts: one is mainly the white portion of the material (T-14), and the other is the brown portion of the material (TO-14). The TO designation was made because the brown material was thought to be opal.

Large Np sorption distribution coefficients (in the range of 20–3,000 ml/g) for the materials may be seen in Table I. Preliminary XRD analyses indicates that most of the highly sorbing materials were composed primarily of calcite, which may be causing these large coefficients. Batch sorption experiments (in J-13 at initial Np concentrations of 7 x 10^{-7} M) using synthetic calcite with surface areas of ~ 0.1 m^2/g yielded sorption coefficients of 50 ml/g. Batch sorption experiments (in J-13 and a Np initial concentration of 7 x 10^{-7} M) using natural calcite (dry-sieved to obtain particles in the 75–500 μm range) with surface area of ~ 0.6 m^2/g yielded sorption coefficients of 1,000 ml/g. These results appear to indicate that Np can be retarded by calcite in the fractures of the tuff at Yucca Mountain. An immediate correlation between surface area and magnitude of the sorption coefficients cannot be made based on the results to date. However, once XRD analyses of these samples are completed and they know (with a greater degree of certainty) which samples are mainly calcite, staff will attempt to make this correlation.

Planned Activities

Continue work in all areas discussed above.

Problem Areas

None

Milestone Progress

3218
30 September 1993
Effects of Water-Rock Ratios on Sorption Coefficients
Internal technical review completed, and comments are being addressed.

3338
30 September 1994
Interim report on Radionuclide Sorption/Whole Rock M3
Internal review completed.

3345
30 September 1993
Neptunium Sorption onto Feldspar
Internal technical review completed.

3346
30 September 1993
Sorption as a Function of Temperature
Internal technical review completed, and comments are being addressed.

3393
30 September 1994
Report on the Effects of Organic Coatings on Radionuclide Sorption

3394
30 September 1994
Report on Influence Sure Pre-reaction on Sorption Properties of Minerals

Publications

M. Kholer, B. D. Honeyman, and J. O. Leckie
Uranyl Interactions in the Goethite /Solution Interface Region: Formation of Binary and Ternary Surface Complexes
Journal article, *Geochemica*
(Milestone 3345)
In preparation.

M. Kholer, B. D. Honeyman, A. van Geen, and J. O. Leckie
Neptunium(V) Sorption on Hematite in Aqueous Suspension: Effects of Carbonate and EDTA
Journal article, *Geochemica*
In preparation.

WBS 1.2.3.4.1.2.3 Sorption Models

Objective

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

Activities and Accomplishments

Staff reviewed a preprint of a paper describing hematite reactions in water and acid solutions, as observed by STM/AFM. The results for reactions of goethite in water presented in this paper are entirely different those obtained in this study. In particular, the reactions of hematite seem to follow the classic model of dissolution at step edges and gradual enlargement of etch pits. This behavior has also observed for calcite and quartz. In contrast, results for goethite obtained by staff in this study show immediate disordering of the entire surface on contact with water.

The staff believes that they can explain this discrepancy by pointing to the differences in the crystal structures of calcite and hematite versus goethite, and on the nonreversibility of structural changes due to hydrolysis of iron on the goethite surface. It is obvious that the reactions of goethite surfaces do not follow standard models.

Planned Activities

Staff plans AFM characterization of several more grains of the magnetite they received from the Mineralogy/Petrology task. They will attempt to break some of the grains to expose fresh surfaces, which will be examined for the presence of natural surface coatings. Following this, staff will observe their reactions with water and compared the reactions to those of freshly cleaved mineral surfaces.

Problem Areas

None

Milestone Progress

3347
30 September 1993
AFM Analysis of Hematite and Goethite
In preparation.

3038
30 September 1994
Report on Sorption Models (M3)

Publications

M. Hawley and P. Rogers
Surface Reactions of Goethite Observed by AFM
Conference abstract, Materials Research Society meeting
Approved by YMPO.

WBS 1.2.3.4.1.2.2 Biological Sorption and Transport

Objective

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 micro-organisms capable of utilizing drilling fluids as growth substrates are of special interest.

Activities and Accomplishments

This work has been deferred because of lack of funds.

WBS 1.2.3.4.1.3 Radionuclide Retardation by Precipitation Processes

Objective

The objective of the solubility determination task is to determine the solubility 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

Speciation. Staff performed additional modeling of Np(V) hydrolysis to test the nonlinear least-squares method for fitting hydrolysis constants from potentiometric data. They explored the possibility of examining the potentiometric and spectrophotometric titration of Np(V) using a guided-wave spectrometer; if this type of system can be made operable, a far more accurate determination of Np(V) hydrolysis should be possible.

Oxygen-17 NMR spectra were obtained at 68 MHz for Np(V) and Np(VI) aquo ions at several different concentrations; the oxygen resonances were readily observable, which suggests that oxygen NMR may be able to be used to examine the hydrolysis reactions of Np(V). (Staff members still have some concern, however, about the accuracy of the titration when they measure the amount of free acid in the Np(V) stock solutions. They believe that they can prepare the well-characterized $NaNpO_2CO_3$ solid and dissolve this solid in a standardized acid solution in order to solve this problem.)

Staff used the Raman spectrometer to obtain corroborative speciation data for "yl"-actinide compounds (e.g. NpO_2^+ species). This system was tested on the well-understood UO_2^{2+}-carbonate system, in which the uranyl stretching frequency was observed to shift from 812 cm^{-1} (monomer) to 832 cm^{-1} (trimer). These resolvable peaks (peak widths = 13 cm^{-1}) imply that Raman spectroscopy can be used in conjunction with their other spectroscopic techniques to obtain highly defendable, consistent thermodynamic equilibrium constants.

Staff requested an official QA-approved version of EQ3/6 modeling software from T. Wolery.

Solubility. LBL staff continued the Np, Pu, and Am solubility experiments in 0.1 M $NaClO_4$. The Np and Pu solutions were assayed twice, and the Am solutions were assayed once. The Np solutions showed no significant changes, and the pH 7 solution appeared to have stabilized at $(1.95\pm0.59)\times10^{-4}$ M. In order to accurately assess the final steady-state concentration of this solution, staff will continue to monitor it for another 60 days. The Np concentrations of the pH 6, 7, and 8.5 solutions are $(3.95\pm0.12)\times10^{-3}$ M, $(1.95\pm0.59)\times10^{-4}$ M, and $(1.16\pm0.04)\times10^{-5}$ M, respectively.

With regard to the Pu solutions, the pH 7 and 8.5 solutions have remained virtually constant since days 53 and 32, respectively. However, it is not apparent that the pH 6 solution has showed a downward trend since day 32. The decreases seen with each assay have been small, but since day 32 the concentration has dropped nearly an order of magnitude. The Pu concentrations in the pH 6,7, and 8.5 solutions are $(4.91\pm0.30)\times10^{-8}$ M, $(4.51\pm0.28)\times10^{-8}$ M, and $(3.13\pm0.20)\times10^{-7}$ M, respectively.

The results of the latest assays taken for the Am/Nd solutions showed a slight decrease in concentration in the pH 6 and 7 solutions and a large decrease in the pH 8.5 solution. The pH 6 and Am/Nd solution has showed slight decreases with the last three assays, which could indicate a downward trend. However, the overall decrease in concentration is relatively small, and the pH 6 solution still appears to be at steady state. The pH 7

Activities and Accomplishments (cont.)

solution has shown slight fluctuations since day 64, but it appeared to have reached steady state. The pH 8.5 solution decreased by half an order of magnitude with the latest assay; this significant decrease could indicate that steady state has not been achieved. Furthermore, the Am/Nd concentration of the pH 8.5 solution was approaching the limit of detection of our γ-counting system. The Am/Nd concentrations in the pH 6, 7, and 8.5 solutions are $(4.91 + 0.26) \times 10^{-6}$ M, $(2.02 + 0.11) \times 10^{-7}$ M, and $(8.93 + 3.32) \times 10^{-11}$ M, respectively. Staff continued to monitor all solutions to ensure that steady-state conditions were reached, and they hope to be able to conclude these experiments within the next 45–60 days.

Staff began to calculate the average steady-state concentrations for the nine solutions. Table I summarizes these preliminary results. The averages reported in Table I were calculated as follows:

pH	Number of Assays Averaged
Np pH 6	average of last 4 assays
pH 7	average of last 4 assays
pH 8.5	average of last 11 assays
Pu pH 6	average of last 5 assays
pH 7	average of last 7 assays
pH 8.5	average of last 9 assays
Am/Nd pH 6	average of last 9 assays
pH 7	average of last 7 assays
pH 8.5	average of last 6 assays

The errors reported in Table I are determined from the standard deviation of the data. The results in Table I are strictly preliminary as some of these solutions have not reached "steady-state."

Table I. Average steady-state concentrations for the 0.1 M $NaClO_4$ experiment (preliminary results)

Nuclide	pH	Average Concentration (M)
Np-237	6	$(3.76\pm0.14)\times10^{-3}$
	7	$(1.87\pm0.14)\times10^{-4}$
	8.5	$(1.53\pm0.19)\times10^{-5}$
Pu-239	6	$(7.20+1.85)\times10^{-8}$
	7	$(5.93+0.74)\times10^{-8}$
	8.5	$(4.21+0.82)\times10^{-7}$
Am-241/ Nd	6	$(8.09+2.81)\times10^{-6}$
	7	$(3.27+1.42)\times10^{-7}$
	8.5	$(3.29+1.93)\times10^{-10}$

Staff continued to closely monitor the pH of each solution. The pH 8.5 solutions have remained relatively stable at their target pH, and have only required adjustment two or three times during the past month. The pH 6 and 7 solutions continue to be stable at their target pH, requiring minimal adjustment.

At Los Alamos, W. Efurd continued formal YMP training, technical reading, and preparation of purchase requests in support of the YMP program. The PEEKROD equipment arrived, and this will enable the fabrication of the reaction vessels and the constant temperature block.

Planned Activities

Continue all work discussed above.

Problem Areas

None

Milestone Progress

3344
30 September 1993
Report on Comparison of Solubilities of Np, Am, and Pu Between J-13 and UE-25p #1 Waters
Completed.

3350
30 September 1993
PAS Analysis of Pu(IV) Carbonate Systems
Completed.

3351
30 September 1993
Carbon-13 and Oxygen-17 Binding Constant Studies of Uranyl and Neptunyl Carbonate Complexes in Near-neutral Solution
Completed.

Milestone Progress (cont.)

3411
30 September 1994
Report on Solubility of Np, Pu, Am in Neutral Solutions

3412
30 September 1994
Report on Solubility Comparison of Np, Pu, Am from Undersaturation

3413
30 September 1994
Report on Np Speciation by NMR and Optical Spectroscopy

4025
30 September 1994
Letter report on Thermochemical Data on Actinides

4026
30 September 1994
Letter report on Status of Pu(IV) Colloid

Publications

D. L. Clark, D. E. Hobart, P. D. Palmer, J. C. Sullivan, and B. E. Stout
Carbon-13 NMR Characterization of Plutonyl(VI) Aqueous Carbonate Complexes
Journal article, *Inorganic Chemistry*
Submitted.

D. L. Clark, C. D. Tait, D. E. Morris, D. E. Hobart, S. A. Ekberg, and P. D. Palmer
Actinide(IV) and Actinide(VI) Carbonate Speciation Studies by NMR and PAS Spectroscopies
Los Alamos report
Approved by YMPO.

D. L. Clark, J. G. Watkin, D. E. Morris, and J. M. Berg
Molecular Models for Actinide Speciation
Los Alamos report
Approved by YMPO.

D. L. Clark et al.
Carbon-13 NMR Kinetics and Ligand Exchange Dynamics of Actinyl(VI) Carbonate Complexes in Aqueous Solution
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

D. L. Clark and P. Palmer
Oxygen-17 and Carbon-13 NMR Studies of Uranyl and Neptunyl Carbonate Complexes in Near-neutral Solution
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

D.L. Clark, P.D. Palmer, T.W. Newton, and W. D. Zwick
^{17}O and ^{13}C NMR Binding Constant Studies of Uranyl Carbonate Complexes in Near-neutral Aqueous Solution
Journal article, *Inorganic Chemistry.*
In preparation.

Publication (cont.)

C. D. Tait, D. E. Morris, J. M. Berg and W. H. Woodruff
Evaluation of Alternative Detection Schemes in Photoacoustic Spectroscopy
Journal article, *Reviews of Scientific Instrumentation*
Approved by YMPO.

C. D. Tait, S. A. Ekberg, P. D. Palmer, and D. E. Morris
Plutonium (IV) Carbonate Speciation Changes
Journal article, *Inorganic Chemistry*
In internal review.

C. D. Tait et al.
Speciation of Neptunium(V) Carbonate as a Function of Temperature Using Absorption Spectroscopies
Conference abstract, *Fourth International Conference on Chemical and Migration Behavior (Migration '93)*
Published.

WBS 1.2.3.4.1.4 Radionuclide Retardation by Dispersive, Diffusive, and Advective Processes

Objective

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

In collaboration with J. Conca of Washington State University, staff conducted experiments to validate the use of batch sorption coefficients to predict the transport of radionuclides under unsaturated conditions through solid tuff columns. Earlier this fiscal year, staff reported results of batch sorption experiments at Los Alamos (October 1993 Los Alamos Monthly Activity Report). In these experiments, the tuff was crushed and sieved, the Se solution was placed in contact with the sieved tuff, the phases were separated using centrifugation, and the amount of Se in each phase was determined using ICP-MS. For completeness, these previous results are presented in Table I.

Table I. Selenium Data for Unsaturated Transport Experiments in Nonwelded Zeolitic Tuff (tuff from the same vicinity as that used in column experiments)

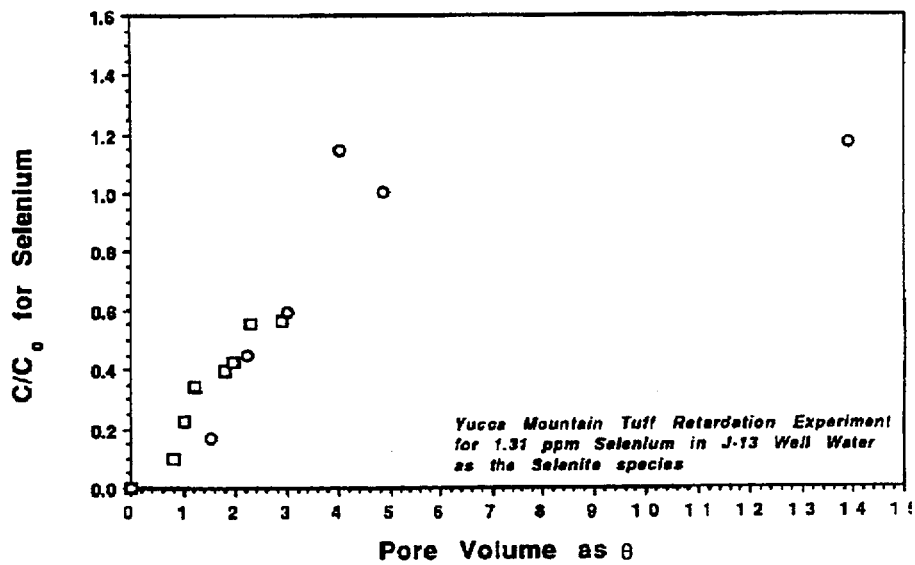
Water type	J - 13
Length of contact	26 days
pH of Water after contact	7.7 - 8.3
Tuff particle size	75 - 500 microns
Temperature	20°C
Selenium concentration	1.4 ppm

Sorption Coefficients

		Kd (ml/g)			
TUFF SOURCE		Trial #1	Trial #2	Trial #3	Trial #4
	Average K_d				
Tunnel 5 (dry sieved)	15.5	16.1	12.6	13.4	1E+01
Tunnel 5 (wet sieved)	14.1	15.3	9.6	12.9	1E+01

Conca's group fabricated columns of solid tuff from the same vicinity as that used in batch experiments. They measured transport of Se through the unsaturated columns using an unsaturated flow apparatus (UFA), an ultracentrifuge with a constant, ultralow-flow-rate pump that provides fluid to the sample surface through a rotating seal assembly and microdispersal system. In the UFA, the effluent is collected in a transparent volumetrically calibrated container at the bottom of the sample assembly, and the fluid driving force is centripetal acceleration. For this 9-day experiment, the UFA rotation speed was set at 2,000 rpm with a flow rate of 0.2 ml/hr into each sample. Fig. 1 shows the breakthrough curves for selenite in Yucca Mountain vitric tuff at 62.6 percent saturation, and for zeolitic nonwelded tuff at 52.8 percent saturation. The experiment was stopped before full breakthrough in the zeolitic nonwelded tuff was reached. The retardation factor for each tuff sample is only 2.5, which results in a K_d of 0.94 ml/g for the Yucca Mountain vitric member and 0.79 ml/g for the zeolitic nonwelded tuff. The unsaturated hydraulic conductivity for each sample was 2.49×10^{-8} cm/s for the vitric tuff and 1.16×10^{-8} cm/s for the zeolitic tuff.

UFA Column Breakthrough Curves for Selenite



o Yucca Mountain vitric member (1.54 g/cc; 62.6% saturated; K= 2.49×10^{-8} cm/s)
□ Zeolitized non-welded tuff from G-TUNNEL (1.21 g/cc; 52.8% saturated; K= 1.16×10^{-8} cm/s)

Staff did not observe the same results for batch and the column experiments using zeolitic tuff (from the same vicinity as the tuff used in the column experiments); consequently, they decided to repeat the batch sorption experiments using zeolitic tuff from the exact location as that used in the column experiments. They also suspected that the reason for the extremely limited retardation observed in the column experiments was caused by the high Se concentration. Table II summarizes the batch results obtained using J-13 water and wet-sieved nonwelded zeolitic tuff (with a particle size in the range from 75 to 500 μm) at 20°C.

Table II. Selenite Data for Unsaturated Transport Experiments in Nonwelded Zeolitic Tuff (using tuff from the same location as the tuff used for column experiments)

Initial Se Concentration ppm	Pretreatment Period, Days	Sorption Period, Days	pH after Sorption	Kd (ml/g)
1.1	6.9	0.04	8.4	-0.2
1.1	6.9	0.04	8.4	0.3
1.1	6.8	13.9	8.5	0.0
1.1	6.8	13.9		0.2
0.5	6.8	13.9	8.6	4
0.5	6.8	13.9		3
0.4	6.8	13.9	8.3	20
0.4	6.8	13.9		10
0.02	6.8	13.9	8.3	40
0.02	6.8	13.9		30

Inspection of Table II and Fig. 1 indicates agreement between the column and the batch sorption results. At an Se concentration of ~ 1 ppm, no sorption of the Se by the tuff is observed (for the zeolitic tuff used for the column and batch experiments in Table II). The reason for the discrepancy between the results presented in Table I and the column results is most likely the difference in the mineralogy of the samples. Another possible cause could be the long sorption time in the batch experiments in Table 1 vs. the shorter contact time between Se and the tuff in the column experiments. The sorption results in Table II (as a function of time) are identical, within experimental error. The kinetics of sorption are generally fast, and Se sorption onto tuff appears to be no exception; consequently, slow kinetics of Se sorption does not appear to be the reason for the discrepancy. Inspection of Table II also indicates that Se sorption is nonlinear with concentration; consequently, the use of a K_d obtained at the same initial concentration as the one used for the column experiments provides a conservative estimate of the Se retardation in tuff.

Planned Activities

Work in all areas mentioned above will continue.

Problem Areas

None

Milestone Progress

3041
30 September 1994
Report on Kinetics of Sorption on Crushed Tuff Colloids

3349
30 September 1993
Summary report on Np Transport through Yucca Mountain Tuffs
In internal technical review.

3383
30 September 1994
Progress report on Colloid-facilitated Radionuclide Transport

3414
30 September 1994
Effect of Fracture Coatings on Radionuclides Transport

3415
30 September 1994
Report on Validation of Batch Sorptions Kds for Radionuclide Transport in Porous Media

4032
30 September 1994
Letter report, *Most Critical Groundwater Parameters Sorption Studies*

4034
30 September 1994
Letter report on Diffusion of Non-Conservative Tracers/Tuff

Publications

J. Conca
Measurement of Unsaturated Hydraulic Conductivity in Yucca Mountain Tuff (3044)
Conference paper, *Focus '93 Site Characterization and Validation*
Published.

A. Meijer
Far-Field Transport of Carbon Dioxide: Retardation Mechanisms and Possible Validation Experiments
Conference paper, *Focus '93 Site Characterization and Validation*
Approved by YMPO; submitted to the American Nuclear Society for publication.

WBS 1.2.3.4.1.5.1 Retardation Sensitivity Analysis

Objective

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 assessable environment.

Activities and Accomplishments

Integrated Transport. Staff began modeling two-dimensional cross sections (antler ridge) using Np K_ds provided by I. Triay of the Sorption task (WBS 1.2.3.4.1.2.1). They investigated the sensitivity of each layer of the model to the K_ds Triay provided, and they identified a problem with the boundary condition on east side of Yucca Mountain when a higher flow (0.3 mm/yr) is used.

Staff constructed a model of Cl-36 with the same cross section described above and produced a steady-state flow field with low and high infiltration rates. Some evidence of lateral flow was apparent when the higher flow was used.

Code Optimization. FEHM was installed in the Configuration Management System. The memory-managed version of the code has passed all the comparison tests with earlier versions.

The mountain-scale model was reproduced with the new version of FEHM.

Staff continued working on GZSOLVE, the equation solver application. They found that reconfiguration was taking more effort than anticipated. The one-degree-of-freedom part is now working and tested. The two-, three-, and four-degrees-of-freedom parts will be tackled next.

Planned Activities

Staff will continue transport simulations with flow fields obtained from the simulations described above. Staff will update the K_d information with the latest results from I. Triay of the Sorption task.

Problem Areas

None

Milestone Progress

3355
30 September 1993
Site-Scale Simulations of Flow and Transport at Yucca Mountain
Delayed; video completed, text in preparation.

3416
30 September 1994
Report on 3D Integrated Transport at Yucca Mountain

4028
31 March 1994
Certification of Multi-use Matrix Solver GZOLVE
Delayed because of redesign requested by the M&O.

Publications

K. Birdsell, K. Eggert, and B. Travis
Three-Dimensional Simulations of Radionuclide Transport at Yucca Mountain
Journal article, *Radioactive Waste Management and the Nuclear Fuel Cycle - Special issue on the Yucca Mountain Project*
Approved by YMPO; accepted for publication.

WBS 1.2.3.4.1.5.2 Demonstration of Applicability of Laboratory Data

Objective

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

Staff continued to prepare the study plan

Planned Activities

Staff will continue to develop the study plan outline.

Problem Areas

None

Milestones

3419
30 September 1994
Report on Criteria for Yucca Mountain Field Test (M3)

WBS 1.2.3.9.7 Special Studies: ESF Test Coordination

Objective

The objective of this task is to manage and integrate ESF testing activities. This is accomplished by the development of test planning and Field Work Activation Job Packages for each scheduled ESF test activity.

Activities and Accomplishments

ESF Testing. Staff provided day-shift field coordination and PI support for ESF North Ramp starter tunnel tests. Planning on the Phase III ESF tests continued, including support for the M&O test-to-test, test-to- construction, and Waste Isolation Evaluations. Finalization of the planning packages for the Radial Borehole test continued.

The construction of the ESF starter tunnel alcove to support testing was completed. The activity is fully supported by geologic mapping, consolidated sampling, hydrochemistry, and construction monitoring test activities; no perched water was identified in the ESF. Geologic mapping was completed in the starter tunnel and information was used to determine the alignment of the borehole to be drilled in the alcove. Drill set for air-coring the alcove test boreholes was initiated.

Staff completed planning and field preparation for a laser-induced breakdown spectroscopy (LIBS) activity to be conducted in conjunction with the hydrochemistry drilling activity being conducted in Test Alcove #1. The activity will provide scoping information on elements present in the dust stream resulting from the air-coring operations.

Record packages for the development of controlled test planning and field work activation job packages that document Phase II ESF testing field activities were completed and submitted to YMPO. Work continued on assembling field document records center files for activities conducted in the starter tunnel.

Planned Activities

Continue support of ESF test coordination site characterization activities in response to Project programmatic requirements.

Problem Areas

None

WBS 1.2.3.11.3 Geophysics: ESF Support, Subsurface Geophysical Testing

Objective

The objectives of these tasks are to integrate ESF support, geophysics activities, and conduct subsurface geophysics instrumentation development and survey services.

ESF Test Coordination Staff began to develop specifications and a procurement action by the LLNL support group for ESF geophysical logging equipment. This includes a borehole color video, four-arm caliper, and neutron-logging tools, including the necessary support equipment. The equipment will be fielded to support drilling activities being conducted in ESF Alcove #1.

Staff provided LIBS experiment design & test related input for the field scoping activity planned for deployment during the ESF air coring to be conducted in ESF Alcove #1 in conjunction with the ESF hydrochemistry test. LIBS System components were assembled and tested in the Laboratory in preparation for deployment at the ESF in February. Necessary YMPO training was completed, and a site safety permit was obtained.

Planned Activities

Staff will continue support of ESF site characterization test activities related to geophysics in response to Project programmaticrequirements.

WBS 1.2.5.2.2 Site Characterization Program

Objective

The purpose of this task is to coordinate the regulatory 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 framework.

Management and Integration

Los Alamos staff continued to revise the *Volcanism Status Report.*

Study Plans

Water Movement Test, R1 (8.3.1.2.2.2). Review comments on Rev. 1 of the Study Plan were received from the YMPO in May 1992; they were addressed and returned to YMPO in December 1992. This study plan was approved on 10 February 1993 by the DOE. It was submitted to the NRC for a Phase I review and accepted on 8 April 1993.

Diffusion Test in the Exploratory Studies Facility, R0 (8.3.1.2.2.5). In April 1992, this study plan was accepted by DOE. In June 1992 it was submitted to the NRC for review. It was accepted by the NRC on 19 January 1993. Sent to the State of Nevada for comments on 1 November 1993.

Testing of the C-Hole Sites With Reactive Tracers, R0 (8.3.1.2.3.1.7). In February 1990, DOE/HQ issued the study plan (8.3.1.2.3.1) as a controlled document; it was then sent to the NRC for comments. The Los Alamos study plan (8.3.1.2.3.1.7) was approved. Staff reviewed NRC comments on the USGS study plan related to the first six C-wells activities and notified the DOE that they agreed with all NRC comments.

Ground Water Chemistry Modeling, R0 (8.3.1.3.1.1). This study plan was returned in May 1992 from YMPO review; comments are now being addressed. Comments addressed by author and sent to YMPO for review on 8 November 1993.

Mineralogy, Petrology, and Chemistry of Transport Pathways, R0 (8.3.1.3.2.1). In January 1992, we submitted revised NRC comments to T. Bjerstedt. In August 1992, YMPO requested that we word process the changes to be incorporated in the revision. That revision is in progress and staff is also responding to review comments from the State of Nevada received in January 1993.

History of Mineralogy and Geochemical Alteration at Yucca Mountain, R0 (8.3.1.3.2.2). The YMPO approved the study plan on 18 December 1991 and submitted it to the NRC on 31 January 1992. The study plan was accepted by the NRC on 27 April 1992. Sent to the State of Nevada for comments on 24 January 1994.

Natural Analog Hydrothermal System in Tuff (8.3.1.3.3.1). This is an out-year activity.

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). No progress during the recording period because of funding.

Sorption Studies and Sorption Modeling, R0 (8.3.1.3.4.1; 8.3.1.3.4.3). A new draft of the study plan combining studies 8.3.1.3.4.1 and 8.3.1.3.4.3 was submitted to YMPO for review in October 1992. Review comments were returned to Los Alamos in February 1993; these comments are being incorporated in the study plan. Comments addressed by author and sent to YMPO on 22 October 1993.

Biological Sorption and Transport, R0 (8.3.1.3.4.2). A revision addressing the Exploratory Shaft Design was submitted in September 1992. The study plan was approved by YMPO on 25 November 1992 and accepted by the NRC on 25 March 1993.

Dissolved Species Concentration Limits, and Colloid Formation and Stability, R0 (8.3.1.3.5.1; 8.3.1.3.5.2). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. Rev. 0 was submitted to YMPO for comment resolution, verification, and approval on 9 October 1992. In preparation for forwarding to the NRC, the study plan was sent to YMPO on 28 July 1993 with all review comments addressed. All comments were verified on 6 August 1993. The study plan was approved by YMPO on 9 September 1993 and accepted by the NRC on 17 September 1993.

Dynamic Transport Column Experiments, R0 (8.3.1.3.6.1). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. This study plan was revised, incorporating YMPO and DOE review comments. It was returned to YMPO in March 1993 for technical review. YMPO comments were completed in June 1993. These comments are now being addressed.

Diffusion, R0 (8.3.1.3.6.2). All YMPO comments on the study plan were resolved by the principal investigator in September 1992. The study plan was revised in response to YMPO comments and returned to YMPO in April 1993. Verification of comment resolution was completed on 28 June 1993. A separate list of technical procedures was sent to YMPO on 13 July 1993 in preparation for forwarding the study plan to the NRC. This study plan was approved by the YMPO on 6 August 1993, and submitted to the NRC on 12 August 1993 for Phase I review. Accepted by the NRC on 19 January 1994.

Retardation Sensitivity Analysis, R0 (8.3.1.3.7.1). This study plan was approved by the DOE and sent to the NRC for review in July 1992. It was accepted by the NRC on 19 January 1993.

Demonstration of the Applicability of Laboratory Data to Repository Transport Calculations, R0 (8.3.1.3.7.2). This study plan is deferred because no funds were allocated.

Gaseous Radionuclide Transport Calculations and Measurements, (8.3.1.3.8.1). This study plan is deferred because no funds were allocated.

Probability of Magmatic Disruption of the Repository, R0 (8.3.1.8.1.1). A detailed technical review was completed in July 1992 by the NRC. In August 1992, a one-day video conference was held with the NRC to discuss their technical review comments. In response to those comments, this study plan was revised and submitted to YMPO for review in February 1993. It was accepted and sent to the NRC on 31 March 1993 for review.

Physical Processes of Magmatism and the Effects on the Repository, R0 (8.3.1.8.1.2). A draft study plan was submitted to DOE for review in October 1992. The review comments were returned in January 1993 for comment resolution. Those comments have now been addressed, and revisions were completed on 2 June 1993. All comments were verified on 30 August 1993. The study plan was approved by YMPO on 21 September 1993. Study Plan was submitted to NRC on 4 October 1993 for review.

Characterization of Volcanic Features, R0 (8.3.1.8.5.1). This study plan was accepted by NRC on 4 September 1990. A minor revision was added in March 1993, which does not require a review by YMPO and the DOE.

WBS 1.2.5.3.5 Technical Database Input

Objective

The objective of this task is to coordinate input of technical data to the Project Technical Database (TDB) and the Automatic Technical Data Tracking System (ATDT).

Activities and Accomplishments

Staff continued checking on TDIFs to be revised because the acquired and developed data entries were indistinguishable. Staff discussed possible revisions to the following TDIFs with S. Weaver of the Sorption task.

- Radionuclide Migration Laboratory Studies for Validation of Batch Sorption Studies Data, DTN LA000000000005.001 and LA000000000005.002
- Laboratory Studies of Radionuclides Migration in Tuff, DTN LA000000000006.001 and LA000000000006.002
- Diffusion of Nonabsorbing Tracers in Yucca Mountain Tuff, DTN LA000000000007.001 and LA000000000007.002
- Actinide Behavior on Crushed Rock Columns, DTN LA000000000008.001 and LA000000000008.002
- Radionuclide Migration as a Function of Mineralogy, DTN LA000000000009.001 and LA000000000009.002
- The Elutions of Radionuclides through Columns of Crushed Rock from the Nevada Test Site, DTN LA000000000010.001 and LA000000000010.002
- Diffusion of Sorbing and Non-sorbing Radionuclides, DTN LA000000000034.001 and LA000000000034.002

Staff continued to work with the PI to compile technical data for submittal on Chemistry of Diagnetically Altered Tuffs at a Potential Nuclear Waste Repository, Yucca Mountain, Nye County, Nevada, DTN LA000000000071.001 and LA000000000071.002

Staff continued reviewing the lists of Los Alamos publications and technical reports with accession numbers that do not appear to be listed in the ATDT to determine if they should be listed. Staff submitted an initial assessment on the backlog. (This is in response to a YMP Project Office letter, Assessment of Technical Data Backlog, dated September 17, 1993.)

Staff started working on new TDIFs for the following documents:

- Pu Carbonate Speciation Changes as Measured in Dilute Solutions, DTN LA000000000076.001
- ^{13}C and ^{17}O NMR Binding Constant Studies of Uranyl Carbonate Complexes in Near-Neutral Aqueous Solutions, DTN LA000000000077.002
- Field, Chemical and Geochronological Evidence for Polycyclic Volcanism at the Lathrop Wells Volcanic Center, Southwestern Nevada, DTN LA000000000078.002
- Effect of Natural Organics on Cd and Np Sorption, DTN LA000000000079.002

Staff prepared a matrix indicating the planned deliverable submittals for FY94 based on the data entered into PACS in December 1993.

Planned Activities

Staff will continue to determine which technical data should be logged into the ATDT for current work on zeolites, saturated fluid flow, and other ongoing work. Staff will continue to determine which data must be submitted to the TDB.

Staff will complete a time and cost estimate for the backlogged data that may need to be entered into ATDT.

Staff will estimate the resource requirements for this task for FY95.

Problem Areas

None

WBS 1.2.5.4.6 Development and Validation of Flow and Transport Models

Objective

Model testing is necessary to assess performance at Yucca Mountain. This task will conduct an experiment in a caisson facility to provide a baseline of confidence in models for transport.

Activities and Accomplishments

The plumbing to the caisson was repaired, and the flow was restarted. The caisson was operating at steady-state flow in approximately four days. Fabrication of a multiple sampling device continued; this device will allow solution samples from four ports to be obtained simultaneously. Once this device has been fabricated and tested, the lithium bromide tracer will be injected.

Planned Activities

Complete fabrication and testing of multi-port sampling device.

Inject lithium-bromide tracers.

Problem Areas

Problems have been encountered with two TDR probes in the top layer of the caisson since the flow was restarted.

Milestone Progress

3418
30 September 1994
Final report on Caisson Experiment (M3)

Publications

None

WBS 1.2.5.4.7 Supporting Calculations for Postclosure Performance Analyses

Objective

This task will provide documentation and results of calculations used in analyses of postclosure performance that supports design of repository, seals, and waste package and perform calculations of postclosure performance needed to support activities carried out under other performance assessment WBS elements.

Activities and Accomplishments

The latest version of the FEHMN user's manual was updated and was being placed in the appropriate format. Staff issued an updated section of FEHMN on solute transport that contained a new description of input variables, along with numerous software verification and validation runs. This version has implemented the multiple reactive solute portion of the code, which will be used to model chemical interactions among species and decay chain radionuclide transport.

Staff attended the Air Flow Workshop sponsored by the State of Nevada.

Planned Activities

No planned activities reported.

Problem Areas

None

Milestone Progress

3359
30 September 1993; Submitted to TPO 12 October 1993
Annual report—Support to Performance Assessment
Completed.

3420
30 September 1994
Update of FEHM Theory & Users Manual: Upgrade Documentation

3423
30 September 1994
Verification Document for FEHM

4004
30 September 1993
Letter report on Thermal Repository Calculations
Completed.

Publications

None

WBS 1.2.6.1./2-3/6 Exploratory Studies Facility

Objective

These Exploratory Studies Facility (ESF) tasks address the issues and information needs associated with the ES-based characterization of Yucca Mountain to determine the suitability of permanently isolating high-level nuclear waste from the biosphere in a geologic repository.

Activities and Accomplishments

Construction. Staff attended the weekly design and construction meetings. They provided design input to support field changes related to the starter tunnel alcove construction and participated in writing of Title II design packages. Staff developed weekly and monthly administrative management reports for testing activities and facilitated job package (JP) record development. Staff provided field test coordination and administrative support for ESF north portal construction.

Staff supported field activities at the Fran Ridge site for the LLNL large-block test. Site preparation for drilling activities were completed, and the isolation saw cutting was underway. The test planning package for the activity was ready for technical and project review and the test construction JP was being finalized.

Quality Assurance and Safety Analysis. Staff attended the weekly design and construction meetings and routinely observed ESF field testing activities. Staff reviewed design input to support field changes related to north portal construction and developing Title II design packages. Staff reviewed test planning records and test related FCR for compliance with QA and safety concerns.

