UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Reply to:

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MEMORANDUM

DATE: July 21, 1989

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

FROM: Paul T. Prestholt, Sr. OR - NNWSI

SUBJECT: Yucca Mountain Project (YMP) Site Report for the month of June, 1989

I. GEOLOGY-GEOPHYSICS

A. Because the State of Nevada has not issued the modification to the Nevada Test Site (NTS) air quality permit, the second phase of the prototype drilling program will not take place on the NTS south of Busted Butte. Arrangements have been made with a Utah mining company to drill on mineral claims in Utah. The site is west of Milford, Utah, about a five hour drive from Las Vegas, (see map), Insert #1.

Site preparation and pad construction is scheduled to start the week of July 17. I plan on going to the drill site on August 9, 10, and 11 to observe the drilling operation.

Encl: Filed in Binder on Shelf

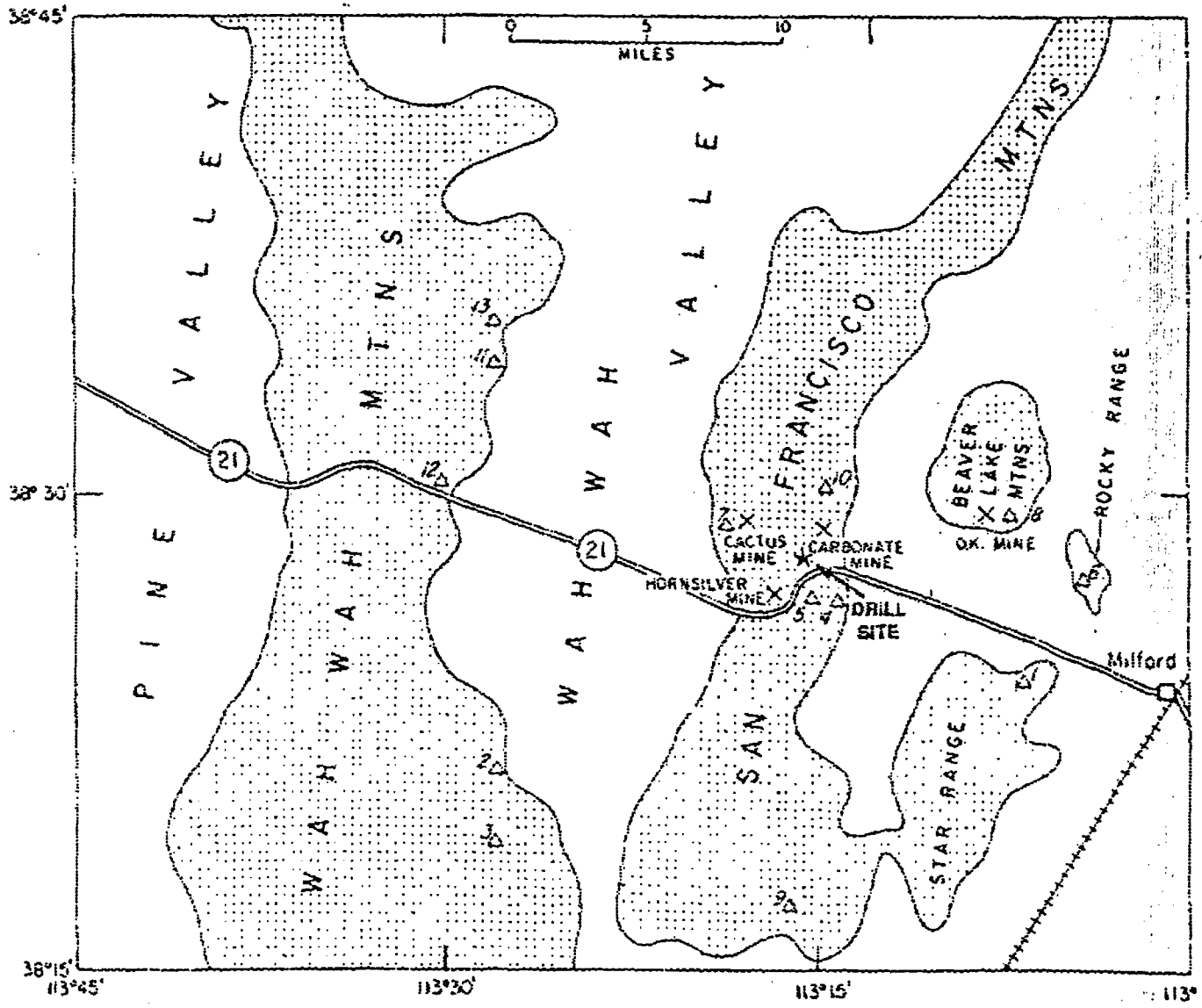
102
WM-11
NH03

8908030165 890721
PDR WASTE
WM-11 PDC

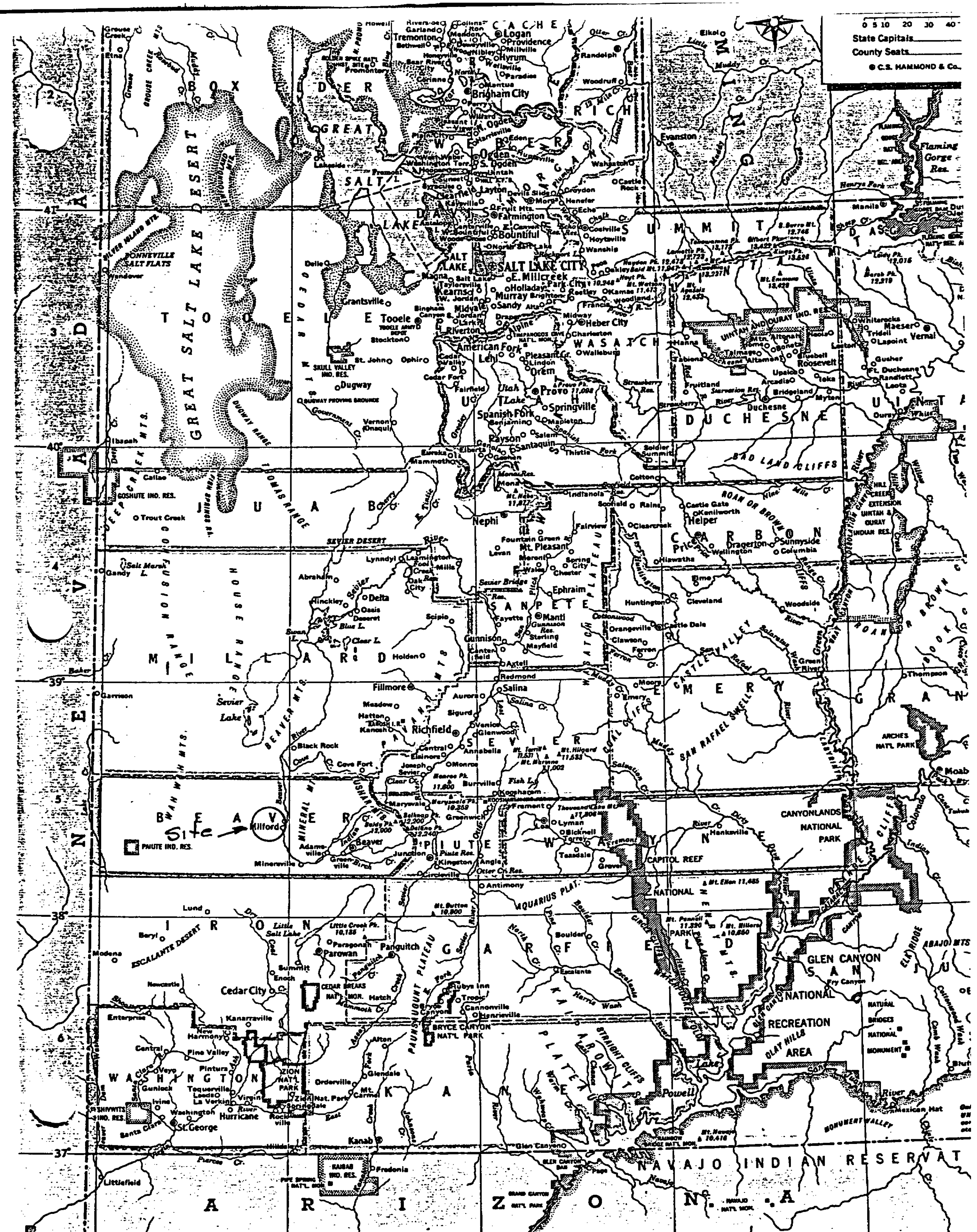
Rec'd w/ltr. dtd 7/21/89 8908030165

PHASE 1C PROTOTYPE LOCATION
OLD FRISCO MINE SITE NEAR MILFORD, UTAH

102



INSERT #1 (a)



State Capitals
County Seats
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BOX ELDER
CACHE
RICH
WEBER
MORGAN
DAVIS
SUMMIT
DAGGETT
TOOELE
SALT LAKE
GREAT SALT LAKE DESERT
GREAT SALT LAKE
BONNEVILLE SALT FLATS
WASATCH
UTAH
DUCHESNE
UINTAH
JUAB
CARBON
SANPETE
MILLARD
SEVIER
EMERY
GRAND
BEAVER
PIUTE
WAYNE
IRON
GARFIELD
SAN JUAN
WASHINGTON
KANE
NEVADA
ARIZONA
WYOMING
Logan
Brigham City
Ogden
Farmington
Bountiful
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Tooele
Provo
Heber City
Vernal
Roosevelt
Duchesne
Nephi
Price
Manti
Fillmore
Richfield
Milford
Beaver
Cedar City
Parowan
Panguitch
St. George
Kanab
Moab
Site
PIUTE IND. RES.
SEVIER DESERT
ESCALANTE DESERT
CANYONLANDS NATIONAL PARK
CAPITOL REEF NATIONAL PARK
ARCHES NAT'L PARK
BRYCE CANYON NAT'L PARK
ZION NAT'L PARK
GLEN CANYON NATIONAL RECREATION AREA
Lake Powell
NAVAJO INDIAN RESERVATION
Flaming Gorge Res.
41°
40°
39°
38°
37°

INSERT # 1 (b)

B. The Geophysics white paper being prepared by Dr. Ernie Hardin, SAIC, is still in review. Dr. Hardin doesn't have a release date at this time.

A geophysics workshop originally scheduled for July 31, August 1 and 2 has been postponed.

The Technical Assessment Review (TAR) panel that was established to study the reported geophysical resistivity anomaly in Coyote Wash conducted a field trip on June 6 and 7. The purpose of the field trip was to locate, on the ground, the position of the lines-of-survey reported by Smith and Ross in USGS-OFR-82-182, and to determine if there was any surface expression of the proposed geologic feature (fault) reported by Smith and Ross.

The lines of survey were located with an error of ± 50 feet or so and walked. The location of the anomaly between exploration shaft (ES) 1 and 2 was examined. No surface expression of the reported anomaly was found.

A meeting of the TAR panel is planned for July 11. The TAR report is scheduled for release in August.

II. HYDROLOGY

The hydrology field trip, originally scheduled for the week of July 10 has been rescheduled for the week of July 24. The four day trip will include "G" tunnel, the shaft and ramp locations at Yucca Mountain, the various hydrologic testing sites at Yucca Mountain, a regional visit to Ash Meadows, Death Valley and Tecopah Springs and a day at the Sample Management Facility (SMF) and the USGS hydrology lab in Area 25 at the NTS.

III. GEOCHEMISTRY

This office has received a copy of the Los Alamos National Laboratory (LANL) "Project Status Report" for May 1989. This report (copy enclosed) lists the ongoing activities by WBS element and describes the status of each element.

IV. REPOSITORY ENGINEERING - ESF (UNDERGROUND)

A. We have received a draft description of the Fennix and Scisson (F&S) design packages for the exploratory shaft underground facility. There are a total of 16 packages. The full description of each draft package is enclosed; a brief introduction follows:

Proposed F&S
Design/Construction Packages
for the Underground Exploratory Shaft Facility

Package No. 1

Activity: This package consists of all of the general arrangement drawings, layouts, plans, sections and necessary dimensioning for the headframes, collars, hoists and foundations. These general arrangement drawings are developed to assure component fit within the facilities and form the basis for the detailed design of the components. These drawings are included in the following packages as required and the development is tracked under the WBS number to which they are assigned.

Package No. 2 - Engineered Barrier System Field Tests and Electric/Hydraulic Powered Track Mounted Drill - WBS 1.2.2.2.4

Activity: Provides for the Title II detailed design for the test alcoves, drifts, drill hole layouts and location of test fixtures, IDS equipment and utility support. In addition, this package will provide a performance specification for a drill capable of drilling the various holes required for these tests. This package will consist of all elements needed to construct the various engineered barrier test alcoves, IDS Equipment Alcoves, and the various ventilation, water, and power supply systems to the test alcoves and drifts.

Package No. 3 - Geohydrology Tests - WBS 1.2.3.3.1

Activity: Provides for the Title II detailed design for the test alcoves, drifts, drillhole layouts, and locations of test fixtures, IDS equipment, and utility support for all of the geohydrology tests located in the ESF.

Package No. 4 - Rock Mechanics - WBS 1.2.4.2.1

Activity: Provides for the Title II detailed design for the various test alcoves, drill hole layouts and locations of test fixtures, IDS equipment and utility support routing.

Package No. 5 - ES-1 Collar Design - WBS 1.2.6.3.2

Activity: Provides for the Title II detailed design for the ES-1 shaft collar and the foundation to the uppermost portion of the shaft used to support the headframe and shaft construction activities.

Package No. 6 - ES-2 Collar Design - WBS 1.2.6.3.3

Activity: Provides for the Title II detailed design for the ES-2 shaft collar.

Package No. 7 - ES-1 Shaft and Lining - WBS 1.2.6.4.1

Activity: Provides for the Title II definitive design for the ES-1 shaft, liner, and sump.

Package No. 8 - ES-1 Hoist and Headframe - WBS 1.2.6.4.2

Activity: Provides for the Title II detailed design for the ES-1 hoist and headframes.

Package No. 9 - ES-2 Shaft and Lining - WBS 1.2.6.5.1

Activity: Provides for the Title II design for the ES-2 shaft, liner, and sump.

Package No. 10 - ES-2 Hoist and Headframe - WBS 1.2.6.5.2

Activity: Provides for the Title II design for the ES-2 hoist and headframe.

Package No. 11 - Main Test Levels - WBS 1.2.6.6.1

Activity: This item includes elements and activities associated with the MTL areas relative to testing and operations support.

Package No. 12 - Exploratory Drifts - WBS 1.2.6.6.2

Activity: This item includes elements and activities associated with the Exploratory Shaft areas relative to testing and operations support.

Package No. 13 - Secondary Levels - WBS 1.2.6.6.3

Activity: This item includes elements and activities associated with the Secondary Level Upper Demonstration to testing and operations support.

Package No. 14 - Utilities and Communications Systems - WBS 1.2.6.7.1

Activity: Provide the Title II design for the Ventilation System, Mine Supply Water System, Mine Waste Water Removal System, Compressed Air System, Underground Electrical Distribution and Lighting System, and certain portions of the Underground Instrumentation and Communications System.

Package No. 15 - ES-1 Shaft Internals and Conveyances - WBS 1.2.6.7.2

Activity: Provides for the Title II design of the ES-1 shaft furnishings.

Package No. 16 - ES-2 Shaft Internals and Conveyances - WBS 1.2.6.7.3

Activity: Provides for the Title II design of the ES-2 shaft furnishings.

In order to structure the scope-of-work for Title II activities, F&S has used the YMP Work Breakdown Structure Dictionary. Therefore, the scope of work elements described identify the primary work breakdown structure and work packages for the Title II effort and are, in fact, the cost accounts that will be used to monitor and measure the work. The design packages will include detailed plans and sections, analyses, specifications and studies. All design will be checked, verified and approved in accordance with an F&S approved QA Program. Design deliverables will include drawings, specifications, analyses and QA grading packages.

F&S is presently preparing general arrangements for the headframes, collars, hoists and foundations. This activity is expected to be completed by mid August at which time the detailed collar design activity will begin (design packages 5 & 6) provided the preliminary soil report is completed by the Bureau of Reclamation.

B. Controlled blasting prototype tests are scheduled for July in "G" tunnel after completion of prototype in situ stress measurements.

V. LICENSING AND DOE-NRC INTERACTIONS

A. The Nuclear Waste Technical Review Board (NWTRB) held a meeting with the DOE and the State of Nevada on June 26, 27 and 28. On the 26th the State of Nevada made a series of presentations to the NWTRB stating the State's technical concerns with the establishment of a High Level Waste Repository in the State (agenda enclosed). One copy of the viewgraphs and supporting materials used in the State's presentation is enclosed.

On the 27th, the DOE briefed the NWTRB on the status of the technical studies conducted by the project. A detailed agenda is enclosed. On the 28th, DOE-YMPO conducted a field trip for the NWTRB and interested parties. The field trip concentrated on the Yucca Mountain site and included the following (from the handout):

TOPICS COVERED ON THE FIELD TRIP - JUNE 28, 1989

General geology: Discussion of outcrops and stratigraphy; volcanology; structural geology; fault locations and ages; geomorphology; neotectonics; Midway Valley hydrogenic deposits; paleoclimatology.

Unsaturated zone testing: Instrumentation; neutron holes, infiltration experiments.

Saturated zone testing: Water-table holes, paleohydrology.

ESF site: Flood potential; nearby faults; drift locations.

Sample Management Facility and cores: General mineralogy-variations in tuffs; fracture studies on cores; sample management facility handling procedures, rock properties, dry drilling status.

The NWTRB was established by Public Law 100-203 dated December 22, 1987. The Board members, as of June 26, 1989 are:

Chairman - DR. CLARENCE R. ALLEN, International Consultant in the construction of shafts, tunnels and dams, engineering geology and rock mechanics, and Adjunct Professor, University of Florida, Gainesville.

Board Members - DR. JOHN E. CANTLON, Vice President for Research and Graduate Studies and Dean of the Graduate School at Michigan State University; DR. MELVIN W. CARTER, Professor Emeritus, Georgia Institute of Technology and an International Radiation Protection Consultant; DR. DONALD LANGMUIR, Professor of Geochemistry at the Colorado School of Mines; DR. D. WARNER NORTH, Principal, decision Focus, Inc., Los Altos California, Consulting Professor, Stanford University, Palo Alto, California and Associate Director, Stanford Center for Risk Assessment; DR. DENNIS L. PRICE, Professor of Industrial Engineering and Operations Research and Director, Safety Project Office, Virginia Polytechnic Institute and State University, Blacksburg, Virginia; DR. ELLIS D. VERINK, Distinguised Service Professor of Metallurgy and former Chairman, Materials Science and Engineering Department, University of Florida, Gainesville, Florida.

Executive Director - MR. BILL COONS, Retired Faculty Member and former Assistant Chairman, Civil Engineering Department, University of Florida, Gainesville, and Retired Captain, United States Navy.

As of June 26, the Board has established five working panels. The title of each panel and the panel members are:

1. Containers and Transportation
   Chairman: Dr. Dennis L. Price
   Members: Dr. Melvin W. Carter, Dr. D. Warner North, Dr. Ellis D. Verink.
2. Risk and Performance Analysis
   Chairman: Dr. D. Warner North
   Members: Dr. John E. Cantlon, Dr. Don U. Deere, Dr. Donald Langmuir, Dr. Dennis L. Price, Dr. Ellis D. Verink.
3. Structural Geology and Geoengineering
   Chairman: Dr. Clarence R. Allen
   Member: Dr. Don U. Deere
4. Hydrogeology and Geochemistry
   Chairman: Dr. Donald Langmuir
   Member: Dr. Clarence R. Allen
5. Environmental and Public Health
   Chairman: Dr. Melvin W. Carter
   Members: Dr. John E. Cantlon, Dr. D. Warner North

Dr. Don U. Deere, panel chairman, held a news conference at the conclusion of the three day meeting and expressed general satisfaction with the presentations.

B. Meetings attended:

- June 6-7 Field trip, geophysical anomaly, TAR
- June 3 Meeting with Carl Gertz

- June 9 Meeting with Carl Gertz, Wendy Dixon, Don Helton and Bob Barton, all with YMPO, conderning data bases
- June 12-16 Vacation
- June 19 Meeting with Carl Gertz
- June 26-28 NWTRB meeting

There was no Technical Project Officer-Project Manager (TPO) meeting in June.

VI. STATE OF NEVADA INTERACTIONS - None

VII. GENERAL

A. The Project Office (YMPO) has reviewed the draft "Technical Position on Tectonic Models in the Assessment of Performance of High-Level Radioactive Waste Repositories". The review comments have been forwarded to DOE-Hq.

B. Enclosed is a memorandum dated June 2, 1989, from Lowell H. Shifley, air quality office to L. H. Dodgion, Administrator of the Nevada Division of Environmental Protection concerning the DOE request for Modification of the NTS air quality permit to allow the YMP to conduct drilling and trenching activities. Also enclosed is the cover letter from Mr. Dodgion to Frank E. Bingham, DOE Nevada Operations Office.

C. The SEPDB has been transferred to the DOE computer.

D. The establishment of a local records center is planned at the NTS. All records generated at the site, including data, will be submitted to the local records center.

There are no new issues that this office has identified that have not been brought to management's attention.

cc: With enclosures: K. Stablein, M/S 4 H3; R. Adler, J. E. Latz
Without enclosures: C. P. Gertz, R. R. Loux, M. Glora, G. Cook, D. M. Kunihiro, R. E. Browning, M/S 4 H3; K. Turner, S. Gagner, M/S 2 G5; L. Kovach, M/S NLS260; H. Thompson, M/S 17 G21; H. Denton, M/S 17 F2; R. Benero, M/S 6 A4

Enclosures: LANL YMP Project Status Report, May 1989; NWTRB Agenda & Overview of Briefing and Field Trip, Max Blanchard; Letter from Dodgion to Bingham (June 5, 1989) & Memo from Shifley to Dodgion (June 2, 1989); Design Packages for the Underground Facility (Draft)

11 additional handouts from the NWTRB to J. J. Linehan only

Los Alamos National Laboratory
Yucca Mountain Project

PROJECT STATUS REPORT
May 1989

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Los Alamos National Laboratory
Yucca Mountain Project

PROJECT STATUS REPORT
May 1989

WBS: 2.1.2.4.A
Project Title: Systems Engineering Integration
Principal Investigator: R. Herbst

The objective of this task is to integrate Yucca Mountain Project technical work through the application of systems engineering techniques.

ACTIVITIES AND ACCOMPLISHMENTS:

No activity to report this month.

WBS: 2.3.2.3.1.A
Project Title: Tectonics and Volcanism
Principal Investigators: B. Crowe and F. Perry

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

ACTIVITIES AND ACCOMPLISHMENTS:

A five-day field trip was held with participants from the Nuclear Regulatory Commission (NRC), the State of Nevada, Department of Energy (DOE)/Las Vegas (LV), DOE/Headquarters (HQ), and Los Alamos. The purpose of the trip was to provide background information on volcanism studies for the NRC and to discuss topics of concern expressed by the State of Nevada. The first day of the trip was spent in the Lake Mead area of Nevada and Arizona. The results of ongoing field studies by participants from University of Nevada at Las Vegas, funded by the State of Nevada, were examined for a group of basalt and basaltic andesite centers that range in age from about 10 to 4.5 Ma. The second day of the trip was in the Yucca Mountain area examining field and chronology data for the Lathrop Wells center, Red Cone, and the two Quaternary centers of the Sleeping Butte site. Field relations of basaltic volcanic rocks were examined in the northern Reveille Range on the third day of the trip. This day concluded with a brief stop at the Lunar Crater volcanic field. The fourth day, we examined two other Quaternary centers of the southern Great Basin, the Ubehebe Craters, and the basalt of southern Death Valley. The final day included examination of basalts of the Cima Volcanic field and concluded with a tour of the "A" cone to establish the age control of the center and provide a discussion of the basis for a geomorphic comparison of this center with the Lathrop Wells volcanic center.

Volcanism sections of the Geological Society of America (GSA) guidebook were revised as part of final preparation of the guidebook for the Yucca Mountain area. This guidebook was a joint effort by participants from Science Applications International Corp., U.S. Geological Survey (USGS), DOE, and Los Alamos. The guidebook will be published by the GSA for their fall national meeting.

Personal certification packages were assembled for the participants in the volcanism task. They will be stored in the Las Vegas office.

We completed consulting arrangements with Steve Forman, University of Colorado, to provide thermoluminescence age determinations for the volcanism studies.

Field work continued at the Cima volcanic field. Geologic mapping was started in the lava flow sequences of the "A" cone. Three major episodes of lava extrusion were recognized with a possible age gap between two of the flow sequences. A paleomagnetic site was identified in the youngest lava flow sequence to determine if there is a difference in the magnetic field directions of the flows. Additional field work continued at the Lathrop Wells volcanic center. The Qs4 sequence was remapped at the east end of the fissure. It is possible that some of the scoria mounds of this rift may be part of the Qs5 sequence. Sites for drilling core for paleomagnetic field directions were identified to attempt to establish the unit identification of the scoria mounds.

PLANNED WORK:

Color aerial photography at a scale of 1:5000 will be obtained in July for the two Quaternary cones of the Sleeping Butte site.

Paleomagnetic studies will be conducted at the Sleeping Butte cones and the Cima volcanic field in June.

BIBLIOGRAPHY:

Author(s)	Title	Type of Publication	Status
Crowe, Harrington, Perry, Wells, McFadden, Renault, Turrin, and Champion	Volcanic Hazard Studies for the Yucca Mountain Project	Paper for meeting - Waste Management '89, Tucson, Feb. 26-March 2, 1989	Project Office approved 5/8/89.
Turrin, Crowe, and Fleck	K-Ar Determinations of Lava Flow Units of the Lathrop Wells Volcanic Center	Article for journal (to be determined)	Being revised after USGS review.

MILESTONE PROGRESS:

The milestone report for the K-Ar report on the Lathrop Wells volcanic center continues to be delayed. A revised draft has been completed, and we are currently adding sections on the geomorphic relations at the center. The manuscript should be completed in June.

Milestone	Date Due	Description or title	Status
T403	5/15/89	Potassium-Argon Geochronology-Basalts of Crater Flat	Delayed; see above.
T404	9/30/88	Progress Report on Rock Varnish Work	Revision sent to Project Office 2/28/89.

WBS: 2.3.4.1.1.A
Project Title: Groundwater Chemistry
Principal Investigator: M. H. Ebinger

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

ACTIVITIES AND ACCOMPLISHMENTS:

Investigation 8.3.1.3.1.1 was split into two activities. Activity 8.3.1.3.1.1.1 will be concerned with development of a conceptual model of groundwater chemistry. The mathematical model of groundwater chemistry will be developed in activity 8.3.1.3.1.1.2 and will begin after the conceptual model is developed. .

Draft of Study Plan for Activity 8.3.1.3.1.1.1 (Conceptual Model of Groundwater Chemistry) will be completed and submitted for internal review in June 1989.

PLANNED WORK:

Continue development of study plan for activity 8.3.1.3.1.1.1 and circulate draft for internal Los Alamos review.

PROBLEM AREAS:

None.

MILESTONE PROGRESS:

No milestones are scheduled in the next three months.

WBS: 2.3.4.1.2.A
Project Title: Natural Isotope Chemistry
Principal Investigator: A. E. Norris

The objective of the natural isotope chemistry task is to determine the distribution of naturally occurring radioactive elements at Yucca Mountain as part of the work to characterize the infiltration of precipitation, the velocity of water movement through the unsaturated zone, and the retardation of radionuclide transport relative to water velocity.

ACTIVITIES AND ACCOMPLISHMENTS:

This month, nine Yucca Mountain Project samples were analyzed for ^{36}Cl at the University of Rochester's accelerator mass spectrometer. Four of the samples were from G-Tunnel material to help verify the

previous single-sample observation of an unexpectedly high value of ^{36}Cl in cuttings from the experiment drift. The ^{36}Cl in two samples from core hole DH-1 cuttings confirmed the high value observed in the nearby DH-2 cuttings. The ^{36}Cl in two samples of cuttings from AC-2 indicates that the high value is present at a distance of 180- to 189-ft east of the fault visible in the experiment drift, but the sample from 232- to 242-ft east of the fault has a background value.

The other five ^{36}Cl samples came from USW UZ-1 cuttings. The purpose of these measurements is to develop a procedure to interpret the ^{36}Cl data in terms of meteoric water movement downward through the unsaturated zone at Yucca Mountain. The data analyses for these samples are being completed.

Large quantities of cuttings must be processed to prepare each sample for ^{36}Cl analysis: often 20 kg are required for a single sample. The development of the technique to trace water movements in the unsaturated zone will necessitate more samples than was previously thought. To help in this work, the U.S. Geological Survey made available an additional 1,815 kg of cuttings from USW UZ-1 and USW UZ-6. These cuttings were shipped this month from the Nevada Test Site to Hydro Geo Chem, Inc., in Tucson, Arizona.

A. E. Norris gave two presentations this month. The first was an invited seminar at the University of Rochester's Nuclear Structure Research Laboratory on May 9. The title of this seminar was, "Analyses of Chlorine-36 in Samples of Tuff from the Yucca Mountain Project." The second talk was a Yucca Mountain Project colloquium at Los Alamos on May 17 titled, "The Use of Chlorine-36 to Trace Water Movement in the Unsaturated Zone."

PLANNED WORK:

The full text of the paper titled, "The Use of Chlorine Isotope Measurements to Trace Water Movements at Yucca Mountain," will be prepared for publication in the proceedings of the DOE/American Nuclear Society meeting "Focus '89." This meeting will be held in Las Vegas, Nevada, in September.

