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QUARTERLY REPORT
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

OCTOBER THROUGH DECEMBER 1980

MARCH 1981

UNITED STATES
DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
LAS VEGAS, NV

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INTRODUCTION

The Nevada Nuclear Waste Storage Investigations (NNWSI) consist of a variety of studies and evaluations in support of the National Waste Terminal Storage (NWTS) Program. These investigations are being managed by the Nevada Operations Office (NV) of the Department of Energy (DOE). The NNWSI were formally organized in 1977 and are primarily oriented toward developing or improving the technology of nuclear waste storage and disposal and determining whether selected underground rock media on or adjoining the Nevada Test Site (NTS) are technically acceptable for a licensed, permanent, high-level nuclear waste repository.

This document is a report of the technical progress of the NNWSI in meeting the objectives described in the NNWSI FY 1981 Project Plan and FY 1982 Forecast (NVO-196-22) during the first quarter of FY 1981. The NNWSI Project Work Breakdown Structure (WBS) for FY 1981 is comprised of eight tasks. This report is organized according to the WBS shown in Figure 1. The Project organization chart is shown in Figure 2.

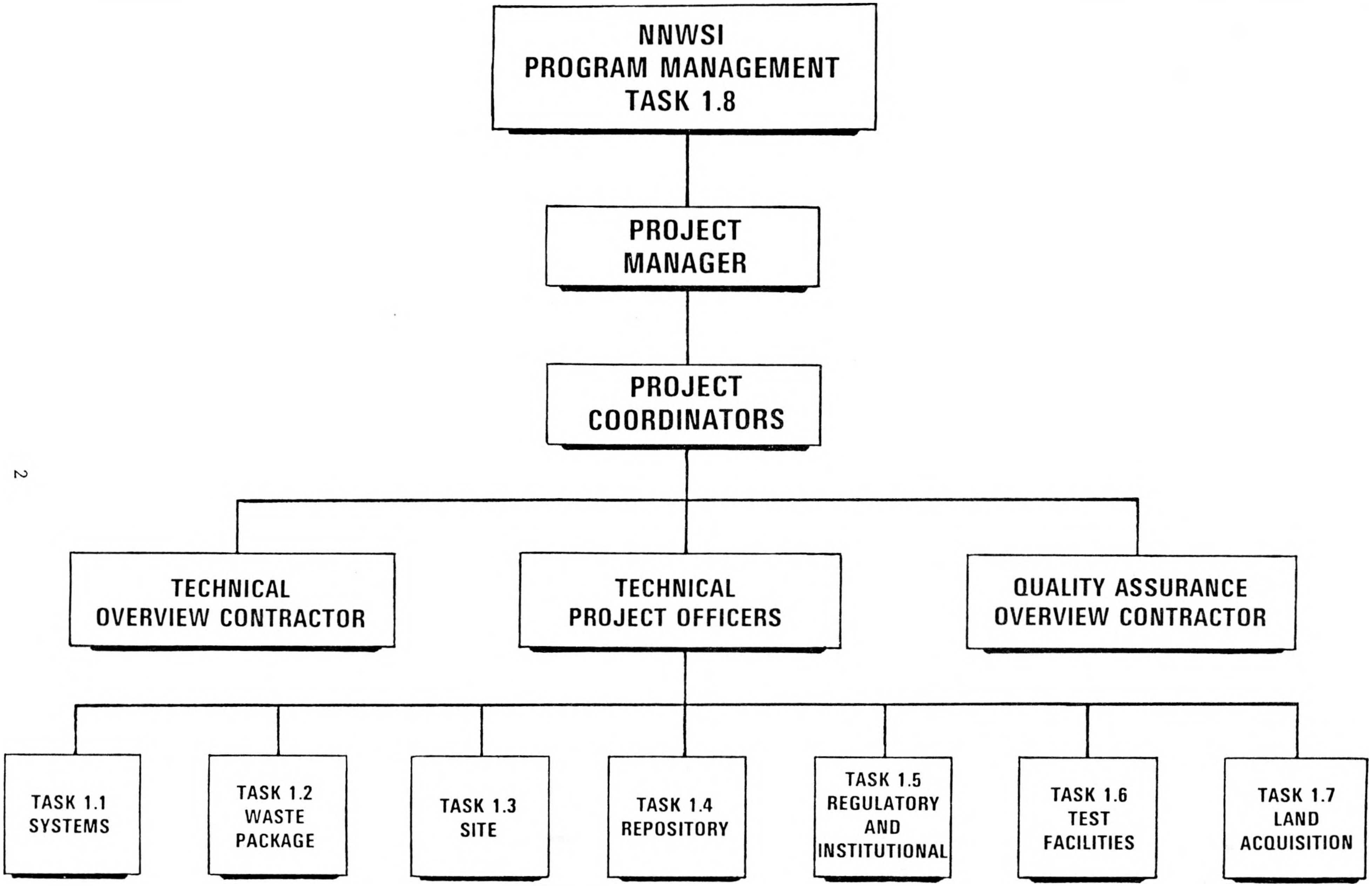

Figure 1. NNWSI Work Breakdown Structure.

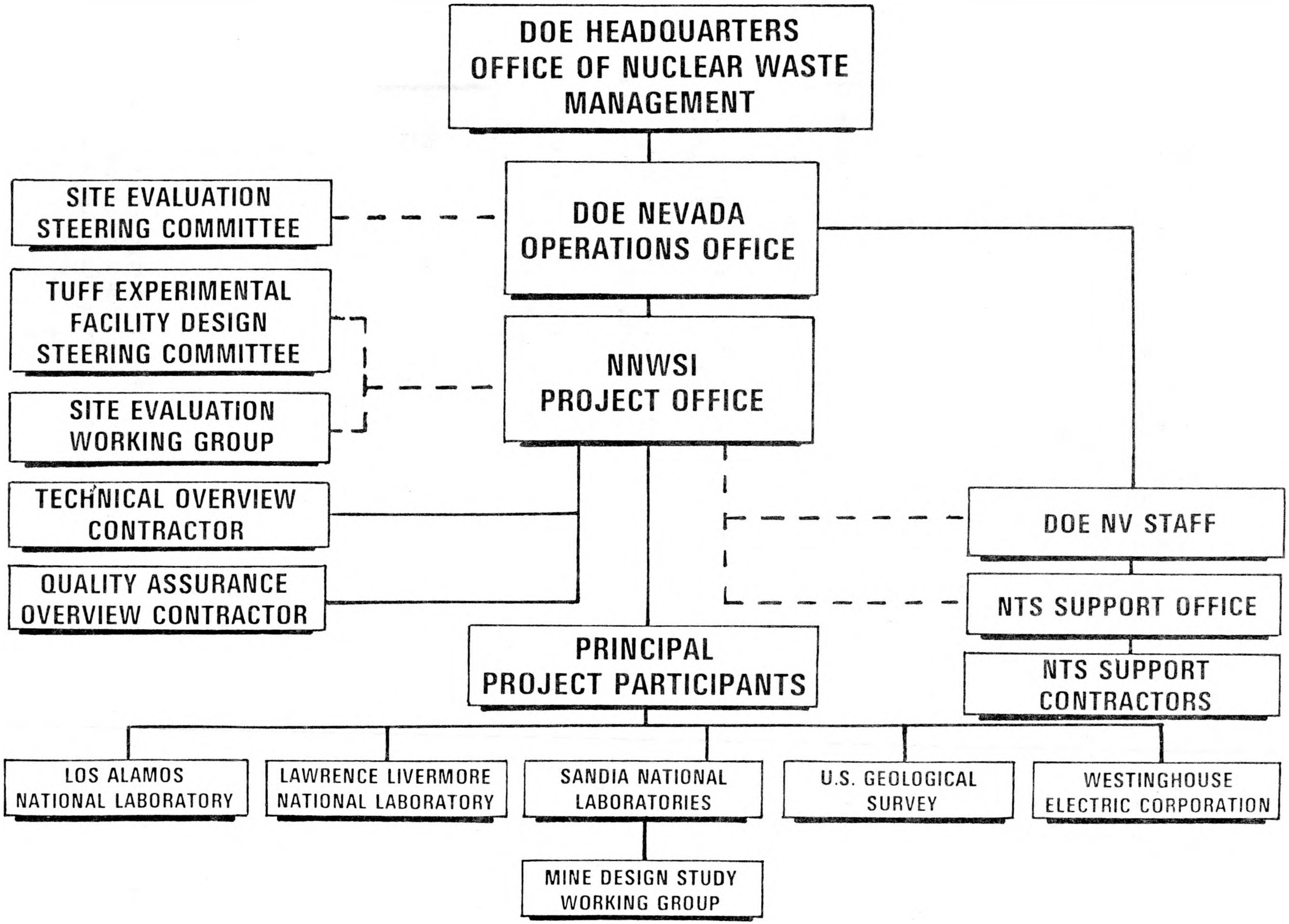

Figure 2. NNWSI Organization Chart.

HIGHLIGHTS

-- The preliminary reference repository conditions for tuff were adopted for the waste package materials characterization studies. A reference waste package design was established and the generalized performance guidelines for the backfill were established and prioritized.

-- The 2 kW Fuel Temperature Test profile conditions were met and the test was completed on December 31, 1980. Test data acquisition was discontinued.

-- The 3 kW Soil Temperature Test was completed and data acquisition was discontinued on December 31, 1980.

-- The EDP Plasma Welder was received and set up in the Cold Bay; the Welder Development Program was initiated.

-- A major overhaul of the E-MAD Wall Mounted Handling System was completed.

-- The R-MAD shielding windows were disassembled, inspected, and packaged for refurbishment by the vendor.

-- The Safety Assessment Document was reviewed to propose revisions necessary for currently scheduled activities and newly installed E-MAD systems.

-- The water collection apparatus for use in the study of radionuclide migration in granite was completed and shipped to the NTS for installation in January 1981.

-- Petrographic characterization of USW-G1 core within the depth range of 1,190 to 3,500 feet reveals that the three major primary components of these tuffs are glass (vitric), rock fragements (lithic), and crystals (felsic and accessory).

-- The major hydrologic drill hole, USW-H1, was completed to a total depth of 6,000 feet; geophysical logging was also completed and hydrologic testing is in progress.

-- The magnetic properties of the geologic units in drill hole USW-VH1, which was completed to a depth of 2,500 feet, appear to be consistent with the aeromagnetic and ground magnetic anomalies found in the area.

-- Data resulting from the hydraulic testing of drill hole USW-G1 have been analyzed; these data indicate that the formations in the hole have low hydraulic conductivity.

-- A zircon fission-track age of about 3 million years on exposed ash near the middle of the Amargosa Valley is regarded as evidence that much of the Amargosa Valley has been relatively stable during the Quaternary period.

-- The Site Evaluation Working Group began assessing a proposed technical approach to area screening and developed a set of maps of 12 rock units of sufficient thickness and depth for a repository in the southwest NTS area.

-- Work on developing information for the Environmental Area Characterization Report was begun this quarter.

-- Three-dimensional heat transfer calculations were completed by the Mine Design Study Working Group for a gross thermal load of 100 kilowatts per acre for both spent reactor fuel and high-level waste in a room-and-pillar geometry in a tuff repository.

-- A large suite of triaxial mechanical tests on the stratigraphy of drill hole USW-G1 has been completed and the data are being interpreted.

-- Reports published:

"A Fundamental Approach to the Analysis of Radionuclide Transport Resulting from Fluid Flow Through Jointed Media."

"Fluid Radionuclide Migration Studies in Climax Granite."

"Geotechnical Status Report for Test Storage of Spent Reactor Fuel in Climax Granite, NTS."

"Thermal Analysis for a Spent Ractor Fuel Storage Test in Granite."

"Spent Fuel Test--Climax Technical Measurements Interim Report FY 1980."

"Response of Borehole Extensometers to Explosively Generated Dynamic Loads."

"Mechanical and Thermomechanical Calculation for a Spent Nuclear Reactor Fuel Test in Granite."

WORK BREAKDOWN STRUCTURE

1.1 SYSTEMS

Objective: To plan, document, and evaluate the performance of the Project and to identify modeling techniques to evaluate the performance of the overall waste package, site, and the repository containment and isolation systems.

1.1.1 PROGRAM BASELINE

Objective: To plan, document, and evaluate the performance of the Project.

The TPOs and the TOC worked with the Project Manager, participating national laboratories, USGS, WEC, contractors, and subcontractors in planning, coordinating, reviewing, documenting, and implementing a balanced technical project. This activity has no reportable progress.

1.1.2 SYSTEMS ANALYSIS

(No NNWSI work funded this fiscal year.)

1.1.3 SOCIOECONOMIC ASSESSMENT

(No NNWSI work funded this fiscal year.)

1.1.4 ALTERNATE DISPOSAL CONCEPTS

(No NNWSI work funded this fiscal year.)

1.1.5 PERFORMANCE ASSESSMENT

Objective: To assess the performance of the overall waste containment and isolation systems.

This activity has no reportable progress.

1.2 WASTE PACKAGE

Objective: To establish the capability to design, construct, and qualify waste packages which provide for the safe handling, storage, and containment of the waste and which permit safe retrieval of the waste package, i.e., everything placed into the repository emplacement hole.

1.2.1 WASTE PACKAGE BASELINE

(No NNWSI work funded this fiscal year.)

1.2.2 WASTE FORM

(No NNWSI work funded this fiscal year.)

1.2.3 BARRIER MATERIALS

(No NNWSI work funded this fiscal year.)

1.2.4 DESIGN AND DEVELOPMENT

Objective: To provide design drawings and specifications for waste package components and to develop package fabrication equipment specifications.

1.2.4.1 Tuff Waste Package Development

Objective: To develop a waste package for emplacement in a tuff repository.

The tuff waste package design and development activity commenced this quarter. This is a new activity within the NNWSI and is a joint program between Sandia and Los Alamos. During the past quarter, the following progress was made:

a. The preliminary reference repository conditions for tuff were adopted for the waste package materials characterization studies.

b. A reference waste package design was established. The design includes the waste form, canister, overpack, and backfill. Dimensions and material properties were assigned to the reference waste package and a series of thermal calculations were initiated to determine potential temperature gradients within the waste package and at the waste package-rock wall interface. The results of the initial calculations will be completed in the second quarter.

c. The generalized performance guidelines for the backfill were established and prioritized. In order of priority performance, the guidelines included controlling water access, conditioning the water (pH, Eh, chemical composition, etc.), sorbing radionuclides, providing for heat transfer to the host rock, and distributing stresses imposed by the host rock.

1.2.4.2 Experimental Demonstrations Program (EDP) Design and Development

Objective: To develop and demonstrate the capability for and feasibility of safely storing high-level waste and spent reactor fuel under dry conditions.

1.2.4.2.1 Canister Cutter

Objective: To establish the operational capability at the E-MAD facility to safely cut open welded metal canisters containing spent reactor fuel assemblies for EDP requirements.

There were no canister cutter activities during this time period.

1.2.4.2.2 Pit Adapters

Objective: To install a new seismic grid in the north lag storage pit that will accept adapters to fit either the present 14-inch stainless steel canister or the new 12-inch carbon steel canisters.

Preliminary drawings for the new Lag Storage Pit seismic grid were reviewed and comments were prepared for the final design review in early January.

1.2.4.2.3 EDP Plasma Welder Development

Objective: To establish a full-penetration plasma welder capability for EDP requirements.

Support equipment to be used during the Weld Development Program was fabricated and the plasma welding system was received in November 1980. The system was set up in the Cold Bay and the first practice weld was completed. A development program and schedule of activities were prepared and initiated. Mock-ups for use in the program are being machined.

1.2.4.2.4 EDP Ultrasonic Weld Inspection System

Objective: To assemble, test, and use as a production inspection tool a remote ultrasonic inspection system which will perform examinations in accordance with the applicable requirements of the ASME Boiler Pressure Vessel Code.

Quality assurance personnel completed design review of the mechanical fixturing device of the Ultrasonic Weld Inspection System and transmitted their comments to AESD-Pittsburgh.

1.2.4.2.5 EDP Grapples

Objective: To design, fabricate, modify, test, and qualify the grapples required for EDP canister, high-level waste log, and boiling water reactor fuel handling.

Modifications to the LLNL grapple for use on the EDP package were finalized.

1.2.4.2.6 EDP Backfill Collar

Objective: To ship EDP backfill collar hardware to the NTS and to provide WEC-AESD support during installation at the E-MAD facility.

No report.

1.2.4.2.7 Safety Assessment Document Update

Objective: To update the current E-MAD Safety Assessment Document (SAD) for activities planned for FY 1981 and later.

The current DOE requirements for the update of the SAD are being analyzed.

1.2.4.2.8 E-MAD Dry Run Hardware

Objective: To procure the material and to fabricate one canister for the E-MAD facility dry runs.

No report.

1.2.4.2.9 Data Acquisition for the Dry Well Experiments

Objective: To collect, review, and chart thermal data from dry well experiments using electric heaters and spent reactor fuel assemblies.

In the Dry Well Interaction Test (Dry Wells 1, 2, 3, Array), the highest thermocouple temperatures after 2,532 hours of operation were:

Fuel Assembly	Dry Well	Canister (^{o}F)	Liner (^{o}F)
B-43	1	180.7	138.0
B-41	2	196.5	153.1
B-03	3	211.6	165.9

At 2,832 hours of operation of the 2-kW Dry Well Test, the maximum canister temperature was 312.8^{o} F and the nearest liner temperature was 254.0^{o} F.

WN-TOP-023, covering operation of the 2-kW Fuel Temperature Test, was revised to add a data channel and correct a minimum vacuum gauge reading; the revision was published.

A definition of the final test profile condition was received from AESD-Large and LLNL and the tests were completed. Temperature controllers were disconnected at 1,600 hours on December 31 and test data acquisition was discontinued. At 2,390 hours of operation, the temperature of the centermost thermocouple in the fuel assembly was 526.7^{o} F and the highest canister temperature was 356.1^{o} F.

Briefings were held and Hot Bay preparations completed for moving the spent fuel assembly (D-15) from the West Process Cell to the Hot Bay for calorimetry and encapsulation. (See Tasks 1.4.2.2.3 and 1.6.5.1.2.)

The 3-kW Soil Temperature Test data acquisition was terminated at 0800 hours on December 31. At 6,558 hours of operation at 3 kW, the maximum canister thermocouple temperature was 721.8° F and the temperature of the nearest liner thermocouple at that time was 684.8° F.

Power to the heater was reduced, with one-half kilowatt of power being applied to prevent rust and moisture collection.

1.2.4.2.10 Dry Well Evaluation

Objective: To determine the cause and effect of water accumulation in dry wells and recommend design modifications.

Preliminary assessment of thermocouple damage from water accumulation in the dry wells was completed.

1.2.4.2.11 Acoustic Emission System

Objective: To provide a recommendation for an on-line nondestructive monitoring system to ensure detection of weld failures in fueled canisters while in storage.

A final report describing the acoustic emission engineering development program results is in progress.

1.2.4.2.12 2 kW Fuel Temperature Test Operation

Objective: To provide WEC-AESD design and test support to the E-MAD facility for the operation of the 2kW Fuel Temperature Test.

No report.

1.2.4.3 Boiling Water Reactor Fuel

(No NNWSI work funded this fiscal year.)

1.2.4.4 Soil Temperature Test Modifications

(No NNWSI work funded this fiscal year.)

1.2.5 PERFORMANCE EVALUATION

Objective: To evaluate the performance of the receipt, handling, and temporary storage of BWIP high-level waste and spent reactor fuel.

1.2.5.1 BWIP--Spent Reactor Fuel

(No NNWSI work funded this fiscal year.)

1.2.5.2 BWIP--High-Level Waste

Objective: To prepare a container for the vitrified high-level waste log for storage in the Near-Surface Test Facility by encapsulation in an EDP canister.

No report.

1.2.5.3 Lag Storage Canister

(No NNWSI work funded this year.)

1.2.5.4 Cask Licensing Support

(No NNWSI work funded this year.)

1.2.5.5 BWIP--Spent Reactor Fuel High-Level Waste Acquisition

(No NNWSI work funded this year.)

1.3 SITE

Objective: To identify and characterize the southwest quadrant of the NTS as a possible site for the construction and operation of a mined geologic repository for radioactive waste.

1.3.1 SITE BASELINE

(No NNWSI work funded this fiscal year.)

1.3.2 EARTH SCIENCES

Objective: To develop the data base and methodology necessary to characterize the geologic system and understand its physical-chemical interactions.

1.3.2.1 Nuclide Migration Field Experiments

Objective: To develop the experimental, instrumental, and safety techniques necessary to conduct controlled small-scale, at-depth nuclide migration experiments in the field.

1.3.2.1.1 Nuclide Migration Field Experiments in Tuff

Objective: To develop in situ nuclide migration assessment techniques in the tuffaceous media of G-Tunnel.

The tuff radionuclide migration field experiment is a joint effort conducted by Los Alamos, Sandia, and Argonne national laboratories.