Staff observed construction activities conducted in support of LLNL large-block test and testing activities conducted in the north ramp facility. Coordinated the Safety Evaluation for conducting multiple shift operations at the Fran Ridge Site in support of the Isolation Saw Cutting Operations. Completed the permitting process to allow use of the Laser System necessary to conduct the LIBS scoping activity in conjunction with the ESF Hydrochemistry Test.

Test Management. Staff attended the weekly design and construction meetings. They supported the development of weekly and monthly administrative management reports for testing activities and facilitated JP record development. Staff provided field test coordination and administrative support for ESF north portal construction.

Staff prepared planning documents for the test construction portion of the LLNL large-block test. The program is being implemented under the control of a series of JP records and a test planning record to be completed before test activities are initiated. The site preparation portion of the work at Fran Ridge was proceeding as planned.

Planned Activities

Construction. Staff will support finalizing of Title II design packages for the north portal surface facility and north ramp excavations. They will continue field test coordination of the Fran Ridge Engineered Barrier test activity and the Construction Monitoring test activities being conducted in the north portal starter tunnel and alcove.

Quality Assurance and Safety Analysis. Staff will support finalizing of Title Activities II Design Packages for the north portal surface facility and north ramp. They will continue field test observations of the Fran Ridge Engineered Barrier test activity and the ESF test activity being conducted in north ramp facility (starter tunnel and alcove).

Test Management. Staff will support finalizing of Title II design packages for the north portal surface facility and starter tunnel alcove. Staff will continue planning document development and field test coordination of the Fran Ridge Engineered Barrier test activity and the ESF tests with construction activities.

Publications

N. Elkins
Planning and Implementation of Underground Testing in the ESF
Conference paper, *Rock Mechanics Conference*
Approved by YMPO.

Problem Areas

None

WBS 1.2.6.8.4 Integrated Data System

Objective

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

Staff actively pursued integration and review of data flow requirements that are implemented and controlled by test planning records and Project procedures. Staff initiated and supported the review of field record submissions and facilitated data transfers to the constructor and test organizations.

Planned Activities

Staff will continue to provide overview for YMPO of the design and development of the IDS by CRWMS M&O. Staff will continue to meeting with principal investigators to develop and discuss the IDS support needs, IDS design requirements, current IDS design status, and data flow considerations.

Publications

H. Kalia
Acquisition of Test Data from the Exploratory Studies Facility for the Yucca Mountain Site Characterization Project
Conference paper, *Second International Symposium on Mine Mechanization and Automation*
Approved by YMPO.

Problem Areas

None

WBS 1.2.9.1.2 Technical Project Office Management

Objective

The objective of this task is to manage the Los Alamos Yucca Mountain Project Site Characterization Program.

Activities and Accomplishments

The TPO, J. Canepa, completed a paper titled "The Yucca Mountain Site Characterization Project: Site-Specific Research and Development on the Chemistry and Migration of Actinides." This paper will appear in the proceedings of the Migration '93 Conference that was held in Charleston, SC, 12-17 December 1993.

Publications

J. Canepa
The Yucca Mountain Site Characterization Project: Site-Specific Research and Development on the Chemistry and Migration of Actinides
Conference proceedings, *Migration '93 Conference*
Submitted to YMPO.

WBS 1.2.9.2.2 Project Control

Objective

The objective of this task is to support management's efforts in planning, scheduling, and controlling the technical work. This task will develop, implement, and maintain computerized cost, schedule, and technical milestone databases and develop strategies to meet management information requirements.

Activities and Accomplishments

Staff attended the Contracting for Project Manager's course at George Washington University. The course is part of the Project Management Master's program.

Staff met with their TCO counterparts in Las Vegas to discuss budge and schedule issues, and to plan the Los Alamos involvement in the additional small-block cut at Fran Ridge.

The December PACS status report was submitted on 13 January.

Planned Activities

The February PACS status report will be submitted.

FY 1996 DOE Unicall. Los Alamos will prepare the its FY 1996 budget submission, which will incorporate the new DOE requirements regarding performance- based budgeting.

Staff will attend a portion of the Technical Program Review in February.

Problem Areas

Quarterly Allocation Process. This newly adopted process creates unnecessary additional work for the Los Alamos Project Control staff and the Los Alamos National Laboratory's financial department.

WBS 1.2.11.2/.3/.5 Quality Assurance Program Development, Verification, and Engineering

Objective

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.

Program Development (WBS 1.2.11.2)

We have completed the revision of all documents to satisfy the new Quality Assurance Requirements and Description (QARD). The new procedures have been distributed and will become effective on 31 January. The appropriate RTN entries have been made, and YMPO has been notified and we are awaiting their review. An all-hands meeting was held on 25 January. Speakers included S. Bolivar (the new QA program), Ned Elkins (ESF Update), B. Crowe (risk simulations) , J. Fabryka-Martin (Cl^{36}), and J. Canepa (budget outlook). Draft versions of the audit schedule and organization chart were distributed for review. A summary of 1993 quality assurance activities was given to the TPO.

Procedure Revisions. There currently are no procedure revisions in progress.

Training. The Orientation class was given to about 20 new employees. The Records Management class (QP-17.6) was also offered and attended by 23 people. This class may need to be modified to better meet the needs of the audience. The Training Coordinator is now making final entries into the new electronic training data base and the data base program is undergoing extensive testing.

Audits & Surveys Performed (WBS 1.2.11.3)

The final report for Internal Audit AR-93-11 (HydroGeoChem) was issued; there were no deficiency reports issued in this audit. Internal survey report SR-93-003, a supplier survey of Mettler Corporation, was completed. Survey SR-93-06, to verify that RTN entries were made correctly, was completed and no major problems identified. This report is in preparation. The fourth-quarter trend report for 1993 was issued. No adverse trends were noted. A draft survey and audit schedule was distributed for examination.

Verifications. We continue to keep the number of open internal deficiency reports (DRs) to less than 20; this was one of our self assessment goals. There are currently 17 open DRs, with 3 awaiting verification. No DRs were issued in January. There are no open YMPO deficiencies.

Quality Engineering (WBS 1.2.11.5)

No significant activities this month.

Planned Activities

Final preparation of slides and view graphs for the QP-17.6 and Orientation class will continue. The majority of efforts will continue to be directed at completing procedure revisions. Survey reports SR-93-003 and SR-93-006 will be completed. The audit and survey schedules will be finalized and distributed. The 1993 Status Report will be started.

Problem Areas

The Records Management class is under review to determine if a mandatory class is really needed.

Publications

S. Bolivar
Los Alamos report, *The Los Alamos National Laboratory YMP Quality Program, A Status Report for January 1, 1992 to December 31, 1992.*
Submitted to YMPO.

WBS 1.2.12.2 1.2.12.5 1.2.13 Local Records Center Operations/Records Management and Document Control

Objective

The objective of this task is to satisfy the records management requirements of the YMP and NQA-1.

Activities and Accomplishments

Twenty-eight records and/or record packages were received by the RPC; six of these were rejected and returned to their originators for corrections. Twenty-four records and/or record packages were submitted to the CRF, and none of these was rejected.

Planned Activities

No planned activities reported.

Problem Areas

None

WBS 1.2.15.2 Administrative Support

Objective

The objective of this task is to provide administrative support for the Los Alamos YMP and the YMPO.

Activities and Accomplishments

S. Klein, Los Alamos editor, reviewed and edited six technical information products (TIPs) and forwarded them to YMPO. She reviewed seven approved TIPs and returned them and the associated approvals to the respective authors.

She completed the October Monthly Activity Report. She also prepared weekly reports and monthly highlights for December and transmitted them to the M&O and YMPO.

S. Klein met with J. Mercer-Smith and J. Walderscheid, the new technical data coordinator, to plan strategy for submitting new data to the YMP database. With assistance from the group word processor, she reorganized and updated the TIP files.

S. Klein met with B. Crowe and F. Perry to discuss strategy for editing their almost-completed 500 page report.

She updated the FY 1993 TIP database and distributed it to Los Alamos YMP management.

S. Klein reviewed FY94 deliverables with Los Alamos Project Control staff.

Planned Activities

S. Klein will attend the Technical Program Review in February.

Continue work in all areas discussed above.

Problem Areas

None

WBS 1.2.15.3 Training

Objective

The objective of this task is to fulfill the training requirements of the Yucca Mountain Project and maintain appropriate training records.

Activities and Accomplishments

Staff worked on the Training Database.

Staff organized the Orientation training class, presented on 26 January, and the Records training class, presented on the 27 January..

Staff distributed three revised training procedures.

Planned Activities

No planned activities reported.

Problem Areas

None

Appendix

* PRELIMINARY WORK TO SUPPORT THE DEVELOPMENT OF THE STUDY PLAN

[redacted]

Ore Deposits Research Section
The Pennsylvania State University
University Park, PA 16802

A Report on the Project

PREPARATION FOR KINETIC MEASUREMENTS ON THE SILICATES OF THE YUCCA MOUNTAIN POTENTIAL REPOSITORY

to

Los Alamos National Laboratory
* June 15, 1993 to September 30, 1993

Part I. The Preparation Of Clinoptilolite, Mordenite And Analcime

Rick

H. L. Barnes and R. T. Wilkin

INTRODUCTION

This report summarizes progress made during the contract period on preparing Na-end member clinoptilolite, mordenite, and analcime. The objective is to use the prepared zeolites during the next contract period to determine rates of dissolution and precipitation in laboratory flow-through systems in both our lab to 350°C and by the geochemists at Yale University to about 80°C. Because clinoptilolite represents the most complicated phase of these three zeolites and it is most abundant at Yucca Mountain, we have concentrated most of our efforts on its preparation. Initially, we explored the possibility of synthesizing pure Na-clinoptilolite; however, this approach, as discussed in detail in the body of the report below, has proven to be less effective for the several hundred grams needed than to treat selected natural materials. Consequently, we have searched for, and have since collected, high-concentration (about 95%) natural

clinoptilolite samples. To further concentrate the natural samples which contain ~5-10% impurities mostly of smectite, a hindered settling technique that takes advantage of the relatively low specific gravity of clinoptilolite coupled with ultrasonic cleaning in de-ionized water has been employed . X-ray powder diffractometry and SEM analysis of the concentrated zeolite indicates that a purity of >99% can be achieved for the needed quantities. This material is now a mixed Na-K zeolite which must then be converted to the pure Na-end member composition. Published work by Pozas *et al.* (1989) and Liang and Sherriff (1993) indicates that the desired composition approaching Na-clinoptilolite can be prepared by hydrothermal cation exchange treatment. By adopting their methods, we anticipate that the necessary end member starting materials will be ready in sufficient quantities so that the kinetic studies can proceed without delay beginning with the next fiscal year contract

mordenite amorphous contamin.

difficult

MATERIAL REQUIREMENTS

For the initial series of kinetic experiments, we plan to use the NA-end members of the zeolite solid solutions before dealing with the other alkali elements. Consequently, we require ~500g of pure Na-zeolites that are well crystallized (>10 μm) and devoid of sharp edges or high defect concentrations that carry excess surface energy.

non-uniformity of natural materials

SYNTHESIS OF ZEOLITES

There are few descriptions in the literature of methods for clinoptilolite synthesis (*e.g.*, Chi and Sand, 1983). The methods that have been described typically yield other undesirable phases and do not provide a significant advantage over natural samples. However, a method was developed following a procedure that has proven to be successful for kaolinite (G. Kakandes, pers. comm.). In summary, organic-based Al (Al-

isopropoxide) and Si (tetraethyl orthosilicate) are heated and mixed in stoichiometric proportions with NaOH to form a homogeneous melt. The melt is hydrated to form a gel which is than dried to form a powder. The powder (~50 mg) is sealed in a glass reaction tube (3 mm I.D. x 10 cm) with excess water and heated to 250°C to crystallize clinoptilolite. This method differs from other methods in that the elements are mixed prior to gel formation; whereas, in the Ludox-based method of Chi and Sand (1983) the elements are added to a pre-existing silica gel. These other methods do not allow for intimate mixing of the elements, and thus, result in the formation of undesired accessory phases.

In the adopted method, the sealed glass reaction tubes were periodically (every ~120 hr) removed from a vertical tube furnace. The tubes were opened and the contents filtered, ground, washed with de-ionized water, and finally, analyzed by X-ray powder diffractometry with Ni filtered $Cu_{K\alpha}$ radiation, scanning from 5-60 degrees 2θ at 2° θ per minute. These experiments, however, yielded mixed results. Clinoptilolite was not produced as a single phase. Instead the products consisted either of a mixture of analcime and albite, or crystallization was incomplete and a broad amorphous hump was observed on the diffraction patterns. The lack of success with these initial experiments provided the impetus to obtain natural samples; however, continuing testing of this method will include varying of temperature (125°C), run duration, and perhaps the addition of clinoptilolite seeds.

In contrast to clinoptilolite, there is a considerable literature dedicated to the synthesis of mordenite (*e.g.*, Bajpai, 1986). Very recently, a straightforward technique has been described by Hurem *et al.* (1993). This method is reported to produce single phase mordenite with variable molar ratios of SiO_2/Al_2O_3 of 10-30 depending on crystallization conditions. We shall test and probably adopt this method for the preparation of the

large port vs small port
unreacted material

need ~1 g
of pure sample
(at least 0.3g

needed quantities of mordenite. In addition, we expect that by varying the relative proportions of elements in the above method for clinoptilolite synthesis, that pure analcime may be produced readily and as a useful alternative to finding and cleaning natural samples.

NATURAL ZEOLITES

Natural clinoptilolite samples have been obtained from Steelhead Specialty Minerals, Spokane, WA. The purity of this material in the 10-30μm size fraction, as determined by X-ray powder diffractometry and SEM analysis, is greater than ~90%. In addition, clinoptilolite samples from Buckhorn, New Mexico; Castle Creek, Idaho; Mud Hills, Idaho; Sheaville, Oregon; and Shoshone, California have been collected. These later samples have been the focus of on going studies of zeolite beneficiation and ion exchange capacity by F.F. Aplan of the Mineral Processing Section at Penn State University. For this project, we have taken advantage of his group's research. The mineralogic composition of the sampled sedimentary zeolite deposits is presented in Table 1. Typical impurity accessory phases in sedimentary zeolite ores include quartz, microcline, Prob. not montmorillonite, and glass. Note the exceptional purity of the Castle Creek deposit (~95%). Figure 1 shows SEM photomicrographs of clinoptilolite from the Castle Creek deposit where the clinoptilolite is in the form of euhedral crystals up to ~20 μm in size. Clinoptilolite from this deposit is enriched in Na_2O (4.80 wt.%) relative to K_2O (1.42 wt.%) (Mondale *et al.*, 1988).

Several methods have been tested in trying to remove impurities from the natural clinoptilolite concentrates. Centrifugation proved to be adequate but inefficient as only small quantities of material could be processed at one time. A hindered settling technique was developed and applied to the sample from Steelhead Specialty Minerals Company.

TABLE 1. Mineralogic composition of several sedimentary zeolite deposits

	Clinoptilolite (%)	Quartz (%)	Montmorillonite (%)	Glass (%)	K-spar (%)	Mordenite (%)	Calcite (%)
Clinoptilolite							
Buckhorn, NM	91	5		2	2		
Castle Creek, ID	95		5				
Mud Hill, CA	90	7		3			
Sheaville, OR	92	1		5	1		1
Shoshone, CA	91	1		5		1	2
Mordenite							
Copper Valley, NV	10	5	4		1	85	

Note: Data from Mondale (1978) and Carland (1980) where percentages were determined by particle counting in transmitted light. We have obtained ~2kg splits of the samples described by these authors.

wow!
low detection limits

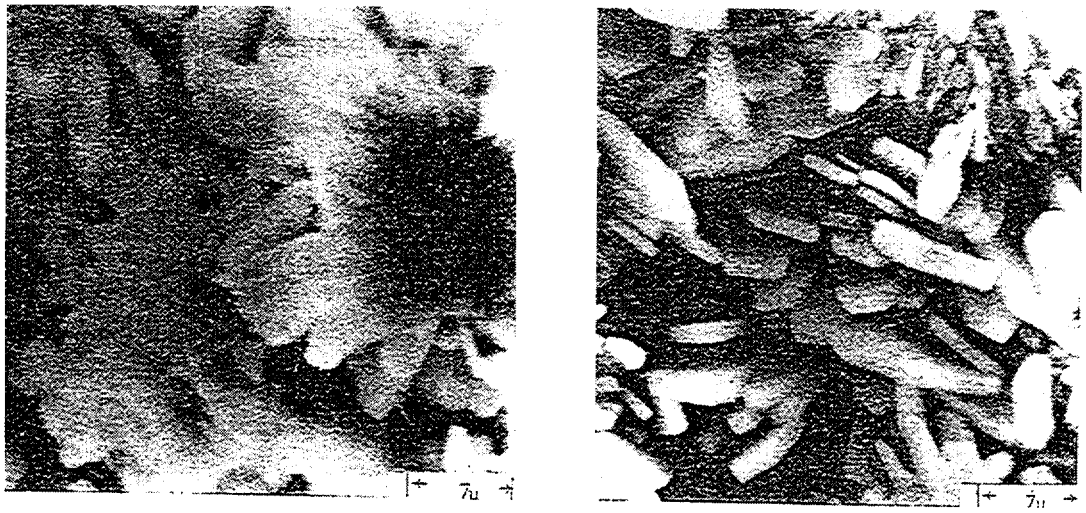


Figure 1. SEM photomicrograph of foliated aggregates of clinoptilolite crystals from Castle Creek, ID (*from* Mondale, 1978).

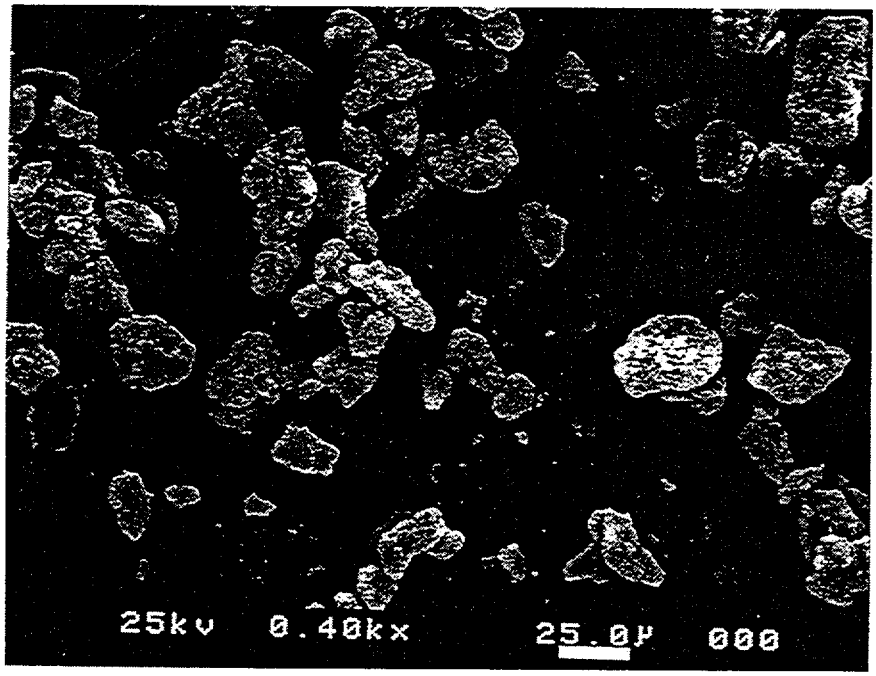


Figure 2. SEM photomicrograph of clinoptilolite ore obtained from Steelhead Specialty Minerals after concentration/ultrasonic treatment.

Approximately 15 g of a -30 mesh clinoptilolite concentrate was placed in a 1 L cylindrical, separatory funnel. Tap water was flowed into the bottom of the funnel at a slow rate, the rate of flow being gradually increased until a clear separation was observed with the heavy particles left at the bottom of the funnel. The suspended material was then transferred to a 1 L graduated cylinder, covered and allowed to settle overnight. The overlying suspension was then siphoned off; the sediment mixed with de-ionized water in a beaker and cleaned in a ultrasonic bath for 1 hour, changing the cleaning solution every 10 minutes. The concentrate was dried at 60°C overnight in an oven. SEM study shows the mineral surfaces are free of ultrafine particles (Fig. 2). X-ray powder diffraction and particle counting using SEM scanning indicates that the final concentrate is greater than 99% clinoptilolite. Approximately 500 g of this material has been processed.

A mordenite-bearing sample from Copper Valley, NV has also been collected (Table 1). Because the sample contains a significant amount of clinoptilolite (~10%) that is not readily separable, mordenite will have to be synthesized.

PRESENT STATUS OF THE ZEOLITE PREPARATIONS

We only recently received and began processing the clinoptilolite samples listed in Table 1 to find if the concentrates made, especially from the Castle Creek sample, are superior to that from the material from the Steelhead Specialty Minerals Company. After the concentrating process is completed, cation exchange will be carried out at 60°C in solutions of 2 M NaCl and 1 M NaOH (10g solid/1L solution). The solutions will be replaced daily and a portion of the solid will be collected for major element analysis by ICP spectroscopy. By this regular sampling and analyses, the change of Na_2O/K_2O in the clinoptilolite can be followed through time until the product becomes satisfactorily close

Long process

to the pure end member. We also will examine the cation-exchanged minerals by microprobe techniques to evaluate grain homogeneity.

Besides the clinoptilolite that is being prepared in large quantities, we have on hand 5.8 g of carefully hand picked material from Succor Creek in addition to the 0.9 g which we have supplied to Yale for initial experiments. It has been analyzed in our Materials Characterization Laboratories and has the following composition:

L.O.I.	39.6	mole percent
SiO_2,	48.3	
Al_2O_3	6.17	
TiO_2	<0.01	
Fe_2O_3	0.02	
MnO	0.01	
CaO	3.10	
MgO	0.35	
Na_2O	1.80	
K_2O	0.61	
Total	99.96	

and the composition, normallized on silica and taking the loss on ignition as water, of:

$$(Ca_{0.64},Na_{0.74}K_{0.25})Al_{1.28}Si_{10}O_{23.1}(H_2O)_{8.20}$$

compared to the nominal composition of:

$$(Na,K)_2Al_2Si_{10}O_{24}(H_2O)_6$$

Although the preparation of clinoptilolite is apparently resolved, more experiments are necessary to complete the design of methods for syntheses of both mordenite and analcime. For this reason, there are underway now further experiments on mordenite synthesis..

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Part II. Draft Manuscript on the Heterogeneous Kinetics of Cristobalite

Precipitation and dissolution rate constants for cristobalite at 150-300°C

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Abstract-- Experiments on the rates of reactions of dissolution and precipitation of cristobalite

$$SiO_2(xtb) + 2H_2O \underset{k_-}{\overset{k_+}{\rightleftharpoons}} Si(OH)_4(aq)$$

were carried at 150-300°C. The rate constant for precipitation in pure water is given by

$$\ln K_- = -2.248 - \Delta E_a/R^*(1/T), \text{ in kilojoules and kelvins.}$$

The energy of activation, ΔE_a, is 50.0±2.4 kJ/mol. These results show that cristobalite may precipitate from hydrothermal solutions if the concentration of $Si(OH)_4$ exceeds that at quartz saturation and is less than that of amorphous silica saturation and if there are cristobalite nuclei present. Such nuclei may occur where there has been devitrification of volcanic glasses, for example. Cristobalite has refused to crystallize in the absence of such nuclei.

Steady state concentrations were reached experimentally after starting at 150° with initially supersaturated solutions and at 200°C starting with either supersaturated or undersaturated solutions. From the steady state conditions, equilibrium constants can be derived for the above reaction: $pK_{150} = 2.22$ and $pK_{200} = 2.10$, values in close agreement with published data.

see p. 14

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Introduction

Kinetic data for quartz, cristobalite, and amorphous silica are necessary to model the presence or absence of these phases under varying conditions of temperature, pressure, and chemistry. While quartz is the stable silica polymorph under the conditions investigated here, which silica polymorph precipitates from solution depends on kinetic in addition to thermodynamic constraints. Examples of systems in which non-equilibrium silica precipitation may occur include; the formation of sinter terraces associated with hot springs, scaling in geothermal energy wells e.g. Wairakei geothermal fields, active hydrothermal systems especially associated with volcanics where cristobalite is in contact with aqueous fluids from temperatures of 25° to 180°C (FOURNIER, 1973 and JACKSON et. al. 1977), and silica dissolution and precipitation induced by localized temperature increases (<200°C) such as would be associated with nuclear waste burial.

The primary objective of this research then was to determined precipitation and dissolution rate constants for cristobalite over the temperature range 150° to 300°C. In addition, this work was undertaken to gain further insight into the microscopic processes involved in the hydrolysis of a silica pure phase.

Although kinetic data for quartz from 25° to 300°C are available, there is relatively little experimentally based, kinetic data for amorphous silica and none for cristobalite. Dissolution rates for quartz in pure H_2O have been measured from 200° to 300°C by DOVE and CRERAR (1990) and 70°C by KNAUSS and WOLERY (1988). RIMSTIDT and BARNES (1980) derived rate constants from precipitation and dissolution experiments in pure H_2O for quartz and amorphous silica from 18° to 305°C.

It has been stated, RIMSTIDT and BARNES (1980), that the precipitation mechanism (on the molecular scale) of all silica polymorphs is the same and therefore their precipitation rates should also be the same for a given temperature and pressure. (Accoarding to transition state theory (EYRING 1935), the rate of a precipitation reaction is directly proportional to the energy (ΔE^{f}) needed to form the intermediate or activated complex. As $Si(OH)_4$ is the reactant in the precipitation of all $SiO_{2(s)}$ polymorphs under hydrothermal conditions of interest here the activated complex and ΔE^{f} must be the same for all silica precipitation reactions, Fig. 1.)

While the results presented do not support the prediction of equivalent precipitation rates, RIMSTIDT and BARNES (1980), for different SiO_2 polymorphs, they do suggest opperatation of the same rate limiting step in the precipitation of quartz, amorphous silica and

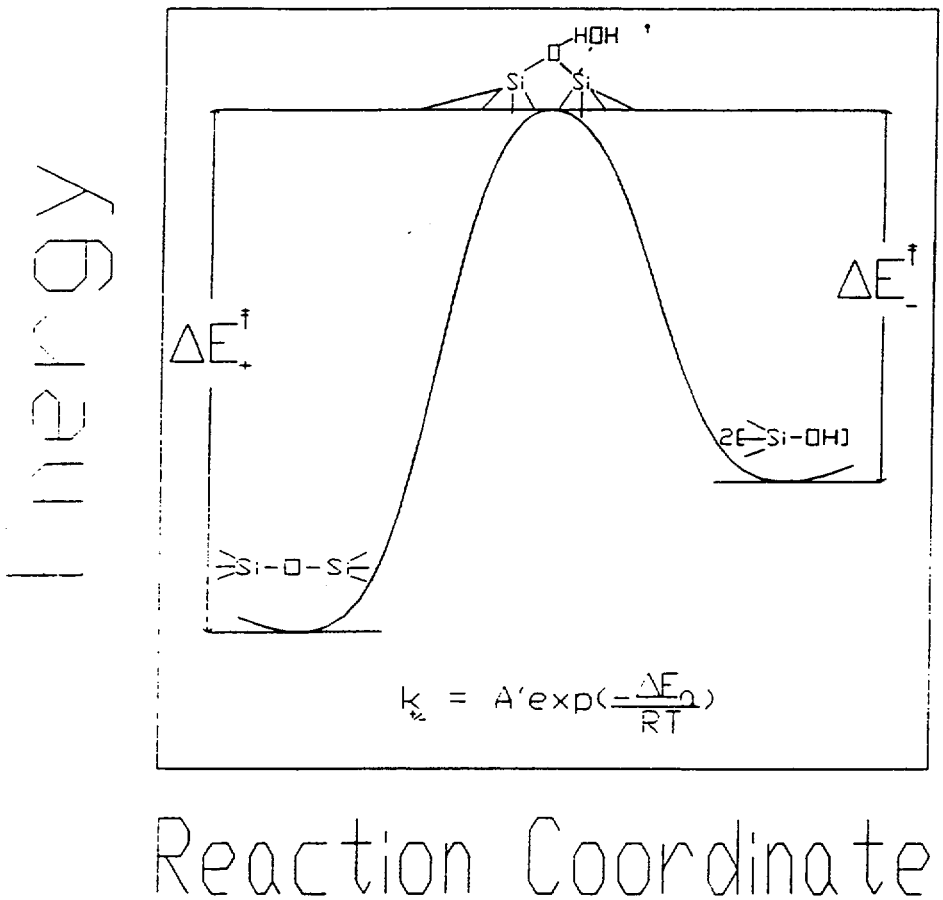

Figure 1. Schematic, modelling the formation of an activated complex during one of a series of elementary reactions leading to the separation/attachment of an orthosilicic acid molecule from/to the $SiO_{2,s}$ polymorph surface. The rate of separation/attachment as quantified by the rate constant k is proportional to E .

cristobalite. This conclusion is based on the similar activation energies for cristobalite precipitation determined here (50.0 +/- 2.4 $kJ \cdot mol^{-1}$) with those for quartz 51 to 55 $kJ \cdot mol^{-1}$ (BIRD et al., 1986) and quartz and amorphous silica (49.8 $kJ \cdot mol^{-1}$) determined by RIMSTIDT and BARNES (1980).

Evidence is also presented which strongly suggests that cristobalite will precipitate directly from aqueous solution as a metastable silica polymorph if cristobalite substrate is present and total molal aqueous silica ($m_{Si(OH)4,t}$) is greater than total molal aqueous silica coresponding to cristobalite saturation ($m_{Si(OH)4,xtb}$). Given that equivalent rate constants for cristobalite were derived from dissolution and precipitation measurements the rate of both processes was shown to be controlled, under conditions of near neutral pH, by an elementary reaction of the type.

$$\equiv Si\text{-}O\text{-}Si \equiv + H_2O = 2[\equiv Si\text{-}OH]$$

Where sequential additions of H_2O molecules to the silica substrate result in the formation of the aqueous silica species $Si(OH)_4$.

Experimental Method

Synthetic cristobalite, ground with a mortar and pestle and sieved to collect the -100 to +400 mesh fraction, was used in all experiments. The sieved fraction was cleaned ultrasonically in distilled water to remove ultra fines (the ultra sonic cleaning rapidly dissolves high energy sites on the cristobalite seed material). SEM photographs before and after cleaning confirmed the absense of ultra fines and sharp edges on the seed material. BET Surface area measurements were made using N_2 as the adsorbate. The actual specific surface areas for the different batches of run material are listed in Table (1). size distrib

Three Phase Experiments

The initial dissolution experiments were conducted along the liquid-vapour curve of the solution in a 0.360 l titanium alloy (Ti-17) autoclave. Approximately 0.2 kg of freshly boiled water was weighed into the evacuated autoclave containing a known mass of cristobalite seed material. The vessel was then heated to the desired run temperature (which was achieved in under 6 hours).

Samples were obtained from the autoclave through a length of coiled 1/16" O.D. stainless steel capillary tubing immersed in an ice-water bath. By quenching the sample, precipitation of silica in the sampling tube, was eliminated due to very slow 0°C precipitation rates. Weighed samples

Table 1. Experimental data for the precipitation rate of cristobalite.

T°C	pK_{eq}[1]	pK_{eq}[2]	Net Reaction direction	A/M (m^2/kg)	logk
150	2.37	2.22	(-)	1.6	-6.55
150	----		(+)	1.2	-6.49
200	2.12	2.10	(-)	0.9	-5.96
200	2.11		(+)	0.55	-5.92
	2.12		(+)		------
210	2.08		(+)	1.4	-5.78
250	1.92		(+)	1.4	-5.55
300	1.75		(+)	0.15	-4.91
300	----		(+)	1.4	-5.18

1 linear regression of Fournier and Rowe (1962) pK vs. 1/T data.

2 values determined by approach to steady state conditions this study

were stabilized with ultra pure HF for analysis (along with blanks treated in an identical manner) by DCP emission spectroscopy.

For experiments above 250°C the increasing length of time required for the autoclave to stabilize reduced the sampling interval necessary to obtain a minimum of three samples having having a mazimum variation in $m_{Si(OH)4}$, and $m_{Si(OH)4,t}$, less than $m_{Si(OH)4,qtz}$. A modified experimental approach, where the runs were conducted at above ambient pressures, was devised which reduced the initial thermal stabilization time to less than 30 minutes. Although the modified procedure was designed specifically for higher temperature runs it had a number of additional advantages over runs along the liquid vapour curve of the system (which are descussed later) and thus was used for all subsequent runs.

Two Phase Experiments

For the remaining experiments a 1.2 l autoclave, used as a pressure ballast and solvent reservoir, was connected to the Ti-17 autoclave by stainless steel capillary tubing as shown in Fig. 2. The evacuated Ti autoclave, containing a known mass (~10^{-3} kg) of cristobalite, was heated to the desired run temperature minus 50°C. The solvent reservoir was then opened to the Ti autoclave, filling the autoclave in less than one minute. The reservoir, still open to the Ti

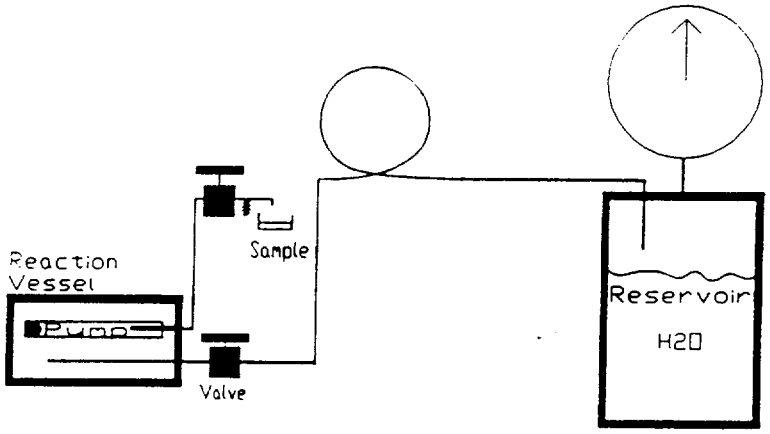

Figure 2. Diagram of the two phase experimental apparatus. Reaction vessel contained only solid and liquid phases under run conditions.

autoclave was finally heated to 350°C generating a total pressure of 165 bars during each experiment.

This procedure significantly reduced the time to achieve temperature equilibrium thereby enabling the attainment of dissolution and precipitation concentration-time data (by filling the reaction vessel with aqueous silica solutions) far from equilibrium especially at temperatures above 200°C. As these experiments were conducted with the reaction vessel containing only solid and liquid phases one further modification (to the original experimental methodology) was required to provide adequate mixing of the contents. A 2.5 cm I.D. 316 stainless steel tube the length of the Ti-17 autoclave's inner chamber was suspended within the reaction vessel. A 2.5 cm diameter 316 stainless steel ball bearing placed inside the tube would roll from end to end of the tube during rocking of the autoclave which circulated the run fluids without damaging the seed material.

Changes in the A/M ratio in these two phase experiments were significantly reduced (A the solid's surface area and M the mass of solution are normally assumed to be constant in heterogeneous rate experiments.) While the value of A would be effected by dissolution to the same extent in these experiments[1] M decreased with each sampling episode during the early experiments while M was a constant in the latter

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1 The worst case was 14% decrease in area at 300°C which is within the uncertainty of the determined rate constants.

runs.

The total mass of solution in the Ti autoclave was calculated from the autoclave's known 25°C volume and the density of H_2O at the temperature of interest. Samples were taken as previously described with solution transfer from the reservoir arrested during sampling. The transfer of H_2O to the reaction vessel after sampling diluted the reacting silica solution by a known amount (the sample mass) and therefore multiple sampling events no longer generated cumulative uncertainties in the calculated rate constant.

Analysis of experimental data

Rate constants were extracted from the experimental data following the method and theory described in RIMSTIDT and BARNES (1980) and LASAGA (1981). A condensed discussion of the key equations and assumptions used in their interpretation follows.