MILESTONE PROGRESS:

No level II milestones are scheduled this fiscal year.

WBS 2.3.4.1.3.A
Project Title: Hydrothermal Geochemistry
Principal Investigator: C. Duffy

The objective of the hydrothermal geochemistry task is to produce a model for past and future mineral alteration in Yucca Mountain. The model is intended to explain 1) natural mineral evolution resulting from the transformation of metastable mineral assemblages to more stable assemblages and 2) the effects of a repository emplacement.

ACTIVITIES AND ACCOMPLISHMENTS:

Most of our effort has remained directed toward the preparation of detailed technical procedures and the review of quality assurance (QA) procedures. We are continuing to make progress on the data acquisition system for the flexible cell hydrothermal system. We are also continuing scoping studies on the kinetics of the cristobalite-to-quartz transition. We continue to confirm a rather large dependence of rate on pressure

as well as temperature. We have completed two long-duration (approximately 1.5 months) experiments at 350°C and 1000 bar this month. These experiments show slightly less than 50% conversion of cristobalite to quartz and definitely confirm a much reduced rate of conversion at 1000 bar relative to 2000 bar. However, both of these experiments produced an inhomogeneous product.

In both cases, there was a volume of essentially complete conversion of cristobalite to quartz along one side of the run capsule, whereas the remainder of the run showed less than 50% conversion to quartz. We have not performed detailed temperature calibrations on these vessels because we lack an accepted means of calibrating our thermocouples for YMP work, but previous experience suggests that temperature variations over the run capsule are less than 1°C. The dominant variation would also be expected along the length of the capsule rather than across its diameter. Therefore, it seems difficult to explain this phenomenon on the basis of temperature gradients. Such inhomogeneity might also arise if quartz nucleation were a rare phenomenon in the experiments so that the quartz grew from only a few centers. However, microscopic examination revealed a very large number of small crystals in both domains.

PLANNED WORK:

Work will continue toward a fully qualified QA program. We will also continue scoping studies on the kinetics of silica transition using cold-seal hydrothermal techniques. As soon as possible, we plan to start scoping studies on the silica concentration in equilibrium with silica polymorphs using the flexible cell hydrothermal system.

We will also be increasing efforts to examine the literature on the smectite/illite transition in preparation for preparing a milestone report on the subject (due at the end of September).

PROBLEM AREAS:

Project-wide problems with the traceability of standards preclude the possibility of standardizing our hydrothermal lab at this time. Because of the long duration of many hydrothermal experiments, this problem could impact the milestone report schedule if not corrected in the near future.

MILESTONE PROGRESS:

No milestones are due in next three months.

WBS: 2.3.4.1.4.A
Project Title: Solubility Determination
Principal Investigator: D. Hobart

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

ACTIVITIES AND ACCOMPLISHMENTS:

The final draft version of the Solubility Task study plan has been resubmitted to the Los Alamos Program Office. Most of our effort was centered on quality assurance (QA). A number of detailed technical procedures (DPs) were completed and submitted, and personnel certification forms were signed.

H. Nitsche visited Los Alamos on May 24 to complete the annual transfer of duplicate records. About 11,500 pages of records from the last 12 months were transmitted to Los Alamos-YMP records manager G. Ortiz. H. Nitsche also discussed his research directions with D. Hobart and introduced S. Carpenter.

Work continues on the solubility experiments for neptunium, plutonium, and neodymium/americium. The ^{237}Np solution in UE-25p#1 at 25°C and pH 6 has reached steady state. Spectrophotometric measurements on the supernatant solution showed that the solution species are uncomplexed NpO_2. Eh measurement gave about 680 mV (Ag/AgCl). Work continues on isolating the solid, which will then be analyzed by x-ray diffraction.

The following DPs are in progress:

- Determining UV-VIS-IR Absorption and Diffuse Reflectance Spectra.
- X-Ray Powder Diffraction Analysis for Solubility (YMP-LBL-DP03).
- Sodium Concentration Determination in Radionuclide Solutions (YMP-LBL-DP05).

Submitted DPs are as follows:

- The Preparation of Solutions of Pure Oxidation States of Neptunium, Plutonium, and Americium (TWS-INC-DP-78). [It should be noted that the DP for preparation of pure oxidation states of neptunium, plutonium, and americium is a joint effort by Los Alamos and Lawrence Berkeley Livermore (LBL) and will be revised soon with LBL additions.]
- Eh (Oxidation--Reduction) Potential Measurements (YMP-LBL-DP06).
- Sample Identification and Handling.
- Purification of Colloidal Plutonium(IV) by Centrifugation and Ion Exchange (YMP-INC-DP80).
- Calibration of Low Energy Gamma Counters (YMP-LBL-DP02).
- Trace Element Characterization by Atomic Emission Spectroscopy (YMP-LBL-DP04).

PLANNED WORK:

We will continue work on a number of DPs that are due this fiscal year.

PROBLEM AREAS:

None.

MILESTONE PROGRESS:

We are unable to report milestone due dates because we lack a fully qualified QA program; however, all milestones will be completed on time.

Milestone	Date Due	Description or title	Status
M367	11/17/88	Progress Report on Colloid Stability	Revision sent to Project Office 4/11/89.
P379	11/17/88	Photoacoustic Spectroscopy Methodology	Sent to Project Office 1/18/89.
T418	11/30/88	Solubility Measurements	Revision sent to Project Office 3/27/89.

WBS: 2.3.4.1.5.A
Project Title: Sorption
Principal Investigator: A. Meijer

The objective of the sorption and precipitation task is to provide sorption coefficients for elements of interest in order to be able to predict radionuclide movements from the repository to the accessible environment.

ACTIVITIES AND ACCOMPLISHMENTS:

Investigation of the influence of water/rock ratios on sorption coefficients has continued. These experiments address concerns of the Nuclear Regulatory Commission about the applicability of sorption coefficients determined in the laboratory (at high water/rock ratios) to the natural environment, where water/rock ratios could be lower. The rock sample selected for these experiments is a zeolitic tuff (G4-1502), and the water/rock ratios selected are 5:1, 10:1, 20:1, and 30:1. As noted in earlier reports, the sorption coefficients for barium (Ba), cesium (Cs), and strontium (Sr) show regular increases, with increasing water/rock ratios contrary to theoretical expectation. We suspected imperfect solution-solid separations by the ultra-centrifugation technique we were using in the experiments might be a factor.

Initial results for Cs in a new set of experiments, in which an ultra-filtration technique was used instead of centrifugation, suggested we were on the right track. However, the results for Ba and Sr indicated that although the water/rock ratio effect was more than an order of magnitude smaller with ultra-filtration than with ultra-centrifugation, a small residual effect remained. The remaining effect is thought to result from rock dissolution reactions, which appear to have a more pronounced effect on experiments with low water/rock ratios than those with high ratios. In essence, the rock dissolution rate appears to be relatively insensitive to the amount of solution present given the time scale of the experiments. This results in greater concentrations of major cations in the small water/rock ratio experiments, which in turn results in greater competition for available adsorption or exchange sites. We are currently analyzing the waters produced in the last experiments for major cations.

Our studies of the sorptive behavior of americium (Am) using natural and synthetic groundwaters and pure minerals are continuing. Initially, we will evaluate the degree to which Am is sorbed to the wall of the containers. This will be followed by batch sorption experiments involving pure mineral separates and various solution compositions. This month, we will pre-equilibrate the containers to be used in the Am experiments. Two teflon bottles are being pre-equilibrated with J-13 water, and the following samples are being equilibrated with a sodium bicarbonate/sodium carbonate buffer (pH = 7.4): two empty teflon

containers, two clinoptilolite samples in teflon containers, and two romanechite (Mn-oxyhydroxide) samples in teflon containers.

Pure minerals to be used in the sorption experiments have been analyzed for the following elements: silicon, iron, sodium, potassium, titanium, magnesium, manganese, aluminum, and phosphorus. Batch sorption experiments involving neptunium (Np) were initiated this month. The pre-equilibration and sorption steps were completed, and the desorption step was started. Two samples of each of the following minerals are being studied: a) synthetic calcite from Merck Chemicals, b) calcite from Mexico (<500 microns), c) synthetic hematite from EM Science, d) montmorillonite from Cheto, Az (<500 microns), e) cryptomelane from Socorro, NM (<500 microns), f) romanechite from Casa Grande, AZ (<500 microns), g) purified clinoptilolite from Castle Creek, ID (<500 microns), and h) synthetic goethite.

The pre-equilibration step involved equilibrating the mineral with a sodium bicarbonate/sodium carbonate buffer having a pH of 8.5. This pH is thought to be appropriate for the far-field in Yucca Mountain. The sorption step involved shaking the pre-equilibrated mineral and the Np solution (buffered with sodium bicarbonate and sodium carbonate to a pH of 8.5) for a period of three weeks and separating the phases. The initial and equilibrated Np solutions are being analyzed.

The normal procedure for batch sorption experiments calls for the solid material to be pre-equilibrated with the groundwater in the experiment. Typically, 1 g of solid is "equilibrated" with 20 ml of groundwater. The idea is that following this procedure, the rock will be "in equilibrium" with the background electrolyte (i.e., groundwater) before the solid is contacted with the groundwater bearing the radionuclides of interest. However, for rocks with high ion-exchange capacities, such as zeolitic tuffs, contact with 20 ml of a dilute groundwater such as J-13 will not result in "equilibration." In fact, it would take on the order of 20 liters of J-13 water to approach "equilibration" for a zeolitic tuff such as G4-1502. If the rocks are not adequately pre-equilibrated, the sorption coefficient obtained may not be appropriate in the sense that it might not be the most conservative value obtainable. In order to obtain an "equilibrated" sample of a zeolitic tuff for future batch and column experiments, we have started a column containing approximately 10 g of sample G4-1502 through which 20 liters of J-13 water will be passed.

The Stanford group was trained for the Los Alamos quality assurance program.

Responses to review comments by Battelle Columbus, Lawrence Livermore, and Science Applications International Corp. (SAIC) on the "Position Paper on Sorption" (Milestone T419) were completed. The report is being revised to reflect the review comments.

Sorption task personnel met with the Technical Integration Group (TIG) to discuss input to performance assessment activities.

The status of the remaining detailed procedures that were rewritten according to TWS-QAS-QP 5.2, R1 follows.

PROCEDURE #	TITLE	STATUS
TWS-INC-DP-05	Sorption, Desorption Ratio Determination of Geologic Materials by a Batch Method	In internal review.
TWS-INC-DP-79	Liquid Scintillation Counting of Samples	Completed and forwarded to the INC QAL.

PLANNED WORK:

Continue the study of Am and Np sorptive behavior using synthetic and natural groundwaters and pure minerals.

Start investigation of the sorptive behavior of technetium on pure minerals.

Continue study of sorption mechanisms for important radionuclides.

Develop and carry out purification procedures for pure mineral samples.

BIBLIOGRAPHY:

Author(s)	Title	Type of Publication	Status
Ines R. Triay and Robert S. Rundberg	Application of Deconvolution to the Analysis of Univalent Ion-Exchange Isotherms in Zeolites X and Y	Journal article	Accepted by *Zeolites*

MILESTONE STATUS:

Milestone	Date Due	Description or title	Status
T419	5/15/88	Position Paper on NNWSI Sorption Studies and Data Needs	Being revised after technical reviews requested by Project Office.
R505	9/30/88	Summary Report: Sorption of Nickel and Neptunium in Tuff Using Ground Waters of Different Composition	Project Office approved 5/24/89.
R720	9/30/88	Report on Deconvolution of Ion-Exchange Isotherms	Project Office approved 5/4/89.

WBS: 2.3.4.1.6.A
Project Title: Dynamic Transport Process
Principal Investigator: R. Rundberg

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

ACTIVITIES AND ACCOMPLISHMENTS:

We are continuing our study with Calico Hills and Topopah solid rock columns to investigate the ability of Yucca Mountain to act as a natural filter for particulate matter. For these studies, we utilize two columns of the Calico Hills tuff G4-1502 and two columns of Topopah tuff GU3-1119. This month, we completed the second tritium elution for each of the columns.

The study of the sorption of radionuclides as a function of time using beakers made of Yucca Mountain tuffs is still in progress (see schedule given in February's monthly report).

We assembled columns using the following minerals: calcite, cryptomelane, montmorillonite, romanechite, hematite, and goethite. The columns made of goethite and montmorillonite will require high pressure. Most of the columns assembled with the pure minerals leaked: consequently, we ordered polycarbonate rod, a sturdier and more chemically inert material, to build new columns.

We are analyzing the results obtained from columns made of Topopah Spring Member outcrop samples to study the transport behavior of barium (Ba), strontium (Sr), and cesium (Cs). This analysis will involve time-dependent dispersion. To compare these results with results obtained using the batch sorption approach, we have measured the Kds of Ba, Sr, and Cs using the same tuff (Topopah outcrop samples) and the batch sorption method. The results follow.

Sample No.	Kd for Ba	Kd for Sr	Kd for Cs
1	722.6	24.9	561.8
2	740.7	24.4	436.4
3	795.1	26.9	494.6
4	925.1	24.8	592.9
5	745.7	24.8	491.6
6	732.2	25.6	486.2
7	730.9	23.7	547.4
8	706.5	23.9	488.6
Average	762.3	23.9	512.4

The status of the detailed procedures (DPs) that have been rewritten according to TWS-QAS-QP 5.2, R1 follows.

PROCEDURE #	TITLE	STATUS
TWS-INC-DP-64	Gamma Counting of Samples for Dynamic Transport (Perkin Elmer Model 9000 Robot)	completed and given to the INC QAL
TWS-INC-DP-75	Determination of Particle Size Distribution by Autocorrelation Photon Spectroscopy	completed and given to the INC QAL

We finished revising the study plans for this task and submitted them to the Los Alamos Program Office on 5/12/89.

PLANNED WORK:

Continue solid rock column experiments.

Continue rock beakers experiment.

Start transport work with pure minerals.

Start validating the Autocorrelation Photon Spectroscopy technique using NBS standards.

PROBLEM AREAS:

We are moving some of the YMP equipment at RC-1, TA-48, to a new room within RC-1. After the equipment is moved, it needs to be installed and checked. Unfortunately, this is a time-consuming process.

BIBLIOGRAPHY:

Author(s)	Title	Type of Publication	Status
A. J. Mitchell, R. S. Rundberg, M. A. Ott, and I. R. Triay	Instrumentation and Operation of an Autocorrelated Photon Spectrometer Used for Particle Size Determinations	Abstract for 198th National Meeting of the American Chemical Society, Miami, FL, September 10-15, 1989	Submitted to Project Office 4/17/89.
M. A. Ott, R. S. Rundberg, and I. R. Triay	Mechanical Manipulation of Intact Tuffaceous Rock to Fabricate and Assemble Solid Rock Columns and Rock Beakers	Abstract for 198th National Meeting of American Chemical Society	Submitted to Project Office 4/17/89.
I. R. Triay, R.S. Rundberg, A.J. Mitchell, and M. A. Ott	Utilization of Inversion Techniques for Particle Size Determinations Using Auto-correlation Photon Spectroscopy	Abstract for 198th National Meeting of the American Chemical Society	Submitted to Project Office 4/17/89.
I. R. Triay, R. S. Rundberg, A. J. Mitchell, M. A. Ott, D. E. Hobart, and P. D. Palmer	Size Determinations of Pu Colloids Using Autocorrelation Photon Spectroscopy	Abstract for 2nd International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere, Monterey, CA, November 6-10, 1989	Submitted to Project Office 5/18/89.

Author(s).	Title	Type of Publication	Status
R. S. Rundberg, I. R. Triay, M. A. Ott, and A. J. Mitchell	Observation of Time Dependent Dispersion in Laboratory Scale Experiments with Intact Tuff Columns	2nd International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere	Submitted to Project Office 5/18/89.
I. R. Triay, A. Meijer, M. R. Cisneros, G. G. Miller, P. D. Palmer, R. E. Perrin, and R. D. Aguilar	Sorption Behavior of Americium in Tuff Samples and Pure Minerals Using Synthetic and Natural Groundwaters	2nd International Conference on Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere	Submitted to Project Office 5/19/89.

MILESTONE PROGRESS:

Milestone	Date Due	Description or title	Status
R743	8/16/88	Dynamic Transport of Colloidal Tracers through Fractured Tuff: 0.10- to 9.55-μm-Diameter Carboxylated Polystyrene Spheres	Revision sent to Project Office 12/7/88.

WBS: 2.3.4.1.7.A
Project Title: Retardation Sensitivity Analysis
Principal Investigator: K. Eggert

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

ACTIVITIES AND ACCOMPLISHMENTS:

Analysis of Physical/Chemical Processes

FEHMN/FEHMSN. A zone capability was added to FEHMN that allows irregulary shaped zones within the grid to be defined by their corner points. A 3-D contour-plotting option was also added. The fully coupled 2-D-stress and 3-D-mass module for FEHMSN converges.

S. Kelkar met with D. Galloway (U.S. Geological Survey, Denver) to discuss coupled hydromechanical modeling of Yucca Mountain.

One- and two-dimensional sample problems were successfully run using the CTCN (Colloid Transport Code - Nuclear) code. The N-D version of MOL, the solution routine used in CTCN, works well with standard examples, but it is having some difficulty with specific examples. The MOL method is being compared with a similar standard code in the Information Management System Library (IMSL) library package.

Geochemical/Geophysical Model

A grid is nearly complete to run a 3-D forward transport calculation with TRACRN. The grid is based on a 3-D model of the hydrologic stratigraphy at Yucca Mountain developed at Sandia (Ortiz et al. 1985). Tilted beds and the Ghost Dance Fault Zone are included. Mineralogy and sorption data will be used to perform sensitivity analyses on transport of cesium, technetium, and neptunium from the repository to the water table.

Transport Models and Related Support

The non-vertical gravity vector option was added to TRACRN and verified. This option simplifies the grid set-up for systems with tilted beds or nonvertical boreholes.

Quality Assurance (QA) and Programmatic

K. Eggert is putting together a set of input parameters for sample transport problems. These problems will be included as part of a set of Technical Integration Group sponsored performance assessment calculations. The team will participate in the solution of these problems.

The verification plan for FEHMN was written and reviewed. Three analytic solutions have been verified.

The Software Requirements and Design Specifications report is being written for CTCN.

PLANNED WORK:

Analysis of Physical/Chemical Processes

FEHMN/FEHMSN. Development of the solution for unsaturated flow will continue, along with improvements on the matrix solver for this type of system.

Transport Models and Related Support

A capability for using the solid state disk (SSD) available on the Cray YMPs will be incorporated into TRACRN, FEHMN, and FEHMSN. The SSD will be used to temporarily store information during calculations, which will increase the allowable problem size.

QA and Programmatic

More runs will be done for verification of FEHMN.

BIBLIOGRAPHY:

Author(s)	Title	Type of Publication	Status
G. Zyvoloski and S. Kelkar	FEHMS - A Finite Element Heat-Mass-Stress Code for Coupled Geological Processes	Los Alamos National Lab document LA-UR-87-1323	

MILESTONE PROGRESS:

MILESTONE T421 - YMPO/SAIC management and QA comments were addressed, and the report was submitted to the Los Alamos Program Office.

Milestone	Date Due	Description or title	Status
R343	5/1/87	Preliminary Geochemical/Geophysical Model of Yucca Mountain	Revision sent to Project Office 1/9/89.
R346	3/31/87	FEHMS: A Finite Element Heat-Mass-Stress Code for Coupled Geological Processes	Memo addressing review comments sent to Project Office 5/23/89.
R749	7/30/88	Results of the COVE2a Benchmarking Calculations Run with TRACR3D	Revision sent to Project Office 12/9/88.
T421	12/15/88	TRACR3D Documentation for Baseline-review.	Submitted to Los Alamos Program Office 5/31/89.
T422	12/30/88	Interim Report: Sorption Characteristics of Sorbing Tracers Using TRANQL/MINEQ	Being revised after N-5 policy review.
T424	12/30/88	Particulate Transport	Project Office approved 5/9/89.

WBS: 2.3.4.1.8.A
Project Title: Reactive Tracer Testing
Principal Investigator: E. Springer

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

ACTIVITIES AND ACCOMPLISHMENTS:

The remaining four detailed procedures (DPs) will require development in conjunction with new instrumentation that has been received; therefore, they will not be completed until July. Training for the DPs has been initiated and will be completed in June.

Comments from management and quality assurance and regulatory reviews of the study plan were received, and responses are being prepared. The study plan was sent to Department of Energy/Headquarters (DOE/HQ).

The FEHMN computer code continues to be baselined. Verification simulations for three-dimensional, transient heat flow in a cube have been completed. Results indicated that the energy balances are being solved properly and that the technique for incorporating irregular-shaped elements is correctly implemented. The dual porosity verification was completed. Results from the code were compared with published solutions obtained for quasi-steady-state transport into and out of matrix blocks, i.e., the block can be treated as a unit of constant pressure. Agreement between the code and the solutions was excellent for conditions in which the assumption was valid (constant pressure); but for conditions in which the assumption breaks down, the simulations deviated from the solution. This effort was the final step in verifying the dual porosity option of FEHMN, and at this time, this option is considered to be properly implemented. The mass transport component of FEHMN is being tested against one-dimensional analytical solutions for linear sorption and the computer code SORBEQ. FEHMN has exhibited slightly more numerical dispersion than SORBEQ: attempts will be made to isolate the source of this dispersion.

PLANNED ACTIVITIES:

Complete training on DPs and prepare individual minerals for new experiments.

Develop four DPs with new instrumentation.

Continue to test the FEHMN code for tracer transport. S. Birdsell will be leaving the project, and his efforts will be transferred to Z. Dash for the remainder of the fiscal year. Both Birdsell and Dash have been working on FEHMN, and no impact on the milestone is expected.

PROBLEM AREAS:

None.

BIBLIOGRAPHY:

Author	Title	Type of Publication	Status
H. Fuentes, W. Polzer, E. Essington, and B. Newman	Characterization of Reactive Tracer for C-well Field Experiments I: Electrostatic Sorption Mechanism, Lithium	LA-series report	Being revised after edit.

MILESTONE PROGRESS:

No milestones are due in the next three months.

Milestone	Date Due	Description or title	Status
R397	3/31/87	Reactive Tracer Experiments in the C-Wells and Other Wells in the Yucca Mountain Vicinity	Submitted to Project Office 2/16/89. (Study Plan)
T426	9/1/88	FRACNET - Fracture Network Model for Water Flow and Solute Transport	Being revised after Project Office review.

WBS 2.3.4.1.9.A
Project Title: Biological Sorption and Transport
Principal Investigator: L. Hersman

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

ACTIVITIES AND ACCOMPLISHMENTS:

Studies have continued on the interaction of colloids and bacteria. As mentioned in last month's report, experiments are now being conducted using cell-free spent medium. The purpose of these experiments is to determine if extra cellular material will affect colloidal agglomeration.

Siderophore is now being purified using a Bio Rad P-2 column, in addition to standard Sephadex C-25 and High-Pressure Liquid Chromatograph column purifications.

PLANNED WORK:

Colloidal agglomeration will continue to be studied. In addition, chelation experiments will be directed towards determining a formation constant with ^{239}Pu.

PROBLEM AREAS:

None.

MILESTONE PROGRESS:

Milestone	Date Due	Description or title	Status
T427	12/30/88	Chelation: Progress Report	Submitted to Project Office 5/24/89.

WBS: 2.3.4.1.11.A
Project Title: Geochemical Field Tests for Validation
Principal Investigator: J. A. Canepa

The purpose of this activity is to test the validity of the laboratory geochemistry data generated by the Geochemistry Test Program and to test the geochemical transport modules. Five subtasks constitute this activity: 1) natural analogs, 2) large block test, 3) caisson test, 4) unsaturated zone geochemistry field test, and 5) radionuclide migration studies at the Nevada Test Site.

ACTIVITIES AND ACCOMPLISHMENTS:

Natural Analogs

The Department of Energy (DOE) requested interactions on this task with the Atomic Energy of Canada Limited (AECL). Work scope and a funding profile for the joint natural analog task are required.

Large Block Test

Interactions of this task with the AECL were requested by the DOE. Work scope and a funding profile for the joint natural analog task are required.

Radionuclide Migration Studies at the Nevada Test Site

No action.

Caisson Tests

No action this month.

Geochemistry Field Tests

We have started work on the conceptual design of a field test for the geochemistry program. The general objective of this test is a validation exercise in the Calico Hills tuffs at as large a scale as is reasonable with the time constraints. This objective will be refined as we determine more of the medium characteristics, scaling laws, and model capabilities. Efforts have focussed on reviewing the literature and compiling all known information about the tuffs of Calico Hills below the repository, starting a list of desired measurement capabilities, and developing scaling relations that treat fracture transport.

WBS: 2.3.4.2.1.A
Project Title: Fracture Mineralogy
Principal Investigator: B. Carlos

The purpose of this task is to study fracture-lining minerals and their paragenesis to (1) assess the role of fractures as transport pathways during past alteration, (2) determine the conditions under which various minerals were deposited, (3) determine the nature of fracture surfaces along possible transport pathways, and (4) evaluate the occurrence of potentially hazardous minerals in the intervals to be mined.

ACTIVITIES AND ACCOMPLISHMENTS:

Developing and implementing a qualified quality assurance (QA) program continues to be top priority. We continue to emphasize writing, reviewing and training in various QA program plans and detailed procedures.

Todorokite was identified in the x-ray diffraction patterns of several samples from the Crater Flat Tuff in USW G-4. Thin sections of the fractures were examined using backscatter imaging on the scanning electron microscope (SEM) and qualitative element analysis. Only in one sample could the todorokite be distinguished from the cryptomelane-hollandite by the intensity of backscatter electrons and qualitative chemistry. The two minerals appear to be intergrown and morphologically indistinguishable. In the other samples, differences in backscatter intensity did not correlate consistently with the chemical differences expected between cryptomelane-hollandite and todorokite, and it was not possible to segregate patches of the two phases in SEM images.

Work continues on the manganese oxides in the Tiva Canyon Member of the Paintbrush Tuff in USW G-4.

PLANNED WORK:

Work towards developing a qualified QA program will continue.

Analysis of the fracture-coating manganese oxides in the Tiva Canyon Member in USW G-4 will continue over the next few months.

Examination and analysis of fracture-coating minerals in the Topopah Spring Member in USW G-1, G-2, and GU-3 will continue as time and sample availability allow.

PROBLEM AREAS:

Unavailability of existing core for examination or sampling continues to impact this activity.

The SEM was down for repair. Because of scheduling limitations, our next days to use the SEM are in July. The loss of the three days this month may delay the completion of the milestone report on manganese oxide minerals in the Tiva Canyon Member in USW G-4.

MILESTONE PROGRESS:

Milestone	Date Due	Description or title	Status
R623	6/30/89	Manganese Oxide Minerals in the Crater Flat Tuff in USW G-4.	Writing 95% complete.

WBS: 2.3.4.2.2.A
Project Title: Alteration History
Principal Investigator: S. Levy

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

ACTIVITIES AND ACCOMPLISHMENTS:

Most of our time this month was directed towards addressing Headquarters' review comments on the alteration history study plan in preparation for the comment resolution session held at Los Alamos on May 31. Project management and quality assurance (QA) comments were also resolved at this meeting, in accordance with AP-1.10Q.

P. Snow and S. Levy worked on corrections to the zeolite mineral code subroutine used for the electron microprobe software. This subroutine calculates a variety of molecular ratios that are used as stoichiometry checks and compositional-plotting parameters.

S. Levy and C. Higby made a preliminary application of graded QA to the alteration history study. Most of the determinations of QA criteria applicability correspond to what is already in the Los Alamos Quality Assurance Program Plan (QAPP); therefore, applying graded QA does not appear to aid, clarify, or benefit this task.

A surveillance of the mineralogy-petrology group was conducted by Los Alamos and the Quality Assurance Support Staff. The main focus of the surveillance was on the alteration history study.

The detailed procedure for operation of the scanning electron microscope was completed, received its technical and QA reviews, and was signed off.

PLANNED WORK:

Our first priority during June will be revising the alteration history study plan in accordance with Headquarters' comment resolutions. Support of QA activities will also continue.

Kevin Crowley, professor of geology at Miami University, Oxford, Ohio, will present a talk in Los Alamos on "Annealing of Fission Tracks in Apatite, with Applications to Geothermal History" on June 6.

In July, S. Levy will give a talk on alteration history research results to the U.S. Geological Survey in Denver.

PROBLEM AREAS:

None.

MILESTONE PROGRESS:

Work on milestone reports has been delayed to redirect effort toward achieving a fully qualified QA program and study plan revision.

WBS: 2.3.4.2.3.A
Project Title: Mineralogy of Transport Pathways
Principal Investigator: D. Vaniman

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

ACTIVITIES AND ACCOMPLISHMENTS:

Petrographic and chemical analyses of devitrified Topopah Spring Member samples for the Exploratory Shaft mineralogy-petrology test are now 90% complete. These data will be analyzed statistically to determine the necessary sample size and sampling density to adequately characterize the rock mass to be excavated during shaft and drift construction.

Scanning electron microscope image analysis is being explored in an attempt to evaluate pore space sizes, aspect ratios, shape factors, and orientations in the Topopah Spring Member. One reason for this analysis is to examine pore-space parameters as a stratigraphic tool; the other reason is to obtain adjunct pore data that may be applicable to transport calculations. The data collected so far are promising and indicate that roughly half of the pore volume in the altered devitrified Topopah above the basal vitrophyre consists of pores with widths less than 25 micrometers (Figs. 1a and b). The three curves shown in Figs. 1a and b represent the cumulative proportion of pore area accounted for by pores plotted in order of increasing pore width. The three curves correspond to analyses ranging from low magnification (198x) and large area coverage to high magnification (840x) and small area coverage. (Fig. 1b is an expanded view of the <10 micrometer portion of the curves; step-wise growth in Fig. 1b seen at lower magnification is due to larger pixel dimensions.) These data are still exploratory: the effects of magnification used in analysis, variability of millimeter to centimeter scales, and data collection methods (e.g., use of differential versus integrated backscattered electron intensity images) must be evaluated before the utility of the results is demonstrated.