During this quarter, there were no changes in experimental objectives or in the technical approach. The responsibility for managing the SNL portion of this task was transferred from J. K. Johnstone to D. R. Fortney as of October 1, 1980. Review of the Nuclide Migration Field Experiments Program Plan was completed and the final draft submitted to WMPO/NV in December 1980. A proposal for ONWI to provide modeling support to the experiment was reviewed and rejected. A SAND report entitled "A Fundamental Approach to the Analysis of Radionuclide Transport Resulting From Fluid Flow Through Jointed Media," by K. Erickson, was written and was sent to the printers in December 1980.

Sandia has several important responsibilities for the tuff Nuclide Migration Field Experiments: geophysical characterization of the experiment site in G-Tunnel; design and development of water and radionuclide control systems; design and fabrication of required instruments to monitor the experiment; laboratory experimentation to define design requirements and to develop transport models; directly carrying out the in situ migration experiments and posttest activities in G-Tunnel; and analysis of experimental results. Technical progress made during the first quarter of FY 1981 in each of these elements of responsibility will be represented by the work reported in three major areas of activity:

a. Field Activities.

b. Equipment Design and Development.

c. Transport Modeling and Analyses.

Field Activities

Some work was done in support of site characterization. Core from HF23 was moved to Albuquerque for identification and redistribtuion. Core samples taken of the parting plane potentially used in the experiment and of the rock matrix on either side of the plane were sent to Los Alamos and Argonne; these samples were from cores RNM 8, 9, and 12. A sample of welded tuff from core EVG 27 was also sent to Argonne for comparison of welded and nonwelded tuff properties.

Approximate orientations for faults occurring near the experiment site were determined using tunnel plan diagrams and core logs. At least two nearly vertical fracture sets cut through the horizontal parting plane of interest. The two fracture sets of concern are approximately parallel to one another, running about N 45^{o} W to N 55^{o} W and occurring at depths of about 12 feet and 19 feet, respectively, from the left rib of HF23 near the EV5 intersection.

Because the elevation of the parting plane of interest is unknown where it occurs between these faults, two options were evaluated for determining the exact position of the plane. The exact position of the plane at depth is needed so that permeability measurements can be made at the parting and so that the water and tracer injector and collector systems can be accurately placed by drilling from HF23. The first option to locate the parting plane's position requires drilling arrays of angled coreholes and estimating the depth at which the parting plane is intersected. The second option requires mining the drift approximately perpendicular to HF23, either as an extension of EV5 or approximately halfway up HF23 where the parting plane is still above the floor. The mining operation was preferred because it would be faster and cheaper and would provide an alcove for the experimental equipment. This option will be pursued as funds permit in the second quarter of FY 1981.

Equipment Design and Development

Design criteria for the field fluid permeability equipment were changed so that more off-the-shelf components could be used. The total fluid capacity and operating pressure are now 120 gallons and up to 200 psi, respectively. In reducing the capacity from 200 to 120 gallons and the pressure from 500 to 200 psi, ready-made tanks could be purchased and the problems of welding, certifying, and transporting were eliminated.

Positive-displacement piston flowmeters were substituted for low-flow turbine meters after it was discovered that long delivery times and mechanical problems with speeding of the turbines could not be reduced. The piston flowmeters have been ordered from Conometrics and will be delivered around the first of April 1981.

All other major components for the permeability measuring equipment have been ordered. It is expected that this equipment will be ready for use on schedule by May 1981.

Detailed design drawings for the water and tracer injector systems and the water and tracer collector systems were started in December. Three experiment concepts were discussed and evaluated during this quarter. Criteria for total containment of the fluid, single-direction line-source water injector, and point-source tracer injector were established. Dimensions for three water and tracer collector systems and definitions of parameters to be measured were determined. Priority for the design requiring the least cost, fabrication time, and expense and best meeting the experiment needs was assigned to a single-hole, multicomponent collector. This collector includes monitors for time of arrival of radionuclides, probes for sensing depth and composition of accumulating fluid, a sampling system capable of collecting discharged radionuclides with excellent spatial and time resolution, and a backup system for excess water removal. Other design options will be detailed as time and money permit.

Transport Modeling and Analysis

During this quarter, the modeling and analysis activities focused on laboratory experiments conducted by the Chemical Technology Division. K. Erickson continued a set of column experiments using man-made "channels" for fluid flow to evaluate the retardation of cesium-137, strontium-85, and europium-155 by nonwelded vitric tuff from G-Tunnel. These experiments are designed to look at both sorption along the channel and diffusion into the porous rock matrix. The results of these experiments are intended to help extend and improve current transport models. During the next quarter, samples of the specific parting plane to be used in the field experiment will be studied; results of these studies will aid in making predictions of radionuclide migration in the field experiment.

Tracer Development

ANL efforts in this quarter concentrated on three major areas of research. Development was started on a radon-222 technique for measuring flow path; the calculations on the production of plutonium-236 and neptunium-235 tracers were completed; and the design and assembly of modifications to the scanning gamma-ray counter were begun. These will be discussed in turn.

Radon-222 Flow Path Tracer

The objective of this task activity is to determine whether the lead-210 daughter, deposition by the radon-222 in solution, will serve to mark the flow path over the fissure surface and also will provide a measure of the thickness of the fissure at each point.

ANL used ground glass flat planar fissures for test purposes and found that the deposition of lead-210 was uniform on the surface. However, studies on wedge-shaped fissures were not conclusive. It is felt that these latter experiments were perturbed by the presence of lead-210 in the initial radon solution and by too-rapid flow rates. An absorption column is presently being constructed for the radon solution and a new radon generator to eliminate those problems.

Production of Plutonium-236 and Neptunium-235

To conserve on cyclotron time, ANL has been investigating the possibility of producing both plutonium-236 and neptunium-235 tracers at the same time on uranium-235 targets. Theoretical calculations indicate that this is feasible and the first test irradiation is proceeding.

Scanning Gamma-Ray Counter

Scanning the surface of large samples of rock will be an important function when large block or in situ experiments are in progress. ANL has been given access to a PhoCon scanning gamma-ray counter which will automatically scan up to a 65- by 200-centimeter area. A collimator is being designed and constructed to allow 0.5- by 0.5-centimeter resolution at about a 10 percent counting efficiency. The output of the counter is also being modified to "dump" the data on a 10-megabyte disk which will be compatible with the ANL system to permit easier data handling.

Groundwater Composition Studies

A series of preliminary experiments were performed in which various crushed rock samples from G-Tunnel were contacted with G-Tunnel seep waters, water from Well J-13, and water from Well 8. The purpose of these experiments was to provide data for choosing the method of preparation of waters for the laboratory and field experiments. Although the data are still being analyzed, it is clear that all of the waters change composition, picking up significant concentrations of silicon and iron. For now, water from Well J-13 pretreated with matrix material from the HF-23 area in G-Tunnel will be used because: (1) none of the natural waters examined are in equilibrium with the rock; (2) the rock-treated waters have roughly the same composition independent of the source; (3) Well J-13 is a reliable source of water, and the water composition does not change with time; (4) the reliability and consistency of composition of the seep waters is not known; (5) the matrix material is available for water pretreatment; and (6) very little fracture-fill material is available (pretreatment with fracture-fill material gives a water composition similar to matrix pretreated water). The decision is, of course, subject to change as experiments in the laboratory progress.

Batch Sorption Studies

Preparation for batch sorption measurements is under way. Water for the experiment is being prepared by pretreating water from Well J-13 with matrix material from hole RNM-9 more than one month. Changes in composition during this time are being measured. Matrix and fracture-fill samples for the sorption experiments are being pretreated with the water. Sorption experiments with contact times from approximately 0.5 hour to several weeks with strontium, cesium, barium, cerium, europium, and technetium will start in mid-January.

The preparation and work are being performed in a controlled nitrogen atmosphere (less 0.2 parts per million oxygen and less than 20 parts per million carbon dioxide).

The samples studied are being analyzed by X-ray diffraction. Neutron activation and X-ray fluorescence analyses are planned. The samples used in the preliminary water experiments are high in clinoptilolite (45 to 80 percent) with the remainder being quartz plus cristobalite (5 to 60 percent), alkali feldspar (5 to 25 percent), and some mordenite (trace to 5 percent).

Transport Studies

Some preliminary experiments concerning fracture flow have been initiated using a small prototype of the block experiments. An artificial fracture was formed by sealing together the edges of two machined surfaces of a G-Tunnel tuff sample with a polyurethane sealant. The blocks had been predrilled to allow for groundwater and tracer injection into the fracture. The block will be used for mechanical tests and to aid in the development of suitable inlet and outlet fixtures. In addition, a Plexiglas model of the block experiment was constructed to aid in the design of tracer injection systems. Dyes will be injected into the fracture to show visibly the shape of the tracer slug after injection. Systems such as this one, constructed from Plexiglas, may prove useful in studying the effects of dispersion in a two-dimensional, uniform flow field. The comparison between theoretical models, Plexiglas models, and tracer experiments using blocks with polished parallel faces should be informative.

A small hydraulic press was purchased and linear variable differential transfer (LVDT) displacement transducers were ordered for the block studies. The LVDTs will be used to precisely determine the aperture of the fracture in block studies.

The sorptive properties of four epoxy and plastic materials of interest for use with whole-core columns and block studies are being studied with batch techniques. In addition, solid cores of HF-23 tuff have been prepared for laboratory elution experiments. These have been encased in epoxy-Plexiglas for elution using a peristaltic-pump system.

1.3.2.1.2 Nuclide Migration Field Experiments in Granite

Objective: To develop in situ nuclide migration assessment techniques in the granitic media of the Climax facility.

The radionuclide migration program plan has been revised and published as UCID-18838, "Field Radionuclide Migration Studies in Climax Granite," by D. Isherwood, E. Raber, D. Coles, and R. Stone. The suggestions of peer and programmatic reviewers were incorporated wherever possible, but the basic experimental design remains the same.

R. Thorpe completed a draft proposal to obtain funding for an in situ block test. The proposal describes a field radionuclide migration experiment to be conducted in an in situ block of Climax granite containing a natural fracture.

The principal feature of this block test is that it can utilize a single natural fracture with well-defined boundary conditions for fluid flow. This allows the test to be an intermediate step between well-controlled laboratory conditions and less certain, yet practical field methods. This proposal is now being internally reviewed.

Project personnel attended the Waste Rock Interaction Technology Conference in Seattle, Washington (October 13-16). In addition, project members attended the Waste Management Symposium, Materials Research Society in Boston (November 17-20). This allowed for discussions concerning the possible interaction between the Swedish Stripa Program and our NTS Climax studies.

Quality assurance photographic and written documentation of hyraulic testing equipment was completed.

Site Selection and Characterization

The water collection apparatus was completed and shipped to NTS for installation in January. The support frame for the apparatus was constructed at the collection site in the Piledriver tunnel. Figure 3 shows the conceptual design of the groundwater collection system.

A third set of boreholes was drilled and core was taken and logged from these holes. Total depths are 35 and 39 feet. These two boreholes, TT5 and TT6, respectively, were visually logged using the borescope. Six high-angle fractures were identified.

Reconnaissance mapping of major fractures in the Piledriver tunnel and tail drift has been completed. The purpose is to (1) provide a base map of potential test locations in addition to those identified in the program plan and (2) study the relationship of fractures currently being tested to others in the surrounding rock mass. A total of 78 major continuous fractures or shear zones have been mapped and characterized. Sixty-eight (68) of these are located in the Piledriver tunnel with a predominant orientation of N 40° W, 85° SW as indicated by the stereonet contour plot of fracture poles in Figure 4. Typical mineralization in these fractures is calcite, with some iron oxides and chlorite. Thickness of the infilling varies widely both on a given fracture and among fractures. For single, unsheared fractures, it is typically 1 to 3 millimeters.

Only ten fractures were identified in the tail drift over a distance of about 30 meters. The mean orientation is about N 10° E, 50° NW as seen in Figure 4. The nature of these fractures appears somewhat different than those mapped in the access drift. Their traces generally appear more planar, and the mineralization, although similar, is thicker at 5 to 20 millimeters.

In terms of potential migration sites, two areas appear promising. First, there are several fractures in the Piledriver tunnel near the heater test drift and lunch room that could be intercepted at some suitable distance from the drift by horizontal boreholes. At least four of these fractures could be accommodated by a pair of 8-meter boreholes. Also, a major low-angle, water-bearing fracture in this area could be intercepted with a slant-drilled borehole.

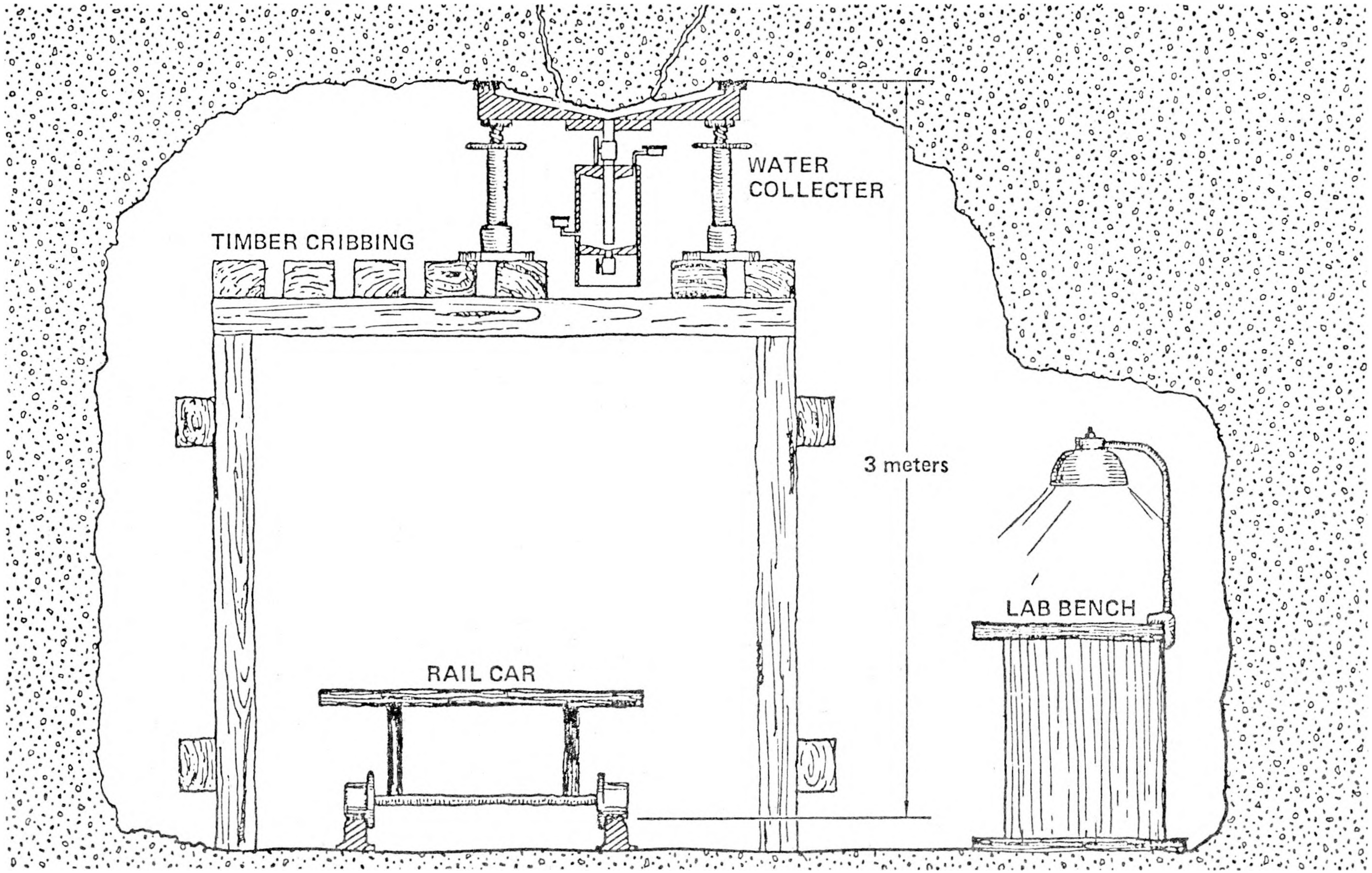

Figure 3. Schematic of the water collector at the Climax stock.

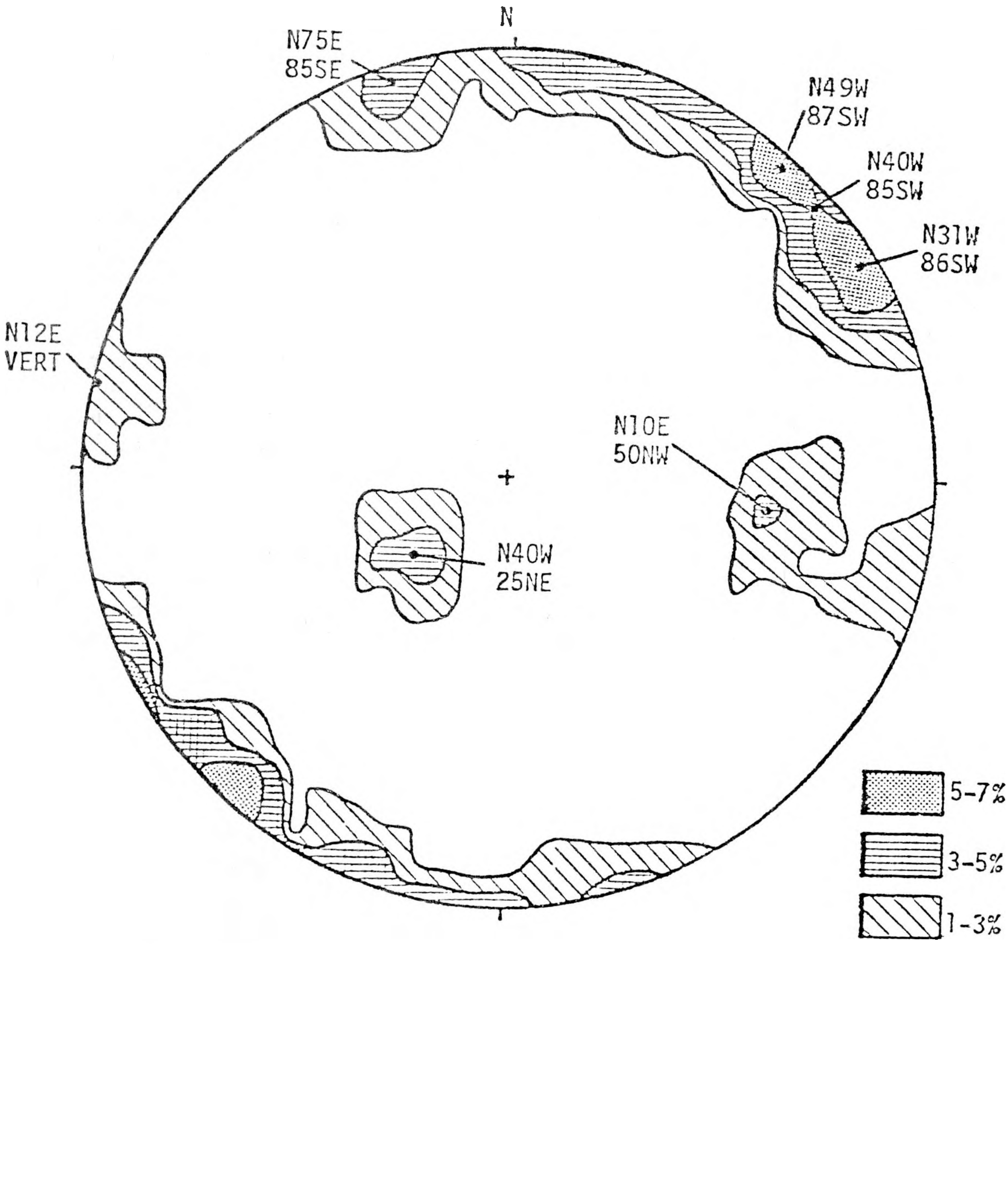

Figure 4. Lower hemisphere Schmidt contour diagram of poles to all fractures mapped in the Piledriver Tunnel and Tail Drift.

This would provide an opportunity to develop testing capabilities for nonvertical fractures, if the need arises in the future.

A second group of candidate fractures was mapped in the tail drift. Although some of these fractures appear highly conductive, the relative lack of major intersecting fractures in the drift makes the area attractive for single-fracture flow studies.

Hydrogeological Investigations

In October and November, the initial flow tests of selected fractures in boreholes TT1 and TT2 were completed. The respective orientation of these fractures and the hydraulic test observations can be seen in Figure 5 and are described below. The fracture at the 4-meter distance was found to be too permeable for the tracer test because an injection pressure could not be maintained in TT1. In the fracture at the 5.5-meter distance, good return flow was obtained and this fracture may have the desired permeability for the radionuclide migration tracer tests. A combination of fractures at about 6 meters in distance were tested. Although these fractures accepted the injected water, a circulating system could not be established. The fracture at about 7 meters in distance was found to be of very low permeability and would not accept water at pressures of 200 psia.