The overall reaction used to describe the dissolution and precipitation of cristobalite was

$$SiO_{2,xtb} + 2H_2O_l = (SiO_2 \cdot 2H_2O) = Si(OH)_{4,aq} \qquad (1)$$

where $(SiO_2 \cdot 2H_2O)$ represents all intermediate steps between the solid and aqueous silica state. (The actual rate limiting elementary step being measured is undetermined, yet it is thought to be one of a series of sequential reactions occurring between hydroxyl and silicon ions in transition from $SiO_{2,xtb}$ to $Si(OH)_4$ and therefore a measurement of the overall rate is also a measurement of the rate limiting step.) It is assumed that Eqn (1) described a reversible reaction, i.e. the rate determining elementary reaction being the same in either direction. This assumption is fundamental to the data treatment followed and is supported by the results obtained.

The net rate of reaction for Eqn. (1) is the sum of the dissolution and precipitation rates:

$$\frac{dm_{Si(OH)_{4,aq}}}{dt} = \left(\frac{A}{M}\right)\left(k_+ a_{SiO_2} a^2_{H_2O} - k_- a_{Si(OH)_4}\right) \qquad (2)$$

where P, T, M, $\acute{o}_{Si(OH)_4}$ are constant and

$dm_{Si(OH)_4}/dt$ = reaction rate (mol m^{-2} s^{-1}) for the $Si(OH)_4$ ion

A = liquid solid interface (m^2)

M = mass of solution (kg)

a_i = activity of the ith component

k_- = precipitation rate constant

k_+ = dissolution rate constant

and the standard states chosen were a hypothetical 1 molal aqueous solution, the pure solid, and pure liquid at the temperature and pressure of interest.

For a system at equilibrium dm/dt = zero and by rearranging Eq (2) the thermodynamic equilibrium constant K_{eq} can be seen to be equal to

$$K_{eq} = k_+/k_- \tag{3}$$

Rearranging (3) and substituting for k_- in (2) results in

$$\frac{dm_{Si(OH)_4,aq}}{dt} = \left(\frac{A}{M}\right) k_+ \, a_{SiO_2} a^2_{H_2O} (1-Q/K_{eq}) \tag{4}$$

where Q is the activity quotient of the system and the ratio Q/K_{eq} defines the degree of saturation of the system.

For these experiments interpretation of the data was carried out by deriving the integral of Eqn (4)

$$t=-(\frac{M}{A})1/k_\ln((1-Q/K_{eq})/(1-Q_o/K_{eq})) \quad (5)$$

which is the equation of a straight line having a slope equal in magnitude to the precipitation rate constant. Finally precipitation and dissolution rate constants where derived from batch dissolution and precipitation experiments using Eqns (3) and (5).

With the rate constants for Eqn (1) determined, the activation energy of the rate limiting elementary step was obtained using an Arrhenius equation

$$\ln k = \ln A' - E_a/R\cdot(1/T) \quad (6)$$

in which A′ is a pre-exponential factor proportional to the entropy of formation for the activated complex, the activity coefficients of the reactants and procucts,

$$A' = \frac{kT}{h}\frac{\acute{O}_r}{O}\cdot \exp 1 \cdot \exp\frac{S}{R} \quad (7)$$

and the fundamental frequency kT/h. (For an in depth discussion of the pre-exponential factor see LASAGA, 1981 and DOVE and CRERAR, 1990.)

Results

Precipitation rate constants determined from net rate measurements in deionized water over a temperature range of 150° to 300°C are summarized in Table 1 and illustrated by the Arrhenius plot, Fig. 3. Figures 4 and 5 illustrate changes in $m_{Si(OH)4}$ vs. time from initially under and over saturated solutions (with respect to cristobalite). Figures 6 and 7 illustrate Q/K_{eq} vs. time data from which values of k_+ were derived.

The assumption inherent in the derivation of k_- and k_+ from the experimental data is that the precipitation and dissolution of cristobalite both proceed through identical rate controlling elementary steps. Values of k_- and k_+ calculated at 150° and 200°C from net dissolution and precipitation experiments are indeed identical within the uncertainty of the experimental method.

Values of K_{eq} for cristobalite were obtained from FOURNIER and ROWE'S (1962) dissolution data and steady state values of $m_{Si(OH)4}$ approached from supersaturated conditions measured in this study, Table 1.

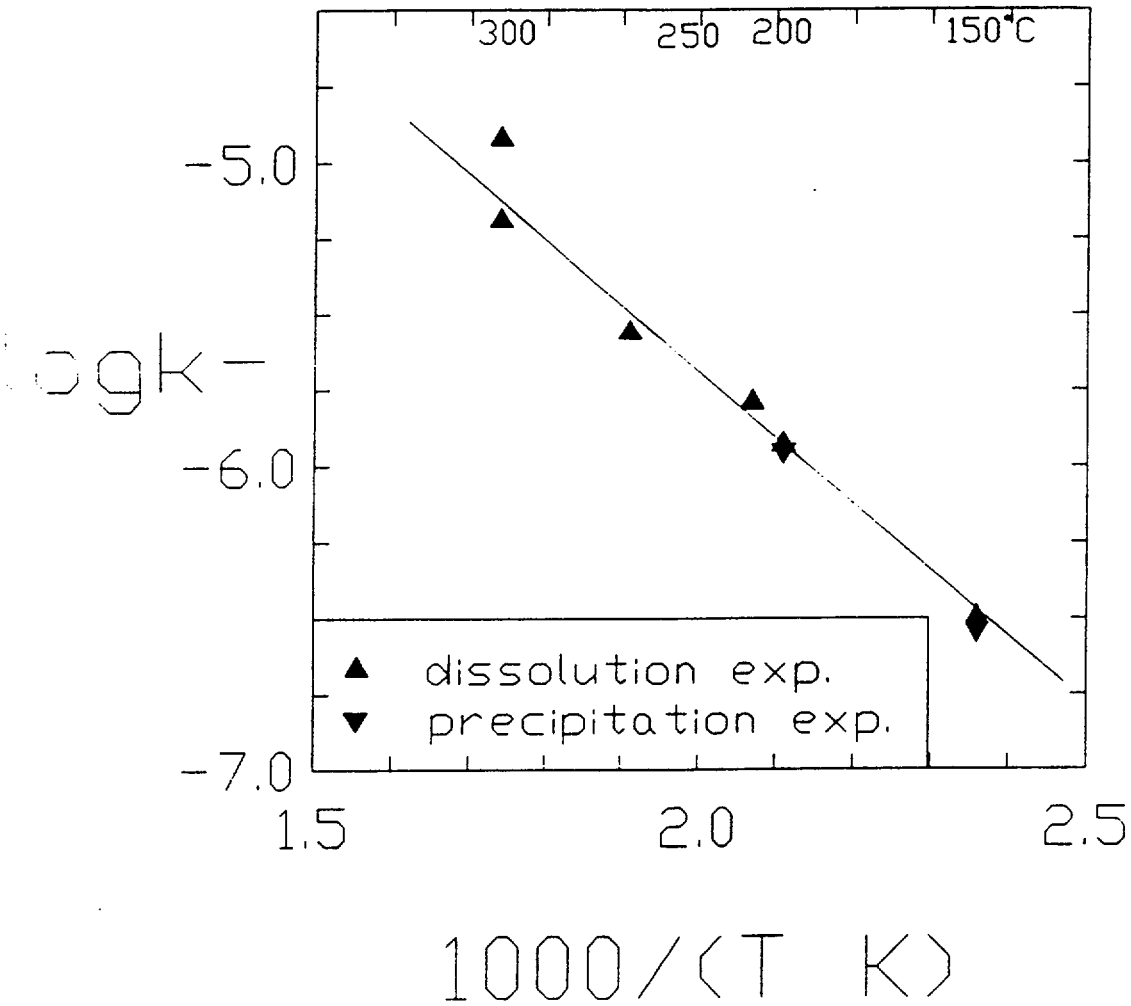

Figure 3. Arrhenius plot of logk$_-$ vs 1000/(T K) for the reaction, $SiO_{2,xtb} + 2H_2O_l = Si(OH)_{4,aq}$, from 150° to 300°C. The energy of activation "E_a" derived from the slope of the curve is $50.0^+/_-2.4$ kJ·mol^{-1}.

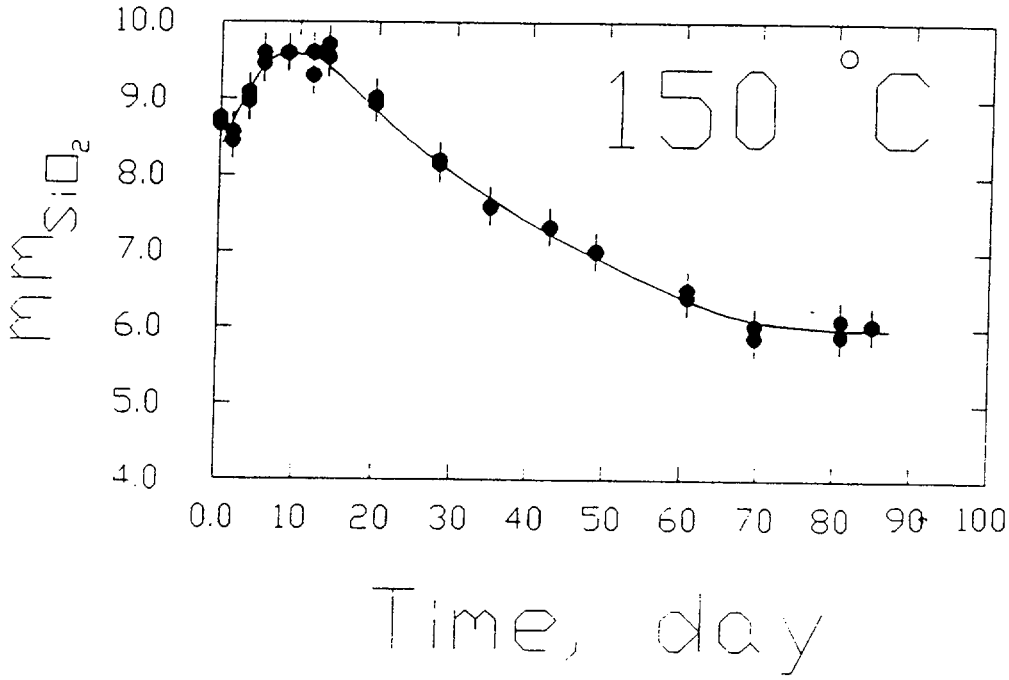

Figure 4. Precipitation of silica from aqueous solution at 150°C on crystalline cristobalite seed material. Two samples were taken at each sampling interval. The vertical line associated with each solid circle represents a 5% variation in analysis of a 10.0 mm_{SiO2} measured concentration.

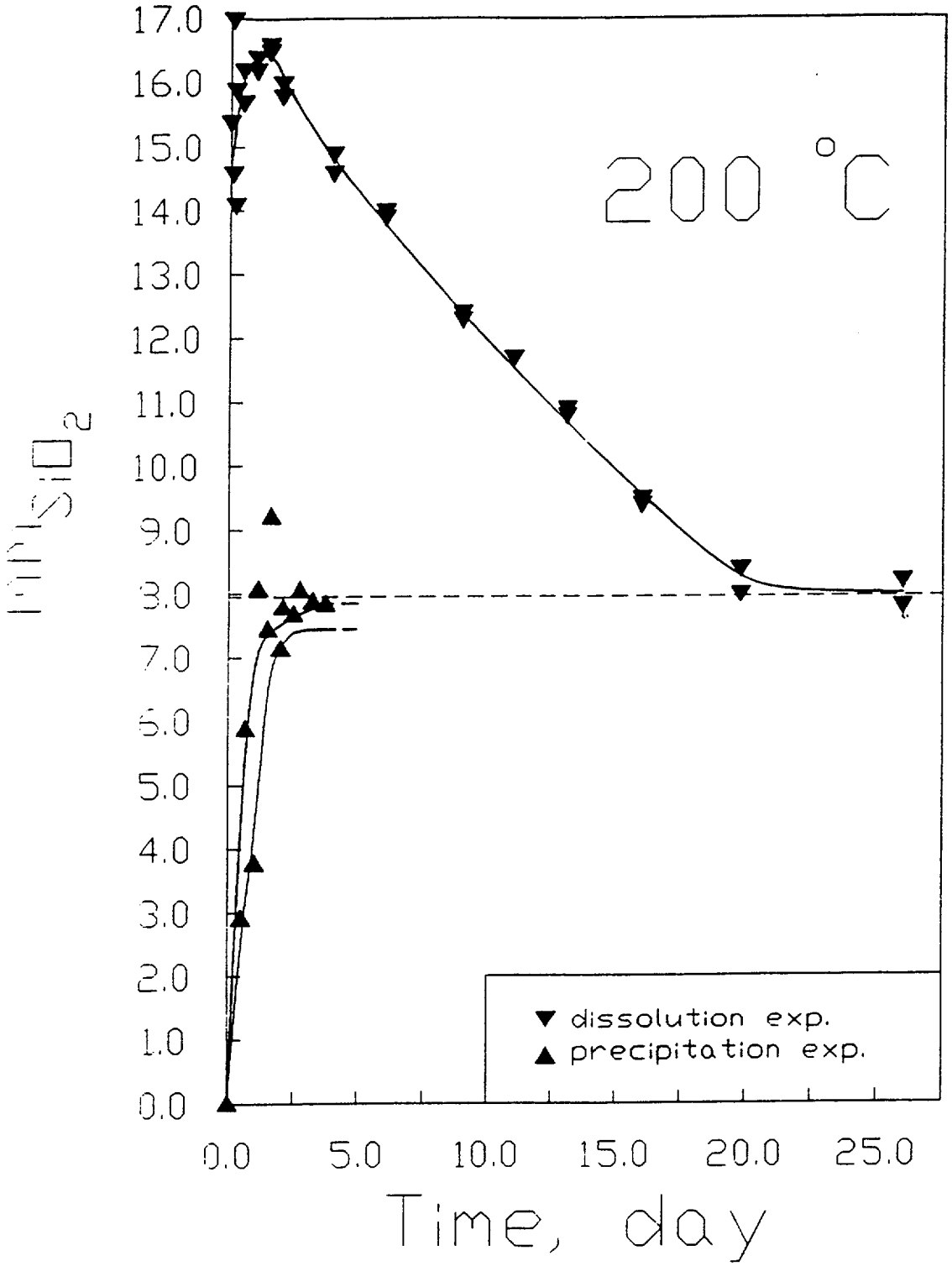

Figure 5. Precipitation of silica from aqueous solution at 200°C on crystalline cristobalite seed material. Two samples were taken at each sampling interval. The vertical line associated with each solid circle represents a 5% variation in analysis of a 10.0 mm_{SiO2} measured concentration.

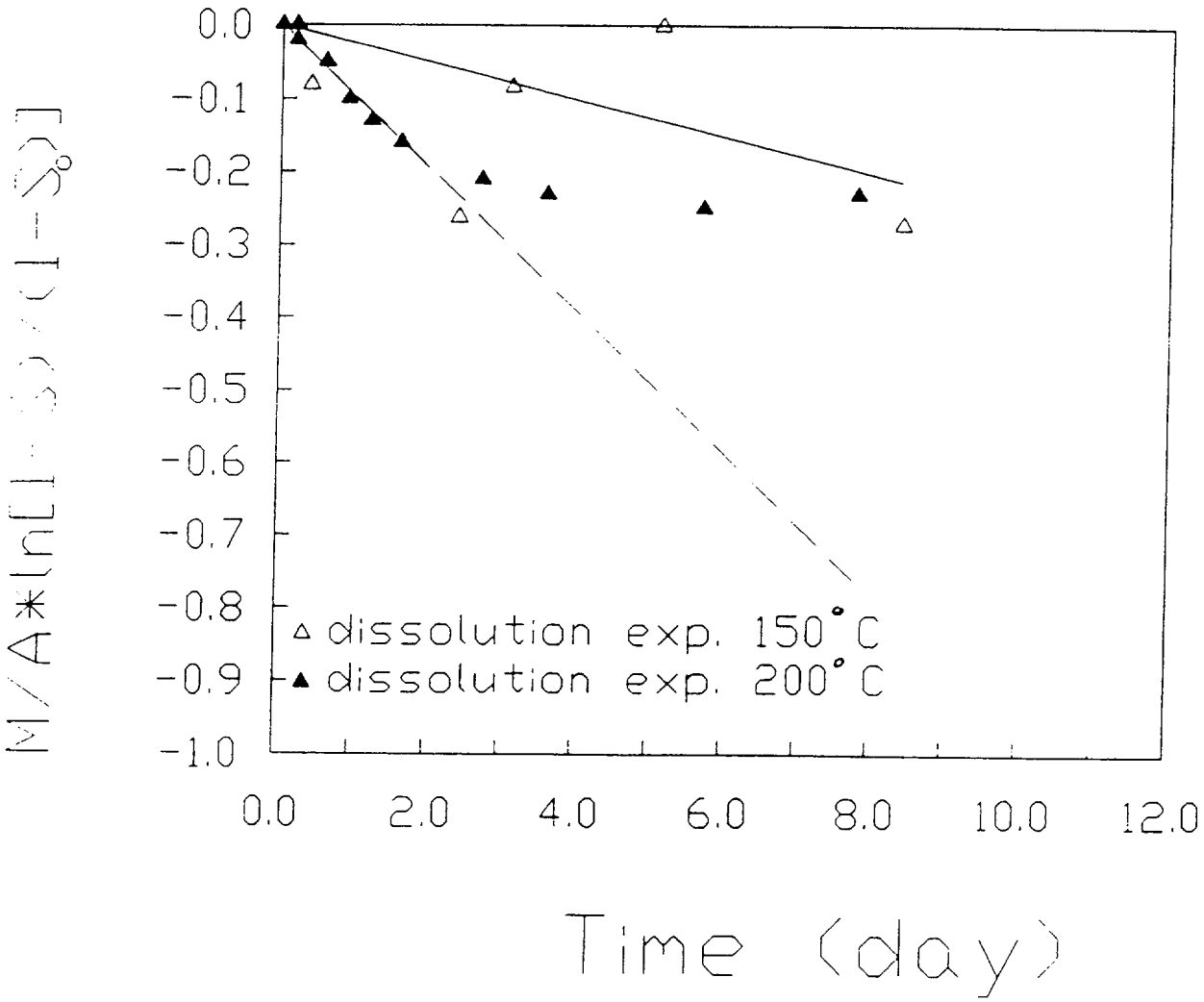

Figure 6. Regression of the rate vs. time data for dissolution experiments from 150° and 200°C. The solid and dashed lines reflect the data regressed in determining $k_{+/-}$. As the measured aqueous silica concentrations approached steady state conditions the relative uncertainties in the plotted data are greatly magnified.

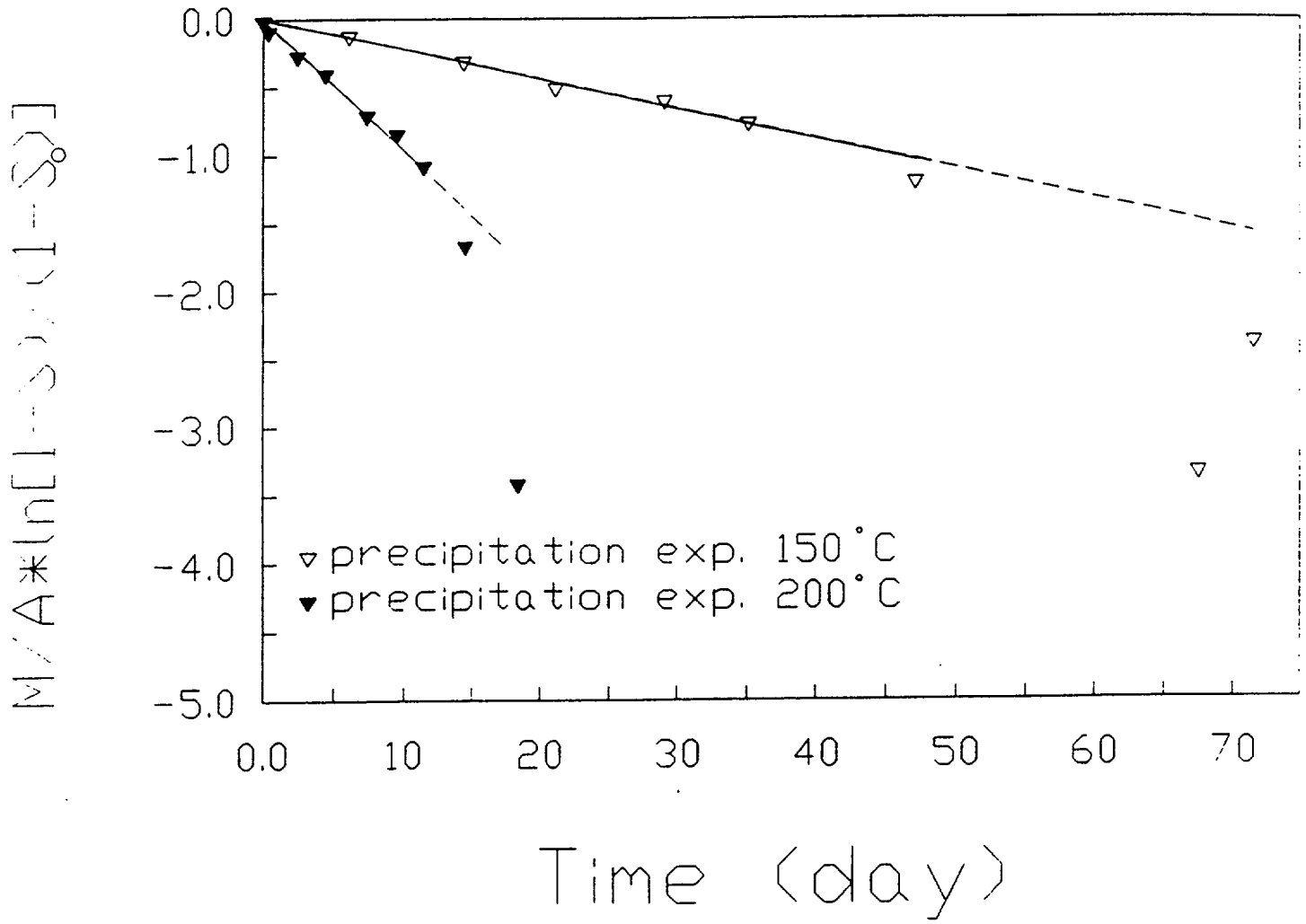

Figure 7. Regression of the rate vs. time data for precipitation experiments from 150° and 200°C. The solid and dashed lines reflect the data regressed in determining $k_{+/-}$. As the measured aqueous silica concentrations approached steady state conditions the relative uncertainties in the plotted data are greatly magnified.

Discussion

The initial kinetic experiments were carried out under three phase conditions, cristobalite seed and two fluid H_2O phases, in a rocking autoclave. This classical experimental approach has been used extensively to determine the solubility and kinetics of different silica phases. A problem which randomly occurred with this experimental approach, at this and one other laboratory, was the precipitation of amorphous silica along the liquid, vapour, autoclave join.

The presence of silica precipitated on the interior autocalve walls was readily observed and data from those experiments were rejected. What was more difficult to determine, if it indeed occurred, was the precipitation of a second silica phase amoungst the starting seed material. The initial dissolution experimental results suggested that the precipitation of a second silica polymorph did occur due to reduced net dissolution rates as silica concentrations exceeded $m_{Si(OH)4,qtz}$. For these three phase experiments only the dissolution data for $m_{Si(OH)4}$ less than $m_{Si(OH)4,qtz}$ were used. While within the above constraints the rocking autoclave dissolution kinetic data was valid, the attendent problems were bothersome and precluded the direct measurement of precipitation data.

By altering the experimental procedure to include only two

phases, cristobalite and liquid H_2O, a number of advantages were realized with minimal increase in experimental complexity. The experimentally unconstrained reaction time during heating of the autoclave was greatly reduced. Amorphous silica nucleation along the autoclave-H_2O_v-H_2O_l join was no longer possible. Silica dissolution rate data were continuous for $m_{Si(OH)4}$ greater than $m_{Si(OH)4,qtz}$ and silica concentrations smoothly approached a reversible steady state condition from under and over saturated conditions, Fig 5. These results suggested that the aqueous liquid-vapour-autoclave join, facilitated the nucleation of quartz and not the cristobalite seed material and as a consequence cristobalite precipitation constants were being reliably measured in the two phase system.

Under the experimental conditions of this study, 150° to 300°C and pressures less than 165 bars, cristobalite is not thermodynamically stable. To determine that cristobalite was the dominant silica polymorph present by the end of each experiment, a powder x-ray diffraction pattern was obtained of the used seed material.

While an XRD pattern will not normally detect cristalline phases present at less than 5% of the total sample mass this sensitivity can be seen to be sufficeint by refering to the 200°C cristobalite precipitation experimental data. Knowing M, a calculation of the net mass of silica precipitated over the length of the experiment results in an increased seed

mass of 13%. The gross rate of cristobalite dissolution during this experiment can also be calculated,

$$\frac{dm_+}{dt} = \frac{A}{M} k_+ \qquad (8)$$

at 200°C this is 10^{-4} kg/day or 10% by weight per day of the seed material. Thus it can be seen that the actual fraction of hydrothermally precipitated silica must be at least 13% and may well be greater. If the hydrothermally grown phase were quartz, with its sharp main diffraction peaks, these peaks certainly would have been observable on the XRD patterns. This type of argument supports the assertian that significant precipitation of quartz did not occur during the precipitation experiments.

During the 200°C precipitation experiment a number of sub millimetre sized highly porous silica spheres were observed in the autoclave at the end of the experiment. A single crystal x-ray scan of these spheres did not result in an identifyable pattern, again it seems likely that if these spheres were quartz the main diffraction lines for quartz would have been detectable.

The final silica concentration of the aqueous phase in equilibrium with these spheres was well below saturation values expected for solutions buffered by amorphous silica and had decreased to values identical to those determined

from cristobalite buffered dissolution experiments. Thus the precipitation of small, porous spheres of truly amorphous silica also seems an unlikely explanation.

It seems most likely that the spheres were cryptocristalline cristobalite (opal CT) which may not exhibit a diffraction pattern and does occur naturally as spheriods, JONES et al., (1964). Opal is also associated with hydrothermal systems having silica supersaturated (with respect to quartz) aqueous fluids.

Examination of dm/dt curves for precipitation experiments at 150° and 200°C, Figs. 4 and 5, identifies an initial period where the aqueous silica concentration actually increased despite crystobalite being the only silica polymorph present and initial silica concentrations being double those determined as dm/dt approached zero.

Having previously removed ultrafine particles and not expecting the measured surface reaction to be dependent on surface morphology, BLUM et al., (1989) and MaCINNIS and BRANTLY (1992), this initial observed increase in silica must reflect the presence of a limited amount of higher energy solid silica. The source of this high energy silica phase material may have been generated from the cristobalite seed during the rather violent filling of the autocalve with the aqueous silica solution or introduced from the reservoir which was contained coarse fragments of amorphous silica.

In either case, the period of increasing silica then corresponds to the time necessary to completely dissolve this high energy material.

Once dm/dt data became negative precipitation rate constants were determined and found to be in excellent agreement with rate constants determined from dissolution experiments.

The bracked steady state cristobalite buffered conditions observed from the 200°C experiments were identicle to those determined from dissolution experiments by FOURNIER and ROWE (1962). At 150°C the dm/dt precipitation data approached zero for an m_{SiO2} of approximately 6.0 mm. This value is significantly higher than that determined by FOURNIER and ROWE (1962), 4.4 mm. The reason for this discrepency is probably due to the range in crystallinity possible for cristoballite. The precipitation rate constants presented in Table 1 were based on the saturation values determined from our 150° and 200°C precipitation data. For the dissolution experiments the final $m_{Si(OH)4}$ resulted from equilibrium with cristobalite which was prepared in a manner similar to that described by FOURNIER and ROWE (1962) and therefore their saturation data was used.

Conclusions

1. The energy of activation for the precipitation of cristobalite is consistent with values determined for the precipitation of quartz and amorphous silica. The

assumption that all silica polymorphs precipitate along the same rate limiting elementary reaction coordinate is confirmed.

2. The presence of cristobalite will cause the metastable precipitation of hydrothermal cristobalite resulting in suspect temperatures when the quartz geothermometer is used in cristobalite bearing terrains.

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* Preliminary work to support the Development of the Study Plan

PROGRESS REPORT ON THE KINETIC MEASUREMENTS OF THE REACTIONS OF THE SILICATES AT THE YUCCA MOUNTAIN POTENTIAL REPOSITORY SITE

to

Los Alamos National Laboratory

* June 15, 1993 to September 30, 1993

A.C. Lasaga and J. Ganor

INTRODUCTION

This report summarizes the results of experiments carried out during the contract period on two of the zeolites of relevance to the Yucca Mountain project: analcime and clinoptilolite. The main objective was to obtain some data on the synthesis and solubility of the zeolites to prepare the way for the kinetic measurements to follow. However, some kinetic measurements have been carried out successfully and are also reported here. Both the characterization of the zeolites, the solubility experiments and the preliminary kinetic experiments indicate that the joint effort between Penn State and Yale University will produce important results that will constrain the treatments of the geochemistry and the hydrogeochemical models at the Yucca Mountain

repository site.

PRELIMINARY RESULTS

The preliminary investigations at Yale University have provided important results over the summer on three areas:

1) Synthesis and characterization of analcime (and Na-clinoptilolite based on Penn State)

2) Batch solubility experiments on analcime and clinoptilolite

3) Thermodynamic modelling of the solubility data

4) Kinetic Flow-through experiments on analcime and clinoptilolite

1) The analcime was obtained from Mt St. Hilaire, Quebec, Canada. A full chemical analysis was carried to chemically characterize the analcime. The result (Table 1) shows that the composition of this analcime is *very* close to the exact ideal stoichiometry and, therefore, that this plentiful source of analcime will be ideal for all future experiments on analcime in the coming year. Thus, synthesis experiments will not be necessary for the analcime.

The clinoptilolite that we used during this period was the one separated by hand from Succor Creek. Penn State has analyzed this clinoptilolite (see their report) and the results suggest a non-trivial composition (see also table 1). While our preliminary results used this clinoptilolite, the preparation of clinoptilolite discussed in the Penn State report seems most suitable for the supply of clinoptilolite for the solubility and kinetic experiments of the coming year.

Surface area studies of the analcime from Canada used a Quantasorb BET system at Yale. The analysis, using a three-point N_2 BET isotherm, gave a value of 1.55 ± 0.16 m^2/g. The clinoptilolite from Succor Creek was similarly characterized and gave a surface area of 1.36 ± 0.14 m^2/g.

Standard surface characterizations (e.g. by SEM) will be done shortly in this coming year. In addition, our research group is currently beginning to set up "in-situ" experiments at the atomic level using our in-house AFM (atomic force microscope). We have already obtained static images of kaolinite and muscovite and plan to apply this technique to the zeolites.

2) The batch experiments were carried out under controlled temperature conditions ($T = 80 \pm 0.1$ °C). The experiments had a water/rock ratio of roughly 1000:1. For example, in the analcime batch experiment, 0.357 g of analcime were put in a teflon bottle with 398.25 g of a solution containing 0.01 M Borax. The batch solutions were shaken once every couple of days. Sampling consisted of the extraction of 15 ml of solution every few days. Each time, 15 ml of the fresh Borax solution were added to the bottle to keep the

total solution volume constant (although there was a slight dilution, the effect should be minor). Figure 1 illustrates a typical run for analcime. Note the approach to equilibrium (or steady state) conditions. Table 2 gives some of the final conditions of the solution as it approached "equilibrium".

Similar data were obtained for clinoptilolite but the treatment will be completed with the new clinoptilolite (see above) during the next year.

The initial slope of the batch experiments can be used to extract dissolution rates. However, because so many variables are changing during the batch experiments, these calculated rates should *not* be as realiable as the rates obtained from flow-through reactors. The rates were obtained by dividing the measured surface area of the analcime in the batch into the total dissolution rate (i.e. the slope of the lines in figure 1). These calculations gave dissolution rates of 1.7×10^{-10} to 2.0×10^{-10} moles/m^2/sec. These rates will be shown later to be about 5 times faster than the rates obtained in the flow-through reactor.

3) The thermodynamic treatment of the batch experiments is applicable once a solution composition has been established as being in "equilibrium" with analcime or clinoptilolite. It is important to note that future experiments (both kinetic and batch) will establish the validity of this equilibrium assumption in a more cogent fashion by varying the initial conditions (supersaturated as well as undersaturated) of the solutions. Taking the final solution composition as the "equilibrium" one, the equilibrium constant of

the reaction:

$$NaAlSi_2O_6 \bullet H_2O + 5\,H_2O \longrightarrow Na^+ + Al(OH)_4^- + 2\,H_4SiO_4 \quad (1)$$

can be calculated from the activities:

$$K_{eq} = \frac{a_{Na^+}\, a_{Al(OH)_4^-}\, a^2_{H_4SiO_4}}{a^5_{H_2O}} \quad (2)$$

The activities were evaluated from speciation calculations (using the speciation equilibrium constants for the aluminum species shown in table 3) and from activity coefficients calculated by the extended Debye-Huckel theory (which is quite valid in our range of ionic strengths - see the parameters in table 4). The result,

$$K_{eq} = 10^{-14.53}$$

can be compared with earlier literature values. Our data gives a solubility that is smaller than the value quoted by Johnson et al. (1982), log K_{eq} = -12.43. The latter group carried out a calorimetric study to arrive at their result. Our data are in closer agreement with the value of Bowers et al. (1984) for analcime (log K_{eq} = -13.01). Nonetheless, the differences are large enough that an important revision may be needed in the solubility data.

4) In addition to the batch experiments, it was important to carry out preliminary **kinetic experiments** on both analcime and clinoptilolite. The kinetic experiments used a flow-through reactor such as used in Nagy et al. (1991), Nagy and Lasaga (1992), Burch et al. (1993). The preliminary results for the zeolites have been quite encouraging.

The dissolution rates were obtained for the overall dissolution reaction of analcime expressed as:

$$NaAlSi_2O_6 \bullet H_2O + 5\,H_2O \longrightarrow Na^+ + Al(OH)_4^- + 2\,H_4SiO_4$$

The experimental conditions used temperatures of 80 °C and basic pH conditions (pH around 8.8). The dissolution rate, R, in a well-mixed flow-through experiment is obtained from the expression:

$$\nu_j R = \frac{V}{A}\frac{dC_j}{dt} + \frac{q}{A}(C_j - C_{j,inp}) \qquad (3)$$

where C_j is the concentration of component j in the reaction cell (which must also equal the concentration of the output solution at that time), $C_{j,inp}$ is the concentration of component j in the input bottle, ν_j is the stoichiometry coefficient of j in the dissolution reaction, t is time, A is the total mineral surface area, V is the volume of the reactor and q is the fluid volume flux through the system. The dissolution rate in such an experiment may be readily obtained if **steady state** is reached i.e., if the composition of the output solution (and therefore of the reactor cell) reaches a constant value. In this case, the dissolution rate is balanced by the difference between input and output solutions:

$$\nu_j R = \frac{q}{A}(C_{j,out} - C_{j,inp}) \qquad (4)$$

where $C_{j,out}$ is also the solution concentration in the reactor cell (C_j).

Gibbs free energy of reaction

The degree of saturation with respect to analcime dissolution reaction is calculated in terms of the Gibbs free energy of reaction:

$$\Delta G = RT\, ln\left(\frac{IAP}{K_{eq}}\right) \tag{5}$$

where R is the gas constant, T is the experimental temperature, IAP is the ion activity product of the solution, and K_{eq} is the equilibrium constant for the zeolite reaction (which was obtained from the batch experiments as explained in the previous section). Assuming that activity of water is very close to 1, the ion activity product for the analcime dissolution reaction is given by

$$IAP = a_{Al(OH)_4^-}\, a^2_{H_4SiO_4}\, a_{Na^+} = \gamma_{Al(OH)_4^-}\, C_{Al(OH)_4^-}\, C^2_{H_4SiO_4}\, \gamma_{Na^+} C_{Na^+} \tag{6}$$

where a, γ and C are the activity, activity coefficient and concentration of each component, respectively. The activity coefficients are calculated as follows:

1. As an initial approximation all activity coefficients are set to 1.

2. Distribution of aqueous species (H^+, OH^-, Na^+, BO_7^{-2}, Al^{+3}, $AlOH^{+2}$, $Al(OH)_2^+$, $Al(OH)_3$, $Al(OH)_4^-$, H_4SiO_4 and $H_3SiO_4^-$) are calculated from total Al, Si, Na and BO_7 concentrations,

pH and hydrolysis constants of table 3.

3. Ionic strength is calculated using all ion concentrations.

4. New activity coefficients are calculated using the extended Debye-Huckel equation with parameters from Wolery (1979) (see Table 4).

