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DEC 19 1989

Mr. Ralph Stein, Associate Director
for Systems Integration and Regulations
Office of Civilian Radioactive Waste Management
U. S. Department of Energy, RW 30
Washington, D.C. 20545

Dear Mr. Stein:

During the week of July 24-27, 1989, DOE and DOE contractors conducted a field trip to the Yucca Mountain site for members of the NRC staff and an NRC contractor. A detailed report of the field trip has been developed by NRC staff members who attended the field trip and is enclosed for your information.

If you have any questions concerning this report, please contact King Stablein (FTS 492-0446) of my staff.

Sincerely,

/S/

John J. Linehan, Director
Repository Licensing and Quality
Assurance Project Directorate
Division of High-Level Waste Management

Enclosure: see enclosure on the shelf
As stated

cc: R. Loux, State of Nevada
C. Gertz, DOE/NV
S. Bradhurst, Nye County
M. Baughman, Lincoln County
D. Bechtel, Clark County
K. Turner, GAO

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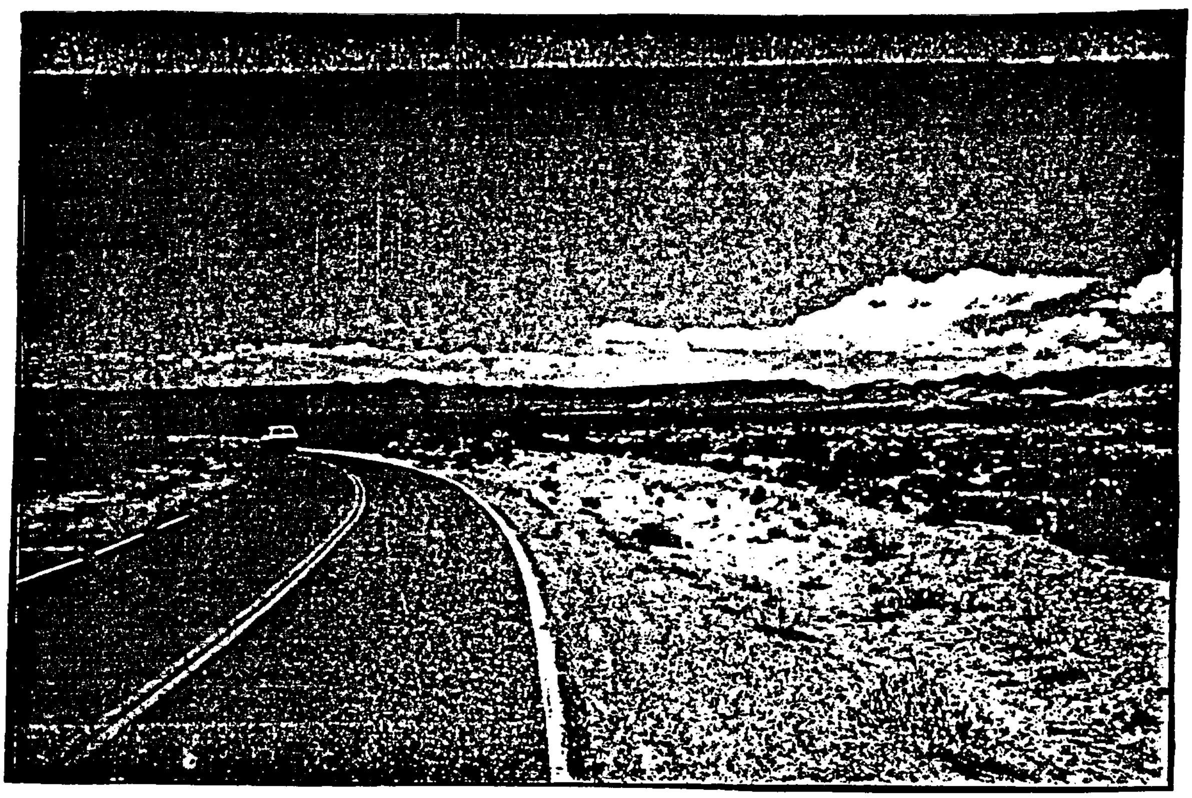
NRC HYDROLOGIC TRANSPORT SECTION
YUCCA MOUNTAIN SITE VISIT
July 24-27, 1989
TRIP REPORT



First view of Yucca Mountain, center, and Calico Hills, right.

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NRC HYDROLOGIC TRANSPORT SECTION
YUCCA MT. FIELD TRIP REPORT
July 24-27, 1989

INTRODUCTION

During the week of July 24, 1989, Dave Brooks, Don Chery, Neil Coleman, Bill Ford, Jeff Pohle, and Fred Ross of the Hydrologic Transport Section and Roberto Pabalan of the CNWRA traveled on a field trip of the Dept. of Energy's Yucca Mountain Project area. The objective of the trip was for staff to have an orientation of the site and regional hydrogeology, hydrology, geochemistry, and geology with particular focus on instrumentation and data collection procedures. The trip was conducted by the DOE with participation of the USGS and LANL principal investigators who are conducting the various hydrologic and geochemical site characterization and prototype testing activities. Field trip leaders were Bill Hughes (DOE) and Tony Buono (USGS).

The trip itinerary included regional and site features of geologic and hydrologic interest, prototype testing locations, present and future hydrologic site characterization data collection stations and tours of the Sample Management Facility and the USGS-YMP Hydrologic Research Facility. The general itinerary was as follows: Day 1 - Mercury, G-Tunnel, Yucca Fault, Trenches 14 & 14a, Busted Butte, Yucca crest; Day 2 - Site wells, gage at Narrows site in 40-mile wash, Pagany Wash, Exploratory Shaft Facility (ESF) site; Day 3 - Sample Management Facility, Hydrologic Research Facility; Day 4 - Field trip to the Amargosa Desert and Death Valley areas, Nevada and California. Figure 1 is a regional map showing the route for all four days. The pre-trip itinerary is provided as Appendix A.

From this field trip and interactions with DOE and the USGS, all the participating Hydrologic Transport Section staff found the selected stops, information, presentations, and demonstrations to be very informative and

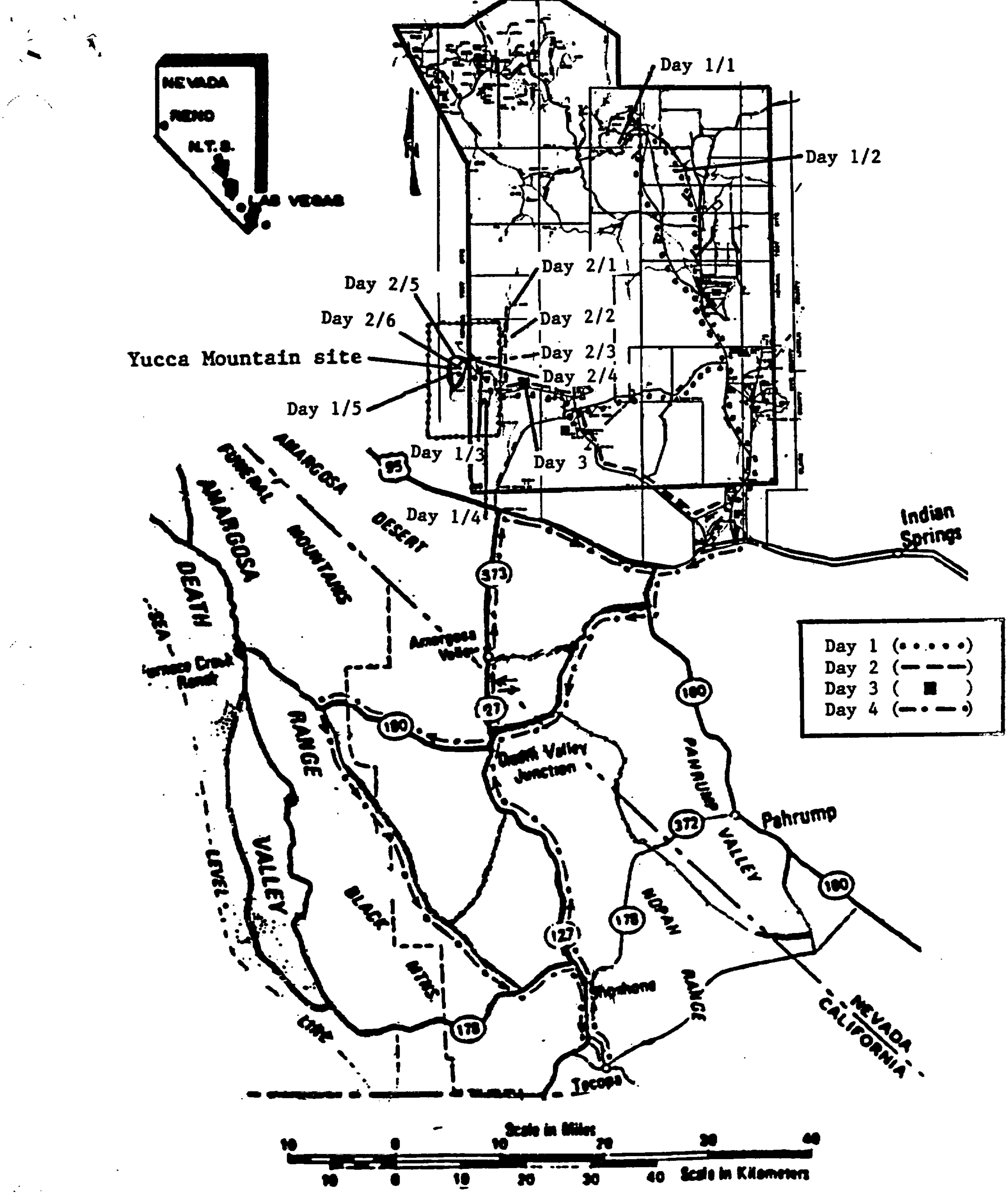


Figure 1 - Yucca Mountain Region
(Routes for HT Field Trip)

beneficial for their understanding of the site and planned site characterization activities. This experience will contribute to better reviews of study plans, reports, and field activities related to the hydrogeology and geochemistry of radionuclide transport at Yucca Mt. Detailed descriptions of various stops in the tour are given below. A list of attendees is given at the end of the report.

July 24, 1989 - NTS and Yucca Mountain   Leader(s)

On this day we visited G-Tunnel, the Carpetbag Fault, the Trench 14 area, Busted Butte, and Yucca Crest. Figures 2 and 3 show actual trip stops.

Tour G-Tunnel - view prototype testing   B. Hughes/J. Rousseau

The G-Tunnel Underground Facility is the focus for NNWSI Prototype testing activities in preparation for Exploratory Shaft Testing at Yucca Mt. It includes drifts and alcoves in welded and nonwelded tuffs similar to those found at Yucca Mt. and is located about 1400 ft. below the top of Rainier Mesa (7500 ft. elevation). However, in contrast to Yucca Mt., Ranier Mesa receives a greater amount of precipitation (about 12 inches per year). Additional information about G-Tunnel is given in Appendix B. In one drift, we observed water dripping from a fault located in the roof of the tunnel. The lateral extent of this saturated water flow is unknown. Elsewhere we observed parts of tunnel walls where there were obvious differences in rock moisture content (localized areas being damper than other areas of the tunnel). This condition was reportedly at a contact between welded and nonwelded tuffs. The USGS plans to conduct prototype tests in part of the tunnel to develop ways to characterize zones of differing moisture content.

B. Hughes conducted a tour of accessible areas where previous studies have been conducted. These studies included the development of dry coring techniques, comparisons of dry and wet drilling methods, thermohydrologic studies utilizing

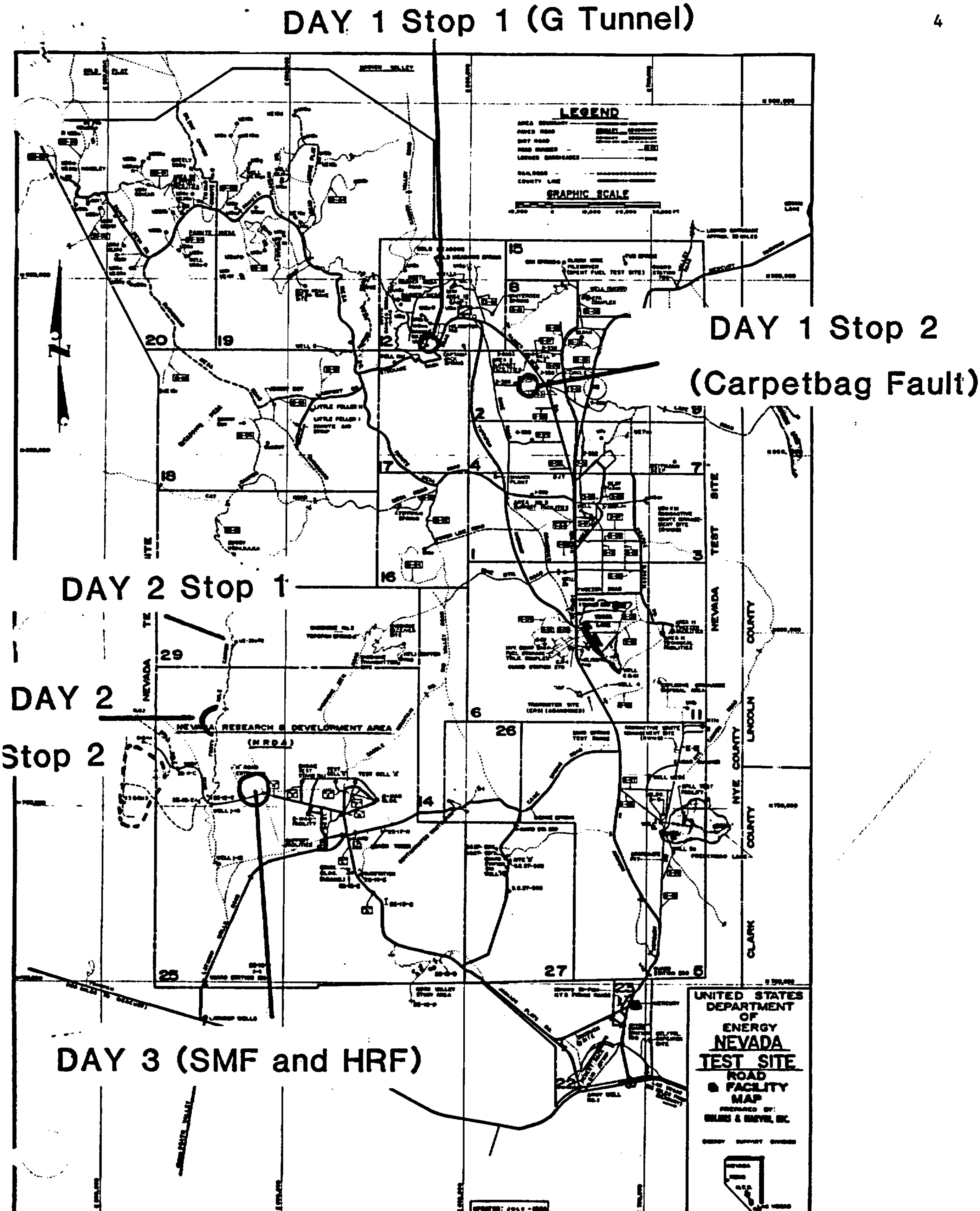


Figure 2 - Tour stops on the
Nevada Test Site

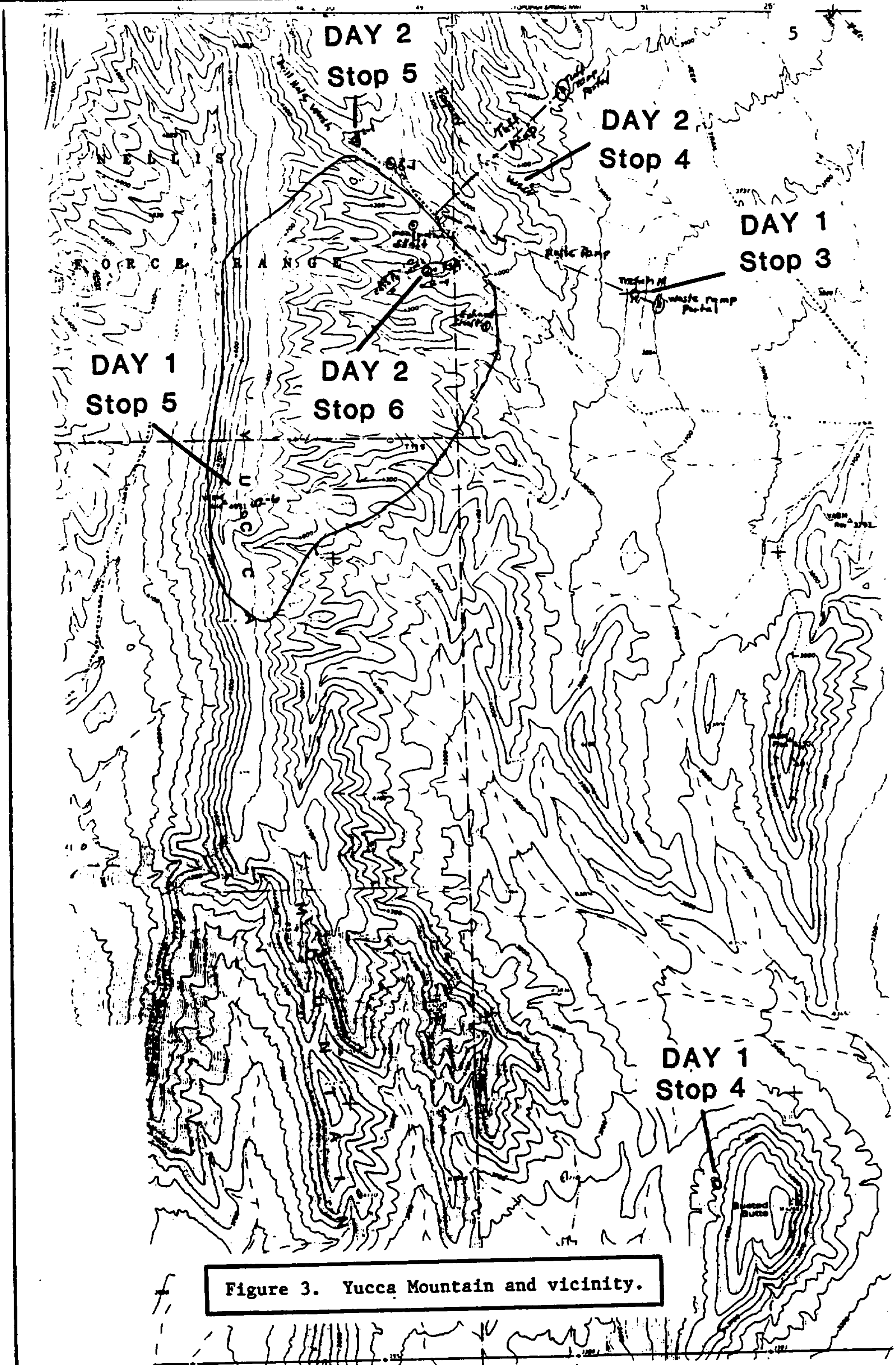


Figure 3. Yucca Mountain and vicinity.

heater emplacement holes and heated block experiments, and also hydrofracture experiments relevant to enhanced oil and gas recovery. In the latter experiments holes were drilled into the tuffs and indigo dye was injected at high pressure from the drill stems. The results are still evident along some of the drifts that were made to intercept the drill stems. The indigo dye traveled essentially along fractures to distances of at least 15 ft. Matrix flow is not evident, probably due to the short duration of these high pressure tests. In the drilling comparison tests, one horizontal hole was drilled dry and then instrumented to detect water content changes in the surrounding rock. Later, another horizontal hole was drilled approximately 5 to 8 feet away with water at the same elevation. No water content changes in the rock around the air-drilled borehole were detected. Measurements of the amount of water lost during drilling of the wet-drilled borehole will be used as part of the INTRAVAL modeling project.

We viewed some prototype testing being conducted in a drift. The testing involved moisture flux studies in a horizontal hole and in a shallow (15 ft) vertical hole. J. Rousseau indicated that atmospheric pressure changes in the tunnel propagate rapidly into the rock and are detected almost instantaneously at most monitored intervals. The data have not shown perturbations caused by nuclear shots, but that is probably a result of the long interval between data recordings. J. Rousseau showed slides of the thermocouple psychrometers used to measure the relative humidity in the drill holes. Some of these psychrometers showed extensive corrosion of the thermocouple wires which implies formation of salt solutions on the metal surface during the operation of the psychrometer. The salts may precipitate during evaporation of formation moisture. Additional information on the USGS psychrometers are given in Appendix B. Al Yang of the USGS will be conducting additional work on the geochemistry of the pore waters and gases in the area. J. Rousseau said that the current series of tests has been running for 6 months and they feel that accurate measurements of temperature, humidity, and air pressure conditions in the rock are being obtained, but they will not be certain for a few more months. See Appendix F for additional information about this trip stop in G Tunnel.

Carpetbag Fault and evidence for reactivation B. Hughes

The surface expression of Carpetbag Fault in Yucca Flat was created by a nuclear shot that was detonated below the water table. The seismic energy generated by such a shot is greater than for shots above the water table, which are more typical. Additional information is given in Appendix C.

Hydrology & geochemistry of Trench 14 & 14a J. Stuckless/S. Levy

The tour group assembled in Trench 14 (Photo 1). Trenches 14 and 14a were previously excavated across faults near Yucca Mt. to assess the extent of Quaternary fault movement (Photo 2). In addition, these trenches revealed secondary calcite and silica deposited in the fault zone as well as associated alteration of the tuff wall rocks. The origin of these deposits is a matter of concern because of their possible hydrothermal origin.

J. Stuckless and S. Levy (LANL) (Photo 2) discussed their studies of the deposits, and S. Levy's preliminary interpretation is that the geochemistry suggests a low-temperature origin for the vein deposits. A low-temperature origin would include pedogenic processes (i. e., those related to soil formation under prevailing climatic conditions). Some scientists have raised the possibility of high-temperature origins which could be associated with volcanic activity and elevated groundwater levels. Future studies are planned to investigate these deposits and other deposits in the area and region to resolve the question. It was stated by USGS and DOE investigators that additional geochemical work will be performed and that there are plans to deepen the trenches to determine the extent of the fault-filling calcite and silica. Additional discussions on the possible origin of the Trench 14

Photo 1. Group assembled to view calcite and silica vein deposits in Trench 14.

Photo 2. Closer view of calcite and silica vein deposits.

Photo 3. Trench 14 opposite side, vein contact with tuff block.

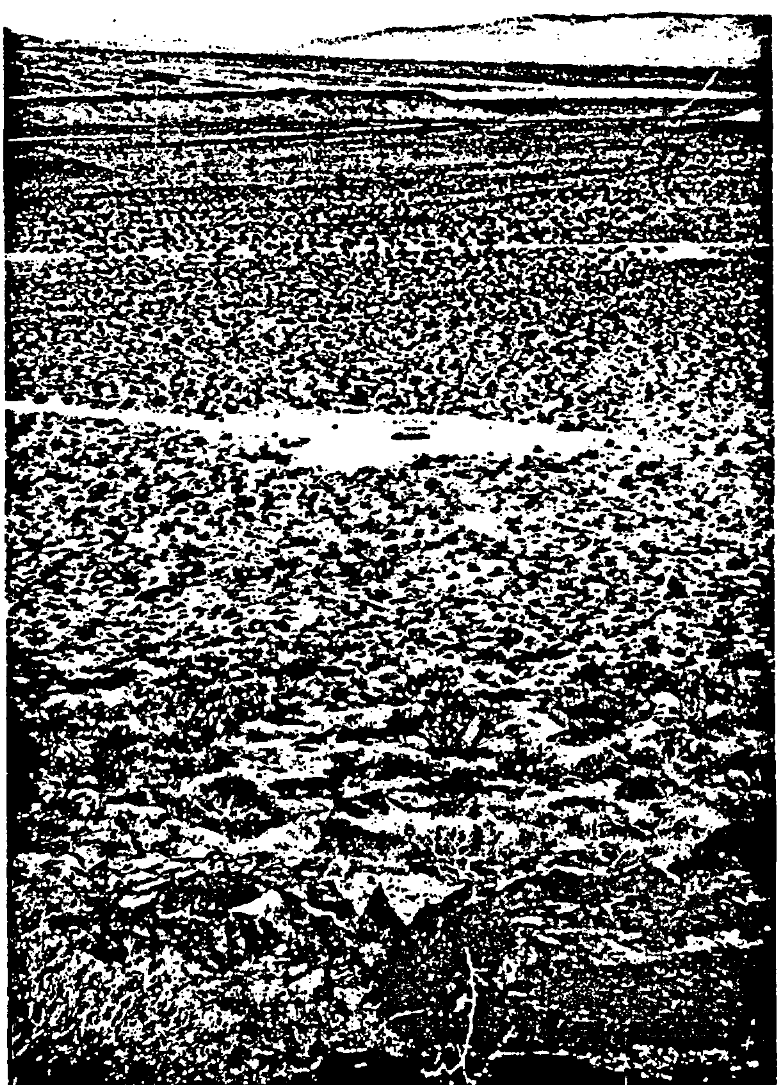


Photo 4. View from Exile Hill east toward future location of the Central Surface Facilities.

deposits are given by Vaniman, Bish and Chipera (1988) (Appendix E, attached). Photo 3 shows detail on the north wall of Trench 14. A comparison of photos 3 and 2 shows textural variations in the vein deposits between the north and south walls of the trench.

The trench will later be deepened between the lines on the trench floor shown in Photo 1. This deepening of the trench is planned to collect evidence on how deep the vein deposits may persist.

Photo 4 is a view to the east from the crest of Exile Hill located immediately east of the Trench 14 complex. This view is toward the proposed Central Surface Facilities, and shows no evidence of significant erosion.

Busted Butte sand ramps - tour & discussion J. Stuckless

The areas around Busted Butte (Photos 5,6,7,8,9) and along the western flank of Fran Ridge have prominent sand deposits several meters to tens of meters thick which record a sequence of wind-blown layers of sand that formed "sand ramps". Calcite-silica deposits which are either slope-parallel deposits or fault-filling vein deposits were observed in a sand ramp on the western flank of Busted Butte. According to Stuckless, these deposits are mineralogically and isotopically similar to those found in Trench 14 and 14a. Extensive occurrences of rootlets replaced by calcite mineralization are also present. The calcite in these deposits were dated to be 93,000 to 29,000 years old. J. Stuckless and S. Levy reiterated their belief that the calcite and silica are low-temperature deposits, most likely pedogenic in origin.

From this location we also observed a prominent basaltic cinder cone located southeast of Yucca Mountain. This cinder cone is shown in photo 9.

Photo 5. Paleosol with caliche and root casts at Busted Butte.