A noncirculating constant injection pressure test and a pulse test in December were performed on the fracture at 5.5 meters in distance in boreholes TT1 and TT2. A comprehensive circulating flow test was also performed on this fracture using three different injection pressures to determine flow rates and percentage recovery. The field results are summarized below.

Circulating Flow Test Results
Location: TT1, TT2; 5.5 m

Injection Pressures (psia)	Injection Flow Rate (ml/min)	Collection Flow Rate (ml/min)	Percent Recovery
20	23	23	100
30	59	54	92
40	90	77	86

The hydraulic tests of fractures in boreholes TT5 and TT6 were initiated. The location of these fractures and preliminary test results can be seen in Figure 6. Water was injected into the fracture at 6.3 meters in TT6 and the return flow was collected from fractures at 6.0 and 6.1 meters in TT5. This return flow rate was very erratic; maximum recovery was only 40 percent at 20-30 psia. Water was injected into the fracture at 6.6 meters in TT6 and water was collected from the fracture at 5.8 meters in TT5. This fracture was extremely permeable and exceeded equipment flow capacity at 40 psia. Water was also injected into the fracture at 7.8 meters in TT6, but no flow was seen from the fractures in TT5 using the borescope.

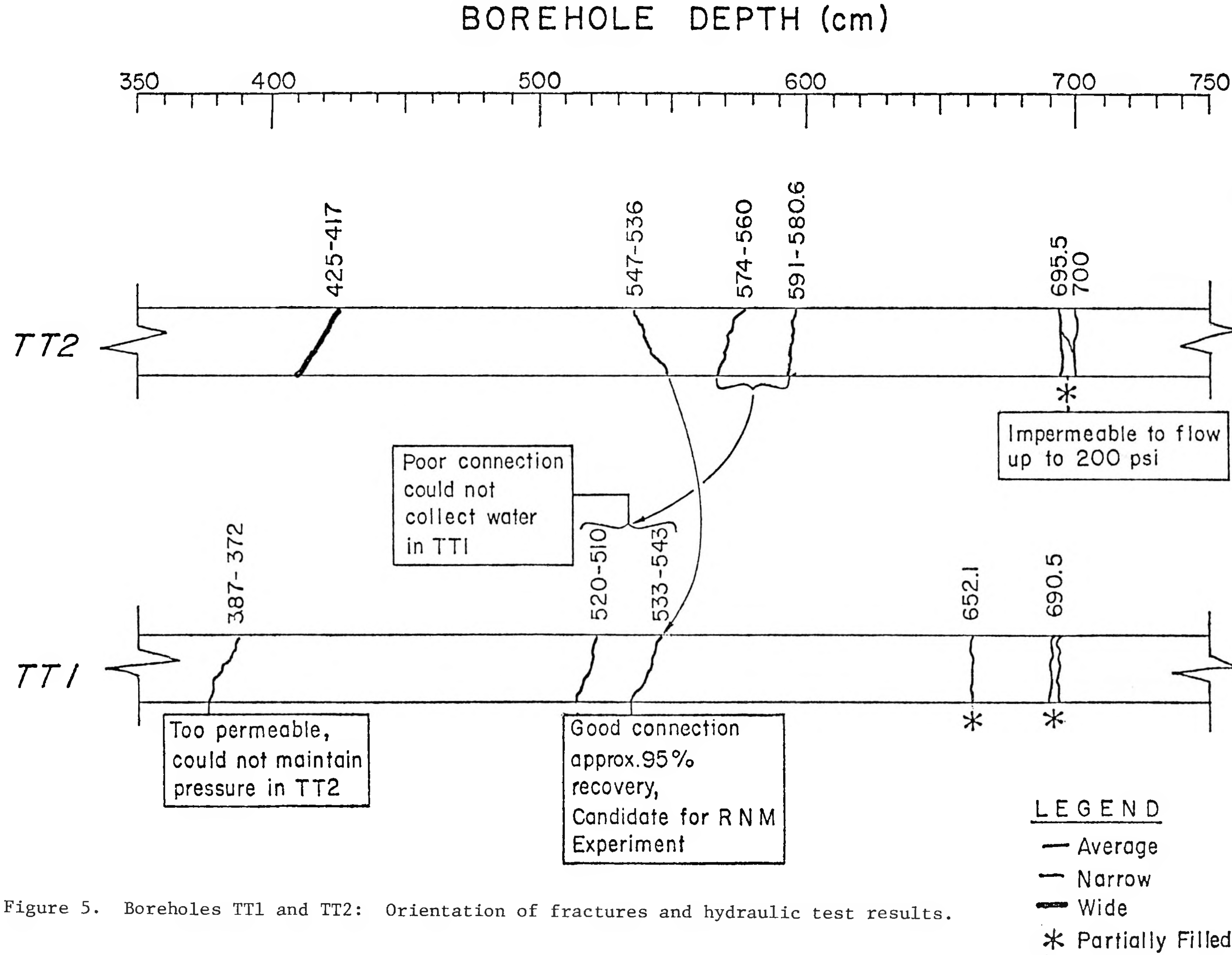

Figure 5. Boreholes TT1 and TT2: Orientation of fractures and hydraulic test results.

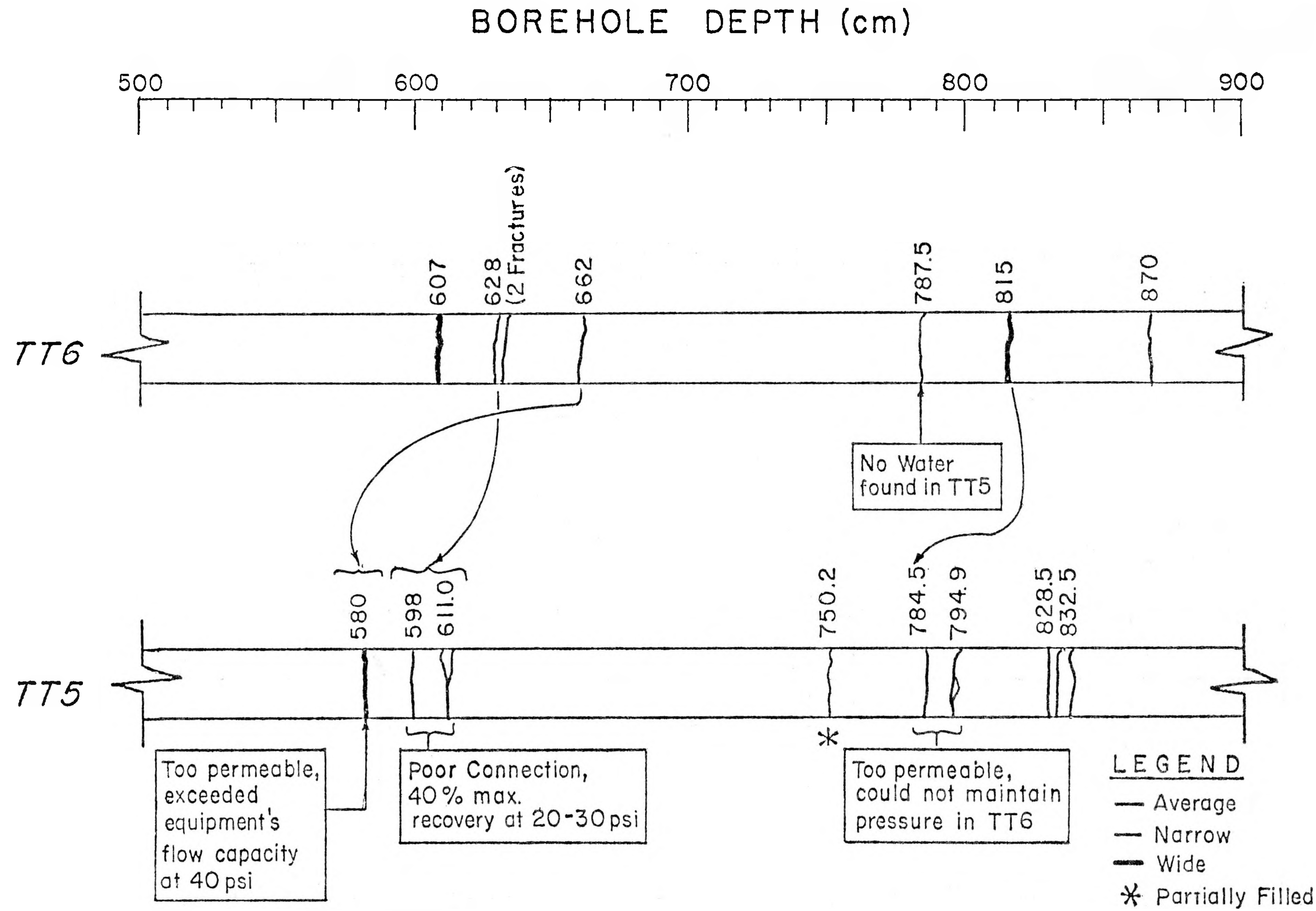

Figure 6. Boreholes TT5 and TT6: Orientation of fractures and hydraulic test results.

The injection response suggests that the fractures in boreholes TT1-TT2 and TT5-TT6 were unsaturated prior to testing. Reasonable efforts were made to saturate the fractures before starting the hydraulic tests. Testing will continue in the next quarter.

1.3.2.2 Tuff Studies

Objective: To determine the geochemical, mineralogical, and petrological properties of tuff.

1.3.2.2.1 Geochemistry

Objective: To determine the geochemical properties of tuff as a basis for predicting the migration of radionuclides to the accessible environment.

Variation of Sorption With Element Concentration

Results from batch measurements on tuff which showed the variation of the sorption ratio with concentration of the sorbing element were reported earlier for strontium, cesium, barium, and europium. These studies have been extended to include sorption of cerium and plutonium. In the following discussions, a devitrified tuff is a tuff containing principally quartz, cristobalite, and/or feldspars. When not specified, the zeolite in zeolitic tuff is clinoptilolite or heulandite.

Isotherm Measurements With Cerium

The less than 75- and 75-500 micrometer fractions of tuff from cores YM-22 (devitrified) and YM-38 (zeolitized) were used in this study. All contacts were for three weeks at ambient temperature under normal atmospheric conditions with the usual batch technique for ^{141}Ce. A single determination was made for each cerium concentration and particle size. A Ce(III) carrier solution was prepared by dissolving a weighed amount of $Ce(NO_3)_3 \cdot 6H_2O$ in deionized water, and a ^{141}Ce stock solution was prepared by drying the tracer and then dissolving it in the appropriate tuff pretreated groundwater. Five solutions of different cerium concentrations were prepared by mixing appropriate volumes of the carrier and tracer solutions and pretreated groundwater. Concentration data for the solutions before contact with the rocks are given in Tables 1 and 2. Initial pH values of the solution were 8.0 for tuff YM-22 and 8.1 for tuff YM-38. Five control samples without tuff were carried along in the experiment.

Results for the two tuff types are given in Tables 1 and 2; data for the samples are presented as sorption ratios while data for the controls are given as percent of the input activity remaining in solution after the shaking period (not removed by centrifuging). For the devitrified tuff, YM-22, the sorption ratio remains rather constant with changing concentration and exhibits no discernable trend with either concentration of cerium or tuff particle size. For the zeolitized tuff, YM-38, sorption ratios for both particle sizes at about 10^{-5} M Ce(III) are about 2.5 times higher than at the lower concentrations where they are relatively constant (except for the datum for the 75-500-micrometer fraction at the lowest concentration).

Interpretation of the data is complicated by the observation that the control solutions also lost significant fractions of the cerium by either precipitation or sorption on the containers. For both waters the loss increased with increasing cerium concentration. It is concluded that, for at least some tuff-groundwater systems, cerium solubility becomes a significant factor in removal of cerium from solution at concentrations greater than 10^{-6} to 10^{-5} molar.

The sorption ratios in Table 1 are lower than the previously reported value of about 1,500 milliliters per gram for tuff from core YM-22; those in Table 2 are in reasonable agreement with the previous value for YM-38 samples of about 900 milliliters per gram. The discrepancy of a factor of 3 to 4 for the YM-22 samples may be due to how the solution is prepared.

Plutonium Isotherm Measurements

Results from batch measurements of the element-concentration dependency of sorption ratios for cesium, strontium, barium, and europium on Yucca Mountain tuff were reported earlier. These studies have been extended to plutonium, using ^{237}Pu as a tracer and adding ^{239}Pu to vary the concentation between 10^{-12} and 10^{-8} molar.

TABLE 1
DATA FOR SORPTION OF Ce(III) ON TUFF YM-22
ISOTHERM MEASUREMENTS

Initial[a] Cerium Concentration (M)	R_d (ml/g) <75μm	R_d (ml/g) 75-500μm	Cerium Left in Control Solution (%)
2.33×10^{-9}	444	285	45.4
2.12×10^{-8}	390	399	25.4
1.35×10^{-7}	537	346	19.7
1.10×10^{-6}	676	537	13.0
5.84×10^{-6}	380	370	9.7

[a]Based on weighed amount of cerium added; corrected for losses during preparation of feed solutions.

TABLE 2
DATA FOR SORPTION OF Ce(III) ON TUFF YM-38
ISOTHERM MEASUREMENTS

Initial[a] Cerium Concentration (M)	R_d (ml/g)		Cerium Left in Control Solution (%)
	<75μm	75-500μm	
4.24×10^{-8}	1,177	85.6	67.2
3.10×10^{-7}	1,011	315	50.8
4.26×10^{-7}	981	563	24.5
1.62×10^{-6}	831	435	18.5
9.67×10^{-6}	2,223	1,218	17.8

[a]Based on weighed amount of cerium added; corrected for losses during preparation of feed solutions.

The ^{237}Pu and total plutonium concentrations in the ^{237}Pu tracer solution, which was obtained from the Argonne National Laboratory, were determined by mass spectrometry. The "Clinton" plutonium (greater than 99.95 atom percent ^{239}Pu) was assayed by alpha counting. Initial traced groundwater feed solutions were prepared by the usual technique, and actual plutonium concentrations at the start of contact with the crushed rock were calculated using the yields through the feed preparation step as determined by ^{237}Pu gamma counting (Table 3). Yields through the feed-preparation procedure were variable, but did not show any strong tendency to be lower at higher plutonium concentrations as would be expected if solubility were the determining factor.

Initial three-week sorption experiments at five plutonium concentrations with two particle sizes, less than 75 and 75-500 micrometers, for each tuff sample were followed by three-week desorptions; both were in air at ambient temperature. Desorption results are not yet available; R_d values for the sorption experiments are given in Table 3. Due to the small amount of ^{237}Pu available, only a single measurement was made for each combination of tuff, particle size, and plutonium concentration. Additional measurements are planned.

Within the accuracy of the limited data, a few general observations can be made. There was no significant difference in sorption ratio for the different particle sizes, in contrast to the factor-of-three variation observed earlier. There was essentially no variation in sorption ratio with a change in plutonium concentration from 10^{-12} to 10^{-8} molar. Average R_d values are 52 milliliters per gram for the YM-22 tuff and 170 milliliters per gram for the YM-49 tuff with standard deviations of the means of 5 and 17 milliliters per gram, respectively. The R_d value for the highest plutonium concentration tends to be low for the YM-22 tuff and high for the YM-49 tuff. A low R_d value at a high concentration could be due to saturation of available sorption sites, while a high R_d value could be due to precipitation of plutonium. Since it would be necessary to invoke different mechanisms to explain the observed differences in behavior, conjecture along these lines is best left until additional measurements are made.

TABLE 3
DEPENDENCE OF PLUTONIUM SORPTION RATIO ON CONCENTRATION

Core	Initial Pu Concentration[a] (M) Added	Actual	R_d (ml/g) <75μm	75-500μm
YM-22	1.2×10^{-11}	8.0×10^{-12}	60	65
	5.6×10^{-11}	3.0×10^{-11}	63	62
	4.4×10^{-10}	2.1×10^{-10}	54	54
	3.9×10^{-9}	1.8×10^{-9}	66	41
	3.9×10^{-8}	1.0×10^{-8}	34	17
YM-49	1.2×10^{-11}	1.6×10^{-12}	170	150
	5.6×10^{-11}	7.7×10^{-12}	160	89
	4.4×10^{-10}	1.3×10^{-10}	130	140
	3.9×10^{-9}	4.3×10^{-10}	180	220
	5.4×10^{-8}	2.9×10^{-8}	270	240

[a]The plutonium concentrations at 100 percent yield based on assay of the ^{237}Pu and ^{239}Pu solutions are shown as "added." The plutonium concentrations actually present at the start of the batch contacts, given or "actual," are lower because of losses during preparation of the feed solutions.

When the Freundlich equation $y = kc^n$, where y is the concentration on the solid in moles per gram and c is the concentration in the aqueous phase in moles per liter, is applied to the plutonium data, the parameters given in Table 4 are obtained. Although the value of n for sample YM-22 is somewhat below 1 and that for sample YM-49 is somewhat above 1, the overall average of 0.98 with a standard deviation of the mean of six percent is consistent with the observation that the sorption ratio did not vary significantly with the plutonium concentration.

TABLE 4
FREUNDLICH ISOTHERM PARAMETERS FOR PLUTONIUM

Core	Fraction (μm)	n	k
YM-22	<75	0.94	0.012
	75-500	0.84	0.001
YM-49	<75	1.05	0.633
	75-500	1.09	1.480

Dependence of Sorption on the Solution-to-Solid Ratio

Batch sorption measurements were performed to determine the dependence of the sorption ratio on the solution-to-solid ratio. Results for both three- and six-week contacts are given in Tables 5 and 6.

The results shown in Table 5 indicate that sorption ratios for the devitrified tuff YM-22 do not generally change greatly with the changing conditions. For the zeolitized tuff YM-38 (Table 6) there is a definite trend of increasing sorption ratio with increasing solution-to-solid ratio. The effect for cesium and strontium is small with changes of less than a factor of two in the sorption ratio. The effect is much larger for barium, cesium, and europium, which exhibit increases as large as a factor of nine. Sorption of the latter group of elements also increases somewhat with increasing solution-to-solid ratios for the YM-38 tuff (Table 5).

The solution-to-solid ratios under natural conditions and in column experiments are much smaller than those of the laboratory batch experiments. The observation of generally increasing sorption ratios with increasing solution-to-solid ratios may be at least a partial explanation for the lower sorption ratios deduced from the crushed-rock column experiments relative to those from the batch determinations.

The results from the three- and six-week determinations are in reasonable agreement, as are those for the two particle-size fractions. In some cases, the smaller fraction showed slightly higher sorption ratios.

Sorption on Tuff Samples From Drill Hole USW-G1

Sorptive properties of samples from drill hole USW-G1 are being determined by the batch procedure. Contact times are three and six weeks at ambient temperatures and under normal atmospheric conditions. Sorption of the nuclides ^{85}Sr, ^{133}Ba, ^{137}Cs, ^{141}Ba, and ^{151}Eu is determined in the same experiment.

Results for samples from cores G1-1436, G1-1883, G1-1982, and G1-2233 are given in Table 7. The number after the G1 designation indicate the depth of the core in feet. The last number in the identification in Table 7 is an internal number at Los Alamos. Data for duplicate determinations are presented.

TABLE 5

VARIATION OF THE SORPTION RATIO FOR YM-22 TUFF WITH THE SOLUTION-TO-SOLID RATIO

Fraction (μm)	Ratio	Contact Time (weeks)	R_d (ml/g) Cs	Sr	Ba	Ce	Eu
<75	5:1	3	827 (4.7)[a]	122 (2.0)	1,490 (1.8)	459 (8.5)	926
	10:1	3	755 (2.9)	80.3 (2.1)	1,360 (1.4)	500 (5.7)	1,270
	30:1	3	749 (2.1)	67.4 (2.1)	1,010 (1.1)	1,050 (4.5)	1,640
	5:1	6	740 (4.6)	129 (2.0)	1,280 (1.8)	297 (8.9)	749 (7.9)
	10:1	6	857 (3.0)	99.4 (2.0)	1,820 (1.5)	748 (7.2)	2,250 (6.2)
	30:1	6	1,100 (2.2)	97.9 (2.3)	1,850 (1.1)	---	---
75-500	5:1	3	363 (3.4)	63.0 (2.0)	601 (2.2)	303 (6.6)	794
	10:1	3	336 (2.5)	44.9 (2.2)	530 (1.9)	508 (5.4)	909
	30:1	3	368 (2.2)	195 (2.0)	412 (1.9)	1,000 (4.6)	1,600
	5:1	6	565 (4.0)	32.5 (3.6)	805 (1.8)	524 (9.5)	910 (6.9)
	10:1	6	457 (2.6)	59.4 (1.5)	605 (1.3)	1,040 (9.2)	1,300 (4.9)
	30:1	6	522 (2.1)		568 (1.2)	1,630 (6.7)	2,010 (3.5)

[a]The values in parentheses are the standard deviations for a single measurement of the R_d values expressed in percent; they were obtained from the errors associated with the activity measurements and estimated uncertainties for the various parameters entering into the calculation; these estimated uncertainties were propagated using the rule of change of variables in a moment matrix assuming independence of the variables.