5. Stages 2 through 4 are repeated until the value of the ionic strength converges.

Kinetic Experimental Set-up

Experiments were carried out using a stirred-flow reactor (35 ml in volume) which was fully immersed in a Plexiglass water bath and held at a constant temperature of 80 °C ± 0.2 °C. Details of the design of the reaction vessel are given in Nagy et al. (1990, 1991). Analcime (0.1 g) reacted with a through-flowing fluid of fixed input composition. For these experiments, the flow rates were controlled by a peristaltic pump to be 0.016 ml/min (± 2%). These particular values of the flow rate and the volume of the reactor yield a residence time within the cell of about 36 hours. Stirring of analcime and fluid was controlled by a stirring plate placed directly beneath the bath. A Teflon-coated stirring bar was mounted on a pin to avoid grinding the analcime. Similar experiments were performed on the clinoptilolite.

Solutions were filtered on the output side of the vessel with a 0.45 μ Durapore (Millipore) filter. Input solutions were 0.01 M Na borate (Borax). Output bottles were replaced once a day and the solutions were analyzed for Al, Na, pH and Si. Total Al and Si were analyzed colorimetrically with a UV-

visible light spectrophotometer, using the catechol violet method (Dougan and Wilson, 1974) and the molybdate blue method (Grasshoff, 1976), respectively. The uncertainty in measured Al and Si concentrations was ± 3%. pH of input and output solutions was measured at 80 °C on an unstirred aliquot of solution using a Ross combination electrode with a reported accuracy of ± 0.02 pH units (± 4.5% in H^+ activities). The pH electrode was standardized against NBS buffers (Bates, 1954) prepared from reagent grade salts. Na^+ was analyzed using ICP emission specrometry. The uncertainty in measured Na^+ was ± 2%.

Each experiment consisted of several stages. During each stage the experimental conditions (i.e. flow rate, pH and Al and Si input concentrations) were mantained constant. Typically, the stage lasted until steady state conditions were obtained as ascertained by output solutions with little variations in the concentrations of the various components with time. After steady state was reached, the experimental conditions were changed to start a new stage. The calculated total dissolved material throughout the experiments was less than 7% of the starting mass of analcime with similar numbers for clinoptilolite.

Figure 2a shows the slight variation in the flow rate for a one-state experiment with analcime. Figure 2b illustrates the approach to steady state of both the silicon and aluminum concentrations. Steady state takes on the order of 150 hours (i.e. four residence times). Figure 2c gives the calculated dissolution rates based on the measured BET surface area. The calculations assumed a stoichiometry of $NaAlSi_2O_6$ for the analcime. Obviously, both

the silicon and the aluminum dissolution predict essentially the same dissolution rate under these conditions i.e. 6×10^{-11} **moles/m^2/sec**. Note that this rate is much slower than the rate calculated with a simple batch experiment as discussed in the earlier section. Figure 2d exhibits the stoichiometric nature of the dissolution of analcime. Basically, the dissolution in the flow-through reactor is stoichiometric. This congruent dissolution behavior is very important for a proper interpretation of the kinetics (and thermodynamics!); although such congruency has not always been demanded in previous kinetic studies. Figure 2e gives the variation in the Gibbs free energy of the dissolution reaction (equation (1)), ΔG. The dissolution rates are obtained for ΔG values around -1 to -1.3 Kcal/mole.

Note that similar congruent behavior was also exhibited in the dissolution of the clinoptilolite (based on the actual stoichiometry as given in Table 1). Therefore, it seems that the kinetic studies of both analcime and clinoptilolite will yield proper kinetic rate constants. We suspect that similar results will be obtained for mordenite, although no experiments have been carried out yet.

Figure 3a gives the flow rate for an analcime dissolution experiment involving several stages (but mantaining the flow rate reasonably constant). Figure 3b shows the approach to steady state of the several stages. The stages were differentiated by varying the input concentration of silicon (as shown in figure 3b). The input amount of aluminum was zero in all cases. Figure 3c gives the calculated rate. Note that, once more, the rates based on the silicon and the aluminum output concentrations (using equation (4))

are essentially the same, i.e. congruent dissolution is taking place (see also figure 3d). The dissolution rate with zero silicon for input solution, 5 x 10^{-11} moles/m^2/sec agrees fairly well with the other experiment. From these preliminary kinetic data, it seems that indeed the rate decreases as the silica concentration in the solution increases (or equivalently, the ΔG approaches zero - see figure 3e). The preliminary experiments with clinoptilolite also showed this behavior. We have found similar behavior in other silicates (e.g. albite, kaolinite and gibbsite) and it will be extremely interesting to pinpoint the kinetic behavior of analcime as well as clinoptilolite and mordenite in this important ΔG region.

Table 1: Chemical characteristic of analcime and clinoptilolite

Analysis of: analcime ANH93-1 from Mt St. Hilaire Quebec Canada (Wards)

Oxide	wt. %
SiO_2	54.1
Al_2O_3	22.9
TiO_2	<0.01
Fe_2O_3	0.01
MnO	0.02
CaO	0.21
MgO	0.01
Na_2O	13.8
K_2O	0.03
LOI as H_2O	1.12
Total	100.15

Calculated formula: $Na_{0.99}$ (Al Si_2 O_6) · 1.12 H_2O
Ideal analcime (Gottardi and Galli, 1985)
Na (Al Si_2 O_6) · 1 H_2O

Analysis of: Clinoptilolite ES 066 61 -Succor Creek clinoptilolite (based on Penn State Report)

Oxide	wt %
SiO_2	63.1
Al_2O_3	13.7
TiO_2	<0.01
Fe_2O_3	0.07
MnO	0.02
CaO	3.78
MgO	0.31
Na_2O	2.43
K_2O	1.25
LOI as H_2O	15.5
Total	100.17

calculated formula:

$(Na_{2.15}\ K_{0.73})\ (Ca_{1.84}\ Mg_{0.21})\ (Al_{7.35}\ Si_{28.7}\ O_{72}) \cdot 23.5\ H_2O$
Ideal clinoptilolite (Gottardi and Galli, 1985)

$(Na, K)_6\ (Al_6\ Si_{30}\ O_{72}) \cdot 20\ H_2O$
Ideal Heulandite: (Gottardi and Galli, 1985)

$(Na, K)\ (Ca_4)\ (Al_9\ Si_{27}\ O_{72}) \cdot 24\ H_2O$
50% Clinoptilolite + 50% Heulandite:

$(Na, K)_{3.5}\ (Ca_{2.0})\ (Al_{7.5}\ Si_{28.5}\ O_{72}) \cdot 22\ H_2O$

Table 2: Final concentrations in analcime batch experiment as it approach 'equilibrium'

	pH	Al (μM)	Si (μM)	Na (M)	K (μM)	Al/Si	log (IAP)
	8.856	101	194	0.020	0.050	0.52	-14.56
	8.797	94	186	0.020	0.050	0.51	-14.58
	8.832	107	211	0.020	0.050	0.50	-14.46
average	8.828	100	197	0.020	0.050	0.51	-14.53
STD	0.030	6	13	0.000	0.000	0.01	0.07

Table 3: Equilibrium constant used in ΔG calculations

Reaction	log K_{eq}
$Al^{+3} + OH^- = Al(OH)^{+2}$	9.2*
$Al^{+3} + 2OH^- = Al(OH)_2^+$	18.1*
$Al^{+3} + 3OH^- = Al(OH)_3$	26.2*
$Al^{+3} + 4OH^- = Al(OH)_4^-$	32.5*
$H^+ + OH^- = H_2O$	12.6**
$H_4SiO_4 = H_3SiO_4^- + H^+$	-8.8***
analcime dissolution (eq. 1)	-14.5****

Source of thermodynamic data

* a second order polynomial fit to the high temperature (150 to 250°C) data of Bourcier *et al.* (1987) and the 25°C constant of May et al. (1979)

** Busey and Mesmer (1978)

*** equilibrium constant at 25°C was obtained from standard state thermodynamic data of Naumov et al. (1974) and a temperature dependece for the heat capacity of H_4SiO_4, derived from the temperature dependence of quartz solubility given by Rimstidt and Barnes (1980)

**** present study batch experiment at 80°C

Table 4: Parameters used for calculations of the extended Debye-Huckel equation (Wolery, 1979)

Ion	size
H^+	9
$Al(OH)_2^+$	4
$Al(OH)_4^-$	4
OH^-	3.5
$AlOH^{+2}$	5
Al^{+3}	9

constants	Value
A	0.5092
B	0.3283

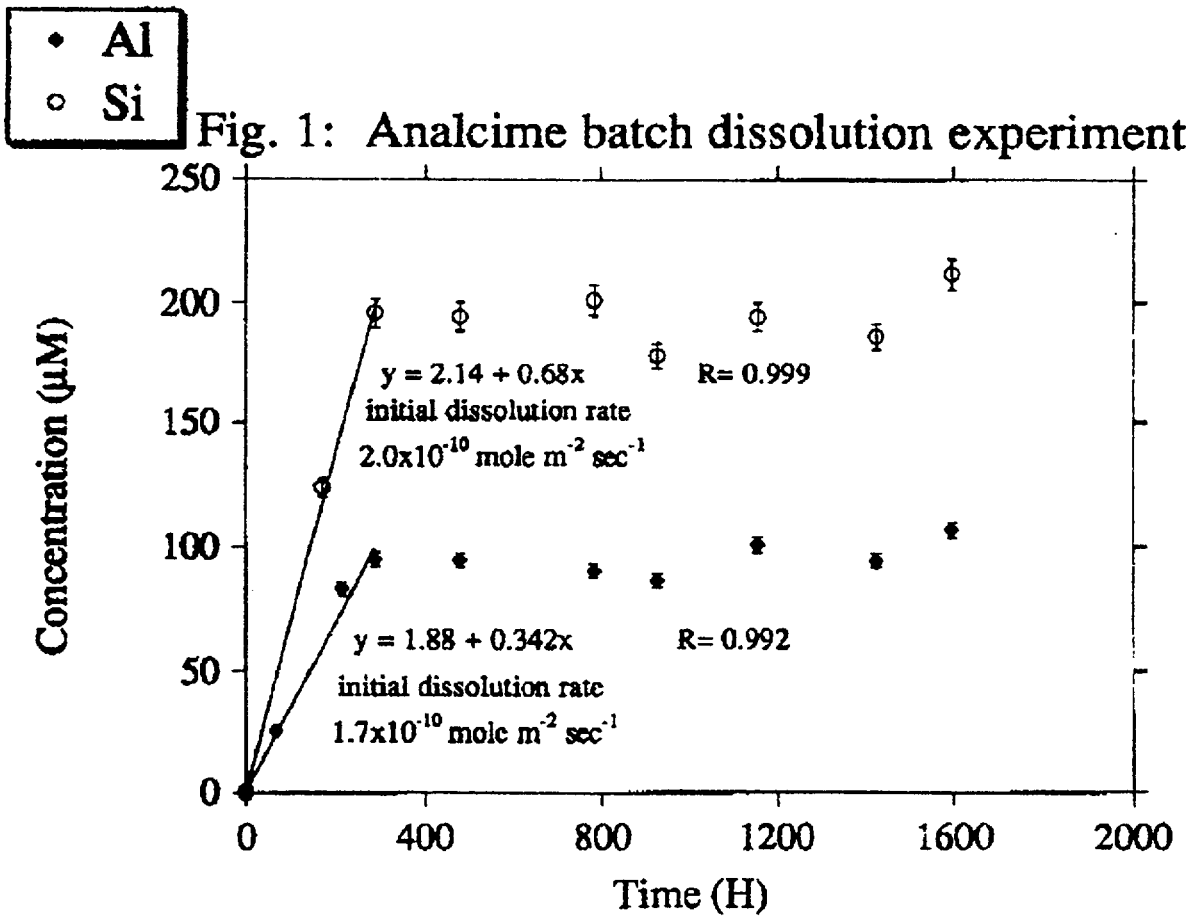
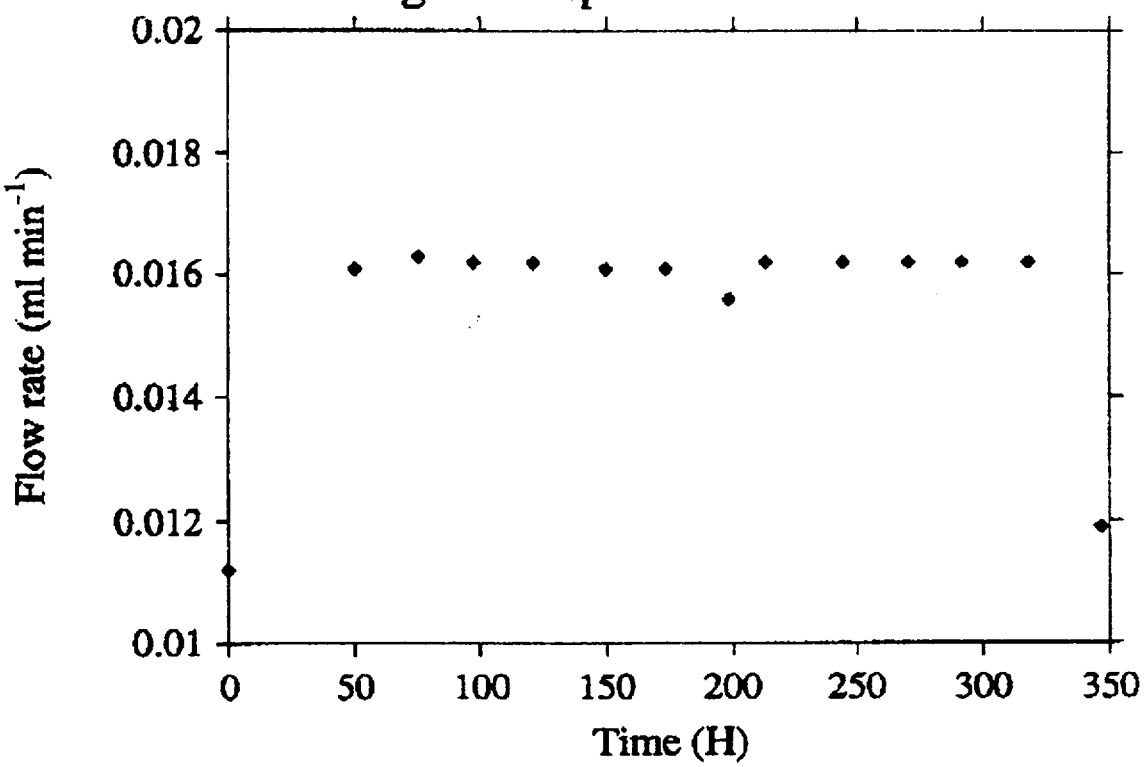
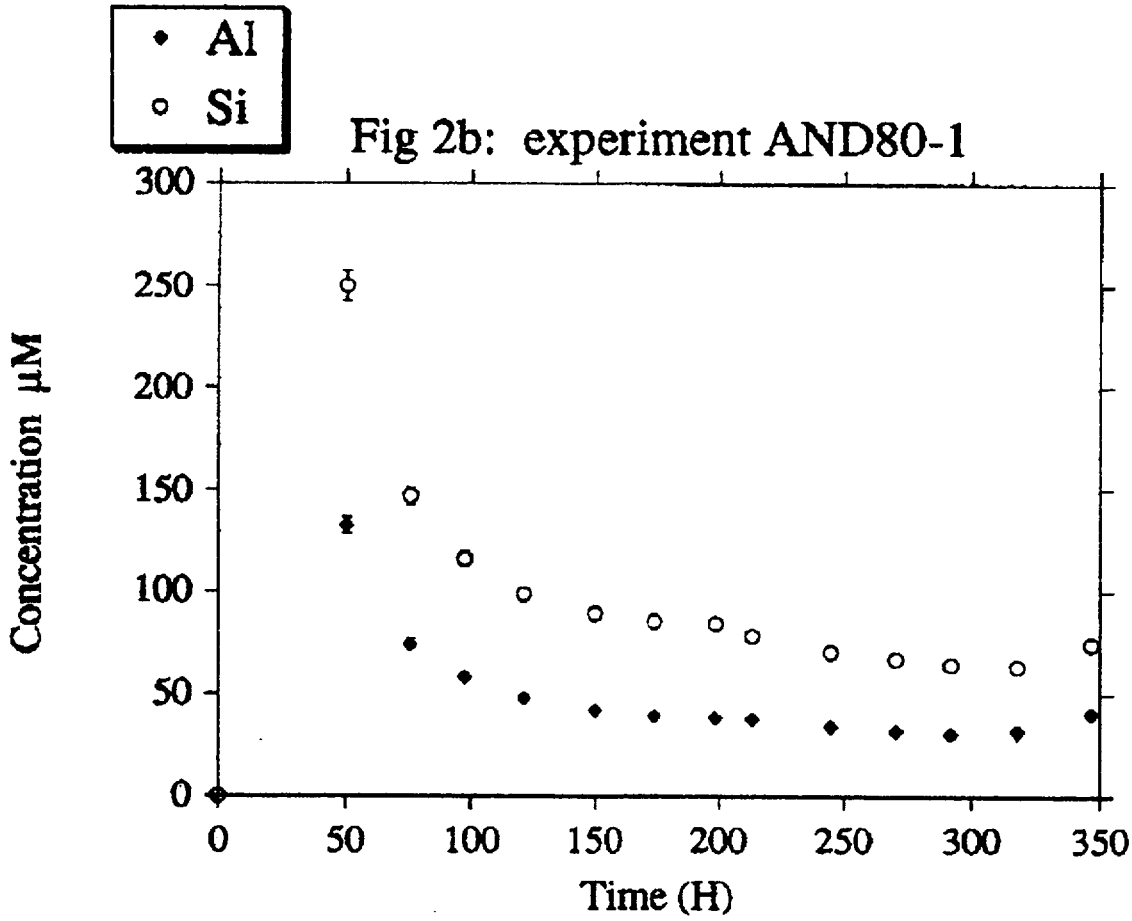


Fig. 1: Analcime batch dissolution experiment

Fig 2a: experiment AND80-1




Al
Si
Fig 2b: experiment AND80-1
Concentration µM
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Time (H)

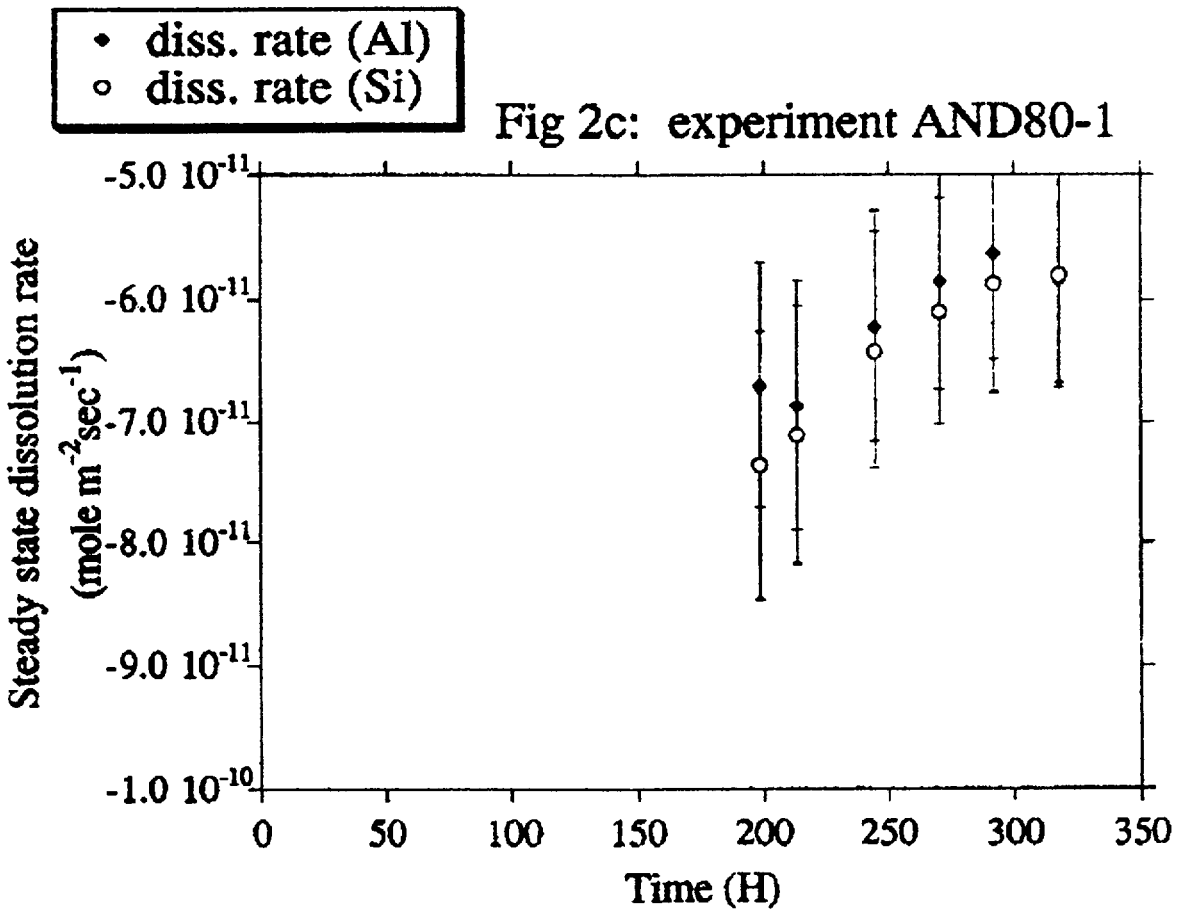

diss. rate (Al)
diss. rate (Si)
Fig 2c: experiment AND80-1
Steady state dissolution rate
(mole m-2sec-1)
-5.0 10-11
-6.0 10-11
-7.0 10-11
-8.0 10-11
-9.0 10-11
-1.0 10-10
0
50
100
150
200
250
300
350
Time (H)

Fig 2d: experiment AND80-1

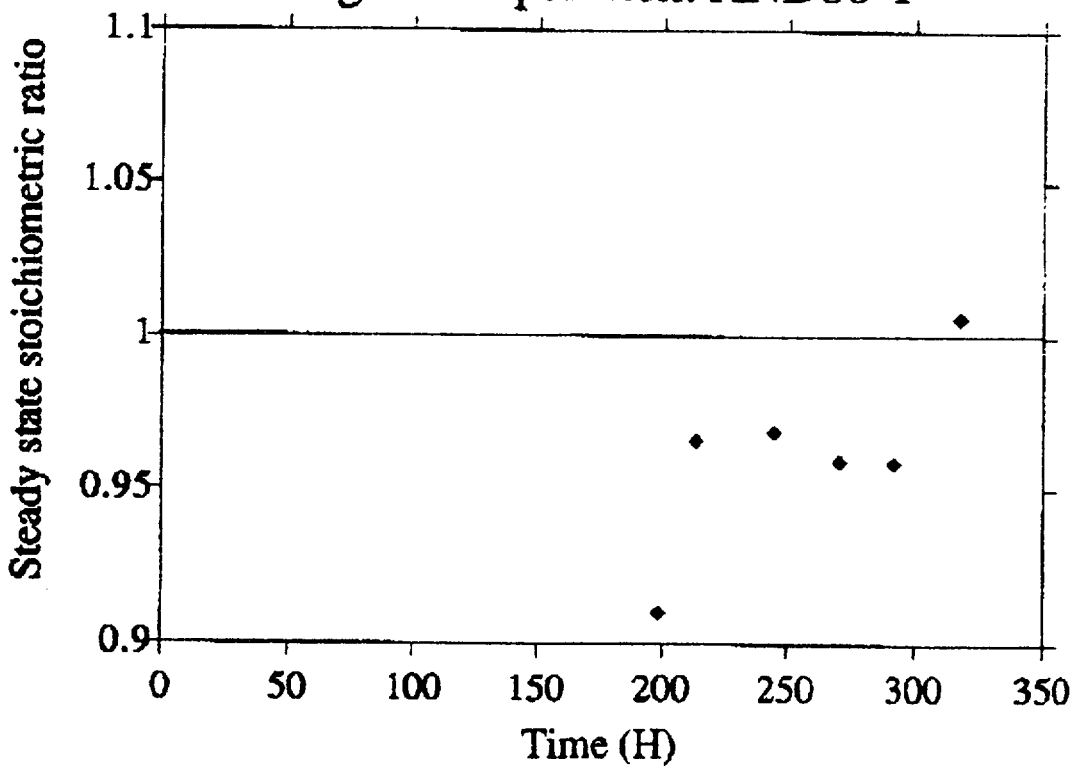


Fig 2e: experiment AND80-1

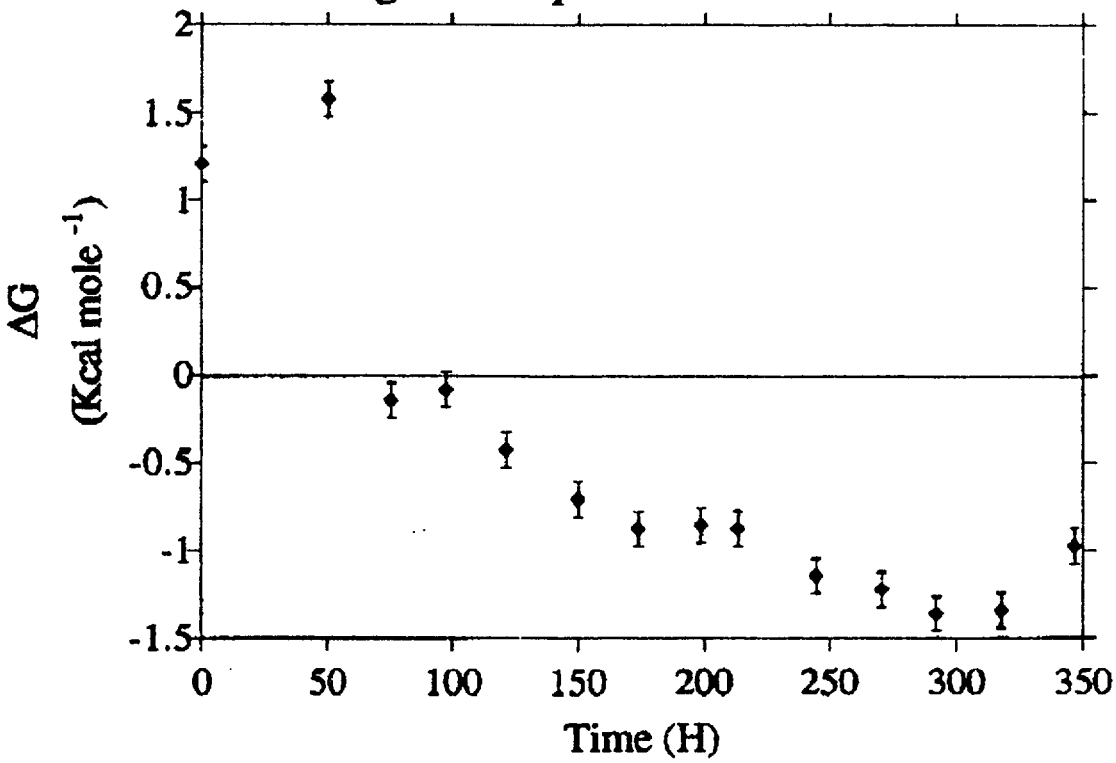
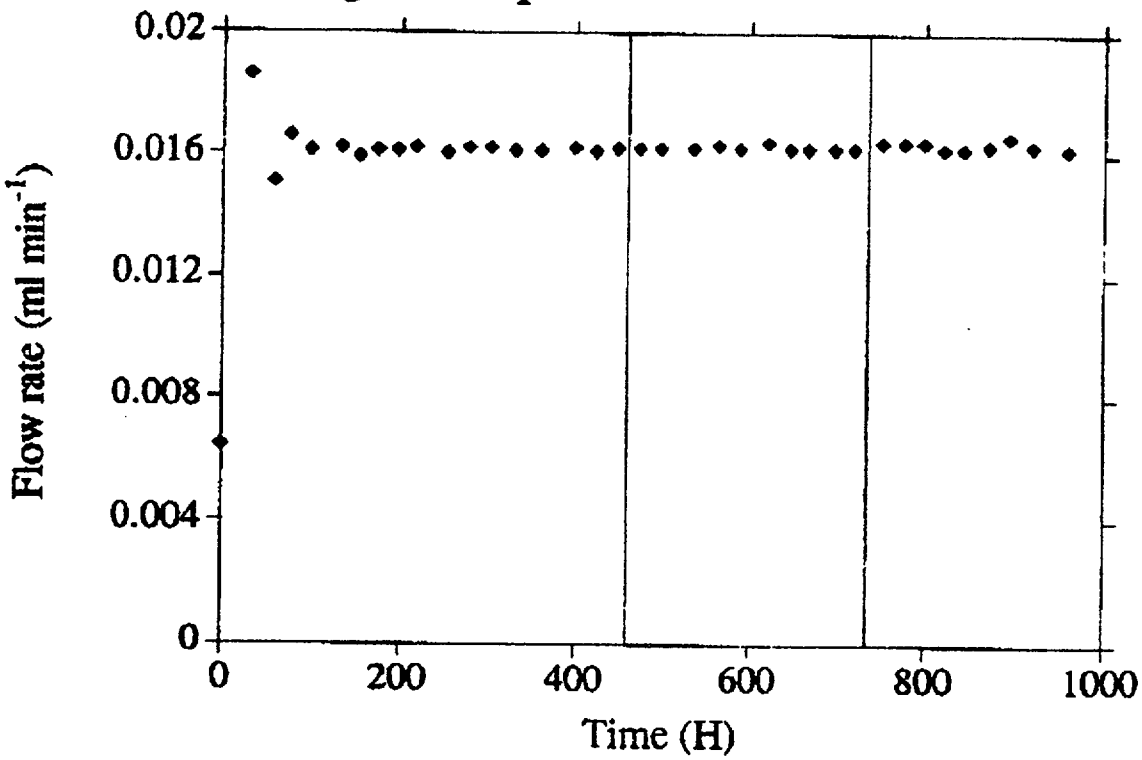
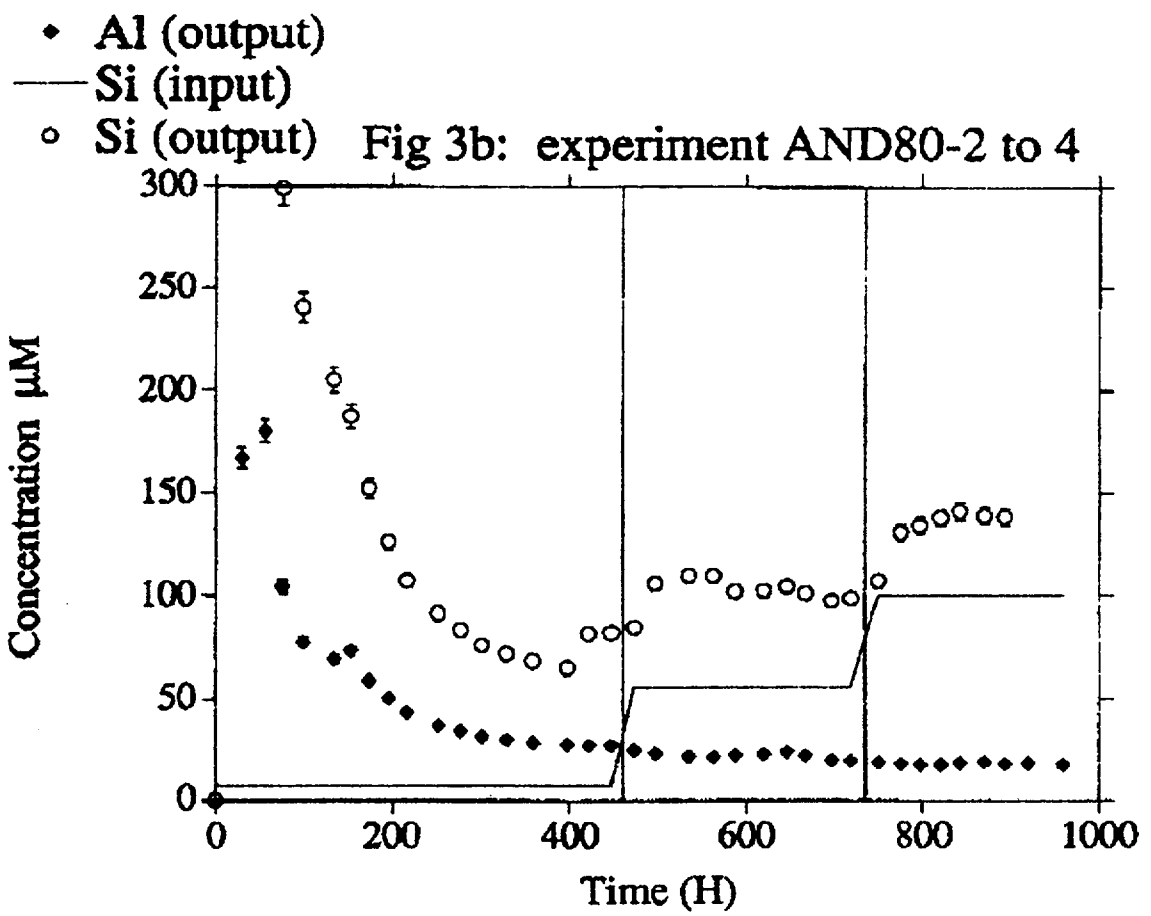


Fig 3a: experiment AND80-2 to 4




Al (output)
Si (input)
Si (output)
Fig 3b: experiment AND80-2 to 4
Concentration µM
300
250
200
150
100
50
0
0
200
400
600
800
1000
Time (H)

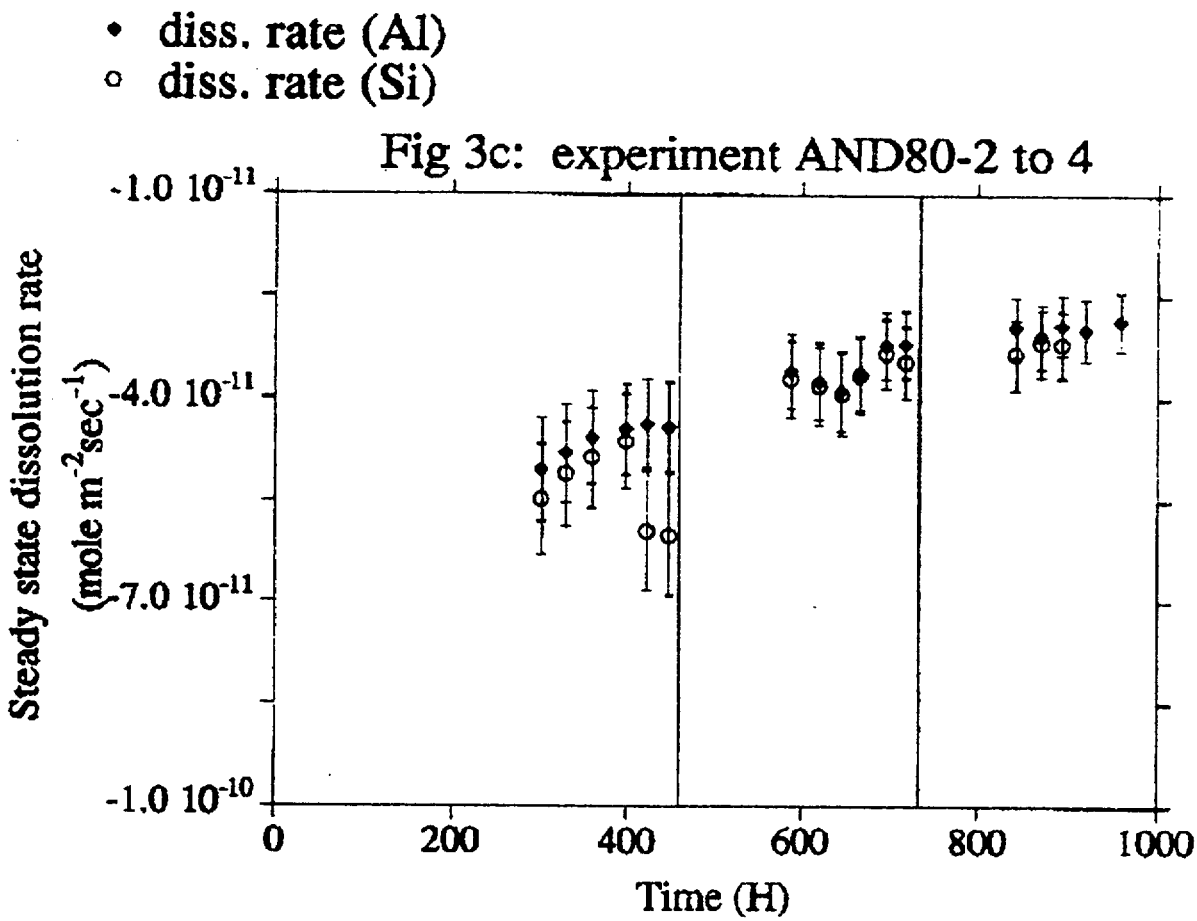

• diss. rate (Al)
○ diss. rate (Si)
Fig 3c: experiment AND80-2 to 4
Steady state dissolution rate
(mole m-2sec-1)
-1.0 10-11
-4.0 10-11
-7.0 10-11
-1.0 10-10
0
200
400
600
800
1000
Time (H)