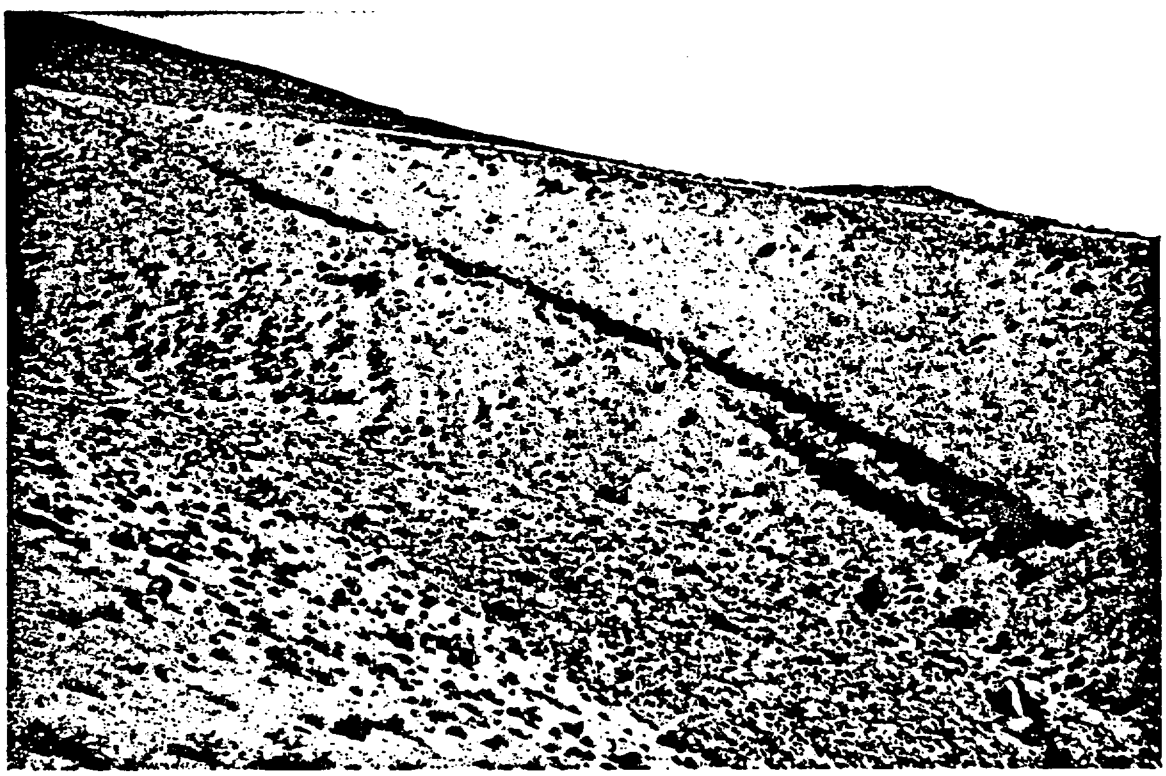


Photo 6. Sand ramp at Busted Butte with exposed paleosols.

Photo 7. Packrat midden (right) and bird's nest (left) in an outcrop on Busted Butte.

Photo 8. Sampling site in calcite vein deposit on Busted Butte.

Photo 9. View of cinder cone in far right background from the sand ramps at Busted Butte.

Yucca Crest

B. Hughes

This location afforded excellent views in all directions from the crest. Photo 10 is a view to the north showing the tour group assembled at the crest. Note the exposed bedding planes in the tuffs along this western flank of Yucca Mt. Photo 11 is also a view toward the north from the crest. We observed the prominent basaltic cinder cones located to the southwest and southeast. Photo 12 is a view to the west across the Solitario Canyon. Drillholes of the UZ-6 cluster have been established at this location along the crest of Yucca Mt. (Photos 13 and 15). Two meteorological stations are in operation at the crest (Photos 14 and 18), including tipping-bucket rain gages (Photos 16,17,19,20). Overall, the location at the crest afforded the best ground-based view of the topographic environs of Yucca Mt. Photo 15 shows the wellhead at UZ-6S, located at Yucca crest. Installed in the top of the wellbore is an instrument to measure air flow in and out of the borehole.

Photo 10. Group at the crest of Yucca Mountain.

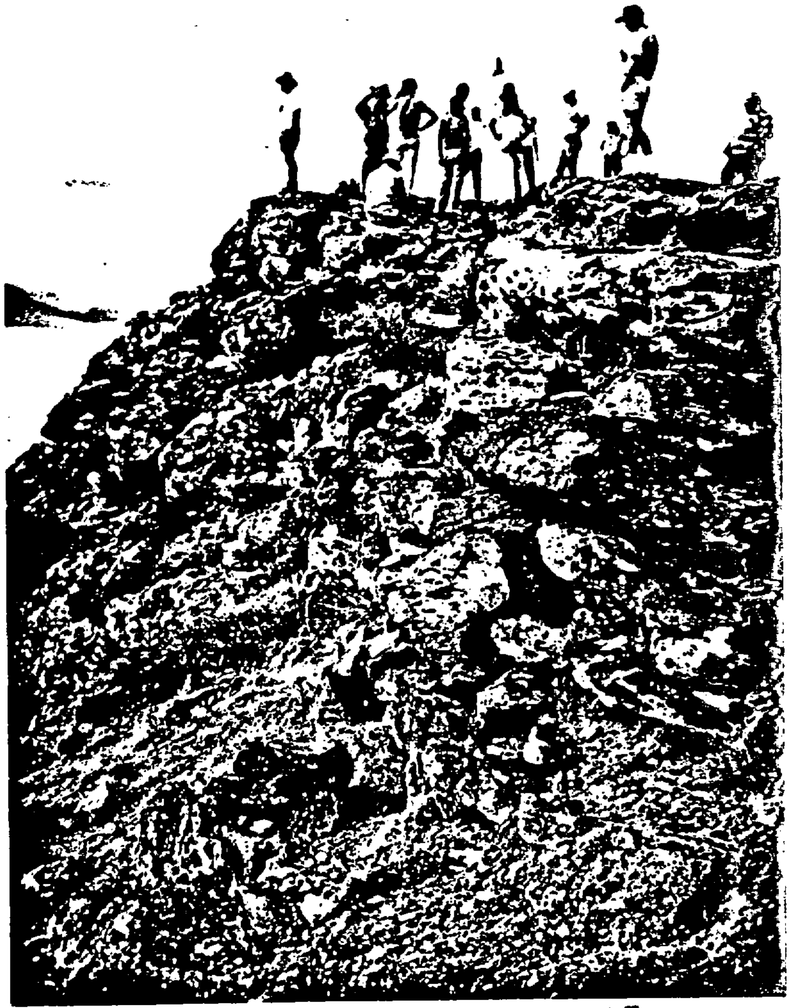


Photo 11. View to the north from crest of Yucca Mountain.

Photo 12. View west across Solitario Canyon from the crest of Yucca Mountain. Drill hole H6 in channel, upper center of photo.

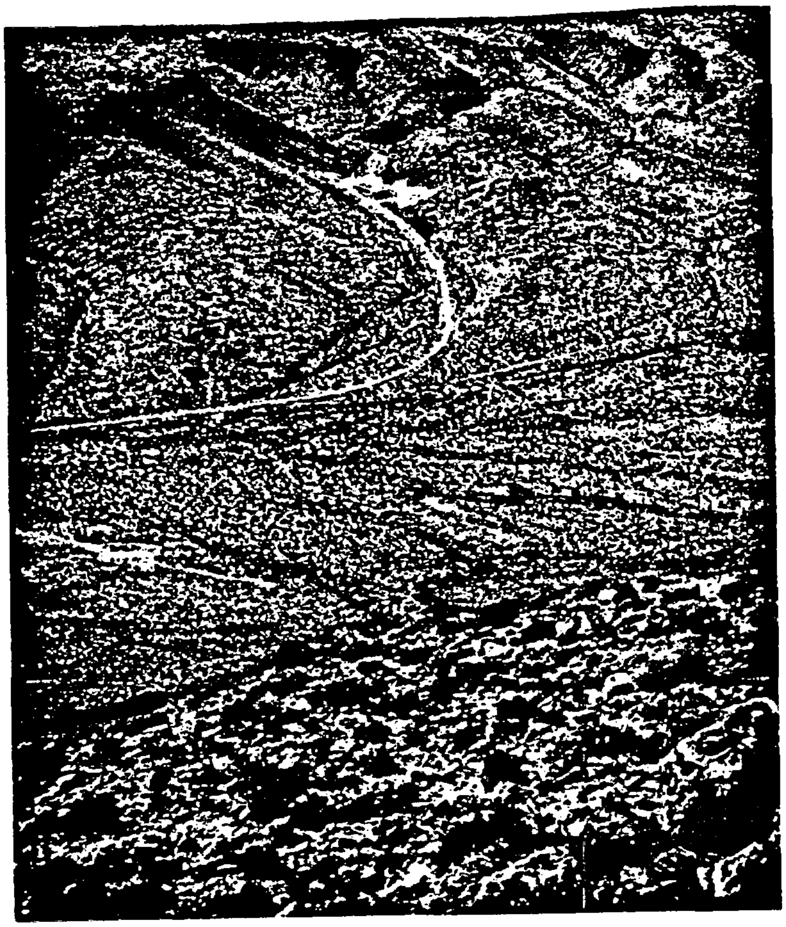


Photo 13. Locations of wells in the UZ-6 cluster near crest of Yucca Mt.

Photo 14. NTS meteorological monitoring tower, raingage (right), and well top (front right), crest of Yucca Mountain.

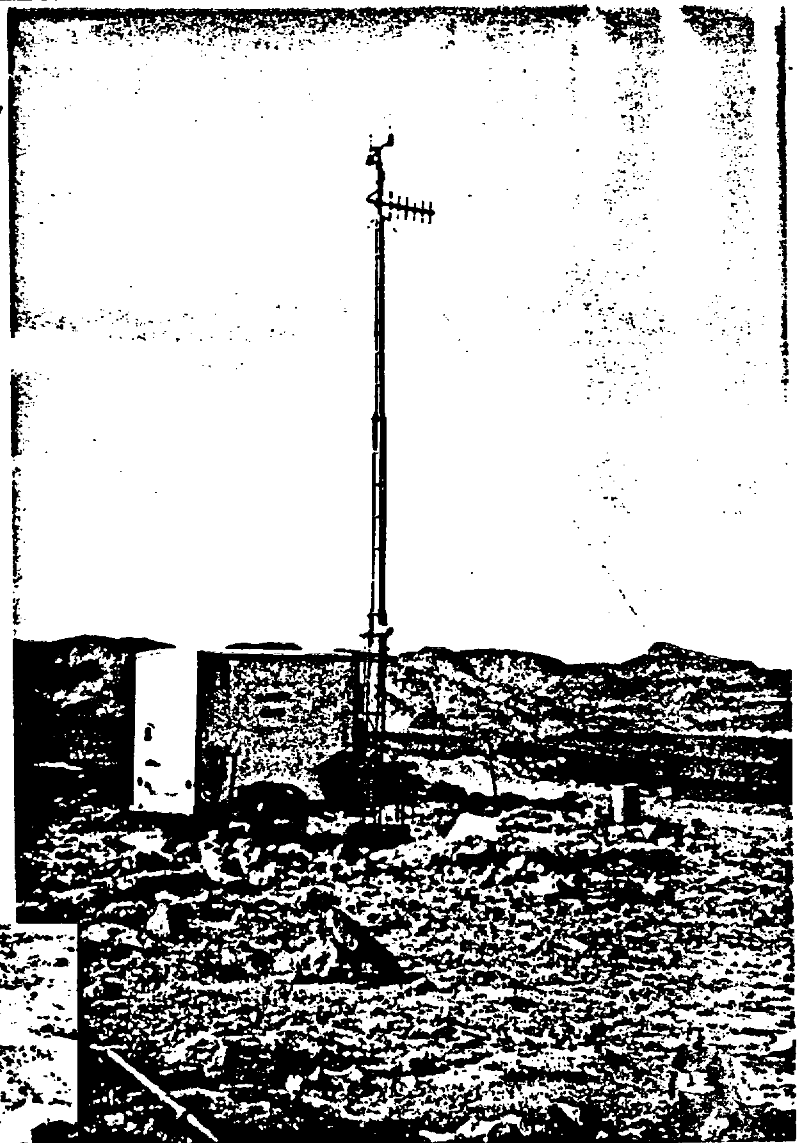


Photo 15. Well head at UZ-6s (see Photo 14.) with instrument to measure air flow.

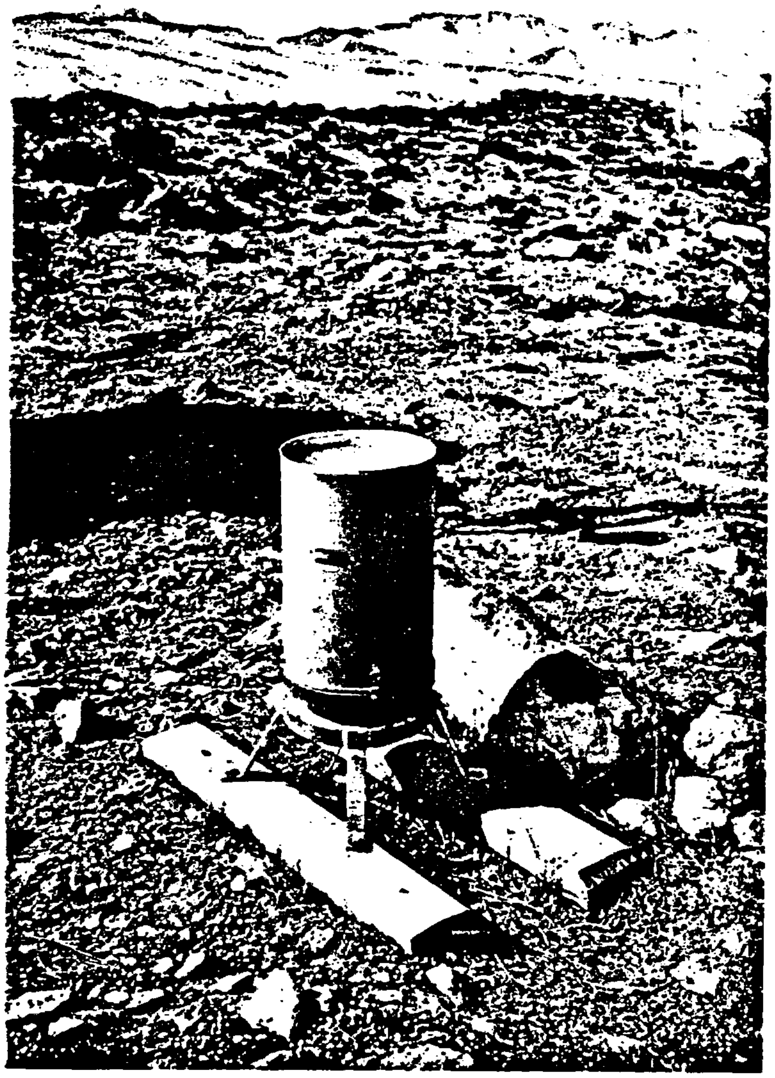


Photo 16. NTS rain gage at crest of Yucca Mountain. See Photo 14.

Photo 17. View inside the NTS rain gage showing the tipping bucket mechanism. Note dust accumulation in the little bucket.

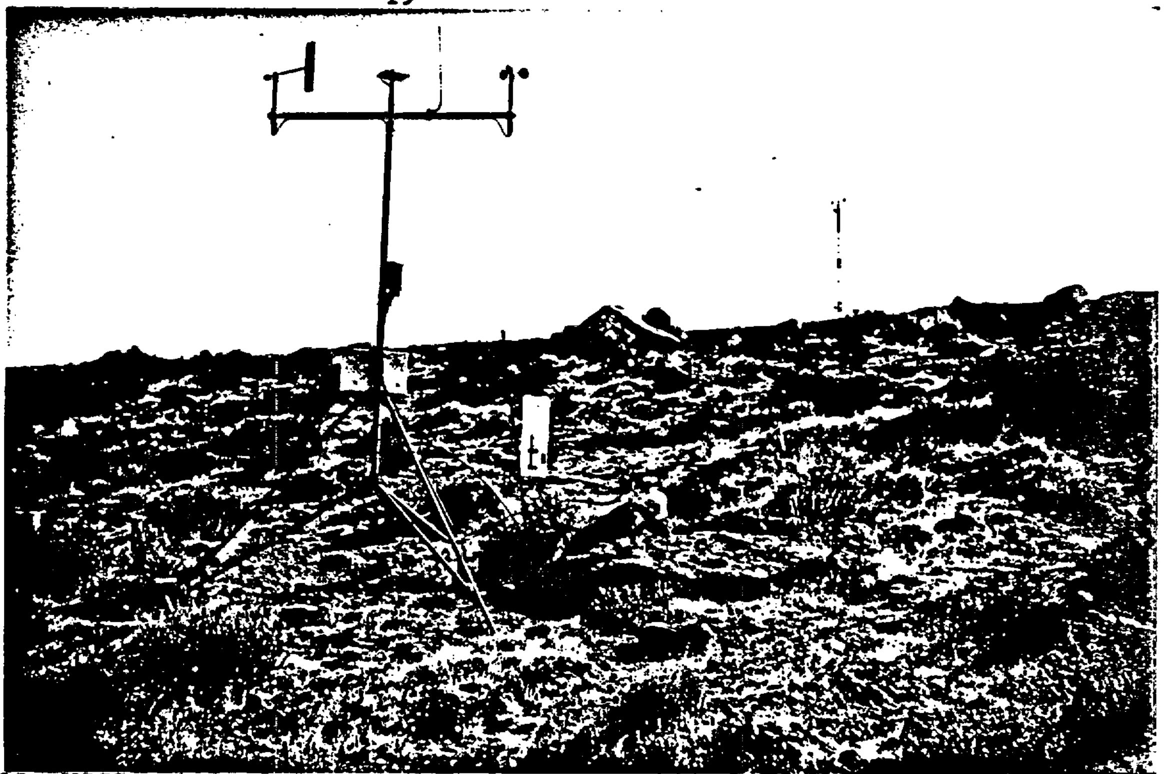


Photo 18. USGS meteor-
ological station with
NTS meteorological
tower in background.

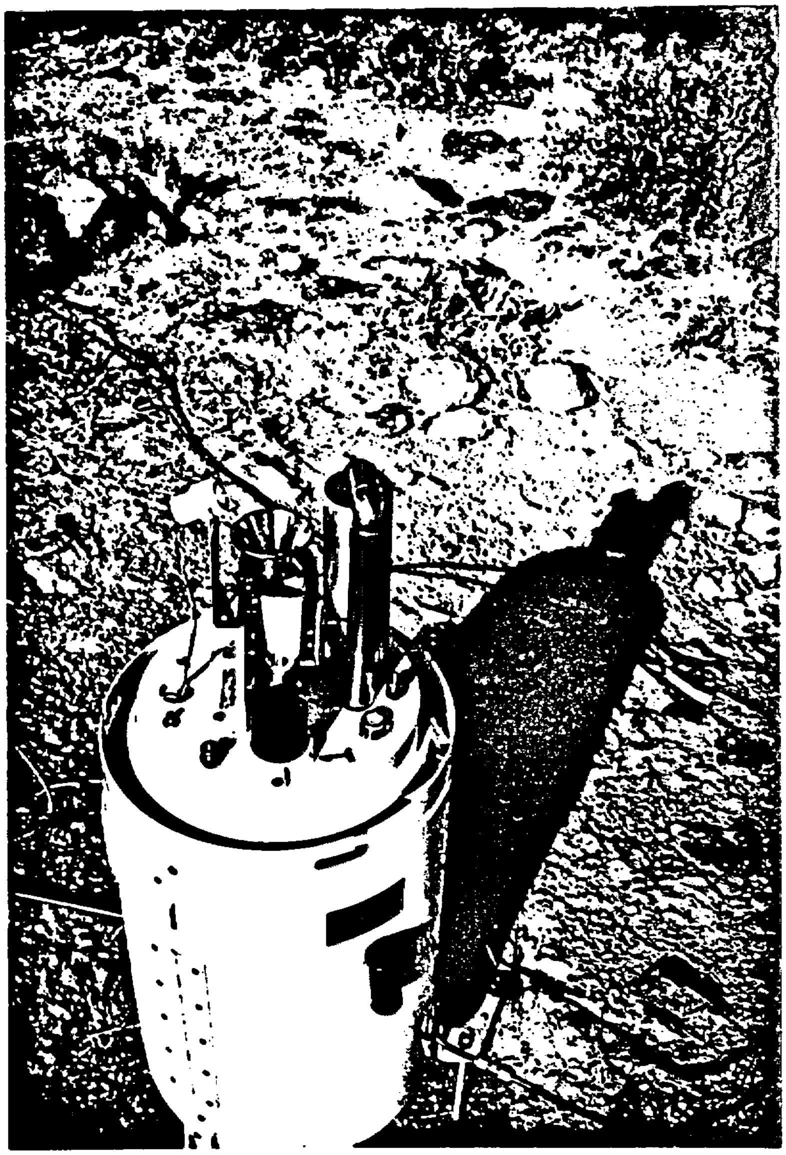


Photo 19. USGS tipping
bucket rain gage,
inside view.

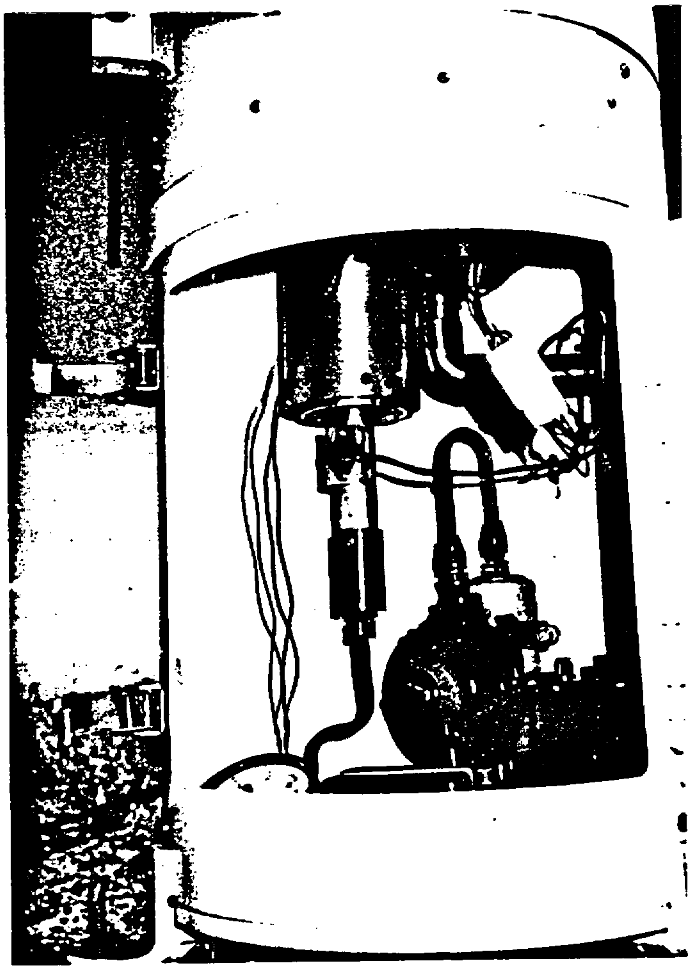


Photo 20. Lower inside view of the USGS rain gage showing the propane heating apparatus.

July 25, 1989 - NTS and Yucca Mountain

Ground-water gradient, age of ground-water J. Czarnecki

John Czarnecki described the possible role of 40-Mile Wash in local and regional hydrogeology. Well UE-29A1 (Photos 21,22) drilled into the alluvial sediment of 40-Mile Wash, encountered the water table at about 100 ft. A second well (UE-29A2) was drilled about 29 ft. away to determine if UE-29A1 encountered a perched water table, but the second well also intersected the water table at about the same depth. The groundwater was dated to be about 3,000 years old, which suggests the groundwater is much younger than at the Yucca Mt. site. The wash may be a major recharge area for groundwater that flows toward and beneath the site. A preliminary look at the geochemistry of surface waters in the wash shows some similarity to the underlying groundwater. However, waters are typically younger near the surface and become older at greater depths. The USGS stated that the last major flow (and possible channel recharge) event in the wash was in 1984. Dr. Czarnecki's preliminary calculations based on his model suggest that doubling the amount of precipitation in the recharge area may raise the water table at Yucca Mt. by 150 meters.

Dr. Czarnecki indicated that the USGS is considering drilling a series of vadose zone holes along the wash near this area to be able to define recharge during the next flooding event. In the meantime, there are plans for artificial infiltration studies in the area.

Photo 21. View north, along upper terrace of of Forty-Mile Wash. Note the alluvial deposits.

Photo 22. Well UE-29 A#1 in the upper reach of Forty-Mile wash monitor- the saturated zone.

Ground-water level measurement demonstation Baldwin

The USGS staff demonstrated the techniques used to manually measure water levels in areas where the water table is very deep (Photos 23,24,25). The method involves placing about 5 ft of double-sided, clear, adhesive tape on the end of a well tape, then dipping the sticky tape in table salt. A plastic sleeve is then placed over the salted tape, sealed at the top and left open at the bottom. The USGS staff said that this is one of the most accurate methods available for manual measurements in deep wells. Methods for measuring water levels in shallow wells were also demonstrated. In general, water table measurements are made either monthly or semi-annually, depending on the particular well.

Gage at Narrows site on 40-mile Wash Stream D. Beck/P. Glancy
Gaging, Scour chains

The USGS has established a flow measuring station at the Narrows, one of the narrowest channel segments of 40-Mile Wash. The confinement of the wash at this point is caused by resistant rock outcrops. A nitrogen pressure gage and gage house are located on the eastern side of the channel (Photos 26,28). Crest stage gages are placed on both sides of the channel (Photo 27). Erosion of the sand and gravel deposits that fill the channel results in an uneven, variable channel base during major events, a condition that makes it difficult to accurately estimate discharges. Scour chains (Photo 29) have been buried in the bed to help show how much the base of the channel will be disturbed by the next flooding event.

The major precipitation event in 1984 indicated the need for a much more extensive rain gage network to evaluate regional and local precipitation levels.

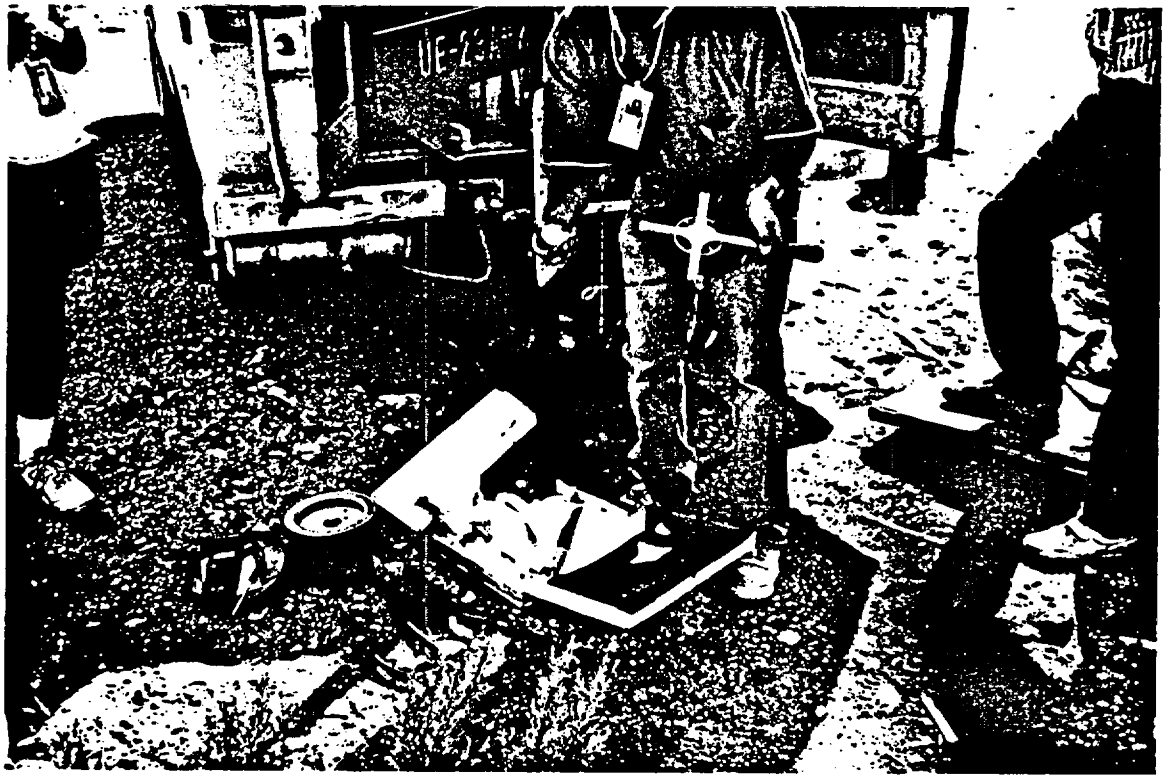


Photo 23. Well monitoring accessories - from left: digital thermometer, altimeter, blue chalk, and small measuring tape.