The sample identification and control procedure for mineralogy-petrology studies is being tested before it is issued. Integration of the procedure with the electronic sample tracking database will be completed in June.

The article "Sampling for Site Characterization of a Potential Waste Repository" has been revised by Los Alamos' A-Division in response to internal review comments and to target it to the readership of Mathematical Geology. A-Division also reviewed G. Koch's book on "Exploration-Geochemical Data Analysis with the IBM PC" for Technometrics.

Work continued on evaluating revised x-ray diffraction data, which will be used to generate simulations of mineralogic composition of Yucca Mountain tuffs for use in TRACR3D.

PLANNED WORK:

Continue work on quality assurance (QA) program development.

Develop Exploratory Shaft sampling plan using data from the Solitario Canyon outcrop.

Evaluate revised x-ray diffraction data using multivariate methods.

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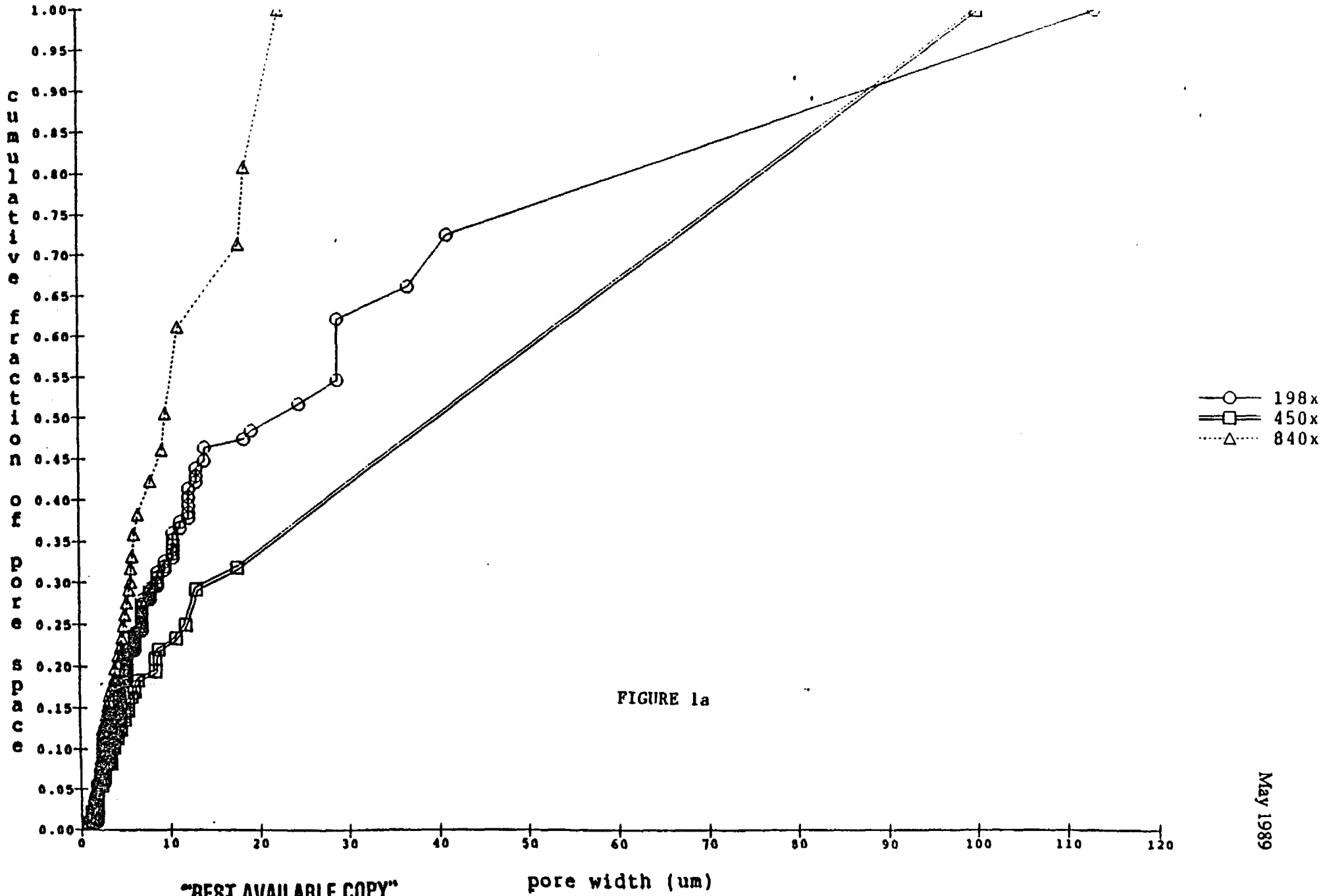

FIGURE 1a

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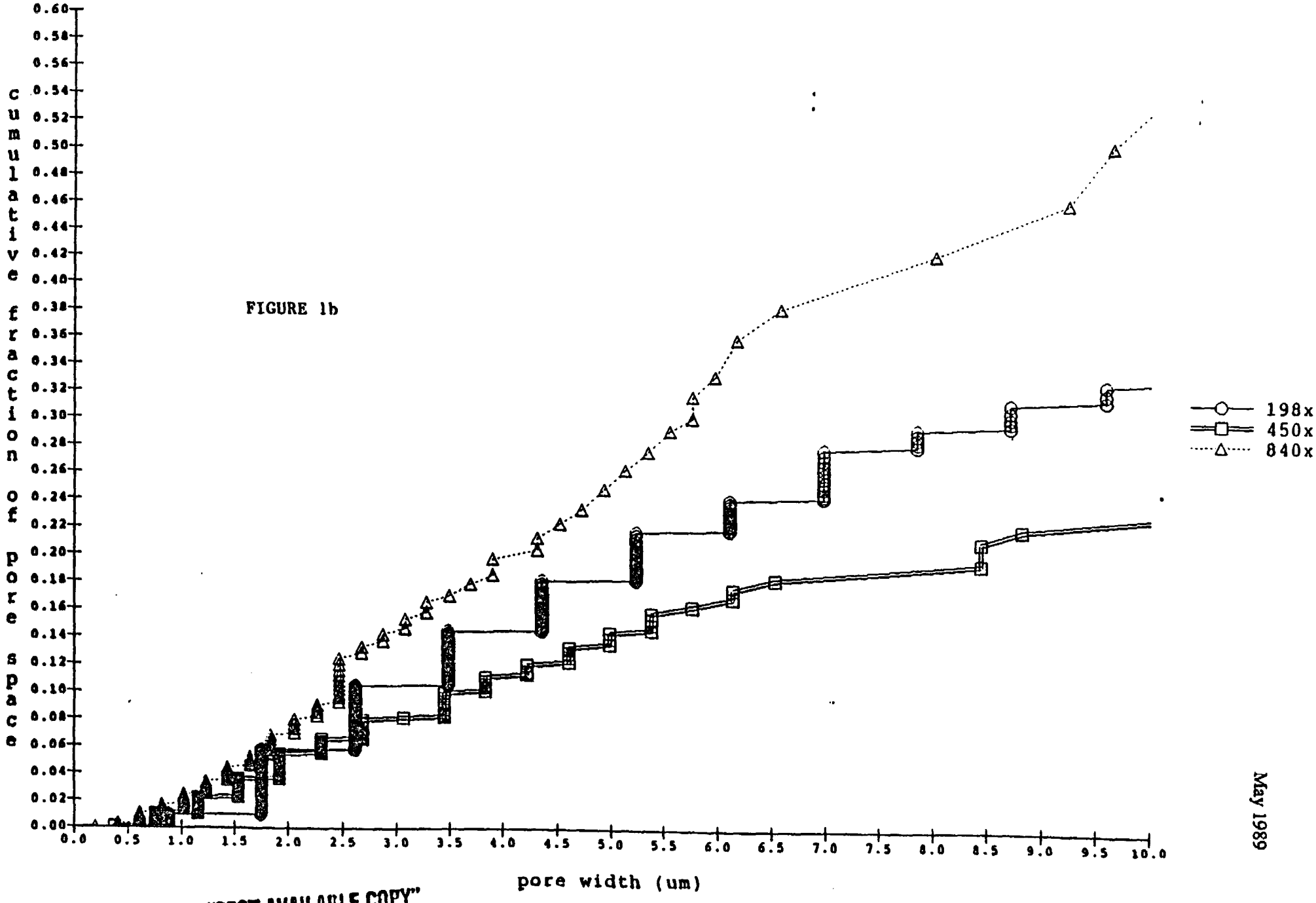

FIGURE 1b

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Work on image analysis methods for texture and trace-mineral analysis.

Develop statistical methods, especially the development of tools for handling compositional data.

Simulate spatial distribution of compositional data for use in transport models, such as TRACR3D.

PROBLEM AREAS:

Milestone progress in FY89 will continue to be delayed while effort is concentrated on revision of QA procedures and preparation of new procedures.

BIBLIOGRAPHY:

Author	Title	Type of Publication	Status
K. Campbell	Sampling for Site Characterization of a Potential Waste Repository	Journal article (*Mathematical Geology*)	Being revised following internal review.
K. Campbell	Statistical Guidelines for Planning a Limited Drilling Program	Article for journal (to be determined)	In technical review.

MILESTONE PROGRESS:

Milestone	Date Due	Description or title	Status
T095	11/30/88	Image Analysis Study of the Topopah Spring Member	Project Office approved 5/24/89.
T433	delayed	XRD Analysis of Batch Sorption Samples	Submitted to Project Office 4/14/89.
T469	2/28/89	The Occurrence and Distribution of Erionite at Yucca Mountain, Nevada	Project Office approved 5/24/89.

WBS: 2.5.2.2.A
Project Title: Regulatory and Institutional
Principal Investigator: J. A. Canepa

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

ACTIVITIES AND ACCOMPLISHMENTS:

Site Characterization Plan

A meeting hosted by the Nuclear Regulatory Commission (NRC) was held May 8 and 10 in Washington, D.C. The purpose of the meeting was for NRC to present review comments on the statutory SCP. Clarifying questions were asked by the Department of Energy (DOE) and the participants: in particular, Los Alamos asked clarifying questions on the NRC comments referring to sorption.

Semi-annual Progress Report (SPR)

Revisions to the SPR were made, and references were added for the Geochemistry section. The Bibliography section also was reviewed, and comments were submitted to DOE.

Study Plans

The status of the study plans is as follows.

Water Movement Test, R3 (8.3.1.2.2.2). Submitted to Yucca Mountain Project Office (Project Office) 1/6/89. Approved by Project Office and Department of Energy Headquarters (DOE/HQ); sent to Nuclear Regulatory Commission (NRC) and State of Nevada.

Diffusion Test, RO (8.3.1.2.2.5). Submitted to Project office 11/1/88. Project Office AP-1.10Q review comments received. Submitted to DOE/HQ 4/18/89. Abstract and SCP-based network submitted 5/25/89.

Testing of the C-Hole Sites With Reactive Tracers, R1 (8.3.1.2.3.1.7). Completed revision based on Project Office and DOE/HQ comments. Revision 1 was sent to DOE/HQ 5/2/89. Project Office AP-1.10Q review comments were received 5/10/89.

Mineralogy, Petrology, and Chemistry of Transport Pathways, R3 (8.3.2.3.2.1). Revision 3, which incorporates Project Office AP- 1.10Q review comments, was submitted to the Project Office 5/25/89.

History of Mineralogy and Geochemical Alteration at Yucca Mountain, RO (8.3.1.3.2.2). Submitted to Project Office 11/02/88. On 1/23/89, information copies of abstract and quality assurance appendix submitted to Project Office so AP-1.10Q review could proceed (1/25/89). LANL received a draft copy of DOE/HQ comments. A comment resolution meeting was held on May 31, 1989, for DOE/HQ comments.

Kinetics and Thermodynamics of Mineral Evolution and Conceptual Model of Mineral Evolution, R0 (8.3.1.3.3.2; 8.3.1.3.3.3). Submitted to Project Office 2/23/89. Study plan submitted to DOE/HQ for review 3/14/89. Draft Project Office AP-1.10Q review comments were received 5/26/89.

Sorption Studies and Sorption Modeling, R0 (8.3.1.3.4.1; 8.3.1.3.4.3). Submitted to Project Office 1/4/89. Undergoing Project Office AP-1.10Q review (1/30/89).

Biological Sorption and Transport, R1 (8.3.1.3.4.2). Revision 1, which incorporates screening review comments, was submitted to the Project Office 5/26/89.

Dissolved Species Concentration Limits, and Colloid Formation and Stability, R0 (8.3.1.3.5.1; 8.3.1.3.5.2). Undergoing Los Alamos QP-07 technical review.

Dynamic Transport Column Experiments, R0 (8.3.1.3.6.1). Los Alamos policy review complete. Study plan revised on basis of policy review comments; back at N-5 for final approval.

Diffusion, R0 (8.3.1.3.6.2). Los Alamos policy review complete. Study plan revised on basis of policy review comments; back at N-5 for final approval.

Probability of Volcanic Eruption Penetrating the Repository, R0 (8.3.1.8.1.1). Submitted to Project Office 3/29/89. The study plan is currently undergoing Project Office AP-1.10Q review (4/27/89). Submitted to DOE/HQ (4/19/89).

Effects of a Volcanic Eruption Penetrating the Repository, R0 (8.3.1.8.1.2). In preparation.

Characterization of Volcanic Features, R0 (8.3.1.8.5.1). Submitted to Project Office 12/14/88. Undergoing Project Office AP-1.10Q review (1/25/89).

Retardation Sensitivity Analysis, R0 (8.3.1.3.7.1). Submitted to Project Office 12/14/88. Undergoing Project Office AP-1.10Q review (2/8/89). Information copy of abstract submitted to Project Office 2/16/89. Study plan submitted to DOE/HQ for review 3/6/89.

Ground Water Chemistry Modeling, R0 (8.3.1.3.1.1). In preparation.

WBS: 2.6.A
Project Title: Exploratory Shaft Management and Planning
Principal Investigator: H. Kalia

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

ACTIVITIES AND ACCOMPLISHMENTS:

We continued to support the updating of the Subsystem Design System Requirements Document (SDRD). We started resolving the DOE Headquarters' comments on the SDRD and supported the preparation of Benchmark 5.

We continue supporting activities to prepare the network logic for testing activities that lead to the start of the shaft sinking and to extend the logic to the end of FY 1995. We met with U.S. Geological Survey (USGS) at Denver to go over their networks; the information they provided is being incorporated into the revised networks.

We supported the project effort for the construction of a prototype excavation (shaft), and interactions consisted of coordinating probable prototype testing in the excavation.

The readiness review for the Blast Effects Test was completed.

Prototype test data collection continued from engineered barrier test and drill hole instrumentation test, and we resumed overcoring for the diffusion test.

Equipment modification for cross hole prototype testing is being implemented at Denver by USGS technicians.

Data is being collected for wet and dry drilling from two drill holes near the end of the U12g12 drift.

Drilling was started for the perched water test is the laser drift. The hole has been dry drilled to a depth of 13 ft with a core recovery of 85.6%.

Overcoring for the in situ stress measurement is continuing in the demonstration drift. Total dry-drilled depth to date is 13 ft with a core recovery of 98.2%.

A briefing was presented to Don Schlick (YMPO) on Los Alamos work on dry drilling and tests on health-related aspects.

Supported Fenix & Scisson (F&S) efforts on the modification to the CMM-2 drill rig as proposed by F&S.

Requested information on the status of the budget for prototype testing from participants.

Los Alamos Technical Associates (LATA) provided a draft on prototype testing; it was reviewed, and comments were submitted to LATA for incorporation.

Effort is continuing on obtaining test procedures for the planned ESF (Exploratory Shaft Facility) tests.

Participated in site coordination meetings and in WIT-4 and project meetings on ESF construction.

Supported ESF budget validation weekly meetings. Provided input required to update the project networks.

Reviewed AP-5.18Q and Design Acceptability Analysis (DAA) Implementation Plan.

Supported task force for the surface-based site characterization work.

Participated in ESF construction-readiness review activities. Prepared action items and readiness review check list.

Work continues to prepare the Test Description Document.

Dr. Ned Elkins joined the Test Managers' Office as ESF design and testing integrator.

PLANNED WORK:

Resources will be provided to ensure that quality assurance (QA)-related documents are developed to fully qualify the QA program.

Los Alamos will continue to update Appendix B and prepare required engineering change requests, and work will continue to update Appendix C, drilling requirements.

Work will continue to prepare logic networks, power study, site population study, and the long-range plan.

We will continue to update the prototype-testing budget and schedule and to schedule readiness reviews for prototype tests.

Work will be started to prepare Safety Analysis Report (SAR) for ESF testing and to prepare Engineering Management Plan (EMP) for ESF testing and IDS design.

Work will continue for the preparation of the ESF Test Description Document and to prepare the report on prototype testing.

We will continue to support the WIT-4 process.

We will continue to participate in the ESF readiness review meetings, site coordination meetings, and ESF design integration meetings.

We will continue to develop testing networks and provide input to technical management and support services to integrate testing with ESF design and construction.

We will track the progress of the prototype cross hole test to be performed in Arizona by USGS.

PROBLEM AREAS:

None.

WBS: 2.6.9.2.4.A
Project Title: Geochemical Testing
Principal Investigator: A. E. Norris

Two geochemical tests have been proposed as part of the site characterization work associated with the construction of the exploratory shaft (ES). One is the measurement of the rate of water movement through the unsaturated zone as traced by chlorine-36. The second is the measurement of effective diffusivity coefficients under in situ conditions in two of the tuffs that will be penetrated by the ES. The data from both tests will be used in assessing the suitability of the Yucca Mountain site for a nuclear waste repository.

ACTIVITIES AND ACCOMPLISHMENTS:

D. Wonderly of Fenix & Scisson finished writing the drilling program for the next phase of the prototype diffusion test in G-Tunnel, which was signed by Los Alamos and Department of Energy/Yucca Mountain Project. The pacing item for implementing this drilling program is acquisition of an appropriate drilling rig to accomplish the large-diameter overcoring in G-Tunnel.

The new motor for use with the Los Alamos ESS-1 rock saw was delivered and installed this month. The rock saw is being used to develop a technique to section 12-in.-diam tuff cores without the use of a liquid coolant.

A. E. Norris participated in a meeting at Mercury, Nevada, on May 1 to discuss additional excavations in G-Tunnel in support of the YMP prototype activities.

Work this month in support of the Los Alamos quality assurance (QA) program included reviewing the following draft procedures:

TWS-QAS-QP-02.3, R0	Procedure for IDS Design and Interface Control
TWS-QAS-QP-02.5, R0	Procedure for Applying Graded Quality Assurance
TWS-QAS-QP-03.6, R0	Procedure for IDS Design and Interface Control
TWS-QAS-QP-03.8, R0	Procedure for the TAR of the IDS

In addition, the certification of A. E. Norris was completed under the new QA procedures.

PLANNED WORK:

Overcoring for the prototype diffusion test will be restarted as soon as the equipment is available.

MILESTONE PROGRESS:

No level II milestones are scheduled. Level III milestones are on schedule.

WBS: 2.6.9.3.A
Project Title: Exploratory Shaft Integrated Data System
Principal Investigator: R. Crowley

The integrated data system (IDS) is part of the supporting facilities for the Exploratory Shaft Facility (ESF). The IDS supports the data acquisition needs of the ESF test program by providing a central facility to automatically measure and control aspects of the ESF tests. The primary purpose of the IDS is to assist the principal investigators (PIs) in acquiring high-quality test data in a uniform, controlled fashion and to transfer those data to the PIs' organizations for data management and analysis.

ACTIVITIES AND ACCOMPLISHMENTS:

We continued to develop the quality assurance (QA) procedure for IDS Design Interface, the IDS Functional Requirements Document, documents for the configuration management of the IDS, and the contract document for Edgertown, Germeshausen & Grier, Inc., (EG&G) support for the IDS.

We prepared input for the Subsystem Design Requirements Documents for IDS, completed the documentation for the IDS Implementation/Requisition Plan, and developed an integrated network (testing, IDS design, and ESF design) for the IDS.

Work continued for the preparation of software QA procedures, which is requiring significant effort to develop. We also continued to develop Technical Interface Procedures to identify how the IDS interfaces with PIs and other users, such as DOE/YMP, Science Applications International Corp., Architect/Engineers, etc.

Work was initiated for the preparation of the "Basis for Design document."

We met with Fenix & Scisson, Holmes & Narver, and REECo to discuss IDS requirements from ESF designers and operators.

Attended course on Software QA offered by General Atomics of San Diego, California.

PLANNED WORK:

Work will continue to complete EG&G procedures and QA Program Plan (QAPP) for a fully qualified QA program, to develop Functional Requirements Document for the design of IDS, and to finalize contract document for EG&G. We will continue to develop procedures for software, IDs Requirements Plan, Interface Procedures, and Facilities Requirements.

Resources will be diverted to develop documentation to obtain DOE authorization to start Title II-Phase 1A design effort as soon as the required procedures have been developed and accepted.

Work will continue on preparation of the IDS Configuration Management Plan, Data Interface Documents, and Hardware Configuration Plan.

We will continue to obtain information from the PIs for the design of the IDS, and we will schedule meetings with PIs to discuss IDS design-related input.

PROBLEM AREAS:

EG&G's QAPP could not be developed in time and on schedule. The resulting delay may impact the ESF testing schedule; however, we are attempting to recoup the lost time.

WBS: 2.9.1.4.A
Project Title: Records Management
Principal Investigator: G. Ortiz

The objective of this task is to manage records and documents related to the licensing of a geologic repository for the disposal of high-level radioactive waste. The requirements are to support the development, implementation, and maintenance of a comprehensive, automated, and integrated information management system.

ACTIVITIES AND ACCOMPLISHMENTS:

All records processed in the Quality Assurance Records Management System (QARMS) will be transferred to the Records Information System (RIS). Los Alamos YMP has approximately 8,000 indexed records in the QARMS, which will not be processed under the records management requirements for the RIS..

A request has been made through the Central Records Facility (CRF) to obtain a listing of all Los Alamos YMP records indexed and microfilmed to date into the RIS.

On May 24, G. Ortiz met with H. Nitsche and S. Carpenter from Lawrence Berkeley Laboratory (LBL) to prepare several records turnover packages for permanent storage.

Comments have been received for Quality Procedures QP 17.1 and 17.2, which will not need substantial modifications. Project Administrative Procedure AP-1.7Q, R2 has just been issued to Project participants. QP 17.1 and 17.2 will be modified to address any relevant requirements imposed by AP-1.7Q, R2.

Records Processing Center (RPC) is currently on-line with the RIS, and information about records can be retrieved through the RIS. No microfilm of Los Alamos records has been sent by the CRF as of date.

PLANNED WORK:

Transfer the RPC from Los Alamos N-5 to Los Alamos Technical Associates (LATA).

Train LATA in RPC operations and records access through the RIS.

On-line access to RIS for Los Alamos N-5 and ESS-1 resident file custodians.

PROBLEM AREAS:

Records rejected by the CRF are in many cases attachment or enclosures of records received from outside organizations.

WBS: 2.9.3.A
Project Title: Quality Assurance
Principal Investigator: H. P. Nunes

The Quality Assurance Program provides quality assurance support to Los Alamos Yucca Mountain Project (YMP) participants. This support is designed to ensure that the YMP efforts of Los Alamos will provide admissible data and evidence for the repository licensing process.

ACTIVITIES AND ACCOMPLISHMENTS:

The annual staff recertification has been completed. Each group has been directed to submit its Quality Assurance (QA) Records package to Los Alamos N-5 for storage in keeping with the Los Alamos dual record storage requirements and the need to maintain personnel records in accordance with the California Privacy Act.

The biweekly Los Alamos meetings to achieve a qualified QA Program continued. The quality procedure revisions (39 total) are on schedule: 30 procedures are completed and issued, and the remaining 9 are in the review comment resolution cycle. All procedures that require formal training before the start of the Title II Design Efforts have been issued, and two procedures remain to be issued that have some impact on the Title II effort. Three formal training modules need to be prepared to support the final Los Alamos training requirements for the remaining procedures currently being developed.

The effort at Edgerton, Germeshausen & Grier (EG&G) is now directed toward revising the EG&G QA Program Plan. This effort, a result of a Project Office directive to prepare a QA Plan for the Integrated Data System (IDS) that was directly traceable to the YMP QA Plan/88-9, R2, is scheduled for completion by July 10. EG&G has been directed to revise its program plan, prepare the needed revisions, and submit them with the appropriate QA Plan/88-9, R2, checklist to the QA Program Leader for review and approval. Additional direction was provided to ensure that the resulting internal implementing procedures will be compatible with the resulting program plan.

The Los Alamos QA staff effort to review the completed quality administrative procedures with the checklists based on the approved Quality Assurance Program Plan (QAPP), R4.3 continues. These

checklists are being used to evaluate the completed implementing procedures, assuring ourselves that all procedures reflect the needed requirements of the approved QAPP.

PLANNED WORK:

Continuation of Los Alamos efforts to achieve a qualified QA program that supports the start of the Title II IDS design efforts is still the first priority of the Los Alamos QA staff. Training the Los Alamos staff will be a second priority to ensure the start of the ongoing research efforts in accordance with the revised Los Alamos QAPP.

The Los Alamos QA staff will continue their review of the completed implementing procedures to ensure that the appropriate requirements from the approved QAPP, R4.3, are completely reflected in the final approved procedure. Revisions will be issued in each case where omissions are found.

Addition staff have been assigned to track and close the outstanding standard deficiency reports, nonconformance reports, and corrective actions reports. These efforts will allow for the timely closure of issues associated with the start of Title IDS design efforts or the Los Alamos Test Manager's Office activities.

TECHNICAL DATA MANAGEMENT SYSTEM SUBMITTAL RECORD

N-AD-035
11/86

TITLE OF DOCUMENT	DESCRIPTION OF DATA OR INFORMATION	AUTHOR OR PRINCIPAL INVESTIGATOR	DATE PUBLISHED	QUALITY ASSURANCE LEVEL	TECHNICAL DATA MANAGEMENT SYSTEM COMPONENT (INDICATE BY "X")				DATE OF SUBMITTAL
					TRC	SEPDB	IGIS	RIB	
NO DATA WERE	SUBMITTED THIS MONTH								

YMP MONTHLY MILESTONE STATUS REPORT

LOS ALAMOS NATIONAL LABORATORY

Number	LANL Proposed Date	CCB Baseline Date	WBS Element	Organization Responsible	Description Comments
FY89 Milestones - Level 1 Completed as of June 01, 1989					
NONE					
FY89 Milestones - Level 2 Completed as of June 01, 1989					
T478	12/15/84		12311A	N-5	Prototype Test Plans, Volume 2 (FY-89 Funded Tests) This milestone is the other part of milestone T435 (Volume 1). The schedulers are incorrectly using M253 for Volume 2. This milestone should not be confused with M105, which is the submission of the prototype test plans for review. M105 is completed. The report entitled "Prototype Test Plans, Volume 2 (FY-89 Funded Tests)" was completed and sent to the Project Office for policy review on 12/15/88, ref. TWS-N5-12-88-034.
T404	09/28/88		1232312A	ESS-1	Progress Report on Rock-Varnish Work Report entitled "Progress Report on Rock-Varnish Work" was completed and sent to the Project Office for policy review on 11/16/88, ref. TWS-N5-10-88-046.
T414	02/28/89		123363A	ESS-1	Final Dust Hazard Assessment Report Report entitled "Evaluation of Dust-Related Health Hazards Associated with Air Coring at G-Tunnel, Nevada Test Site" was completed and sent to the Project Office for review on 04/14/89, ref. TWS-N5-04-89-055.
T415	12/16/88		123363A	ESS-1	Final Drilling and Technology Report The final report draft of the Prototype Air Coring Test was completed and sent to the Project Office on 01/17/89, ref. TWS-ESS-1-1/89-11. Report entitled "The Yucca Mountain Project Prototype Air-Coring Test, U12g Tunnel, Nevada Test Site" was sent to the Project Office for policy review on 05/09/89, ref. TWS-N5-89-045.
M367	11/17/88		123414A	INC-11	Interim Progress Report on Colloid Stability Report entitled "Interim Progress Report on Colloid Stability: Voltammetric Studies of the Redox Reactivity of Plutonium (IV) Colloid" was completed and sent to the Project Office for policy review on 12/12/88, ref. TWS-N5-12-88-033.
P379	11/17/88		123414A	INC-11	Progress Report: Photoacoustic Spectroscopy Methodology (PAS) Report entitled "Photoacoustic Spectroscopy Methodology" was completed and submitted to the Project Office for policy review on 01/18/89, ref. TWS-N5-01-89-058.