Fig 3d: experiment AND80-2 to 4

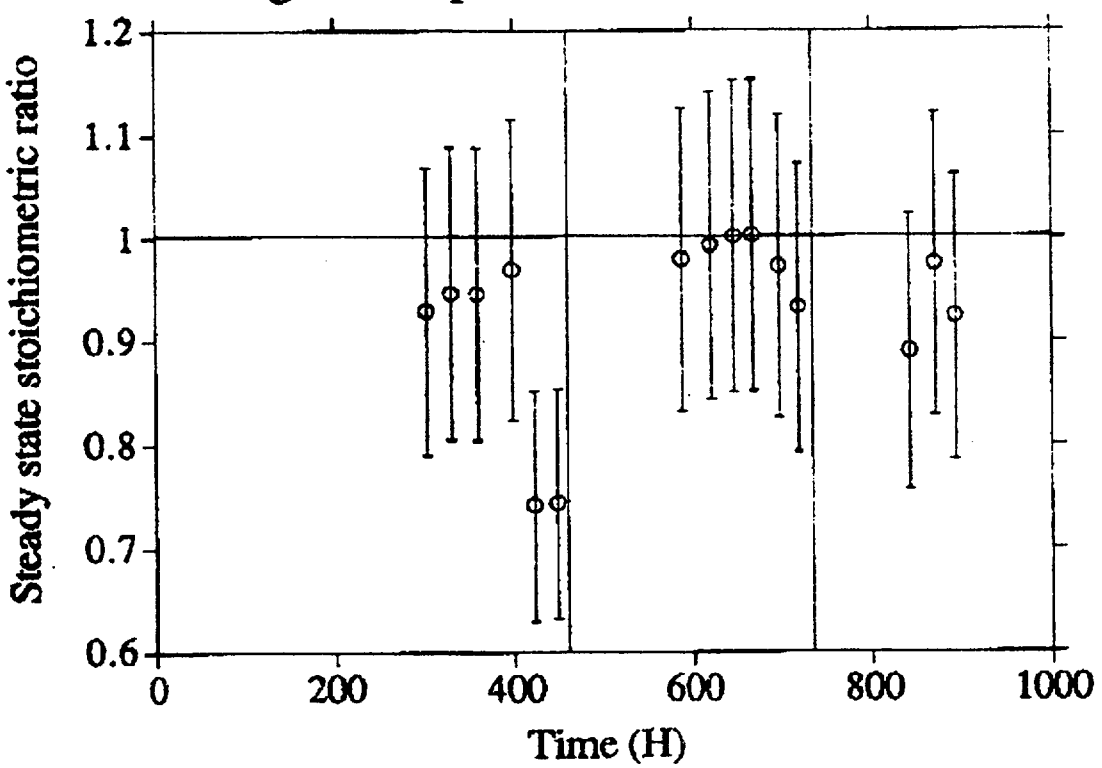
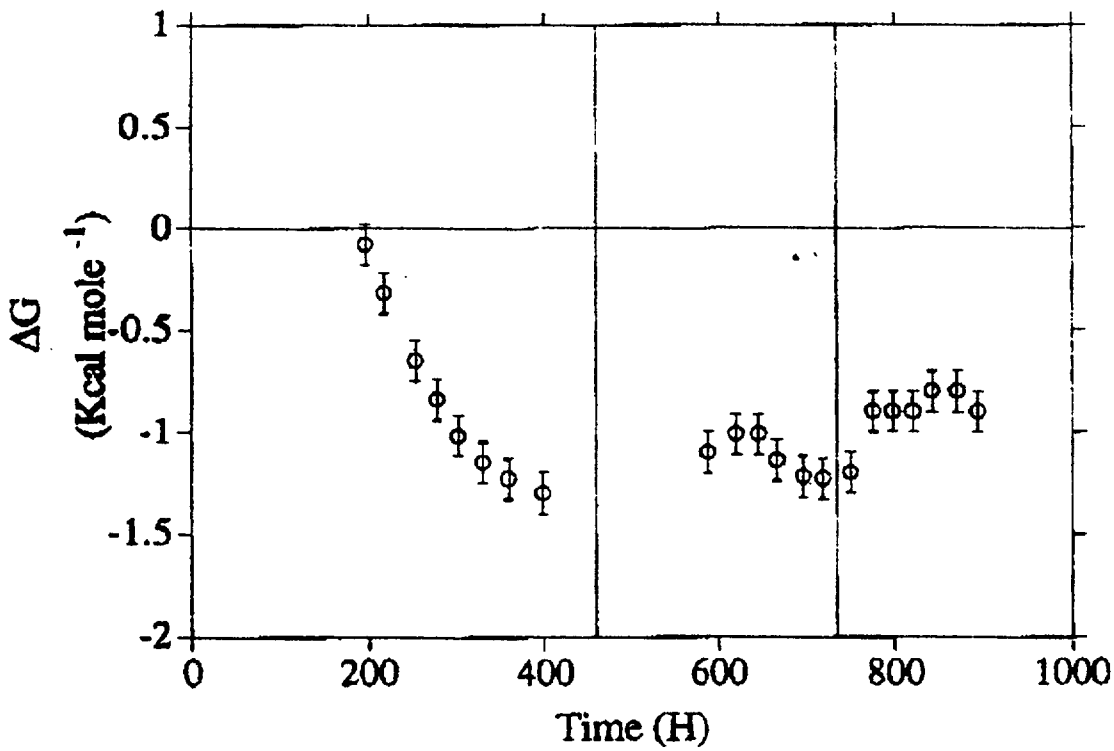


Fig 3e: experiment AND80-2 to 4



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WBS 1.2.6.1.1, 1.2.3.1
"QA N/A"

Susan for Jan monthly

memorandum

LA-EES-13-LV-02-94-012

February 9, 1994
702/794-7095
M/S 527

TO: S. B. Jones, DOE/YMPO
W. B. Simecka, DOE/YMPO

FROM: R. D. Oliver, LANL For

SUBJECT: EXPLORATORY STUDIES FACILITY TESTING ACTIVITIES - JANUARY 1994 - MONTHLY PROGRESS REPORT (SCPB: N/A)

GENERAL EXPLORATORY STUDIES FACILITY ACTIVITIES

TEST PROGRAM: EXECUTIVE SUMMARY

Test Coordination during January covered a broad spectrum of work including Test Planning, quality improvement, integration and presentation. Test Alcove #1 was determined to be of the necessary length and in the proper geologic setting required to start drilling for the Radial Borehole Test (Attachment 1). The U.S. Bureau of Reclamation (USBR) completed mapping in the test alcove from CS 0+27.4 (90') to CS 0+34.4 (113') (Attachment 2). Under the Construction Monitoring Job Package three convergence pin stations were installed and three Multipoint Borehole Extensometer (MPBX) gauges were put into place (Attachment 3). Activities at Fran Ridge (Engineered Barrier - Large Block Experiment) included completion of the first saw cut (North Side see Attachment 4) and modification of the work/safety plan to accommodate the use of extended work hours.

The Test Coordination Office (TCO) has reviewed Design Package 1C (Compressed Air & Standby Power) and provided comment. In response to a request by the constructor (TWS-EES-13-LV-01-94-15) the TCO reviewed the use of "Shell Bolts" in Test Alcove #1 with the Test Lead and concurred that the opportunity be taken to evaluate a method of ground stabilization which does not require cementitious materials or epoxy (pull test results and location included as Attachment 5). The Exploratory Studies Facility (ESF) schematic provided as Attachment 7 reflects progress of ramp construction, relationship to existing and proposed drill holes and the location of the major faults. A current copy of the ESF Working Test Schedule is also provided as Attachment 8.

INITIATIVES

Core samples from ESF Test Alcove #1 that are not directly required for hydrochemistry analyses will be utilized in a core packaging inquiry aimed at establishing the most cost effective

FEB 1 0 1994

system for long-term preservation of moisture content and isotopic composition. The packaging evaluation will be conducted in support of the United States Geological Survey hydrochemistry program; results being reported in this publication (TCO Monthly Report).

Laboratory preparation for deployment of a Laser-Induced Breakdown Spectroscopy (LIBS) experiment which will be employed during the drilling of holes for the Hydrochemistry Job Package is complete. Field testing will include real time analysis of the dust stream coming from the air-coring operation with particular attention to calcite silica concentrations and other identifiable minerals.

FIELD ACTIVITIES

Field Activities are further detailed in appendices attached to this report and construction turnover reports are found at Attachment 6. Each of the appendices contains a description of the progress in milestones and deliverables, a summary of field activities, a brief description of the manner of data flow, and a schedule. When pertinent, additional graphic information is provided to illustrate progress or concerns.

Appendix I - Geologic Mapping of the ESF (JP 92-20A)
Appendix II - Perched Water Testing in the ESF (JP 92-20B)
Appendix III - Consolidated Sampling in the ESF (JP 92-20C)
Appendix IV - Construction Monitoring in the ESF (JP 92-20D)
Appendix V - Engineered Barrier-Fran Ridge Large Block Experiment (JP 93-10)
Appendix VI - Hydrochemistry (JP 92-20E)

INTEGRATED DATA SYSTEM

Efforts during January were concentrated on identifying and planning for the Data Acquisition Stations (DAS) needs of the principal investigators and communication of these needs to the IDS Design Section of the Civilian Radioactive Waste Management System Management & Operating Contractor. Work continues on identifying and evaluating the various possible approaches to meet the principal investigators data acquisition needs in a timely and cost effective manner.

ADMINISTRATIVE SCHEDULE AND SUMMARY TABLE

Table I identifies the field activities in progress at the ESF. The Administrative Schedule (Attachment 8) is based on information provided by the ESF Design Team and is consistent with the illustration "NRG, SRG, SD, and UZ Borehole/ESF Locations and Schedule" (Attachment 7).

TABLE I
ESF Testing Field Activity
North Ramp Starter Tunnel

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	WBS ELEMENT	TCO TEST EVENT NAME	TPP #	JP #
Rock Characteristic Program	Characterization of Structural Features in the Site Area	8.3.1.4.2.2	Geologic Mapping of the ESF	1.2.3.2.2.1.2	Geologic Mapping - Starter Tunnel	TPP 92-10	JP 92-20A
Geohydrology Program	Characterization of YM Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Perched Water Testing in the ESF	1.2.3.3.1.2.4	Perched Water - Starter Tunnel (Contingency)	TPP 92-11	JP 92-20B
			Hydrochemistry Tests in the ESF	1.2.3.3.1.2.4	Hydrochemistry Testing	TPP 92-12	JP 92-20E
			Radial Borehole Tests in the ESF	1.2.3.3.1.2.4	Radial Borehole Testing	TPP 92-13	JP 92-20F
Thermal and Mechanical Rock Properties Program	In Situ Design Verification	8.3.1.15.1.8	Evaluation of Mining Methods Monitoring of Ground Support Systems	1.2.4.2.1.1.4	Construction Monitoring in the ESF	TPP T-93-2	JP 92-20D
Geochemistry Program	Water Movement Tests, Rev. 0 Water Movement Tests, Rev. 1	8.3.1.2.2.2	Chloride and Chlorine-36 Measurements of Percolation at YM	1.2.3.3.1.2.2	Consolidated Sampling in the ESF	TPP 92-14	JP 92-20C
	History of Mineralogic and Geochemical Alteration of YM	8.3.1.3.2.2	History of Mineralogic and Geochemical Alteration of YM	1.2.3.2.1.1.2			
	Mineralogy, Petrology, and Chemistry of Transport Pathways	8.3.1.3.2.1	Mineral Distribution Between Host Rock and Accessible Environment	1.2.3.2.1.1.1			
	Mineralogy, Petrology, and Chemistry of Transport Pathways	8.3.1.3.2.1	Fracture Mineralogy Studies	1.2.3.2.1.1.1			
Repository Horizon Rock-Water Interaction Large Block Experiment	Engineered Barrier System Field Tests	SIP-NF-2 Rev. 0	Repository Horizon Rock Water Interaction - Large Block Experiment	1.2.2.2.4	Engineered Barrier-Fran Ridge Large Block Experiment	NA	JP 93-10

ENVIRONMENTAL, SAFETY, AND HEALTH (ES&H) ACTIVITIES

Tracer water used underground by REECo for January totaled 43.8 kiloliters (11,590 gallons), showing a total usage of 1,714 kiloliters (452,811 gallons).

The ESF Safety Coordinator submitted the Accident/Incident report for the fourth quarter (cal. 93) per DOE Order 5484.1 and attended the Safety Advisory Committee and ALARA meetings representing the TCO. The TCO requested and obtained an operations permit for the laser that will be employed in the LIBS package in Test Alcove #1. A review of the work plan and safety plan for the Large Block-Engineered Barrier Experiment was initiated to incorporate provisions for extended hour operations when required. Training for this period included GET training for selected employees at Los Alamos and incidental Mine Safety Training for eight visitors.

SITE CONSTRUCTION

JOB PACKAGE (JP) 92-20 ESF NORTH PORTAL PAD AND FACILITIES

Construction of ESF Test Alcove #1 was completed by the constructor with the face at CS 0+34.4 (113'). The crown of the test alcove was fibercreted from the entrance to CS 0+27.4 (90') and the constructor shotcreted the high wall in the box cut.

ISSUES: None

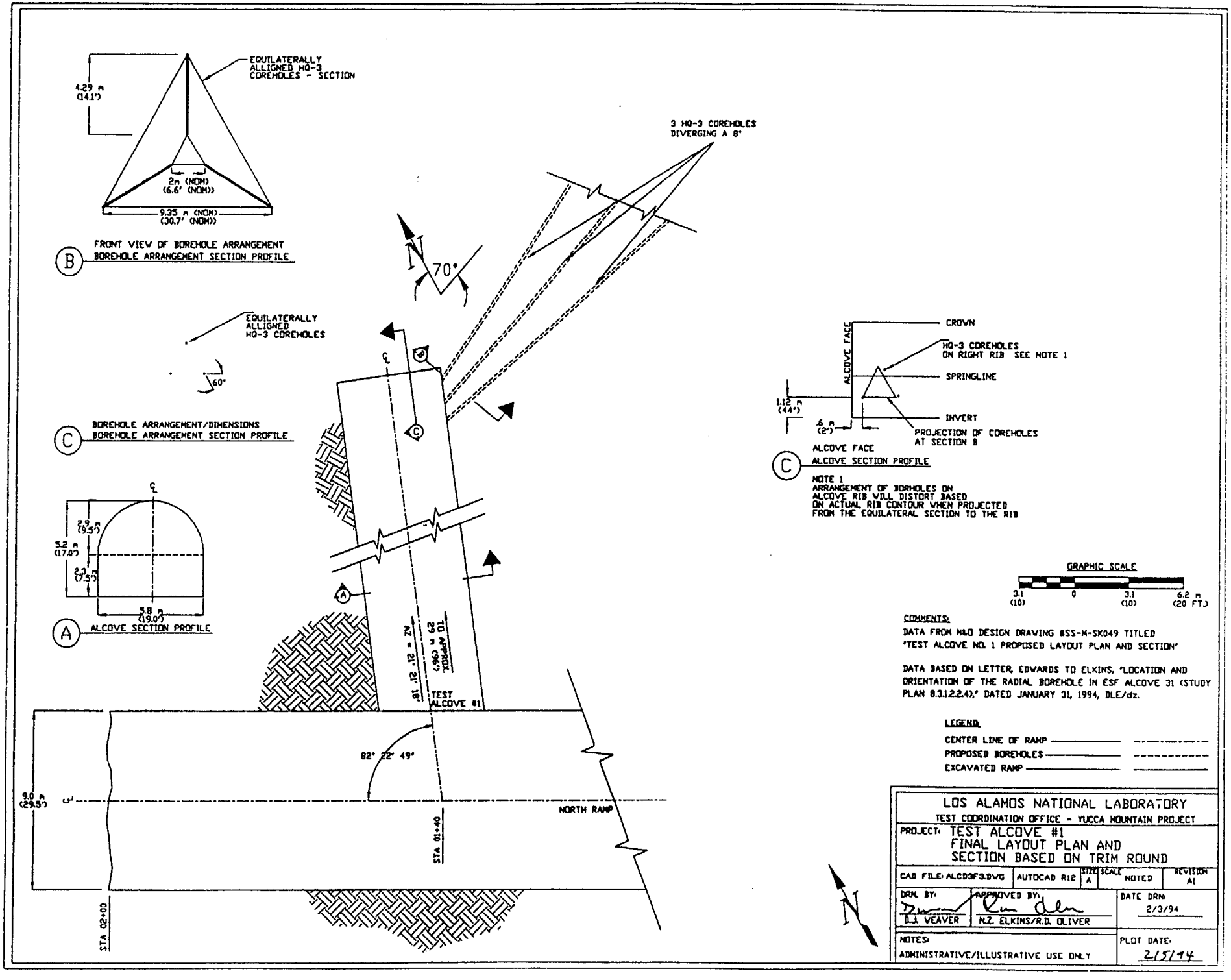
Attachments "Limited Value Material"

RDO:dm10

Cy: W. J. Boyle, DOE/YMPO, MS 523
R. A. Crawley, DOE/YMPO, MS 523
J. R. Dyer, DOE/YMPO, MS 523
V. F. Iorii, DOE/YMPO, MS 523
E. H. Petrie, DOE/YMPO, MS 523
K. J. Skipper, DOE/YMPO, MS 523
M. W. Smith, DOE/YMPO, MS 523
D. P. Stucker, DOE/YMPO, MS 523
R. S. Waters, DOE/YMP, MS 523
R. J. White, DOE/YMPO, MS 523
D. R. Williams, DOE/YMPO, MS 523
W. A. Girdley, DOE/FOC, MS 717
W. A. Wilson, DOE/FOC, MS 717
W. C. Kopatich, RSN, MS 403
E. L. Wright, RSN, MS 403

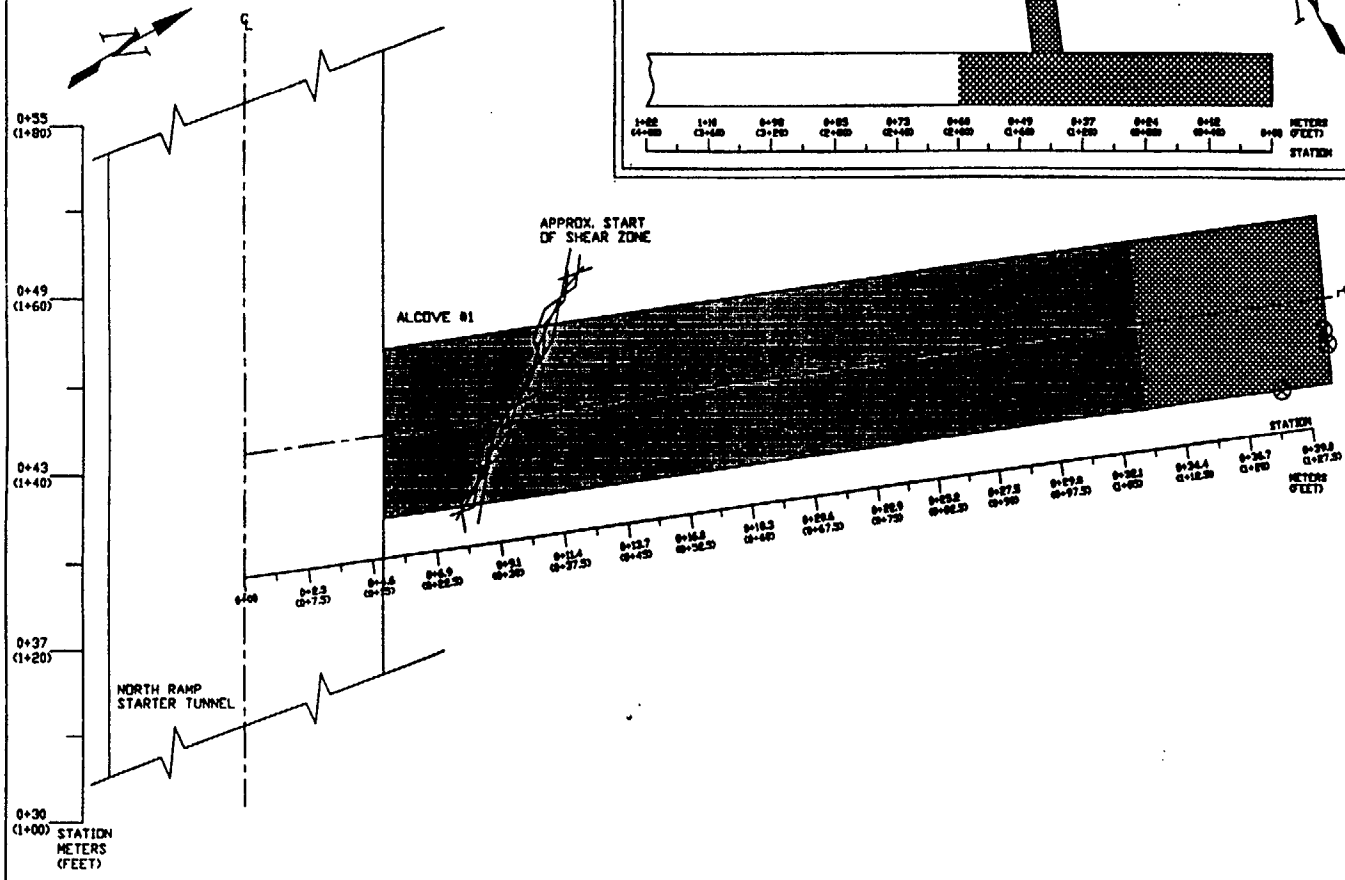
Cy con't:

B. R. Gardella, REECo, MS 408
R. C. McDonald, CRWMS M&O, MS 423
R. W. Craig, USGS/LV, MS 509
D. L. Edwards, USGS/LV, MS 509
L. R. Hayes, USGS, Denver, CO
M. D. Voegele, SAIC, MS 517
D. S. Kessel, SNL/LV, MS 509
L. E. Shephard, SNL, Dept. 6302, Albuquerque, NM
J. A. Blink, LLNL/LV, MS 465
W. L. Clarke, LLNL, Livermore, CA
J. A. Canepa, LANL, EES-13, MS J521
D. M. Boak, LANL, EES-13/LV, MS 527
N. Z. Elkins, LANL, EES-13/LV, MS 527
E. F. Homuth, LANL, EES-13/LV, MS 527
K. L. Kinter, LANL, EES-13/LV, MS 527
A. J. Mitchell, LANL, EES-13/LV, MS 527
D. J. Weaver, LANL, EES-13/LV, MS 527
J. H. Berry, LANL/FOC, MS 735
R. G. Kovach, LANL/FOC, MS 735
EES-13/LV, LANL, MS 527

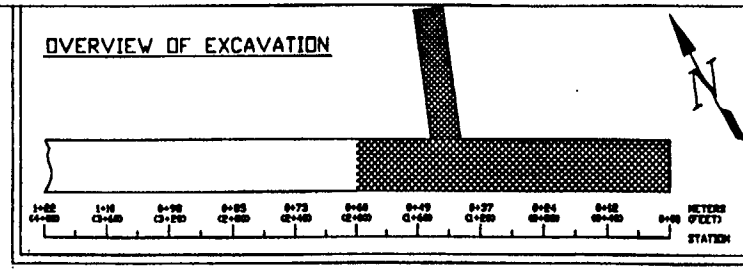


LA-EES-13-LV-02-94-012
Attachment 1
1 Page

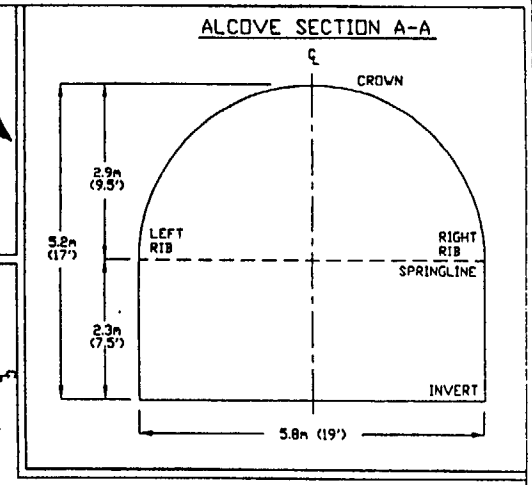
DETAILED ALCOVE SECTION - TOP VIEW



OVERVIEW OF EXCAVATION



ALCOVE SECTION A-A



SAMPLE BAR CODE #	DATE COLLECTED	LOCATION
SPC00500786	1/26/94	ALCOVE #1 - RIGHT RIB CS 0+32.6, 1.7 m ABOVE INVERT
SPC00500787	1/26/94	ALCOVE #1 - FACE CS 0+34.4, 1.8 m FROM RIGHT RIB 1.4 m ABOVE INVERT
SPC00500788	1/26/94	ALCOVE #1 - FACE CS 0+34.4, 2.4 m FROM RIGHT RIB 1.5 m ABOVE INVERT

GRAPHIC SCALE

3.1 (10) 0 3.1 (10) 6.2 m (20 FT.)

LEGEND:

- CENTER LINE OF RAMP
- UNEXCAVATED MATERIAL
- EXCAVATED RAMP
- SAMPLE LOCATION
- CONVERGENCE PINS
- LOAD CELLS
- PHOTOGRAMMETRY TARGET LOCATIONS
- MAPPING PROGRESS
- EXCAVATION PROGRESS

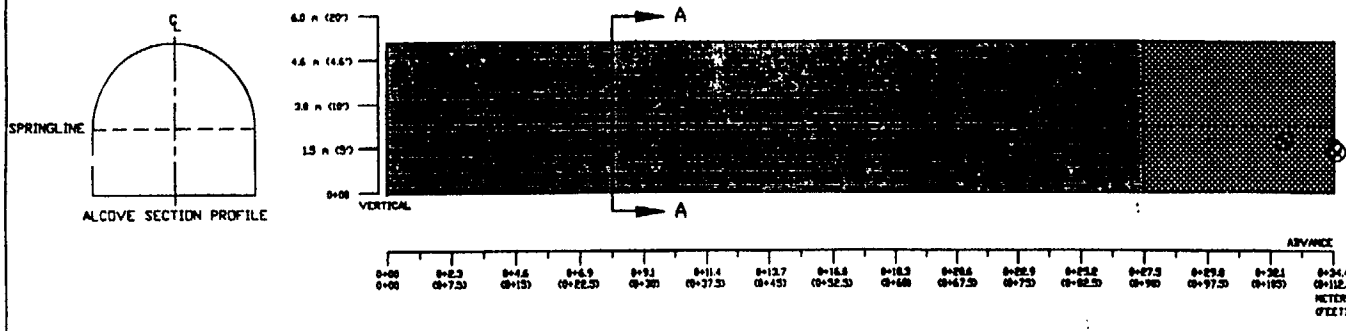
COMMENTS:

ALCOVE CENTER LINE AT 0+43m (CS 1+40)

ALCOVE EXCAVATION TO APPROX. 34.4 m (113')

THE REQUIRED DEPTH OF ALCOVE #1 HAS BEEN DETERMINED IN THE FIELD.

ALCOVE #1 DETAIL FOR SAMPLE LOCATION



LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

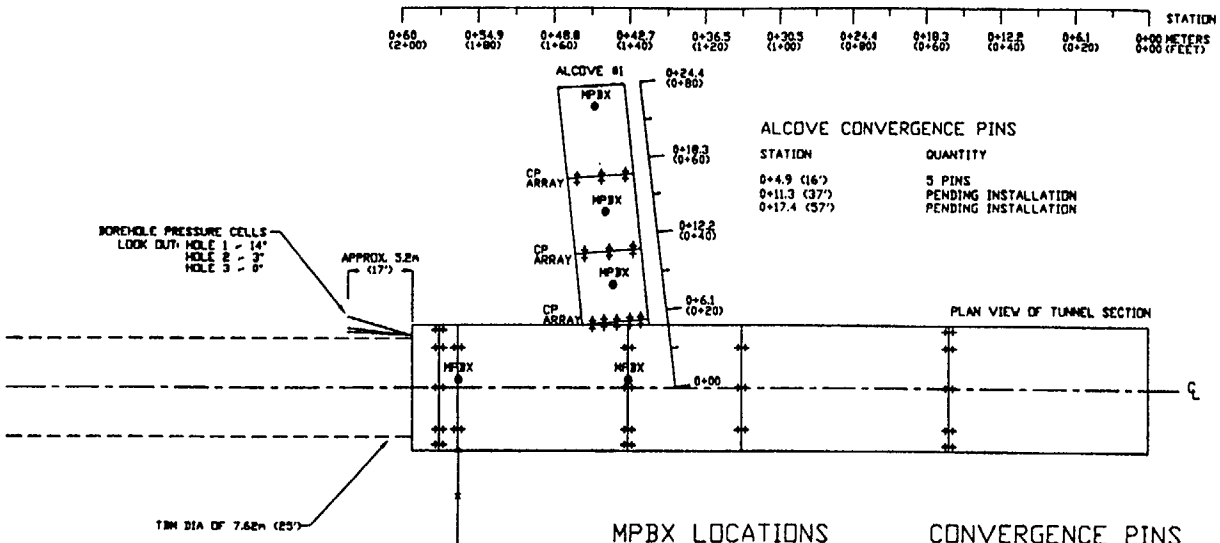
PROJECT: GEOLOGIC MAPPING/CONSOLIDATED SAMPLING AND CONSTRUCTION MONITORING IN ALCOVE #1

CAD FILE: ALCRPRTB.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1

DRN. BY:	APPROVED BY:	DATE DRN:
D.J. WEAVER	ON FILE N.Z. ELKINS/R.D. OLIVER	2/1/94

NOTES:
ADMINISTRATIVE/ILLUSTRATIVE USE ONLY

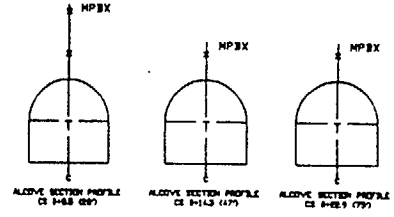
PLOT DATE: 2/1/94



ALCOVE CONVERGENCE PINS

STATION	QUANTITY
0+4.9 (16')	5 PINS
0+11.3 (37')	PENDING INSTALLATION
0+17.4 (57')	PENDING INSTALLATION

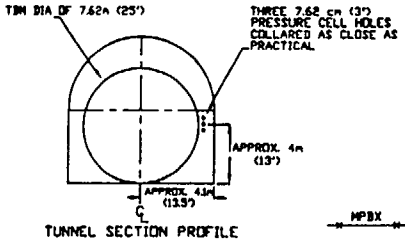
ALCOVE MPBX LOCATIONS



MPBX LOCATIONS

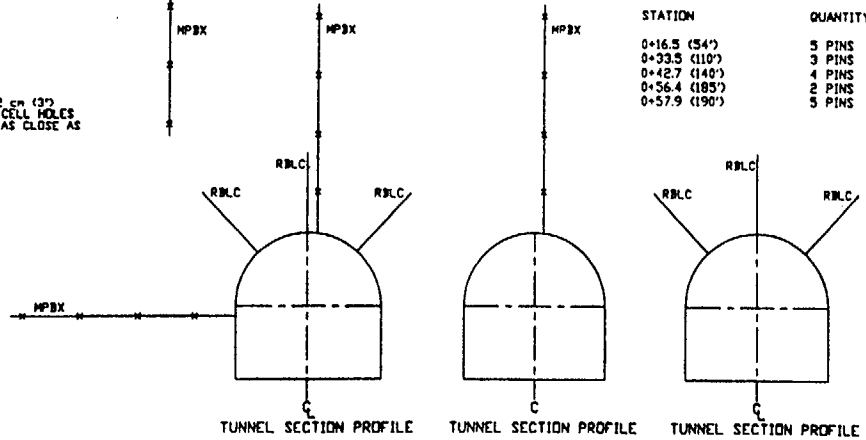
CONVERGENCE PINS

STATION	QUANTITY
0+16.5 (54')	5 PINS
0+33.5 (110')	3 PINS
0+42.7 (140')	4 PINS
0+56.4 (185')	2 PINS
0+57.9 (190')	5 PINS



TUNNEL SECTION PROFILE
TUNNEL FACE - CS 0+60 (197')

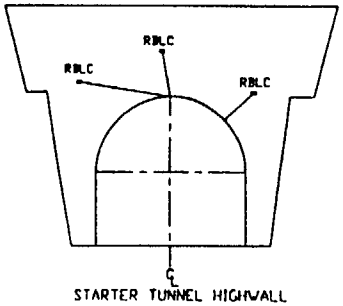
BOREHOLE PRESSEURE CELLS



TUNNEL SECTION PROFILE
CS 0+56.4 (185')

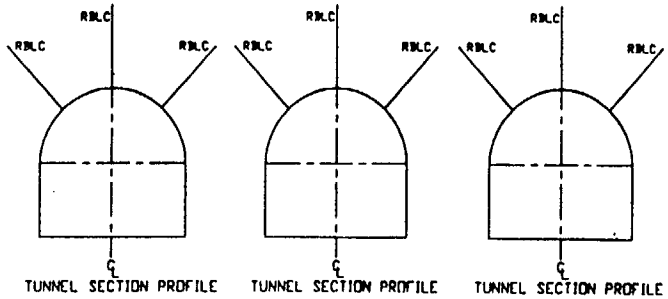
TUNNEL SECTION PROFILE
CS 0+44.2 (145')

TUNNEL SECTION PROFILE
CS 0+42.7 (140')



STARTER TUNNEL HIGHWALL
CS 0+00

HORIZONTAL ROCKBOLT LOAD CELLS



TUNNEL SECTION PROFILE
CS 0+33.5 (110')

TUNNEL SECTION PROFILE
CS 0+27.4 (90')

TUNNEL SECTION PROFILE
CS 0+16.8 (55')

ROCKBOLT LOAD CELL LOCATIONS

LEGEND:

- CENTER LINE OF RAMP
- UNEXCAVATED MATERIAL
- EXCAVATED RAMP
- MPBX HOLE
- BOREHOLE LOCATION
- PRESSURE CELLS
- ROCK BOLT LOAD CELL
- CONVERGENCE PIN ARRAY

COMMENTS:

NORTH PORTAL BOX CUT FACE AT CS 0+00

CROWN DRIFT AND RIB SECTION EXCAVATION TO 0+60m (CS 1+97). BENCH EXCAVATION TO 0+60m (CS 1+97).