Photo 24. Demonstration of manual water level measurement at well UE-29A#2 (applying sticky tape to the steel measuring tape and then salt is spread on the sticky tape).

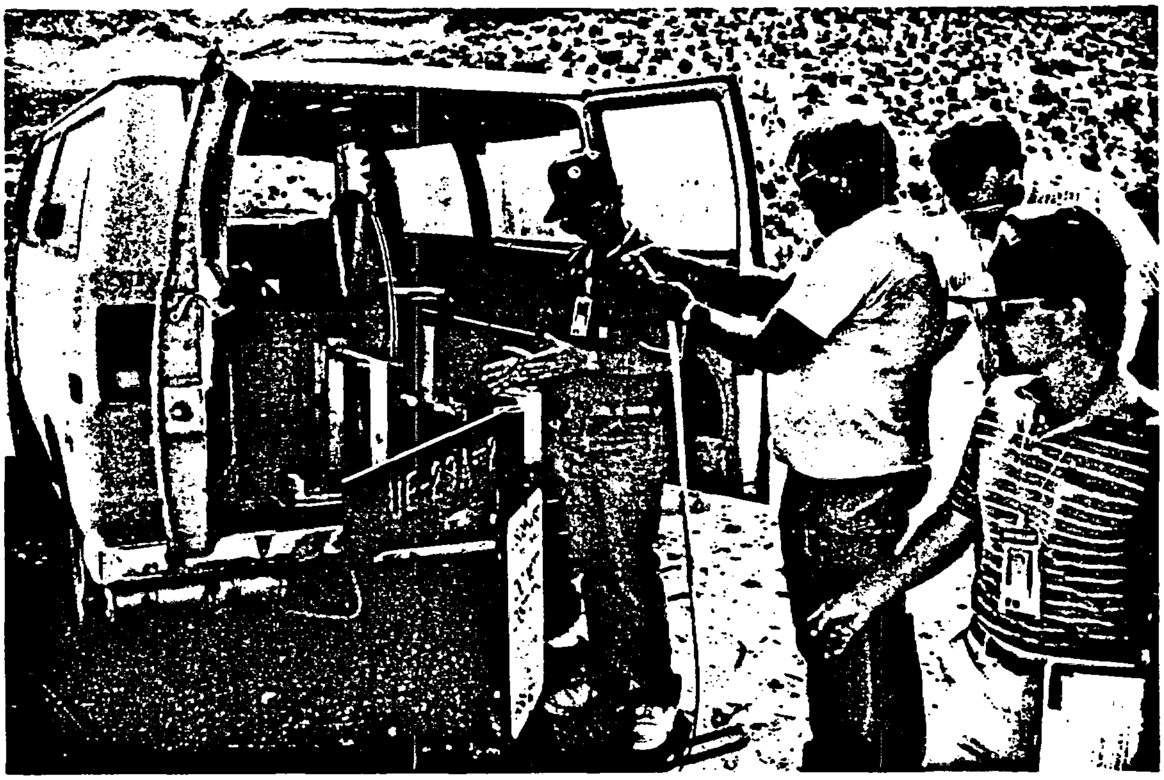


Photo 25. Sliding plastic sleeve over the salted measuring tape. Note the large motor driven reel with steel measuring tape inside the van for measuring water levels in deep wells.

Photo 26. Stream flow gaging station at "The Narrows" in Forty-Mile Wash. Nitrogen pressure line in pipe for measur- water levels. Note the debris on the pipe which shows the highest level reached by last flood in the channel (1984).

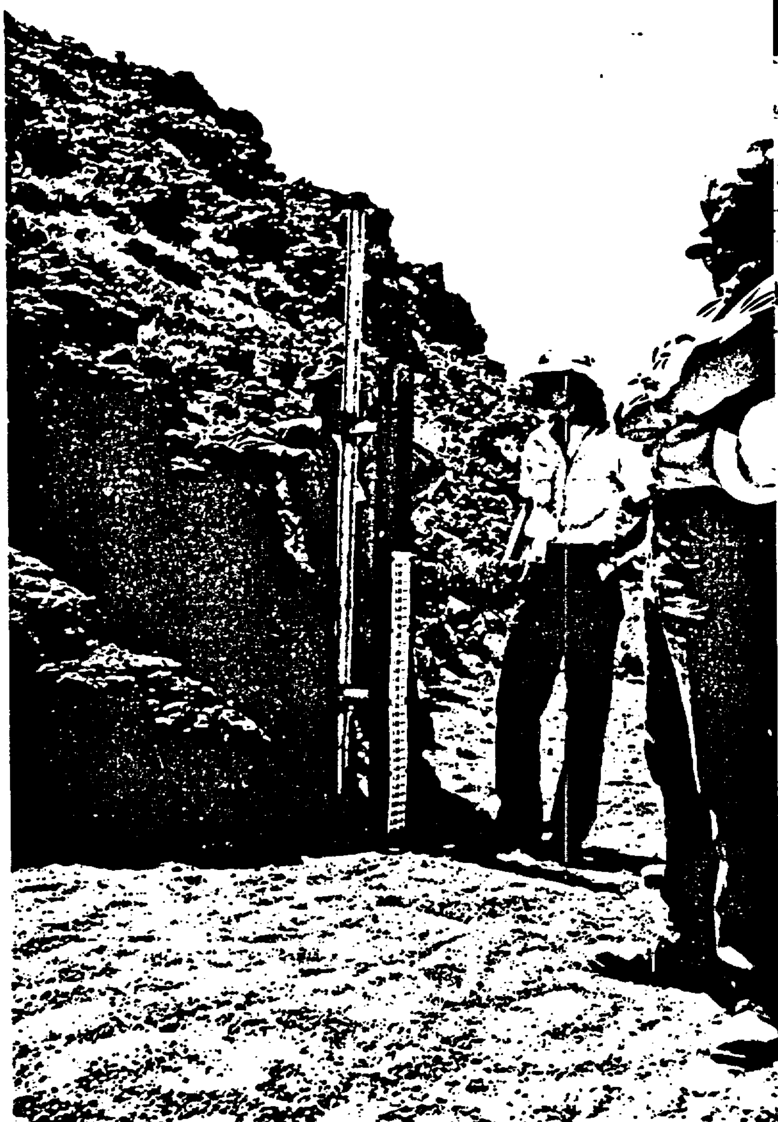


Photo 27. Staff gage and flood crest gage (pipe with measuring staff and powdered cork).

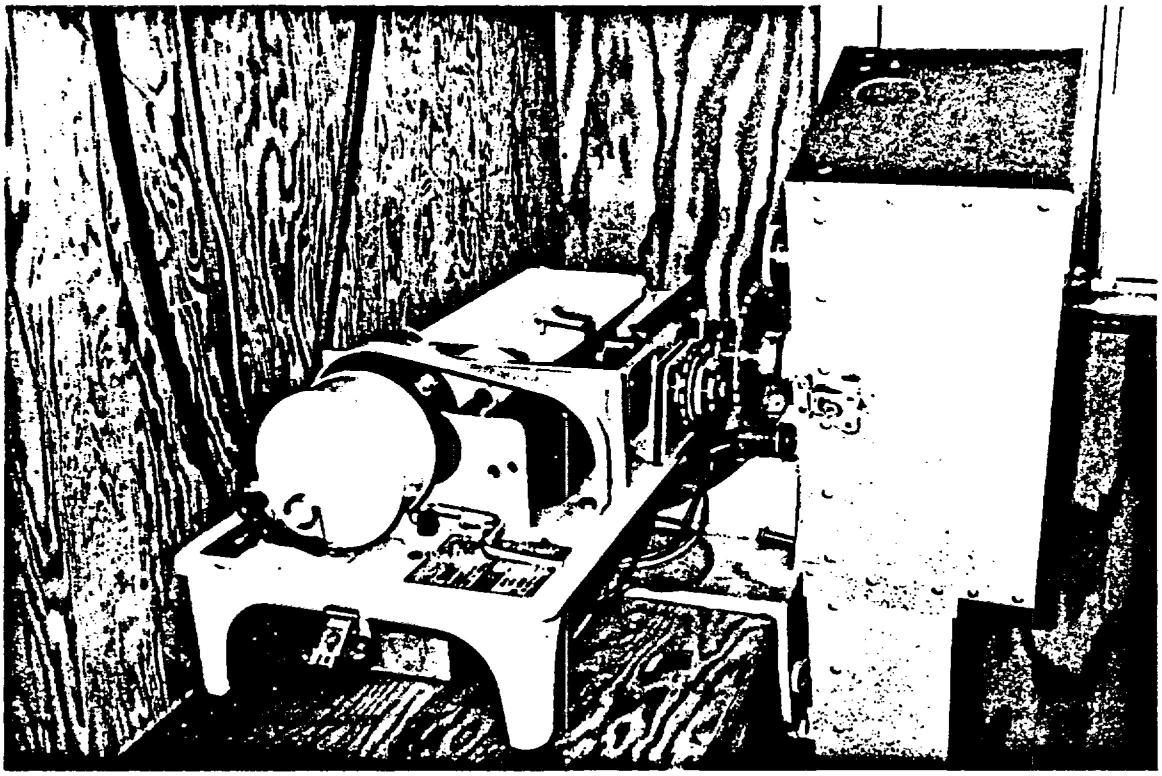


Photo 28. A-35 strip chart recorder and nitrogen bubbler mechanism in gage house at "The Narrows."

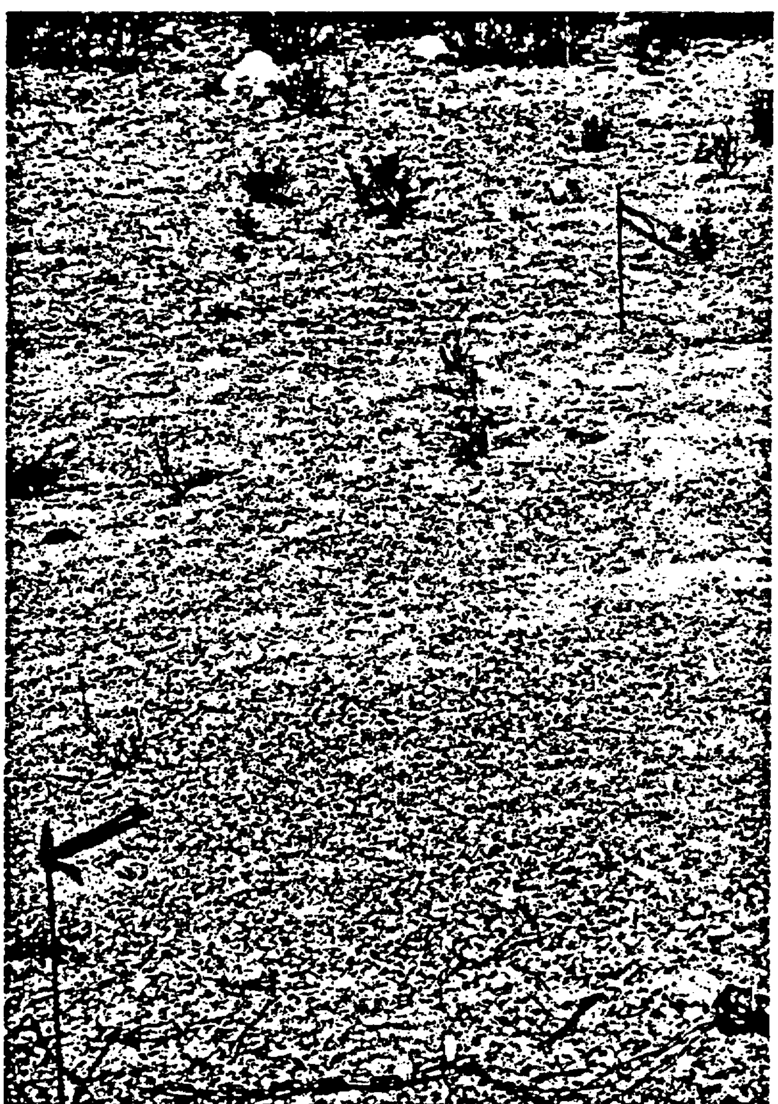


Photo 29. Scour chains across the channel at "The Narrows."

40-Mile Wash Recharge Studies Savard

A neutron hole is located about 80-90 m up-channel from the gage house to help monitor current conditions and infiltration after the next flow event.

WT-15 (Continuation of discussion from UE-29A2) J. Czarnecki

The location of this stop at well WT-15 is shown in Figure 4. This figure also shows locations of other water table monitoring wells in relation to the proposed perimeter drift (dotted line). Czarnecki stated that the depth to groundwater at this site (Photo 30) is about 350 m below the surface. The dramatic decrease in water levels from north to south has previously been interpreted to be caused by some kind of groundwater barrier. This "barrier" would be located somewhere between wells WT-15 and UE-29A. An alternative interpretation given by Czarnecki is that the average hydraulic conductivity of the unconfined aquifer system increases toward the south, resulting in lower hydraulic heads and very low lateral hydraulic gradients.

Neutron hole data collection (Pagany Wash) A. Flint/ D. Blout

Alan Flint of the USGS described the types of testing conducted in Pagany wash. A series of 8 neutron holes 5 to 10 m deep have been placed across the wash (Photo 31). A demonstration of periodic neutron measurements was made in hole UE-25UZ-N8 (Photo 32). Most of the holes are drilled in alluvium, terminating at or a short distance into the bedrock. Some alteration of the site was performed to protect equipment from flooding, such as the construction of earthen dikes at a short distance up the wash.

At this site, it is reported that tritium levels characteristic of the pre-bomb period occur at a depth of about 18 ft. It was mentioned that elsewhere at the site, bomb tritium has been found much deeper, on the order of hundreds of

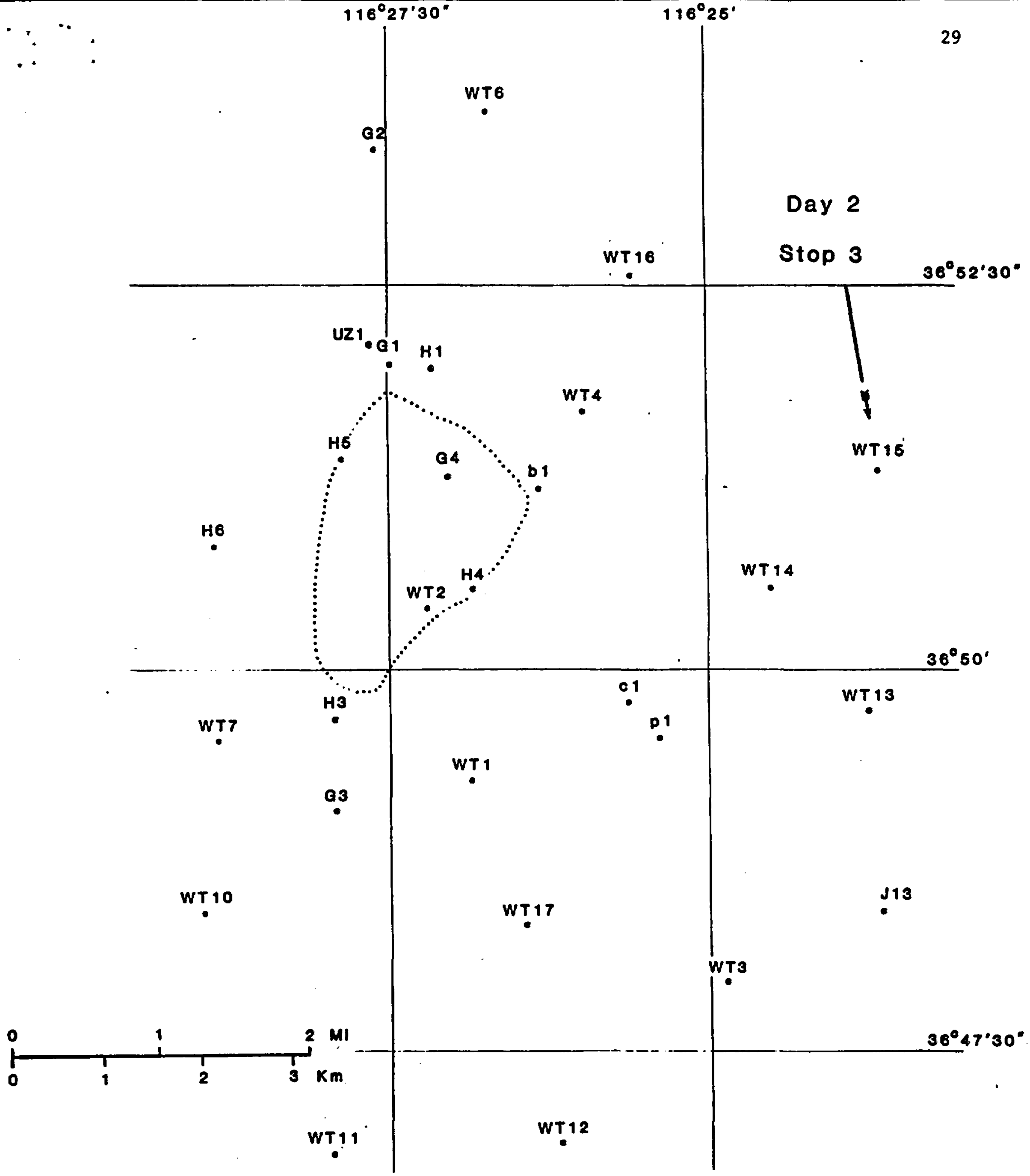


Figure 4. Location of stop 3 on day 2 (well WT-15)

Photo 30. Well WT-15 a saturated zone monitoring well near the mid reach of Forty-Mile Wash where the water level is about 450 feet below the surface.

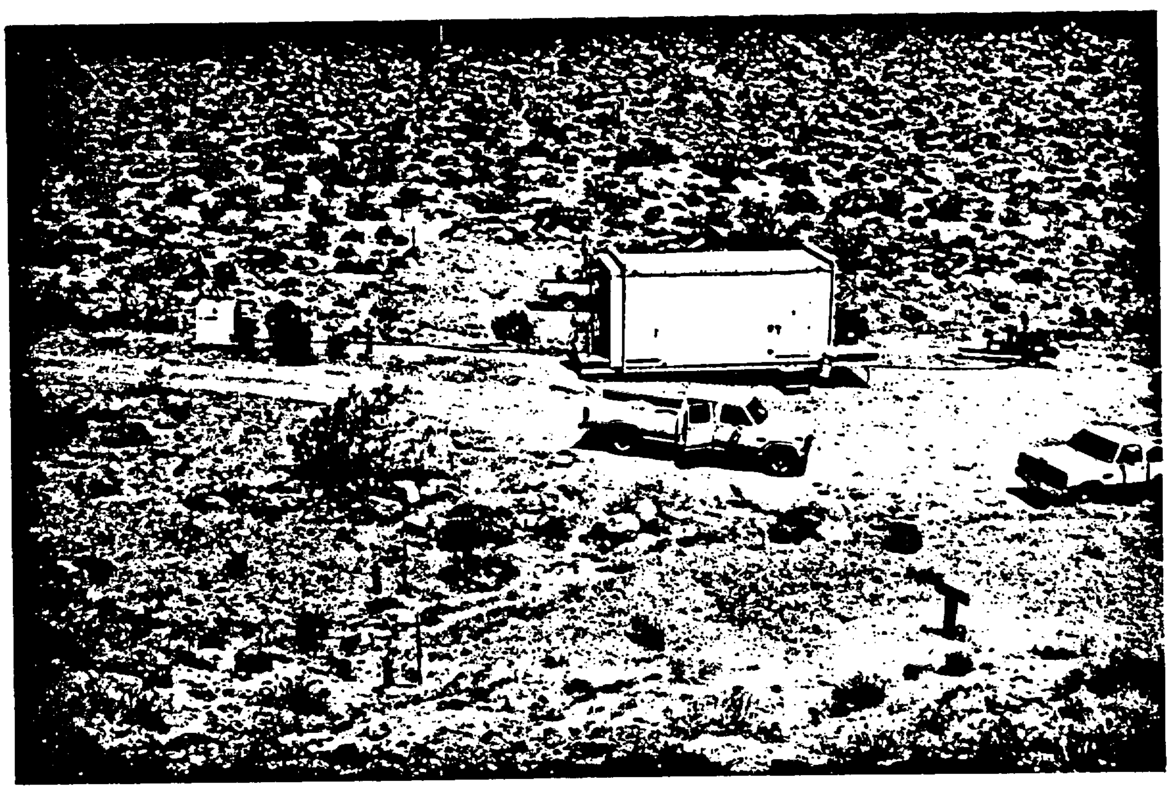


Photo 31. A line of neutron monitoring holes across Pagany Wash and deep well UE25 WT18, at the end of the white sand bags.

Photo 32. Demonstration of a neutron probe measurement of moisture content in channel alluvium, Pagany Wash.

feet. Initial results indicated that below about 2 to 3 meters, the moisture level in the unsaturated zone changes very little (by only about 2-3%). It was also stated that inifiltration into the alluvial sediments is fast, reaching 15 ft in a 24 hour period. A major problem with using neutron logs is calibration of the instrument because of the varying lithology below the surface. There are plans for drilling and correlating neutron logs with the mineralogy of the core samples. Previous results for the neutron logs are kept in the form of raw data (counts per unit time) until an adequate calibration equation is available to convert the raw data into water content.

A question was asked of the USGS regarding what reliance could be placed on isotopic data from the deep unsaturated zone for isotopes such as tritium and carbon-14, which can move between the liquid and vapor phases. One response was that if in the unsaturated zone post-bomb levels of these radioisotopes are not found it might be concluded that the groundwater is old. However, if post-bomb levels of radioisotopes are found, it would be necessary to determine if they were transported either as a vapor or a liquid (or both). The detection of post-bomb levels of radioisotopes in the deep unsaturated zone could be used as an indicator of groundwater travel time in that zone.

Meteorological data collection (UZ-1) A. Flint

A. Flint demonstrated the collection of data from a meteorological station. Data on temperature, wind velocity and direction, humidity, precipitation, barometric pressure, and incoming solar radiation (Photo 33). He then discussed some of the problems encountered with equipment used to monitor meterological conditions. For example, tipping bucket rain gages have shown as much as 30% error in controlled tests, even some of those calibrated by the manufacturer againsts NBS traceable standards. The USGS is working with the manufacturers of this and other equipment to try to improve the measurement accuracy and precision. They will be presenting a paper at an upcoming meeting to publish results to date.

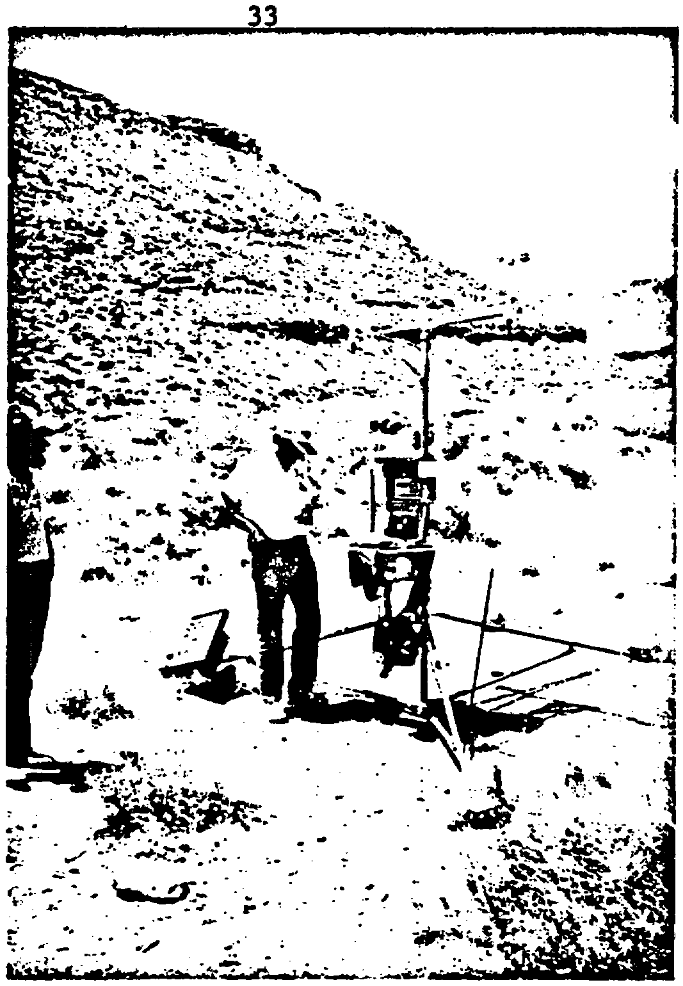


Photo 33. USGS meteorological station near UZ-1.

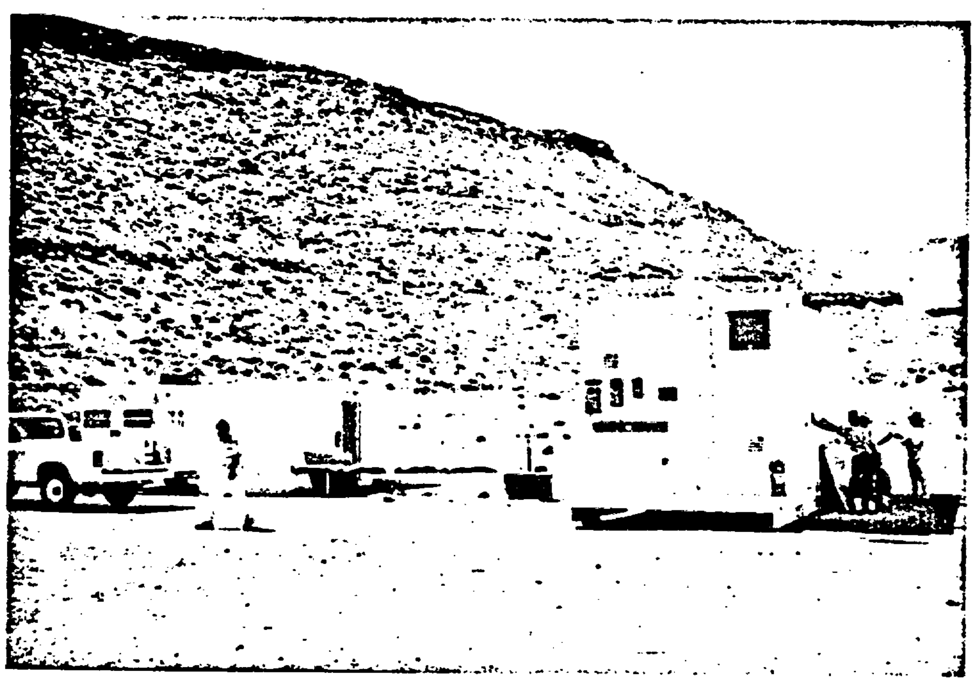


Photo 34. Special designed data collection trailer (right side of photo) for deep unsaturated well tests. Well UZ-1 just to left side of trailer. Data are transmitted to a base station by microwaves.