TABLE 6

VARIATION OF THE SORPTION RATIO FOR YM-38 TUFF WITH THE SOLUTION-TO-SOLID RATIO

Fraction (μm)	Ratio	Contact Time (weeks)	R_d (ml/g)				
			Cs	Sr	Ba	Ce	Eu
<75	5:1	3	5,970 (11.7)[a]	2,770 (5.4)	11,000 (5.1)	1,330 (17.3)	2,700 (17.7)
	10:1	3	5,760 (7.5)	2,790 (3.4)	60,000 (9.6)	6,390 (13.1)	9,070 (13.2)
	30:1	3	7,980 (3.4)	3,610 (2.2)	81,500 (3.6)	9,070 (6.0)	9,700 (5.4)
	5:1	6	5,100 (12.2)	2,370 (6.4)	9,020 (5.2)	1,140 (20.4)	2,160 (18.4)
	10:1	6	5,120 (6.1)	2,410 (3.4)	16,000 (3.4)	5,460 (15.3)	4,330 (9.4)
	30:1	6	8,050 (3.8)	3,700 (2.4)	78,900 (3.7)	9,190 (8.3)	6,000 (5.7)
75-500	5:1	3	3,660 (10.6)	2,040 (4.9)	7,410 (5.1)	2,560 (17.2)	3,060 (1.63)
	10:1	3	5,750 (7.0)	2,840 (3.3)	48,000 (7.2)	7,230 (13.0)	6,780 (11.3)
	30:1	3	5,540 (3.2)	2,770 (2.1)	54,200 (3.1)	16,000 (5.8)	10,400 (4.9)
	5:1	6	5,110 (18.1)	1,760 (5.5)	6,180 (4.1)	1,600 (19.3)	2,500 (17.7)
	10:1	6	7,280 (7.0)	3,080 (3.8)	23,200 (3.9)	6,050 (15.3)	6,330 (11.2)
	30:1	6	6,270 (4.3)	2,050 (2.6)	49,200 (2.6)	11,600 (11.3)	8,810 (7.4)

[a]The values in parentheses are the standard deviations for a single measurement of the R_d values expressed in percent; they were obtained from the errors associated with the activity measurements and estimated uncertainties for the various parameters entering into the calculation; these estimated uncertainties were propagated using the rule of change of variables in a moment matrix assuming independence of the variables.

TABLE 7
SORPTION RATIOS FOR USW-G1 SAMPLES[a]

Sample	Contact Time (Weeks)	R_d (ml/g)				
		Cs	Sr	Ba	Ce	Eu
G1-1436-1	3	6,990 (3.8)	31,400 (3.5)	152,000 (4.1)	58,100 (10.7)	30,100 (6.7)
G1-1436-3	3	7,870 (4.0)	36,200 (3.7)	139,000 (4.0)	61,900 (0.9)	32,100 (6.7)
G1-1436-2	6	7,350 (3.9)	33,000 (3.8)	92,799 (3.2)	40,600 (10.3)	25,300 (6.5)
G1-1436-4	6	8,950 (4.3)	44,700 (4.5)	207,000 (5.1)	74,000 (11.9)	33,800 (7.1)
G1-1883-1	3	385 (2.2)	58.2 (2.4)	4,330 (1.1)	148 (4.1)	177 (3.1)
G1-1883-3	3	348 (2.2)	59.5 (2.4)	250 (1.6)	147 (4.1)	180 (3.0)
G1-1883-2	6	437 (2.2)	57.4 (2.4)	482 (1.1)	296 (4.1)	334 (3.1)
G1-1883-4	6	437 (2.2)	58.4 (2.4)	486 (1.1)	258 (4.2)	304 (3.1)
G1-1982-1	3	1,430 (2.5)	430 (1.9)	2,470 (1.2)	519 (4.4)	1,530 (3.8)
G1-1982-3	3	1,410 (2.5)	433 (1.9)	2,250 (1.2)	451 (4.4)	1,300 (3.6)
G1-1982-2	6	1,820 (2.6)	449 (1.9)	3,120 (1.2)	645 (4.6)	2,010 (3.9)
G1-1982-4	6	1,810 (2.6)	453 (1.9)	3,220 (1.2)	604 (4.6)	1,910 (3.9)
G1-2233-1	3	13,400 (6.5)	40,200 (3.9)	201,000 (2.3)	837 (8.5)	524 (7.8)
F1-2233-3	3	11,300 (5.2)	54,600 (4.1)	209,000 (6.9)	1,320 (7.9)	919 (7.4)
G1-2233-3	6	15,300 (5.4)	48,900 (4.6)	330,000 (9.1)	2,100 (8.3)	1,320 (7.7)
F1-2233-4	6	14,100 (5.2)	50,300 (4.6)	255,000 (7.3)	1,250 (8.0)	886 (7.4)

[a]All samples ground to less than 500 micrometers.

Full interpretation of these data will be made after the detailed mineralogy-petrology data become available. Preliminary information regarding the mineralogy of these samples is as follows: sample G1-1436 is highly zeolitized (65-85 percent clinoptilolite); samples G1-1883 and G1-1982 are devitrified tuffs that contain only alkali feldspars and quartz and/or cristobalite; sample G1-2233 contains moderate amounts of clinoptilolite (20 to 40 percent) and mordenite (15 to 30 percent); cursory examination of the information confirms the trends of sorption with mineralogy that have been noted previously.

Crushed-Rock Columns

The gradual elution of ^{85}Sr and ^{137}Cs from the first crushed tuff JA-18 column is continuing. Because this column had exhibited an unusual, possibly anomalous sharp peak containing 9 percent of the total activity, a second JA-18 column was started. Eluate samples from the first 150 days have shown no ^{85}Sr or ^{137}Cs activity, and samples taken since that time are being counted.

Elution of the five columns recently started with crushed tuff from USW-G1 cores at depths of 1,292, 1,883 (two cores), 1,982, and 3,658 feet is continuing. The flow rates from the columns are 0.90 to 1.01 milliliters per day.

Radionuclide Sorption Experiments Using Solid Rock Cores

Two cores of YM-49 (zeolitized) tuff were cast in epoxy. One core, YM-49-b, was cast with stainless steel endcaps that had been sand-blasted to help the epoxy adhere to the steel. The other core, YM-49-c, was cast with stainless steel end caps which have grooves cut on the perimeter for the same purpose. Water from Well J-13 which had been pretreated with YM-49 tuff was passed through the columns for about six weeks at a pressure of 200 psi without confining pressure to pretreat the rock with the water. By the end of this period core YM-49-b had developed a leak between the epoxy and the end cap. The remaining cores will be loaded with ^{237}Pu and ^{239}Pu to examine the migration of plutonium.

A new method of encasing permeable rock with epoxy for use in a low-pressure chromatography apparatus is being developed. The advantage of this technique is that the columns can be run on a laboratory bench top using a peristaltic pump, thus making it more convenient to run numerous solid-rock columns simultaneously. Two cores from the USW-G1 hole, G1-1982 (partially welded Prow Pass member) and G1-2901 (welded Tram member containing apparently filled fractures), were encased in epoxy with a 1.5 centimeters-outside-diameter glass jacket. Water flow was achieved with a peristaltic pump. The G1-2901 core is highly fractured and thus requires very little pressure to attain sufficient flow. The G1-1982 core, however, contains no fractures and therefore requires a high pressure on the manifold tubing to achieve water flow through the core, which may reduce the lifetime of the tubing. A stable flow rate of about one milliliter per day through each core was achieved by adjusting the pump speed and individual manifold tubing pressures. The cores were equilibrated with pretreated groundwater; after about four weeks, cracks were observed in the glass jackets of both cores. The occurrence of cracks in the glass jackets was surprising since X-ray diffraction results had not shown high concentrations of clays in these cores. It is not clear whether the cracking is due to swelling in the rock or the epoxy; however, rapid swelling was observed in some regions of G1-1982 tuff disks when they were treated with groundwater. This suggests the presence of clays like montmorillonite. As a result, glass will no longer be used as a material for encasing rock cores. Plexiglas has been chosen as an alternative material.

A core of G1-1982 was sealed into a Plexiglas cylinder with the ends machined to 15 millimeters outside diameter for use with the low-pressure column system. After treatment with groundwater for two weeks, the column was loaded with a tritium spike to measure the free column volume and the dispersion. After four weeks of water flow, the Plexiglas has shown no signs of damage. A flow rate of 1.0 milliliters per day was established in another F1-1982 core with a peristaltic pump. This flow rate is in good agreement with a value of 0.8 milliliters per day predicted from the measured permeability of another F1-1982 core for a pressure of 50 psi.

Sample Preparation and Characterization

A laboratory has been set up to make thin sections of tuff samples that have been used in experiments with radioisotopes. This will enable us to investigate phenomena, such as mineral alteration, which could occur during the course of an experiment.

The laboratory will also be used to remove 10-micrometer increments from the surfaces of wafers made from tuff to study diffusion of nuclides into the rock. Tests on tuffs from USW-G1 are in progress to determine the degree of retention of the fluids used in making wafers, thin sections, etc. A series of desorption measurements are also in progress with the same tuffs and the isotopes ^{85}Sr, ^{137}Cs, ^{133}Ba, ^{141}Ce, and ^{152}Eu and fluids such as kerosene, Pella oil, and ethylene glycol. Once it is ascertained that the rock is not being contaminated by fluids during sample preparation and that solvents will not desorb or otherwise "move" activity on the wafer, the diffusion studies will begin.

Tuff Permeability Measurements

The permeability as a function of effective confining pressure (confining pressure minus pore pressure) was measured for three tuff samples, one from the USW-G1 hole and two from G-Tunnel. The first G-Tunnel sample was from hole U12G-RNM-9 in the HF-23 area. It was made from a section 0.8-1.0-foot from the tunnel wall and was cored near the parting plane (labeled NF). The second G-Tunnel sample was made from a section (16.2 to 17.5 feet) of tuff from the same hole, was cored parallel to the original core, and contained only matrix material (labeled PC). Sample G1-1982 is extensively welded, while the G-Tunnel samples show very little welding. Figure 7 shows the results for sample F1-1982. The data are fit quite well by the equation

$$k = 5.34\ 10^{-18}/(1 + 12.55P_e)^{0.238}$$

where k is the permeabiity in square meters and P_e, the effective confining pressure in megapascal (MPa). The data for the two G-Tunnel samples are shown in Figures 8 and 9. These data could not be well fit with the above equation.

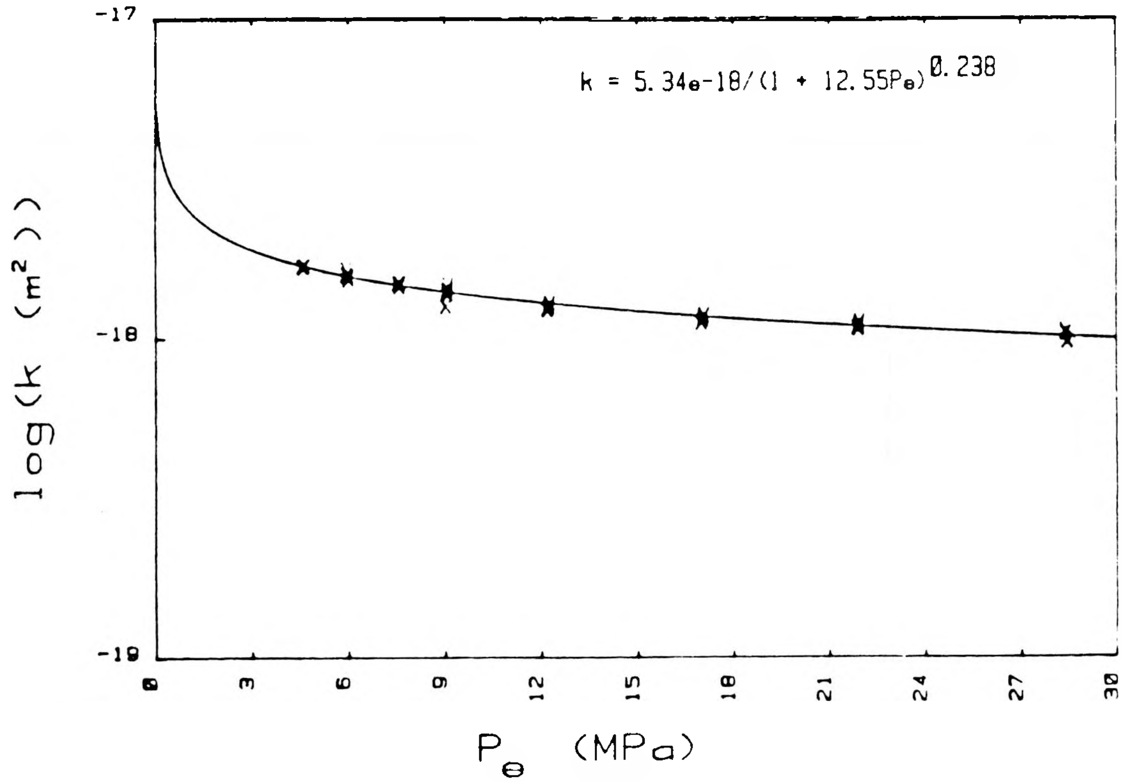

Figure 7. Permeability of tuff sample USW-G1 1982 as a function of effective confining pressure.

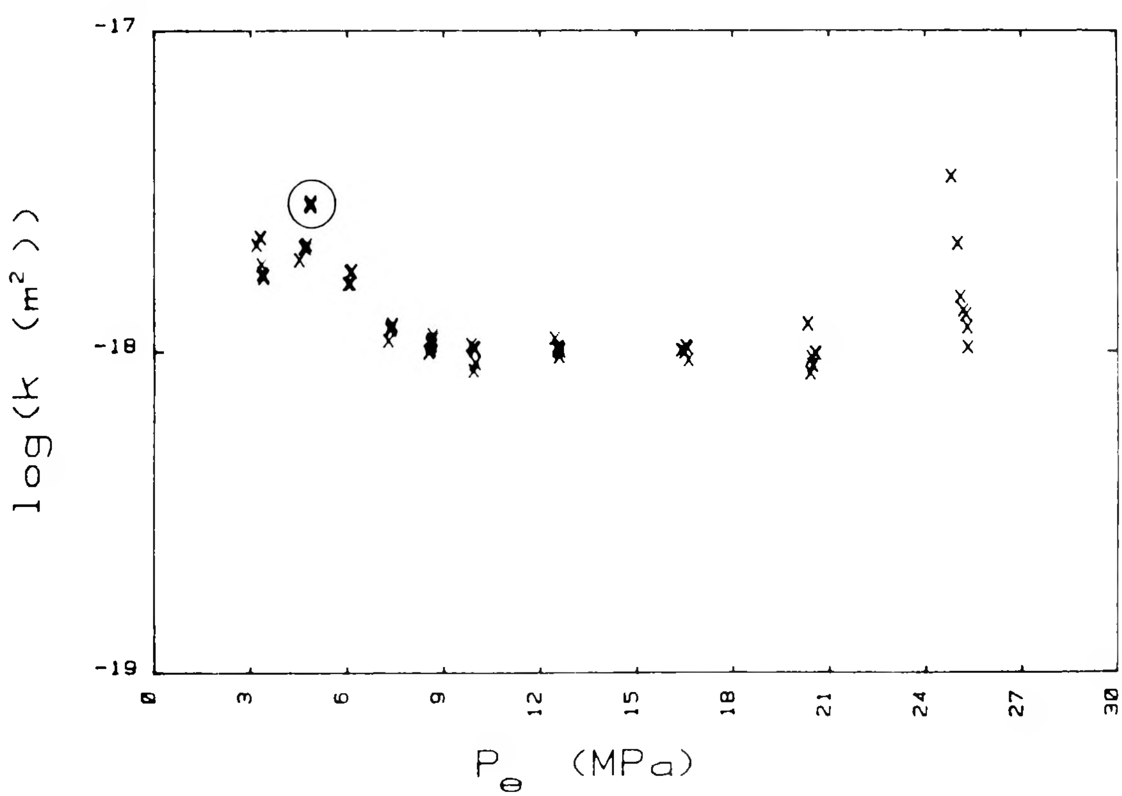

Figure 8. Permeability of tuff sample U12G-RNM9, 0.8-1.0, NF. The sample was cored near the parting plane fracture.

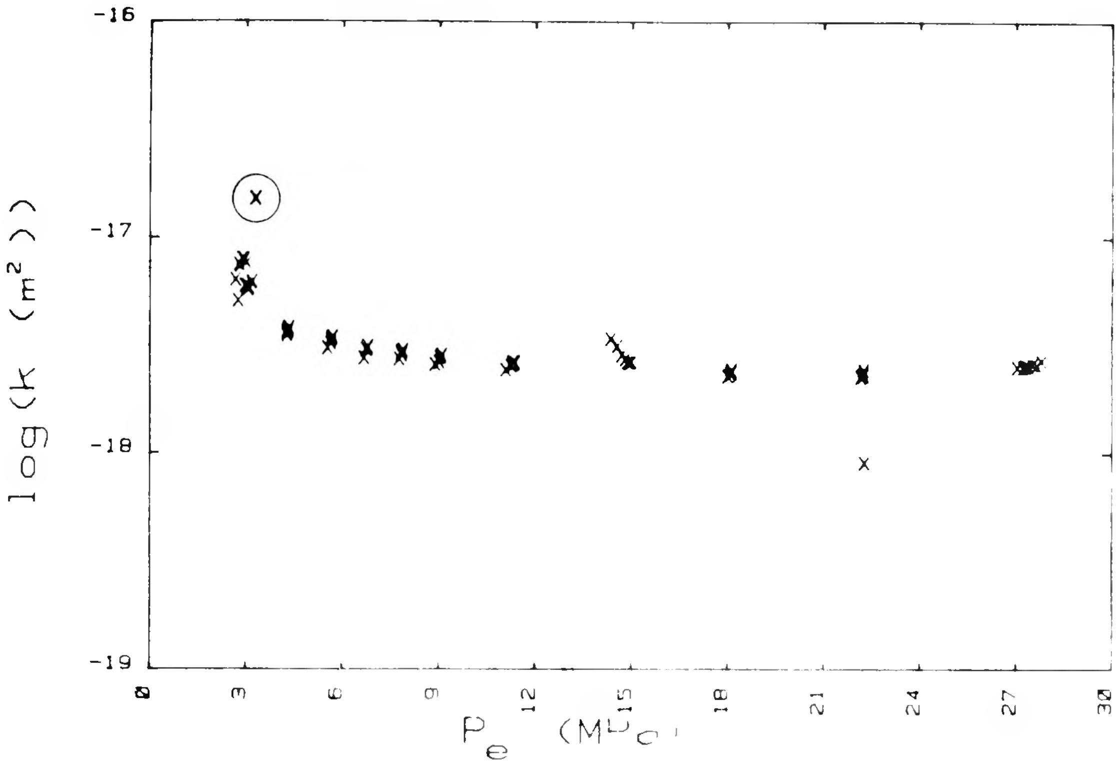

Figure 9. Permeability of tuff sample U12G-RNM9, 16.2-17.5, PC. The sample contains matrix material only. It was cored parallel to the axis.

The data for the first sample (U12G, RNM9, 0.8-1.0, NF) are anomalously high at 25 MPa. This was caused by attempting to measure the permeability before the porosity of the rock had completely adjusted to the high P_e. In both the G-Tunnel samples permeability measurements were initially made at low P_e (3-4 MPa). These data are circled. The pressure was then raised to its maximum value, and the remaining data collected with decreasing P_e. In both cases there was a small but definite permanent decrease in permeability caused by pressurization of the rock.

Two features of the data for the G-Tunnel samples are striking. First, the permeability is quite low, especially considering that the porosity of these rocks is probably quite high (20 to 40 percent). Secondly, the permeability is relatively insensitive to P_e. Granites show a two-to-three order-of-magnitude variation in permeability over the same range of P_e.

The primary difference between the two G-Tunnel samples is that the first (Figure 8) was cored very near a parting plane. Examination of thin sections of the material near this parting plane showed a zone 5- to 7-millimeters wide adjacent to the plane that had much lower porosity than the remainder of the rock. If the difference in permeability of these two samples is due solely to the presence of this low-porosity material, it would imply that the low-porosity zone has much lower permeability than the bulk rock since it constitutes only a small part of the core.

Characterization of Plutonium Oxidation States

Work with emphasis on the preparation of trace amounts of plutonium in various oxidation states and the identification of different oxidation states by chemical separation has been started. Work on the chemical separation of plutonium oxidation states from weakly acidic solutions has been started.

Control of Eh in the Laboratory

A glass manifold to purify the argon gas used to sparge the potentiostat cell was built. Included in the system are a chromous-perchlorate, zinc-amalgam scrubber, and an acid scrubber. A 3-millimeter porous Vycor disc that served as a bridge in the potentiostat was not large enough a conductor. It was replaced with an 8-millimeter tube of porous unfired Vycor that works well.