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YMP MONTHLY MILESTONE STATUS REPORT

LOS ALAMOS NATIONAL LABORATORY

Number	LANL Proposed Date	CCB Baseline Date	WBS Element	Organization Responsible	Description Comments
T418	11/30/88		123414A	INC-11	Letter Report: Progress Report on Solubility Measurements Report entitled "Letter Report: Progress Report on Solubility Measurements" was completed and sent to the Project Office for policy review on 11/28/88, ref. TWS-N5-11-88-069. The report wa approved for publication by the Project Office on 05/09/89, ref. TWS-N5-05-89-047.
R505	11/25/88		123415A	INC-7	Summary Report: Sorption of Nickel and Neptunium in Tuff Using Groundwaters of Different Composition Milestone completed on 10/21/88 and the report entitled "Sorptior of Nickel and Neptunium in Tuff using Groundwaters of Various Compositions" was sent to the Project Office, ref. TWS-N5-10-88-050. This report was approved
R720	11/01/88		123415A	INC-7	Issue Report on Deconvolution of Ion-Exchange Isotherms Report entitled "Deconvolution of Ion-Exchange Isotherms" was reviewed, and a copy of the revised paper was sent to the Project Office on 02/17/89, ref. TWS-N5-02-89-058.
T421	12/15/88		123417A	ESS-5	TRACR3D Documentation for Baselined Version Report entitled "TRACR3D 1.0: A Model of Flow and Transport in Porous Media for the Yucca Mountain Project - Model Description a User's Manual" was completed and sent to the Project Office for policy review on 12/12/88, ref. TWS-N5-12-88-032. Final Revision in Progress
T424	02/28/89		123417A	ESS-5	Interim Report: Letter Report on Particulate Transport Report entitled "Interim Report on Particle Transport" was completed and sent to the Project Office for policy review on 02/24/89, ref. TWS-N5-02-89-072. The report was approved for publication by the Project Office on 05/09/89, ref. TWS-N5-89-048.
T426	11/25/88		123418A	ESS-4	FRACNET - Fracture Network Model For Water Flow and Solute Transport Milestone completed on 10/25/88. A policy review conducted on report entitled "FRACNET - Fracture Network Model for Water Flow and Solute Transport", was sent to the Project Office, ref. TWS-N5-10-88-059.
T207	11/30/88		123422A	ESS-1	Dating Zeolitization at Yucca Mountain with Tectonic and Structural Data Report entitled "Dating Zeolitization at Yucca Mountain with Tectonic and Structural Data" was completed and sent to the Project Office for policy review on 12/01/88, ref. TWS-N5-12-88-003.
T095	11/30/88		123423A	ESS-1	Issue Report: Statistical Test of Repeatability and Operator Variance on Modal Analysis Report entitled "Status of Image Analysis Methods to Delineate Stratigraphic Position in the Topopah Spring Member of the Painthrush Tuff, Yucca Mountain, Nye County, Nevada" was completed and sent to the Project Office for policy review on 12/23/88, ref. TWS-N5-12-88-072.

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YMP MONTHLY MILESTONE STATUS REPORT

LOS ALAMOS NATIONAL LABORATORY

Number	LANL Proposed Date	CCB Baseline Date	WBS Element	Organization Responsible	Description Comments
T469	02/28/89		123423A	ESS-1	Issue Report on Erionite Abundances at Yucca Mountain. Report entitled "The Occurrence and Distribution of Erionite at Yucca Mountain, Nevada" was completed and sent to the Project Office for policy review on 02/14/89, ref. TWS-M5-02-89-045.
R321	12/23/88		123431A	WX-4	Complete Design of the Exploratory Shaft Water Tracer System Demonstrated to H&N use of the equipment and provided drawings to H&N. No further action is required. This milestone was completed on 03/09/89, ref. TWS-ESS-LV-1-03-89-17.
T163	11/30/88		12611A	WX-4	Revised NNWSI 'White Paper' on "ES Fluids and Materials Usage" Delivere to WMPO. Report entitled "Nevada Nuclear Waste Storage Investigations Exploratory Shaft Facility and Materials Evaluation" was completed and sent to the Project Office on 12/15/88, ref. TWS-M5-12/88/043.

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YMP MONTHLY MILESTONE STATUS REPORT

LOS ALAMOS NATIONAL LABORATORY

Number	LANL Proposed Date	CCB Baseline Date	New WBS Element	Organization Responsible	Description Comments

FY89 Level 1 Open Milestone List

NONE

FY89 Level 2 Open Milestone List

New WBS Number 1.2.3

M287	09/01/89	1231	ESS1/WI	Compile Draft ES Test Procedures (Construction Phase) Precursor to M651.
R705	06/30/~~89~~ 90	1232122	INC-7	Issue Letter Report: Thermodynamics and Kinetics of Phases Important to Silica Activity at Yucca Mountain
3115	09/01/89	1232551	ESS-1	Issue report varnish analysis utilizing SEM and microprobe techniques. Work is ongoing on both SEM and microprobe to resolve problem of Ti and Ba peak overlap and deconvolution of these peaks to obtain accurate analyses where both Ti and Ba occur within varnish samples. Several possible avenues of approach to the problem are being evaluated.
M160	07/31/89	12341	N-5	SCP Progress Report: Results of Geochemistry Investigations
T535	04/17/89	123411	HSE-12	Study Plan Approved (Ground Water Chemistry Model)

not in contract X

New WBS Number 1.2.5

T001	03/15/89	12522	N-5	Submit draft ongoing Geochemistry Test Program Study Plans to WMPO/NV for review. Will be completed when all study plans are submitted to the Project Office.

New WBS Number 1.2.6

M667	02/24/89	12684	WX-4	IDS Phase 1 Final Design Issued Review completed.

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YMP MONTHLY MILESTONE STATUS REPORT

LOS ALAMOS NATIONAL LABORATORY

Number	LANL Proposed Date	CCB Baseline Date	New WBS Element	Organization Responsible	Description Comments
T062	01/10/89		12684	WX-4	IDS Phase 2 Final Design Issued. Delayed due to fully qualified QA program effort.
T436	06/08/88		12684	WX-4	IDS Development System - Status Report #1
T437	06/10/88		12684	WX-4	IDS Phase 1 Software - Interim Design Report #1
T438	10/17/88		12684	WX-4	IDS Phase 1 & 2 Facilities - Detailed Requirements
T439	10/17/88		12684	WX-4	IDS Phase 1 Hardware - Interim Design Report
T440	10/17/88		12684	WX-4	IDS Phase 1 Software - Interim Design Report #2
T443	02/01/89		12684	WX-4	IDS Phase 2 Hardware - Interim Design Report
T444	02/01/89		12684	WX-4	IDS Development System - Status Report #2
T445	05/01/89		12684	WX-4	IDS Phase 1 Software - Validation and Verification Report
T446	05/01/89		12684	WX-4	IDS Phase 1 Hardware - Acceptance Test Report
T447	05/01/89		12684	WX-4	IDS Phase 2 Software - Interim Design Report #1
T448	09/01/89		12684	WX-4	IDS Phase 2 Software - Interim Design Report #2

ASSUMPTIONS:
ES start date 11/89
WBS Structure baseline 7/22/86
Prep: 06/01/89
A. Pratt

DISTRIBUTION:
J.A. Canepa, N-5, J521
H.N. Kalia, ESS-1, J900/527
R.L. Byers, N-5, J521
D.T. Oakley, N-5, J521
K.A. West, N-5 , J521

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: LANL
31 May 1989

SIGNIFICANT MILESTONES ACCOMPLISHED SINCE LAST REPORT	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	ACTUAL DATE TO PROJ	PENDING C/SCR	COMMENT

NO. MILESTONES IN THIS SECTION: 0

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: LANL
31 May 1989

SIGNIFICANT MILESTONES OPEN	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	FORECAST DATE TO PROJ	PENDING C/SCR #	COMMENT

NO. MILESTONES IN THIS SECTION: 0

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: LANL
31 May 1989

KEY MILESTONES UPCOMING - NEXT THREE MONTHS	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	FORECAST DATE TO PROJ	PENDING C/SCH	COMMENT
WBS: 1.2.3.4							
Submit Draft Geochemistry Test Program Study Plans to YMPO for Review	Blanchard	2	T001 (P)	16 Jun 89	21 July 89		[illegible] Due To [illegible]
WBS: 1.2.3.4.1.1.A							
Study Plan Approved (Ground Water Chemistry Model)	Clanton	2	T535 (P)	25 Aug 89			[illegible]
WBS: 1.2.3.4.1.3.A							
Issue Letter Report: Thermodynamics and Kinetics of Phases Important to Silica Activity at Yucca Mountain	Livingston	2	R705 (P)	30 Jun ~~89~~ 90			Typo [illegible] Late [illegible]
WBS: 1.2.3.4.3.1.A							
Complete Design of the Exploratory Shaft Water Tracer System	Robson	2	R321 (P)	28 Jul 89			[illegible]

NO. MILESTONES IN THIS SECTION: 4

"BEST AVAILABLE COPY"

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: YMP/LANL
31 May 1989

SIGNIFICANT MILESTONES ACCOMPLISHED SINCE LAST REPORT	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	ACTUAL DATE TO PROJ	PENDING C/SCR	COMMENT

NO. MILESTONES IN THIS SECTION: 0

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: YMP/LANL
31 May 1989

SIGNIFICANT MILESTONES OPEN	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	FORECAST DATE TO PROJ	PENDING C/SCR	COMMENT

NO. MILESTONES IN THIS SECTION: 0

YUCCA MOUNTAIN PROJECT
MILESTONE WORKSHEET FOR MONTHLY STATUS REPORT FOR MAY 1989
RESPONSIBILITY CODE: YMP/LANL
31 May 1989

KEY MILESTONES UPCOMING - NEXT THREE MONTHS	PROJ RESP	LEV	MILESTONE NUMBERS	PROJ/HQ DATE	FORECAST DATE TO PROJ	PENDING C/SCR	COMMENT

NO. MILESTONES IN THIS SECTION: 0

LOS ALAMOS NATIONAL LABORATORY
OUTSTANDING PROJECT OFFICE ACTION ITEMS
May 30, 1989

Policy Reviews

1. Milestone R743 report: resubmitted 12/7/88 with response to Project Office review. ✓

2. Milestone R749 report: resubmitted 12/9/88 with response to Project Office review. ✓

3. Milestone R343 report: resubmitted 1/9/89 with response to Project Office review. ✓

4. Milestone P379 report: resubmitted 1/18/89. ✓

5. Milestone T404 report: resubmitted 2/28/89 with response to Project Office review. ✓

6. Milestone R346 report: resubmitted 4/4/89; responded to Project Office comments 5/23/89.

7. Milestone M367 report: resubmitted 4/11/89 with response to Project Office review.

8. Milestone T414 report: submitted 4/14/89.

9. Milestone T433 report: submitted 4/14/89.

10. Milestone T415 report: submitted 5/9/89.

11. Milestone T427 report: submitted 5/24/89.

12. Abstract - B. Crowe et al., "Polycyclic Volcanism: A Common Eruption Mechanism of Small Volume Basaltic Volcanic Centers of the Southern Great Basin, USA": submitted 3/6/89. ✓

13. Report manuscript - S. G. Wells et al., "A Geomorphic Assessment of Late Quaternary Volcanism in the Yucca Mountain Area, Southern Nevada: Implications for Volcanic Hazard Assessment at the Proposed High-Level Radioactive Waste Repository": submitted 4/11/89

14. Book contributions - B. Crowe, "GSA Field Trip Segment: Lathrop Wells Volcanic Center" and "GSA Field Trip Segment: Crater Flats": submitted 4/27/89.

15. Abstract - H. Nitsche, "Solubility Studies of Transuranium Elements for Nuclear Waste Disposal: Principles and Overview": submitted 5/11/89.

16. Abstract - R. A. Rundberg et al., "Observation of Time-Dependent Dispersion in Laboratory Scale Experiments with Intact Tuff Columns": submitted 5/16/89.

17. Abstract - L. E. Hersman, "Effects of Microorganisms on the Transport of Actinide Elements": submitted 5/16/89.

18. Abstract - I. R. Triay et al., "Sorption Behavior of Americium in Tuff Samples and Pure Minerals Using Synthetic and Natural Groundwaters": submitted 5/19/89.

19. Abstract - I. R. Triay et al., "Size Determinations of Pu Colloids Using Autocorrelation Photon Spectroscopy": submitted 5/19/89.

NUCLEAR WASTE TECHNICAL REVIEW BOARD
1111 18th Street, N.W., Suite 801
Washington, D.C. 20036

AGENDA

June 26, 1989	BRIEFING BY REPRESENTATIVES OF STATE OF NEVADA
8:30 a.m	Introduction and Welcome
	Don U. Deere, Nuclear Waste Technical Review Board
	Robert Loux, Nevada Agency for Nuclear Projects
	Overview of Technical Concerns
	Carl A. Johnson, Nevada Agency for Nuclear Projects
	Techtonics
	Dr. Michael Ellis and Dr. Richard Schweikert, Center for Neotechtonic Studies, University of Nevada-Reno
10:00 - 10:15 a.m.	Break
	Faulting
	John Bell, Nevada Bureau of Mines and Geology, Reno, Nevada
	Unsaturated Zone Hydrology
	Dr. Martin Mifflin, Mifflin & Associates, Las Vegas, Nevada
	Saturated Zone Hydrology
	Dr. John Fordham, Water Resources Center, Desert Research Institute, Reno, Nevada
12:00 - 1:15 p.m. Lunch	
1:15 p.m.	Reconvene

(over)

Telephone: 202-254-4792 Fax: 202-254-4803

1:15 p.m. Hydrologic Modeling

Scott Tyler, Water Resources Center, Desert Research Institute, Reno, Nevada

Performance Assessment

Linda Lehman, L. Lehman and Associates, Minneapolis, Minnesota

Geochemistry

Dr. Maurice Morgenstern and Dr. Donald Shettel, Mifflin & Associates, Las Vegas, Nevada

3:00 - 3:15 p.m. Break

Volcanism

Dr. Eugene Smith, Department of Geoscience, University of Nevada-Las Vegas

Climate Change

Dr. Martin Mifflin, Mifflin and Associates, Las Vegas, Nevada

Mineral Resources

Dr. Lawrence Larson, MacKay School of Mines, University of Nevada-Reno

Summary

Carl A. Johnson, Nevada Agency for Nuclear Projects

5:00 p.m. Recess

June 27, 1989	BRIEFING BY REPRESENTATIVES OF THE U.S. DEPARTMENT OF ENERGY
8:30 a.m.	Introduction and Welcome
	Don U. Deere, Nuclear Waste Technical Review Board
	Carl P. Gertz, Yucca Mountain Project Office
	Brief Overview of Site Characterization
	Carl P. Gertz, Yucca Mountain Project Office
9:15 a.m.	Overview of Briefing and Field Trip
	Maxwell B. Blanchard, Yucca Mountain Project Office
	Geologic Description of Yucca Mountain Site
	David C. Dobson, Yucca Mountain Project Office
10:30 - 10:45 a.m.	Break
	Volcanism in Vicinity of Yucca Mountain
	Bruce M. Crowe, Los Alamos National Laboratory, Las Vegas, Nevada
	Seismicity in the Vicinity of Yucca Mountain
	Jerry L. King, Science Applications International Corporation (SAIC), Las Vegas, Nevada
12:00 - 1:15 p.m. Lunch	
1:15 p.m.	Hydrologic Conditions at Yucca Mountain Site
	W. E. Wilson and William W. Dudley, U.S. Geological Survey, Denver, Colorada
3:00 - 3:15 p.m. Break	

(over)

3:15 p.m.	Plans for Site Characterization
	Jean L. Younker, Science Applications International Corporation (SAIC), Las Vegas, Nevada
4:45 p.m.	Summary and Discussion: Plans for Field Trip
	Maxwell B. Blanchard, Yucca Mountain Project Office
5:30	Adjourn
June 28, 1989	SITE VISIT TO YUCCA MOUNTAIN
6:00 a.m. 8:00 p.m.	Field Trip will be led by Uel S. Clanton, Yucca Mountain Project Office
June 29, 1989	PRESS CONFERENCE BY THE NUCLEAR WASTE TECHNICAL REVIEW BOARD
9:00	Introduction and Overview of NWTRB's Purpose and Activities to Date
	Don U. Deere, Nuclear Waste Technical Review Board
9:20 - 10:00 a.m.	Questions and Answers

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: OVERVIEW OF BRIEFING AND FIELD TRIP

PRESENTER: MAX BLANCHARD

PRESENTER'S TITLE AND ORGANIZATION: GEOLOGIST AND MANAGER,
REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN PROJECT OFFICE
U.S. DEPARTMENT OF ENERGY
LAS VEGAS, NV

PRESENTER'S TELEPHONE NUMBER: (702) 794-7939

JUNE 27, 1989

SUMMARY AGENDA FOR THE NWTRB MEETING

OVERVIEW OF THE YUCCA MOUNTAIN SITE JUNE 27, 1989

TOPICS COVERED IN TODAY'S BRIEFING

GEOLOGIC DESCRIPTION OF THE YUCCA MOUNTAIN SITE

VOLCANISM IN THE VICINITY OF YUCCA MOUNTAIN, AND THE APPROACH FOR ASSESSING THE POTENTIAL FOR VOLCANIC HAZARDS

SEISMICITY IN THE VICINITY OF YUCCA MOUNTAIN AND THE APPROACH FOR ASSESSING THE POTENTIAL FOR SEISMIC HAZARDS

HYDROLOGIC CONDITIONS AT THE SITE

PLANS FOR SITE CHARACTERIZATION

SUMMARY AGENDA FOR THE NWTRB MEETING

(CONTINUED)

JUNE 28, 1989

TOPICS COVERED ON THE FIELD TRIP

GENERAL GEOLOGY: DISCUSSION OF OUTCROPS AND STRATIGRAPHY; VOLCANOLOGY; STRUCTURAL GEOLOGY; FAULT LOCATIONS AND AGES; GEOMORPHOLOGY; NEOTECTONICS; MIDWAY VALLEY HYDROGENIC DEPOSITS; PALEOCLIMATOLOGY

UNSATURATED ZONE TESTING: INSTRUMENTATION; NEUTRON HOLES; INFILTRATION EXPERIMENTS

SATURATED ZONE TESTING: WATER-TABLE HOLES; PALEOHYDROLOGY

ESF SITE: FLOOD POTENTIAL; NEARBY FAULTS; DRIFT LOCATIONS

SAMPLE MANAGEMENT FACILITY AND CORES: GENERAL MINERALOGY-PETROLOGY VARIATIONS IN TUFFS; FRACTURE STUDIES ON CORES; SAMPLE MANAGEMENT FACILITY HANDLING PROCEDURES, ROCK PROPERTIES, DRY DRILLING STATUS

NWTRB PRESENTATION
DETAILED AGENDA, JUNE 27, 1989

8:30	INTRODUCTION AND WELCOME	C. GERTZ D. DEERE
	- BRIEF OVERVIEW OF SITE CHARACTERIZATION	C. GERTZ
9:15	OVERVIEW OF BRIEFING AND FIELD TRIP	M. BLANCHARD
9:30	GEOLOGIC DESCRIPTION OF YUCCA MOUNTAIN SITE ● REVIEW GEOLOGIC SETTING AND CHARACTERISTICS OF SITE ● REVIEW STRUCTURAL GEOLOGY AND TECTONICS OF SITE ● DISCUSSION OF MINERAL RESOURCE POTENTIAL	D. DOBSON
10:30	BREAK	

DETAILED AGENDA, JUNE 27, 1989

(CONTINUED)

10:45 VOLCANISM IN THE VICINITY OF YUCCA MOUNTAIN AND THE APPROACH FOR ASSESSING THE POTENTIAL FOR VOLCANIC HAZARDS — B. CROWE

- REVIEW PREVIOUS ASSESSMENTS OF VOLCANIC HAZARDS
- DISCUSS RECENT INFORMATION ABOUT VOLCANIC CENTERS NEAR YUCCA MOUNTAIN (I.E., LATHROP WELLS)
- APPROACHES FOR IMPROVING ESTIMATES OF VOLCANIC HAZARDS
- CURRENT ASSESSMENT OF VOLCANIC HAZARD

11:15 SEISMICITY IN THE VICINITY OF YUCCA MOUNTAIN AND THE APPROACH FOR ASSESSING THE POTENTIAL FOR SEISMIC HAZARDS — J. KING

- REVIEW SEISMIC PHENOMENA OF INTEREST
- GROUND-MOTION HAZARDS
- FAULTING HAZARDS
- TECTONIC INTERACTIONS WITH GROUND WATER

12:00 LUNCH

DETAILED AGENDA, JUNE 27, 1989

(CONTINUED)

1:15	CURRENT KNOWLEDGE OF HYDROLOGIC CONDITIONS AT THE SITE • DISCUSSION OF REGIONAL HYDROLOGY • SITE HYDROLOGY - SATURATED ZONE • SITE HYDROLOGY - UNSATURATED ZONE • DISCUSSION OF PALEOHYDROLOGY AND PALEO- AND FUTURE CLIMATE • STABILITY OF WATER TABLE • EVIDENCE OF VAST DISCHARGE	W. WILSON/ W. DUDLEY
3:00	BREAK	
3:15	PLANS FOR SITE CHARACTERIZATION • PURPOSE OF SITE CHARACTERIZATION • ORGANIZING PRINCIPLES FOR SITE PROGRAM • DETAILED OVERVIEW OF SITE STUDIES	J. YOUNKER
4:45	SUMMARY AND DISCUSSION: • PLANS AND LOGISTICS FOR FIELD TRIP TO YUCCA MOUNTAIN	M. BLANCHARD
5:30	ADJOURN	

BOB MILLER, *Acting Governor*

STATE OF NEVADA

Administration 702/885-4670
Air Quality 885-5065
Construction Grants 885-5870

Groundwater 702/885-4670
Waste Management 885-5872
Water Pollution 885-4670

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF ENVIRONMENTAL PROTECTION

201 South Fall Street
Carson City, Nevada 89710

June 5, 1989

ACTION E PA

Frank E. Bingham, Director
Environmental Protection Division
Department of Energy
Nevada Operations Office
P.O. Box 98518
Las Vegas, Nevada 89193-8518

Re: Modification, Nevada Test Stie Air Quality Operating Permit No. 1591

Dear Mr. Bingham:

The Division of Environmental Protection has reviewed the application in accordance with NAC 445.707 and determined that additional information is needed as detailed in the attached staff memo.

Sincerely,

L. H. Dodgion, P.E.
Administrator

LHD:mlw
Attachment
cc: Lowell Shifley

JUN 8 1989

BOB MILLER, Acting Governor

STATE OF NEVADA

Administration 702/885-4670
Air Quality 885-5065
Construction Grants 885-5870

Groundwater 702/885-467
Waste Management 885-587
Water Pollution 885-467

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
201 South Fall Street
Carson City, Nevada 89710

June 2, 1989

MEMORANDUM

TO: L. H. Dodgion, Administrator

FROM: Lowell H. Shifley, Jr., P.E.
Air Quality Officer LHS

SUBJECT: DOE Request for Modification to Operating Permit 1591

The additional information required in your letter of May 15, 1989, to Frank Bingham, has been partially addressed, as follows:

1. Detailed description of "prototype testing activities"

   Mr. Bingham's letter of May 15, 1989 does include a descriptive statement on these activities. However, no mention is made of how many boreholes will be drilled, depth and diameter.

2 Location of each such proposed activity

   The two specified locations for the activities (south of the Yucca Mountain area and the east side of Fran Ridge on the NTS) is too general. Section, township and range or UTM coordinates are required. Also, a topographic map indicating the exact location of the disturbances is required.

3. Number of acres which will be disturbed for each activity

   Mr. Bingham's May 15 letter does state that the drilling activities will be less than two acres of disturbance. The mapping program will use existing test pits, pads, and roads. However, the exact disturbances should be indicated on the topographic map.

4. Method of controlling TSP emissions and post activity area stabilization

   Mr. Bingham addresses dust control adequately in his May 23, 1989, letter. The proposed dust control is a standard method.

5. Associated activities which will generate TSP, such as increased traffic to the sites.

   No mention is made of secondary particulate emissions in either of Mr. Bingham's letters. The increased vehicle traffic and quantified emissions should be detailed.

The fee of $200.00 has been received.

From the above, it can be determined that the application for amendment to Operating Permit 1591 is incomplete.

from ~~F&A~~ F&S

DRAFT

May, 1989
Revision 1

In order to structure the scope-of-work for Title II activities, FSN has used the YMP Work Breakdown Structure Dictionary. Therefore, the scope of work elements described ~~below~~ identify the primary work breakdown structure and work packages for the Title II effort and are, in fact, the cost accounts that will be used to monitor and measure the work. The design packages ~~also~~ will include detailed plans and sections, analyses, specifications and studies. All designs ~~are~~ will be checked, verified and approved in accordance with F&S approved QA Program. Design deliverables will include drawings, specifications, analyses and QA grading packages. ~~The YMP WBS numbers precede the title of each package. Note that this required numbering system is a different numbering system than the one contained in the SDRD~~.

PACKAGE 1

This package consists of all of the general arrangement drawings, layouts, plans, sections and necessary dimensioning for the headframes, collars, hoists and foundations. These general arrangement drawings are developed to assure component fit within the facilities and form the basis for the detailed design of the components. These drawings are included in the following packages as required and the development is tracked under the WBS number to which they are assigned.

PACKAGE 2

1.2.2.2.4 Engineered Barrier System Field Tests and Electric/Hydraulic Powered Track Mounted Drill (WBS1.2.2.2.4) Activity: Provides for the Title II detailed design for the test alcoves, drifts, drill home layouts and location of test fixtures, IDS equipment and utility support. In addition, this package will provide a performance specification for a drill capable of drilling the various holes required for these tests. This package will consist of all elements needed to construct the various engineered barrier test alcoves, IDS Equipment Alcoves, and the various ventilation, water, and power supply systems to the test alcoves and drifts. These elements are:

- o General arrangement drawings of the MTL Engineered Barrier Test Facilities.
- o General arrangement and detailed drawings of the test drill holes.
- o The necessary detailed analyses to support any designed component of the test.
- o Technical assessments, verification and approval of the designs if an when required.

PACKAGE 3

1.2.3.3.1 - Geohydrology Tests - Provides for the Title II detailed design for the test alcoves, drifts, drillhole layouts, and locations of test fixtures, IDS equipment, and utility support for all of the geohydrology tests located in the ESF.

This package will consist of all the elements needed to construct the various facilities required for the subsurface hydrological tests. The tests covered in this package are:

- o Intact Fracture Test
- o Percolation
- o Bulk Permeability
- o Radial Bore Holes
- o Excavation Effects
- o Perched Water
- o Diffusion Test
- o Chlorine - 36
- o Hydrologic Properties Samples
- o General arrangement drawings of the ES-1 and ES-2 shafts, the UDBR and the MTL showing the various test fixture locations.
- o General arrangement and detailed drawings of each of the test alcoves and drill hole arrays located in the shafts and underground spaces.
- o The necessary detailed analyses and calculations required to support any designed component of the test fixtures, holes and alcoves.
- o Detailed design drawings and specifications.

- Technical assessments, verification and approval of the designs if and when required.

PACKAGE 4

1.2.4.2.1 Rock Mechanics - Provides for the Title II detailed design for the various test alcoves, drill hole layouts andlocations of test fixtures, IDS equipment and utility support routing.

This item will consist of all elements needed to construct the various test alcoves, the IDS alcoves, and various ventilation, water, and power supply systems to the test alcoves. The tests covered in this package are:

- Underground Geologic Mapping
- Vertical Seismic Profiling
- Shaft Convergence
- Demonstration Breakout Rooms
- Sequential Drift Mining
- TSWI Heater
- Mining Methods
- Air Quality and Ventilation
- Seal Testing
- Canister Scale Heater
  - Heated Block
  - Thermal Stress
  - Heated Room
  - Plate Loading
  - Rock Mass Response
  - Ground Support
  - Overcore Stress

The elements which will be provided are:

- General arrangement drawings of the ES-1 and ES-2 shafts, the UDBR and the MTL showing the various test fixture locations.
- General arrangement and detailed drawings of each of the test alcoves and drill hole arrays located in the shafts and underground spaces.
- The necessary detailed analyses and calculations required to support any designed component of the test fixtures, holes and alcoves.
- Detailed design drawings and specifications.
- Technical assessments, verification and approval of the designs if and when required.

PACKAGE 5

1.2.6.3.2 ES-1 Collar Design (1.2.6.3.2) - provides for the Title II detailed design for the ES-1 shaft collar and the foundation to the uppermost portion of the shaft used to support the headframe and shaft construction activities.

This item consists of all elements needed to construct a shaft collar at the ES-1 which are:

- General arrangements and layout drawings for both the sinking and operating phases.
- The necessary detailed analyses and calculations to support and develop the design.
- Detailed design drawings and specifications.
- Concrete specifications and cast-in-place concrete.
- Technical assessments, verification and approval of the design.

PACKAGE 6

1.2.6.3.3 ES-2 Collar Design - provides for the Title II detailed design for the ES-2 shaft collar.

This item consists of all elements needed to construct a shaft collar at the ES-2 which are:

- General arrangements and layout drawings for both the sinking and operating phases.
- The necessary detailed analyses and calculations to support and develop the design.
- Detailed design drawings and specifications.
- Concrete specifications and cast-in-place concrete.
- Technical assessments, verification and approval of the design.

PACKAGE 7

1.2.6.4.1 ES-1 Shaft and Lining - provides for the Title II definitive design for the ES-1 shaft, liner, and sump.

This package contains all of the related shaft and liner items to excavate and line the ES-1 shaft which are:

- o General arrangement and layout drawings.
- o Detailed analyses and calculations to support the design of the liner.
- o Stratigraphy and rock classification.
- o Temporary rock support details.
- o Detailed design drawings and specification.
- o Detailed shaft test details drawings.
- o Liner analyses for seismic, dynamic, static and thermal loads.
- o Determination of materials specifications.
- o Detailed plans and sections for liner, stations, foundations, reinforcement and miscellaneous cutouts.
- o Temporary rock support.
- o Stratigraphy and rock mass classification.
- o Specifications for materials such as concrete, steel, grout and ground support.
- o Excavation details for controlled drilling and blasting.
- o Testing details (such as liner penetration and cable routing
- o Technical assessment, verification and approval.