The data acquisition is automated. The meteorological stations have DataLoggers (Campbell) which record the various data like temperature, barometric pressure, wind speed and direction, etc. onto a cassette tape which is then retrieved on a periodic basis. These data are then transferred into a local database at the USGS YMP Hydrologic Research Facility adjacent to the Sample Management Facility (SMF).

Deep Unsaturated Zone data collection (UZ-1) J. Rousseau

Rufus Getzen described a sophisticated data acquisition system they have setup in a trailer to monitor (in real time) the psychrometers and other equipment in well UZ-1 (Photo 34). The system cost approximately $300,000 to develop and construct, but they hope to bring down the cost when they set up 10 more of these stations. At present, however, most data collection at UZ-1 has been terminated.

Based on the experience gained from UZ-1, future deep, unsaturated borehole installations will be developed using a number of design modifications. These include:

1. Access for replacing individual instruments (transducers, psychrometers, etc.) that fail.
2. Overall simplification of downhole instrumentation and emplacement modes.
3. Real-time data aquisition and transmission to the USGS facility near the SMF.

UZ hydrochemical data collection C. Peters

This discussion concentrated on gas sampling from UZ-1. C. Peters described the methods used to get gas samples from the UZ-1 hole for chemical and isotopic analysis. It takes about 3-10 days to take a 1/2 liter sample. A problem with their method is the condensation of moisture inside the holes leading to erratic results.

ESF tour/discussion (Coyote Wash) B. Hughes

We visited Coyote Wash and the staked-out location for the ESF (Photos 35,36,37,39). The new ESF site is located further up the hillside from the previous location and should be much better protected from any possible flooding or debris hazards. Views of nearby washes are given in Photos 35 and 37. The view in Photos 38 and 39 is from the bottom of the channel toward the ESF location on the hillside where the people are standing [in Photo 37].

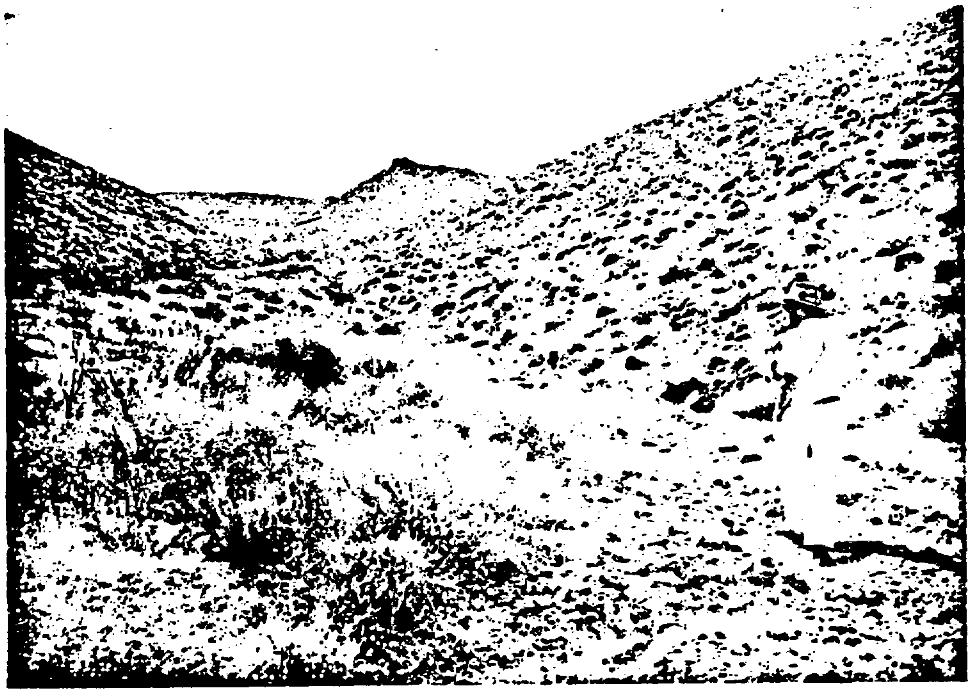


Photo 35. Channel of dry wash upstream from the ESF location.

Photo 36. Proposed ESF location. View west toward upper watershed areas.

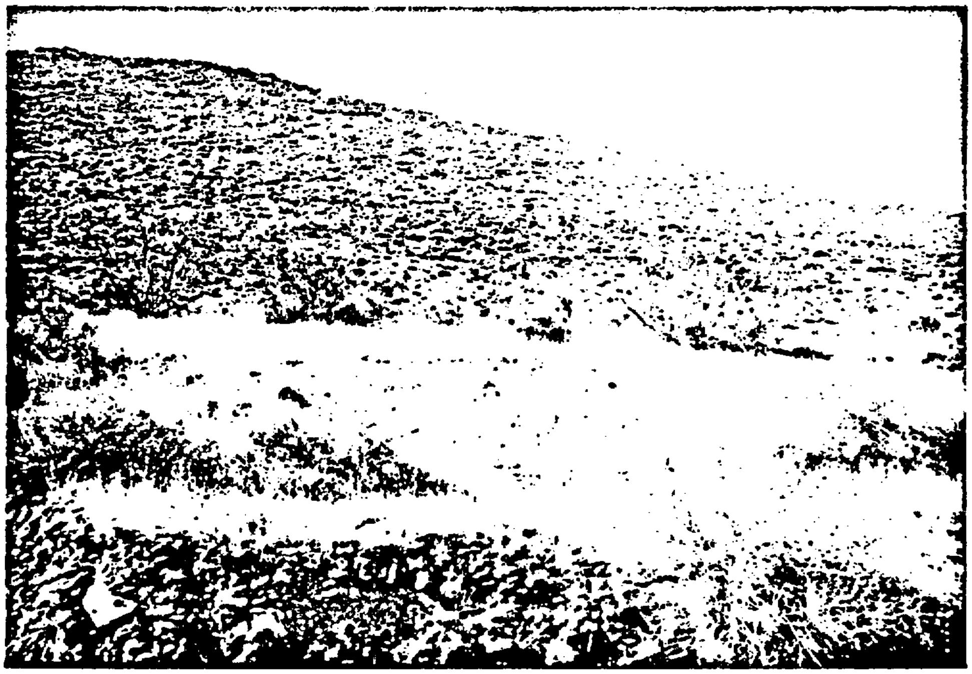


Photo 37. View from bottom of channel directly below ESF location (see people on the hillside).

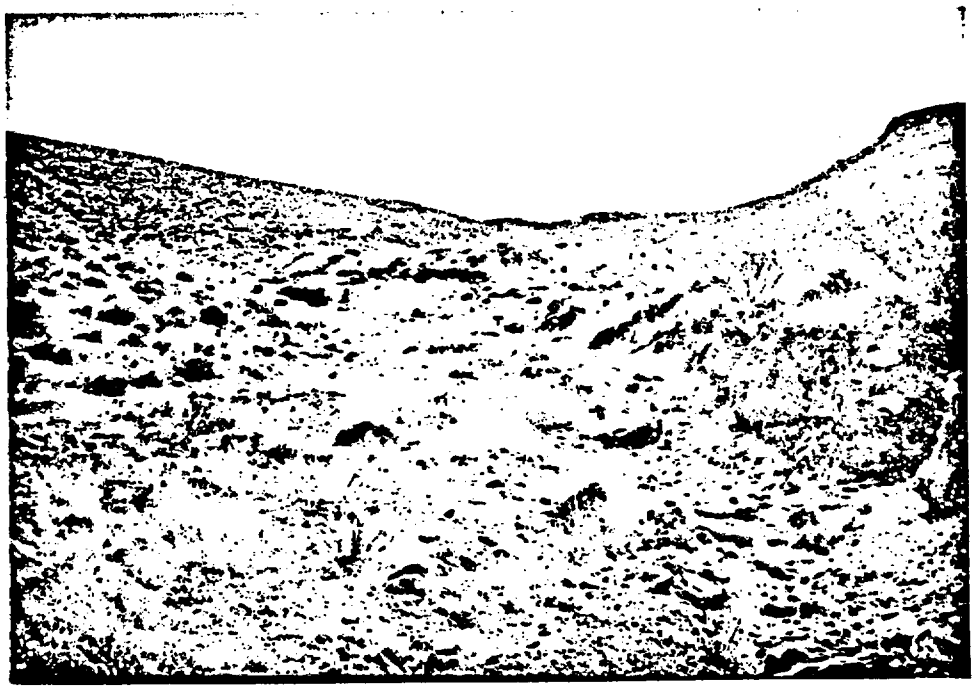


Photo 38. Channel directly below ESF location looking upstream.

Photo 39. View further up-channel from scene in Photo 38. Note fracture in bedrock exposed in channel bed at lower left.

July 26, 1989

Tour Sample Management Facility (SMF) - Observation of selected core

C. Lewis

A tcur of the SMF in Area 25 of the Nevada Research and Development Area (NRDA) was provided by C. Lewis (refer to Photos (40,41,43,44,45). The SMF consists of two large warehouse-type buildings and several smaller storage areas and includes a reception area, office spaces, low-temperature storage area (for unsaturated zone and water samples), a large core warehouse/archive, and sample preparation areas. There are two core examination rooms, one of which will be used for older core samples. Technical and administrative procedures have been prepared to control the acquisition, chain-of-custody, storage and preparation of samples frcm drill core and cuttings. Samples are tagged with bar codes (Photo 42), and real time communication with a computer database at the Las Vegas office is available. Polaroid photographs of the core samples are taken before the core boxes are transported to enable reconstruction of the core sequence in case of an accident.

Core samples from drill holes Utah Prototype and G-4 were examined. The G-4 drill cores represent a stratigraphic cross-section of Yucca Mt. The Utah Prototype drill cores were obtained during the prototype drilling program which tested various techniques for dry core drilling. A 10-minute video on this prototype drilling program was also showo.

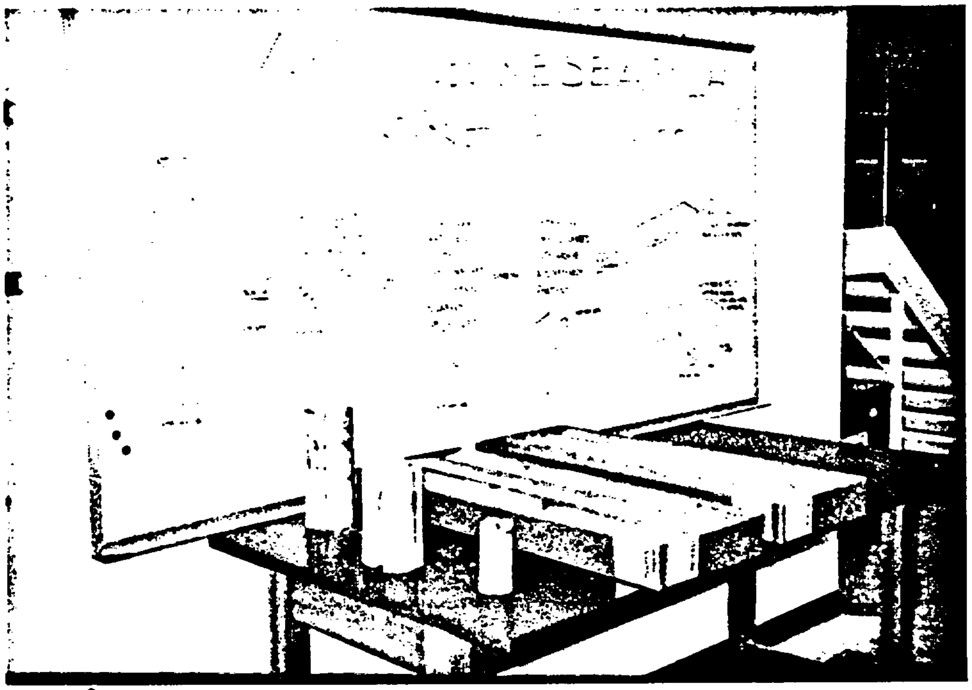


Photo 40. Poster of core handling process at the Sample Management Facility.

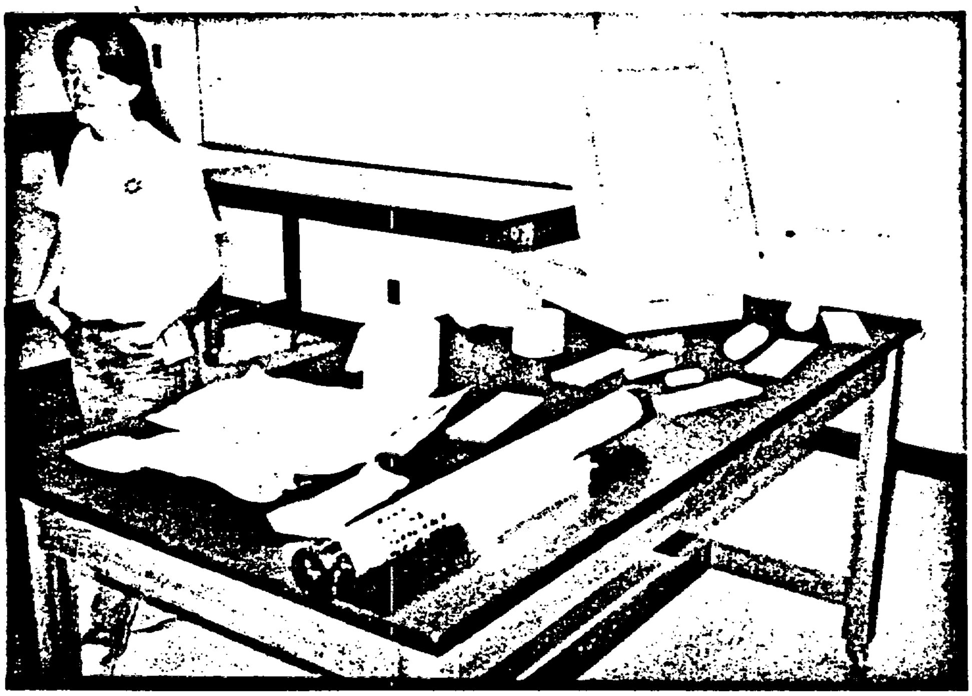


Photo 41. Sealing materials for core samples.

Photo 42. Fred Ross with bar code reader.

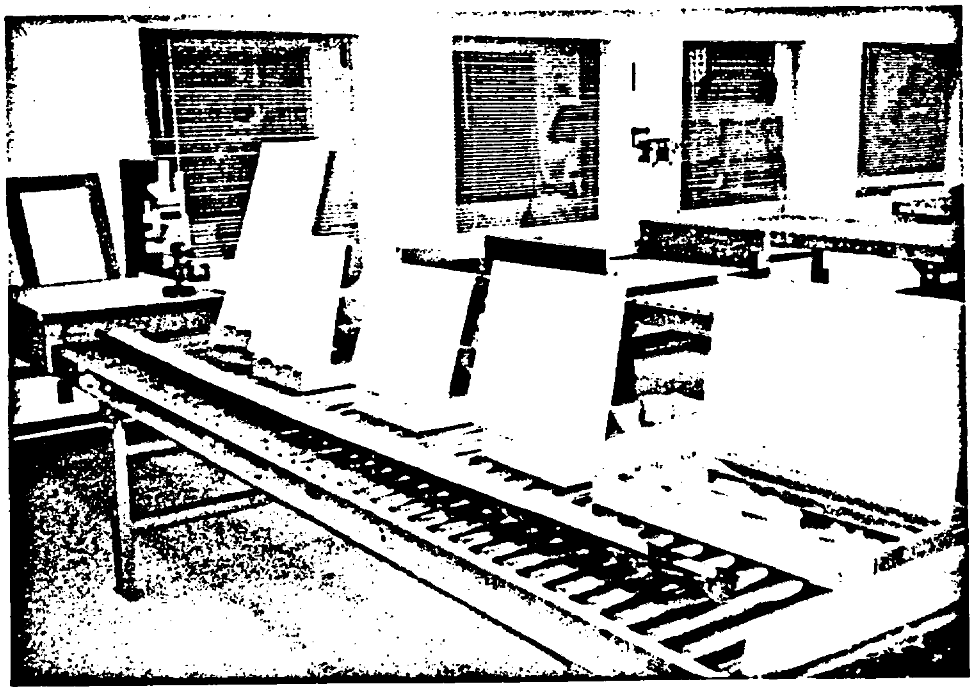


Photo 43. Selected cores on display at the Sample Management Facility.

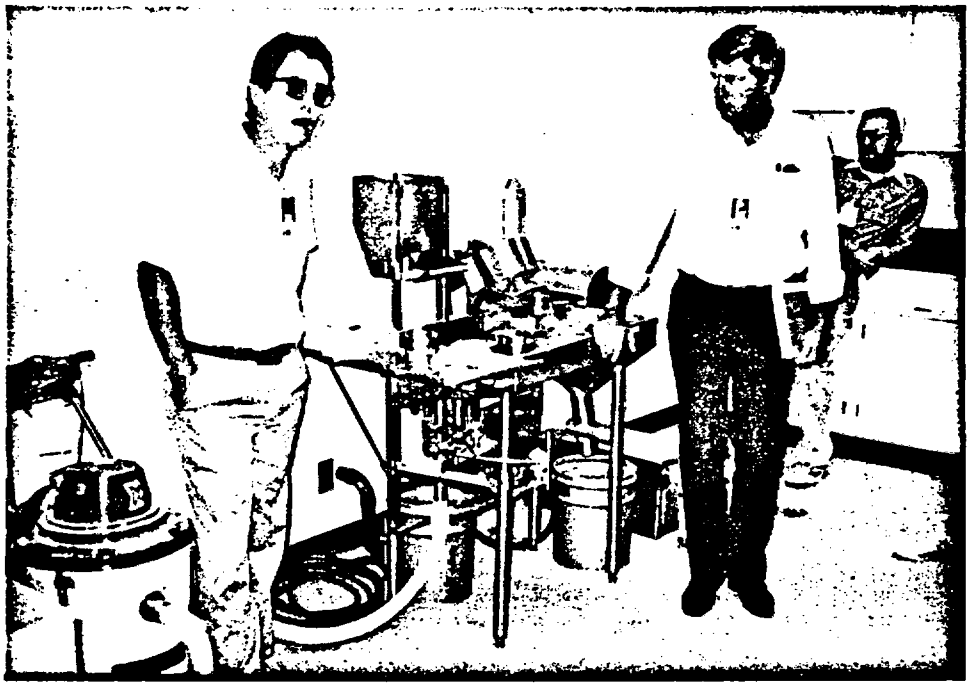


Photo 44. Core cutting equipment at the Sample Management Facility.

Photo 45. Selected cores cut in half.

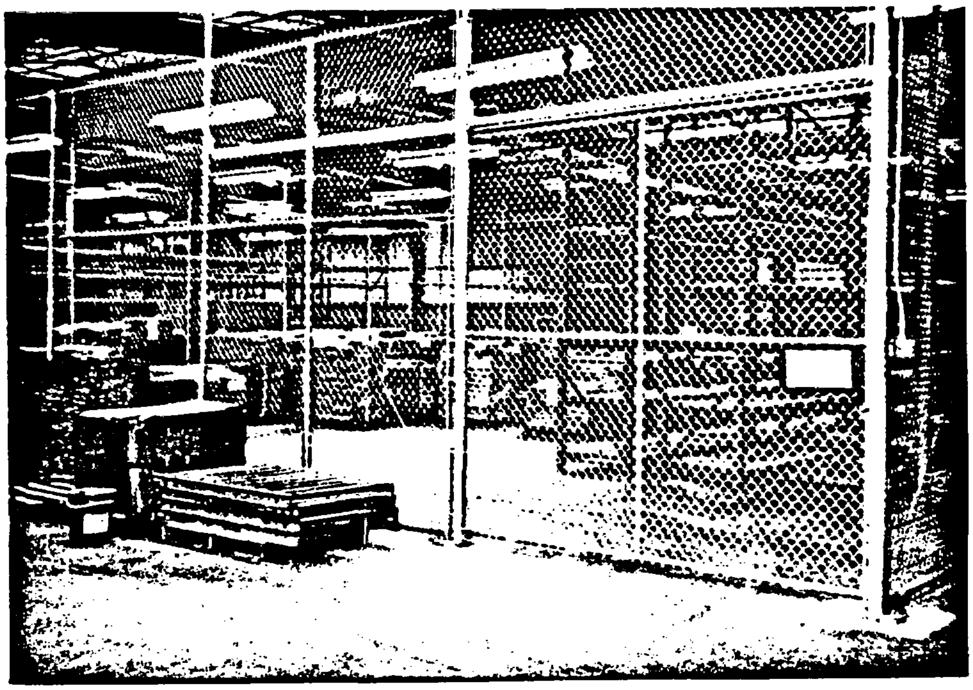


Photo 46. Secure storage area at the Sample Management Facility.

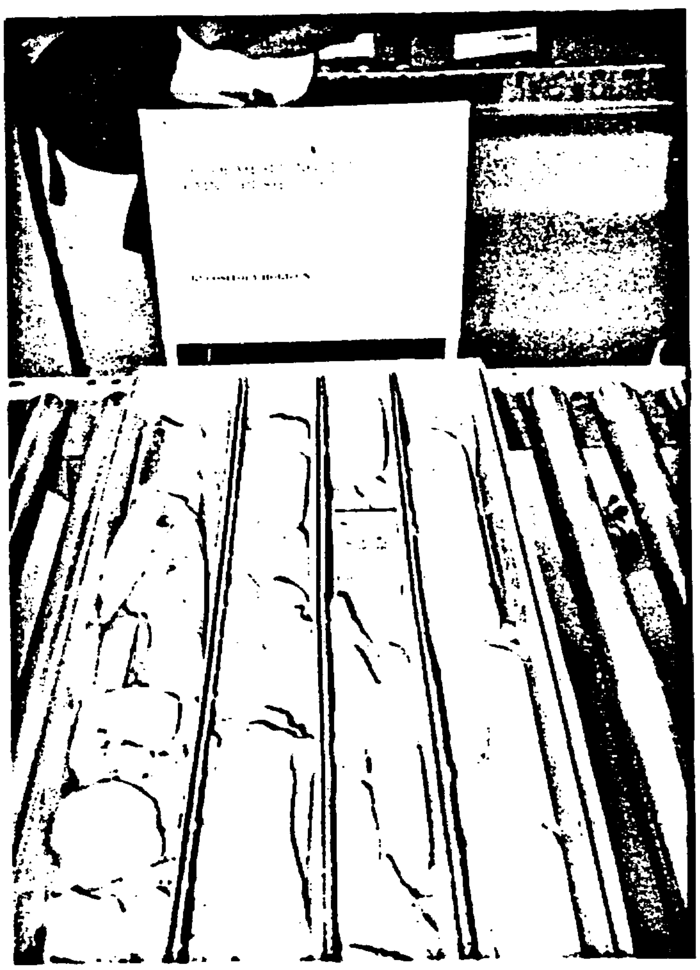


Photo 47. Selected cores from the Topopah Spring member of Paintbursh Tuff.

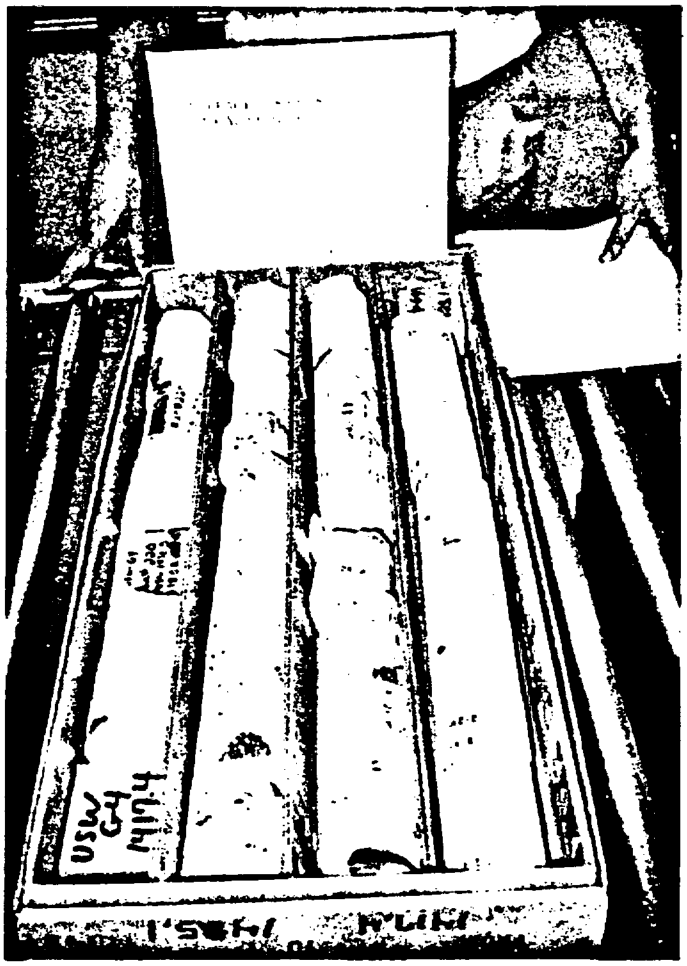


Photo 48. Selectied core form tuffaceous beds of Calico Hills formation.

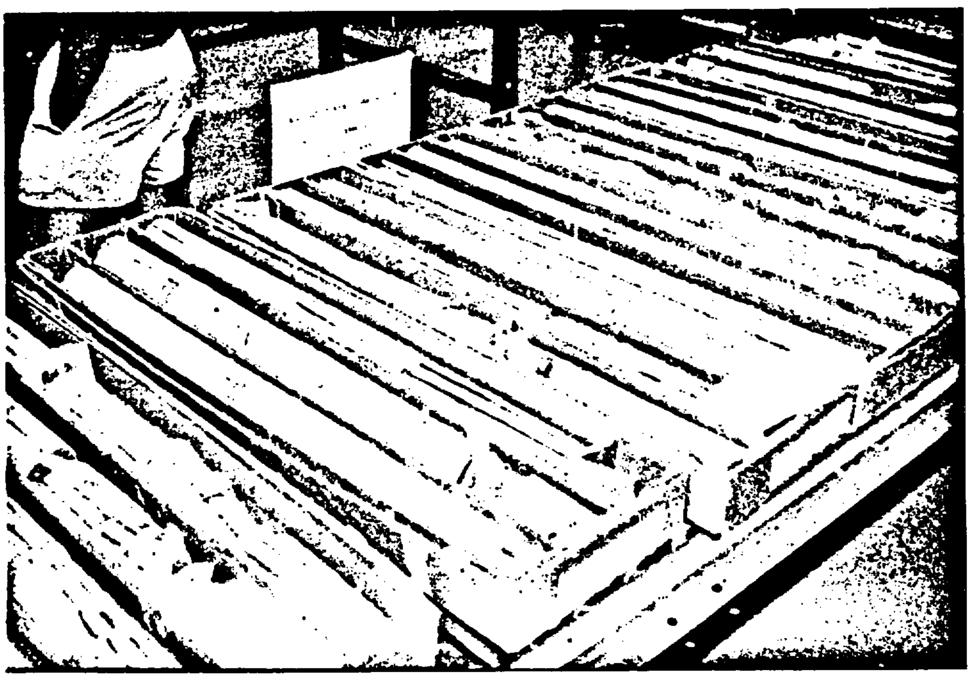


Photo 49. Selected cores from the Utah "dry" prototype drilling tests.