A Vacuum/Atmospheres controlled-inert-atmosphere glovebox and a Dri-Train purification system have been received and are being installed in the Alpha Wing of the Radiochemistry Laboratory. A two-month delay in the receipt of the Los Alamos National Laboratory-approved hydrogen gas manifold needed for the purification system will unfortunately delay the startup of the glovebox. This glovebox will be used for experiments pertaining to Eh buffer systems and other methods of producing and measuring low-oxygen-fugacity water systems.

The organic dye Indigo Carmine (at 10^{-5} M) appears promising as an Eh buffer. After reduction with the potentiostat, the solution was bottled under argon. No change was noted over several hours. In an earlier study, ferrous ortho-phenanthrate was successfully oxidized and reduced by the potentiostat. In an attempt to reduce Nile Blue at 10^{-5} M, a precipitation took place, probably because of the low true solubility ($<10^{-7}$ M) of the dye.

Possible Inorganic Eh Moderators

Work has begun on the development of inorganic Eh buffers or moderators for use in actinide solubility determinations. Couples consisting of certain complexes of Os(II) may have the required potentials, stabilities, and kinetic properties. Current work involves the Os(II-III)(bipy) couple, where bipy stands for 2,2′-dipyridyl. The potential is reported to be 0.878 volt. This is such that the solubility equilibrium for plutonium is expected to be

$$PuO_2 \cdot nH_2O + Os(bipy)_3{}^{3+} = PuO_2 + Os(bipy)_3{}^{2+} + nH_2O.$$

Other couples with lower potentials will be required for other important solubility equilibria.

The compound $(Os(bipy)_3)(ClO_4)_2 \cdot 2H_2O$ was prepared from $(NH_4)_2OsCl_6$ by the method of Bailar. A spectomphotometric redox titration method was developed for assaying the compound. In this method aliquots containing 6 to 7 milligrams of the compound are diluted to about 140 milliliters and titrated in a special absorption cell with a 2-centimeter optical path. The titrant is a standardized Ce(IV) solution (about 0.05 N) delivered from a micrometer syringe; the wavelength used is 479 nm. The average precision of the method is ± 0.5 percent based on five determinations.

Three determinations of the equivalent weight of two separate preparations gave widely varying results, ranging from 978 to 1,210 grams per equivalent. It was thus necessary to purify the compound by recrystallization from water. This was somewhat inconvenient due to the low solubility of the material (about 1.55 grams per liter based on our measurements). The equivalent weights found for two separate batches of recrystallized, air-dried material were both

889 ± 13 grams per equivalent; the uncertainty is due primarily to the error associated with weighing 30-milligram samples. The molecular weight of (Os (bipy)$_3$)(ClO_4)$_2$·$2H_2O$ is 894, so the preparations are probably of satisfactory purity.

The absorption spectrum of the compound was determined with a Cary Model 14 spectrophotometer. The extinction coefficients of the principal features are listed in Table 8. The uncertainties are probably all about 0.03 x 10^4 $M^{-1}cm^{-1}$.

Solutions of Os(bipy)$_3^{2+}$ are readily oxidized to the +3 state by chlorine gas. The spectrum of a neutral solution prepared in this way is summarized in Table 9. The spectra of solutions of Os(III) prepared by the titration of the Os(II) complex with Ce(IV) in 0.2-0.3 M H_2SO_4 were essentially the same as that indicated in Table 9.

Preliminary experiments to determine the stability of the Os(II) nd Os(III) complexes were as follows. A sample of the Os(II) complex was refluxed with 6 M NaCl for 18 hours. After this rather drastic treatment, the spectrum was found to be essentially unchanged. The Os(III) complex was refluxed for one hour with 6 M NaCl; this gave a solution with a spectrum completely different from that of the starting material. However, when the solution was reduced with a small amount of Fe(II), the characteristic spectrum of Os(bipy)$_3^{2+}$ was restored. In another experiment the Os(III) complex was allowed to stand in water for about 42 hours. This resulted in a 4.9 percent decrease in the absorbance at the 550 nanometer peak and small increases in the relative absorbances at the other peaks. Thus, the decomposition rate of Os(bipy)$_3^{3+}$ is at least 2.8 percent per day at room temperature. When the same solution was heated to 90° C for 1.5 hours, evidence for significant further decompositon was observed. The absorbance at 550 nanometers decreased an additional 8 percent.

Further characterization of this tris bipyridyl system will involve studies of the electrochemical behavior when a potentiostat is used and of the kinetic behavior with trace concentrations of plutonium. Other future work will be the preparation of complexes with lower oxidation potentials.

Measurement of Dissolved Oxygen and Eh in Water From Well J-13

To understand some of the redox conditions in a tuff groundwater system, attempts were made to measure dissolved oxygen and the Eh in the water from Well J-13 before it contacted the atmosphere. Most of the measurements were made at the well head in a flow-cell (Sensorex) before the water contacted the atmosphere. A few, quickly made under stagnant conditions in a deep beaker that had been filled from the bottom directly from the well, gave essentially the same results.

Dissolved oxygen measurements were made with a Yellow Springs Instrument Company Model 54A dissolved oxygen meter having a Model 5750 probe. The probe has a Clark-type membrane covering a polarographic sensor. The instrument was calibrated in air-saturated water (6.4 ppm oxygen at 33° C at an elevation of 3,318 feet) according to the manufacturer's recommendation. Measurements of

TABLE 8

SPECTRUM OF $(Os(bipy)_3)(ClO_4)_2.2H_2$ IN WATER AT 23^{o} C

Feature	Valley	Peak	Shoulder	Valley	Peak	Valley	Peak	Valley	Peak
λ(nm)	347	366	385	409	435	459	479	543	589
$\varepsilon x10^{-4}$ $(M^{-1}cm^{-1})$	0.84	1.06	0.99	0.87	1.26	1.18	1.34	0.31	0.37

TABLE 9

SPECTRUM OF $(Os(bipy)_3)Cl(ClO_4)_2$ IN WATER AT 23^{o} C

Feature	Peak	Peak	Valley	Peak
λ(nm)	424	455	470	550
$\varepsilon(M^{-1}cm^{-1})$	820	420	260	650

5.7 ± 0.2 ppm oxygen were made in the water flowing through the flow cell and 5.6 ± 0.4 ppm in the stagnant water.

Two commercial platinum-reference electrode pairs (Beckman with a calomel reference and Markson with a silver-silver chloride reference) were used for the potential measurements. The electrodes were new and were not checked with an Eh buffer until after the measurements at the well. The subsequent check indicated that the electrodes operated satisfactorily in a ZoBell buffer. The apparent Eh of water from the well in either the flowing or stagnant system is 350 ± 50 millivolts. The measured value for air-saturated water at the well was 340 ± 50 millivolts in agreement with other observations for air-saturated groundwaters. The pH of the water was 7.4.

In related work, similar measurements were made with alluvial groundwater from the RNM-2S site at the NTS. A dissolved oxygen content of 5.3 ppm and an apparent Eh of 330 millivolts were measured.

The problems in making and interpreting Eh measurements and in using Eh as an operational parameter are well known. Indeed, the response of our electrodes is close to the response expected for a platinum-oxide coated electrode which is dependent on pH rather than redox conditions. The electrodes most probably did not respond to changes in dissolved oxygen, nor are the concentrations of other couples (total Fe $< x\ 10^{-7}$ M) sufficiently high to dominate response at the electrode. Thus, extreme caution in interpreting these and other electrode potential measurements is recommended, particularly above +350 millivolts and below -200 millivolts in the pH region between 6 and 8.5.

Since the time of the above measurements in September 1980, it was learned that significant concentrations of dissolved oxygen levels were measured at tuffaceous Wells J-12 and J-13 (7 and 6 ppm, respectively) as well as in some other deep waters. Dissolved oxygen probes, Hatch kits, and Winkler titrations were used in these investigations.

Thus, there are two independent investigations that at least hint that conditions in a tuff groundwater system may not be strongly reducing. Although the investigations indicate that oxygen is present, they do not indicate whether the oxygen-water couple is in equilibrium with other redox couples that might be present in trace concentrations.

1.3.2.2.2 Mineralogy/Petrology

Objective: To determine the major mineral phases present in strata encountered in the drilling exploration program and to determine their relative abundances, textural relationships, chemical properties, and stability relations where appropriate.

Petrographic Characterization of USW-G1 Core

A summary of significant primary and secondary features defined during the reporting period for USW-G1 core samples within the 1,190-3,500-foot depth range is given below. Although the results are preliminary and in some cases require additional verification, they provide a timely description of the general petrographic characteristics of the USW-G1 core. The supporting data will be available during the forthcoming quarter.

The three major primary components of tuffs are glass, rock fragments, and crystals which are termed the vitric, lithic, and crystal components, respectively. The crystal component, which has been thoroughly characterized, consists of felsic, mafic, oxide, and accessory crystals. Efforts have concentrated on determining the relative proportion of felsic crystals (quartz, alkali feldspar, and plagioclase) and the presence of accessory crystals (allanite, zircon, sphene, and apatite) because they can be used, in conjunction with stratigraphic data to identify the major tuff units exposed at Yucca Mountain.

Except for a few anomalous samples, both the relative proportion of the largest felsic crystals and the accessory crystals present are one of the most distinct and consistent characteristics of each USW-G1 tuff unit (Table 10). The crystal contents, combined with the proportion of lithic fragments, indicate a significant petrographic difference among samples from the upper versus the lower portion of the Tram tuff (Table 10). The requirement for a rapid and accurate estimate of relative felsic crystal proportions necessitated development of a procedure utilizing microprobe analysis that yields relative proportions of the largest felsic crystals.

The X-ray diffraction (XRD) analyses of over 150 samples of USW-G1 core were completed this quarter and, together with bulk density measurements and petrographic examinations, have resulted in definitions of complex secondary mineralogic zones.

TABLE 10

SUMMARY OF DEFINITIVE PRIMARY FEATURES
OF USW-G1 CORE BETWEEN 1,190-3,500 FEET IN DEPTH

Unit	Depth (ft)	Distinctive Primary Features
Topopah Springs	1,191-1,426	Crystal- and lithic-poor; dominant felsic crystals plagioclase
Calico Hills	1,426-1,802	Zircon common im matrix; large felsic cyrstals quartz-rich
Prow Pass	1,802-2,173	Large felsic crystals; quartz-poor
Bullfrog	2,173-2,639	Large felsic crystals; quartz-poor at base, but proportion of quartz and total felsic crystal contents increase upward
Upper Tram	2,639-3,083[a]	Large felsic crystals; quartz-rich
Lower Tram	3,083[a]-3,558	Large felsic crystals; quartz-rich; lithic clasts abundant; allanite common

[a]Depth of lithologic change observed by the USGS.

Densely-welded zones which have crystallized principally to quartz and alkali feldspar with lesser cristobalite, have been recognized in the Prow Pass (1,867-1,976 feet), Bullfrog (2,318-2,547 feet), and Tram tuffs (2,790-3,000 feet). Post-welding alteration of these units has produced minor (generally less than 5 percent each) clay, calcite, and chlorite. The Topopah Springs tuff contains a very thick, densely welded zone between 280-1,342 feet that includes a dense, glassy vitrophyre between 1,287-1,342 feet. The complex mineral assemblage within the Topopah Springs tuff has not been completely characterized yet for the USW-G1 core. All depth intervals were established by combining the petrographic results from Los Alamos with those of the USGS.

The second type of secondary mineral assemblage is produced in response to groundwater interaction in permeable (generally nonwelded) tuff. In marine tuffs, the felsic secondary assemblage varies systematically with increasing depth as follows: opal + glass (zone I); clinoptilolite + mordenite ± opal and/or cristobalite (zone II); analcime (zone III); and albite (zone IV). The depth zoning observed for felsic secondary minerals in nonwelded tuff of USW-G1 core is broadly similar to the sequence observed in marine tuffs. Glass has not been recognized below 1,400-feet in depth, and opal has not been recognized below 2,290 feet. Mordenite is found only between 2,083-2,698 feet, and clinoptilolite is not generally present below 3,914-feet depth. Analcime is found only below 3,001 feet, and secondary albite has been identified below, 4,000-feet depth. The recognition of depth zones for the USW-G1 core provides an important framework for predicting secondary mineral assemblages in Yucca Mountain tuffs.

The nature of exsolved cubic and rhombohedral phases in Fe-Ti oxides is determined by the prevalent oxygen fugacity during tuff recrystallization. In USW-G1 tuffs, the degree of oxidation of the oxides is closely related to the original porosity of the tuff unit. Oxides in welded zones exhibit low degrees of oxidation, whereas those in orginally porous nonwelded zones exhibit maximum degrees of oxidation. The Fe-Ti oxides may reflect prevalent high oxygen fugacity (i.e., high positive Eh) conditions during alternation.

Opal has been recognized optically in nearly all samples from nonwelded tuff within the 1,819-2,290-feet depth interval of the Prow Pass and upper Bullfrog tuff. Opal is particularly abundant in the Prow Pass and replaces shards and pumice and perlite in both units. However, the amount that might replace the fine-grained groundmass within these or any other samples is unknown because the opal and cristobalite (or mixtures of the two) cannot be distinguished in ordinary tuffs by XRD. Opal and cristobalite may exhibit markedly different responses to thermal stress in a waste repository. Cristobalite is an anhydrous crystalline silica phase with a relatively high thermal conductivity, whereas opal is an amorphous to partly crystalline hydrous silica phase that might exhibit a lower thermal conductivity and also could fracture upon dehydration.

Zeolite Stablity Studies

A final report on scanning electron microscope (SEM) investigations of zeolites was received from the contractor. Zeolite minerals could not be distinguished by cathodoluminescence in the SEM. Numerous high-quality SEM photographs of zeolite mineral morphologies resulted from his work; they will be used in subsequent reports.

Four samples of differing mineralogy were selected for investigation of dehydration phenomena by use of an isopiestic balance developed at Los Alamos. This balance will measure water weight gain as a function of water vapor pressure and temperature. This will quantify the dehydration reactions of clinoptilolite and analcime and allow prediction of mechanical shrinkage effects which might take place on drying.

A draft of a report entitled "Review of the Thermal Stability and Ion Exchange Properties of the Zeolite Minerals Clinoptilolite, Mordenite, and Analcime: Applications to Radioactive Waste Isolation in Silicic Tuff" has been prepared and is currently undergoing review. The report reviews mineralogy, occurrence, chemical properties, and thermal stability of these minerals. The major conclusion of the report is the recognition of potential mineralogical reactions among zeolite phases at relatively low temperatures. These reactions may limit the minimum temperature rise in zeolitized horizons adjacent to densely welded zeolite-free zones which are currently viewed as potential emplacement horizons. In particular, the reaction of clinoptilolite to yield analcime, silica, and water may begin in these rocks as low as 95° C. Because these reactions will likely open fractures due to a net volume loss as well as release water, a tentative maximum temperature for clinoptilolite zones is recommended to be about 85° C.

1.3.3 GEOLOGIC CHARACTERIZATION

Objective: To determine the geologic and hydrologic characteristics of candidate repository locations and to evaluate the feasibility of developing a mined repository.

1.3.3.1 Geologic Investigations

Objective: To locate and characterize rock masses on or near the NTS to determine their suitability for hosting a nuclear waste repository.

Shale/Argillite

The report, "Geology of the Syncline Ridge Area Related to Nuclear Waste Disposal, Nevada Test Site, Nye County, Nevada" by D. L. Hoover and J. N. Morrison, has been distributed as USGS Open-File Report 80-942.

Tuff

The report, "Preliminary Geologic Results From Borehole USW-G1, Yucca Mountain, Nevada Test Site" by R. W. Spengler and others, is in preparation.

Drill hole USW-H1 was completed. Geologic contacts in USW-H1 are, in general, 80 feet deeper than in USW-G1. With corrections for dip and collar evaluations, this offset in contacts can be explained by regional dip, although the possibility of a minor fault less than a few tens of feet cannot be eliminated.

Drill hole USW-VH1 in Crater Flat was completed to a total depth of 2,500 feet.

Continued petrographic studies of Crater Flat and older tuffs in drill hole USW-G1 in an attempt to correlate them with pre-Crater Flat tuff units in Water Well J-12 at Fortymile Canyon. Petrographic collaboration has also been established with R. G. Warren of G-4, Los Alamos National Laboratory.

No new evidence is available to alter or revise our estimate of approximately 10,000 feet to basement rocks under Yucca Mountain which was reported in the last quarterly report.

The geology of the southwest quadrant of the NTS (nine 7 1/2-minute quadrangles) compiled by Florian Maldonado has been completed and is in review.

Granitic Rocks

The report, "Geology of the Twinridge Pluton Area, Nevada Test Site, Nevada" by Florian Maldonado, has been reviewed and is awaiting director's approval before being released as an open-file report.

1.3.3.2 Geophysical Investigations

Objective: To determine the subsurface distribution and configuration of physical properties on or near the NTS.

Electromagnetism and Geomagnetism

Yucca Mountain, Calico Hills, and Wahmonie--The three reports listed in the last quarterly report are in the process of revision following Branch review.

Regional Studies--Work on the hydrologic support studies in the Amargosa area was temporarily suspended.

Magnetotelluric fieldwork performed under contract was completed, with 15 soundings being obtained at or near the seismic network stations on or near the NTS. The sounding curves and one-dimensional inversions have been supplied, although the final report has not been delivered. The remote reference technique was used to attempt to obtain better data than had been obtained in the past.

The data supplied appear to be excellent and are a significant improvement over earlier soundings data. Soundings near station EPN, Echo Park, and GLR, Groom Lake Road, show a thick high-resistivity crust consistent with known negative P delays near the Echo Peak station and the presence of a granitic intrusive near station GLR. The sounding which showed a very conductive body nearest to the surface was near station AMR, Amargosa, California.

Seismicity

An in-house seismic planning conference was held in Denver on October 30-31 which was attended by about 20 seismic and structural geologic experts. The main conclusions of the conference are that seismic reflection data are needed over the block defined by Fortymile Wash on the east, Bare Mountain on the west, the Timber Mountain caldera on the north, and Lathrop Wells on the south. Much of the work will have to be contracted commercially over a two-year period (FY 1982 and FY 1983).

Interpretation of the five previous refraction profiles at Yucca Mountain, Calico Hills, and Wahmonie were completed and a report was started covering those data. Steps have also been taken to convert the 100 portable seismometers used in the P-delay studies last April to begin taping on signal from some distant point such as the NTS Control Center.

Gravity

Data from 72 gravity stations were obtained in November in the Bare Mountain, Crater Flat, and southern Yucca Mountain areas; these data will increase the detail of the residual gravity map of Yucca Mountain and vicinity. This residual map, reduced to a density of 2.0 grams per cubic centimeter and incorporating Airy-Heiskanen isostatic corrections, indicates a wide north-south trending band of low gravity values embracing the entire area between Fortymile Wash and Bare Mountain. Preliminary interpretation indicates at least 10,000 feet of tuff filling either an ancient caldera segment extending south from the Timber Mountain complex or a large rift or graben in the pre-Tertiary rocks beneath both Yucca Mountain and Crater Flat.

Regional isostatic residual maps were compiled of the four $1^{\circ} \times 2^{\circ}$ sheets which incorporate and surround the southwest NTS (Death Valley, Las Vegas, Caliente, and Goldfield). These maps have the effect of deep crustal structures removed from them and thus largely reflect density distributions within the upper 10 kilometers of the earth's crust.

Separate reports on the interpretations of gravity data at Calico Hills and Wahmonie were completed. The Calico Hills report was approved by both DOE and the Director, USGS, in December for release. The Wahmonie report is through technical review and is in final typing.

Magnetism

Magnetic properties of the geologic units in drill hole USW-VH1, which was completed to a depth of 2,500 feet during the quarter, appear to be consistent with the aeromagnetic and ground magnetic anomalies found in the area. USW-VH1 was positioned on a broad regional aeromagnetic high of 380 gammas measured 400 feet above the surface, and a local ground magnetic high of 150 gammas which is superimposed on the regional high. The local high is interpreted as the effect of the north edge of the basalt flow that was found to have a depth of 80 feet, thickness of 200 feet, and reversed magnetic polarity. The regional high is interpreted as the effects of the Topopah Spring and Crater Flat tuffs that were found to have a minimum total thickness of 1,500 feet. Plans are being made to study the properties of drill core, and thereby provide the values that are needed to compute the magnetic anomalies arising from the penetrated units. The small hole diameter is causing some difficulty in arranging for susceptibility and magnetometer logs of the USW-VH1 hole.

Heat Flow

A meeting was held on December 16 between personnel of the USGS Water Resources Division and personnel of Geothermal Studies Project to make plans for joint investigations of the Yucca Mountain area. About 40 thermal conductivity measurements were made on waxed samples of the core from the USW-G1 hole between 2,810 and 6,000 feet. No systematic variations were apparent in that depth range, and these data tend to confirm previously reported heat flow measurements.

Borehole Geophysics

Theoretical models (layered earth, two-dimensional, and three-dimensional) have been developed for modeling hole-to-surface resistivity data. Residual models (subtraction of theoretical layered earth response from field data) clearly define three linear resistivity anomalies. The X-ray analysis of samples from drill holes UE25a-4, UE25a-5, UE25a-6, and UE25a-7 has been completed. A comprehensive reinterpretation of borehole geophysical data from drill holes UE25a-1, -4, -5, -6, and -7 has been started.