PACKAGE 8

1.2.6.4.2 - ES-1 Hoist and Headframe - provides for the Title II detailed design for the ES-1 hoist and headframes.

This package includes civil/structural and mining group input relative to the ES-1 Hoist and Headframe package. Items and activities covered are:

- Prepare general arrangement drawings and layout showing the plans and sections of headframe for sinking and operations phase including hoist house.
- Headframe geometry and load analysis.
- Headframe computer analysis and detailed design calculations.
- Calculation and analysis of main hoist concrete foundation (900 hp).
- Hoist house miscellaneous detail drawings.
- Detailed drawings and calculations for sinking hoists.
- Establish hoist data, hoist duty cycle and detailed requirements.
- Detailed headframe framing plans and sections.
- Specifications for ES-1 headframe, structural steel, miscellaneous steel.
- 900 H. P. Hoist evaluation, refurbishing program tracking, inspection and acceptance report.
- Complete drawing set and maintenance manuals including "as-built" drawings.
- Analyses and specifications for a portable emergency hoist for site use in either ES-1 or ES-2.

Also included in this package are technical assessments of the design, design verification, comment incorporation and QA acceptance of the design.

PACKAGE 9

1.2.6.5.1 ES-2 Shaft and Lining - provides for the Title II design for the ES-2 shaft, liner, and sump.

This package contains all of the related shaft and liner items to line the ES-2 shaft which are:

- General arrangement and layout drawings.

- o Detailed analysts and calculations to support the design of the liner.
- o Stratigraphy and rock classification.
- o Temporary rock support details.
- o Detailed design drawings and specification.
- o Excavation details for controlled drilling and blasting.
- o Testing details such as liner penetrations and cable routing.
- o Technical assessment, verification and approval.
- o Detailed shaft test detail drawings.
- o Liner analyses for seismic, dynamic, static and thermal loads.
- o Determination of materials specifications.
- o Detailed plans and sections for liner, stations, foundations, reinforcement and miscellaneous cutouts.
- o Stratigraphy and rock mass classification.
- o Specifications for materials such as concrete, steel, grout and ground support.
- o UBDR Station details.

PACKAGE 10

1.2.6.5.2 ES-2 Hoist and Headframe - provides for the Title II design for the ES-2 hoist and headframe.

This package includes civil/structural and mining group input relative to the ES-2 Hoist and Headframe package. Items and activities covered are:

- o Prepare general arrangement drawings and layout showing the plans and sections of headframe for sinking and operations phase including hoist house.
- o Headframe geometry and load analysis.

- Headframe computer analysis detailed design calculations.
- Calculation and analysis of main hoist concrete foundation (1500 hp).
- Hoist house miscellaneous detail drawings.
- Detailed drawings and calculations for sinking hoists.
- Establish hoist data, hoist duty cycle and detailed requirements.
- Detailed headframe framing plans and sections.
- Specifications for ES-2 headframe, structural steel, miscellaneous steel and skip/cage.
- Hoist evaluation and assessment of GFE suitability for ESF performance.
- Complete drawing set on ES-2 hoist, including mechanical and as-builts, and maintenance manuals.

Hoist assessment will outline the suitability of refurbishment and related costs, as well as specify mechanical and electrical details of rebuilding. Also included in the assessment are the comments, recommendations and conclusions by the two hoist consultant with FSN recommendations. If the hoist assessment is negative (not refurbishable) FSN will review alternatives and attendant costs of these alternatives. Efforts will include interfaces with other program participants as well as outside organizations and consultants.

Also included in this package are technical assessments of the design, design verification, comment incorporation and QA acceptance of the design.

PACKAGE 11

1.2.6.6.1 Main Test Levels - This item includes elements and activities associated with the MTL areas relative to testing and operations support which are:

- o Detailed plans for excavation, testing, drilling, blasting control and rock support (both temporary and permanent).
- o Analyses of opening support including modeling, evaluation and thermal loading.
- o Trade-off studies, analyses, and calculations for mechanical systems and geotechnical responses.
- o Details of test support, operation of mechanical systems/components.
- o Technical assessment, verification and approval.
- o Excavation sequencing to fulfill test and site characterization goals.

Package includes all deliverables, checking, verification, software qualification, quality grading, and quality control procedures.

PACKAGE 12

1.2.6.6.2 Exploratory Drifts - This item includes elements and activities associated with the Exploratory ~~Draft~~ Shaft areas relative to testing and operations support which are:

- o Detailed plans for excavation, testing, drilling, blasting control and rock support (both temporary and permanent)
- o Analyses of opening support including modeling, evaluation and thermal loading.

- o Trade-off studies, analyses, and calculations for mechanical systems and geotechnical responses.
- o Details of test support, operation of mechanical systems/components.
- o Technical assessment, verification and approval.
- o Excavation sequencing to fulfill test and site characterization goals.

Package includes all deliverables, checking, verification, software qualification, quality grading, and quality control procedures.

PACKAGE 13

1.2.6.6.3 Secondary Levels - This item includes elements and activities associated with the Secondary Level Upper Demonstration Breakout Room (UDBR) areas relative to testing and operations support which are:

- o Detailed plans for excavation, testing, drilling, blasting control and rock support (both temporary and permanent).
- o Analyses of opening support including modeling, evaluation and thermal loading.
- o Trade-off studies, analyses, and calculations for mechanical systems and geotechnical responses.
- o Details of test support, and operation of mechanical systems/components.
- o Technical assessment, verification and approval
- o Excavation sequencing to fulfill test and site characterization goals.

Package includes all deliverables, checking, verification, software qualification, quality grading, and quality control procedures.

DRAFT

May, 1989
Revision 1

PACKAGE 14

1.2.6.7.1 Utilities and Communications Systems - Provide the Title II design for the Ventilation System, Mine Supply Water System, Mine Waste Water Removal System, Compressed Air System, Underground Electrical Distribution and Lighting System, and certain portions of the Underground Instrumentation and Communications System.

This item consists of all elements related to complete Title II design and support the Title III construction for the subsurface water, waste water, electrical supply, piping, instrumentation/control and shaft communication system, which included are the general arrangements and layout drawings, necessary detailed analyses and calculations to support and develop the design, detailed design drawings and specifications, technical assessments, verification and approval of the design. Also included are design changes, drawing modifications and as-built drawings, which include:

- Source input plan for the strategic location of gas monitors, temperature/humidity sensors, air velocity sensors, fire door status switch, fan controls, and fan operating status switches.
- Source input plan for the related wiring routes of the items used to monitor ventilation systems.
- Detailed plans and procedures to operate/calibrate record/report monitoring of ventilation system and related instrument or equipment.

The package also includes the technical assessments of the design, design verification, comment incorporation and QA acceptance of the design.

Electrical

- Electrical connection plans and details of ES-1 and ES-2 ventilation fans.
- Waste water pump electrical connection details and control schematic layouts.
- Subsurface 480V one-line and testing power distribution diagrams.
- Electrical connection plans and details of UDBR, MTL, tail shaft, stations and DAS stations.
- Subsurface lighting plan and connection details.
- Circuit and wiring or cable runs (schedules) including panel identifications (schedules).
- ES-1 and ES-2 hoists electrical connection details and controls.
- ES-2 skip loader wiring details.
- Subsurface grounding details.
- 480V motor control center connection details.
- MTL fire door and vent regulator operators.
- Shaft cable support detail dwgs.

Communications

- Mine signal switch (pull bottles) bell and buzzer hoist signalling systems electrical details and schematics.
- FM radio hoist/cage transceiver system plans and details.

Instrumentation

- Instrument connection loop diagrams for ventilation, compressed air, water and waste water systems.
- Instrument installation detail drawings.
- MTL test instrument cable routing and detail

Also included in the package are the technical assessments of the design, design verification and comment incorporation.

PACKAGE 15

1.2.6.7.2 ES-1 Shaft Internals and Conveyances - provides for the Title II design of the ES-1 shaft furnishings.

This package includes those items and activities associated with the ES-1 shaft internals and conveyance package. These are:

- o General arrangement of shaft cross-section, plans and sections of shaft stations, loading pocket and tailshaft.
- o Design analysis and detailed calculation for shaft outfitting, bunton/brackets, station framing, stage and concrete liner forms.
- o Detailed design drawings for bunton/bracket, station framing and crash beams.
- o Detailed plans and sections for station brow reinforcement, shaft inserts, station platforms and manway.
- o Details of sinking stage and concrete liner forms.
- o Design guidelines for shaft outfitting, guides and buntons.
- o Specifications for miscellaneous steel and anchor bolts and embedded items.

Also included in this package are technical assessments of the design, design verification and comment incorporation.

PACKAGE 16

1.2.6.7.3 ES-2 Shaft Internals and Conveyances - provides for the Title II design of the ES-2 shaft furnishings.

This package includes those items and activities associated with the ES-2 shaft internals and conveyance package. These are:

- o General arrangement of shaft cross-section, plans and sections of shaft station, loading pocket and tailshaft.

- Design analysis and detailed calculation for shaft outfitting, bunton/brackets, skip/cage geometry, counterweight design and miscellaneous tailshaft framing.
- Detailed design drawings for bunton/bracket, station framing, crash beams, surge bin, measuring flask and spillage hopper.
- Detailed plans and sections for station brow reinforcement, shaft inserts, station platforms and manway.
- Mechanical details of spill box, surge bin and measuring flask gate and chute.
- Design guidelines for shaft outfitting, guide and buntons.
- Specifications for ES-1 conveyance, miscellaneous steel, anchor bolts and embedded items.

Also included in this package are technical assessments of the design, design verification and comment incorporation.

STATE OF NEVADA

Presentation To

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: INTRODUCTION

DATE: JUNE 26, 1989

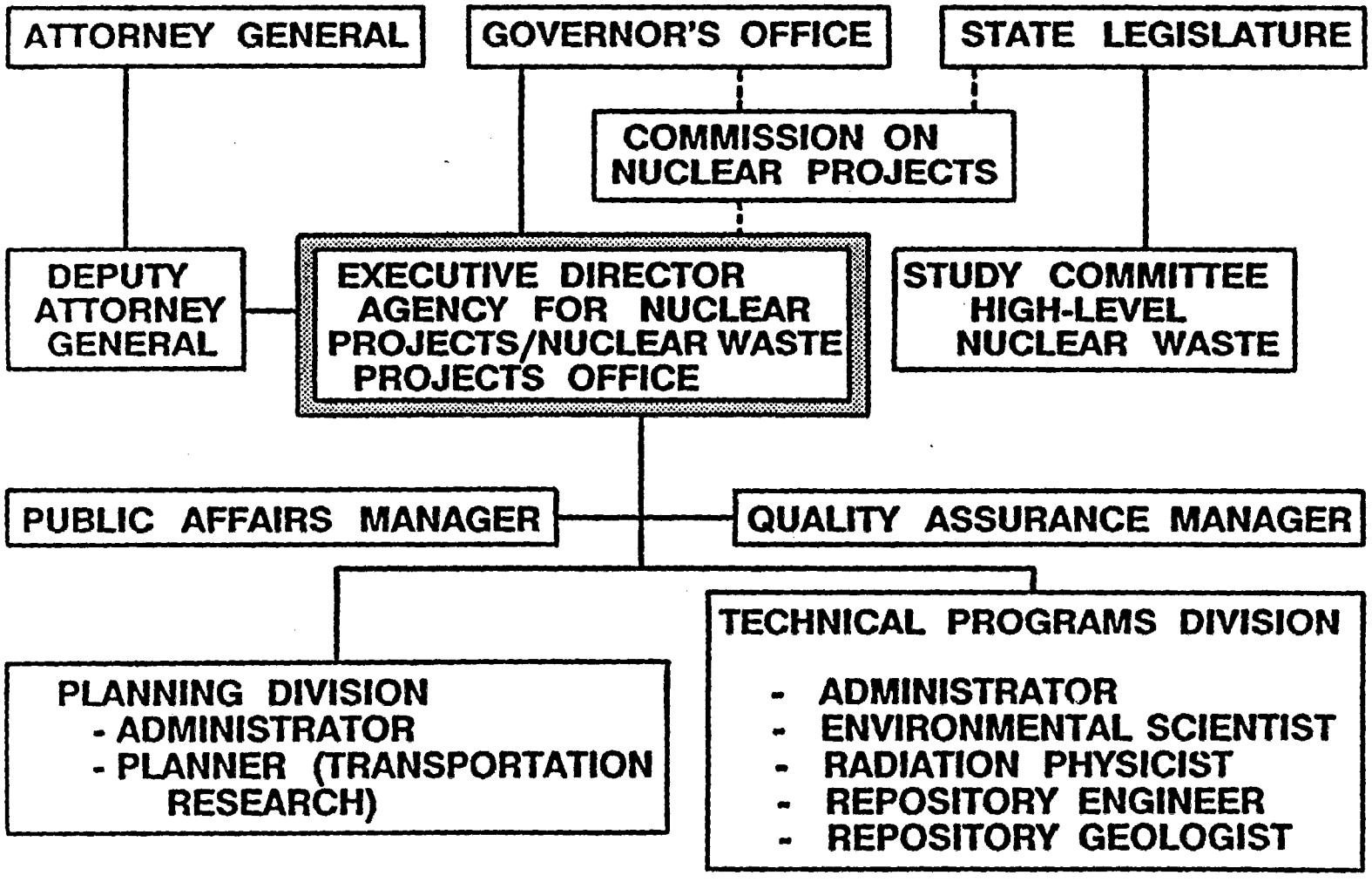
PRESENTER: ROBERT R. LOUX

TITLE: EXECUTIVE DIRECTOR

ORGANIZATION: NEVADA AGENCY FOR NUCLEAR PROJECTS
CARSON CITY, NEVADA

TELEPHONE: (702) 885-3744

STATE OF NEVADA AGENCY FOR NUCLEAR PROJECTS ORGANIZATIONAL CHART



NWPO

- AGENCY FOR NUCLEAR PROJECTS RESPONSIBLE FOR OVERSIGHT OF DOE'S HIGH-LEVEL RADIOACTIVE WASTE REPOSITORY PROGRAM.
- AGENCY ACTIVITIES FUNDED THROUGH DOE GRANTS FROM NWPA NUCLEAR WASTE FUND.

AGENCY GOALS

- TO INSURE THAT PUBLIC HEALTH AND SAFETY AND THE ENVIRONMENT ARE ADEQUATELY PROTECTED.
- TO ASSESS SOCIAL, ECONOMIC AND TRANSPORTATION IMPACTS THAT THE STATE COULD EXPERIENCE.
- TO PROVIDE POLICY GUIDANCE TO THE GOVERNOR AND OTHER STATE LEADERS.

TECHNICAL ACTIVITIES

- DEFINE TECHNICAL ISSUES CRITICAL TO THE HEALTH AND SAFETY OF NEVADANS AND THEIR ENVIRONMENT.
- REVIEW DOE PLANS, STUDIES, AND DOCUMENTS.
- MONITOR DOE FIELD AND LABORATORY ACTIVITIES.
- CONDUCT INDEPENDENT STUDIES RELATED TO ISSUES OF CONCERN.

NWPO

STATE OF NEVADA

Presentation To

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: OVERVIEW OF TECHNICAL CONCERNS ABOUT PROPOSED YUCCA MOUNTAIN NUCLEAR WASTE REPOSITORY.

DATE: JUNE 26, 1989

PRESENTER: CARL A. JOHNSON

TITLE: ADMINISTRATOR OF TECHNICAL PROGRAMS

ORGANIZATION: NEVADA AGENCY FOR NUCLEAR PROJECTS
CARSON CITY, NEVADA

TELEPHONE: (702) 885-3744

PURPOSE OF PRESENTATION

DISCUSS NEVADA'S TECHNICAL SITE SUITABILITY CONCERNS RELATED TO THE PROPOSED YUCCA MOUNTAIN REPOSITORY SITE.

OVERVIEW PRESENTATION AGENDA

- GENERAL SITE SUITABILITY CONCERNS
- SITE SUITABILITY TECHNICAL ISSUES

GENERAL SITE SUITABILITY CONCERNS

1. SITE SUITABILITY TECHNICAL ISSUES

- 1987 NWPAA INDENTIFYING THE LOCATION OF YUCCA MOUNTAIN AS THE SINGLE CANDIDATE SITE FOR CHARACTERIZATION DOES NOT ASSURE THE SUITABILITY OF THE SITE.
  - EARLY RESOLUTION OF SITE KEY SUITABILITY ISSUES

2. REGULATORY POLICY ISSUES

- 10 CFR PART 100, APPENDIX A
- DATA SUFFICIENCY
- DETERMINISTIC vs. PROBABALISTIC APPROACHES
- SYSTEM LICENSING
- PHASED LICENSING
- LAND OWNERSHIP AND CONTROL

3. SITE DISTURBANCE ISSUES

- DEVELOPMENT OF SUFFICIENT DATA WITHOUT SACRIFICING SITE INTEGRITY
  - USE OF HIGH RESOLUTION GEOPHYSICS
  - PENETRATION OF CALICO HILLS TUFF
  - CHARACTERIZATION OF FRACTURE SYSTEMS

4. LONG-TERM POST-CLOSURE ISSUES

- DEEP GEOLOGIC REPOSITORY IS A 10,000 YEAR PROJECT
  - PREDICTABILITY
  - LONG-TERM RISKS
  - ENGINEERED BARRIERS
  - AVAILABLE TECHNOLOGY

BASIS OF TECHNICAL CONCERN

10 CFR 60.31(a) PROVIDES THAT THE COMMISSION MAY AUTHORIZE CONSTRUCTION IF IT DETERMINES:

> "That there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed [<u>at the site proposed</u>] without unreasonable risk to the health and safety of the public. . . .".

SITE SUITABILITY

TECHNICAL ISSUES

1. UNDERSTANDING THE TECTONIC SETTING OF SOUTHERN NEVADA AND ITS IMPLICATIONS FOR YUCCA MOUNTAIN SITE SUITABILITY
   - GEOLOGIC PROCESSES
   - DEEP GEOLOGIC STRUCTURES
   - EARTHQUAKE vs. FAULT RELATIONSHIPS
   - EFFECT OF NUCLEAR TESTING
   - STRESS REGIME
   - TECTONIC AFFECT ON HYDROLOGY

2. ACTIVE FAULTING AT YUCCA MOUNTAIN

- ACTIVE FAULTS IDENTIFIED
- STYLES OF FAULTING
- RECURRENCE RATES
- EARTHQUAKE vs FAULT RELATIONSHIPS
- RELATION TO HYDROLOGIC REGIME

3. CHARACTERISTICS OF THE VADOSE (UNSATURATED) ZONE

- MATRIX vs FRACTURE FLOW
  - ROCK PORES PARTIALLY FILLED
  - TUFFS HIGHLY FRACTURED
  - EVIDENCE OF FRACTURE FLOW
  - RAPID FLOW RATES
  - FRACTURE CHANGES WITH TIME
- GASEOUS PHASE MOVEMENT

4. REGIONAL GROUNDWATER FLOW

- RELATIONSHIP OF YUCCA MOUNTAIN AQUIFIER TO REGIONAL FLOW SYSTEM
- RAPID FLOW
- FUTURE WATER SUPPLY

5. UNCERTAINTY IN MODELING AND PERFORMANCE ASSESSMENT

- LACK OF ACCEPTED MODELS
- LACK OF EXPERIENCE IN MODELING PERFORMANCE FOR 10,000 YEARS
- REPRESENTATIVENESS OF DATA
- COMPLEXITY OF NATURAL SYSTEMS
  - DYNAMIC NATURAL SYSTEMS
  - COUPLED PROCESSES

6. GEOCHEMISTRY

- RETARDATION
  - ABILITY OF SORPTIVE MINERALS TO RETARD RADIONUCLIDES
  - REDUCTION IN SORPTIVE CAPACITY WITH INCREASED TEMPERATURES
  - LIMITED SORPTIVE MINERALS ALONG FRACTURES
- DISTURBED ZONE
  - ALTERATION OF VADOSE WATER CHEMISTRY
  - ALTERATION OF HOST ROCK

7. VOLCANISM

- YOUNG VOLCANIC EVENTS
- RECURRENCE RATES
- VOLCANISM vs. HYDROLOGY RELATIONSHIPS
- STRUCTURAL CONTROL

8. CLIMATE CHANGE

- EFFECT ON HYDROLOGIC SYSTEM
- PREDICTABILITY
- "PAST MAY NOT BE KEY TO FUTURE"
  - GREENHOUSE EFFECT
  - RATES OF CHANGE

9. NATURAL RESOURCE POTENTIAL

- MINERAL RESOURCES
- OIL AND GAS RESOURCES
- GEOTHERMAL RESOURCES
- WATER RESOURCES

TECHNICAL PRESENTATIONS

TECTONICS	DR. MICHAEL ELLIS DR. RICHARD SCHWEICKERT
FAULTING	JOHN BELL
HYDROLOGY	
UNSATURATED ZONE	DR. MARTIN MIFFLIN
SATURATED ZONE	DR. JOHN FORDHAM
HYDROLOGIC MODELING	SCOTT TYLER
PERFORMANCE ASSESSMENT	LINDA LEHMAN
GEOCHEMISTRY	DR. MAURICE MORGENSTEIN DR. DONALD SHETTEL
VOLCANISM	DR. EUGENE SMITH
CLIMATE CHANGE	DR. MARTIN MIFFLIN
MINERAL RESOURCES	DR. LAWRENCE LARSON

State of Nevada
Presentation to the
Technical Review Board

Subject: **Active Tectonics of the Yucca Mountain Region**

Date: June 26, 1989

Presenter: **Dr. Michael A. Ellis**

Title and Organization: Research Associate and Co-Principal Invesigator,
Center for Neotectonic Studies
Mackay School of Mines
University of Nevada - Reno
Reno, Nevada 89557
Tel. (702) 784-6610/1382

Main Points

- Yucca Mountain and its Geological Context
- Regional Seismicity and the Potential for Temporal and Spatial Clustering
- Mechanisms of Modern Deformation in the Southern Great Basin

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Conclusions

Yucca Mountain is part of an active geological system whose components are inextricably linked to each other.

In order to better understand (and anticipate) geological processes at Yucca Mountain we need to better understand the system as a whole.

Any interpretation of Yucca Mountain must be consistent with that of the region.

We must be certain that probabalistic analyses are provided with a thorough and an as-complete-as-possible database.

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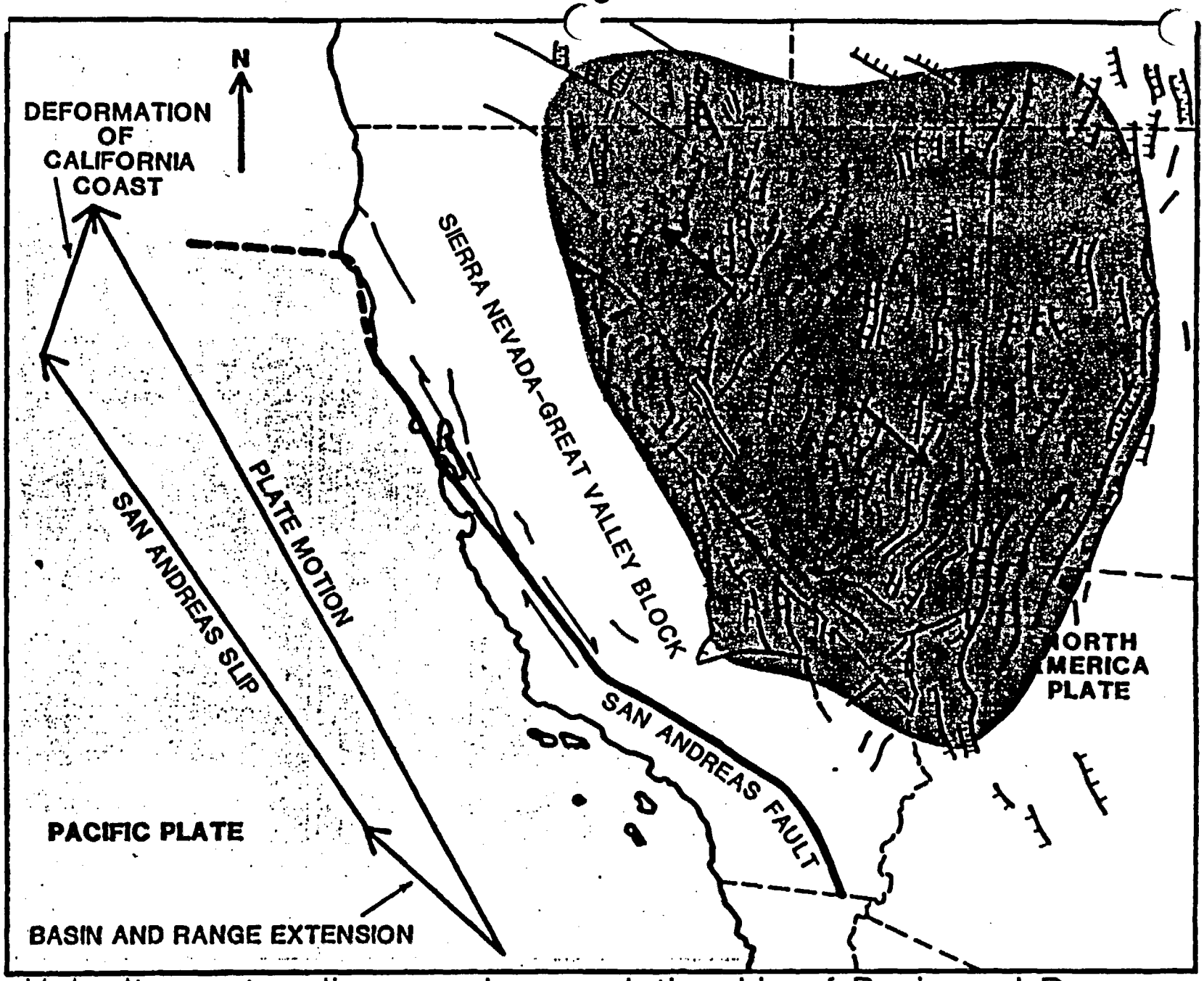
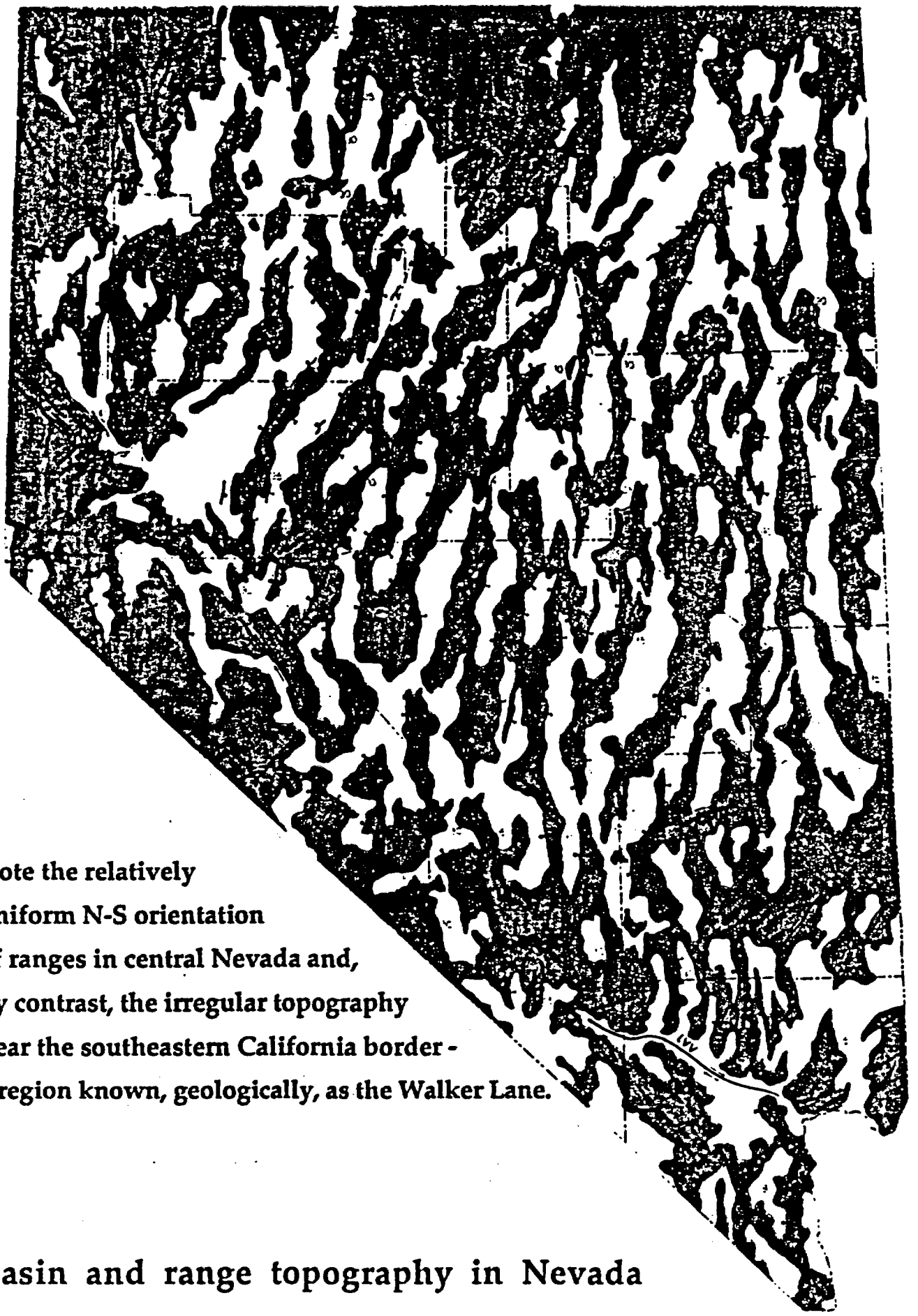
Plate Tectonic Setting of Yucca Mountain



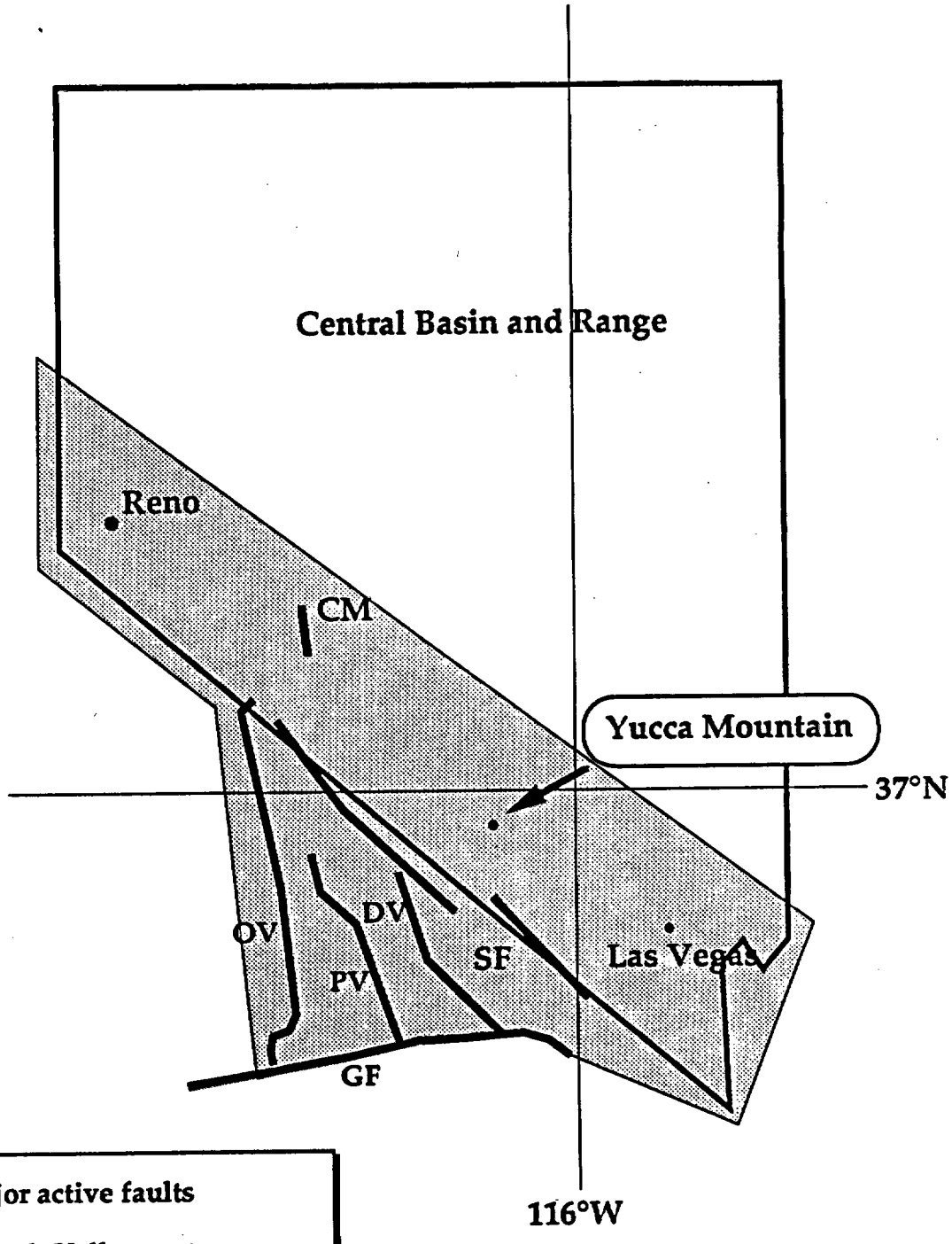
Velocity vector diagram shows relationship of Basin and Range deformation to that of the western USA



Note the relatively uniform N-S orientation of ranges in central Nevada and, by contrast, the irregular topography near the southeastern California border - a region known, geologically, as the Walker Lane.