LOCATIONS OF INSTRUMENTS FROM SNL SKETCH "INSTRUMENTATION LAYOUT," DATED 11-3-93

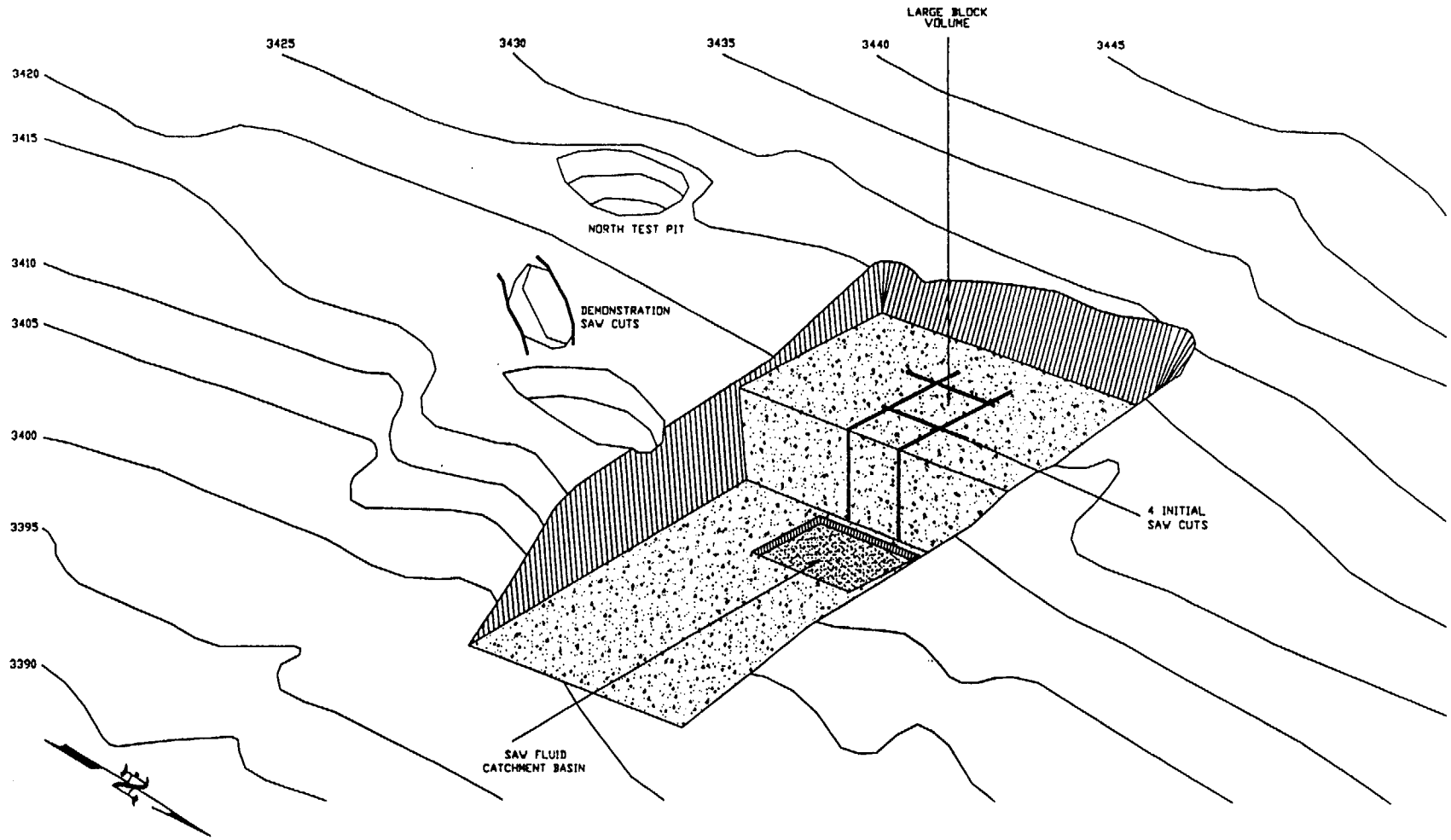
CP = "CONVERGENCE PIN"
RBLC = "ROCK BOLT LOAD CELL"

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: CONSTRUCTION MONITORING ILLUSTRATION - MPBX AND PRESSURE CELL LOCATIONS

CAD FILE: MPBX4.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
DRN. BY: D.J. WEAVER	APPROVED BY: ON FILE N.Z. ELKINS\R.D. OLIVER		DATE DRN: 1/10/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 2/1/94	

LA-EES-13-LV-02-94-012
Attachment 3
1 Page



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH #SK-93-D-PL17, 'FRAN RIDGE SITE PHASE I, 3-D PERSPECTIVE'

ACTUAL SAW CUT CONFIGURATIONS WILL BE DETERMINED IN THE FIELD.

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1928. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH #SK-93-D-PL17.

LEGEND:

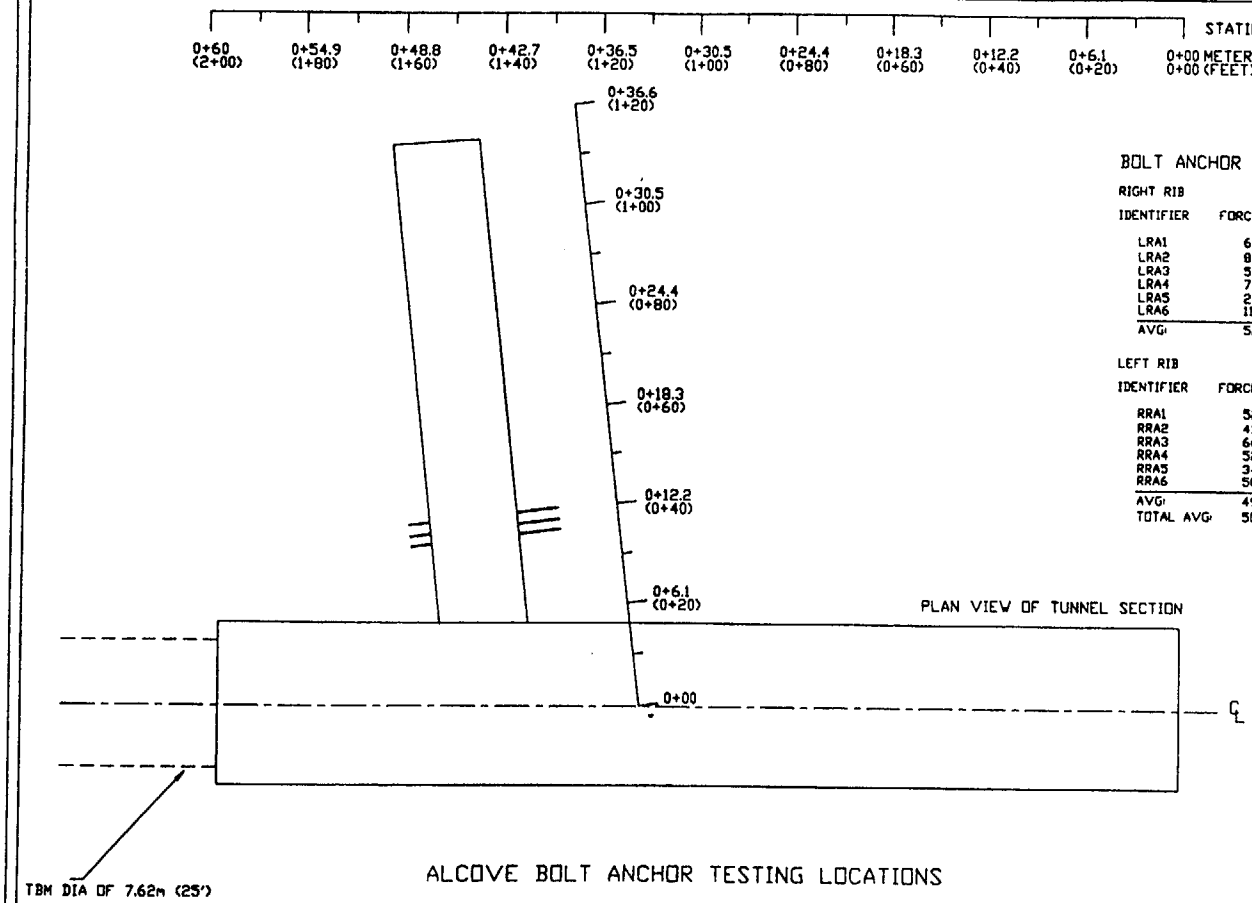
SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT: PHASE II EXCAVATION STRATEGY ILLUSTRATION

CAD FILE: EXCAV2B.DWG	AUTOCAD R12	SIZE: A	SCALE: NOTED	REVISION: A1

DRN. BY: D.J. WEAVER	APPROVED BY: ON FILE N.Z. ELKINS/R.D. OLIVER	DATE DRN: 1/7/94
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY		PLOT DATE: 1/19/94



BOLT ANCHOR TESTING (1/13/94)

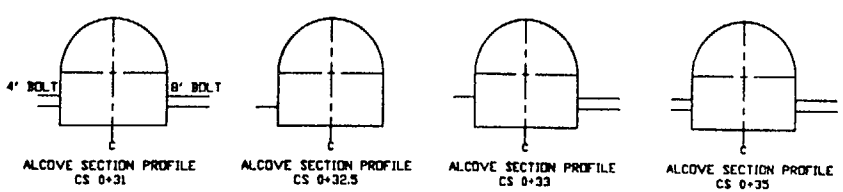
RIGHT RIB

IDENTIFIER	FORCE/UNIT AREA	FORCE	BOLT LENGTH	LOCATION
LRA1	6600 PSI	38,874 LBS	4'	CS 0+31
LRA2	8200 PSI	48,298 LBS	4'	CS 0+31
LRA3	5400 PSI	31,806 LBS	4'	CS 0+33
LRA4	7400 PSI	43,586 LBS	4'	CS 0+32.5
LRA5	2900 PSI	17,081 LBS	4'	CS 0+35
LRA6	1100 PSI	6,479 LBS	4'	CS 0+35
AVG:	5267 PSI	31,020 LBS		

LEFT RIB

IDENTIFIER	FORCE/UNIT AREA	FORCE	BOLT LENGTH	LOCATION
RRA1	5200 PSI	30,628 LBS	8'	CS 0+31
RRA2	4100 PSI	24,149 LBS	8'	CS 0+31
RRA3	6600 PSI	38,874 LBS	8'	CS 0+33
RRA4	5200 PSI	30,628 LBS	8'	CS 0+33
RRA5	3400 PSI	20,026 LBS	8'	CS 0+35
RRA6	5000 PSI	29,450 LBS	8'	CS 0+35
AVG:	4917 PSI	28,959 LBS		
TOTAL AVG:	5092 PSI	29,989 LBS		

ALCOVE BOLT ANCHOR TESTING LOCATIONS



LEGEND:

- CENTER LINE OF RAMP
- UNEXCAVATED MATERIAL
- EXCAVATED RAMP
- MPBX HOLE
- BOREHOLE LOCATION
- PRESSURE CELLS
- ROCK BOLT LOAD CELL
- CONVERGENCE PIN ARRAY

COMMENTS:

NORTH PORTAL BOX CUT FACE AT CS 0+00

CROWN DRIFT AND RIB SECTION EXCAVATION TO 0+60m (CS 1+97). BENCH EXCAVATION TO 0+60m (CS 1+97).

LOCATIONS OF INSTRUMENTS FROM SNL SKETCH 'INSTRUMENTATION LAYOUT,' DATED 11-3-93

CP = 'CONVERGENCE PIN'
RBLC = 'ROCK BOLT LOAD CELL'

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: CONSTRUCTION MONITORING ILLUSTRATION - BOLT ANCHOR TESTING LOCATIONS

CAD FILE: PULLTST.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
DRN. BY: D.J. WEAVER	APPROVED BY: ON FILE N.Z. ELKINS\R.D. OLIVER		DATE DRN: 2/8/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE:	

LOS ALAMOS EXPLORATORY STUDIES FACILITY
TEST COORDINATION OFFICE

DATE: 27 JAN 94	SHIFT: DAY	ID# 25	PAGE 1 OF 1

TCO FIELD REPRESENTATIVE (ORIGINATOR): R. G. KOVACH

DOE LEAD CONTACTS: ARCH GIRDLEY
TOM FORTNER

A. RELEASE FROM REECO CONSTRUCTION STATION CS 0+27.4 (90 ft) TO CS 0+34.4 (113 ft)

Release is for Test Alcove.

B. AREAS EXCLUDED FROM CONSTRUCTION ACTIVITIES & IDENTIFICATION

C. SPECIFIC REQUIREMENTS FOR FUTURE ACCESS WITHIN RELEASE AREAS

THE USE of FiberCrete OR Grouted Rock Bolts IS PROHIBITED IN THE AREA identified IN PART A.

D. ADDITIONAL REMARKS OR COMMENTS

USE of CHAIN LINK for GROUND Support IS acceptable.

cc. R. Oliver, LANL/TCO MS-J-900/527
K. Skipper, DOE/YMPO MS-523
L. Renegar, CRWMS/YMPO MS-423
T. Leonard, REECO MS-408

TABLE\RK01.TBL

LA-EES-13-LV-02-94-012
Attachment 7
2 Pages

LOS ALAMOS NATIONAL LABORATORY TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT				
PROJECT: NRG, SRG, SD AND UZ BOREHOLE/ ESF LOCATIONS AND SHEDULE				
CAD FILE: ESFBORE.DVG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A4
DRN. BY: D.J. VEAVER	APPROVED BY: DN FILE N.Z. ELKINS/R.D. OLIVER		DATE DRN: 1/31/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 2/3/94	

COMMENTS:

NORTH PORTAL BOX CUT FACE AT CS 0+00

ALCOVE #1 APPROXIMATELY LOCATED AT CS 1+40

TWO THOUSAND FEET GRID. ENGLISH COORDINATES ARE BASED ON THE NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE.

DIMENSIONS AND ELEVATIONS ARE SHOWN IN METERS. METERS ARE ROUNDED TO TWO DECIMAL PLACES. WHERE DESCREPANCIES BETWEEN ELEVATIONS AND GRADIENTS OCCUR DUE TO ROUNDING, ELEVATIONS WILL GOVERN.

STARTER TUNNEL CONFIGURATION AND AZIMUTH FOR THE FIRST 60.960 m (200 FT) IS BASED ON TITLE II PACKAGE 1A DESIGN DRAWINGS.

EXISTING DRILLHOLE LOCATIONS ARE BASED ON FIELD SURVEYS. PROPOSED DRILLHOLE LOCATIONS ARE BASED ON INFORMATION CONTAINED IN THE WORK PROGRAMS AND FROM GENESIS, "BOREHOLE LOCATIONS FOR YUCCA MOUNTAIN PROJECT," NR94012793.

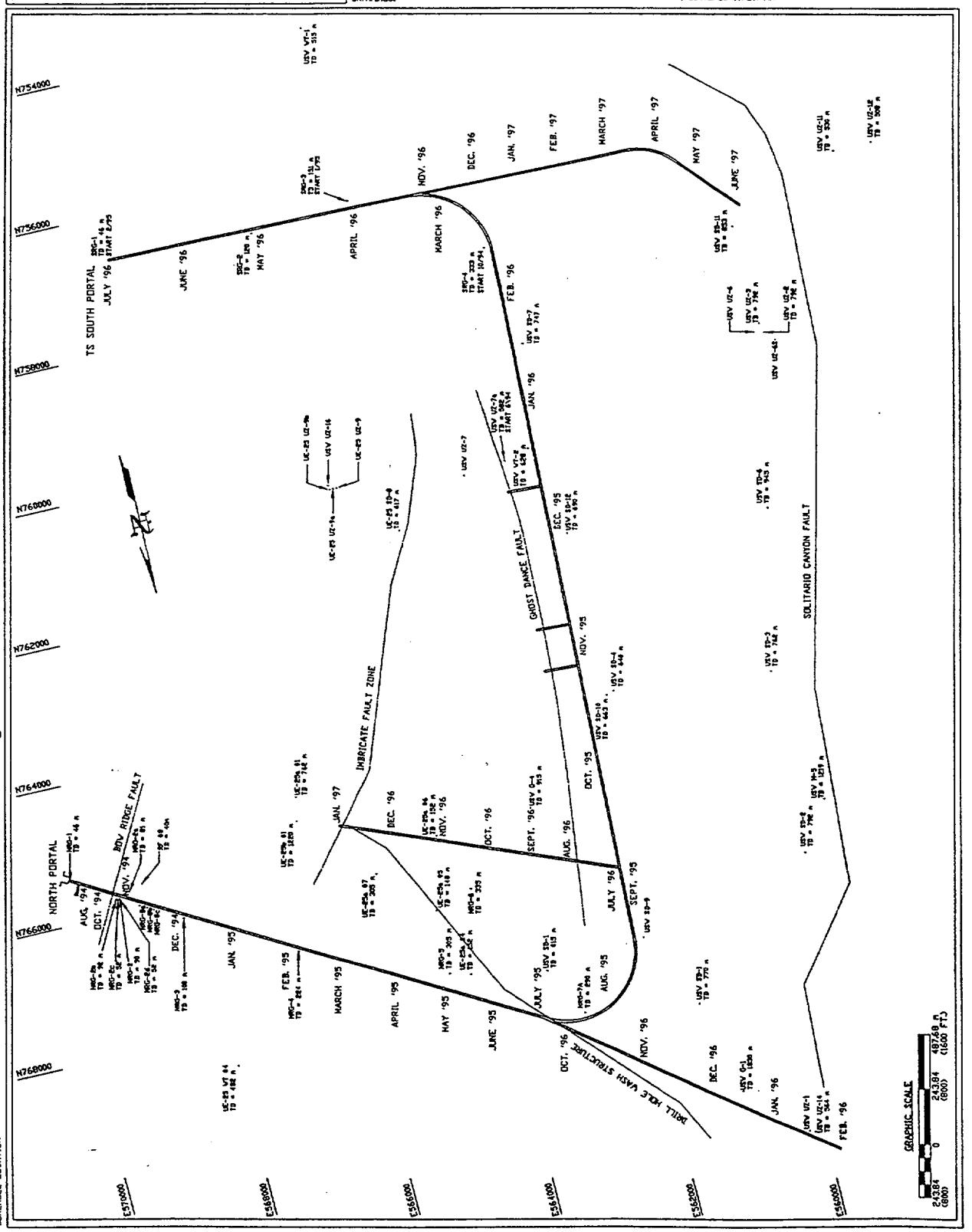
FAULT TRACE LOCATIONS, EXCEPT FOR THE BOV RIDGE FAULT, ARE APPROXIMATIONS BASED ON AT-DEPTH PROJECTIONS OF INFORMATION FROM USGS OPEN FILE REPORT 84-494, PRELIMINARY GEOLOGIC MAP AND SECTIONS, BY SCOTT AND BONK. THE BOV RIDGE FAULT TRACE IS AN AT-DEPTH PROJECTION BASED ON PRELIMINARY FIELD WORK FROM ON-GOING ROCK AND SOIL INVESTIGATIONS.

ILLUSTRATION BASED ON START, FINISH AND OTHER EXCAVATION MILESTONES. DATES DO NOT CORRESPOND TO A LINEAR EXCAVATION RATE.

DATES OBTAINED FROM M&O SCHEDULE "ESFMASTER PRELIMINARY DRAFT", OBTAINED 10/29/93.

FOR SIMPLICITY, THE CORE TEST AREA HAS NOT BEEN ILLUSTRATED

EXCAVATE MTA - THERMAL TEST MAY/01/96 - DEC/09/96
EXCAVATE REMAINING MTA DEC/09/96 - FEB/10/98
EXCAVATE GHOST DANCE DRIFTS JUL/01/96 - OCT/08/96

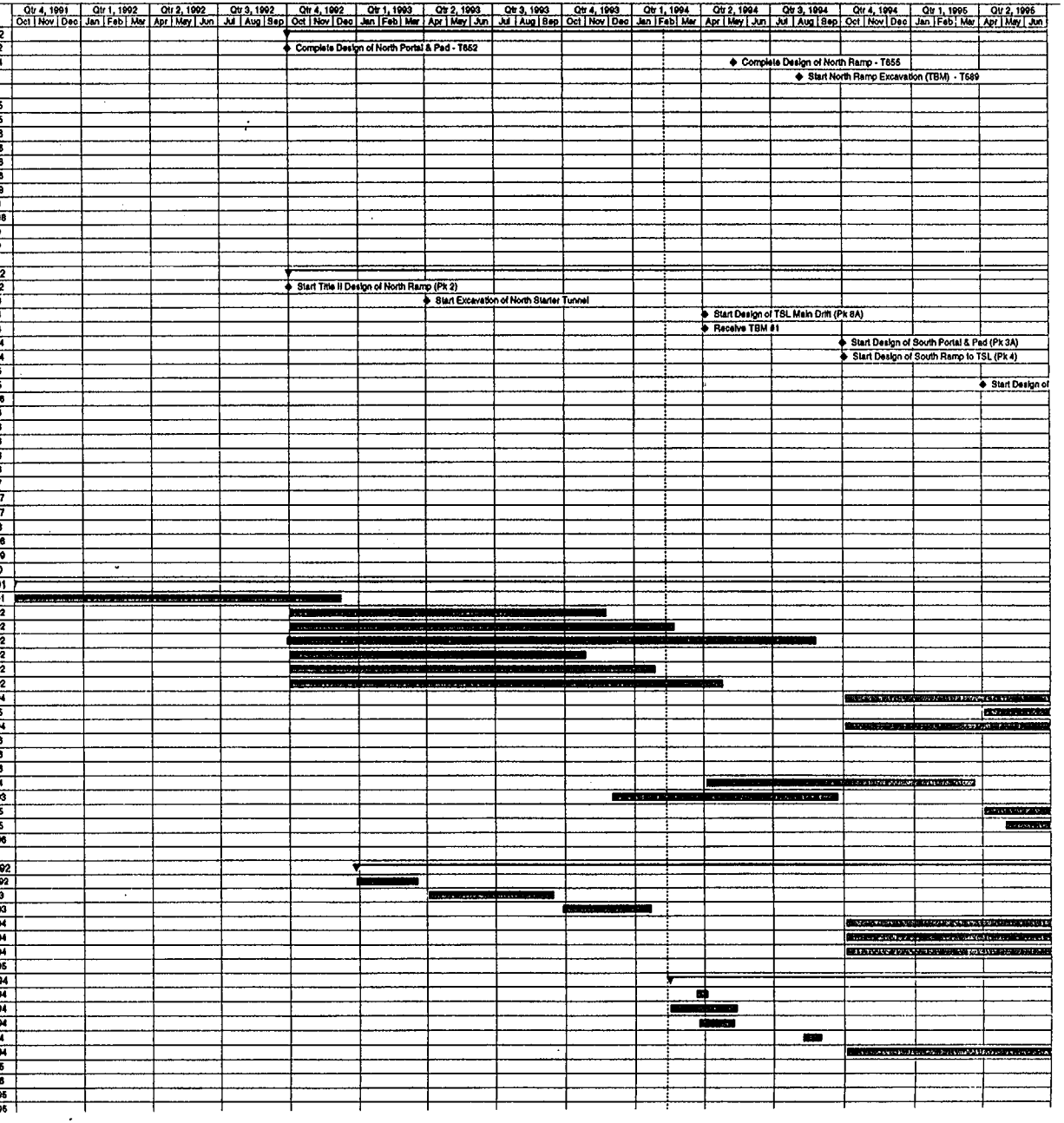


LEGEND:
FAULT ZONE
RAMP CONFIGURATION
REFERENCE GRID
BOREHOLE LOCATION

COMPLETE
IN PROGRESS
PLANNED

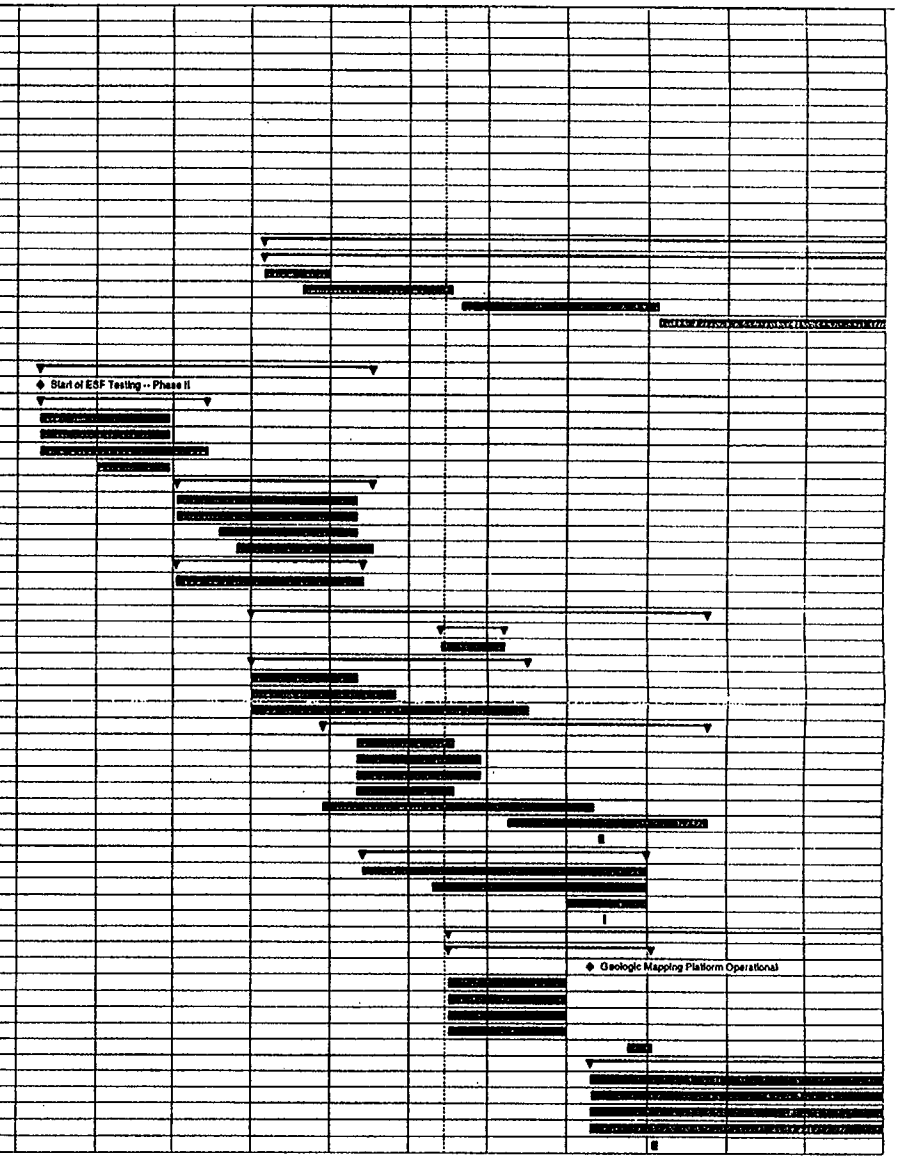
Engineered Barrier - Large Block Experiment (JP 93-10)
Field Activity Working Schedule
LANL ESF Test Coordination Office

ID	Name	Dur	Start
1	ESF Design & Construction - Level II Milestones	1783d	10/1/92
2	Complete Design of North Portal & Pad - T652	0d	10/1/92
3	Complete Design of North Ramp - T655	0d	5/13/94
4	Start North Ramp Excavation (TBM) - T689	0d	8/8/94
5	Complete North Ramp Excavation - T592	0d	8/1/95
6	Complete Design of South Ramp - T656	0d	9/29/95
7	Start South Portal & Pad Construction - T688 & T687	0d	10/2/95
8	Complete Design of MTL - T657	0d	4/30/96
9	Complete South Ramp Excavation, Daylight - T594	0d	8/28/96
10	Complete North Access Surface Facilities - T593	0d	10/2/96
11	Complete South Access Surface Facilities - T595	0d	10/8/96
12	Complete MTL Excavations - T650	0d	2/10/99
13	Start CHL South Ramp Excavation - T648	0d	7/1/98
14	Complete CHL South Ramp Excavation - T647	0d	10/31/98
15	Complete CHL North Ramp Excavation - T596 & T651	0d	1/1/99
16	Start CHL North Ramp Excavation - T649	0d	6/3/99
17			
18	ESF Design & Construction - Level III Milestones	1893d	10/1/92
19	Start Title II Design of North Ramp (Pk 2)	0d	10/1/92
20	Start Excavation of North Starter Tunnel	0d	4/2/93
21	Start Design of TSL Main Drift (Pk 8A)	0d	4/4/94
22	Receive TBM #1	0d	4/4/94
23	Start Design of South Portal & Pad (Pk 3A)	0d	10/1/94
24	Start Design of South Ramp to TSL (Pk 4)	0d	10/3/94
25	Start Excavation of TSL Main Drift	0d	8/2/95
26	Start Design of South Portal Surface Facilities (Pk 3B)	0d	4/3/95
27	Receive 2nd TBM	0d	10/1/96
28	Calico Hill Drift Decision	0d	2/1/96
29	Start Design of Calico Hills Level (Pk 5,6 & 7)	0d	2/1/96
30	Start Excavation of Main Test Level	0d	5/1/96
31	Optional Shaft Decision Point	0d	6/3/96
32	Start Excavation of TSL Ghost Dance Fault Drifts	0d	7/1/96
33	Start Excavation of Imbricate Fault Drift	0d	1/2/97
34	Start Thermal Testing	0d	5/14/97
35	Start Construction Optional Shaft Facilities	0d	10/1/97
36	Start Construction of SR CHL Launch Chamber	0d	4/1/98
37	Start Excavation of CHL main Drift	0d	11/3/98
38	Start Optional Shaft Excavation	0d	2/28/99
39	Start Excavation of CHL Cross Drifts	0d	1/4/00
40	ESF Design Activities	1556d	10/1/91
41	Site Preparation & Portal of North Ramp (Pk 1A)	311d	10/1/91
42	Surface Facilities at North Portal (Pk 1B)	300d	10/1/92
43	Surface Facilities at North Portal (Pk 1C)	363d	10/1/92
44	Surface Facilities at North Portal (Pk 1D)	500d	9/27/92
45	North Ramp xxxxxx (Pk 2A)	281d	10/1/92
46	North Ramp xxxxxx (Pk 2B)	346d	10/1/92
47	North Ramp xxxxxx (Pk 2C)	408d	10/1/92
48	South Ramp Portal & Pad (Pk 3A)	231d	10/3/94
49	South Ramp Portal & Pad (Pk 3B)	251d	4/3/95
50	South Ramp from TSL to Portal (Pk 4)	252d	10/3/94
51	North Ramp to CHL (Pk 5)	252d	2/1/96
52	CHL Main & Cross Drifts (Pk 6)	252d	2/1/96
53	South Ramp from CHL (Pk 7)	252d	2/1/96
54	TSL Main Drifts (Pk 8A)	252d	4/4/94
55	TSL Main Drifts (Pk 8B)	213d	12/1/93
56	TSL Main Drifts (Pk 8C)	251d	4/3/95
57	Main Test Area (Pk 9)	253d	5/1/95
58	Optional Shaft (Pk 10)	250d	10/1/96
59			
60	NORTH PORTAL - JP 92-20 - CONSTRUCTION	972d	12/27/92
61	Drill & Blast North Portal Wall & Slot -- (621104)	60d	12/27/92
62	Drill & Blast 60 m Starter Tunnel -- (64101)	119d	4/2/93
63	Drill & Blast Testing Alcove #1	85d	9/27/93
64	Construct Warehouse	252d	10/3/94
65	Construct Shop	252d	10/3/94
66	Construct Change House	252d	10/3/94
67	Construct Operations Building	252d	10/2/95
68	ESF EXCAVATION - JP 92-20 - CONSTRUCTION	1697d	2/14/94
69	Receive 1st TBM	11d	3/21/94
70	Assemble and Test 1st TBM	65d	2/14/94
71	Construct Launch facility	33d	3/24/94
72	Excavate 30 m of North Ramp - TBM	18d	8/8/94
73	Excavate North Ramp to TSL	210d	10/3/94
74	Excavate Main Drift TSL	145d	8/2/95
75	Excavate South Ramp to South Portal	85d	3/1/96
76	Construct South Portal Pad & Road	84d	10/2/95
77	Revive 2nd TBM	11d	12/1/95



LA-EES-13-LV-02-94-012
Attachment 8
2 Pages

78	Assemble & Test 2nd TBM	77d	12/16/95
79	Excavate North Ramp Extension	85d	7/1/96
80	Excavate South Ramp Extension	155d	10/31/96
81	Receive MTA Excavator	11d	10/1/95
82	Assemble & Test MTL Excavator	66d	10/17/95
83	Excavate MTL for Thermal Test	154d	5/1/96
84	Excavate Remaining MTL	197d	12/9/96
85	Excavate Ghost Dance Drifts	70d	7/1/96
86	Excavate Calico Hills North Ramp	118d	2/3/97
87	Excavate Calico Hills Main Drift	118d	7/22/97
88	Excavate Calico Hills South Ramp	97d	1/12/98
89	Excavate Calico Hills Cross Drifts	353d	1/12/98
90	Excavate Optional Shaft	398d	2/9/99
91			
92	ENGINEERED BARRIER - FIELD TESTS	705d	7/15/93
93	Large Block Test - Fran Ridge Tasks	705d	7/15/93
94	Demonstration Saw Cuts	58d	7/15/93
95	Phase I - Site Preparation - JP 93-10	125d	8/30/93
96	Phase II - Test Construction - JP 93-10A	162d	3/1/94
97	Phase III - Test Operation - TPP T-93-3 / JP 93-10B	300d	10/13/94
98	Phase IV - Post Activity Excavation - JP 93-10C	80d	12/7/95
99			
100	ESF TESTING -- PHASE II - STARTER TUNNEL	279d	10/27/92
101	Start of ESF Testing -- Phase II	0d	10/27/92
102	ESF Test Planning -- Phase II	140d	10/27/92
103	Geologic Mapping - Starter Tunnel (TPP 92-10/JP 92-20A)	109d	10/27/92
104	Perched Water - Starter Tunnel (Contingency) -- (TPP 92-11/JP 92-20B)	109d	10/27/92
105	Consolidated Sampling - Starter Tunnel (TPP 92-14/JP 92-20C)	140d	10/27/92
106	Construction Monitoring - Starter Tunnel (TPP T-93-2/JP 92-20D)	61d	1/1/93
107	ESF Test Implementation -- Phase II	165d	4/5/93
108	Geologic Mapping - Starter Tunnel (TPP 92-10/JP 92-20A)	151d	4/5/93
109	Perched Water - Starter Tunnel (TPP 92-11/JP 92-20B)	151d	4/5/93
110	Consolidated Sampling - Starter Tunnel (TPP 92-14/JP 92-20C)	116d	5/24/93
111	Construction Monitoring - Starter Tunnel (TPP T-93-2/JP 92-20D)	116d	6/13/93
112	ESF Test Monitoring -- Phase II	158d	4/4/93
113	Construction Monitoring - Starter Tunnel (TPP T-93-2/JP 92-20D)	235d	4/4/93
114			
115	ESF TESTING -- PHASE IIA - STARTER TUNNEL ALCOVE	377d	7/1/93
116	JP 92-20E Hydrochemistry - Drilling Support	54d	2/7/94
117	Air Coring Test Holes (3 each)	54d	2/7/94
118	ESF Test Planning -- Phase IIA Starter Tnl. Alc. 1	229d	7/1/93
119	Hydrochemistry Testing - Alcove #1 (TPP 92-12/JP 92-20E)	88d	7/1/93
120	Radial Borehole Testing - Alcove #1 (TPP 92-13/JP 92-20E)	120d	7/1/93
121	Hydrologic Props. of Major Faults - Thermal Hole (TPP 94-XX)	229d	7/1/93
122	ESF Test Implementation --Phase IIA	317d	9/23/93
123	Geologic Mapping - Alcove #1 (TPP 92-10/JP 92-20A)	81d	11/1/93
124	Perched Water - Alcove #1 (TPP 92-11/JP 92-20B)	104d	11/1/93
125	Consolidated Sampling - Alcove #1 (TPP 92-14/JP 92-20C)	104d	11/1/93
126	Construction Monitoring - Alcove #1 (TPP T-93-2/JP 92-20D)	81d	11/1/93
127	Hydrochemistry Testing - Alcove #1 - (TPP 92-12/JP 92-20E)	223d	9/23/93
128	Radial Borehole Testing - Alcove #1 (TPP 92-13/JP 92-20E)	165d	4/25/94
129	Hydrologic Props. of Major Faults - Thermal Hole	5d	8/7/94
130	ESF Test Monitoring - Phase IIA	235d	11/8/93
131	Construction Monitoring - Alcove #1 (TPP T-93-2/JP 92-20D)	235d	11/8/93
132	Hydrochemistry Testing - Alcove #1 - (TPP 92-12)	176d	1/28/94
133	Radial Borehole Testing - Alcove #1 (TPP 92-13)	66d	7/1/94
134	Hydrologic Props. of Major Faults - Thermal Hole	1d	8/12/94
135	ESF TESTING PHASE III - RAMPS & MAIN	1697d	2/15/94
136	ESF Test Planning -- Phase III	167d	2/15/94
137	Geologic Mapping Platform Operational	0d	7/28/94
138	Geologic Mapping (TPP 92-10)	98d	2/15/94
139	Perched Water (TPP 92-11)	98d	2/15/94
140	Consolidated Sampling (TPP 92-14)	98d	2/15/94
141	Construction Monitoring (TPP T-93-2)	98d	2/15/94
142	Hydrologic Props. of Major Faults - Thermal Hole (TPP T-94-xx)	20d	9/8/94
143	ESF Test Implementation --Phase III	1580d	7/28/94
144	Geologic Mapping (TPP 92-10)	1580d	7/28/94
145	Perched Water (TPP 92-11)	1579d	7/29/94
146	Consolidated Sampling (TPP 92-14)	1580d	7/28/94
147	Construction Monitoring (TPP T-93-2)	1580d	7/28/94
148	Hydrologic Props. of Major Faults - Thermal Hole (TPP T-94-xx)	5d	10/8/94



Project: ESF
Date: 2/10/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up

Checked by: Approved by:

ESFJAN2.MPP

ADMINISTRATIVE USE ONLY

GEOLOGIC MAPPING OF THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The geologic mapping data collection activity started with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

The U.S. Bureau of Reclamation (USBR) completed geologic mapping in Test Alcove #1 from CS 0+27.4 (90') to CS 0+34.4 (113'). Geologic mapping and site characterization for the test alcove was completed on January 26, 1994.