1.3.3.3 Hydrologic Investigations

Objective: To determine the present and past hydrologic regimes of the NTS and surrounding area as a basis for predicting future hydrologic regimes and the potential for hydrologic transport of nuclear wastes to the biosphere.

Present Hydrology

Data resulting from the hydraulic testing of well USW-G1 have been analyzed; they indicate that the formations have low hydraulic conductivity.

Well USW-H1 has been drilled to its total depth of 6,000 feet and hydraulic testing was continuing at the end of the quarter. Preliminary results indicate that the rocks are moderately conductive above the depth of about 2,300 feet, but below that depth they appear to have a very low hydraulic conductivity.

Paleohydrology

Results of complete wetting and drying cycle experiments for smectite clay basal spacing diagnostics have been added to the compilation of X-ray diffraction data on bulk alluvial fines and less than 1-micrometer clay fractions. Samples are from 22 intervals between 525 and 1,100 feet in the U11g borehole north of Frenchman Flat. Chemical analyses of major oxides in less than 5-micrometer fractions have been completed. These data suggest a subtle mineralogic change about 200 feet above the present water table. Evaluation of the nature of this change is being pursued, and a draft of a data compilation report has begun. Revision of the draft manuscript describing the Amargosa complex mixed-layer kerolite/stevensite formed in the discharge area of the NTS groundwater system is nearly complete. The last phase of rat midden fieldwork has been satisfactorily concluded. A sufficient number of sites were located in the Ash Meadows area to yield macrofossil assemblages believed to span the entire sequence of climatic regimes from the full glacial to the early Holocene, or from roughly 17,000 to 8,000 years before present.

Laboratory processing was completed on all samples chosen for analysis in this project. Completion of the last four samples is targeted for the end of the third week in January, and all samples for radiocarbon dating have been submitted. Final dating results are due from the laboratories by the middle of March.

An additional 15 radiocarbon dates were received during this quarter; this brings the total number of final dates to 40. These dates provide one of the most elaborate paleoenvironmental records for the middle-Wisconsin interstadial and the full glacial stages in the arid western United States.

Solute-Transport Model

A manuscript on the two-dimensional flow model for the NTS and vicinity has been completed and is in review. The development of procedures to predict transport of radionuclides that was begun during the second quarter of FY 1980 was continued.

1.3.3.4 Tectonics, Seismicity, Volcanism

Objective: To assess the potential for faulting, damaging earthquakes, volcanic activity, and accelerated erosion to affect long-term repository performance.

Tectonics

Work was continued on geomorphology and alluvium in the Crater Flat-Yucca Mountain area and has shown that the east flank of Bare Mountain, though not exhibiting any youthful (Holocene) fault scarps, does have geomorphic evidence, such as steep fans, which indicates that it has been an area of persistent uplift during at least early and middle Quaternary time.

A zircon fission-track age was received on an ash exposed near the middle of the Amargosa Valley, confirming that the containing lake beds are about 3 million years old. This is regarded as evidence that much of the Amargosa Valley has been relatively stable during the Quaternary period.

Mapping was begun of the alluvium in the northeastern part of the Big Dune and southwestern part of the Bare Mountain quadrangles.

Volcanism

During the quarter, drill hole USW-VH1 was begun and core drilling was completed in December at a depth of 2,500 feet. The hole is located in east-central Crater Flat about 10 kilometers southwest of the proposed Yucca Mountain site area and was drilled to explore an aeromagnetic anomaly, to look for volcanic rocks older than nearby 3.75 million-year-old basalts, and to provide a hydrologic data point in a large area without any information. Very preliminary results indicate the following section was penetrated:

Unit	Depth (Feet)
Alluvium	0- 95
Basalt	95- 275
Alluvium	275- 550
Tiva Canyon Member	550- 860
Bedded tuff	860- 870
Topopah Spring Member	870-1,765
Calico tuffs	1,765- ?
Crater Flat Tuff	? -2,500

Since no unusual young volcanic rocks were found, the positive anomaly must be from the Topopah Spring Member and underlying tuffs.

Several more significant dates were received on volcanic rocks. Rechecks of two basalt samples confirmed the 1.1-million-year age of the northernmost vent in Crater Flat and reinforced the evidence that all four centers along this rift were active at the same time. A bomb and scoriaceous basalt sample from the Lathrop Wells cinder cone gave ages of 230,000 and 300,000 years, respectively; these ages agree reasonably well with the previous ones obtained on the underlying lava of about 250,000 to 300,000 years. New dates on basalts from the eastern edge of the NTS, including one from a drill hole in Yucca Flat, gave ages of 6.3, 8.1, and 8.5 million years. These dates, together with others obtained previously, suggest additional synchronous activity at several places in the eastern NTS area. A basalt from the Black Rock flow in the Lunar Crater area north of the NTS gave an age of 570,000 years, which is somewhat older than expected.

A trachyte from north of Beatty was found to be 9.6 million years old, nearly the same as the rhyolite of Ribbon Cliff, a precursor of the Black Mountain activity which produced the Thirsty Canyon Tuff.

A dike on Bare Mountain gave an age of 13.9 million years, which is the same as lava flows at Beatty Wash which are associated with the Tram Member of the Crater Flat Tuff. The dike is one of a group that describes an arcuate pattern on Bare Mountain, concave toward Crater Flat. This pattern suggests the northern part of Crater Flat is the source area or caldera for the Tram Member.

Seismicity

Earthquakes recorded and located during the period June 1, 1980, through September 30, 1980, are plotted on Figure 10. Four clusters of events or aftershocks occurred within the boundaries of the NTS. On Pahute Mesa, two magnitude 3+ and a magnitude 4 aftershock occurred within four hours of the July 25 detonation. On August 25, several magnitude 1.5-2.5 earthquakes occurred on Pahute Mesa. The second group, on Yucca Flat, included two magnitude 3+ aftershocks that occurred within an hour of the July 31 detonation. The third group included about 18 magnitude 1.0-2.0 earthquakes that occurred in the vicinity of Frenchman Flat and the Ranger Mountains. The fourth group included about ten magnitude 0.0-2.0 earthquakes at Shoshone and Little Skull Mountain and at Jackass Flats. Approximately 50 small earthquakes ($M_L < 3.0$) were located outside the NTS during the third quarter. One earthquake occurred near the northwestern portion of Yucca Mountain, although it is poorly located. The Yucca Mountain area continues to appear largely aseismic, at least for events above the current magnitude threshold.

Geochemical Studies

Geochemical studies of basaltic rocks continued in the south-central Great Basin during the reporting period. Additional trace-element data were obtained on the basalts of Crater Flat. These data provide increased support for the previously recognized anomalous incompatible-element enrichment (Figure 11). Analyses of heavy incompatible elements (e.g., uranium and thorium) and lighter

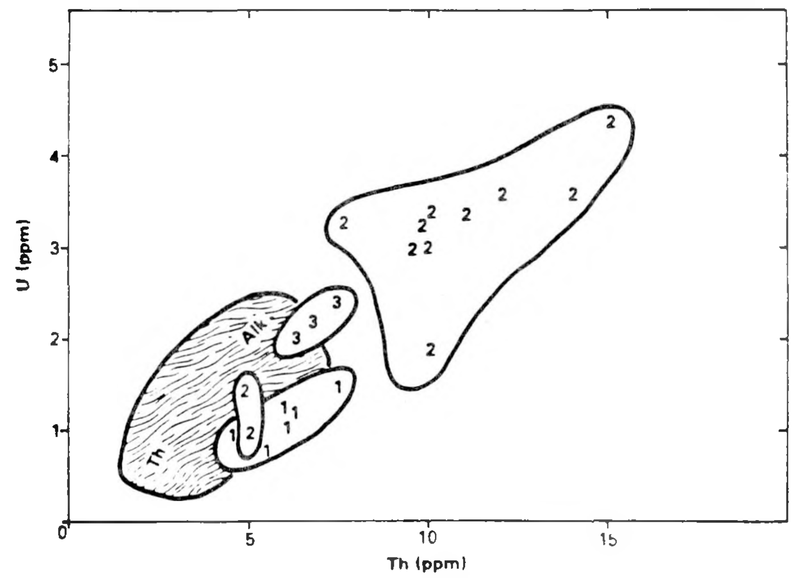

Figure 11. A plot of U vs. Th in basalts of the three volcanic cycles at Crater Flat: 1 (3.7 million years), 2 (1.1 million years), and 3 (0.3 million years). A field of common tholeiitic (Th) and alkaline (Alk) basalt data is shown for comparison.

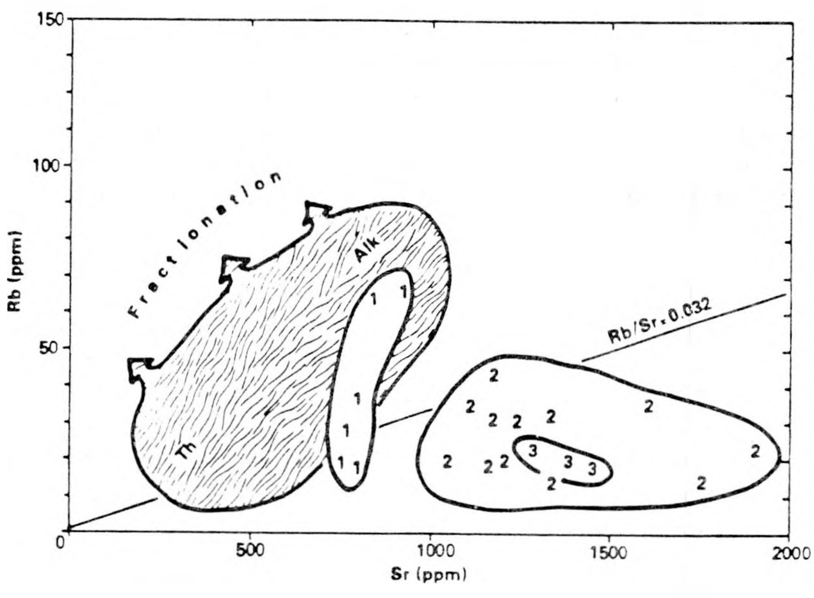

Figure 12. A plot of rubidium versus strontium in basalts of the three volcanic cycles at Crater Flat. Symbols are the same as Figure 11. An anomalously low rubidium/strontium ratio in the younger basalts of Crater Flat is discussed in the text.

incompatible elements (e.g., lanthanum and strontium) show twice the concentrations of comparable basalts from other localities throughout the world. The enrichment in strontium, along with published $^{87}Sr/^{86}Sr$ data (0.707) for the basalts of Crater flat, requires ancient rubidium enrichment in the mantle sources for these rocks. Figure 12 indicates that this requirement is not satisfied by the observed low rubidium contents in the younger basalts of Crater Flat (1.1 and 0.3 million years). The Rb/Sr ratio of 0.032 in Figure 12 is a model earth value that would lead to an $^{87}Sr/^{86}Sr$ ratio of 0.705; clearly the basalt samples that plot below the 0.032 line have lost rubidium in their present $^{87}Sr/^{86}Sr$ ratio is 0.707. This rubidium anomaly cannot be explained by fractionation. It therefore suggests a recent depletion of rubidium in the mantel source region, possibly in Late Cenozic time. The trace-element characteristics of the rocks will be compared with trace-element data from other basalt localities in the southcentral Great Basin. These rocks were prepared and submitted during the quarter for 30-element, automated instrumental neutron activation analysis.

Disruptive Event Studies

Preliminary data have been gathered for safety assessment studies of the effects of disruption of a waste repository by basaltic volcanism. Liquidus temperatures for the basalts of Crater Flat were calculated at 1210 ± 80^{o} C based on plagioclase-whole rock compositions. Dike widths of basalt dikes inferred to have fed surface eruptions are 0.6 to 5 meters; shallow conduit plugs are 10-50 meters wide. The average number of dikes for a basalt center (dikes of greater than 300 meters) is 3; measured extent ranges from 1.3 to 3.6 kilometers. Vent zone migration in the evolution of basaltic centers averages 0.7 kilometer and is predominantly from south to north for the basalts of Crater Flat. The volume of the Lathrop Wells cone is calculated at 2.5 x 10^{6} 3 cubic meters; the volume of Red Cone is 1.5 x 10^{6} cubic meters (volumes calculated as magma volumes). The percentage of fines (less than 0.06 millimeters) is estimated at 4.1 weight percent for phreatomagnatic eruptions and 1.4 weight percent for Strombolian eruptions. These data will be incorporated into the disruptive event report to be prepared during the next quarter.

1.3.3.5 Geochronology

Objective: To provide potassium-argon, fission-track, uranium-trend, and uranium-series ages on geologic samples for use in determining the history of geologic events and conditions.

Potassium-argon, uranium-series, and fission-track ages are determined for geologic samples that are suitable for one or more of the various dating techniques. Uranium-trend dating is used on alluvium and eolian samples from trenches cut in Quaternary surfaces and in altered volcanic ash deposits. The samples used for dating usually are selected or provided by the geologists that are working directly on field studies for the geologic and hydrologic investigations tasks. The uranium-series disequilibrium systematics are monitored in fracture fillings in silicic tuff samples selected from drill cores obtained from the NTS.

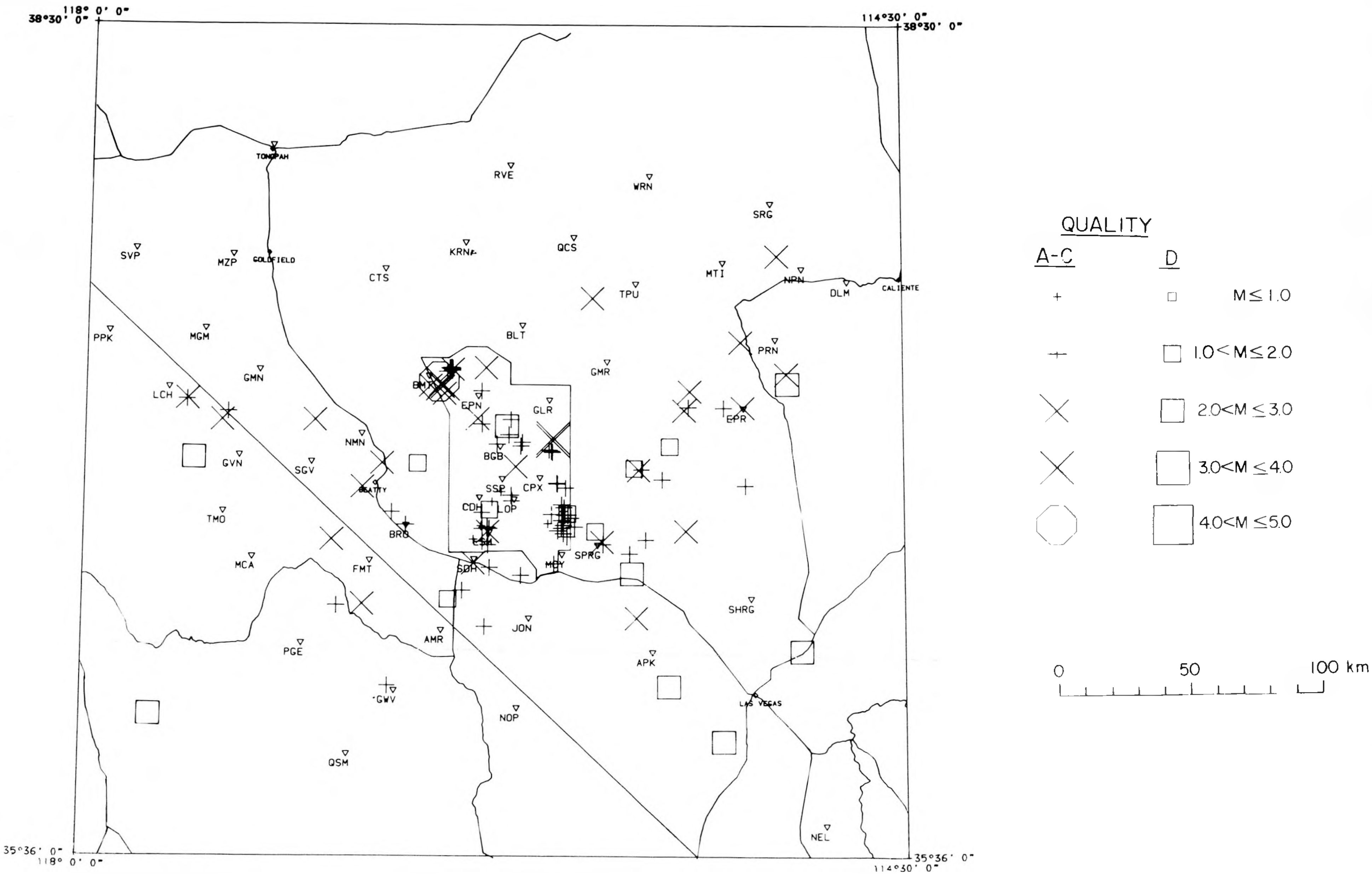

Figure 10. Locations of seismic epicenters for the period July 1, 1980 to September 30, 1980.

Potassium-Argon Dating

During the last quarter of 1980, 19 potassium-argon ages were determined for NTS samples. These ages range between 0.2 and 16.3 million years. The oldest age was obtained for a gneiss, but the age does not date the formation of the gneiss. The age does indicate that a thermal event occurred some time after 17 million years; this thermal event reset (lowered) the potassium-argon age of the muscovite in the gneiss sample. Other potassium-argon ages indicate that rhyolitic igneous activity occurred 13.9 million years ago and at various times between 10.4 and 8.9 million years ago. Basaltic volcanic activity occurred at approximately 8.5, 5.3, and 3.7 million years ago. Sporadic volcanic activity has also occurred during the last million years. A basalt flow in Lincoln County was determined to be 6.3 million years old.

The above remarks are assuredly not a complete geochronologic picture for the volcanic rocks of the NTS; they pertain only to the potassium-argon ages determined in recent months.

Uranium-Series Dating and Disequilibrium

Ten samples of zeolitically altered tuff from USW-G1 hole have been obtained from J. R. Smyth, Los Alamos National Laboratory, for analysis. Isotopic ratios of uranium-234/uranium-238 will be determined in these splits for comparison to similar analyses in zeolitically altered rock in other areas. Reported results are contained in a recent publication this quarter: Rosholt, J. N., 1980, "Uranium and Thorium Disequilibrium in Zeolitically Altered Rock," Nuclear Technology, v. 51, pp. 143-146.

Fission-Track Dating

Five samples submitted by Will Carr were dated by the fission-track technique.

Gamma-Ray Spectrometry

The radioelement (radium-equivalent uranium, thorium, and potassium) contents of selected samples from drill hole USW-G1 are being measured. These data will be used to characterize the lithologic units penetrated by the drill hole and to ascertain variation in radioelement contents and ratios which may reflect permeable zones within the units.

Preliminary results obtained from the sampled interval from 2,800-5,800 feet indicate a general reduction in radium-equivalent uranium content with depth, but no similar trend in the thorium and potassium contents. An anomalous zone in which the thorium content is unusually high occurs at 5,000 ± 50 feet near the contact between a lithic-rich tuff and older undivided tuffs. Radium-equivalent uranium and thorium contents are significantly higher in the upper half of the Tram Member of the Crater Flat Tuff than in the lower half of the member.

1.3.3.6 Drilling Plans and Engineering

Objective: To provide Project participants with technical support from the NTS contractors.

These support requirements are reported in the various task activity sections to which they are applicable.

1.3.3.7 Field Geology and Core Library Support

Objective: To provide and maintain a cadre of Fenix & Scisson geologists to support the Project participants, to provide and maintain core library facilities at the NTS for handling and storaging rock samples, and to provide general NNWSI Project support to the USGS.

Fenix & Scisson geologists provided support to (1) Task 1.3.3.1, for fracture and fault analyses of USW-G1 and USW-H1 core, mapping of surface features at Yucca Mountain, and monitoring of the USW-VH1 drill hole in Crater Flat; (2) Task 1.3.3.3, for monitoring and hydrologic testing of the USW-H1 drill hole; and (3) Task 1.3.3.4, for mapping Quaternary deposits in Crater Flat.

1.3.3.8 Weapons Test Seismic Investigations

Objective: To measure weapons-test-induced ground motion for determining its changes with distance, depth, and yield and to obtain site-specific ground motion data for evaluating potential repository sites.

A total of 87 ground motion measurements were made during the quarter; 24 of these measurements were made downhole. A gauge malfunction developed on the vertical gauge at the downhole station in UE4aa, necessitating the replacement of the canister after the first of the calendar year.

Processing of data for all events fired before FY 1981 has been completed. The processed data have been entered into the data bank.

A seismic event detector developed in connection with another program was applied to seismic data for the surface and downhole stations in the Climax Stock, using one nuclear event as the seismic source. The arrivals within a waveform of separate wavelets arriving at the station via different transmission paths from the source agree well with arrivals determined from particle displacement trajectories. The path used represents one of the simpler geologies on the NTS and, after evaluation using more complex geologies, it is expected to be useful in understanding seismic anomalies.