Basin and range topography in Nevada

Walker Lane Belt and Major Active Faults in the Southern Great Basin



Major active faults

DV - Death Valley system
PV - Panamint Valley system
OV - Owens Valley system
GF - Garlock fault
SF - Stateline fault
CM - Cedar Mountain fault

Walker Lane Belt

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Regional Seismicity and the potential for spatial and temporal clustering

Seismicity and modern deformation in the Yucca Mountain region affects the following features:

- ground water flow
- mineral resource potential
- volcanic eruptive processes
- strong ground motions during seismic events
- ground deformation due to blind faults

In order to evaluate the seismicity that will directly affect Yucca Mountain we need to evaluate the potential for both spatial and temporal clustering of seismic events in the region - we need to understand how the region has been responding to extension during the past tens of thousands of years.

No amount of probabalistic analysis will yield an appropriate seismic hazard map if the data base is fundamentally inadequate.

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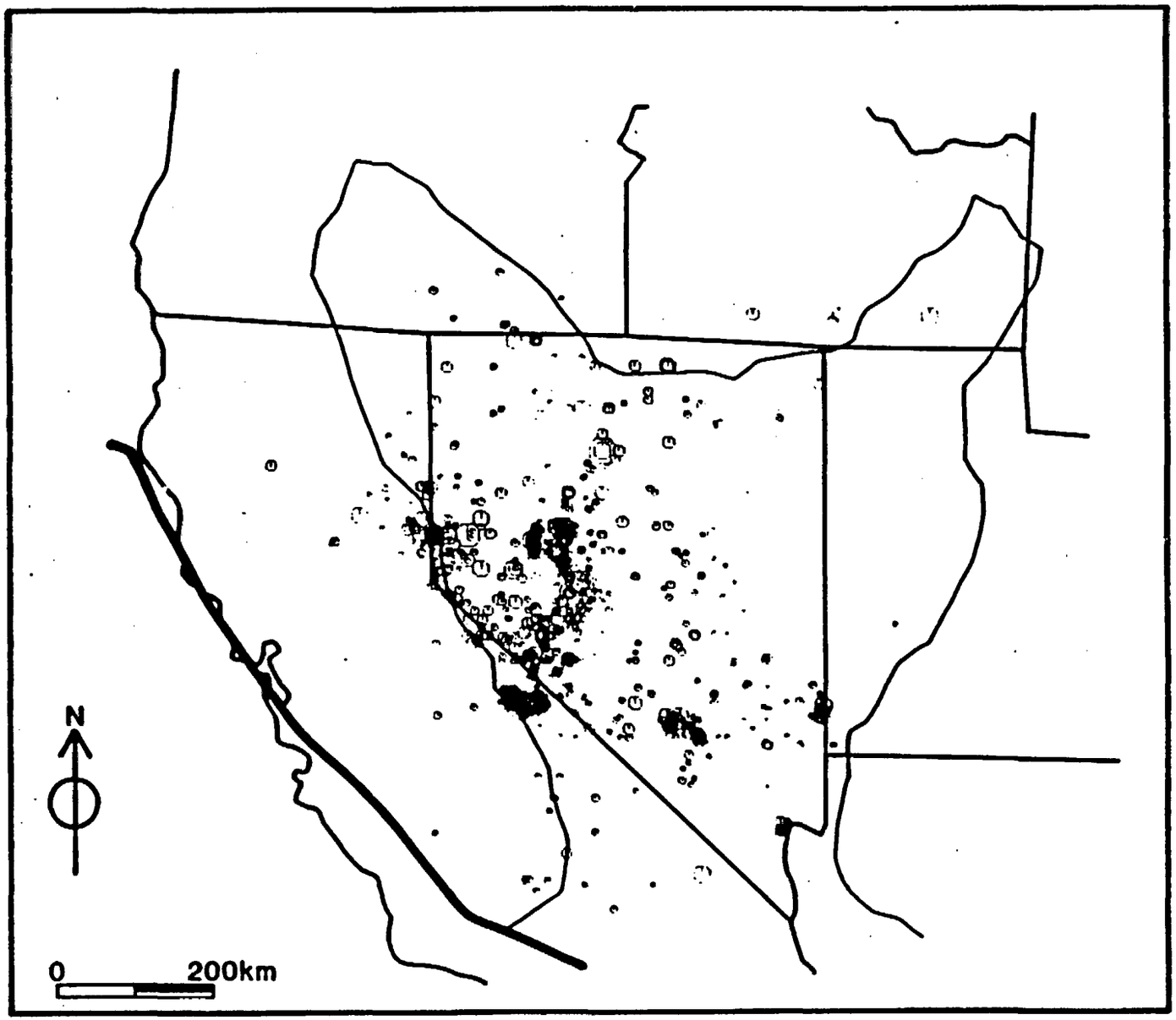
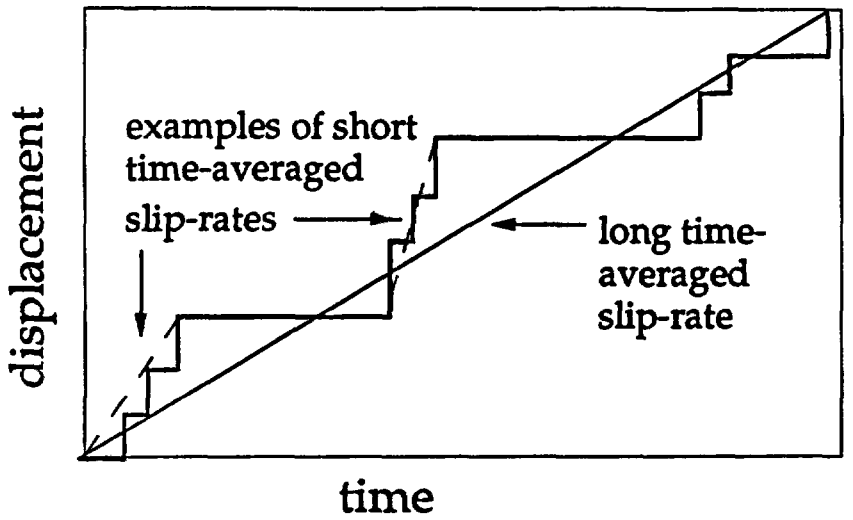
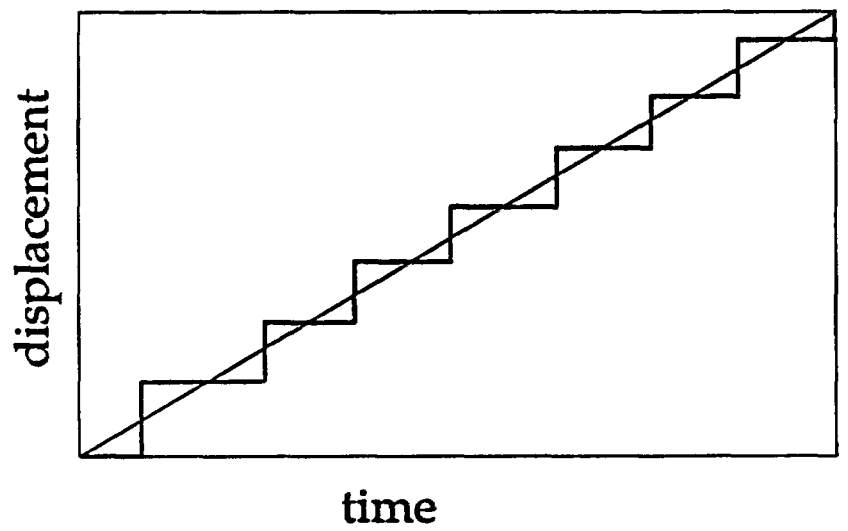
Central and Northern Nevada Seismicity, 1852-1988



Earthquakes greater than M 4.0 1852 to 1988. UNR cat. only.



Temporal Clustering



Temporal Regularity

Schematic illustration of temporal clustering versus temporal regularity during seismic deformation. Note that apparent slip-rate depends on the sampled time-interval.

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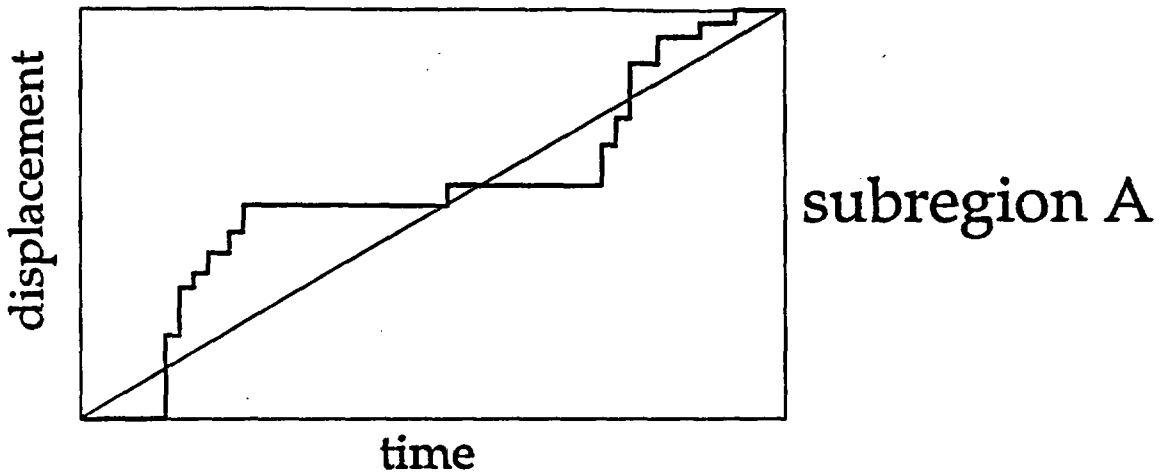
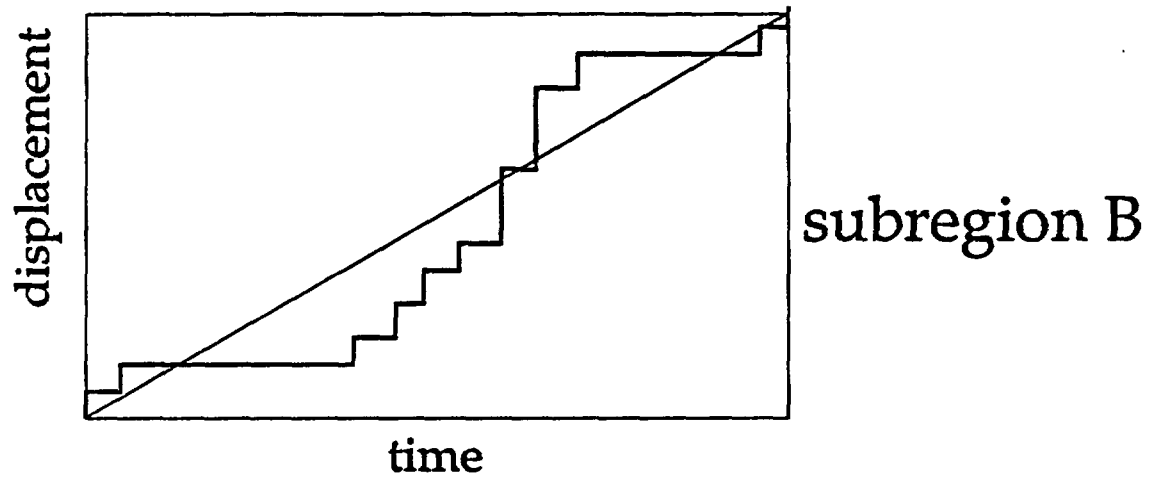
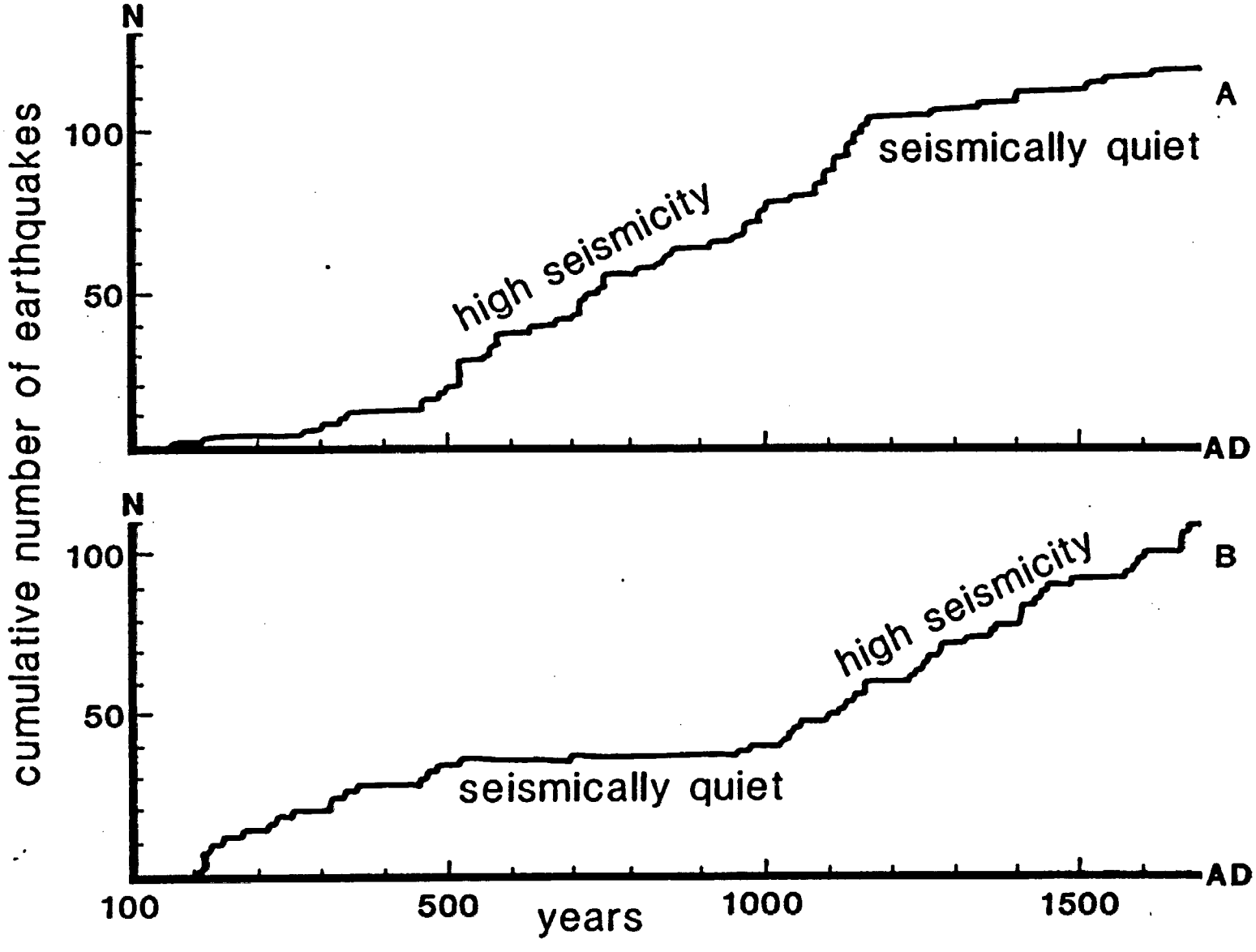




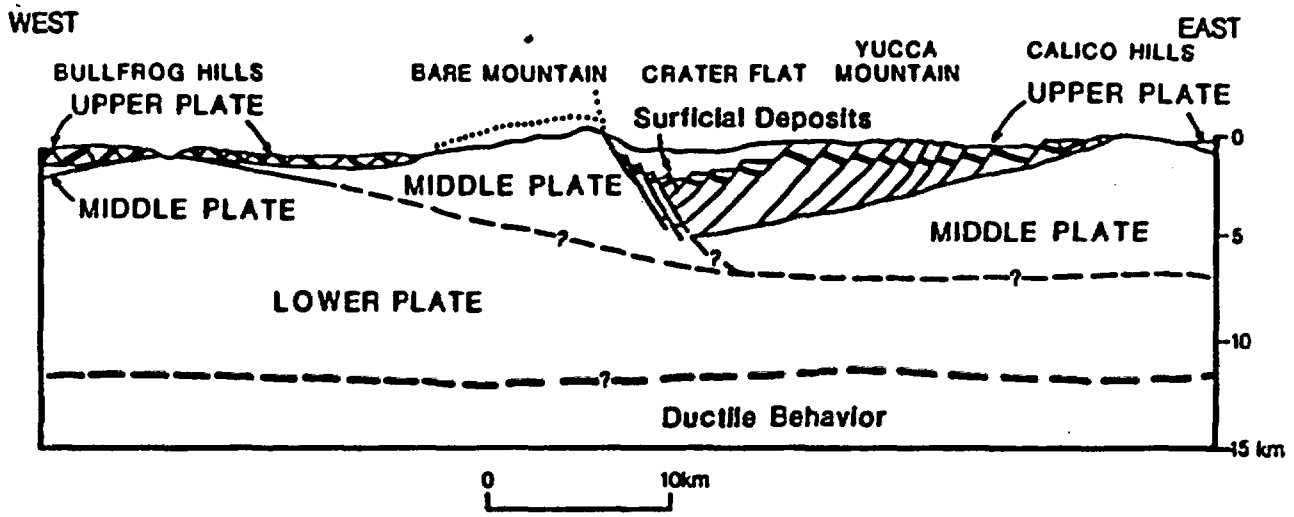
Schematic illustration of spatial and temporal clustering in two subregions within one larger region.

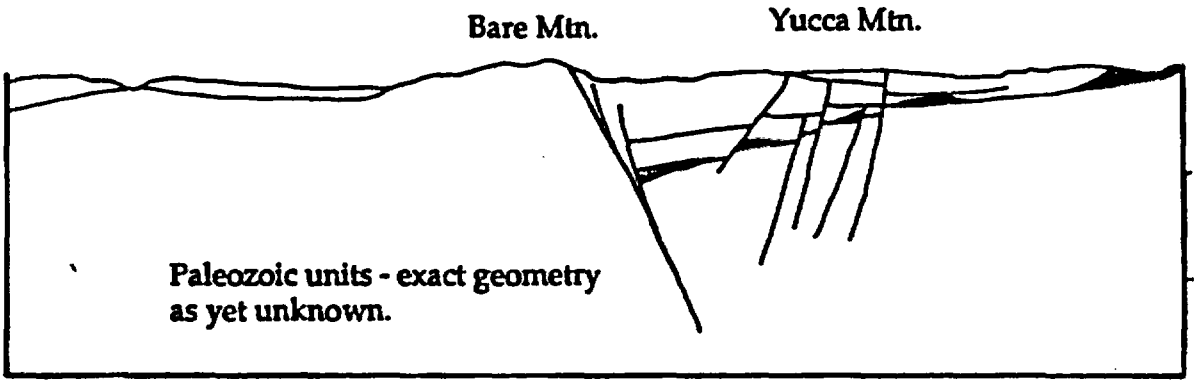
"Consequently, it is simply not logical to ignore the possibility that all of our observations may be for a quiescent period in the seismic activity of a region. . .this is the chief reason why statistics based on short period data alone do not provide a reliable assessment of earthquake hazard."
Ambraseys, 1989, Geophys. Journ. v96, p.314.

SEISMIC ACTIVITY IN ADJACENT REGIONS IN AN INTRA-CONTINENTAL SETTING



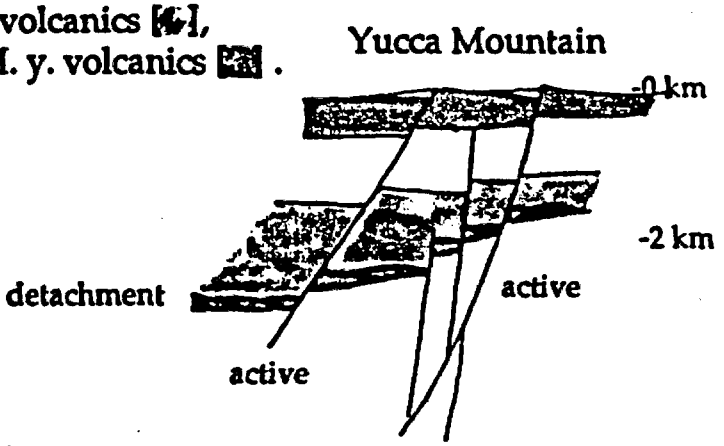
Two cross-sections of the Yucca Mountain region: top one by USGS, bottom one by Center for Neotectonic Studies, UNR.





Key to enlargement only: Pre-13.5 M.y. volcanics [ ], 13.5 - 11 M. y. volcanics, [ ], post-11.5 M. y. volcanics [ ]. Sediments < 2 M. y.,

Cross-sections are schematic only.



Enlargement of region above, showing three generations of extensional faulting and displacement of volcanic units and older detachment.

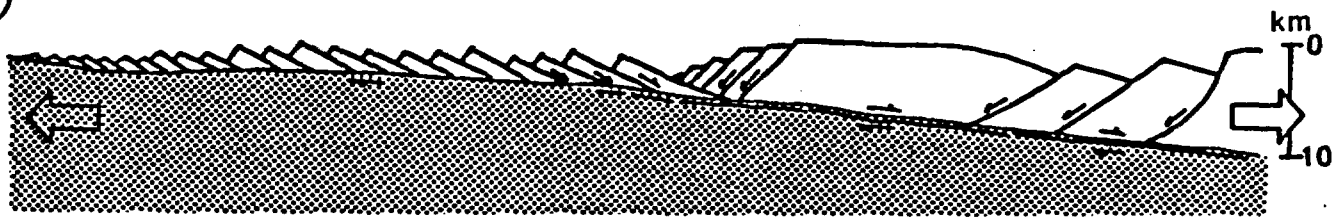
<u>Significant differences between cross-sections:</u>

- we include more realistic fault geometry, and show the potential distribution of Lower Paleozoic (aquifer) units.
- we include three generations of faulting indicated by field evidence.
- we show one subhorizontal detachment, as opposed to three, for which there is good evidence.

(A)

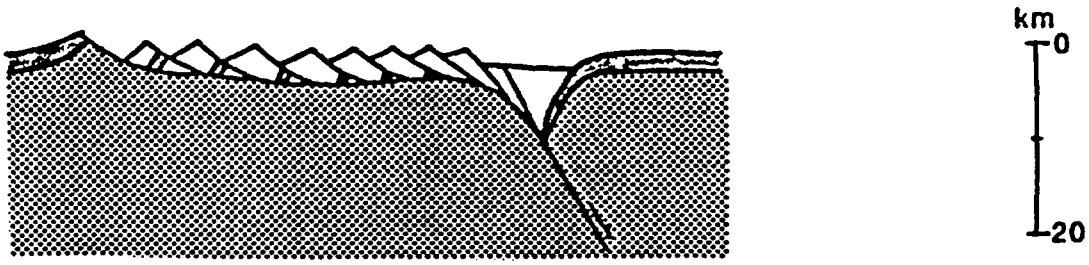
"PURE SHEAR"–Uniform stretching through crust.

(B)



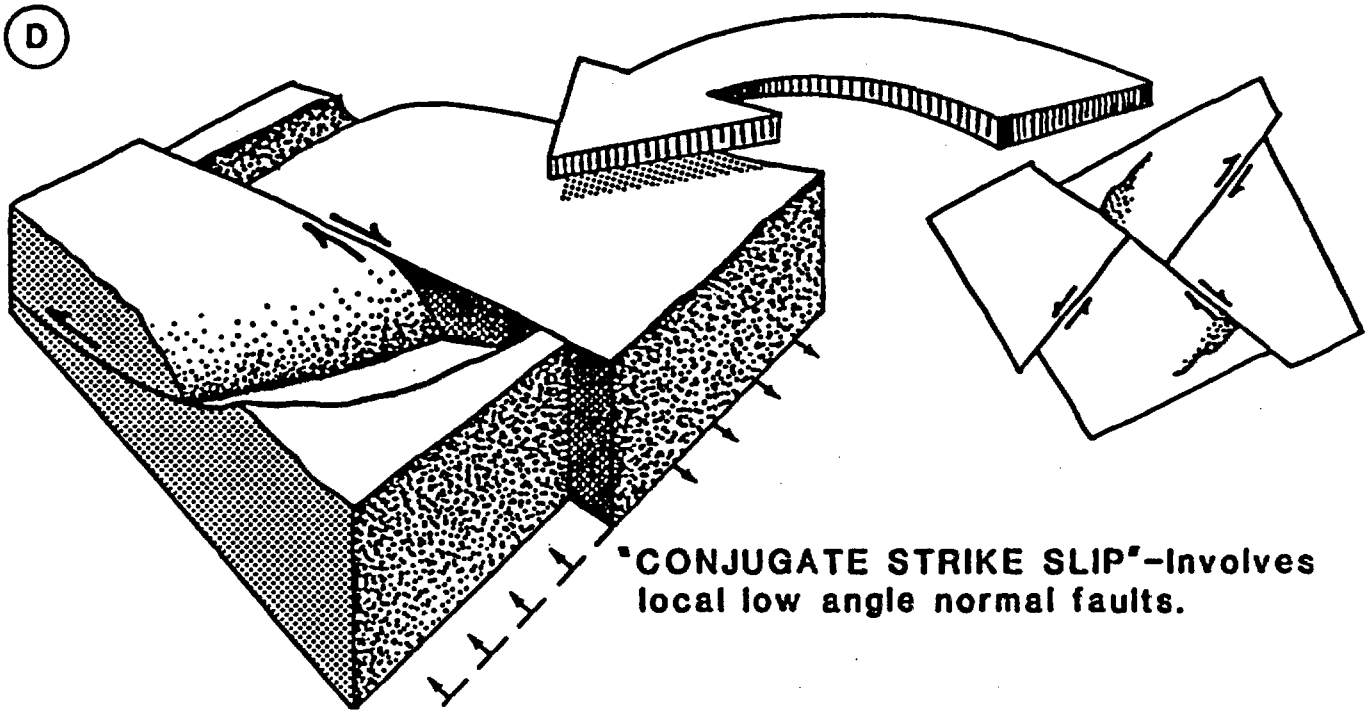
"SIMPLE SHEAR"–Non uniform stretching through crust involves significant low angle detachment.