DATA FLOW INFORMATION

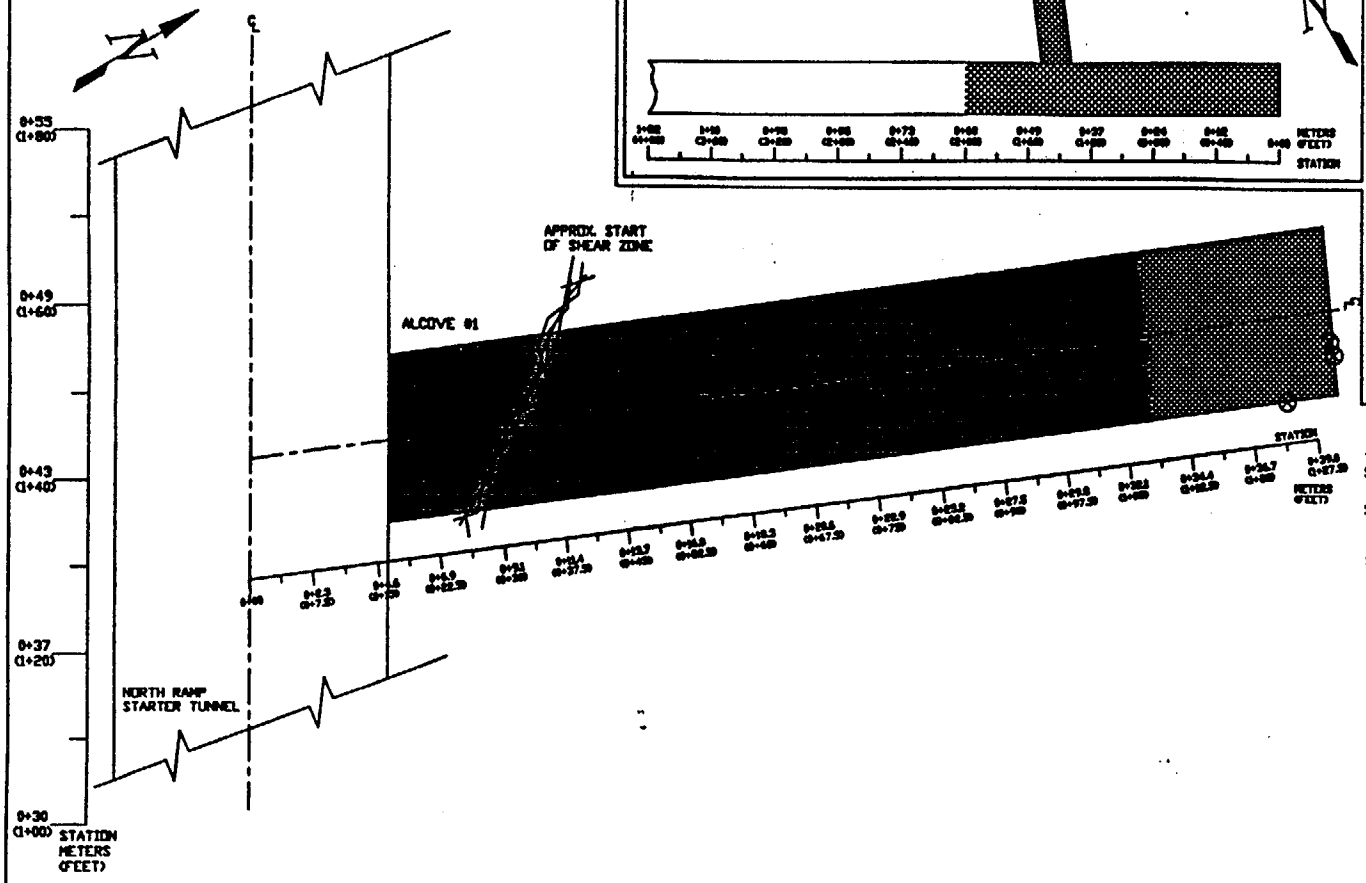
Analysis of geologic mapping field data by investigating organizations is progressing and information from the starter tunnel and Test Alcove #1 has been shared with the constructor, facility design teams, and construction management.

COST AND SCHEDULE SUMMARY

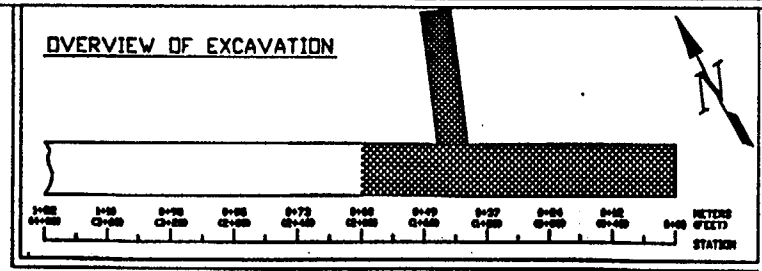
The costs and progress estimates on this activity are within the scope set by JP 92-20A. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Rock Characteristic Program	Characterization of Structural Features in the Site Area	8.3.1.4.2.2	Geologic Mapping of the ESF	TPP 92-10	JP 92-20A

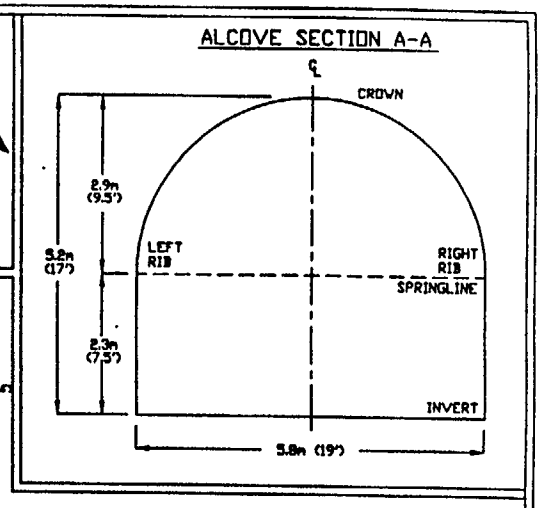
DETAILED ALCOVE SECTION - TOP VIEW



OVERVIEW OF EXCAVATION



ALCOVE SECTION A-A



SAMPLE BAR CODE #	DATE COLLECTED	LOCATION
SPC00500786	1/26/94	ALCOVE 01 - RIGHT RIB CS 0+32.6, 1.7 m ABOVE INVERT
SPC00500787	1/26/94	ALCOVE 01 - FACE CS 0+34.4, 1.8 m FROM RIGHT RIB 1.4 m ABOVE INVERT
SPC00500788	1/26/94	ALCOVE 01 - FACE CS 0+34.4, 2.4 m FROM RIGHT RIB 1.5 m ABOVE INVERT

GRAPHIC SCALE

3.1 (10) 0 3.1 (10) 6.2 m (20 FT.)

LEGEND:

- CENTER LINE OF RAMP
- UNEXCAVATED MATERIAL
- EXCAVATED RAMP
- SAMPLE LOCATION
- CONVERGENCE PINS
- LOAD CELLS
- PHOTOGRAMMETRY TARGET LOCATIONS
- MAPPING PROGRESS
- EXCAVATION PROGRESS

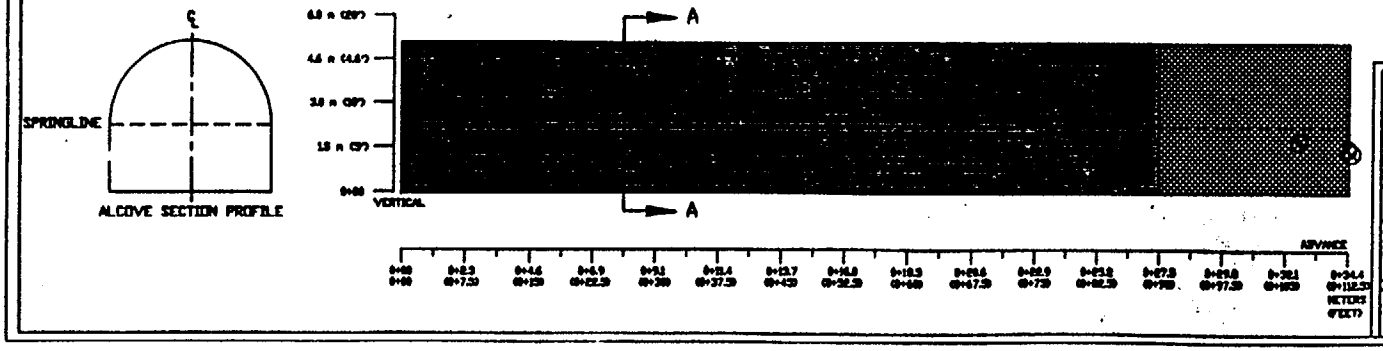
COMMENTS:

ALCOVE CENTER LINE AT 0+43m (CS 1+40)

ALCOVE EXCAVATION TO APPROX. 34.4 m (113')

THE REQUIRED DEPTH OF ALCOVE 01 HAS BEEN DETERMINED IN THE FIELD.

ALCOVE #1 DETAIL FOR SAMPLE LOCATION



LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: GEOLOGIC MAPPING/CONSOLIDATED SAMPLING AND CONSTRUCTION MONITORING IN ALCOVE #1

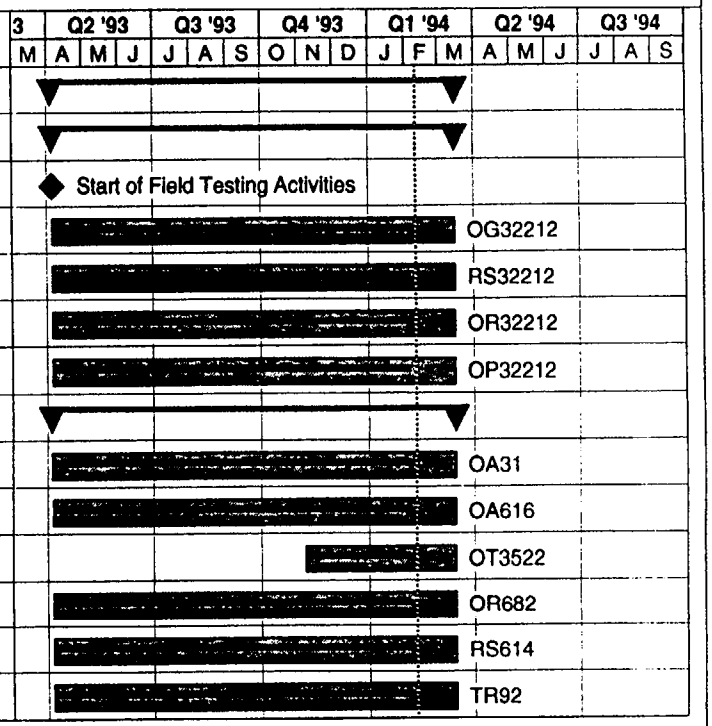
CAD FILE: ALCRPRT8.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
DRN. BY: D.J. VEAVER	APPROVED BY: ON FILE N.Z. ELKINS/R.D. OLIVER		DATE DRN: 2/1/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 2/1/94	

Geologic Mapping (TTP 92-10/JP 92-20A)

Field Activity Working Schedule

LANL ESF Test Coordination Office

ID	Name	Dur	Start	Summary Acct.
1	**TEST IMPLEMENTATION - GEOLOGIC MAPPING**	**247d**	**4/4/93**	
2	**Test Implementation - Discrete**	**247d**	**4/5/93**	
3	*Start of Field Testing Activities*	*0d*	*4/5/93*	
4	USGS/USBR Test Implementation (*1)	247d	4/5/93	OG32212D93
5	RSN Field Survey & Processing	247d	4/5/93	RS3522N4
6	REECo Test Construction & Procurement	247d	4/5/93	OR32212L4
7	JC Photography & Process	247d	4/5/93	OP355L94
8	**Test Implementation - Matrix Support Elements**	**247d**	**4/4/93**	
9	Los Alamos TCO Coordination & Planning (Field Test Coordination Support)	247d	4/4/93	OA310BL4
10	Los Alamos TCO Test Management (Project Engineer Support)	247d	4/5/93	OA616AL4
11	T&MSS Direct Support Services (Photo Support)	92d	11/7/93	OT3522EL
12	REECo Construction & Operations Support	247d	4/5/93	OR682L4
13	RSN Survey Support / Capital Procurement (Interim WBS)	247d	4/5/93	RS614P94
14	CRWMS M&O Networking & Baseline Planning Support (Network & Progres:	247d	4/5/93	TR921CA1



Project: t-92-10
Date: 2/9/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up — Checked by: — Approved by:

T9210TI.MPP

ADMINISTRATIVE USE ONLY

PERCHED WATER TESTING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The ESF perched water data collection contingency activity was started with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

No water or samples were collected during the period. Equipment to collect samples, if identified, is on station.

DATA FLOW INFORMATION

Perched water sample data and observations will be recorded in a scientific notebook if encountered.

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20B. No detailed cost and scheduling information is provided for the monthly report.

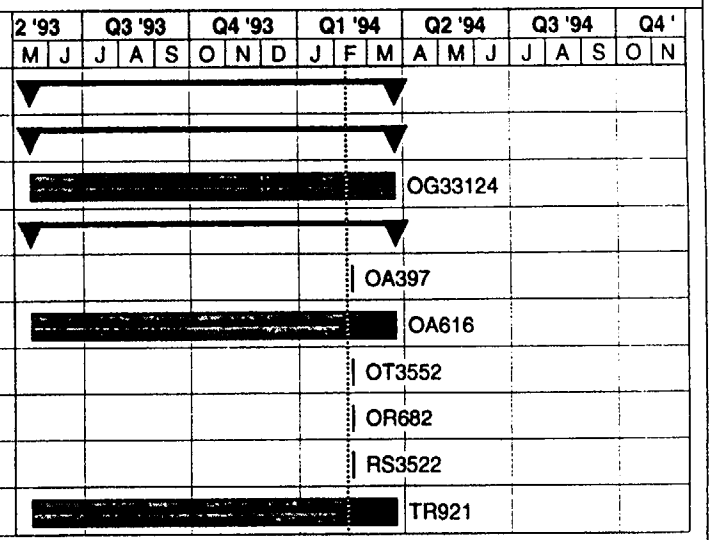
SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program	Characterization of YM Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Perched Water Testing in the ESF	TPP 92-11	JP 92-20B

Perched Water (TTP 92-11/JP 92-20B)

Field Activity Working Schedule

LANL ESF Test Coordination Office

ID	Name	Dur	Start	Summary Acct.
1	**TEST IMPLEMENTATION - PERCHED WATER**	**224d**	**5/16/93**	
2	**Test Implementation - Discrete**	**224d**	**5/16/93**	
3	USGS Test Implementation	224d	5/16/93	OG33124G94
4	**Test Implementation - Matrix Support**	**224d**	**5/16/93**	
5	Los Alamos TCO Coordination & Planning (Field Test Coordination Support)	2d	2/14/94	OA397BL4
6	Los Alamos TCO Test Management (Project Engineer Support)	224d	5/16/93	OA616AL4
7	T&MSS Direct Support Services (Photo Support)	2d	2/14/94	OT3522EL
8	REECo Construction & Operations Support (Contingency) - (*1)	2d	2/14/94	OR682L4
9	RSN ESF Test Support	2d	2/14/94	RS3522N4
10	CRWMS M&O Project Control Support	224d	5/16/93	TR921CA1



Project: t-92-11
Date: 2/9/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up

Checked by: _____

Approved by: _____

T9211TI.MPP

ADMINISTRATIVE USE ONLY

CONSOLIDATED SAMPLING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The consolidated sampling data collection and observation activity began when the starter tunnel construction exposed suitable rock. The Test Planning Package (TPP) and Job Package (JP) for consolidated sampling were revised during October.

SUMMARY OF FIELD ACTIVITIES

Samples were taken on January 26, 1994, the distribution of samples is as follows:

Bar Code	Location	For
SPC 00500786	Test Alcove, right rib CS 0+36.6 (107′), 1.7 meters (5.5′) above invert	S. Levy
SPC 00500787	Test Alcove, at the face CS 0+34.4 (113′), 1.8m (6′) from the right rib, 1.4m (4.5′) above the invert	S. Levy
SPC 00500788	Test Alcove, at the face CS 0+34.4 (113′), 2.4m (8′) from the right rib, 1.5m (5′) above invert	S. Levy

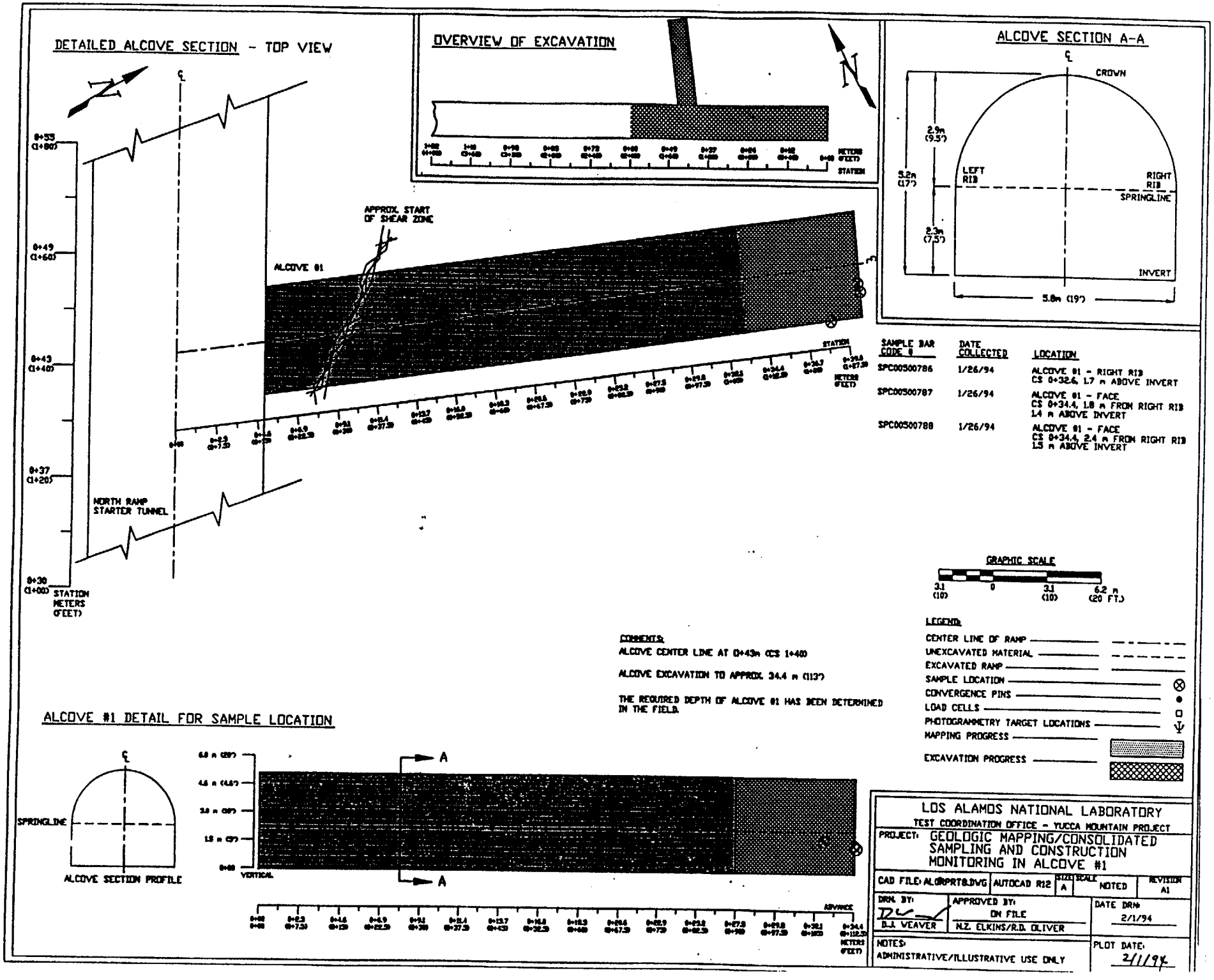
DATA FLOW INFORMATION

Consolidated sampling data and sample collection activities are controlled by the JP Document and Records Center files, scientific notebooks, and by AP-6.26Q, sample collection report records and bar codes. Test-related photo and survey mission data is being submitted to the JP record file and the PIs.

COST & SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20C. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program & Geochemistry Program	Water Movement Tests, Rev. 0 Water Movement Tests, Rev. 1 Characterization of the Percolation in the Unsaturated-Zone Surface-Based Study History of Mineralogic and Geochemical Alteration of YM	8.3.1.2.2.2 8.3.1.2.2.3 8.3.1.3.2.2	Consolidated Sampling in the ESF	TPP 92-14	JP 92-20C

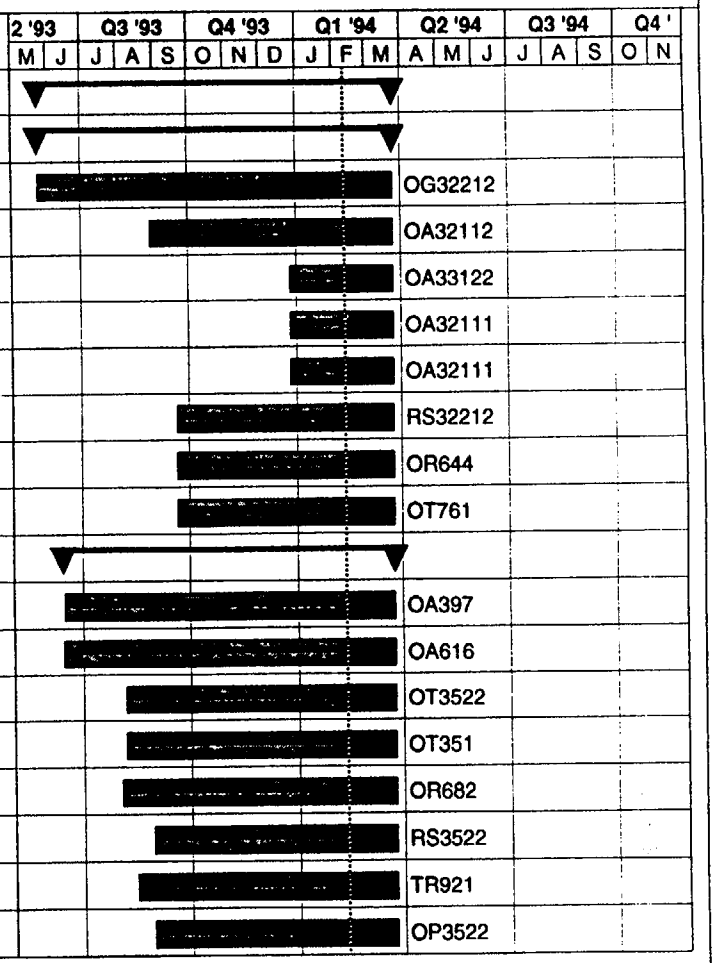

DETAILED ALCOVE SECTION - TOP VIEW
OVERVIEW OF EXCAVATION
ALCOVE SECTION A-A
CROWN
2.9m (9.5')
5.2m (17')
2.3m (7.5')
LEFT RIB
RIGHT RIB
SPRINGLINE
INVERT
5.8m (19')
APPROX. START OF SHEAR ZONE
ALCOVE #1
NORTH RAMP STARTER TUNNEL
STATION METERS (FEET)
SAMPLE BAR CODE #
DATE COLLECTED
LOCATION
SPC00500786 1/26/94 ALCOVE #1 - RIGHT RIB CS 0+32.6, 1.7 m ABOVE INVERT
SPC00500787 1/26/94 ALCOVE #1 - FACE CS 0+34.4, 1.8 m FROM RIGHT RIB 1.4 m ABOVE INVERT
SPC00500788 1/26/94 ALCOVE #1 - FACE CS 0+34.4, 2.4 m FROM RIGHT RIB 1.5 m ABOVE INVERT
GRAPHIC SCALE
3.1 (10) 0 3.1 (10) 6.2 m (20 FT.)
COMMENTS:
ALCOVE CENTER LINE AT 0+43m (CS 1+40)
ALCOVE EXCAVATION TO APPROX. 34.4 m (113')
THE REQUIRED DEPTH OF ALCOVE #1 HAS BEEN DETERMINED IN THE FIELD.
LEGEND:
CENTER LINE OF RAMP
UNEXCAVATED MATERIAL
EXCAVATED RAMP
SAMPLE LOCATION
CONVERGENCE PINS
LOAD CELLS
PHOTOGRAMMETRY TARGET LOCATIONS
MAPPING PROGRESS
EXCAVATION PROGRESS
ALCOVE #1 DETAIL FOR SAMPLE LOCATION
SPRINGLINE
ALCOVE SECTION PROFILE
VERTICAL
ADVANCE
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: GEOLOGIC MAPPING/CONSOLIDATED SAMPLING AND CONSTRUCTION MONITORING IN ALCOVE #1
CAD FILE: AL@PRT8.DWG
AUTOCAD R12
SIZE A
SCALE NOTED
REVISION A1
DRN. BY: D.J. WEAVER
APPROVED BY: ON FILE N.Z. ELKINS/R.D. OLIVER
DATE DRN: 2/1/94
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 2/1/94

Consolidated Sampling (TTP 92-14/JP 92-20C)

Field Activity Working Schedule

LANL ESF Test Coordination Office

ID	Name	Dur	Start	Summary Acct.
1	**TEST IMPLEMENTATION - CONSOLIDATED SAMPLING**	**219d**	**5/24/93**	
2	**Test Implementation - Discrete**	**219d**	**5/24/93**	
3	USGS/USBR Structural Features	219d	5/24/93	OG32212D94
4	History of Mineralogic & Geochemical Alteration at YM	149d	8/29/93	OA32112CB4
5	Chloride and Chlorine-36 Measurements of Percolation at YM	64d	12/26/93	OA33122HB3
6	Fracture Mineralogy Studies	64d	12/26/93	OA32111B60
7	Mineral Distribution Between Host Rock and Accessible Environment	64d	12/26/93	OA32111BAF
8	RSN Field Survey & Processing	134d	9/20/93	
9	REECo Test Construction & Procurement	134d	9/20/93	OR644L4
10	T&MSS Photography & Process	134d	9/20/93	OT761EL
11	**Test Implementation - Matrix Support Elements**	**204d**	**6/13/93**	
12	Los Alamos TCO Coordination & Planning (Field Test Coordination Support)	204d	6/14/93	OA397BL4
13	Los Alamos TCO Test Management (Project Engineer Support)	204d	6/13/93	OA616AL4
14	T&MSS Direct Support Services EDD	165d	8/6/93	OT3522EL
15	T&MSS Sample Management Facility	165d	8/6/93	OT351EL
16	REECo Construction & Operations Support (Interim WBS)	169d	8/2/93	OR662L3
17	Engineering Survey Support / Survey Processing (Interim WBS)	149d	8/29/93	RS3522N4
18	CRWMS M&O Networking & Baseline Planning Support (Monthly Cost & Pro	159d	8/15/93	TR921CA1
19	JC Photography & Process (Interim WBS)	149d	8/29/93	OP3522L94



Project: t-92-14
Date: 2/9/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up

Checked by: _____

Approved by: _____

T9214TI.MPP

ADMINISTRATIVE USE ONLY

CONSTRUCTION MONITORING IN THE ESF

PROGRESS - MILESTONES AND DELIVERABLES

The construction monitoring data collection and observation activity began with starter tunnel construction.

SUMMARY OF FIELD ACTIVITIES

The SNL Field Team has continued monitoring the blasting activity and the Peak Particle Velocity (PPV) for the test alcove. Three convergence pin stations were installed in the test alcove at CS 0+4.9 (16'), CS 0+11.3 (37'), and CS 0+17.4 (57'). Three MPBX gauges were installed, one at CS 0+8.5 (28') (a 6.1m gauge) and two 3 meter gauges at CS 0+14.3 (47') and CS 0+22.9 (75'). In addition, the Field Team gathered data from load cells and convergence pins that had previously been installed.

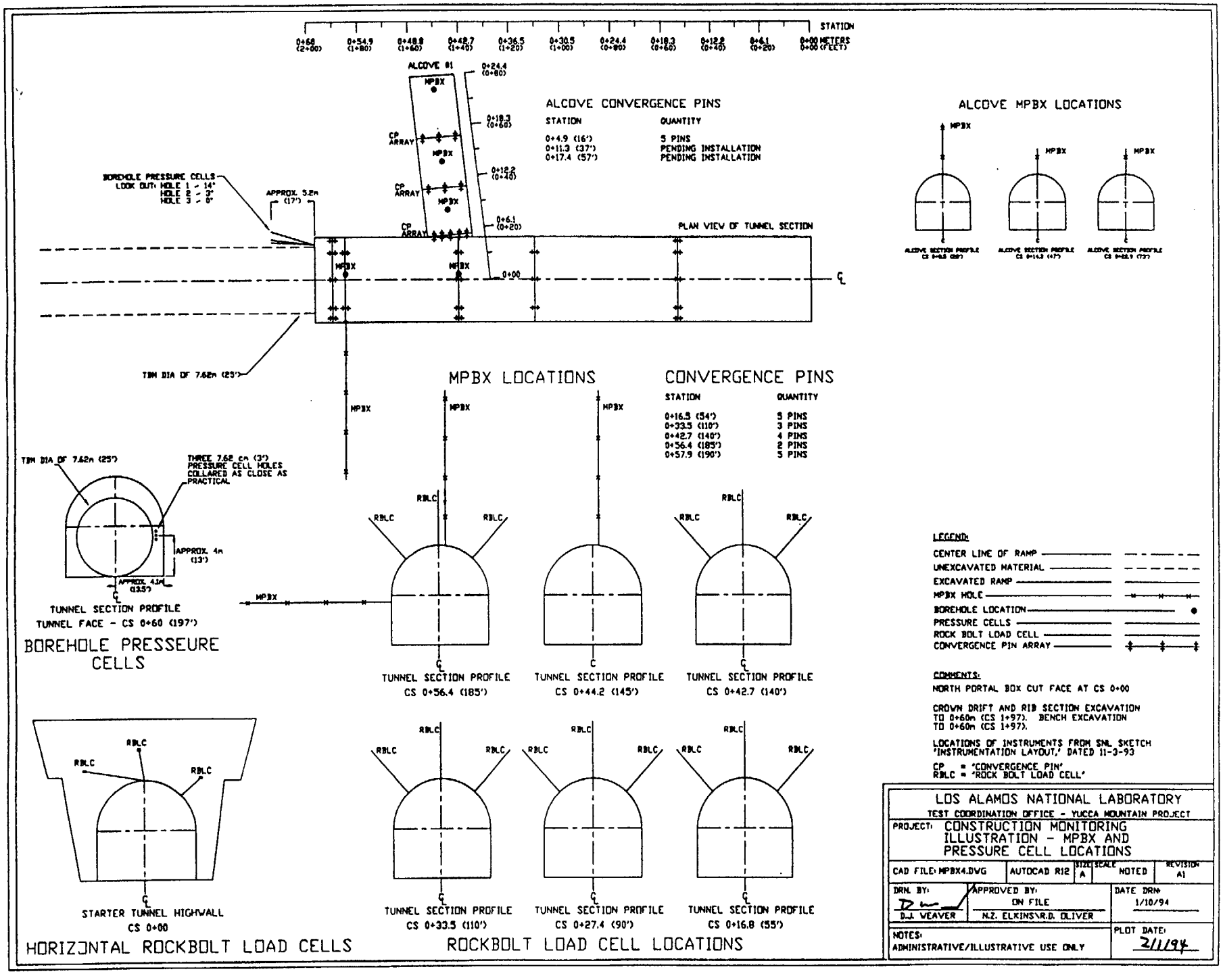
DATA FLOW INFORMATION

Construction monitoring data was recorded in a scientific notebook. Test-related photo and survey mission data is being submitted to the JP record file and the PIs.

COST AND SCHEDULE SUMMARY

The costs and progress estimates on this activity are within the scope set by JP 92-20D. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Thermal and Mechanical Rock Properties Program	In Situ Design Verification	8.3.1.1.5.1.8	Construction Monitoring in the ESF	TPP T-93-2	JP 92-20D

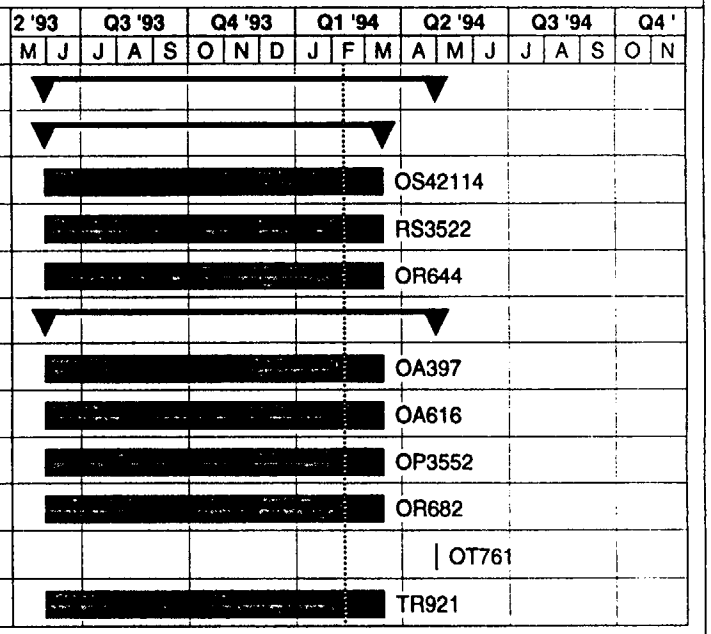

STATION
0+68 (2+00)
0+54.9 (1+80)
0+48.8 (1+60)
0+42.7 (1+40)
0+36.5 (1+20)
0+30.5 (1+00)
0+24.4 (0+80)
0+18.3 (0+60)
0+12.2 (0+40)
0+6.1 (0+20)
0+00 METERS
0+00 (FEET)
ALCOVE #1
MPBX
CP ARRAY
BOREHOLE PRESSURE CELLS
LOOK OUT: HOLE 1 - 14°
HOLE 2 - 3°
HOLE 3 - 0°
APPROX. 5.2m (17')
PLAN VIEW OF TUNNEL SECTION
TBM DIA OF 7.62m (25')
ALCOVE CONVERGENCE PINS
STATION
QUANTITY
0+4.9 (16')
5 PINS
0+11.3 (37')
PENDING INSTALLATION
0+17.4 (57')
PENDING INSTALLATION
ALCOVE MPBX LOCATIONS
MPBX LOCATIONS
CONVERGENCE PINS
STATION
QUANTITY
0+16.5 (54')
5 PINS
0+33.5 (110')
3 PINS
0+42.7 (140')
4 PINS
0+56.4 (185')
2 PINS
0+57.9 (190')
5 PINS
TBM DIA OF 7.62m (25')
THREE 7.62 cm (3") PRESSURE CELL HOLES COLLARED AS CLOSE AS PRACTICAL
APPROX. 4m (13')
APPROX. 4.1m (13.5')
TUNNEL SECTION PROFILE
TUNNEL FACE - CS 0+60 (197')
BOREHOLE PRESSEURE CELLS
RBLC
TUNNEL SECTION PROFILE
CS 0+56.4 (185')
TUNNEL SECTION PROFILE
CS 0+44.2 (145')
TUNNEL SECTION PROFILE
CS 0+42.7 (140')
STARTER TUNNEL HIGHWALL
CS 0+00
HORIZONTAL ROCKBOLT LOAD CELLS
TUNNEL SECTION PROFILE
CS 0+33.5 (110')
TUNNEL SECTION PROFILE
CS 0+27.4 (90')
TUNNEL SECTION PROFILE
CS 0+16.8 (55')
ROCKBOLT LOAD CELL LOCATIONS
LEGEND:
CENTER LINE OF RAMP
UNEXCAVATED MATERIAL
EXCAVATED RAMP
MPBX HOLE
BOREHOLE LOCATION
PRESSURE CELLS
ROCK BOLT LOAD CELL
CONVERGENCE PIN ARRAY
COMMENTS:
NORTH PORTAL BOX CUT FACE AT CS 0+00
CROWN DRIFT AND RIB SECTION EXCAVATION TO 0+60m (CS 1+97). BENCH EXCAVATION TO 0+60m (CS 1+97).
LOCATIONS OF INSTRUMENTS FROM SNL SKETCH 'INSTRUMENTATION LAYOUT,' DATED 11-3-93
CP = 'CONVERGENCE PIN'
RBLC = 'ROCK BOLT LOAD CELL'
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: CONSTRUCTION MONITORING ILLUSTRATION - MPBX AND PRESSURE CELL LOCATIONS
CAD FILE: MPBX4.DWG
AUTOCAD R12
SIZE A
SCALE NOTED
REVISION A1
DRN. BY: D.J. VEAVER
APPROVED BY: ON FILE
N.Z. ELKINS\R.D. OLIVER
DATE DRN: 1/10/94
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 2/1/94

Construction Monitoring (TTP 93-2/JP 92-20D)

Field Activity Working Schedule

LANL ESF Test Coordination Office

ID	Name	Dur	Start	Summary Acct.
1	**TEST IMPLEMENTATION - CONSTRUCTION MONITORING**	**240d**	**5/30/93**	
2	**Test Implementation - Discrete**	**207d**	**5/30/93**	
3	SNL Test Implementation	207d	5/30/93	OS42114L94
4	RSN Field Survey & Processing	207d	5/30/93	RS3522N4
5	REECo Test Construction & Support	207d	5/30/93	OR644L4
6	**Test Implementation - Matrix Support**	**240d**	**5/30/93**	
7	Los Alamos TCO Coordination & Planning (Field Test Coordination Support)	207d	5/30/93	OA397BL4
8	Los Alamos TCO Test Management (Project Engineer Support)	207d	5/30/93	OA616AL4
9	T&MSS Direct Support Services (Photo Support)	207d	5/30/93	OP3522L94
10	REECo Construction & Operations Support (Contingency) - (*1)	207d	5/30/93	OR682L4
11	JC Photography & Processing	1d	4/29/94	OT761EL
12	CRWMS M&O Networking & Baseline Planning Support (Monthly Cost & Pro	207d	5/30/93	TR921CA1



Project: T-93-2
Date: 2/9/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up

Checked by: _____

Approved by: _____

T932TI94.MPP

ADMINISTRATIVE USE ONLY

ENGINEERED BARRIER-FRAN RIDGE LARGE BLOCK EXPERIMENT

PROGRESS - MILESTONES AND DELIVERABLES

The Engineered Barrier - Large Block Experiment Site Preparation activity began with site cleaning and selection activities. The 17 vertical instrumentation holes were drilled in December.