Work progressed on developing transfer functions between surface and downhole ground motions. There was considerable variation on a shot-to-shot basis, and an effort was begun to see if a generalized transfer function could be derived which would result in less variation.

This effort parallels one of cataloging amplification and deamplification factors for each of the seismic stations for nuclear tests on Pahute Mesa. These factors are a measure of seismic anomalies and are the ratio of the measured peak vector acceleration for each station to that given for the same distance by a log-log root mean square (RMS) fit to the data from all of the stations.

A major operational problem was solved during the quarter. One nuclear event, for example, required 28 tapes to store the digitized data after all processing was completed. This meant that for certain analysis operations, several tapes would have to be called from the tape library and mounted to meet the needs of a single piece of software. This increased the work load of operators at the central computer facility, and often slowed the return of computer runs. By reformatting and compressing the digital data, it is now possible to get all the data for this event on the equivalent of two-thirds of one tape. Actually, the compressed data are put on the permanent disk, and as a result, data from several events are available for immediate access. The weapons test seismic program has been using a larger share of the Sandia tape library than any other user, and the compression will allow the same work to be accomplished with fewer tapes in the library.

1.3.4 HYDROLOGIC CHARACTERIZATION

(These task activities are included in Task 1.3.3.)

1.3.5 ENVIRONMENTAL CHARACTERIZATION

Objective: To perform the area-to-location screening and to inventory and analyze the existing environmental information relevant to potential repository locations within the screening area.

1.3.5.1 Area-to-Location Screening

Objective: To develop the approach and to perform the area-to-location screening of potential repository rock units.

The draft technical approach to the area-to-location screening activity was prepared by SNL Technical Overview. The Site Evaluation Working Group (SEWG) held a meeting on October 27-28 to discuss the proposed technical approach and to begin assessing its usefulness as a working tool for screening the NTS. Copies of the draft approach were provided to the NNWSI Technical Project Officer for review.

The SEWG met for two days in Las Vegas on November 12-13 to work on the practical aspects of implementing the proposed technical approach for area-to-location screening. A "walk-through" of one attribute category of the approach, thermo-physical properties, was conducted to help in determining whether the approach was feasible, to provide a basis for estimating time and manpower requirements, and to provide an example of the results format. The SEWG members decided to exercise and further evaluate the usefulness of the proposed approach with minor revisions to the objectives tree and modifications to simplify implementation and focus efforts on the most promising lithologic units in the NTS area. In addition, attributes on the objectives tree were given a preliminary review to identify those attributes which might be exclusionary or nondiscriminatory for locations in the NTS area. The relatively homogeneous lithologic units available in the nine-quadrangle southwest NTS area were reviewed and evaluated against three minimum guidelines for further consideration: Is the unit thick enough? Is the unit deep enough? Is the unit shallow enough?

On December 18-19, a Site Evaluation Working Group meeting was held at the USGS offices in Denver. A set of maps showing the locations and extents of 12 rock units of sufficient thickness and depth for a repository were presented. Thermal and mechanical properties were assigned to each rock unit and the properties were rated with respect to relative suitability for repository development. Plans were initiated for involving appropriate technical experts within each major participant organization in completing the data input for area screening. There was consensus among the Working Group members that the screening methodology is both reasonable and workable. A paper, "Method for Screening for Repository Locations on and Contiguous to the Nevada Test Site," was presented at the NWTS Annual Information Meeting in Columbus.

Florian Maldonado (USGS) met with Scott Sinnock (SNL) in Albuquerque, New Mexico, to compile areal extent maps for various rock units of the southwest NTS area prior to a third Site Evaluation Working Group meeting held December 18-19 in Denver, Colorado.

1.3.5.2 Environmental Area Characterization

Objective: To prepare an Environmental Area Characterization Report (EACR) that will be the initial data base for subsequent environmental impact analyses and to identify environmental factors and information significant for area-to-location screening.

Early in this quarter, subcontractors were identified by SNL and the scope of work was defined for the Environmental Area Characterization. In November, work statements were developed and cost estimates were received for the subcontractors covering the following topics: cultural resources (Desert Research Institute), atmosphere (Desert Research Institute), ecology (EG&G), background radiaton (REECo-on-NTS; EPA-off-NTS), and human environment (UNLV, Center for Business and Economic Research).

A meeting of the contractor representatives was held on November 12 at the DOE/NV. This meeting provided an orientation to the NWTS, NNWSI, and the NNWSI area screening (Task 1.3.5.1). A preliminary set of objectives was developed for the environmental portion of the objectives tree.

During December, work was begun on the literature survey and evaluation for the Environmental Area Characterization Report (EACR). A month or more delay occurred in contract start-up for most of the contracts. However, the target date for completion of the annotated bibliography, February 1, 1981, should be met by all contractors except that the report will be in draft form. Development of the objectives for screening continued.

1.3.6 SOCIOECONOMIC EVALUATION

(No NNWSI work funded this fiscal year.)

1.3.7 PERFORMANCE EVALUATION

Objective: To determine if new site performance evaluation techniques and/or more detailed data must be developed, particularly for basaltic volcanism, and to perform sensitivity evaluations in support of site characterization and performance evaluation.

Plans were developed and the work scope was defined for the parametric studies of the radiological consequences of basaltic volcanism; the contract has entered the procurement process and should go out for bid during January.

1.4 REPOSITORY

Objective: To establish the technological basis for repository development necessary to assure adequate repository and waste package containment and isolation capabilities.

1.4.1 REPOSITORY BASELINE

(No NNWSI work funded this fiscal year.)

1.4.2 REPOSITORY DATA BASE DEVELOPMENT

Objective: To develop the information needed to support the development of an adequate repository design.

1.4.2.1 Tuff Investigations

Objective: To develop a data base for a repository in tuff.

1.4.2.1.1 Laboratory and Modeling

Objective: To investigate several long-term effects of repository conditions on tuff.

Mine Design Study Working Group

Two meetings of the Mine Design Study Working Group were held this last quarter. The main items of interest at these meetings were:

a. A comparison of the thermal-mechanical codes was presented in October. There were some minor differences in the results. Changes were made in the codes which should make the results even closer. Both of the thermal-mechanical codes have the same basic approaches. A report will be written on the comparison of the thermal-mechanical codes.

b. Field test issues were reviewed and finalized. The field test issues were summarized in ten main issues in the report "Technical Concepts for Design of Field Experiments in Tuff in G-Tunnel at the Nevada Test Site."

c. Preliminary creep data were presented. Results from two tests indicated that Bullfrog Tuff creeps, the creep rates are low, and tertiary creep may occur at high stress levels. Additional tests are in progress to confirm these observations and complete scoping the test matrix. A report will be written summarizing the creep testing.

d. Three-dimensional heat transfer calculations were completed for a gross thermal load (GTL) of 100 kilowatts per acre for both spent fuel (SF) and high-level waste (HLW) in a room-and-pillar geometry. Results from these calculations have been input into a paper on interim repository conditions by the Reference Repository Conditions--Interface Working Group (RRC-IWG) and are being input into a paper, "Thermal Analysis of Waste Emplacement in Tuff," which summarizes the thermal results of the Working Group calculations.

e. Recently received data from USW-G1 at Yucca Mountain were presented.

f. Dean Nelson of Los Alamos presented the present plans for an at-depth test facility.

Work packages which were assigned at the December meeting include:

a. Very near field thermal modeling of a canister with different waste packages.

b. Very near field modeling of proposed conceptual rock mechanics experiments (thermal-mechanical modeling of a heated block, thermal-hydrologic modeling of a small-scale heater, thermal-mechanical modeling of a single heater, and thermal-mechanical modeling of a unit cell).

c. Modeling of blast cooling and continuous cooling for the conceptual repository design task.

d. Room-and-pillar thermal-mechanical modeling using new property data from USW-G1 for the conceptual repository design task.

Another Working Group meeting was scheduled for March 3-4, 1981.

Yucca Mountain Evaluation

A comparison of the data from the two geologic exploration holes, UE25a-1 and USW-G1, allowed the definition of two horizons for potential repository locations. The fact that drill hole USW-G1 (unlike UE25a-1) penetrated all of the Bullfrog Member has allowed definition of the welded zone extending from a depth of 2,345 to 2,545 feet (715 to 776 meters) as the primary zone of interest in the Bullfrog Member. The zone is consistent with both bulk density and mineralogical zonation. At present, thermal conductivity of seven additional samples is being measured to better define this zone and to detail the changes in thermal conductivity at its upper and lower boundaries.

A second welded zone, again not penetrated by drill hole UE25a-1, was identified between the approximate depths of 2,750 and 3,050 feet in hole USW-G1, in the Tram Member of the Crater Flat Tuff. To date, three natural-state thermal conductivities are available from this interval, averaging 2.27 ± 0.15 watts per meter-degree celsius (W/m^{o} C). If this unit is to be considered much further, an effort must be made to penetrate it in additional holes.

Laboratory and Modeling Support

The first round of thermal property measurements on material from drill hole USW-G1 has been nearly completed. To date, conductivity measurements have been made on four samples from welded portions of the Bullfrog Member of the Crater Flat Tuff. The natural-state thermal conductivity of these samples averages 1.86 ± 0.17 W/m^{o} C, as compared to 2.06 ± 43 W/m^{o} C for six samples from the same unit in hole UE25-1. The differences appear to be consistent with differences in bulk densities and porosities measured on material from the two holes.

Measurements of thermal conductivity parallel and perpendicular to bedding were made on four partially welded, fully dehydrated samples from the Grouse Canyon Member of the Belted Range Tuff to determine if there is any significant matrix thermal anisotropy of this unit. The conductivities, which average about 1.2 W/m^{o} C independent of temperature, are in good agreement with previous results. In addition, they indicate that there is only a 2 to 3 percent effect due to different directions of heat flow. Limited additional measurements are to be made in the Bullfrog Member and one or more nonwelded tuffs to confirm this result. If confirmed, the results would indicate that any in situ thermal anisotropy would result largely from the presence of joints.

Steady-state liquid permeability on three tuff samples has been measured. The permeability of two samples has been measured. The permeability of two samples of welded Grouse Canyon Tuff ranges from 0.5 to 1.7 x 10^{-17} square meters. This is only slightly higher than measured values on the matrix of the Topopah Springs Member of the Paintbrush Tuff. The new permeability values, combined with measured pore-size distributions in the Grouse Canyon Member, will be used to extend the in-house thermal dehydration model being applied to the results of the Tuff Water Migration/Heater Experiment. The measured matrix permeability of a sample of the Bedded Tuff of Calico Hills from hole UE25a-1 is 1.4 x 10^{-18} square meters.

A large suite of triaxial mechanical tests on the stratigraphy of drill hole USW-G1 has been completed; the data results are presently undergoing interpretation. Initial interpretation indicates that the Bullfrog Member in hole USW-G1 tends to be a little weaker than in drill hole UE25a-1; this is, again, consistent with material property measurements. The material, however, appears to behave regularly and to show little sensitivity to increases in temperature between ambient and 200^{o} C. Thermal and mechanical results from USW-G1 will be combined into a definition of far-field stratigraphy during the second quarter of the fiscal year.

During this quarter, potential matrix failure behavior was included in the in-house jointed rock mass model. Results to date indicate that there is the potential for a small amount of matrix fracturing in the Bullfrog Member as a result of repository excavation and waste emplacement based on mechanical data from drill hole UE25a-1. The model already incorporates variable and statistically scattered joint orientations. During the upcoming quarter, the treatment will be extended to include the material properties data from drill hole USW-G1.

Initial calculations, including potential two-phase flow through porous tuff, have been completed, examining the potential heat release into a repository resulting from fluid flow. With permeability of 1 x 10^{-15} square meters and initial thermal output of 1.0 kilowatts per canister, up to 30 percent of the total heat given off by the HLW up to 50 years after emplacement could be released as a result of fluid flow into the workings. In this relatively low-powered case, only one-phase flow is involved. Calculations are presently ongoing that involve higher thermal loadings in the canister. It remains to be seen whether the additional power will result in any higher proportion of heat being released by fluid flow.

Rock Physics

The rock physics effort consists of (1) hydrothermal soak tests and (2) studies of time dependent failure in NTS tuffs and in situ field tests in NTS tuffs. In the soak tests, tuff samples are exposed to simulated repository conditions for extended (six month) periods and the recovered samples are examined for changes in physical and mineralogic properties. During this quarter, the first two tests were started and have been running for eight weeks. The tests are on samples of Calico Hills (bedded) tuff and Topopah Springs (partly welded) tuff from UE25a-1. The two tests are at 80° C with confining pressure/pore pressures of 200 bars/50 bars and 100 bars/5 bars, respectively. Additional samples are being sealed in their pressure vessels. New work plans and detailed procedures have been drafted for this work, taking advantage of discussions in the Mine Design Study Working Group.

Studies of time dependent failure in tuff are proceeding on schedule with the FY 1981 operating plan. Design of equipment to perform the long-term creep tests on tuff samples is complete and the prototype is about 75 percent constructed. The load application system of this device is designed to apply and control a true differential stress to the sample. Initial tests indicate that the desired stress level can be attained within a few seconds. This will allow transient creep data to be obtained as well as the long-term deformation rate. The design also incorporates the capability to measure water permeability of the sample during deformation. It will be possible to use either a pulse-decay or constant-flow method, depending on sample permeability range. It is expected that this system will allow determination of how permeability changes with time in tuff as a sample deforms under conditions appropriate to the near-field environment of a high-level nuclear waste repository. A quality assurance work plan has been drafted outlining the conditions of the test to be performed.

Conceptual arrangements and functional requirements are being developed for methods to conduct in situ field tests in tuff. A milestone chart has also been prepared to show the interaction of site confirmation, repository design, and in situ testing activities. This information was presented at an Exploratory Shaft Meeting held at the Nevada Operations Office on December 4, 1980, and at the Mine Design Study Working Group meeting at Sandia National Laboratories on December 16, 1980. A visit was made to the Yucca Mountain Site on October 28, 1980, to examine the terrain from the standpoint of locating a field test facility.

1.4.2.1.2 Rock Mechanics Field Experiments in Tuff

Objective: To develop test plans for determining and evaluating the physical, chemical, and mechanical properties needed to utilize tuff as an emplacement medium for radioactive waste.

The rock mass properties and site exploration activities of FY 1980 were integrated into an expanded rock mechanics program for FY 1981. The first quarter was devoted primarily to project planning, task definition, and scheduling. A technical concepts documents was drafted and distributed to the DOE/NV and ONWI for review. Representatives from Sandia, RE/SPEC, and Texas A&M University contributed to the preparation of this document. The proposed tasks include:

a. Definition of Field Tests.

b. Laboratory Testing.

c. Site Exploration.

d. Geotechnical Field Measurements.

e. Conceptual Design of Field Tests.

f. Detailed Design of Field Tests.

g. Preparation of Test Plan.

The first five tasks were initiated during the reporting period. Task a. included the preparation of the technical concepts document and a follow-on preconceptual definition of the field experiments document that was prepared for the first peer review. Included in this document are descriptions of proposed experiments that are being planned in the other tasks. These experiments consist of small- and canister-scale heater experiments, with the latter in single heater and unit cell configurations, and geotechnical measurements, with "Rocha" slot and thermal probe tests. All of these are proposed for G-Tunnel during the period FY 1982 to FY 1984.

Efforts in the remaining four tasks were concentrated on planning and experiment definitions. Tasks b., c., and d. are to be completed by reports in FY 1981 and will provide a complete description of the physical and geologic properties of tuff in G-Tunnel for ambient temperatures. Modeling definitions were made for Task e. and assignments were made to incorporate the results into the conceptual designs of the experiments. In particular, the two-phase moisture effects were to be incorporated in the thermal models.

The first five of these studies will be completed in FY 1981. The first four have been described in detail and assigned to members of the Working Group for execution. The remaining two studies will be completed during the first half of FY 1982. No results are available from any of the studies at this time.

An annotated outline was completed for the data summary. This document will abstract the information from the site exploration and laboratory programs in a form suitable for use by the conceptual design team. The annotated outline presented a listing of the types of information required and in most cases identified sources for this data.

Purchase requisitions for the contracts to be awarded for technical assistance in preparation of the design guidelines were completed. This effort included scopes of work and selection criteria for the contracts. Contract award is scheduled for April 1, 1981.

1.4.2.2 Granite Investigations

Objective: To assess the suitability of granite as a repository host rock.

1.4.2.2.1 Permeability Studies

Objective: To determine the permeability of granite at elevated temperatures and pressures.

After shutdown of work on this project during the fourth quarter of FY 1980, the project was restarted on October 1, 1980. In the current quarter, two groups of granitic samples have been tested at 20^{o} C. Testing of each group was terminated earlier than orginally planned due to minor apparatus technique problems. In the first group, one Stripa granite and two Climax quartz monzonite samples were tested to 20 MPa confining pressure (10 MPa effective pressure). Measured permeabilities for both were about 10-20 square meters (10^{-8} D). Testing on the second group of samples produced acceptable data only on two Climax samples. These results have not yet been reduced. The next test group (which is planned to begin shortly) will include three Climax and one Westerly granite samples. If this run goes as planned, LLNL will have complete results to a confining pressure at 100 MPa and achievement of the March 1981 milestone is expected.

1.4.2.2.2 Rock Mechanics Field Experiments in Granite

(No NNWSI work funded this fiscal year.)

1.4.2.2.3 Spent Fuel Test--Climax

Objective: To conduct a test of the feasibility of storing spent reactor fuel assemblies safely and reliably at a plausible repository depth in a typical granitic rock.

The principal activities during the quarter were continued data collection on the storage phase of the test and preparation of the procedures, checklists, and other documentation required for the periodic fuel exchange operations. Additional malfunctions of stress and near-field displacement instrumentation have occurred and a significant effort has been mounted to diagnose the problems. Most instrumentation continued to operate normally and the computer-based data acquisition system continued to collect, validate, and record information with satisfactory reliability.

The peak canister temperatures steadily declined during the quarter, reflecting the decay of the spent fuel assemblies. The power output of each assembly is approximately 1,125 watts at the end of the quarter and the canister temperatures are now approximately 130-135^{o} C. The peak rock temperatures at the storage hole walls have been reached; they are in the 80-85^{o} C range.

Measured displacements of less than one millimeter continue to be observed in the test area.

Fuel Canister Handling Operations

There were no canister handling operations during the quarter. The technical operating procedures for fuel canister handling operations were revised, reviewed, approved, and issued in December. Final mothballing and demothballing checklists, interlock verification checklists, and other documentation to support the handling system were completed and issued during the quarter.

Detailed schedules for the first fuel exchange operation were revised and distributed in December. The schedule envisions a two-week effort, with the first week devoted to system reactivation and recertification and the hot operations and deactivation in the second week.

The final draft of the canister handling system technical manual was reviewed and approved for publication.

Thermal and Thermomechanical Modeling

The newest version of the ADINA/ADINAT thermomechanical code was installed on the CRAY computer last quarter. A test case ADINAT calculation has been run using the SFT-C as-built configuration. The CDC 7600 and CRAY results were identical. The CRAY provides a two- to threefold increase in running speed.

A review of work on a ubiquitous joint model for ADINA revealed inadequacies in the model. Both oral and written presentations of the contractor's research pointed out unrealistic modeling of rock failure along sets of ubiquitous joints. Additional development in this area is planned to be done by LLNL.

Field Geologic Studies

Composite sketches of geologic features present in the ribs of the two heater drifts and the canister drift as well as the invert of the canister drift were completed. These sketches will be published at a later date when all data on the subsurface geology at the SFT-C are assembled and analyzed.

Water levels in the recently deepened exploratory hole UG-02 have apparently stabilized at 479 vertical feet beneath the canister drift. This represents about 40 vertical feet of water in this hole.

Instrumentation Program

Many of the 48 near-field vertical extensometer units and all 6 of the near-field vibrating-wire stressmeters have malfunctioned. The onset of failure was masked because the units indicated reasonable readings for several weeks. Examination of data plots and raw data indicated no instrument problems. A field inspection of the extensometers last quarter clearly showed that although the data acquisition system (DAS) displayed displacements of several millimeters, the potentiometer shafts had moved imperceptibly. At about the same time, stressmeters began "winking out," that is, not always sending a reading to the DAS.

A major effort has been launched to diagnose the problems and to determine the cause of the malfunctions seen to date. Two symptons were observed in the extensometers. Some precision resistors were found to be out of specification. X-ray analysis indicated void defects in these units, possibly caused by water or chemical vapor action. This problem is limited both in occurrence and in magnitude of effect. The more serious symptom is change in resistance of several potentiometers. Inspection of these units uncovered apparent degradation of the surface of the potentiometer substrate such that a gummy film covered the surface of the substrate. The only likely cause is chemical action. The stressmeter signals were displayed on an oscilloscope, where severe damping of the output signal was observed. This could be due to electrical damping in the lead wires or mechanical damping of the vibrating wire itself.