(C)

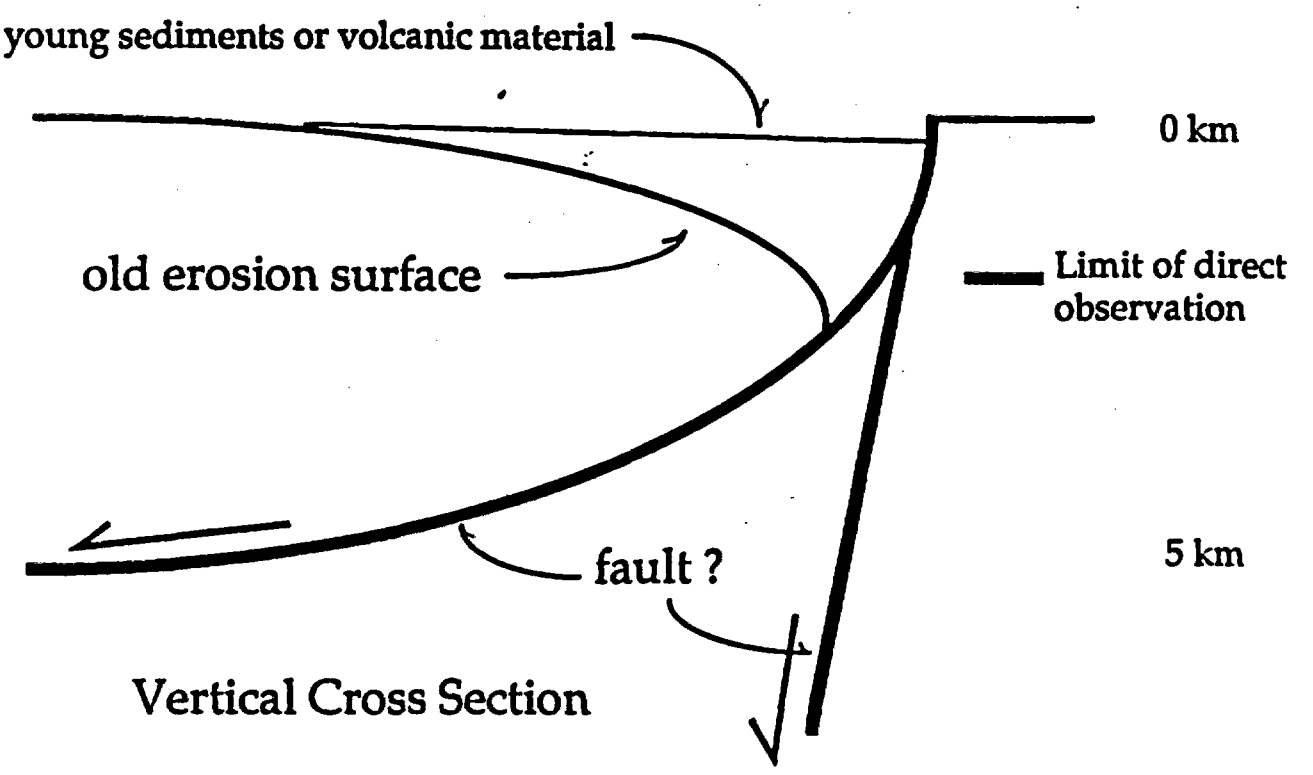


"ROLLING HINGE"–High angle fault is stranded as inactive "detachment".

(D)



"CONJUGATE STRIKE SLIP"–Involves local low angle normal faults.



Subsurface Fault Geometry -

- planar to seismogenic depths (10 - 15 km)
- curved and flattening to relatively shallow depths (5 km)

(In the latter model, the curvature is a function of the style of deformation in the hanging wall, HW.)

Conclusions

In order to accurately anticipate the geological processes at Yucca Mountain over the next 10,000 years, we need to understand the geological system of which the proposed respository site is but a component.

This requires both detailed regional and site specific studies.

Geological research in this region is continually breaking new ground, much of it represents new concepts, and in this sense the various hypotheses proposed require particularly careful evaluation.

Probabalistic analyses will ultimately yield the engineering parameters for any repository design - we must be certain that the database from which these analyses are derived are as complete as possible.

State of Nevada

Presentation to the

Technical Review Board

Subject: Tectonic framework of Yucca Mountain

Date: June 26, 1989

Presenter: Dr. Richard A. Schweickert

Title/Organization: Professor of Geology and
Principal Investigator
Center for Neotectonic Studies
Mackay School of Mines
University of Nevada--Reno
Reno, Nevada 89557

Telephone: (702) 784-6901

PURPOSE

1. BRIEFLY OUTLINE TECTONIC FRAMEWORK AND PRINCIPAL TECTONIC FEATURES OF YUCCA MTN AREA

2. CLARIFY STATE'S CONCERNS ABOUT REQUIRED STUDIES AND THE FEASIBILITY OF SITE CHARACTERIZATION

SUMMARY

- O FAULTS AT YUCCA MOUNTAIN ARE DIFFICULT TO CHARACTERIZE

- O EXPOSED FAULTS ARE NEITHER PURE STRIKE-SLIP NOR PURE DIP-SLIP

- O SEVERAL CLASSES OF FAULTS ARE CONCEALED, AND THESE MAY CONTRIBUTE TO SEISMIC AND RESOURCE POTENTIAL

- O COMPLEXITY OF SUBSURFACE STRUCTURE MAY MAKE IT IMPOSSIBLE TO DEVELOP UNIQUE MODELS OR TO SET REALISTIC BOUNDARY CONDITIONS FOR GROUNDWATER MODELS

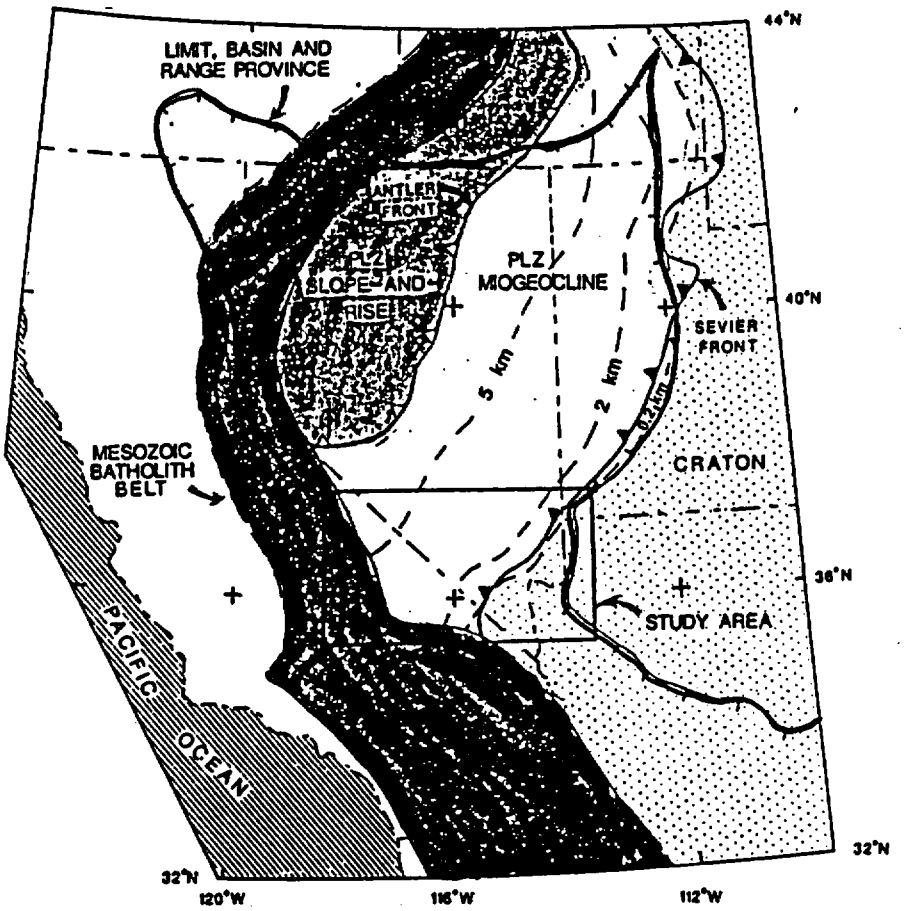
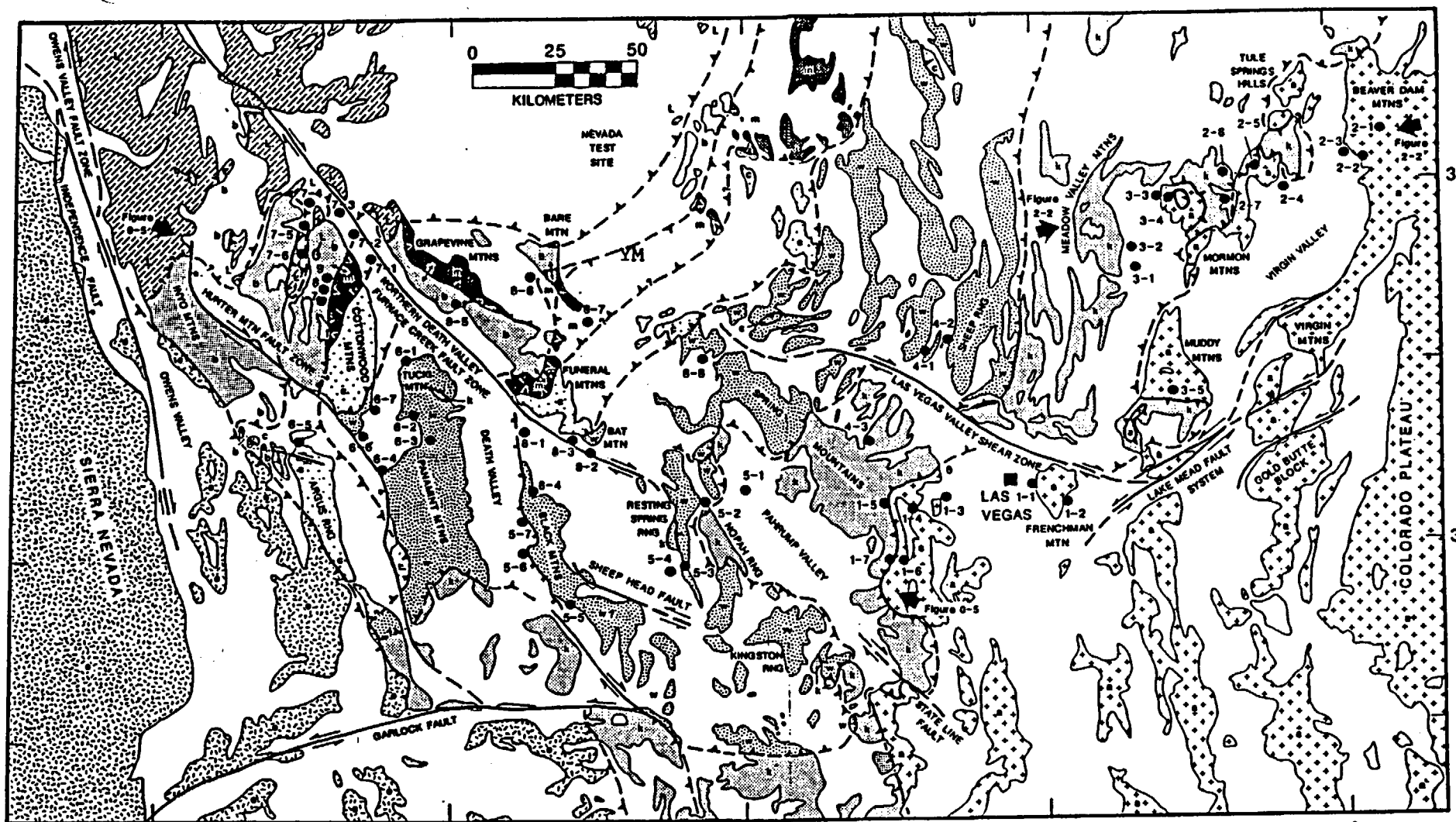


Fig. 0–2: Regional setting of the field trip area with respect to major components of the Cordilleran orogen [from Wernicke et al., 1988].



MESOZOIC TECTONIC UNITS

- rocks of EAST SIERRAN THRUST plate
- rocks of LAST CHANCE THRUST plate and equivalents
- rocks of MARBLE CANYON THRUST plate and equivalents above
- WHITE TOP MOUNTAIN BACKFOLD and equivalents
- rocks of Marble Canyon thrust plate BELOW backfold and equivalents
- rocks of CLERY THRUST plate and equivalents
- rocks of WHEELER PASS THRUST plate and equivalents
- rocks of KEYSTONE THRUST plate and equivalents
- AUTOCHTHONOUS and parautochthonous rocks below Keystone thrust and equivalents

WERNICKE AND OTHERS, 1989

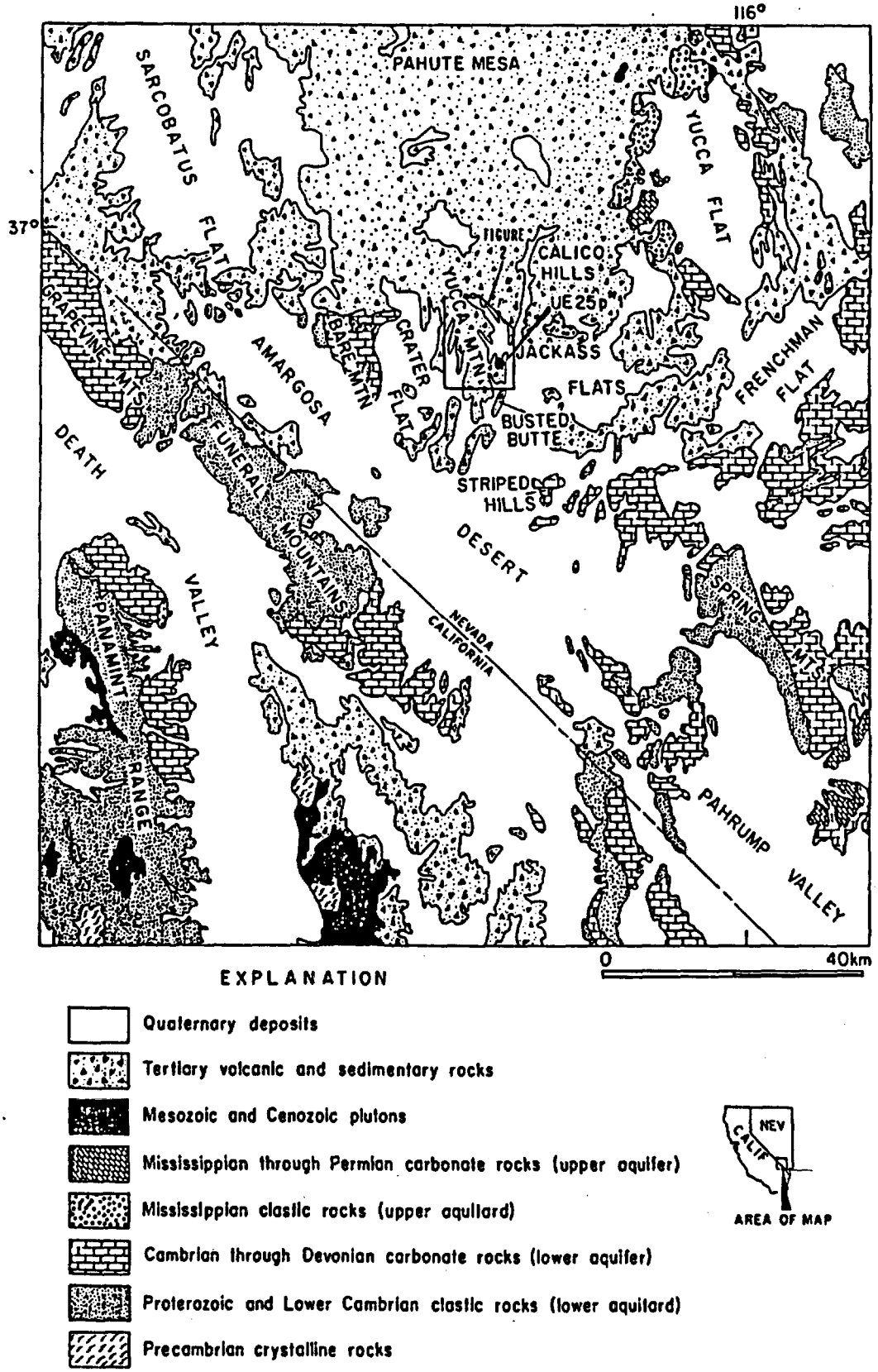


Figure 1. Generalized geologic map showing the major hydrogeologic units of Winograd and Thordarson (1975) in the region surrounding Yucca Mountain.

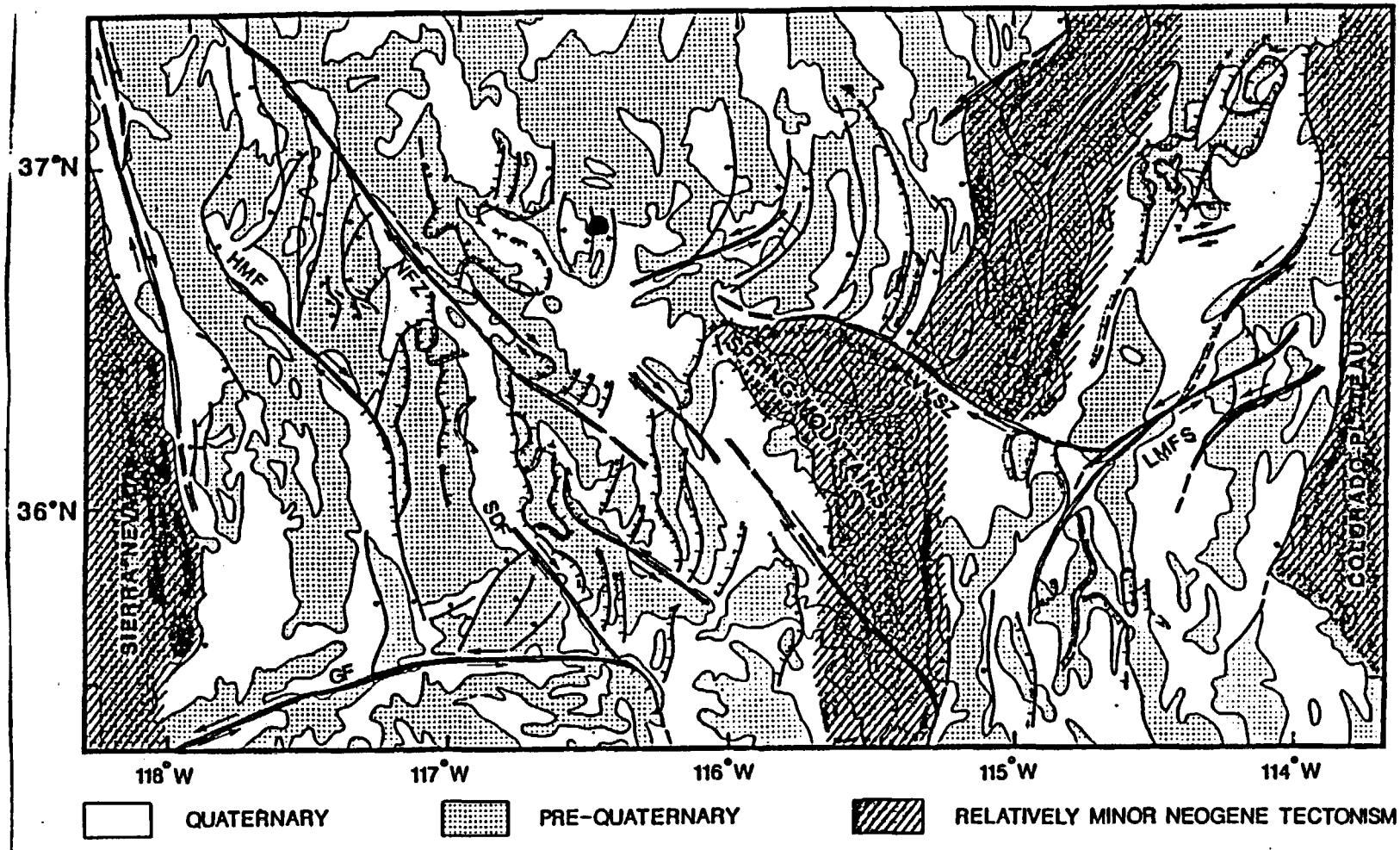


Fig. 0–6: Tectonic map of the Basin and Range province at the latitude of Las Vegas showing major Cenozoic fault systems. Areas of relatively minor Neogene tectonism bound two major extensional belts, the Death Valley extensional system to the west and the Las Vegas extensional system to the east. Tick-marked lines, low-angle normal faults; ball-and-bar symbol, high-angle normal faults; arrows, strike-slip faults; GF, Garlock fault; SDF, Southern Death Valley fault zone; HMF, Hunter Mountain fault; NFZ, Northern Death Valley-Furnace Creek fault zone; LVVSZ, Las Vegas Valley shear zone; LMFS, Lake Mead fault system. Note that left-lateral strike-slip faults tend to strike northeastward while right-lateral strike-slip faults strike northwestward [modified from Burchfiel and Davis, 1988 and Wernicke et al., 1988].

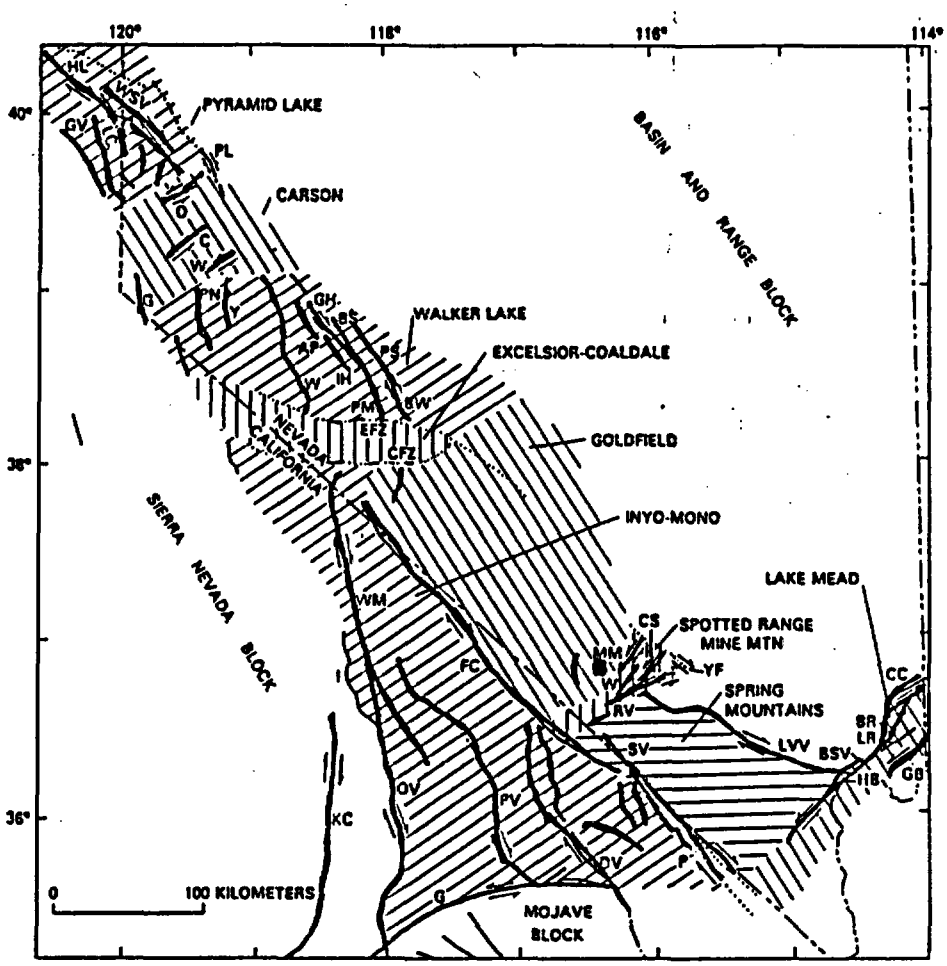


FIG. 25-3. Regional structural blocks and major faults in Walker Lane belt. Arrows indicate relative movement on strike-slip faults. Major faults or fault zone listed by structural blocks: PYRAMID LAKE BLOCK: HL, Honey Lake; GV, Grizzly Valley; LC, Last Chance; WSV, Warm Springs Valley; PL, Pyramid Lake. CARSON BLOCK: O, Olinghouse; C, Carson; W. Wabuska. WALKER LAKE BLOCK: G, Genoa; PN, Pine Nut; Y, Yerington; W, Wassuk; AP, Agai Pah Hills; GH, Gumdrop Hills; IH, Indian Head; BS, Benton Spring; PS, Petrifield Springs; PM, Pilot Mountains; BW, Bettles Well. EXCELSIOR-COALDALE BLOCK: EFZ, Excelsior; CFZ, Coaldale. INYO-MONO BLOCK: KC, Kern Canyon; I, Independence; WM, White Mountain; OV, Owens Valley; FC, Furnace Creek; PV, Panamint Valley; DV, Death Valley; G, Garlock; SV, Stewart Valley; P, Pahrump. SPOTTED RANGE-MINE MOUNTAIN BLOCK: MM, Mine Mountain; W, Wahmonie; RV, Rock Valley; CS, Cane Spring; YF, Yucca-Frenchman. SPRING MOUNTAINS BLOCK: LVV, Las Vegas Valley. LAKE MEAD BLOCK: BSV, Bitter Spring Valley; HB, Hamblin Bay; CC, Cabin Canyon; BR, Bitter Ridge; LR, Lime Ridge; GB, Gold Butte.