SUMMARY OF FIELD ACTIVITIES

Lawrence Livermore National Laboratory (LLNL) and the SNL Field Team completed setting up the large saw for the first cut (north side) on the large block which has now been completed. The second cut, on the east side of the block, is in progress. A meeting was held at Fran Ridge on January 20, 1994, to identify safety and work plan modifications necessary for multi-shift sawing operations. An extended work schedule has been implemented as of January 31.

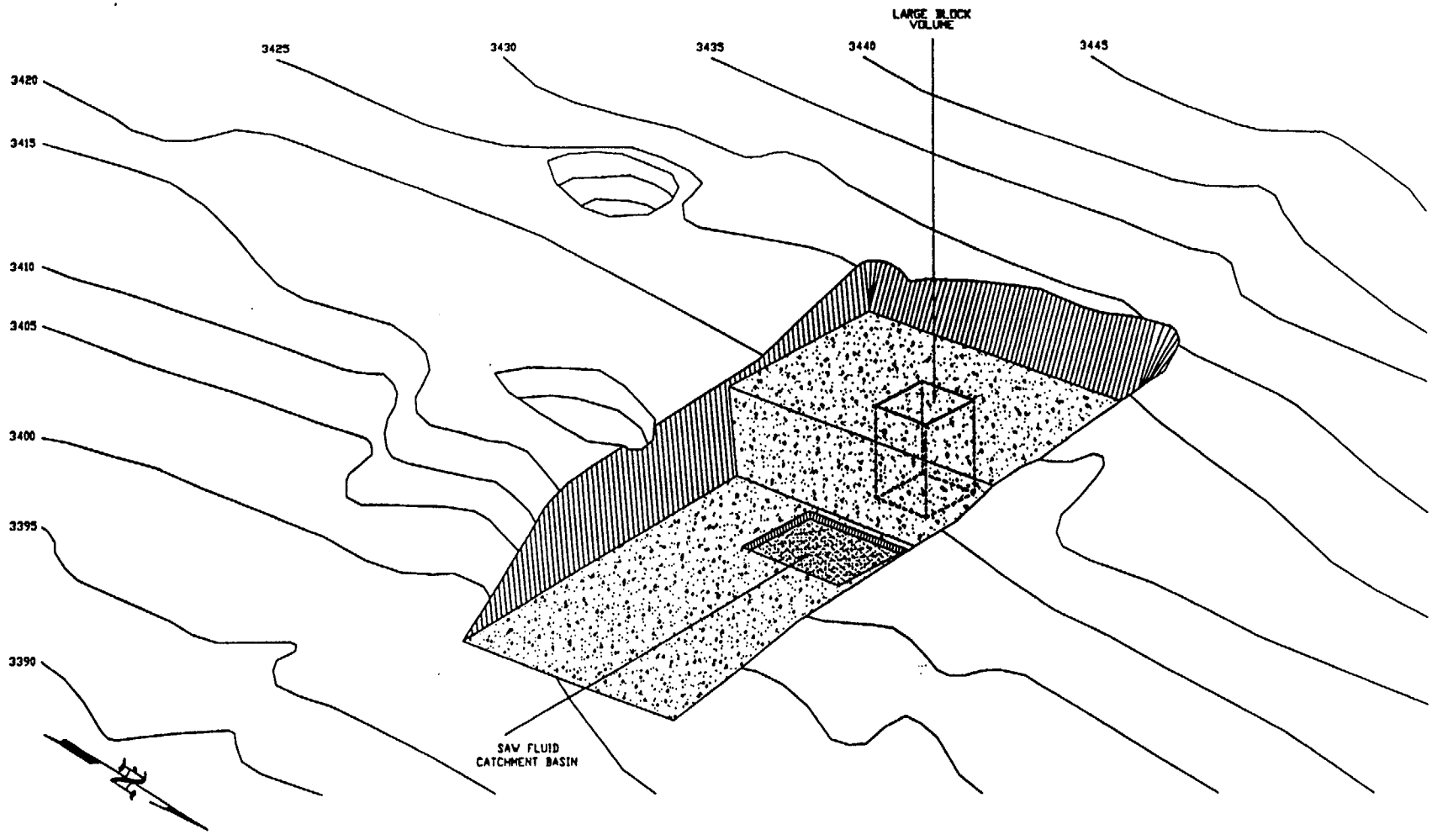
DATA FLOW INFORMATION

Construction monitoring data was recorded in a scientific notebook. Test-related photo and survey mission data is being submitted to DRC 059 and to the PIs.

COST AND SCHEDULE SUMMARY

See attached illustrations for detailed schedule information. No cost schedule is included in this monthly report. Illustrations are provided to show progress and Test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Repository Horizon Rock-Water Interaction Large Block Experiment	Large Block Experiment	SIP-NF-2	Engineered Barrier-Fran Ridge Large Block Experiment	NA	JP 93-10



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH #SK-93-D-PL17, 'FRAN RIDGE SITE PHASE 1, 3-D PERSPECTIVE'

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1928. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH #SK-93-D-PL17.

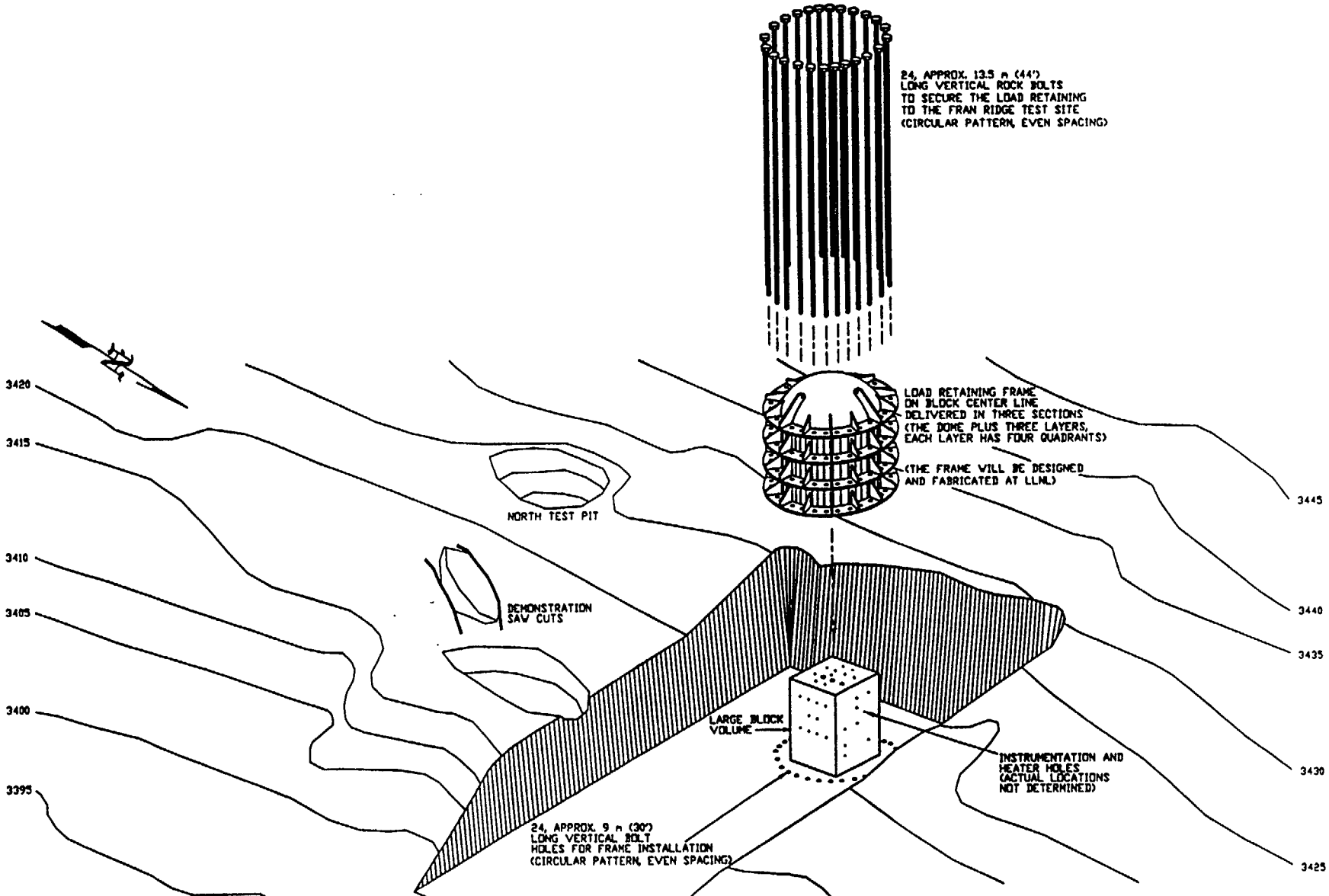
LEGEND:

SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT: PHASE II EXCAVATION STRATEGY ILLUSTRATION

CAD FILE: EXCAV2A.DVG	AUTOCAD R12	SIZE: A	SCALE: NOTED	REVISION: A1
DRN. BY: D.J. VEAVER	APPROVED BY: N.Z. ELKINS/R.D. OLIVER		DATE DRN: 1/7/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 1/14/94	



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH #SK-93-D-PL17, 'FRAN RIDGE SITE PHASE 1, 3-D PERSPECTIVE'

THE LOAD RETAINING FRAME IS AN ILLUSTRATION DERIVED FROM FIGURE 4 OF SIP-NF-02, REV.0 AND IS NOT INTENDED TO BE USED FOR DESIGN.

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1928. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH #SK-93-D-PL17.

LEGEND:

SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: ENGINEERED BARRIER - LARGE BLOCK EXPERIMENT: PHASE II LOAD RETAINING FRAME OVERVIEW

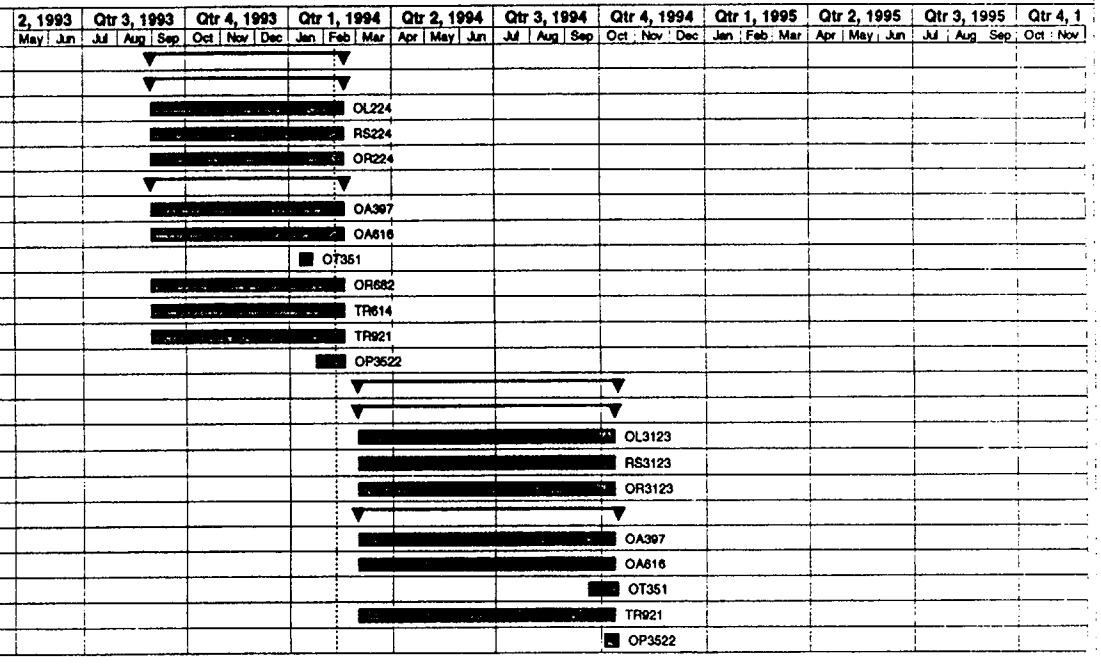
CAD FILE: FRAMEOV.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
DRN. BY: D.J. WEAVER	APPROVED BY: N.Z. ELKINS/R.D. OLIVER		DATE DRN: 1/13/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 1/13/94	

Engineered Barrier - Large Block Experiment (JP 93-10)

Field Activity Working Schedule

Los Alamos National Lab

ID	Name	Dur	Start	Summary Acct.
1	**PHASE I - SITE PREPARATION - EB LRG. BLOCK TEST (JP 93-10)**	125d	8/30/93	
2	**Site Preparation - Discrete**	125d	8/30/93	
3	LLNL Site Preparation Monitoring	125d	8/30/93	OL224HZA
4	RSN Field Survey & Processing	125d	8/30/93	RS224A94
5	REECo Test Construction & Procurement	125d	8/30/93	OR224(TBD)
6	**Construction Implementation - Matrix Support Elements**	125d	8/30/93	
7	Los Alamos TCO Coord. & Planning (Field Test Coord)	125d	8/30/93	OA397CL4
8	Los Alamos TCO Test Mgt. (Project Engineer Support)	125d	8/30/93	OA616AL4
9	T&MSS Sample Management Facility	10d	1/10/94	OT351EL
10	REECo Construction & Operations Support - Interim WBS	125d	8/30/93	OR682LH
11	Engineering &Survey Support/Survey Processing - Interim WBS	125d	8/30/93	TR614CAF1
12	CRWMS M&O Network & Baseline Plan Support (Mo Cost/ Progress Rpt)	125d	8/30/93	TR921BA1
13	JC Photo & Processing	20d	1/24/94	OP3522L94
14	**PHASE II - TEST CONSTRUCTION - EB LRG. BLOCK TEST (JP 93-10A)**	164d	3/1/94	
15	**Test Construction - Discrete**	162d	3/1/94	
16	LLNL Test Construction	162d	3/1/94	OL224HZA
17	RSN Field Engineering & Survey	162d	3/1/94	RS224A94
18	REECo Test Construction & Procurement	162d	3/1/94	OR224(TBD)
19	**Test Construction - Matrix Support Elements**	164d	3/1/94	
20	Los Alamos TCO Coord. & Planning (Field Test Coord)	162d	3/1/94	OA397CL4
21	Los Alamos TCO Test Mgt. (Project Engineer Support)	162d	3/1/94	OA616AL4
22	T&MSS Sample Management Facility	20d	9/19/94	OT351EL
23	CRWMS M&O Network & Baseline Plan Support (Mo Cost/ Progress Rpt)	162d	3/1/94	TR921BA1
24	JC Photo & Processing	10d	10/3/94	OP3522L94



Project: JP 93-1(
Date: 2/9/94
Revision #3

Critical — Progress — Summary — Checked by: ____
Noncritical — Milestone — Rolled Up — Approved by: ____

T93LBT94.MPP

ADMINISTRATIVE USE ONLY

HYDROCHEMISTRY

PROGRESS - MILESTONES AND DELIVERABLES

The Hydrochemistry Tests in Alcove #1 began in November and will run though June of 1994. The TCO will submit weekly activity reports to the FTC and monthly data collection status reports.

SUMMARY OF FIELD ACTIVITIES

No Hydrochemistry tests were performed this month. A meeting on January 26, 1994, with representatives from United States Geological Survey (USGS), USBR, DOE Yucca Mountain Site Characterization Project, and Los Alamos National Laboratory to determine if the Test Alcove #1 was in the proper geologic setting to commence drilling for Hydrochemistry/Radial Borehole tests. It was determined that the alcove had exposed the area necessary and that the orientation of the drill holes could be determined after geologic mapping of the rock structure.

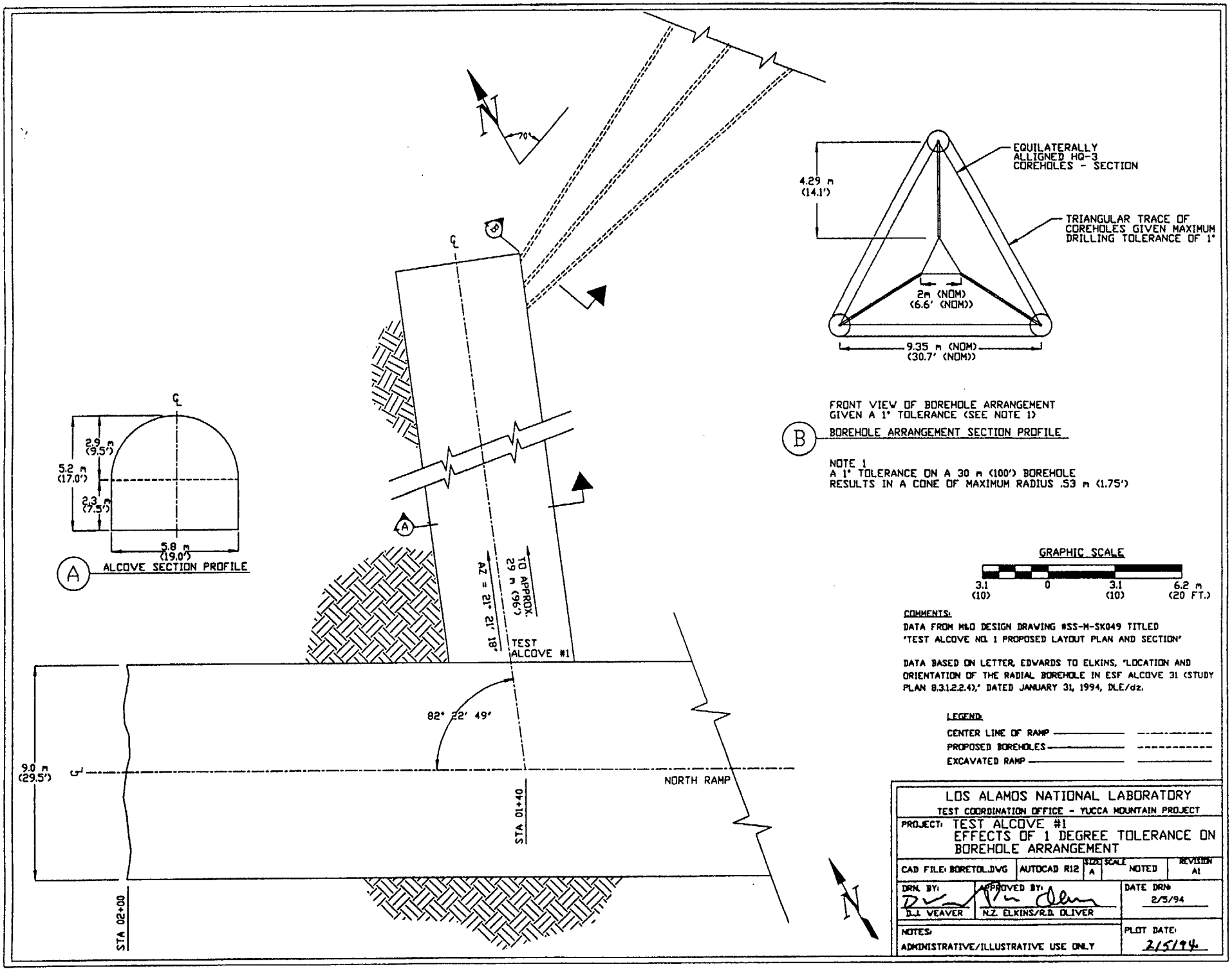
DATA FLOW INFORMATION

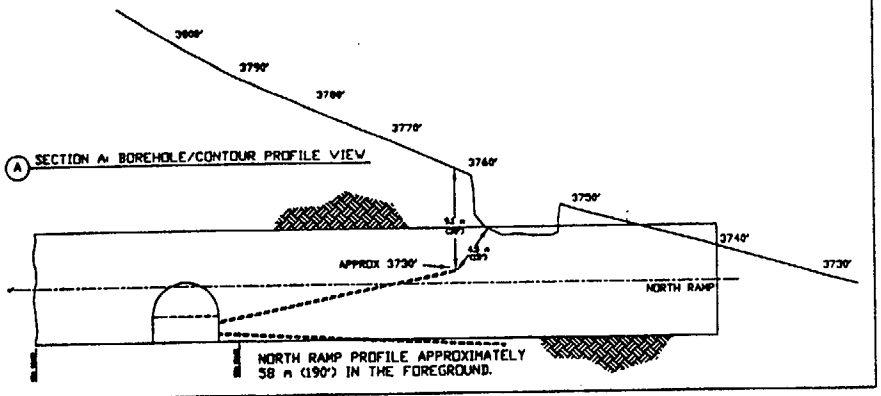
All field issues affecting data collection shall be brought to the attention of the Los Alamos Field Test Representative (LANL FTR). The Sample Management Facility will submit all records called for in AP-6.26Q or associated procedures, such as sample collection forms and records documenting visual core recording techniques (video, etc.) to the LANL FTR. The Test Coordination Office will submit a close out report under this Job Package (JP).

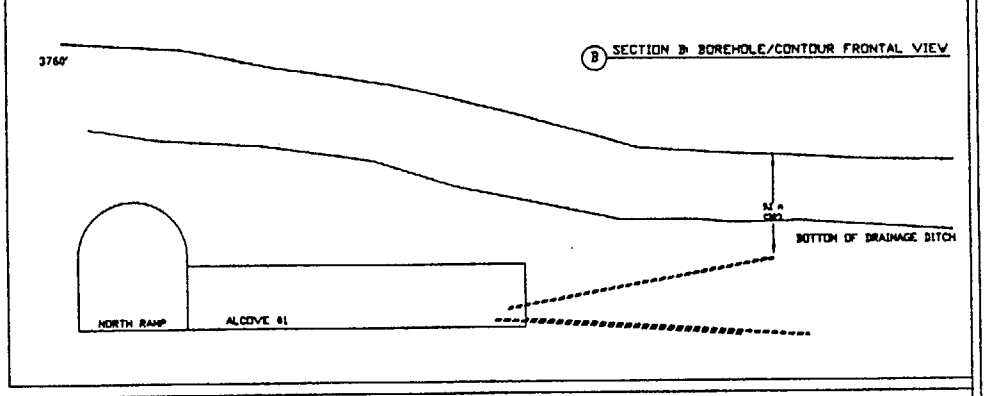
COST AND SCHEDULE SUMMARY

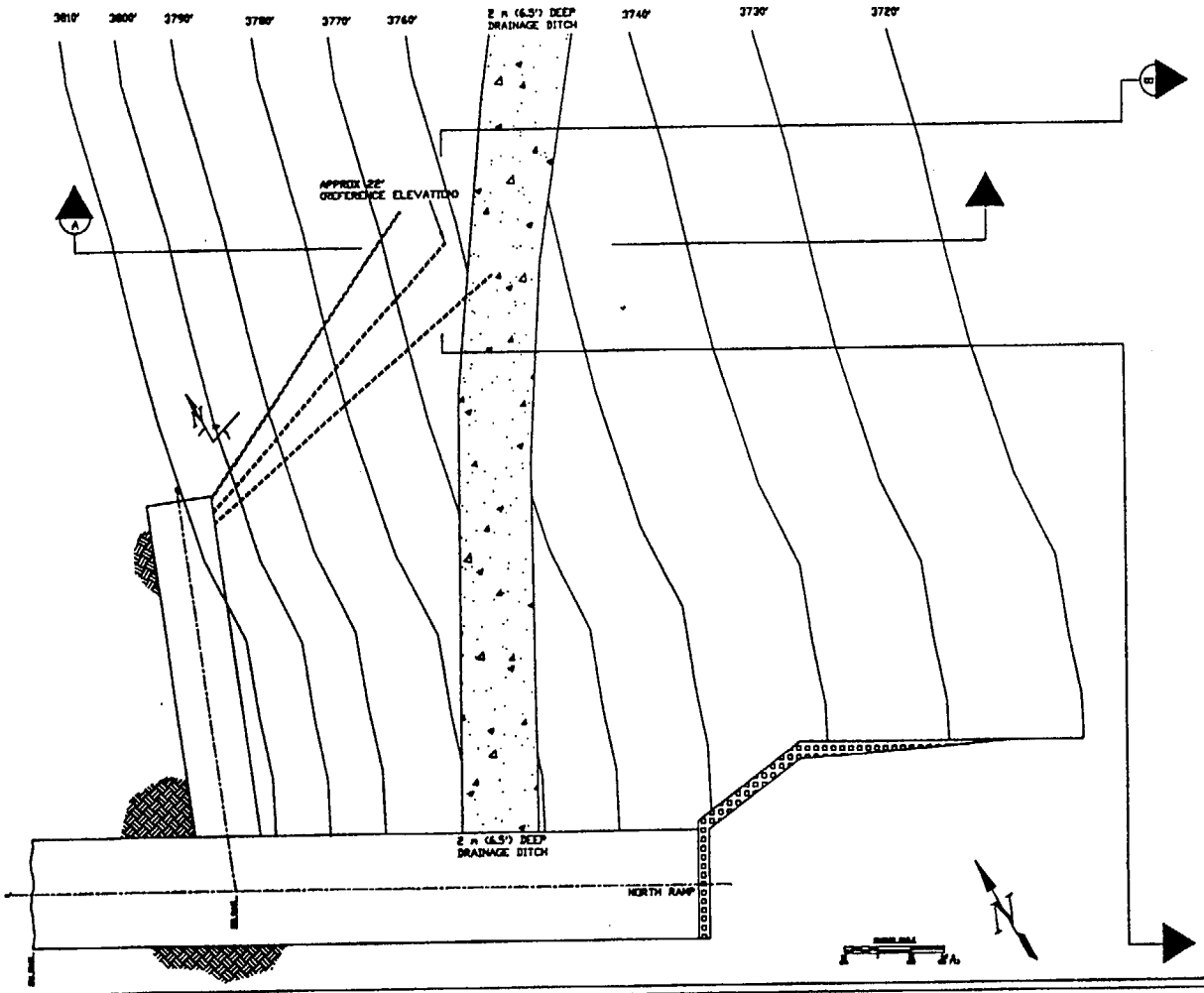
The costs and progress estimates on this activity are within the scope set by JP 92-20E. No detailed cost schedule is included in this monthly report. Illustrations are provided to show progress and test status.

SCP PROGRAM NAME	SCP STUDY NAME	SCP STUDY PLAN NUMBER	TEST NAME (SCP ACTIVITY)	TPP #	JP #
Geohydrology Program	Characterization of Percolation in the Unsaturated-Zone ESF Investigation	8.3.1.2.2.4	Hydrochemistry Tests in the ESF	TPP 92-12	JP 92-20E


N
70°
4.29 m
(14.1')
EQUILATERALLY ALLIGNED HQ-3 COREHOLES - SECTION
TRIANGULAR TRACE OF COREHOLES GIVEN MAXIMUM DRILLING TOLERANCE OF 1°
2m (NOM)
(6.6' (NOM))
9.35 m (NOM)
(30.7' (NOM))
FRONT VIEW OF BOREHOLE ARRANGEMENT GIVEN A 1° TOLERANCE (SEE NOTE 1)
B
BOREHOLE ARRANGEMENT SECTION PROFILE
NOTE 1
A 1° TOLERANCE ON A 30 m (100') BOREHOLE RESULTS IN A CONE OF MAXIMUM RADIUS .53 m (1.75')
2.9 m
(9.5')
5.2 m
(17.0')
2.3 m
(7.5')
5.8 m
(19.0')
A
ALCOVE SECTION PROFILE
TO APPROX. 29 m (96')
AZ = 21° 21' 18"
TEST ALCOVE #1
82° 22' 49"
9.0 m
(29.5')
NORTH RAMP
STA 01+40
STA 02+00
GRAPHIC SCALE
3.1
(10)
0
3.1
(10)
6.2 m
(20 FT.)
COMMENTS:
DATA FROM M&O DESIGN DRAWING #SS-M-SK049 TITLED 'TEST ALCOVE NO. 1 PROPOSED LAYOUT PLAN AND SECTION'
DATA BASED ON LETTER, EDWARDS TO ELKINS, 'LOCATION AND ORIENTATION OF THE RADIAL BOREHOLE IN ESF ALCOVE 31 (STUDY PLAN 8.3.1.2.2.4),' DATED JANUARY 31, 1994, DLE/dz.
LEGEND:
CENTER LINE OF RAMP
PROPOSED BOREHOLES
EXCAVATED RAMP
LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT
PROJECT: TEST ALCOVE #1
EFFECTS OF 1 DEGREE TOLERANCE ON BOREHOLE ARRANGEMENT
CAD FILE: BORETOL.DWG
AUTOCAD R12
SIZE A
SCALE NOTED
REVISION A1
DRN. BY: D.J. WEAVER
APPROVED BY: N.Z. ELKINS/R.D. OLIVER
DATE DRN: 2/5/94
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY
PLOT DATE: 2/5/94







COMMENTS:

DATA FROM M&O DESIGN DRAWING #SS-M-SK049 TITLED 'TEST ALCOVE NO. 1 PROPOSED LAYOUT PLAN AND SECTION'

DATA BASED ON LETTER, EDWARDS TO ELKINS, 'LOCATION AND ORIENTATION OF THE RADIAL BOREHOLE IN ESF ALCOVE 31 (STUDY PLAN 8.3.1.2.2.4),' DATED JANUARY 31, 1994, DLE/dz.

GROUND CONTOURS APPROXIMATED FROM RSN FILE, 'ESF,' PRODUCED FROM THE EG&G DATA BASE. ALL CONTOUR INFORMATION GOOD TO APPROXIMATELY PLUS/MINUS 3 m (10').

LEGEND:

CENTER LINE OF RAMP
PROPOSED BOREHOLES
EXCAVATED RAMP
GROUND CONTOURS

LOS ALAMOS NATIONAL LABORATORY
TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT

PROJECT: TEST ALCOVE #1
FINAL LAYOUT PLAN AND
SECTION W.R.T. GROUND CONTOUR

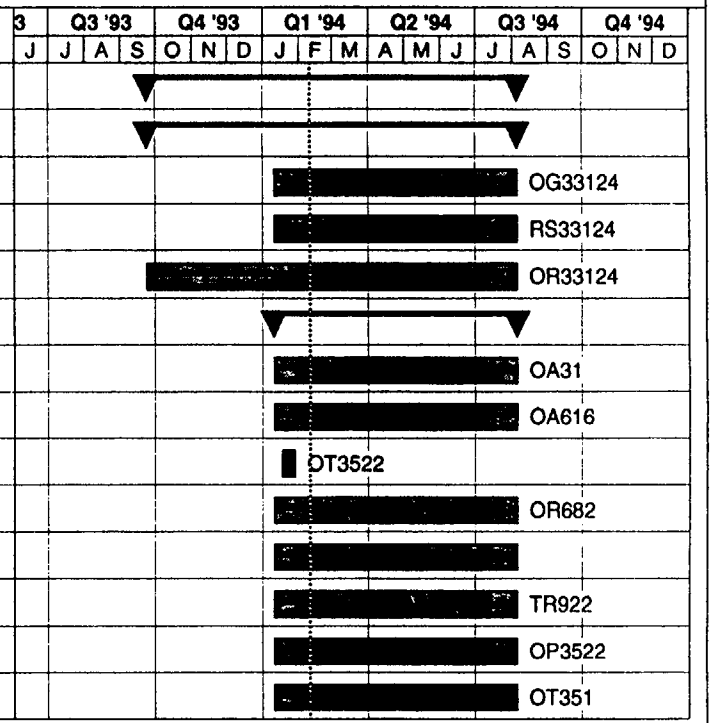
CAD FILE: RBCONTR.DWG	AUTOCAD R12	SIZE: A	SCALE: NOTED	REVISION: A1
DRN. BY: D.J. VEAVER	APPROVED BY: N.Z. ELKINS/R.D. OLIVER		DATE DRN: 2/7/94	
NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 2/7/94	

Hydrochemistry (TTP 92-12/JP 92-20E)

Field Activity Working Schedule

LANL ESF Test Coordination Office

ID	Name	Dur	Start	Summary Acct.
1	**TEST IMPLEMENTATION - ESF HYDROCHEMISTRY TESTING**	**227d**	**9/23/93**	
2	**Test Implementation - Discrete**	**227d**	**9/23/93**	
3	USGS Test Implementation	150d	1/10/94	OG33124H94
4	RSN Field Survey & Processing	150d	1/10/94	RS3522n4
5	REECo Test Construction & Procurement	227d	9/23/93	OR644c4
6	**Test Implementation - Matrix Support Elements**	**150d**	**1/10/94**	
7	Los Alamos TCO Coordination & Planning (Field Test Coordination Support)	150d	1/10/94	OA397BL4
8	Los Alamos TCO Test Management (Project Engineer Support)	150d	1/10/94	OA616AL4
9	T&MSS Direct Support Services (Photo Support)	10d	1/17/94	OT3522EL
10	REECo Construction & Operations Support (Interim WBS)	150d	1/10/94	OR682L4
11	RSN Survey Support / Capital Procurement (Interim WBS)	150d	1/10/94	RS614P94
12	CRWMS M&O Networking & Baseline Planning Support (Network & Progres:	150d	1/10/94	TR921CA1
13	JC Photo & Processing (General)	150d	1/10/94	OP3522L94
14	T&MSS SMF	150d	1/10/94	OT351EL



Project: t-92-12
Date: 2/9/94
Revision #3

Critical — Noncritical — Progress — Milestone — Summary — Rolled Up

Checked by: _____

Approved by: _____

T9212T94.MPP

ADMINISTRATIVE USE ONLY

P. Justus, NRC, Las Vegas, NV

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545