The symptoms of the instrument malfunctions are quite well understood. However, the exact cause is yet to be identified. All failures apparently began to occur as temperatures reached 40 to 50^{o} C. Gas samples have been obtained from all boreholes involved. These consistently show elevated levels of H_2 and CO_2 with traces of organic compounds. The latter occur in concentrations too small to be identified by the mass spectrometer. Gas chromatographic studies looking for a few specific compounds are under way. Samples of various materials used in the instruments are being evaluated for out-gassing at temperatures seen in the boreholes.

Equipment has been designed, built, and fielded to recover all six near-field stressmeters. Photomicrographs of key areas such as the vibrating wire swage fittings have been taken and several units are being shipped to the manufacturer for disassembly and evaluation. Once stressmeters were removed, radiation measurements in the two holes were made. A peak value of 15 mR/hr was observed at this location (about 0.8 of a meter from the canisters). Radiation fields of this intensity are not expected to adversely affect the gauges.

Expenditures of manpower to date have been significant and are anticipated to increase when repairs are begun. All analyses have been done in-house or free of charge by the respective component manufacturers (Vishay, Bourns, and IRAD Gauge) so only charges for personnel have occurred.

Despite these severe problems with near-field geotechnical instruments, most devices continue to function reliably. Thermocouples and intermediate-filled borehole extensometers, wire extensometers, fracture monitors, and stressmeters have experienced few problems to date.

Problems with instrument drift have been observed in some continuous air monitor (CAM) units. Investigation and correction of this problem is under way. Temperature and moisture effects are the suspected causes.

Data Acquisition System

The DAS is continuing to take experimental data and monitor personnel radiation safety. Every three to four weeks, a data tape is being sent to Livermore for processing.

There have been several hardware failures with the computers and peripheral equipment that have interrupted normal data acquisition. The average failure rate, however, is below the predicted failure rate that was made when the system was purchased. During the course of this quarter, the first computer has been down a total of about four weeks and the second computer about two weeks. Maintenance of the computers continues to be performed by the manufacturer, Hewlett-Packard.

Several software improvements have been made in the operating system codes and the application codes to improve the throughput and reliability of the system. Work is still continuing to debug the remote alarming codes. Hardware failures with the remote alarm terminal have caused some delays.

Stressmeter data is now going directly into the computers as a result of completing the application codes for it. Data were previously displayed in hard copy form from which it was manually keypunched and inserted into the data set at Livermore.

Documentation of the DAS is well under way at this time.

Data Management System

Improvements in data plotting capabilities continued to be made this quarter. Informal internal documentation of existing data management software was completed this quarter.

During the quarter, eight tapes were received from the NTS and processed into the data bank. Over 1.5. million readings were added, which brought the total number of data points to over 3.2 million. Data continues to accrue at a rate of about 0.5 million data points per month.

Technical Reporting and Public Information Activities

Reports published:

-- "Geotechnical Status Report for Test Storage of Spent Reactor Fuel in Climax Granite, NTS," D. Wilder and W. Patrick, Preprint UCRL-85096, November 1980.

-- "Thermal Analysis for a Spent Reactor Fuel Storage Test in Granite," D. Montan, Preprint UCRL-83995, September 1980.

Reports in publication process:

-- "Spent Fuel Test--Climax Technical Measurements Interim Report FY 1980"; R. Carlson, W. Patrick, D. Wilder, W. Brough, D. Montan, P. Harben, L. Ballou, H. Heard; UCRL-53064 September 1980 (available in March 1981).

-- "Response of Borehole Extensometers to Explosively Generated Dynamic Loads," UCRL in preparation, W. Patrick, W. Brough.

-- "Mechanical and Thermomechanical Calculation for a Spent Nuclear Reactor Fuel Test in Granite," UCRL in preparation, T. Butkovich.

Papers presented:

-- "Thermal Analysis for a Spent Reactor Fuel Storage Test in Granite," D. Montan. Presented at the International Symposium on the Scientific Basis for Nuclear Waste Management, Boston, Massachusetts. November 16-20, 1980.

-- "Geotechnical Status Report for Test Storage of Spent Reactor Fuel in Climax Granite, NTS," D. Wilder. Presented at the Symposium on Geological Disposal of High-Level Radioactive Wastes, Dallas, Texas. October 24, 1980.

-- "Field Testing at the Climax Stock in the Nevada Test Site: Spent Fuel Test and Radionuclide Migration Experiments," L. Ballou. Presented at the ONWI 1980 National Waste Terminal Storage Program Information Meeting, Columbus, Ohio. December 9-11, 1980. (Extended abstract published in the proceedings, ONWI-212.)

Climax Fuel Transfers

Two procedures were revised and issued in preparation for the January 1981 Climax Fuel Exchange using fuel assembly D-15: WN-TOP-012 for preparing and shipping Climax fueled canisters and WN-TOP-017 for receiving fueled canisters from Climax and installing them in temporary storage facilities. Guidelines and references were upgraded in both procedures and TPO-012 was also revised to permit loading of the surface transport vehicle with a fueled canister previously prepared for shipment.

1.4.3 EQUIPMENT DEVELOPMENT

(No NNWSI work funded this fiscal year.)

1.4.4 INSTRUMENTATION DEVELOPMENT

(No NNWSI work funded this fiscal year.)

1.4.5 REPOSITORY SEAL DEVELOPMENT

(No NNWSI work funded this fiscal year.)

1.4.6 GENERIC REPOSITORY ENGINEERING

(No NNWSI work funded this fiscal year.)

1.4.7 REPOSITORY CONCEPTUAL DESIGN

Objective: To develop a conceptual repository design which will serve as the basis for a Title I design.

1.4.7.1 Preliminary Data Package Development

Objective: To prepare design guidelines and summaries of geotechnical fluid and laboratory work and computer modeling efforts for a subsequent conceptual repository design.

During the first quarter of FY 1981, detailed scheduling and budgeting for the tuff repository conceptual design was completed. The conceptual design activity is still scheduled for completion in mid-FY 1983. Along with the scheduling and budgeting efforts, the three major areas of effort (analysis summaries, data summaries, and design guidelines) were initiated.

Seven analytical studies needed to provide information for the conceptual design were identified. These studies are as follows:

a. Shaft Pillar Stability Analysis

b. Ventilation Requirements and Constraints

c. Blast Cooling

d. Thermomechanical Calculation Update

e. Sequential Loading

f. Barrier Pillars

g. Water Migration (with and without heating)

1.4.8 PERFORMANCE EVALUATION

(No NNWSI work funded this fiscal year.)

1.5 REGULATORY AND INSTITUTIONAL

Objective: To assess and document the safety and environmental characteristics of a repository system in a manner which meets anticipated NRC licensing requirements and the requirements of the NEPA.

1.5.1 REGULATORY BASELINE

Objective: To ensure that NNWSI licensing assumptions and plans are consistent with NWTS assumptions and plans.

This task has no reportable progress.

1.5.2 LICENSING APPLICATIONS

Objective: To plan and coordinate the preparation of licensing-related documentation.

This task has no reportable progress.

1.5.3 NEPA DOCUMENTS

Objective: To plan and coordinate the preparation of the NEPA documentation.

This task has no reportable progress.

1.5.4 COMMUNITY AND INSTITUTIONAL LIAISON

Obective: To inform and coordinate appropriate NNWSI activities with the affected community and government institutions.

This task has no reportable progress.

1.6 TEST FACILITIES

Objective: To ensure the availability of test facilities and equipment necessary to support research, development, and demonstration activities of the NWTS Program.

1.6.1 SALT FACILITIES

(Not applicable to the NNWSI.)

1.6.2 GRANITE FACILITIES

1.6.2.1 Climate Test Facility

Objective: To operate and maintain the Climax Test Facility.

Reportable activities conducted under this task are reported in the applicable section.

1.6.3 BASALT FACILITIES

(No NNWSI work funded this fiscal year.)

1.6.4 TUFF FACILITIES

(No NNWSI work funded this fiscal year.)

1.6.5 SUPPORT FACILITIES

1.6.5.1 E-MAD Facility

Objective: To ensure the availability of E-MAD facility personnel equipment and to develop and maintain the facilities and capabilities to meet programmatic requirements.

1.6.5.1.1,2 E-MAD Capability Maintenance and Operations

Objective: To maintain the readiness of both personnel and project-related equipment at the E-MAD facility to respond promptly to programmatic requirements.

AESD-Nevada staff members conducted tours of the E-MAD facility for 21 groups.

Safety

a. Lectures and training classes were presented to all E-MAD personnel for industrial safety, emergency response, radiation safety, first aid, and cardiopulmonary resuscitation.

b. A safety and radiological orientation lecture was presented to Westinghouse and contractor personnel prior to the shield window disassembly operation in the Cold Bay.

Operator Qualification and Training

a. Four technicians were qualified on the turntables and one technician was qualified on the V-202 remote bridge crane.

b. The training conducted consisted of 204 hours in the classroom; lectures, 379 hours of lecture time and 1,046 hours hands-on training.

c. One hundred (100) hours of training were provided for the Bell Telephone 2000 Dimension System being installed at the E-MAD facility.

Documentation

a. The following Technical Operations Procedures were revised, approved, and published.

   (1) WN-TOP-009, "Transfer Spent Fuel Assembly From Temporary Storage to Fuel Temperature Test Assembly and Transfer to West Process Cell," was revised to delete a duplicated step.

   (2) WN-TOP-014, "The Spent Fuel Calorimeter System," was revised to reflect actual operating conditions and to document the orientation of a fuel assembly when installed into a canister.

b. Technical Operations Procedures for handling a fuel assembly during calorimetry (WN-TOP-027) and for transfer of a canister to the Weld Pit (WN-TOP-028) were prepared, approved, and published.

c. Three specifications were completed and published, covering hoist equipment proof testing, recertification, and maintenance of the E-MAD spacer car, flatcars, and emplacement installation vehicle; also, the specification covering the calibration procedure for the Astro arc welder was revised and published.

d. Six facility equipment operating procedures were completed, approved, and issued.

Facility and Equipment Maintenance/Repair

a. A major overhaul of the wall-mounted handling system was completed as scheduled.

b. Annual maintenance was completed on the Warner-Swasey crane and semiannual maintenance on the Railroad Transport System (RTS) was accomplished.

c. Temporary liners for Dry Wells 2 and 3 were fabricated and installed.

d. The canister evacuation and Varian leak detector systems were calibrated and checked out.

Energy Conservation

The Energy Conservation Employees Awareness Program kickoff meeting was held November 18, 1980, with all E-MAD employees in attendance.

Audits

a. An audit of AESD-Nevada Operations is being performed by the DOE/NV audit staff.

b. A DOE facility utilization team audited E-MAD facility and equipment utilization on December 3, 1980.

1.6.5.1.3.1 Allied General Nuclear Services (AGNS) Heater

Objective: To investigate the relationship between the AGNS heater assembly and a pressurized water reactor spent fuel assembly with respect to temperature distribution for dry storage.

There were no AGNS heater activities during this time period.

1.6.5.1.3.2 CAM/RAM and Stack Monitoring Engineering Support

Objective: To operate a total radiation monitoring system to maintain the health and safety of operating personnel and to provide necessary protection against contamination of the E-MAD facility.

Sound barrier panels were fabricated and installed on the CAM (Continuous Air Monitor) units. Installation of the RAM (Remote Area Monitor) system continues; the system in the East Gallery was completed and checked out.

1.6.5.1.3.3 Activation of the East Process Cell (EPC)

Objective: To activate the EPC as a general-purpose hot cell having remote handling capabilities similar to those of the West Process Cell.

The R-MAD shield windows were transferred from R-MAD to the E-MAD Cold Bay. Disassembly and inspection were completed and the cover glasses and shield glasses were packaged for shipment and stored on pallets in the Cold Bay. Window housings and trim frames were loaded on a rail flatcar and moved to R-MAD for storage.

1.7 LAND ACQUISITION

Objective: To acquire land for the potential construction of a repository.

1.8 PROGRAM MANAGEMENT

Objective: To direct and assure coordination of all activities to fulfill the goals and objectives of the Project and to coordinate the Project with the NWTS Program.

1.8.1 PROGRAM MANAGEMENT

Objective: To provide the management interfaces between the participating organizations.

This task has no reportable progress.

1.8.2 PROJECT CONTROL

Objective: To monitor the fiscal and technical accomplishments of the Project.

This task has no reportable progress.

1.8.3 INTERFACE ACTIVITIES

Objective: To implement technical interfaces between NWTS Projects.

Sandia National Laboratories

Developing and maintaining the waste package interfaces throughout the NWTS Program has been a time-consuming activity. Included in these activities have been the WP-ICG, the Waste Package Design and Barrier Materials Technical Information Exchange Meetings, extensive document reviews such as the NWTS Waste Package Program Plan (ONWI 96, Volume III), Waste Package Criteria (ONWI 33(4)), and the recently received Engineered Waste Package System Design Specification (AESD-TME-3055).

Two meetings of the Repository ICG were held in the first quarter of FY 1981. Reviews of four documents have been initiated and some are completed.

1.8.4 QUALITY ASSURANCE

Objective: To provide the necessary planned and systematic actions and administrative controls to assure all NNWSI activities which affect quality, safety, reliability, or maintainability are conducted in accordance with established Project requirements.

Quality Assurance Overview Contractor

The Milestone and Deliverable Summary List for FY 1981 was submitted to WMPO/NV per the new administrative procedure. The list has been reviewed by WMPO/NV and, with slight modifications, has been accepted. Work has been started toward completion of the activities on the list.

The FY 1981 NNWSI Project Office audit schedule was developed and submitted to WMPO/NV to meet a deliverable commitment. Audit 81-1 was the first audit on the schedule and was partially completed in December. The purpose of the audit was to review criteria development and conduct of the drilling operations on the USW-H1 and USW-VH1 drill holes. The portion of the audit covering drilling activities conducted by F&S and REECo was completed, and no findings of a significant nature were discovered. The portion of the audit reviewing USGS generation and control of criteria for the drill holes is scheduled for January 1981. The final report for Audit 81-1 has been postponed until completion of the USGS portion of the audit because of potential impacts on findings from the drilling activities portion of the audit.

The Quality Assurance Overview Contractor (QAOC) is progressing toward completion of the quality assurance procedures implementing the Management and Overview Quality Assurance Program Plan (M&O-QAPP). The NNWSI Record Management Plan and a procedure defining the format and document control requirements for the QMP series of procedures have been submitted to WMPO/NV, partially satisfying the March 1981 commitment for procedure development. Drafts of four internal Sandia quality assurance procedures have been completed and will be ready for Sandia review in January 1981.

The QAOC has begun development of materials for an orientation briefing on the operation of the M&O-QAPP. These briefings are intended for WMPO/NV and Technical Overview Contractor (TOC) personnel and should satisfy the training requirements in the M&O-QAPP.

The TOC and QAOC began discussions on the quality assurance actions that should be incorporated into the NNWSI Area Screening and Location Recommendation (ASLR) activity. The QAOC has provided the TOC with suggested quality assurance actions that might be appropriate for inclusion in proposed ASLR activities. TOC responses and further dialogue on quality assurance in ASLR activities should occur in January 1981.

The QAOC conducted another auditor training course to qualify Sandia personnel as auditors.

The QAOC developed a Quality Operation Instruction as defined in the M&O-QAPP for use in QAOC surveillance of the USW-H1 and USW-VH1 drill holes. No nonconformances were found in either operation.

Two ONWI documents were reviewed and comments were forwarded to the TOC as requested.

a. Preliminary Information Report on Geologic Waste Repositories, ONWI-121.

b. National Site Characterization and Selection Plan, Volume 1.

The QAOC hosted the October meeting of the NWTS Quality Assurance Interface Coordination Group (QA-ICG). The QAOC action item from this meeting was to draft an NWTS quality assurance program requirements document for the December 1980 QA-ICG meeting. F. W. Muller distributed the finished draft to the QA-ICG members at the December meeting, thus completing this QAOC action item.

Sandia National Laboratories

Quality assurance activities for the first quarter of FY 1981 have included general quality assurance support for Sandia/NNWSI Project tasks; the defining and distributing of the FY 1981 audit schedule; and performing, reporting, and following up on audits both internal and external to Sandia. Audits internal to Sandia included design control, inspection, thermal instrumentation laboratory, nonconformance reporting and corrective action, and the field activities at the NTS. Audits on contractors were performed at Terra Tek, Inc., in Salt Lake City, Utah, and RE/SPEC, Inc., in Rapid City, South Dakota.

Westinghouse Electric Corporation

Four potential suppliers were surveyed during this reporting period. The product lines of these suppliers were lead glass refinishing, radiation counting devices, ASME code welding materials, and metal fasteners. Three of the four suppliers evaluated had acceptable manufacturing capabilities and quality programs and their names have been added to the Westinghouse Approved Supplier List.

Corrective action for the observation provided during the DOE/NV SNL QAOC September 3 and 4 quality audits were developed, documented, and implemented. Twenty-six (26) CAM/RAM monitors and the plasma arch welder were source inspected and released for shipment to E-MAD.

U.S. Geological Survey

The second draft of the USGS Quality Assurance Program Plan for the NNWSI Project was approved by the NNWSI Project Coordinator and was made effective on November 1, 1980.

USGS and Los Alamos National Laboratory quality assurance personnel spent five days in the USGS Menlo Park offices collecting data for three geophysical procedures from Howard W. Oliver, John H. Healy, and Arthur H. Lachenbruch. The first drafts of each procedure have been submitted for technical review.

First drafts of four quality assurance procedures for surface geophysics and four procedures for hydrologic testing have been submitted for technical review.

Second drafts of six procedures for the geochronology investigations and two quality assurance procedures were submitted for technical review.

Compilation of four loose-leaf copies of all USGS NNWSI quality assurance materials as of December 10, 1980, was begun.

Los Alamos National Laboratory

The following procedures were written, reviewed, approved, and distributed during the last quarter:

TWS-G9-DP-19, RO--Preparation of Rock Sample Powders
TWS-G9-DP-20, RO--Preparation of Fused Beads for Rock Samples Analyses by Electron Microprobe
TWSCNC11-DP-08, RL--TWS Procurement Procedure
TWS-CNC7-DP-22, RO--Preparation of Microautoradiographs
TWS-G7-WP-07, RO--"Soak" Test Work Plan
TWS-G&-DP-12, RO--High Temperature/Pressure Exposure Equipment (HTP)

A work plan for the creep experiment has been written and reviewed. The NNWSI work that is being done by Los Alamos Group CNC-2 and the University of Arizona are being brought into the quality assurance system. A Quality Assurance Program Plan was received from the University of Arizona personnel who will perform matrix diffusion and solute transport studies. Documented surveillance of program activities continued.

Trips were made to Denver, NTS, and Menlo Park for surveillance and procedure writing activities. The Quality Assurance Program Plan was approved for implementation into the program effective November 1, 1980. Sixteen detailed procedures are in Denver for program management approval.

An audit was performed at the NTS.

1.8.5 LAWRENCE LIVERMORE NATIONAL LABORATORY

A Spent Fuel Test--Climax internal quality assurance audit was conducted according to plan on October 8, 1980. Its purpose was to help assure readiness of the spent fuel handling system with special reference to the fuel canister exchange scheduled for January 1981. The audit proved to be useful as an aid to the project in planning the January operation.

Copies of data tapes from the SFT-C data acquisition system are being added to the quality assurance files as they are produced.

A quality assurance file is being maintained for quality assurance-related documents resulting from activities in the Granite Field Radionuclide Migration Experiment.

1.8.5 SPECIAL SUPPORT

Objective: To provide special technical support to the NWTS Program.

U.S. Geological Survey

The USGS participated in the briefing on the progress of the NNWSI Project to the Technical Advisory Committee of the NWTS Program at Las Vegas on October 20, 1980.

The USGS participated in the NWTS Program Annual Information Meeting held at Columbus, Ohio, December 9-11, 1980. The following NNWSI papers were presented:

Carr, W. J., "Tectonics of the Southern Great Basin: Studies in Support of the Nevada Nuclear Waste Storage Investigations."

Byers, F. M., and G. L. Dixon, "Current Geologic Investigations in the Southwest Quadrant of the Nevada Test Site in Support of the Nuclear Waste Program."

Wilson, W. E., "Status of Geohydrologic Investigations That Are Part of the Nevada Nuclear Waste Storage Investigations Program."

The USGS Project Coordinator attended the Basalt Waste Isolation Project Annual Information Meeting held at Richland, Washington, December 2-3, 1980.

The USGS Project Coordinator participated as a member of the Geology Overview Committee for the Basalt Waste Isolation Project at a committee meeting held at Richland, Washington, December 16-17, 1980.

The USGS participated in the Early Shaft Workshop held in St. Louis, Missouri, December 16-17, 1980.

Technical Overview contractor

Two meetings with the National Academy of Sciences were prepared for and participated in by the Technical Overview Contractor (TOC).

Review of the safety assessment section of the Preliminary Information Report (ONWI-121) was completed by the TOC and review comments were provided to the WMPO/NV. Appropriate portions of the report were distributed to several NNWSI participants for their information. Event trees and branching scenarios for a potential repository site in the southwestern NTS area are under development.

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