Tour of the YMP Hydrologic Research Facility (HRF) operated by the USGS — Flint/Rousseau/Getzen/Beck/Luckey

A. Flint provided a tour of the Hydrology laboratory (Photos 50,51,52). Tests were being conducted to study the imbibition of water into the pores of rock cylinders. These are relatively simple experiments which measure as a function of time the change in the weight of a column of water connected to a container where a rock sample is in contact with the water. A. Flint also discussed the methods they use to calibrate their meteorological equipment, such as the tipping bucket rain gages. A future laboratory for geochemical work was also shown. The USGS is attempting to increase the accuracy of thermocouple psychrometer and transducer measurements by developing data conversion equations calibrated to the range of conditions expected in the drillhole.

Neutron logging, infiltration, & meteorologic data reduction — A. Flint

A. Flint discussed their methods (Photo 53) in evaluating their meteorologic, neutron logging, and infiltration data. He discussed the general hydrology of Yucca Mt. and vicinity and the applications of kriging methods and geostatistics in reducing uncertainties in the data and in determining where data collection stations are needed.

UZ borehole data reduction and calibration data reduction/IDAS — J. Rousseau/R. Getzen

J. Rousseau conducted a tour of his laboratory and discussed their efforts to develop procedures for calibrating their psychrometers, pressure transducers, and other equipment. R. Getzen showed a computerized data acquisition system which included Digital Equip. Corp. PDP 11/70's and Hewlett Packard IEEE compatible data buses. The software for their system is proprietary and monitors the identity and allowable job functions of any user.

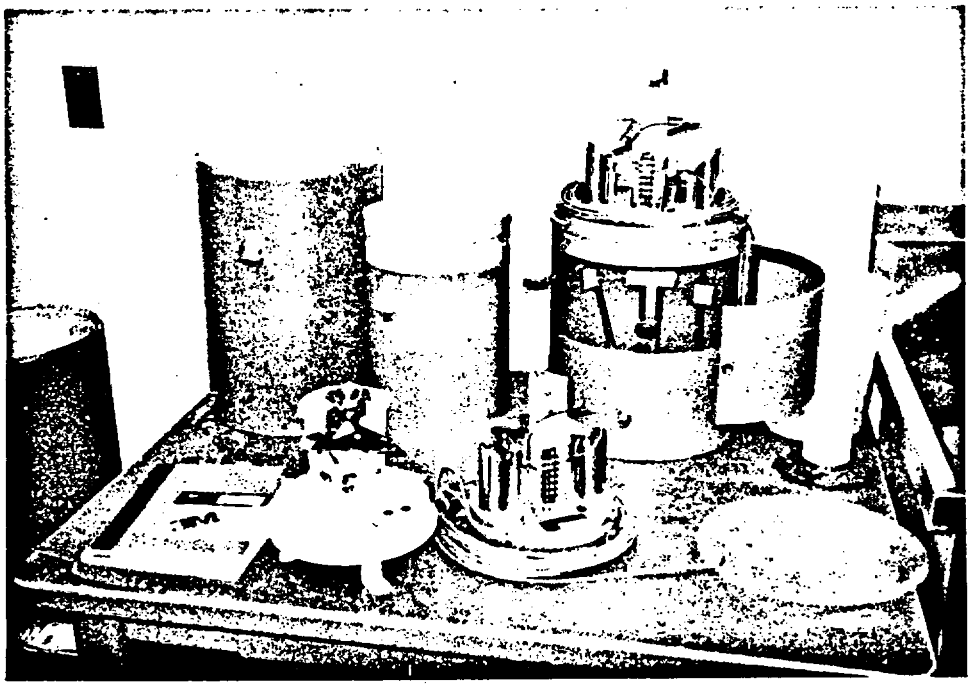


Photo 50. Rain gages disassembled for calibration.

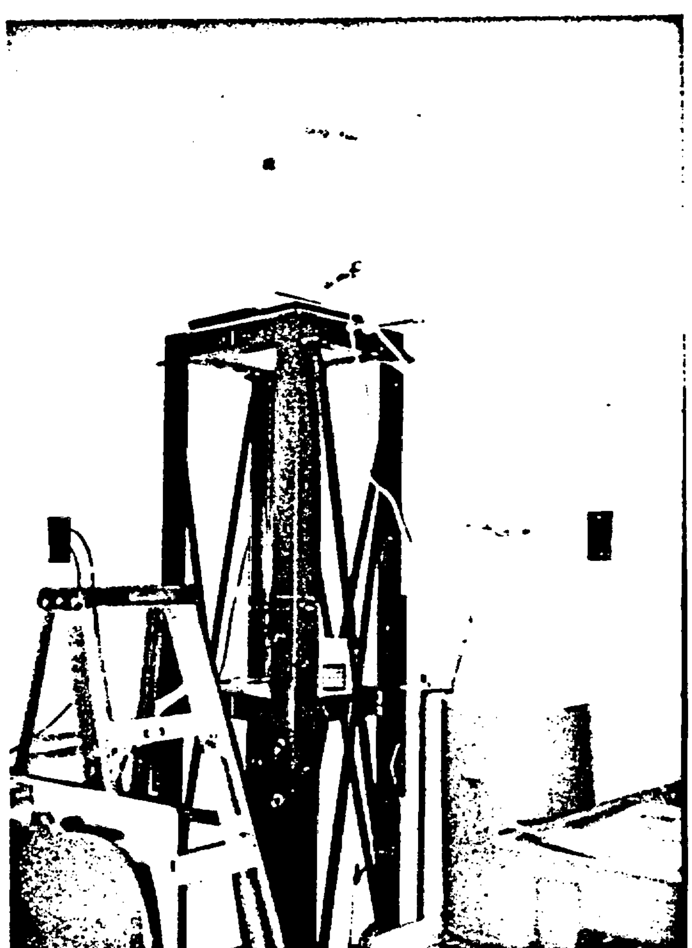


Photo 51. Apparatus for calibrating rain gages. USGS Hydrologic Research Facility.

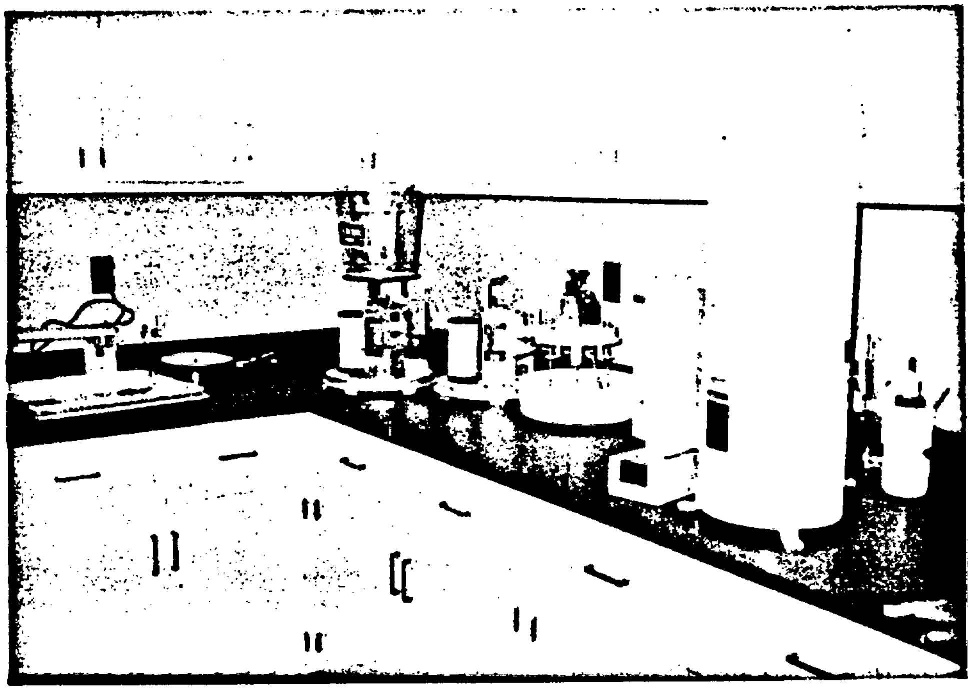


Photo 52. Lab at the USGS Hydrologic Research Facility.

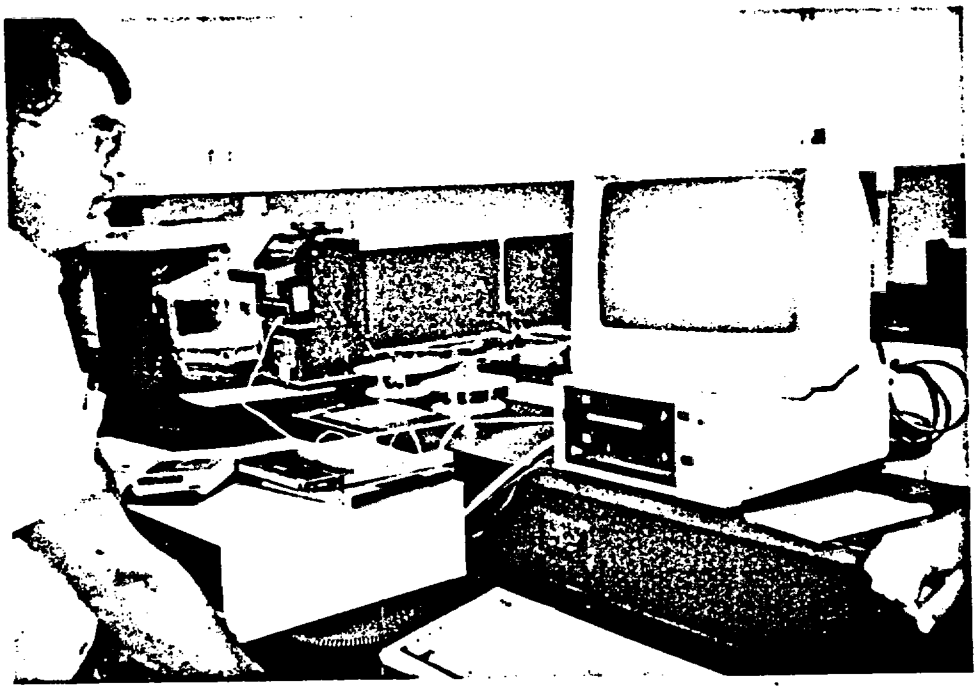


Photo 53. Data analysis demonstration. Data collected met. station the previous day. See photo 33.

Saturated zone water level data reduction

D. Gillies led a brief discussion of the C-hole complex. A new principal investigator will soon be hired by the USGS to replace the one who left the agency.

Discussion of water-level data Luckey

J. Luckey discussed the water table elevation data and problems that have been encountered in transducer data. It seems that the transducers (or their connecting cables) may be affected by lightning discharges which cause corresponding spikes in the data readouts. Some of the transducer data will be published in the near future.

Data from the site indicate a low water table gradient at Yucca Mt. but a very high horizontal hydraulic gradient in the northern part of the area. Czarnecki's discussions addressed this gradient. Transient changes in measured water levels at wellsites are small, typically less than 1 ft.

<u>July 27, 1989</u>

Destinations: Ash Meadows, Amargosa Desert, and Death Valley

Leaders: Downey, Gutentag, Czarnecki

Figure 5 shows a map view of our trip route from Mercury southwest to the Amargosa Desert and on to Death Valley. Refer to photos 54-67 for glimpses of this tour of regional hydrogeology. Highlights included visits to springs, a cinder cone, outcrops, and other sites of interest. A detailed road log of this trip, prepared by Downey and Gutentag, is attached as Appendix D.

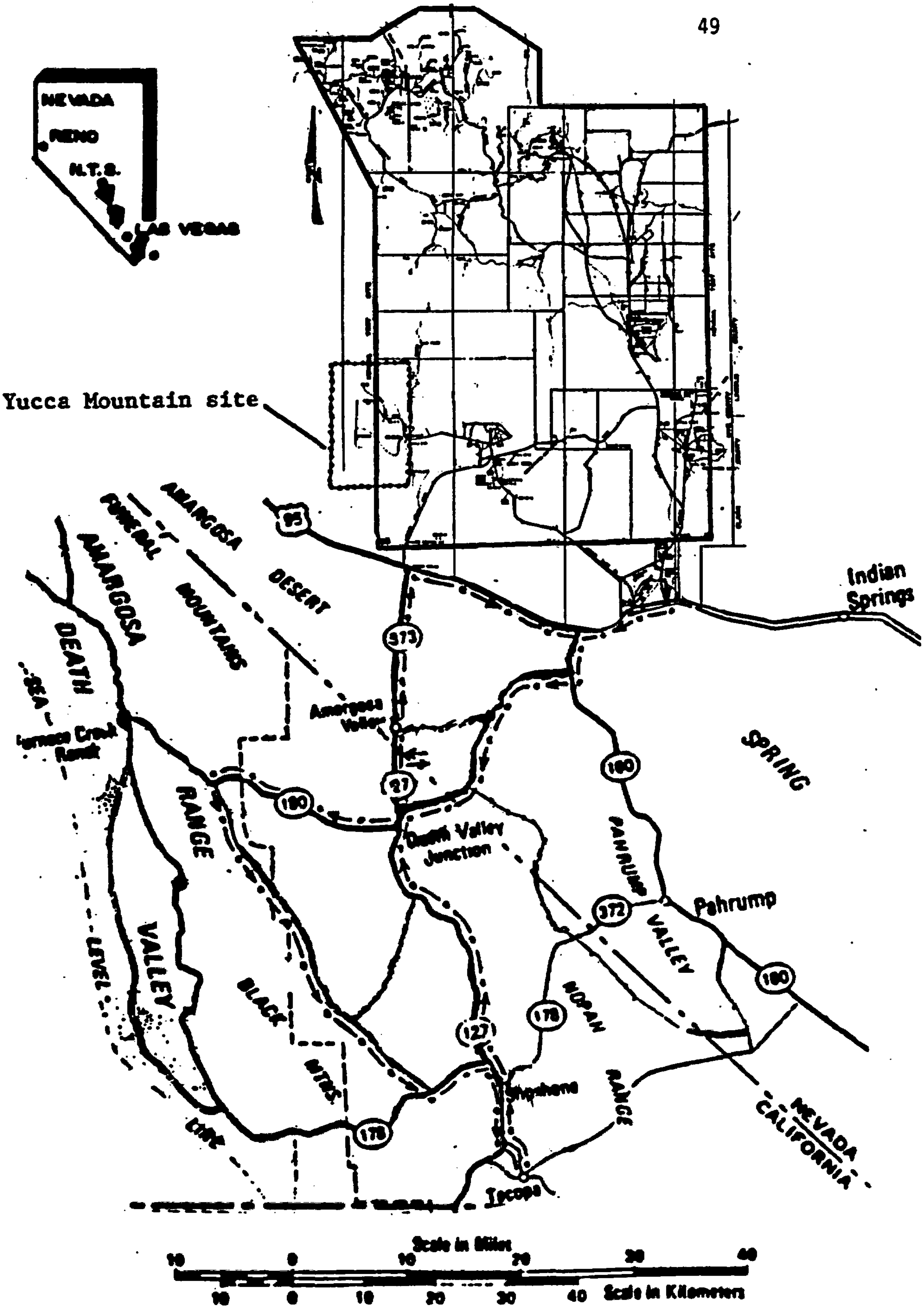


Figure 5 - Route of trip on Day 4 to Amargosa Desert and Death Valley

(—►•—•—►)

Photo 54. Devil's Hole, the entrance to a deep water-filled cavern which is home to a specie of endangered Pupfish.

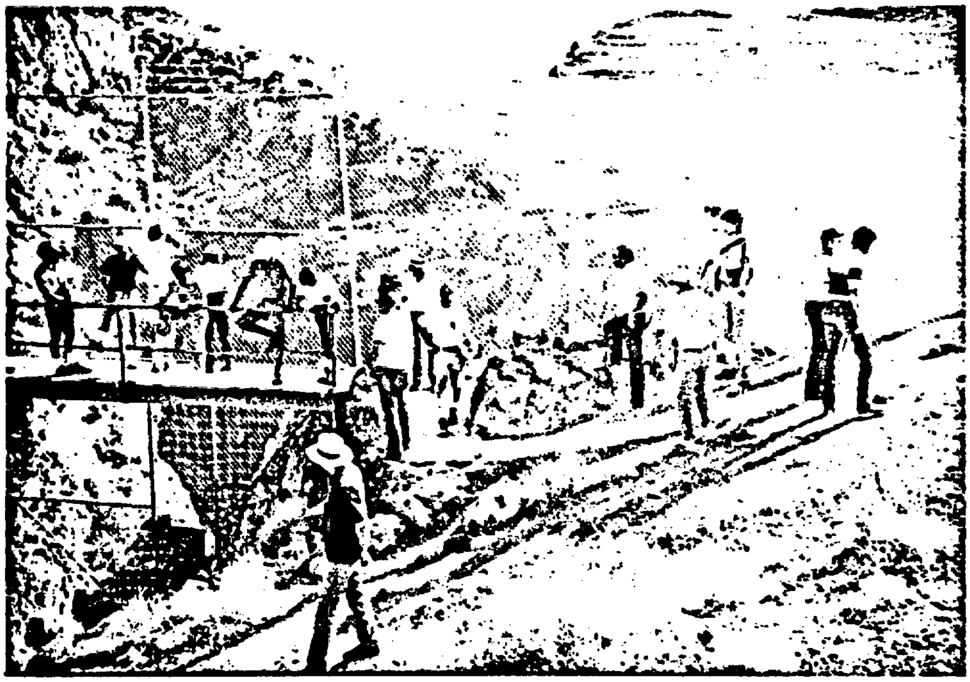


Photo 55. The area around the entrance to Devil's Hole. drilling tests.

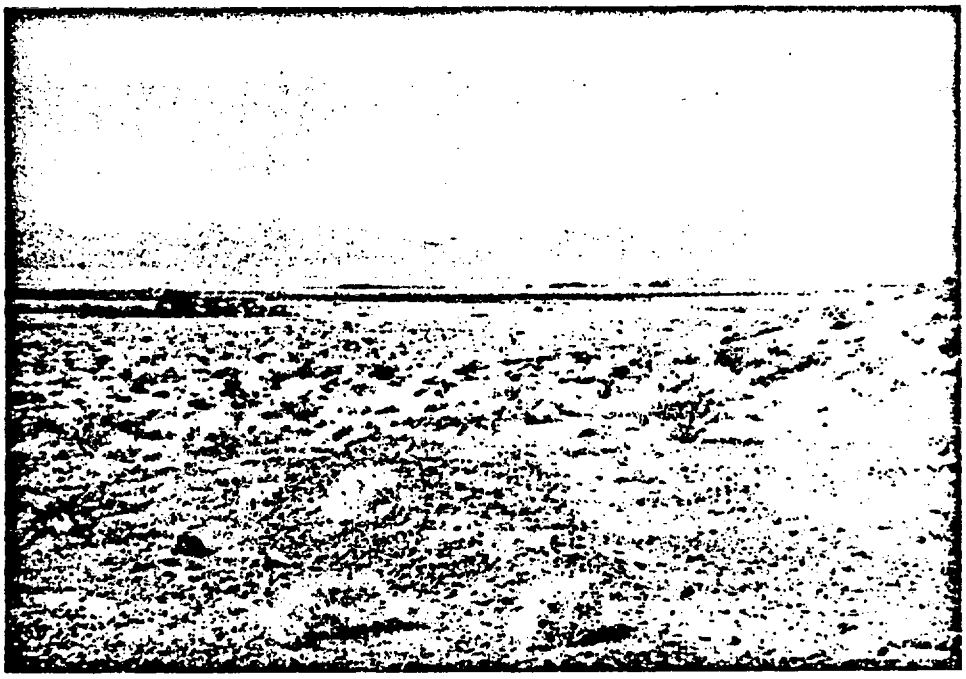


Photo 56. Spring-fed lake in Ash Meadows. View to the southwest from Devil's Hole. Funeral Mountains in the distance on right side.

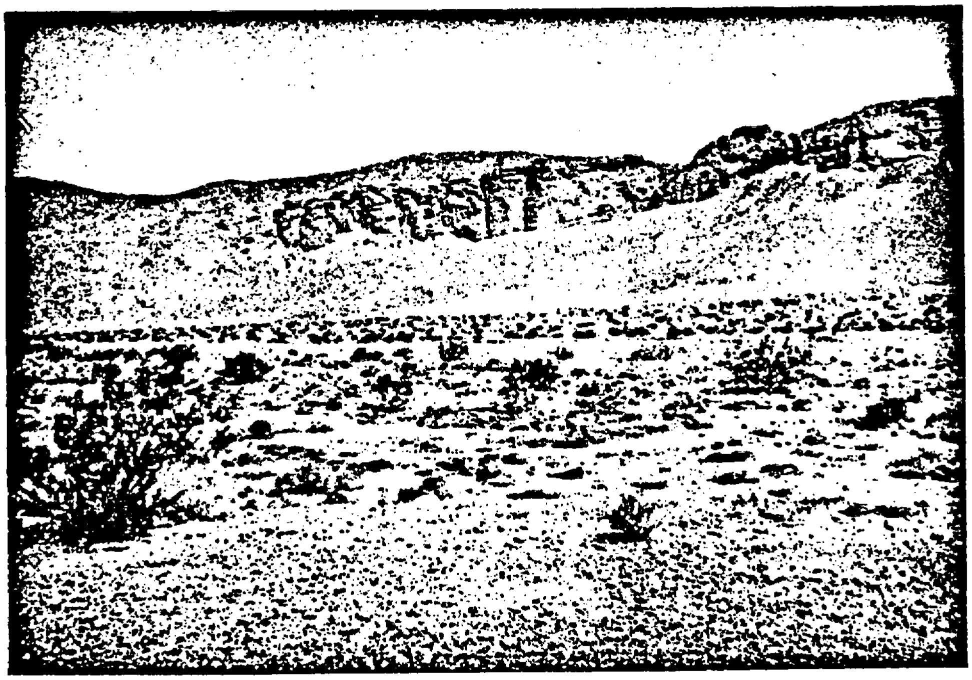


Photo 57. Spring deposits seen in outcrop on descent into Death Valley.

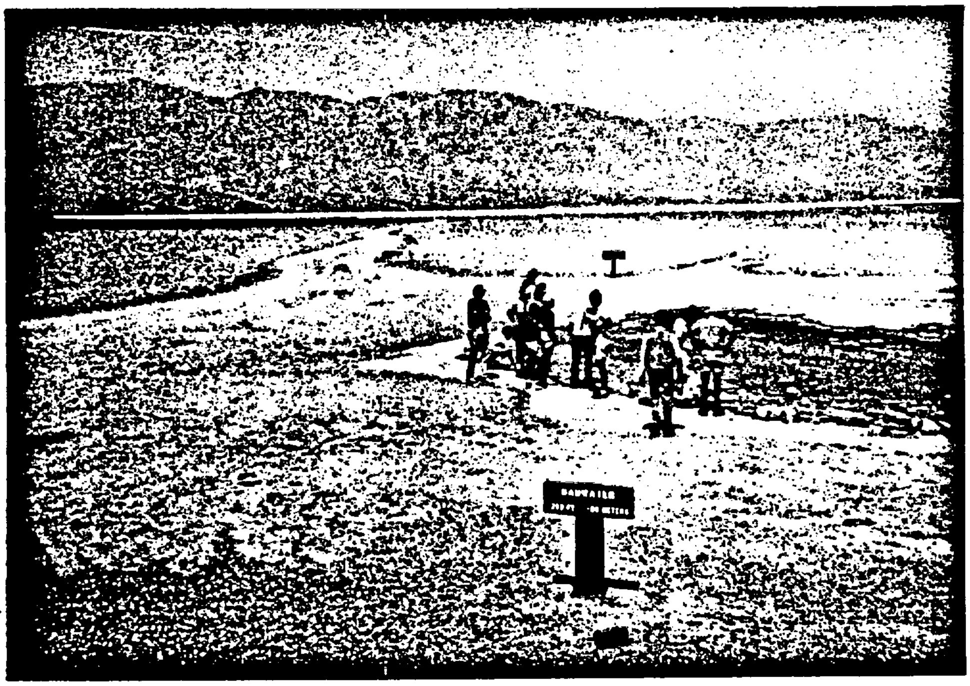


Photo 58. "Badwater" - saline spring in Death Valley, located near lowest elevation in the U. S.

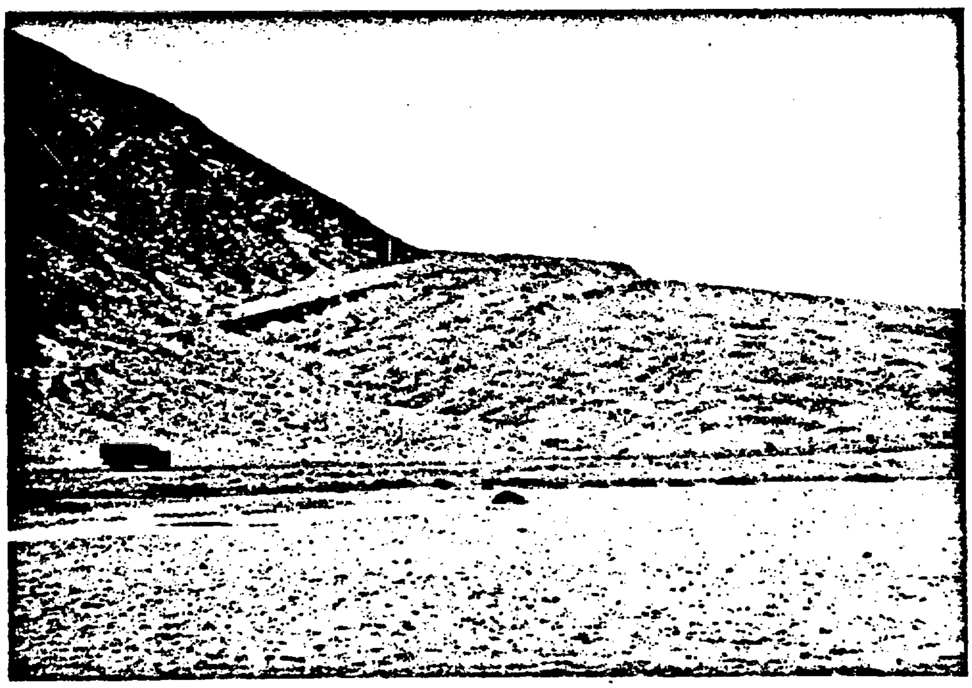


Photo 59. Fault scarps crossing alluvial fan near "Badwater."

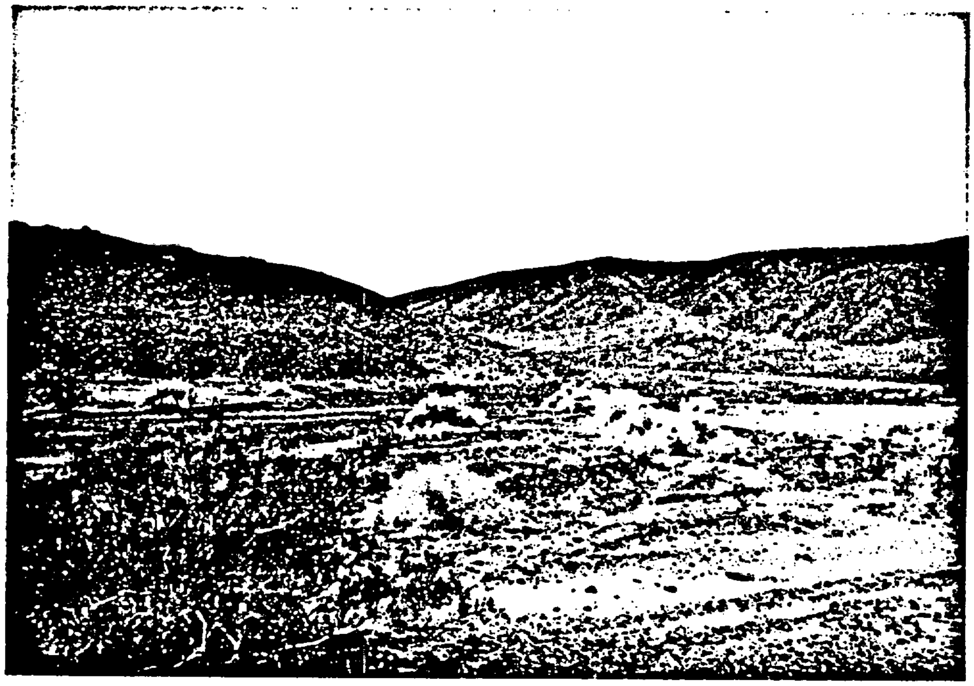


Photo 60. Faulted cinder cone in Death Valley.

Photo 61. Basalt flows across valley from faulted cinder cone.

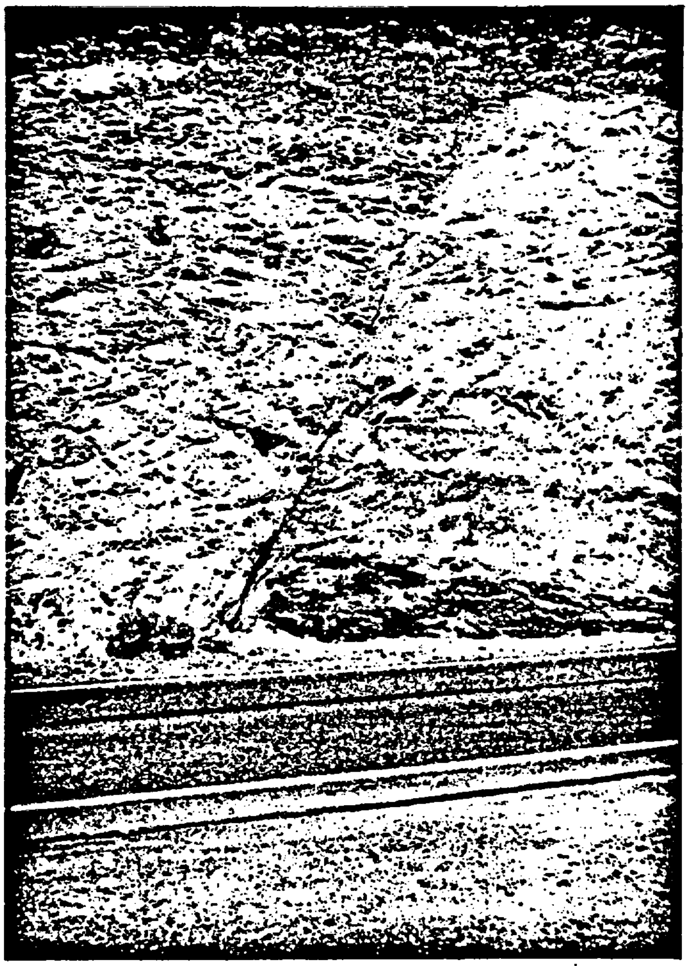


Photo 62. Roadside fault in tuffs.

Photo 63. Vitrophyre (glassy) zone in roadside tuff outcrop.

Photo 64. Artesian well near site of the Amargosa Borax Works.

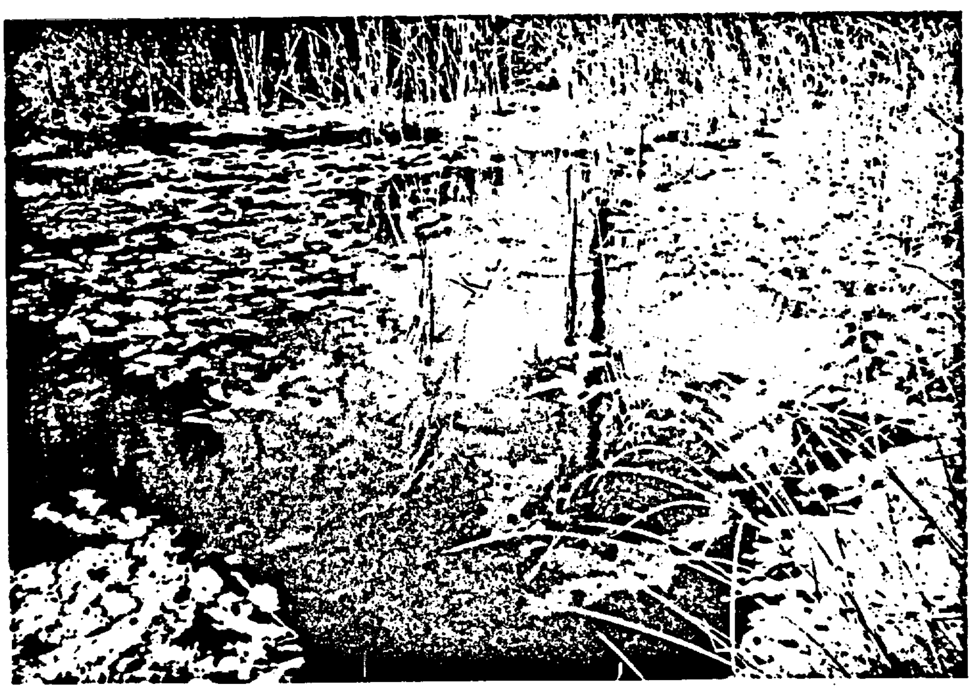


Photo 65. Crystal Pool spring.

Photo 66. Parshall flume measuring flow from the Cyrstal Pool spring.

Photo 67. Calcite vein; note whitish rubble on right side of photo (last stop of trip).

LIST OF ATTENDEES

NRC

D. Brooks
D. Chery
N. Coleman
W. Ford
R. Pabalan (CNWRA)
J. Pohle
P. Prestholt
F. Ross

DOE

B. Hughes
R. Dyer
D. Dobson
J. Boak
S. Levy
C. Lewis
M. Pendleton
R. Cady
K. Albrecht
I. Rosencrantz
R. Barth

USGS

R. Wallace
T. Buono
D. Gillies
J. Rousseau
J. Stuckless
J. Czarnecki

State of California, Inyo County

P. Payne, Co. Supervisor
R. DeHart, Co. Planning Director
C. Thistlethwaite, Assoc. Planner

BACKGROUND INFORMATION

This section contains Appendices A-F. Only cover pages are provided for Appendices E & F. The complete Appendices E & F are contained in the HT copy of the trip report notebook.

Appendix A

Yucca Mountain Field Trip for NRC Staff
July 24-27, 1989

A trip itinerary is attached. Housing is reserved in Mercury for all participants at $10.00 per night. Mr. Pabalan will be staying in Indian Springs. Breakfast and dinner are available at the cafeteria in Mercury, at subsidized (ca. 1962) prices. Dinner is also available at the Mercury steak house for about $10 - $20.

Box lunches, soft drinks, gatorade, and water have been ordered for the four field days. The cost of these arrangements is $4 per day (includes cups and trash bags). Please arrange payment to Bill Hughes through Paul Prestholt, Carl Johnson, Tony Buono, or Ralph Cady, by lunch on Monday, or as early as otherwise possible.

July 14, 1989

NRC HYDROLOGY-GEOCHEMISTRY FIELD TRIP

FIELD TRIP LEADERS: Bill Hughes, SIB RSED
Tony Buono, USGS-YMPB, Las Vegas

<u>July 24, 1989</u> - NTS and Yucca Mountain		<u>Leader</u>
0600	Depart from Valley Bank Center	
0630-0700	State of Nevada Paleodischarge studies near Corn Creek Rd (near Hwy. 95)	Shettel
0800-0830	Arrive Mercury for badging and to pick up lunches	
0830-0930	Travel to G-Tunnel	
1 0930-1130	Tour G-Tunnel - view prototype testing	Hughes Rousseau
1130-1145	Travel to Carpetbag Fault	
2 1145-1215	Carpetbag Fault and evidence for reactivation	Hughes
1215-1330	Travel to Trenches 14, 14a - eat box lunches while traveling	
3 1330-1500	Hydrology and geochemistry of Trenches 14, 14a	Stuckless Levy
1500-1530	Travel to Busted Butte sand ramps (4x4 vehicles)	
1530-1730	Busted Butte sand ramps - tour and discussion	Stuckless
1730-1830	Travel to Mercury	
	Spend night on NTS	

<u>July 25, 1989</u> - NTS and Yucca Mountain		<u>Leader</u>
0730	Depart Mercury Cafeteria for UE-29A2	
0845	Arrive UE-29A2 site	
0845-0900	Ground-water gradient, age of ground water, recharge history	Czarnecki
0900-0915	DRI geochemistry studies	Matuska or Fordham

0915-0945	Ground-water-level measurement demonstration	Baldwin
0945-1005	Travel to gage at Narrows site	
1005-1035	Gage at Narrows site on 40-mile Wash Stream gaging Scour chains Precipitation Station	Beck
1035-1105	40-mile Wash Recharge Studies	Savard
1105-1120	Travel to WT-15	
1120-1135	WT-15 (continuation of disussion from UE-29A2 site)	Czarnecki
1135-1150	Travel to Pagany Wash	
1150-1250	Lunch	
1250-1350	Neutron hole data collection	Flint Blout
1350-1405	Travel to UZ-1 site	
1405-1435	Meteorological data collection	Flint
1435-1520	Deep Unsaturated Zone data collection	Rousseau
1520-1550	UZ hydrochemical data collection	Peters
1550-1600	Travel to ESF site	
1600-1700	ESF tour/discussion	Hughes
1700	Depart for Mercury	
	Spend night in Mercury	

July 26, 1989		Leader
0730	Depart Mercury for SMF	
0800-1020	Tour SMF - Observation of selected core	Davidson Chornack
1020-1040	State of Nevada proposed - UZ studies Geochmeical studies	Mifflin Morgenstein
1040-1045	Walk across street to the USGS-YMP Hydrologic Research Facility (HRF)	
1045-1200	Tour of the YMP Hydrologic Research Facility (HRF) operated by the USGS	

1200-1230	Lunch	
1230-1400	Neutron logging, infiltration, and meteorologic data reduction	Flint
1400-1530	UZ borehole data reduction and calibration data reduction	Rousseau
	IDAS	Getzen
1530-1545	Break	
1545-1615	Stream-flow data reduction	Beck
1615-1700	Saturated zone water level data reduction	Luckey
1700-1715	Discussion of water-level data	Lehman
1715	Travel to Mercury	
	Spend night in Mercury	

<u>July 27, 1989</u>

Destinations:	Ash Meadows, Amargosa Desert, and Death Valley
Leaders:	Downey, Gutentag, Czarnecki
Depart:	Mercury cafeteria 0800
Arrive:	Las Vegas 1800

23-Jul-1989
PARTICIPANTS FOR NRC HYDROLOGY FIELD TRIP, JULY 24-27, 1989

NRC:

Paul Prestholt (702) 388-6125
David Brooks
Don Chery
Neil Coleman
William Ford
Jeffrey Pohle
Frederick Ross
Roberto Pabalan [cannot stay overnight on NTS]

DOE:

Bill Hughes (702) 794-7959
Russ Dyer +/or Dave Dobson
Jerry Boak (24th only)
Martha Pendleton (24th, 25th, 26th)
Ralph Cady (FTS 896-1223)
Karen Albrecht
Rolf Barth
Ingrid Rosencrantz (contact Ed? Mitchell, (202) 646-6745)

USGS-HQ

Ray Wallace

USGS/YMP:

Tony Buono (702) 794-7088 (FAX 7090)

State of NV:

Carl Johnson (702) 885-3744 (FAX 885-5277)
Don Shettel
Atef Elzeftawy
John Fordham
Eric Hansen
Kerry Keen
Linda Lehman
Martin Mifflin (25th, 26th, 27th)
Maurice Morgenstein
Nancy Matuska (25th only)

Clark County: cancelled

Dennis Bechtel (702) 455-3115 (FAX 455-3558)

Jay L. Smith Co. (EEI): cancelled (707) 573-8235; FAX (707) 573-1274

Morris Balderman

23-Jul-1989

Accompanying trip on 7/27:

Inyo County [requested 7/12] (FAX (619) 878-2542)

Chuck Thislethwaite (27th) (619) 878-2411
also Planning Director (?), County Coordinator (?)

State of California, c/o Dan Nix, [requested 7/17] (916) 324-3167 (FAX -3029)

Carl Hague, Dept of Water Resources (cancel)
Gil Torres, Water Resources Control Board
Jeff Howard, Div. Mines and Geology
James Doyle, Parks and Recreation

George Tiubiano, CA Regional Water Quality Board, La Junta Region
(per request, 7/20, from Hisam Baqai)
(619) 241-6583, FAX 7308

Also contacted by Bob Pierotti, CA Dept of Water (Resources?) (213) 620-4147
(7/19)

23-Jul-1989
Room assignments:

Building 532 (from LLNL)

209 Paul Prestholt (702) 388-6125
210 David Brooks
211 Don Chery
212 Neil Coleman
213 William Ford
214 Jeffrey Pohle
215 Frederick Ross
216 Linda Lehman
217 Bill Hughes (702) 794-7959
218 Martha Pendleton (24th, 25th)
219 Ralph Cady (FTS 896-1223)
220 Karen Albrecht
221 Rolf Barth
222 Ray Wallace
223 Tony Buono (702) 794-7088 (FAX 7090)
224 Dan Gillies
225 Carl Johnson (702) 885-3744 (FAX 885-5277)
226 Nancy Matuska (24th), Martin Mifflin (25th, 26th)
227 John Fordham
228 Russ Dyer/ Dave Dobson (24th)

Block Houses (behind REECo Medical):

(from DOE):

1108 J. C. Laul, PNL
1109 Joe Schmitt, PNL

1143 Eric Hansen
1144 Maury Morgenstein
1145 Atef Elzeftawy
1146 Don Shettel
1147 Ingrid Rosencrantz
1148 Kerry Keen

(from Housing):

1201 John Czarnecki
1202 Rufus Getzen
1203 Joe Rousseau
1204 Dan Muhs or John Stuckless (24th), Joe Downey (26th)
1205 Charlie Peters (24th), Ed Gutentag (26th)
1206 Bill Steinkampf (24th, 25th), Dick Luckey (26th)

(from USGS):

1226 Martin Mifflin (if needed 24th), Bill Langer (26th)

23-Jul-1989
USGS:

	7/24		7/25		7/26		7/27
	Lunch	Room	Lunch	Room	Lunch	Room	Lunch
Buono	x	x	x	x	x	x	x
Czarnecki		x	x	x		x	x
Downey						x	x
Getzen		x		x		x	
Gillies	x	x	x	x	x	x	x
Gutentag						x	x
Langer						x	x
Luckey						x	
Muhs		x					
Peters		x					
Rousseau	x	x		x		x	
Steinkampf		x	x	x			
Stuckless		?					
Totals	3	8	4	6	2	9	6

23-Jul-1989

NRC:

	7/24		7/25		7/26		7/27
	Lunch	Room	Lunch	Room	Lunch	Room	Lunch
Paul Prestholt	x	x	x	x	x	x	x
David Brooks	x	x	x	x	x	x	x
Don Chery	x	x	x	x	x	x	x
Neil Coleman	x	x	x	x	x	x	x
William Ford	x	x	x	x	x	x	x
Jeffrey Pohle	x	x	x	x	x	x	x
Frederick Ross	x	x	x	x	x	x	x
Roberto Pabalan	x		x		x		x
Totals:	8	7	8	7	8	7	8

23-Jul-1989

DOE:

	7/24		7/25		7/26		7/27
	Lunch	Room	Lunch	Room	Lunch	Room	Lunch
Bill Hughes	x	x	x	x	x	x	x
Dyer/ Dobson	x	x	x				x
Jerry Boak	x						
M. Pendleton	x	x	x	x	x		
Ralph Cady	x	x	x	x	x	x	x
Karen Albrecht	x	x	x	x	x	x	x
Rolf Barth	x	x	x	x	x	x	x
I. Rosencrantz	x	x	x	x	x	x	x
USGS-HQ							
Ray Wallace	x		x		x		x
Totals:	9	7	8	6	7	5	7

23-Jul-1989

State of NV:

	7/24		7/25		7/26		7/27
	Lunch	Room	Lunch	Room	Lunch	Room	Lunch
Carl Johnson	x	x	x	x	x	x	x
Don Shettel	x	x	x	x	x	x	x
Atef Elzeftawy	x	x	x	x	x	x	x
John Fordham	x	x	x	x	x	x	x
Eric Hansen	x	x	x	x	x	x	x
Kerry Keen	x	x	x	x	x	x	x
Linda Lehman	x	x	x	x	x	x	x
Martin Mifflin		?	x	x	x	x	x
M. Morgenstein	x	x	x	x	x	x	x
Nancy Matuska		x	x				
Totals:	8	10	10	9	9	9	9

Appendix B

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN PROJECT

TUNNEL SAFETY

- ALWAYS WEAR:

  HARDHAT
  STEEL-TOED SHOES
  SAFETY GLASSES

- REMAIN SEATED IN THE TRAIN

- WALK TO THE LIGHTED SIDE OF DRIFTS

- NOTE LOCATIONS OF REFUGE STATIONS

- IN EMERGENCIES, MINERS WILL ASSIST YOU. FOLLOW THEIR DIRECTIONS.

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

UNITED STATES DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN PROJECT

WHY G-TUNNEL?

- UNDERGROUND ACCESS TO YUCCA MOUNTAIN IS NOT AVAILABLE
- G-TUNNEL IS AVAILABLE AND HAS BEDDED NONWELDED AND WELDED TUFFS SIMILAR TO THOSE AT YUCCA MOUNTAIN.
- THE OVERBURDEN AT THE G-TUNNEL UNDERGROUND FACILITY (GTUF) IS SIMILAR TO THE REPOSITORY HORIZON AT YUCCA MOUNTAIN.
- THE GTUF IS ABOVE THE WATER TABLE.

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

UNITED STATES DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE/YUCCA MOUNTAIN PROJECT OFFICE

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

G-TUNNEL UNDERGROUND FACILITY

BACKGROUND

The G-Tunnel Underground Facility (GTUF), part of the G-Tunnel Complex, was developed under the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. The G-Tunnel Complex was established for nuclear weapons testing events, which occurred between 1962 and 1971. Since 1971, it has been used an an underground research facility by Sandia National Laboratories (SNL). Programs have included (1) containment and gate development studies for weapons work, (2) hydraulic and explosive fracturing studies for enhanced gas and oil recovery, and (3) recent testing in support of NNWSI.

NNWSI has been involved in evaluating the potential for nuclear waste repository developments at Yucca Mountain. SNL, a participant in NNWSI, initiated the development of the GTUF in 1979 primarily for underground geomechanics studies. Important phenomena being studied were

- Thermal (heat flow characteristics)
- Mechanical (stress-strain responses, excavation effects, strength relationships)
- Thermomechanical (volumetric expansion)
- Hydrothermal (heat induced water migration)

The facility now includes drifts and alcoves in welded and nonwelded tuffs on three major floor levels. Major SNL experimental efforts have been

- In Situ Stress Measurements (in welded tuff)
- Small Diameter Heater Experiments (in welded and nonwelded tuffs)
- Heated Block Experiment (featuring thermal and mechanical loadings)
- Welded Tuff Mining Evaluations (excavation of demonstration drifts)
- Pressurized Slot Testing (featuring chain saw developments).

PROTOTYPE TESTING

In 1987, the GTUF became a focus for NNWSI Prototype Testing efforts in preparation for Exploratory Shaft Testing at Yucca Mountain. NNWSI researchers can perform in situ measurements in a welded tuff having thermal and mechanical properties and stress states that are similar to the welded tuff at Yucca Mountain. Similarities in welded and nonwelded tuff stratigraphies also exist. Planned activities include

- Geological Mapping Investigations (USGS)
- Development of Drilling Methods (LANL)
- Hydrologic Investigations and Flow Evaluations (USGS, LANL)
- Engineering Barrier Simulations (LLNL)
- Thermal Stress Measurements (SNL)
- Instrumentation Evaluations (USGS, LLNL, SNL)

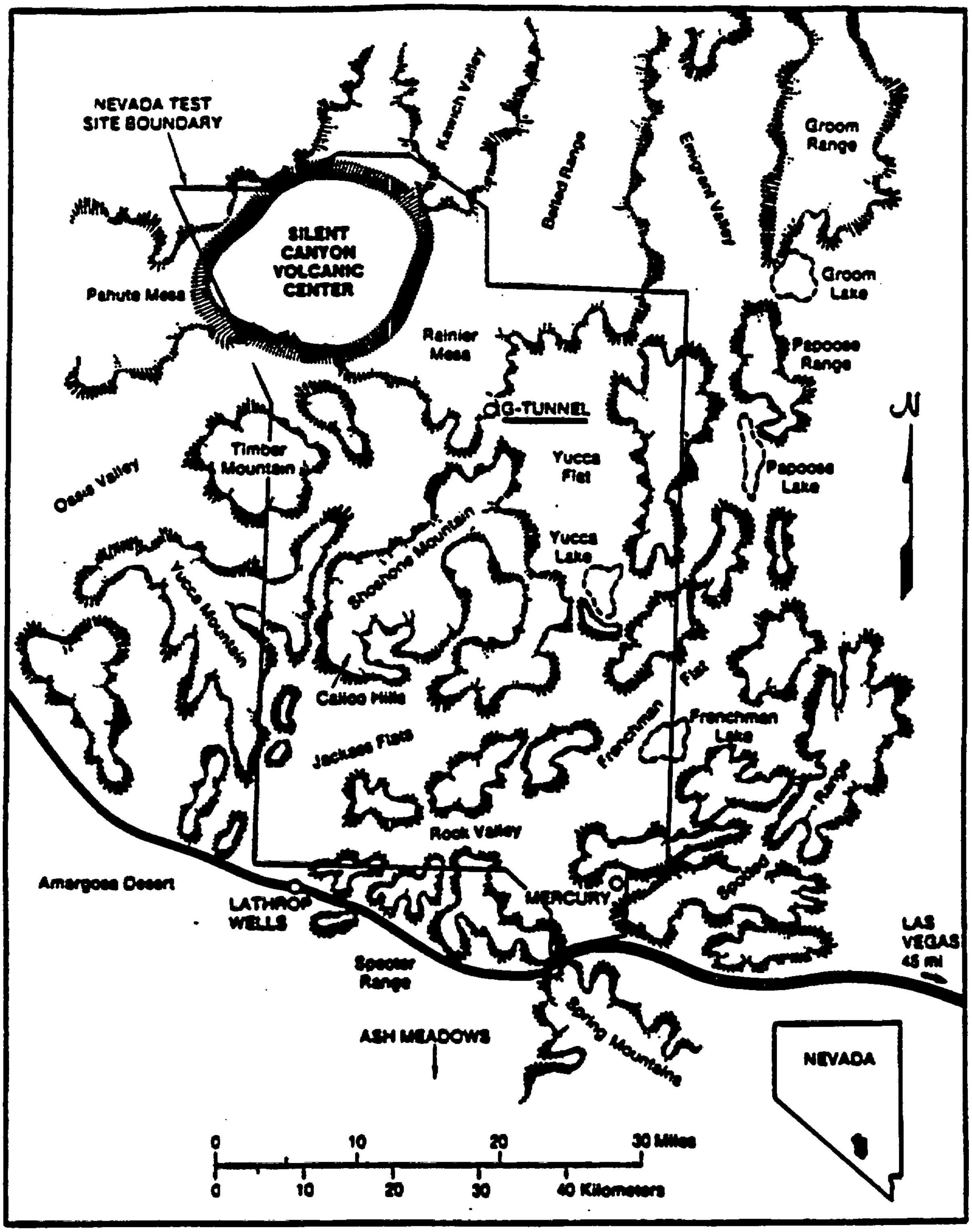
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
G-TUNNEL UNDERGROUND FACILITY (GTUF)
PROTOTYPE TESTING

LA/RO
3/16/89

PRIOR WORK	OBJECTIVES	ORG.	STATUS
Geotechnical Field Measurements	In-Situ Stress, mechanical hydrologic phenomena	SNL	Report published
Small Diameter Heater	Thermal, hydrothermal phenomena	SNL	Report published
Heated Block	Thermomechanical properties phenomena	SNL	Report published
Pressurized Slot	Mechanical properties phenomena	SNL	Completed, report in preparation
Mining Evaluation	Mechanical properties phenomena	SNL	Completed, report in preparation
Air coring	Specialized drilling operations	LANL	Completed, report in preparation
Tracer	Hydrologic properties	USGS	Field work completed
Mineralogy/ Petrology	Methodology development, concept validation	LANL	Field work completed

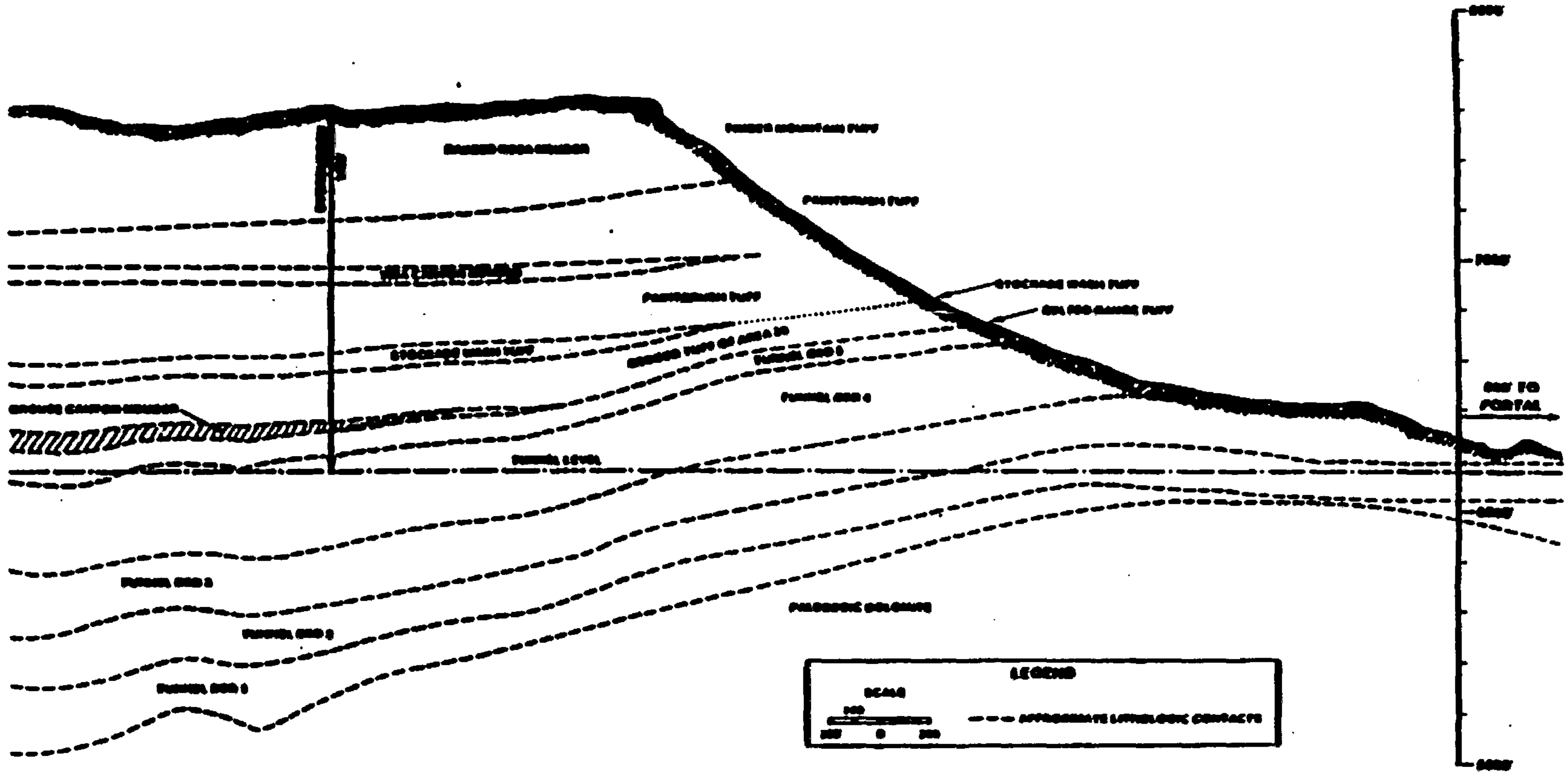
WORK	OBJECTIVES	ORG.	STATUS
Drift Wall Mapping Photogrammetry G-tunnel	Methodology development, concept validation	USGS	95 % completed
Drift Wall Mapping Photogrammetry Fran Ridge	Methodology development, concept validation	USGS	Planning completed Air quality permit
Drill Hole Instrumentation	Design/function validation	USGS	Data collection, report in preparation
Cross Hole Testing	Hydrologic properties, transport mechanisms	USGS	Drilling completed
Intact Fracture	Flow mechanisms	USGS	Drilling in progress
Infiltrometer Test	Fluid flow properties	USGS	No NTS activities planned

WORK	OBJECTIVES	ORG.	STATUS
Bulk Permeability	Hydrologic properties phenomena	USGS	No NTS activities planned
Thermal Stress Test	Thermomechanical properties phenomena	USGS	Planning
Waste Package Environment Vert. Test	Hydrothermal properties phenomena	LLNL	85 % completed
Waste Package Environment Horz. Test	Hydrothermal properties phenomena	LLNL	Planning
Diffusion Test	Geochemical processes phenomena	LANL	75 % completed
Wet & Dry Drilling	Specialized drilling operations, Hydrologic properties/phenomena	USGS	Data collection, report in preparation
Dry Rubble Coring	Hydrologic properties phenomena	USGS	Approved plans
Optimal Rubble Test	Hydrologic properties phenomena	USGS	Approved plans
Perched Water Test	Hydrologic properties phenomena	USGS	Approved plans
In-Situ Stress	Methodology development, concept validation	USGS	Approved plans
Blast Effects	Design/function validation	USBR SNL	Planning
Excavation Effects	Design/function validation	USGS	Approved plans
Controlled Blasting	Design/function validation	USBR	Planning



NEVADA TEST SITE BOUNDARY
SILENT CANYON VOLCANIC CENTER
Pahute Mesa
Kawich Valley
Belted Range
Emigrant Valley
Groom Range
Groom Lake
Rainier Mesa
Papoose Range
G-TUNNEL
Timber Mountain
Oasis Valley
Yucca Flat
Papoose Lake
Shoshone Mountain
Yucca Lake
Yucca Mountain
Calico Hills
Jackass Flats
Frenchman Flat
Frenchman Lake
Rock Valley
Amargosa Desert
LATHROP WELLS
MERCURY
Specter Range
LAS VEGAS 45 mi
ASH MEADOWS
Spring Mountains
NEVADA
0 10 20 30 Miles
0 10 20 30 40 Kilometers

RTZ-08/85x



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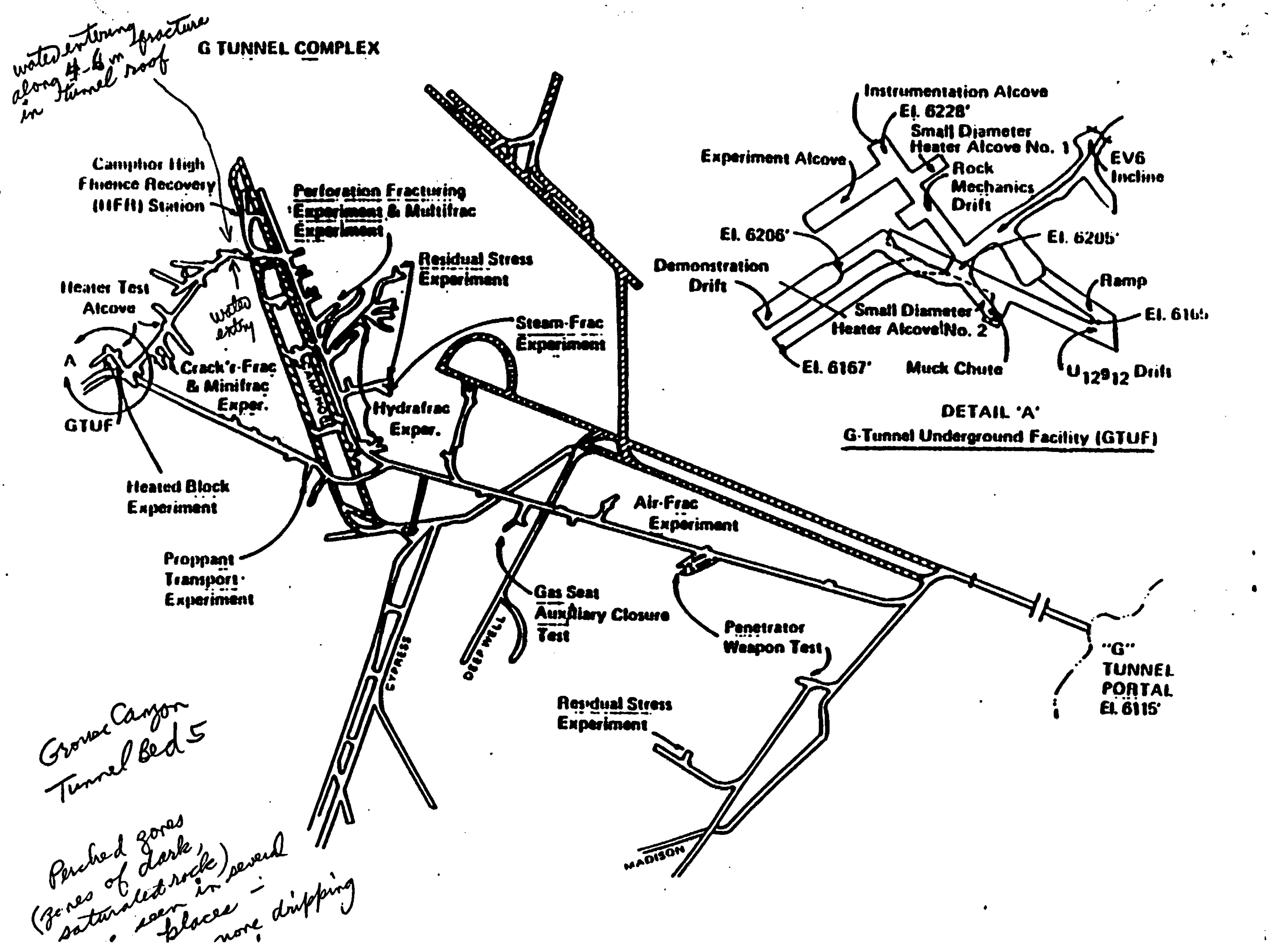
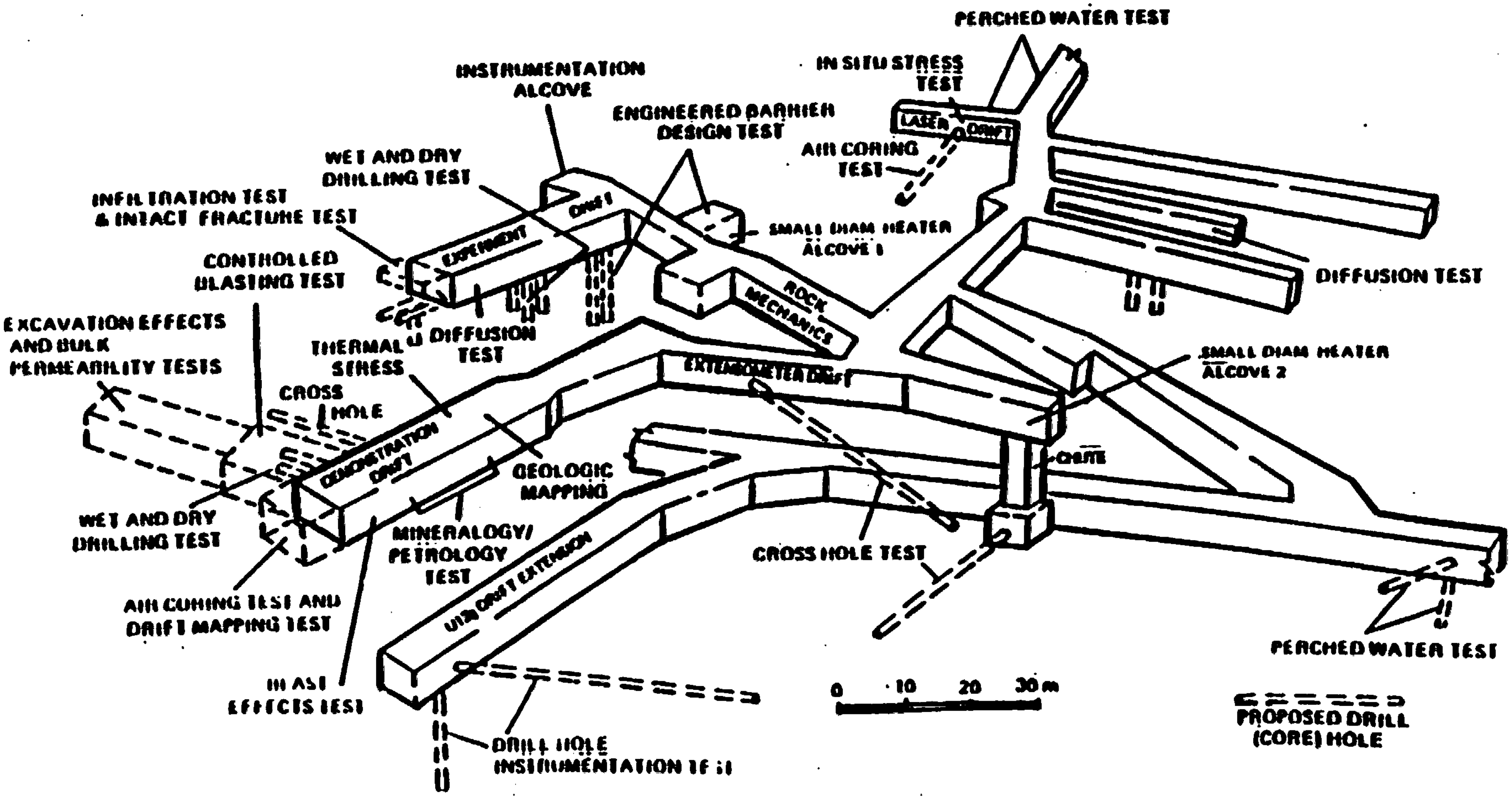

G TUNNEL COMPLEX
water entering along 4-6 in fracture in tunnel roof
Camphor High Fluence Recovery (HFR) Station
Perforation Fracturing Experiment & Multifrac Experiment
Residual Stress Experiment
Heater Test Alcove
water entry
Crack's-Frac & Minifrac Exper.
A
GTUF
Heated Block Experiment
Proppant Transport Experiment
Hydrafrac Exper.
Steam-Frac Experiment
Air-Frac Experiment
Gas Seat Auxiliary Closure Test
Penetrator Weapon Test
Residual Stress Experiment
CYPRESS
DEEP WELL
MADISON
CAMPHOR
"G" TUNNEL PORTAL El. 6115'
Instrumentation Alcove
El. 6228'
Small Diameter Heater Alcove No. 1
Experiment Alcove
Rock Mechanics Drift
EV6 Incline
El. 6206'
El. 6205'
Demonstration Drift
Ramp
Small Diameter Heater Alcove No. 2
El. 6165
El. 6167'
Muck Chute
$U_{12}g_{12}$ Drift
DETAIL 'A'
G-Tunnel Underground Facility (GTUF)
Grouse Canyon Tunnel Bed 5
Perched zones (zones of dark, saturated rock) seen in several places – none dripping

PLAN VIEW OF GTUF NORTHWEST SECTION OF G-TUNNEL



Appendix C

STOP 11. Morphology of the Carpetbag fault. Park bus and walk 0.3 miles to Carpetbag fault scarps (Fig. 17).

The north-trending Carpetbag fault system consists of a series of east-dipping Basin and Range style faults that traverse the length of Yucca Flat on the western side (D. L. Healey, USGS unpublished gravity data). Post-tuff dip-slip displacement is 300 m in the area of Carpetbag scarp (Ander, 1984); a large amount of right-lateral motion has also been postulated (Carr, 1974). Two major fault scarps of the system were propagated to the surface as a result of the detonation of the Carpetbag event in 1970. This event also caused the Carpetbag sink and a series of concentric cracks extending out about 1000 m from the edge of the sink. This type of surface cracking may have been due to detonation of the nuclear device below the static water level, a practice now avoided.

The graben bounded by the two fault scarps extends for about 2600 m on the western side, where 11 to 590 cm of post-testing dip-slip displacement has been documented on the western fault scarp. On the eastern side, three fault strands ranging in trend from N-S to N40°E (E. C. Jenkins, USGS written commun., 1973) form two major scarps, 1525 m long, with dip-slip displacements of 9 to 490 cm. About 0.9 m of right-lateral motion has been recorded along the system since 1970.

Ramp features extending northeast from the northern end of the western fault scarps have surfaces that dip 10° to the southeast and are bounded by low scarps at the toe of the slope. Trenching Fig. 17 reveals that the ramps are shallow features that die out a short distance from the main fault. The ramps are proposed as resulting from one or more of the following possible causes: (1) surface expression of splays or "horsetails" from the main Carpetbag fault; (2) lowering of ground-water table causing surface subsidence; and (3) underground nuclear testing causing differential ground subsidence.

Surficial deposits exposed in the wall of the graben help constrain the ages of recent fault movement. Young fluvial sands, gravel, and slopewash postdate the last major movement on the Carpetbag fault. These deposits have stage I soil-carbonate morphology of Gile and others (1966) and are probable equivalents of Holocene units described by Hoover and others (1981). The older units predating fault movement have a thin K-horizon with stages III to IV morphology and have uranium-trend dates of 270,000 to 310,000 yrs (J. N. Rosholt, USGS written commun., 1983). Uranium-series dating of secondary carbonate along fractures brackets the displacement between 93,000 and 37,000 yr (Knauss, 1981), which correlates well with the lack of distinguishable fault scarps in the younger (Holocene?) gravels before nuclear testing in 1970.

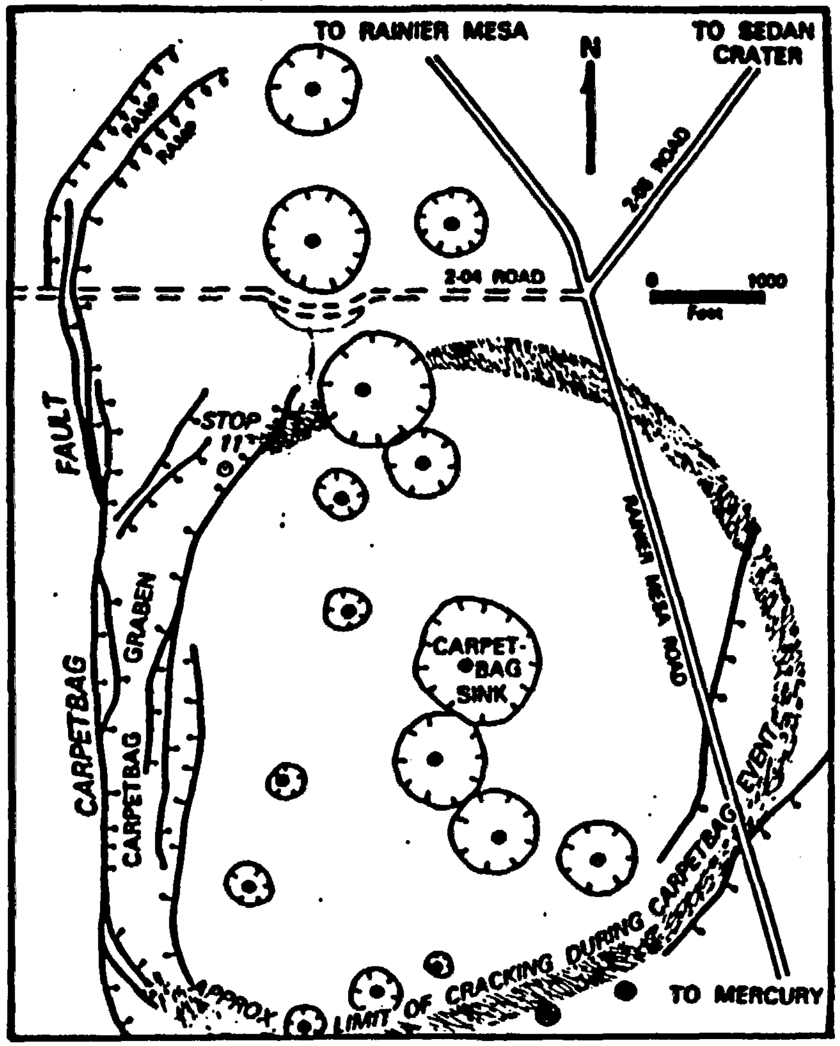


Fig. 17.
Carpetbag fault system (Stop 11).

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UC-11
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Nevada Test Site Field Trip Guidebook 1984

Compiled by
Holly A. Dockery*
F. M. Byers, Jr.
Paul P. Orkild**

Contributors

Harley Barnes†
David E. Broxton
W. J. Carr**
Bruce M. Crowe
Ward L. Hawkins
Evan C. Jenkins**
Donathon J. Krier
Schon S. Levy
F. G. Poole**
Robert B. Scott**
Ralph R. Shroba**
Martha G. Van De Werken**
David T. Vaniman
Richard Waddell**
Richard G. Warren

*Consultant. Los Alamos National Laboratory, NSP/SP, MS F681, Los Alamos, NM 87545.
**US Geological Survey, Denver, CO 80225.
†Deceased.

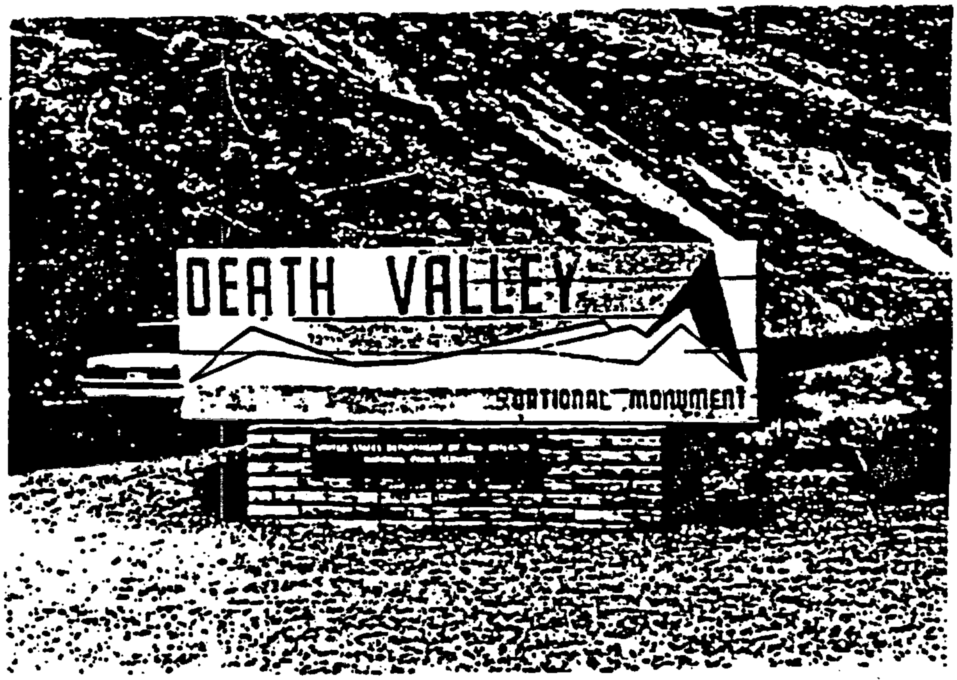
Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Appendix D

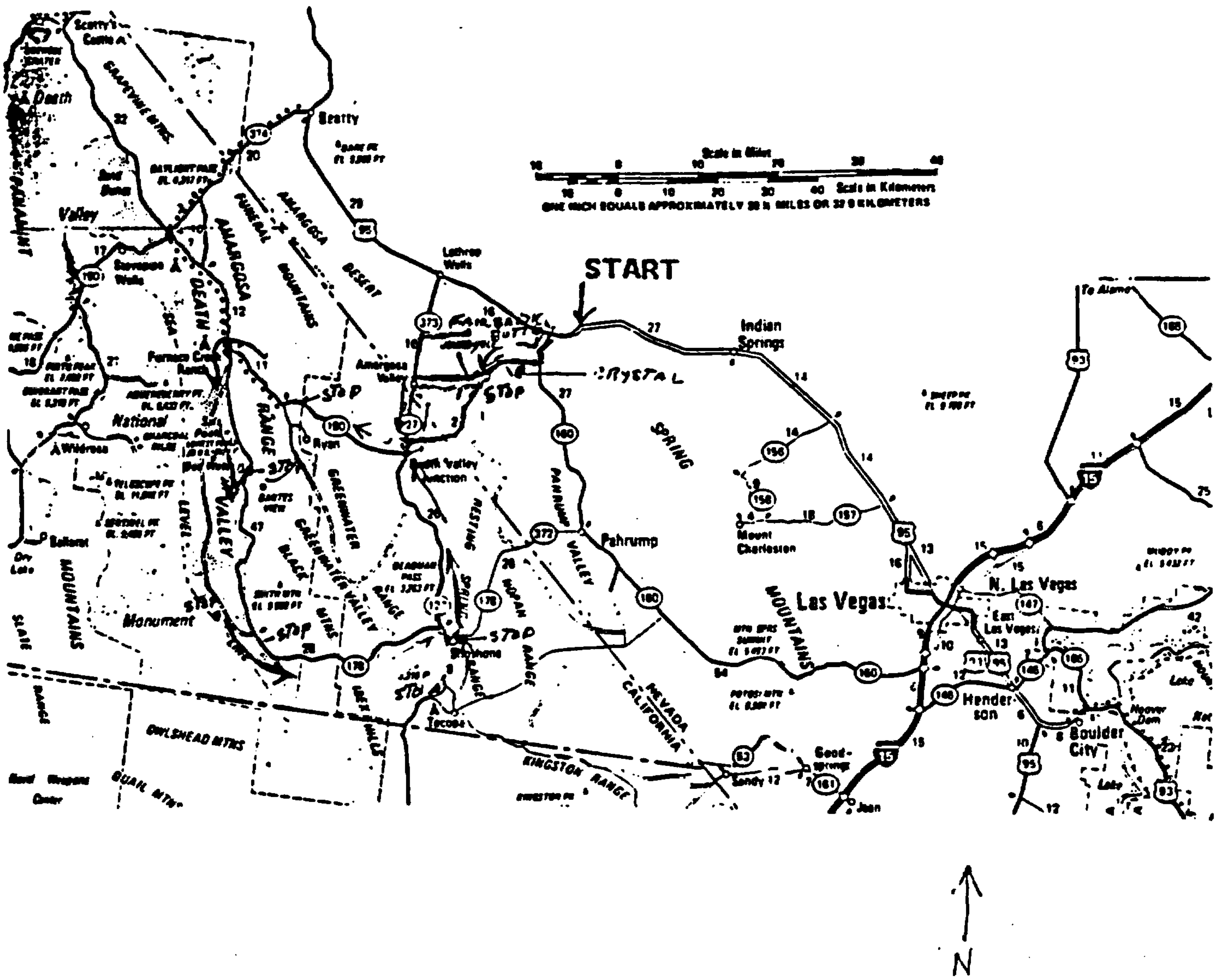
HYDROGEOLOGIC ROAD LOG

BY

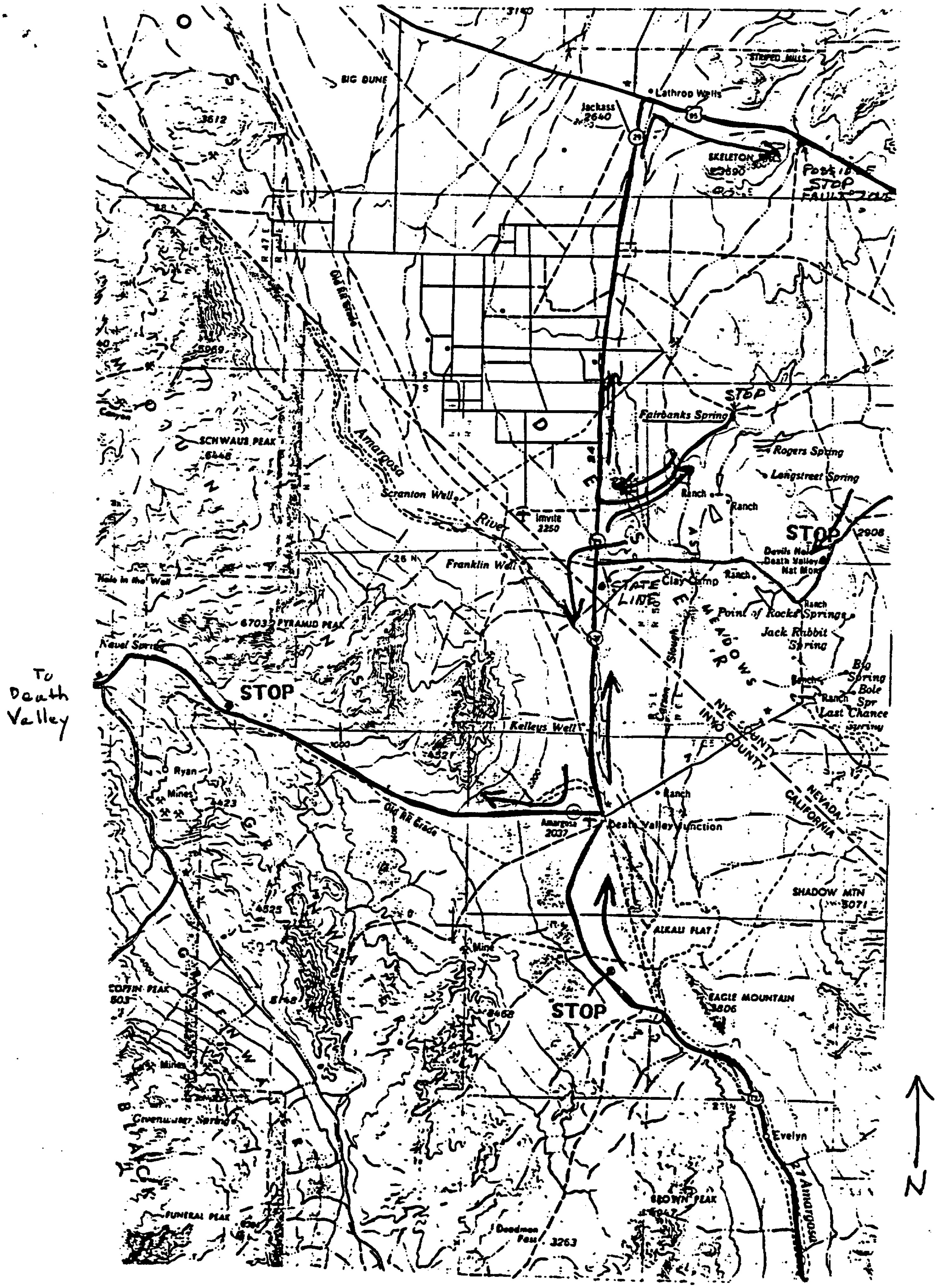
JOE S. DOWNEY
ED GUTENTAG
U.S. GEOLOGICAL SURVEY
DENVER, COLORADO



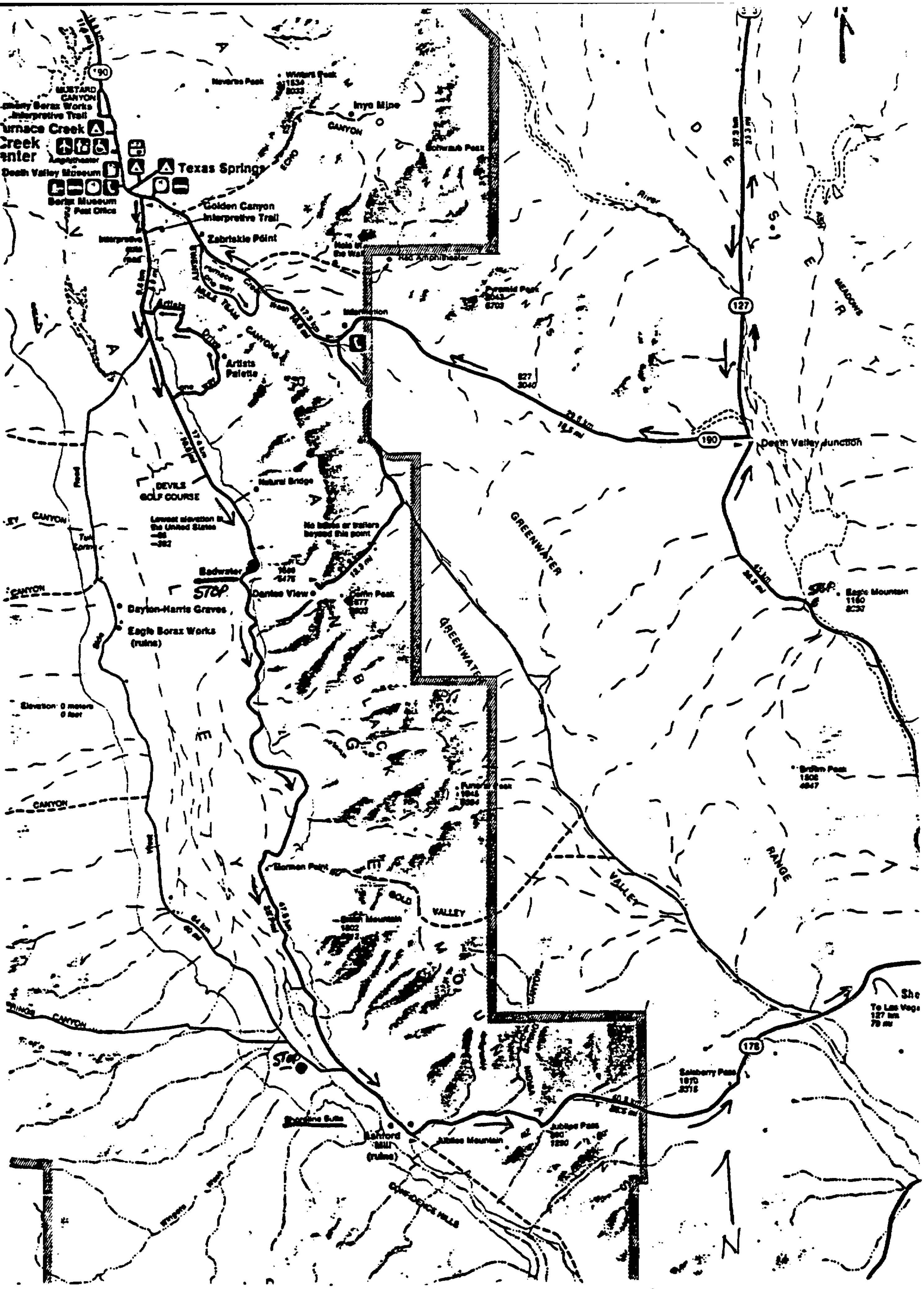
FOR AMARGOSA DESERT AND DEATH VALLEY AREAS, NEVADA AND CALIFORNIA



REGIONAL MAP SHOWING GENERAL FIELD TRIP ROUTE.



BIG DUNE
Lathrop Wells
Jackass
2640
STRIPED HILLS
SKELETON HILLS
STOP
Fairbanks Spring
Rogers Spring
Longstreet Spring
Ranch
Invite
3250
Scranton Well
Amargosa
River
Franklin Well
STATE LINE
Clay Camp
Point of Rocks Springs
Jack Rabbit Spring
STOP
Devils Hole
Death Valley Nat Mon
2908
SCHWAUS PEAK
Hole in the Wall
6703 PYRAMID PEAK
STOP
Kelleys Well
Ryan
Mines
Old RR Grade
Amargosa
2037
Death Valley Junction
NYE COUNTY
INYO COUNTY
NEVADA
CALIFORNIA
Big Spring
Bole Spr
Last Chance Spring
SHADOW MTN
5071
ALKALI FLAT
EAGLE MOUNTAIN
STOP
COFFIN PEAK
Greenwater Spring
FUNERAL PEAK
Deadman Pass
3263
BROWN PEAK
Evelyn
Amargosa
To Death Valley
N



190
Mustard Canyon
Harmony Borax Works Interpretive Trail
Furnace Creek
Texas Springs
Death Valley Museum
Borax Museum
Post Office
Inyo Mine
Canyon
Golden Canyon Interpretive Trail
Zabriskie Point
Artists Drive
Artists Palette
Death Valley Junction
127
190
Devils Golf Course
Natural Bridge
Lowest elevation in the United States
Badwater
STOP
Dantes View
Dayton-Harris Graves
Eagle Borax Works (ruins)
Greenwater
Eagle Mountain
Funeral Peak
Mormon Point
Gold Valley
Valley
Range
Shoreline Butte
Ashford Mill (ruins)
Jubilee Pass
Salsberry Pass
178
To Las Vegas

Compilation of ERTS imagery courtesy California Division of Mines and Geology. Central and southern Death Valley form the prominent valley that occupies the center of the photograph. Panamint and Owlshead Mountains on left; Fort Irwin area and Avawatz Mountains occupy lower third of photo. Black Mountains, Greenwater Range, Resting Spring Range in uppermost right and Nopah Range from center to right center of photo. Funeral Mountains occupy upper left part of photo.

HYDROGEOLOGIC FIELD TRIP LOG

Prepared By

Joe S. Downey

Ed Gutentag

U.S. Geological Survey

July 1989

Miles	Total Miles	Feature
Start	0	Intersection US Highway 95 and road to Mercury at bridge. "Peace Camp" area on south side of Highway 95.
0.9	0.9	End of 4-lane Hwy.
1.3	2.2	Water Well Army No. 1 used as a source of water for Mercury.
1.0	3.2	Entering a narrow part of Mercury Valley and passing through Paleozoic limestone.
1.5	4.7	Brick building - telephone relay station.
0.9	5.6	Point-of-Rocks-Road bearing almost due west.
1.1	6.7	White colored materials south of Highway are Tertiary (Miocene?) lake beds.
1.0	7.7	Junction U.S. Highway 95 and Nevada Highway 160. Turn south. Tertiary lake deposits are east of highway. High mountains to east and southeast are the Spring Mts. In the middle foreground is the Jonnie Formation of late Precambrian age. Due south at 12:00 O'clock are Paleozoic Limestones that may be slide blocks surrounded by alluvial fans.
1.3	9.0	Road crossing alluvial fan.
3.7	12.7	Turn right heading west on paved road to town of Crystal. Highlands dead ahead are Funeral Mts - low flat top mesa at 12:30 O'clock is Fairbanks Butte composed of Tertiary freshwater limestone.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
2.2	14.9	Crystal Municipal Airport and road to Cherry Patch Ranch, Mable's brothel of Sinful Joys, and Oriental Message and bathhouse.
0.6	17.1	Downtown Crystal.
0.2	17.3	End of pavement.
1.1	18.4	Entering Amargosa Flat or Peters Playa. Vegetation on right and left of road are Mesquite growing on sand dunes.
0.5	18.4	Road curves and passes through sand dunes covered by mesquite along sides of road.
1.0	19.9	Powerline crossing. Road fork--bear left. Edge of mesquite growth. Entering Playa proper. Elevation about 2,660 feet.
1.6	21.5	Fork in road, continue south on road. Road north goes to Fairbanks Butte, Fairbanks Spring and paved road to Lathrop Wells.
.5	22.0	Turn off to Moratti Clay Pit. Water levels in Pit less less than 20 ft below land surface.
1.8	23.8	Road winding through outcrops of Paleozoic Limestone of the Bonanza King Formation.
2.20	26.0	Turn right (west) on dirt road to Devils Hole, Elevation about 2,720 feet.
0.10	26.1	Devil's Hole--park--return to main road.
0.20	26.3	Turn right on main road and head southwest. Pond in distance at 2:00 O'clock is Crystal Pool supplied by Crystal Spring.
0.80	27.1	Phreatophyptes growing at seep area or area of diffuse ground-water discharge area. Elevation about 2,650 feet. To left, lush growth at Ash Meadow Spring Discharge Sites.
0.2	27.3	Passing through Paleospring deposits. White deposits are cemented by calcium carbonate.
0.3	27.6	Road forks--continue straight (west), road to left goes to Pahrump, Nevada.
1.2	28.8	Road to Crystal Pool.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
.2	29.0	Diffuse ground-water discharge area supporting phreatophyte growth.
.2	29.2	Road turns due west. Plant in distance is mill for processing borate minerals.
1.3	30.5	Passing through diffuse ground-water discharge area with phreatophytes and grass. Tamerisk (salt cedar) and other phreatophytes.
1.4	31.9	Crossing channel of Carson Slough.
0.9	32.8	Crossing erosional scarp caused by downcutting of Carson Slough. Road curves right.
2.2	35.0	Junction of Pahrump Road (Spring Meadows Drive) with State Highway 373. Turn left on Highway 373 heading south. Tooth Shaped mountain at 10:00 O'clock is Eagle moutain at south end of the Amargosa Desert.
1.1	36.1	Stateline Community.
0.7	36.8	Stateline, CA-NV. California Highway CA 127. Stream-cut terrace east of the modern Amargosa River floodplain exposing a section of fossiliferous sediments. Sediments consist of non-bedded silt-sized grains with possible root casts up to 2 cm in diameter. These sediments may have been transported by wind and trapped by the marsh vegetation and/or wetted soil. This area corresponds with that predicted by numerical models of ground-water flow that simulated past wetter conditions, and may prove useful in validating the results of these models. A possible analogous area to this one exists in north Las Vegas Valley along US 95 where marsh-type sediments may be seen. However, at this site the sediments contain diatoms and volcanic ash shards similar to those found in the Tecopa Lake beds to the south.
1.4	38.2	Crossed Amargosa River.
4.1	42.3	Road turns about 30° directly South--at 11:00 O'clock is Eagle Mt.
1.5	43.8	Town ahead is Death Valley Junction. Junction of California Highway CA 190, and CA 127--right turn to Death Valley National Monument. Elevation about 2,000 feet.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
	43.8	Proceed west with Funeral Mts. on right. Green Water Range is straight ahead.
5.5	49.3	At 9:00 O'clock--Basalt Flows capping Tertiary (?) deposits. Basalt has been dated at about 3.9 my.
7.5	56.8	Road cut through Pliocene Basalt flow. Elevation about 2,820 feet.
2.1	58.9	Upturned and distorted Tertiary (Oligocene (?) to Miocene) sediments. Elevation 2,580 feet.
0.4	59.3	At 1-2 O'clock, white deposits are Paleospring deposits.
0.6	59.9	Stop. Entering Death Valley National Monument--Travertine Point. Notice white veins cutting exposures. These are composed of $CaCO_3$ spring deposits. Elevation about 2,480 feet.
0.6	60.5	At 12:00 O'clock mine dumps from Borax mining. At 9:00 O'clock is the Billie Mine.
1.1	61.6	Road left to Dante's View, continue straight. Elevation about 2,000 feet.
3.2	64.8	Road by upturned Pliocene Lava beds of the Furnace Creek Frm.
1.3	66.1	Upturned sand and gravel deposits capping Miocene Lake Beds - about 1,150-ft elevation.
1.4	67.5	20 Mule Team Canyon - Miocene/Pliocene Lake beds. Elevation about 990 feet.
1.2	68.7	At left road to Zabriskie Pt., Elevation about 780 feet.
0.8	69.5	Road parallels major drainage. Note channel deposits from past flood events.
1.0	70.5	Travertine Spring to right with phreatophytes growth--Note Palm trees. Elevation about 480 feet.
		Major discharge area for flow system--Note lush growth. Screwbean Mesquite on right.
1.0	71.5	Paleospring deposit about 220 feet elevation. upturned Miocene-Pliocene Lake beds.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
0.5	72.2	Furnace Creek Inn - (Harvey House Operator). Turn left on paved road south to Badwater. Elevation 0 msl.
		Alluvial Fan at 1:00 O'clock and phreatophytes growing in valley.
8.8	73.0	Fault Scarp on left side. At 3:00 O'clock (right) notice large alluvial fans across valley.
2.8	75.8	Road to left goes to Desolation Canyon - continue straight.
0.4	76.2	Road winds around Basalt flows.
0.3	76.5	Mushroom Rock on left.
1.5	78.0	Road on right to west side of Death Valley.
2.6	80.6	One-way road to Artists Drive on left. At 2:00 O'clock salt deposits on floor of Death Valley.
1.7	82.3	Road crossing large alluvial fan. Note rills on left and right showing coarse deposits from past flood events.
2.1	84.4	Road to Natural Bridge on left.
1.4	85.8	At 2:00 O'clock, large expanse of salt deposits.
0.9	86.7	Ground-water discharge areas on right. Note at 12:00 O'clock small alluvial fan built out from toe of mountain.
1.1	87.8	Sign pointing to Telescope Peak across valley in the Pananimint Range. Elevation of peak is 11,049 feet.
0.6	88.4	Parking lot at Badwater--resident ostracode is *Cyprideis beaconensis*. Elevation 282 feet below msl.
0.5	88.9	Crossing toe of Alluvial fan.
0.4	89.3	Notice coarse alluvial debris from flood events.
3.7	93.0	Toe of Mountain Front. Note altered rocks along fault zone.
0.8	93.8	3:00 O'clock. Note ground-water seepage area from fault area.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
2.5	96.3	Starting across large alluvial fan that enters valley from east side.
2.7	99.0	At 1:00 O'clock note small fans built out from mountain front.
2.6	101.6	At 12:00 O'clock note older dissected alluvial fans.
2.5	104.1	Mormon Pt on left.
0.5	104.6	Ground-water seepage from toe of dissected fans.
1.7	106.3	Ground-water seepage area from toe of fans.
1.6	107.9	Ground-water seepage area from toe of alluvial fans and phreatophytes.
4.8	112.7	At 10:00 O'clock, east side of road are Basalt flows.
0.6	113.3	Junction with west side road, turn right on to dirt road heading west.
0.7	114.0	Crossing channel of Amargosa River as it enters Death Valley from south.
1.1	115.1	Stop. Turn vehicles around at Cinder Cone on south side of road.
		Stop at Cinder Cone. Cinder Cone split by movement along major fault. Return to paved road.
1.8	116.9	Return to paved road from "West Side" road, turn right and proceed south.
0.4	118.2	Shoreline Butte on west.
		Stop. Note shorelines of Lake Manly cut into Butte. Pleistocene Lake Manly reached a depth of about 600 feet in Death Valley and was the result of melting of glaciers far upstream in the highlands of the Sierra Nevada mountains. The lake dried up about 10,000 years ago and has been dry since, except for a period about 2,000 years ago when a shallow lake/pond about 30 feet deep occurred in the Badwater area.
		If you look closely at Shore Line Butte to the south you will see many features that appear to be terraces or benches cut into the rock. These are wave cut features at former shorelines of Lake Manly.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
		Lake Manly sediments in the valley offer an opportunity to obtain much aditional information on the Pleistocene/Recent climate in the region.
1.3	119.5	Ashford Mill ruins and channel of Amargosa River to the west.
2.0	121.5	Paved road turns left, dirt road straight ahead goes to Baker, California.
0.8	122.3	At 10:00 O'clock note small sand ramps to the east.
3.9	126.2	Jubilee Pass, Elev 1,290 feet.
3.6	129.8	Basalt flows on northeast side of road and other basalt capped hills in local area.
1.7	131.5	Basalt flows and National Monument boundary sign--Road now California 178.
4.1	135.6	Salsbury Pass - Elevation 3,315 feet road passes through Miocene/Pliocene volcanics. Resting Springs Mts is the high range to the east.
10.6	146.2	Junction of Highway California 190 and California 127. Turn right on California Highway 127; go south.
0.2	146.4	Large diffuse ground-water discharge area with springs.
0.6	147.0	At 9:00 O'clock, Basalt flow - near Shoshone, California.
0.7	147.7	Shoshone, California.
0.1	147.8	Junction Highway 127 and Highway 178 to Pahrump, Nevada; refer to log for side trip "A" for more information.
0.1	147.8	Shoshone International Airport on east side of road - watch out for low flying aircraft.
2.9	150.7	Passing through Tecopa lake beds - greenish yellow bed capping tops of some beds is the Lava Creek ash.
2.3	153.0	Tecopa Hot Springs junction.
0.8	153.8	Flowing well near the site of the Amargosa Borax Works. After stop return to paved road and proceed north.
8.6	162.4	North to intersection of California Highway 129 and California 178 (west).

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
1.2	163.6	Winding road through Tecopa Lake beds which are covered with alluvium.
1.4	165.0	Channel of Amargosa River east of road.
2.3	167.3	Road follows west bank of Amargosa River.
1.2	168.5	Road crosses Amargosa River Channel.
0.5	169.0	Road crosses Amargosa River Channel.
3.4	172.4	12:00 O'clock - Eagle Mountain dead ahead. Composed of Paleozic limestones, this 600-m high block of Paleozoic and Precambrian rocks is thought to have slid along a listric fault surface from the Resting Spring Mountains to the east. Tertiary fanglomerates, siltstones and sandstones lie uncomformably on the southern end of Eagle Mountain. The mountain may act as a barrier to ground-water flow causing the abrupt change in water-table altitude observed in drill holes at Franklin Lake playa to the north (water levels at 600 m) and drill holes 1 mile south of Eagle Mountain (water levels at about 530 m). The mountain may also be, in part, responsible for ground water to discharge at Franklin Lake playa.
3.8	176.2	Road crosses Amargosa River Channel.
1.6	177.8	Eagle Mt may be a "slide block" that moved downslope to the Basin center. Basalt flow on west side of road.
1.0	178.8	Road follows Amargosa River channel.
1.6	180.4	Stop - Alkali Flat or Franklin Lake playa. This 14^2 "dry" lake is one of the principal discharge areas for the ground-water flow system from Yucca Mountain and vicinity. Annual estimates of ground-water discharge at Franklin Lake playa range from 1 to 3 mm/d throughout the year. Total discharge is estimated to be about 23,000 m^3/d, most of which occurs as bare-soil evaporation from the water table which ranges in depth from 3 m to 0.2 m below land surface. Over thirty piezometers were used to determine vertical and lateral distribution of hydraulic head at the playa. The lighter colored areas of the playa correspond to areas with efflorescent salts; dark-colored areas have a soft, puffy, porous surface believed to result from ground-water capillarity causing salt crystal growth and swelling of clays.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
7.0	187.4	Small town of Death Valley Junction and Historic District.
0.10	187.5	Junction California Highway 127 and California Highway 190 to Death Valley, stay on Highway-127 north.
1.7	189.2	At 2:00 O'clock - white deposits are Ash Meadow Spring line. At 9:00 O'clock, Funeral Mts. Straight ahead in far distance is Busted Butte near Yucca Mt. Large Mountain Block at 11:00 O'clock is Bare Mt.
3.9	193.1	Amargosa River Channel - "watch out for rafts and water skiers."
1.5	194.5	Entering the Silver State on Highway Nevada-373.
0.2	194.8	Metropolis of State Line, Nevada, and Junction of Spring Meadows Drive and Nevada Highway 373.
1.5	196.3	Road to Ash Meadows. Continue staight on Hwy 373.
0.9	187.2	Turn right on dirt road to Fairbanks Butte. Bend ahead--Ash Meadow Spring Line visible in distance. High peaks in distance are Spring Mts with Mt Charleston at 1:00 O'clock.
2.7	198.9	At 12:00 to 2:00 O'clock - north end of Ash Meadows Spring line.
1.0	200.9	Crossing marsh and lake deposits of Miocene to Pliocene age.
1.7	202.6	Fairbanks Spring and National Wildlife Refuge. On left Fairbanks Butte composed of Tertiary fresh-water limestone. Turn around and return to Highway 373.
5.5	208.10	Junction of Fairbanks Spring Road and Highway 373. Turn right on Hwy 373 - Road continuing to west goes to clay processing plant.
3.1	211.2	Amargosa Valley commercial area (El Camino). A modern ghost town that was overdeveloped during economic boom period.
2.1	213.3	Amargosa Valley Post Office on west side of highway.
2.9	216.2	Yucca Mt at 11:00 O'clock. Road going west goes to Amargosa Farms area.

HYDROGEOLOGIC FIELD TRIP LOG

Miles	Total Miles	Feature
5.1	221.3	Junction with U.S. Highway 95, turn right.
0.6	221.9	10:00 to 11:00 O'clock. Stripped Hills composed of upturned Paleozoic Carbonate. At 2:00 O'clock is Specter Range, notice sand ramps.
1.8	223.7	At 10:00 O'clock large sand ramp on flank of Stripped Hills.
2.9	227.8	To right - Rock Valley Fault Zone - Note, Calcium Carbonate Caliche deposits in road cut.
1.2	227.8	2:00 O'clock Peters or Amargosa Flats Playa. At 12:00 O'clock North end of Spring Mts.
8.4	236.2	Paleozoic carbonate "Inselberg."
1.5	237.7	Junction U.S. Highway 95 and Nevada Highway 160 to Pahrump, Nevada.
7.7	245.4	Mercury cutoff and return to starting point.

Appendix E

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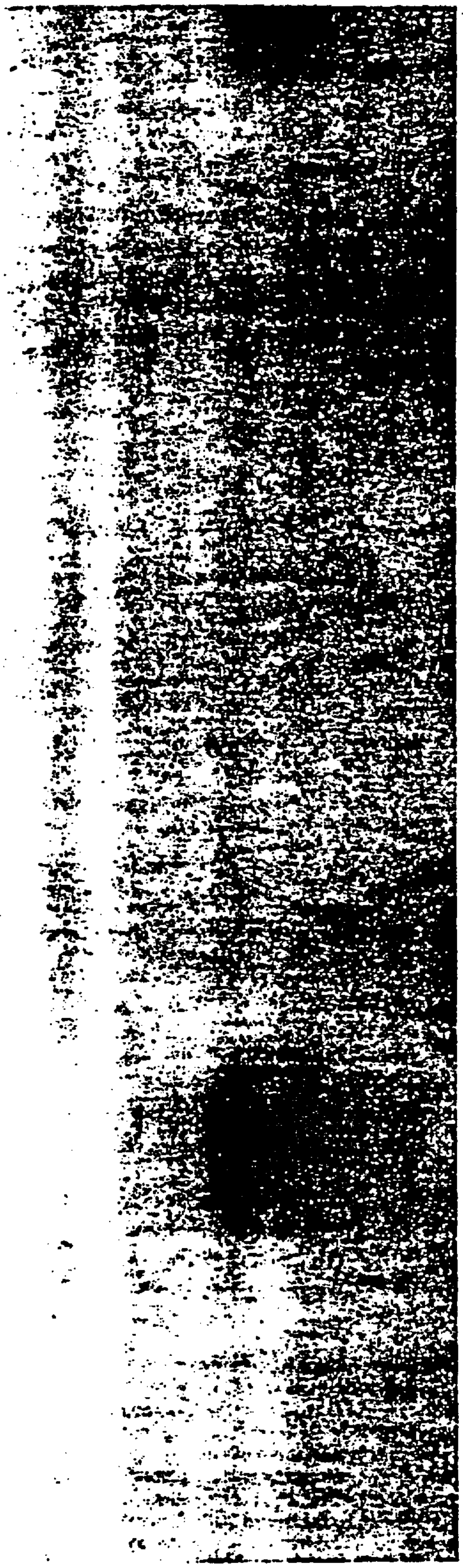

A Preliminary Comparison of Mineral Deposits in Faults near Yucca Mountain, Nevada, with Possible Analogs

Los Alamos

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