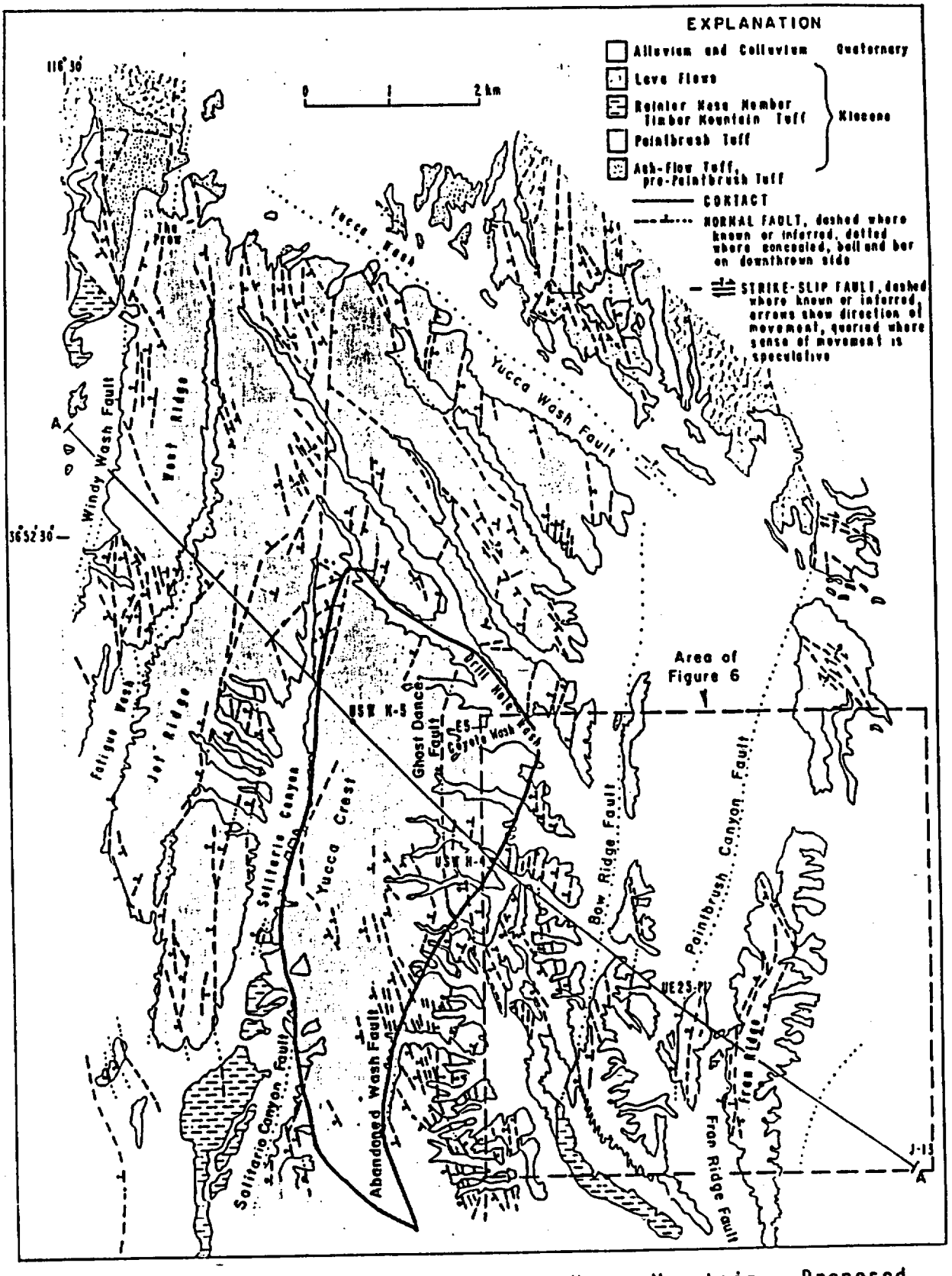
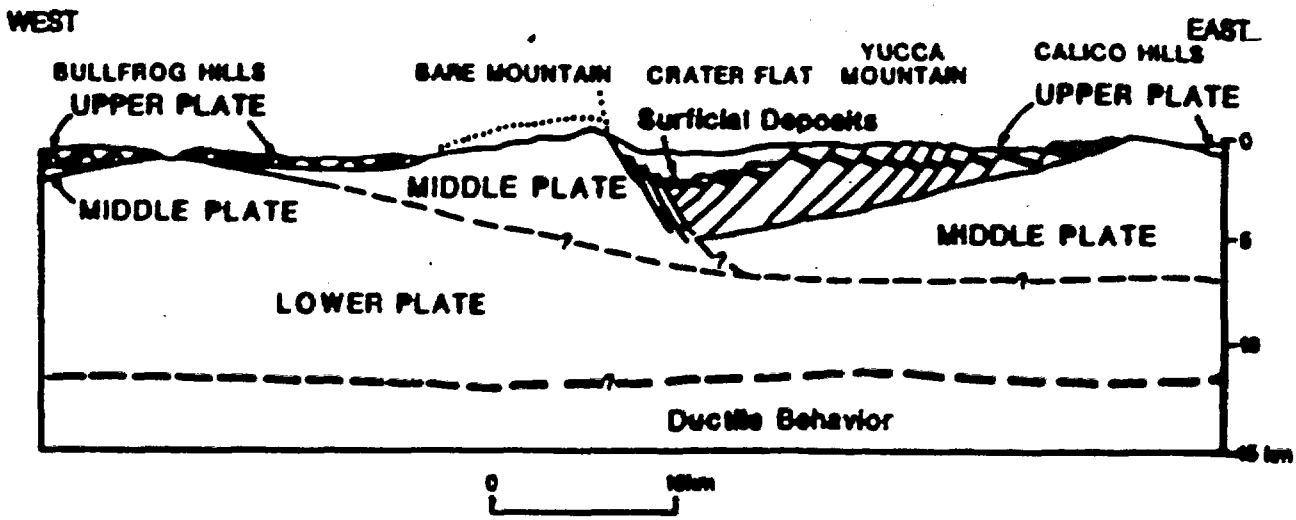
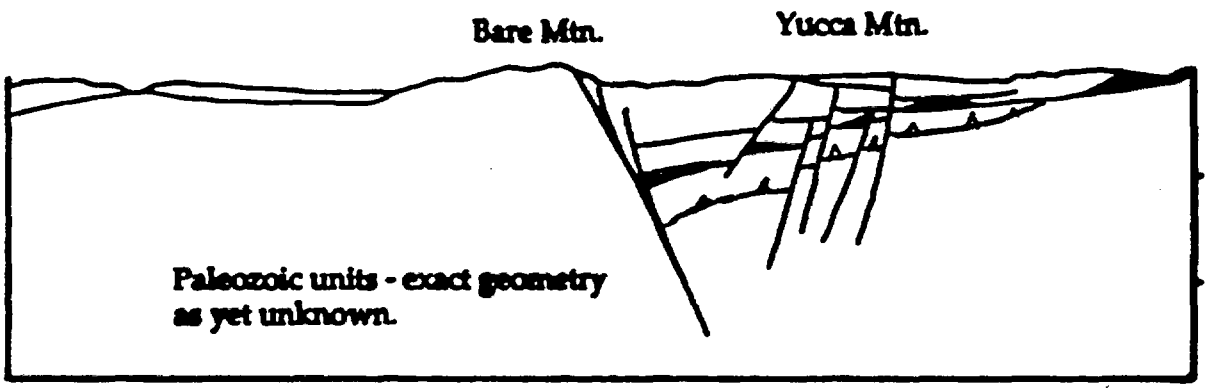


Figure 2. Generalized geologic map of Yucca Mountain. Proposed repository outlined by heavy line. Area of map corresponds to diagonally ruled area on figure 1. Modified after Scott and Castellanos (1984).

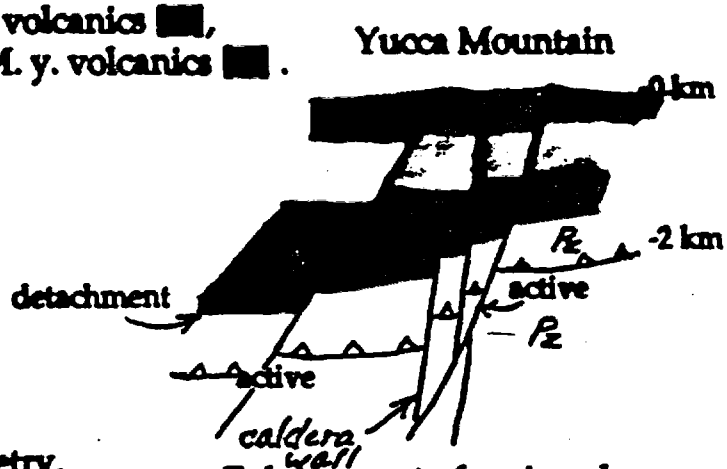
Two cross-sections of the Yucca Mountain region: top one by USGS, bottom one by Center for Neotectonic Studies, UNR.





Key to enlargement only: Pre-13.5 M.y. volcanics ▇, 13.5 - 11 M. y. volcanics, [ ], post-11.5 M. y. volcanics ▇. Sediments < 2 M. y.,

Cross-sections are schematic only.



Enlargement of region above, showing three generations of extensional faulting and displacement of volcanic units and older detachment.

<u>Significant differences between cross-sections:</u>

- we include more realistic fault geometry, and show the potential distribution of Lower Paleozoic (aquifer) units.
- we include three generations of faulting indicated by field evidence.
- we show one subhorizontal detachment, as opposed to three, for which there is good evidence.

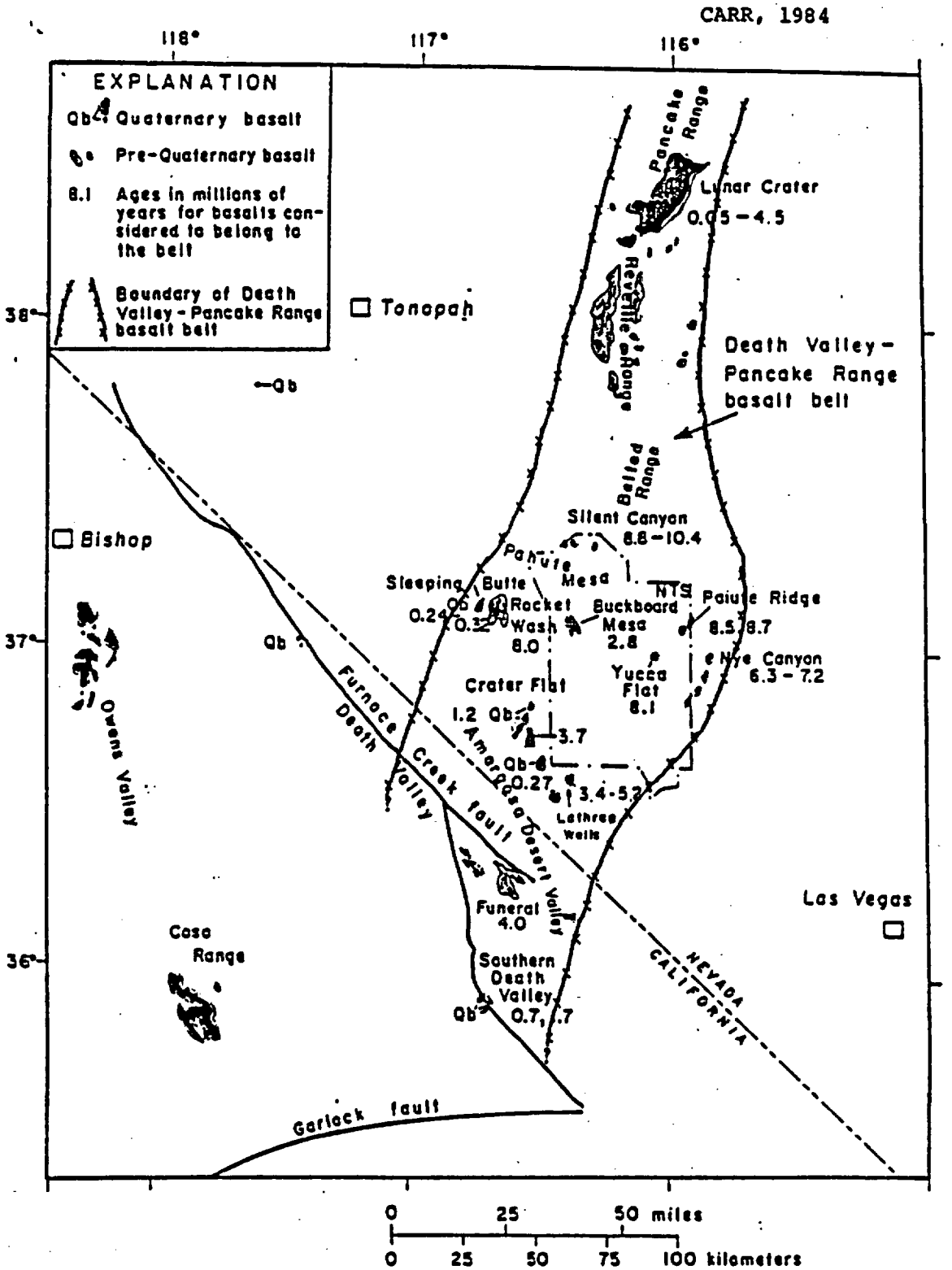


Figure 14.--Location and chronology of the Death Valley-Pancake Range basalt belt. Buried basalt just south of Lathrop Wells has reverse polarity and its age is therefore considered to be roughly that of the Gilbert magnetic epoch. Ages of the Lunar Crater and Reveille basalt fields are based on estimates from reconnaissance by W. J. Carr and two dates: (1) lower flow in Lunar Crater dated at 4.2±0.3 m.y. (R. F. Marvin, U.S. Geol. Survey, written commun., 1981), and (2) flow in the Reveille quadrangle, age reported as 5.7±0.2 m.y. (Ekren and others, 1973).

CNS YM PROJECT TASK 5: June 26, 1989

TYPES OF FAULTS AT YUCCA MOUNTAIN	Exposed/Buried
1. Mesozoic thrusts with west and east vergence -generally place lower Pz carbonates on upper Pz clastics	Buried
2. pre-Middle Miocene detachment faults -evidence exists for large extension prior to 14 Ma	Buried
3. pre-Middle Miocene strike-slip faults -evidence exists for large dextral displacement prior to 14 Ma	Buried
4. ±14 Ma cauldron subsidence faults related to Crater Flat caldera	Buried
5. exposed faults that postdate Paintbrush Tuff -large normal displacement pre-Timber Mtn Tuff -moderate normal and strike-slip displacements post-Timber Mtn Tuff	Exposed

CNS YM PROJECT TASK 5: June 26, 1989

POTENTIAL SIGNIFICANCE OF OLDER BURIED FAULTS AT YUCCA MOUNTAIN

1. Seismicity--They could be reactivated or could be intermittently active under different stress regimes

2. Hydrogeology--They could have a significant effect on groundwater flow paths and may be important to boundary conditions for groundwater models

3. Hydrocarbon potential--They could be responsible for the formation of hydrocarbon traps

4. Mineral potential--They could have formed channelways for hydrothermal fluids during various volcanotectonic events

5. Volcanic assessments--They could provide conduits for basaltic magma during volcanic events

SUMMARY

- O FAULTS AT YUCCA MOUNTAIN ARE DIFFICULT TO CHARACTERIZE

- O EXPOSED FAULTS ARE NEITHER PURE STRIKE-SLIP NOR PURE DIP-SLIP

- O SEVERAL CLASSES OF FAULTS ARE CONCEALED, AND THESE MAY CONTRIBUTE TO SEISMIC AND RESOURCE POTENTIAL

- O COMPLEXITY OF SUBSURFACE STRUCTURE MAY MAKE IT IMPOSSIBLE TO DEVELOP UNIQUE MODELS OR TO SET REALISTIC BOUNDARY CONDITIONS FOR GROUNDWATER MODELS

VITAE

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Born: [redacted]
Social Security No.: [redacted]
Degrees:

B.S. with distinction and honors, Stanford University, Stanford, California, 1967 (major: Geology).

Ph.D., Stanford University, Stanford, California, 1972 (Geology); Dissertation entitled, "Shallow-level intrusions in the eastern Sierra Nevada, California."

Positions Held:

Surveying aid, U.S., Forest Service, Stanislaus N.F., California; summer, 1964, 1965, 1966; Party chief, 1966.

Field geologist, International Minerals and Chemical Corporation, Skokie, Illinois; summer 1967.

Teaching assistant, Stanford University, 1967-70.
Acting instructor of geology, Summer Field Geology, Stanford University; Summer, 1968, 1970.

Exploration geologist, Texaco, Inc., Los Angeles, California, 1971-72.

Assistant Professor of Geology (temporary), California State College, Sonoma, Rohnert Park, California; Fall, 1972-73; courses in mineralogy and introductory geology.
Geologist, U.S. Geological Survey, Menlo Park, California; Spring, 1973.

Lecturer in Geology, California State University, San Jose, California; Spring, 1973: Course in advanced structural geology.

Visiting Assistant Professor of Geology, California State University, San Francisco, San Francisco, California; Summer, 1973: course in field geology.

Assistant Professor of Geology, Columbia University, New York, N.Y.; July, 1973 - June, 1978.

Associate Professor of Geology, Columbia University, New York, N.Y.; July, 1978 - June, 1982: Courses in stratigraphy, tectonics, and field geology.

Member of Senior Staff, Lamont-Doherty Geological Observatory of Columbia University; September, 1973 - June 1982.

Adjunct Professor of Geological Sciences; Columbia University, New York, N.Y.; July 1982 - present.

Professor of Geology, University of Nevada, Reno, Nevada; July, 1982 - present: Courses in structural geology, stratigraphy, field geology.

Geologist, U.S. Geological Survey, WAE, Summer, 1984, 1985.

Fellowships and Awards

1967 Honorary International Minerals and Chemical Corporation - Louis Ware Fellow (stipend turned down to accept NSF Fellowship).

1968-71 National Science Foundation Fellow, Stanford University.

1971 Recipient of Roy Angus MacDiarmid Award of Stanford University presented by Geology Faculty.

Geological Field Experience:

Summer, 1966, and 1968; winter, 1969: Mapping of Eocene-Miocene marine and nonmarine sedimentary rocks in Transverse Ranges of California.

Summer, 1966 and 1968 (latter half): Mapping of plutonic, volcanic, and metamorphic rocks in the eastern Sierra Nevada, California.

Summer, 1967: Detailed mapping and economic evaluation of pegmatites, anorthosites, and nepheline syenites in North Carolina, Virginia, Ontario (Canada), and South Dakota.

1968-71: Detailed mapping of key areas and reconnaissance mapping of a larger region in the eastern Sierra Nevada, California; study of shallow-level plutons and metamorphosed Mesozoic pyroclastic rocks in roof pendants.

Summer, 1972: Reconnaissance mapping and measurement of stratigraphic sections in an 80 by 250 mile segment of Alaska Peninsula.

Summer, 1974, 1975: Mapping of blueschist terrane, northern Sierra Nevada.

August, 1974 and August, 1975: Field study of Dunnage melange and associated intrusive rocks, Newfoundland.

Summer, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983: Detailed mapping of Paleozoic island-arc sequence and its basement, northern Sierra Nevada; reconnaissance of Paleozoic rocks of Sierran belt; structural and tectonic study of Calaveras Complex, central Sierra Nevada, California.

December-January, 1975-1976: Structural study of metamorphosed basement rocks in the South Shetlands, Antarctica.

May, 1978, September, 1978: Reconnaissance and structural study of Schistes Lustres terrane, Corsica.

Summer, 1982, 1983, 1984, 1985, 1986, 1987, 1988: Structural study of high Sierra roof pendants, eastern Sierra Nevada, California.

Summer, 1986: Structural and neotectonic study of faults in Santa Maria basin, California

1988-1989: Tectonic study of Yucca Mountain region, southern Nevada

Field Courses Taught:

Summer 1973, 1976, 1979, 1981: Northern Sierra Nevada, California.

Summer, 1983: Snake Range, Nevada.

May 1975: Northern Scotland.

August, 1978: Swiss Alps.

Invited Lectures:

1976	Cornell University; SUNY Albany.
1978	Caltech; Cornell University; U.C. Berkeley; UCLA; Princeton University; Lamont-Doherty Geological Observatory.
1979	Franklin and Marshall College; U.C. Davis; Rice University.
1980	Skidmore College; U.C. Davis; University of South Carolina.
1981	Stanford University; University of Nevada--Reno; University of Washington; U.C. Santa Cruz; U.S. Geological Survey, Menlo Park.
1982	New Jersey Gem and Mineral Society.
1983	University of Kansas; Geological Society of Nevada.
1984	University of California, Santa Barbara; San Diego State University.
1985	Stanford University.
1986	UCLA; University of Nevada--Reno.
1987	Humboldt State University.
1988	UCLA, California Division of Mines and Geology, USC.
1989	University of Washington, University of California, Davis

Publications:

A. Published papers.

1. Refereed Journals.

Dickinson, W. R., Cowan, D.S., and **Schweickert, R.A.**, 1972, Test of new global tectonics: American Association of Petroleum Geologists Bulletin, v. 56, p. 375-384.

Schweickert, R.A., and Cowan, D.S., 1975, Early Mesozoic tectonic evolution of the western Sierra Nevada, California: Geological Society of America Bulletin, v. 86, p. 1329-1336.

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Alvarez, W., Kent, E.V., Premoli-Silva, I., **Schweickert, R.A.**, Larson, R.L., 1980, Franciscan Complex limestone deposited at 17 degrees south paleolatitude: Geological Society of America Bulletin, v. 91, p. 476-484.

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Bogen, N.L., and **Schweickert, R.A.**, 1985, Magnitude of crustal extension across the northern Basin and Range province: Constraints from paleomagnetism: Earth and Planetary Science Letters, v. 75, p. 93-100.

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Nelson, K.D., Zhu, T.F., Gibbs, A., Harris, R., Oliver, J.E., Kaufman, S., Brown, L., and **Schweickert, R.A.**, 1986, COCORP deep seismic reflection profiling in the northern Sierra Nevada mountains, California: Tectonics, v. 5, p.

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2. Invited, refereed papers in symposia.

Schweickert, R.A., Saleeby, J.B., Tobisch, O.T., and Wright, W.H., III, 1977, Paleotectonic and paleogeographic significance of the Calaveras Complex, western Sierra Nevada, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, Symposium on Pacific Coast Paleozoic Paleogeography, P. 381-394.

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Batten, R.L., and **Schweickert, R.A.**, 1981, The lost Pacifica continent: A mobilistic speculation: Discussion: Vicariance Biogeography Symposium, American Museum of Natural History, Columbia University Press, p. 359-366.

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3. Field Trip Guides.

Schweickert, R.A., and Wright, W.H., III, 1975, Structural studies of the Calaveras Formation along the Stanislaus River and their tectonic implications: Geological Society of Sacramento, Annual Field Trip Guidebook, p. 38-47.

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4. Maps.

Schweickert, R.A., Harwood, D.S., Girty, G.H., and Hanson, R.E., in press, Geologic map of the Emigrant Gap 15' quadrangle, Sierra County, California: U.S. Geological Survey Map.

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5. Other.

Noble, D.C., McKee, E.H., and **Schweickert, R.A.**, 1973, K-Ar ages on post-Lower Jurassic granodiorite form the southern Pine Nut Range, western Nevada: Isochron West, v. 3.

Contributor to: Northern California Region, Correlation of stratigraphic units of North America (COSUNA) Project, AAPG, 1984.

B. PAPERS IN PRESS.

Schweickert, R. A., and Lahren, M. M., 1989, Speculative reconstruction of a major Early Cretaceous(?) dextral fault zone in the Sierra Nevada: Implications for Paleozoic and Mesozoic orogenesis in the western United States: Geol. Soc. America Spec. Paper.

ABSTRACTS.

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Jacobi, R.D., and Schweickert, R.A., 1976, Implications of new data on stratigraphic and structural relations of Ordovician rocks on NEw World Island, north central Newfoundland: Geological Society of America Abstracts with Programs, v. 8, p. 206.
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Bond, G.C., and Schweickert, R.A., 1981, Significance of pre-Devonian melange in the Shoo Fly Complex, northern Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 13, p. 46.
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Hanson, R.E., Schweickert, R.A., and Wilson, T.J., 1981, Ignimbrite dikes in the Jurassic section of the northern Sierra Nevcada, California: Geological Society of America Abstracts with Programs, v. 13, p. 59.
Girty, G.H., and Schweickert, R.A., 1982, The lower Paleozoic Bowman Mountain

basalt, northern Sierra Nevada, stratigraphic and geochemical evidence for an intraplate eruptive setting: Geological Society of America Abstracts with Programs, v. 14, p. 166.

Hanson, R.E., and Schweickert, R.A., 1982, Stratigraphy of the upper Paleozoic arc sequence of the northern Sierra Nevada: New data and implications for submarine facies variations in island arcs: Geological Society of America Abstracts with Programs, v. 14, p. 170.

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Schweickert, R.A., and Lahren, M.M., 1988, Geologic and tectonic evolution of Saddlebag Lake pendant, eastern Sierra Nevada, California: in preparation.
Lahren, M.M., and Schweickert, R.A., in prep., Structure, metamorphism, and tectonic implications of Snow Lake pendant, Yosemite-Emigrant Wildernesses, Sierra Nevada, California.
Lahren, M.M., and Schweickert, R.A., in prep., Small scale Tertiary and possibly Holocene strike-slip faulting within the Sierra Nevada batholith, Snow

Lake pendant, central Sierra Nevada, California.

Activities Related to Professional Development.

a. Member of professional organizations:
   Geological Society of America
   American Geophysical Union
   Society of Economic Paleontologists and Mineralogists
b. Associate Editor, Geological Society of America Bulletin, 1981-88.
c. Reviewer of manuscripts for:
   Geology
   Geological Society of America Bulletin
   Tectonics
   Journal of Geophysical Research
   Nature
   Journal of Geology
d. Reviewer of research proposals to:
   National Science Foundation
   Department of Energy
   American Chemical Society-Petroleum Research Fund
e. Member of National Science Foundation Advisory Panel in Crustal Structure and Tectonics, and Petrogenesis and Mineral Resources, 1989-1991
f. Research grants received:

   NSF-EAR-89-03963
   Timing, magnitude of displacement, and implications of a major intrabatholithic crustal shear zone in eastern California and western Nevada, Schweickert, 7/1/89 - 6/30/91.
   $101,000

   STATE OF NEVADA-AGENCY FOR NUCLEAR PROJECTS
   Tectonic and neotectonic framework of the Yucca Mountain region, southern Nevada, Schweickert, 7/1/88 - 6/30/89.
   $190,000

   NSF-EAR-87-07312
   Truncation of Antler and Sonoma orogenic belts: Tectonic significance of prebatholithic structural breads, eastern Sierra Nevada, California, Schweickert, 7/15/87 - 7/15/89.
   $104,976

   NSF-EAR-84-18338
   Possible extensions of the Antler and Sonoma orogenic belts in the Saddlebag Lake pendant, eastern California, Schweickert, 11/30/84 - 12/1/86.
   $95,634

NSF-EAR-82-11624
Tectonic significance of Paleozoic basement terranes in the west-central Sierra Nevada: Continuation and transect across the central Sierra, Schweickert, 6/1/82 - 5/30/84.
$38,889

NSF-EAR-78-14779
Tectonic evolution of a late Paleozoic island arc and its basement, northern Sierra Nevada, Caliofornia, Schweickert, R.A., Snyder, W.S., Schreiber, B.C., 11/1/78 - 12/31/81.
$55,900, year 1; $54,418, year 2; $46,569, year 3

USGS 14-08-001-18376
Detailed analysis of deformation associated with the Melones fault: A deeply eroded former plate boundary--western Sierra Nevada, California, Schweickert, R.A., Engelder, J.T., 11/1/79 - 5/31/81.
$33,354

NSF-EAR-78-23567
Tectonic significance of Paleozoic basement terranes in the west-central Sierra Nevada, California, Schweickert, 2/1/79 - 4/30/81.
$46,810

NSF-EAR-79-05722
Tectonic evolution of the Havallah sequence, a late Paleozoic marginal sea, northern Nevada, Snyder, W.S., Brueckner, H.B., Schweickert, R.A., 6/1/80 - 11/30/81.
$29,800

NSF-EAR-79-11301
Rb-Sr dating of chert: A potential geochronological tool, Brueckner, H.B., Snyder, W.S., Schweickert, R.A., 6/1/80 - 11/30/81.
$29,800

USGS 14--08--001-17224
Movement and deformation on the southern part of the foothills fault system, Sierra Nevada, California, Schweickert, R.A., Engelder, J.T., Kent, D., 11/1/78 - 10/31/79.
$30,209

NSF-EAR-76-10979
The origin, deformation, and metamorphism of chaotic rocks of the Calaveras Formation, western Sierra Nevada, CAlifornia, Schweickert,

R.A., 8/15/76 - 1/31/78.
$51,100

NSF-EAR-76-84320
Mediterranean tectonic processes and history: A study of the Corsica-northern Apennine transect, Alvarez, W., Schweickert, R.A., 4/1/77 - 9/30/78.
$40,000

NSF-DES 73-06663 AO1
The original pattern and subsequent fragmentation of the Alpine orogenic belt, Alvarez, W., Schweickert, R.A., 4/1/77 - 9/30/78.

NSF-EAR-74-17854
The probable nature of the ancient Atlantic Ocean, Kay, M., Schweickert, R.A., 9/1/74 - 2/29/77.
$17,778

Other Indications of Merit:
Listed in American Men and Women in Science; Who's Who in American Science.

QUATERNARY FAULTING CONCERNS AT YUCCA MOUNTAIN

John W. Bell, Presenter
Alan R. Ramelli
Craig M. dePolo

Nevada Bureau of Mines and Geology
University of Nevada-Reno

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

MAJOR CONCERNS

- Existence of Quaternary (potentially active) faults
- Paleoseismic history
- Regional analogues
- Coupled processes
- Interpretation of future events

EXISTENCE OF QUATERNARY (POTENTIALLY ACTIVE) FAULTS

- **Multiple potentially active faults**

Surface displacements indicate moderate- to large magnitude events recurring on the same fault traces

- **Faults may be difficult to detect**

Lack of definition; small vertical offsets

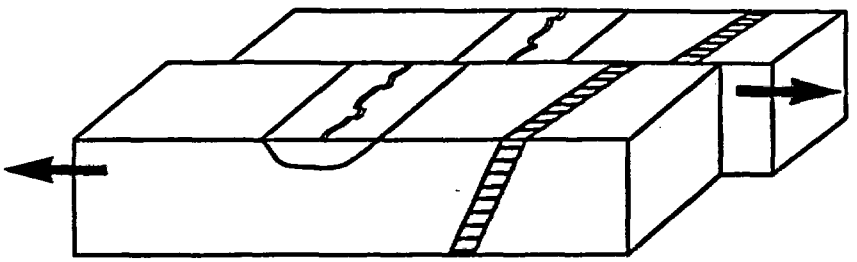
- **Unmapped faults have been identified**

Low-sun-angle aerial photography highlights subtle features

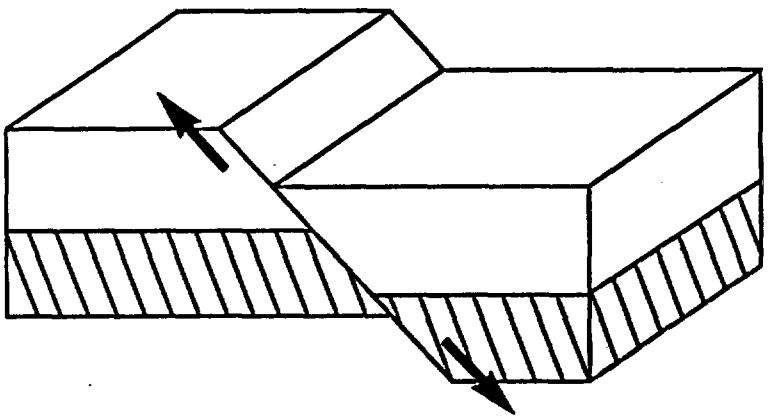
- **Other unrecognized faults likely**

Additional aerial photography and ground investigation required

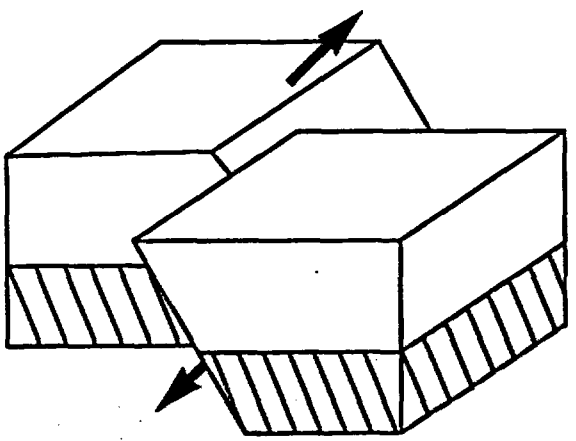
STRIKE-SLIP FAULT



NORMAL-SLIP FAULT



OBLIQUE-SLIP FAULT



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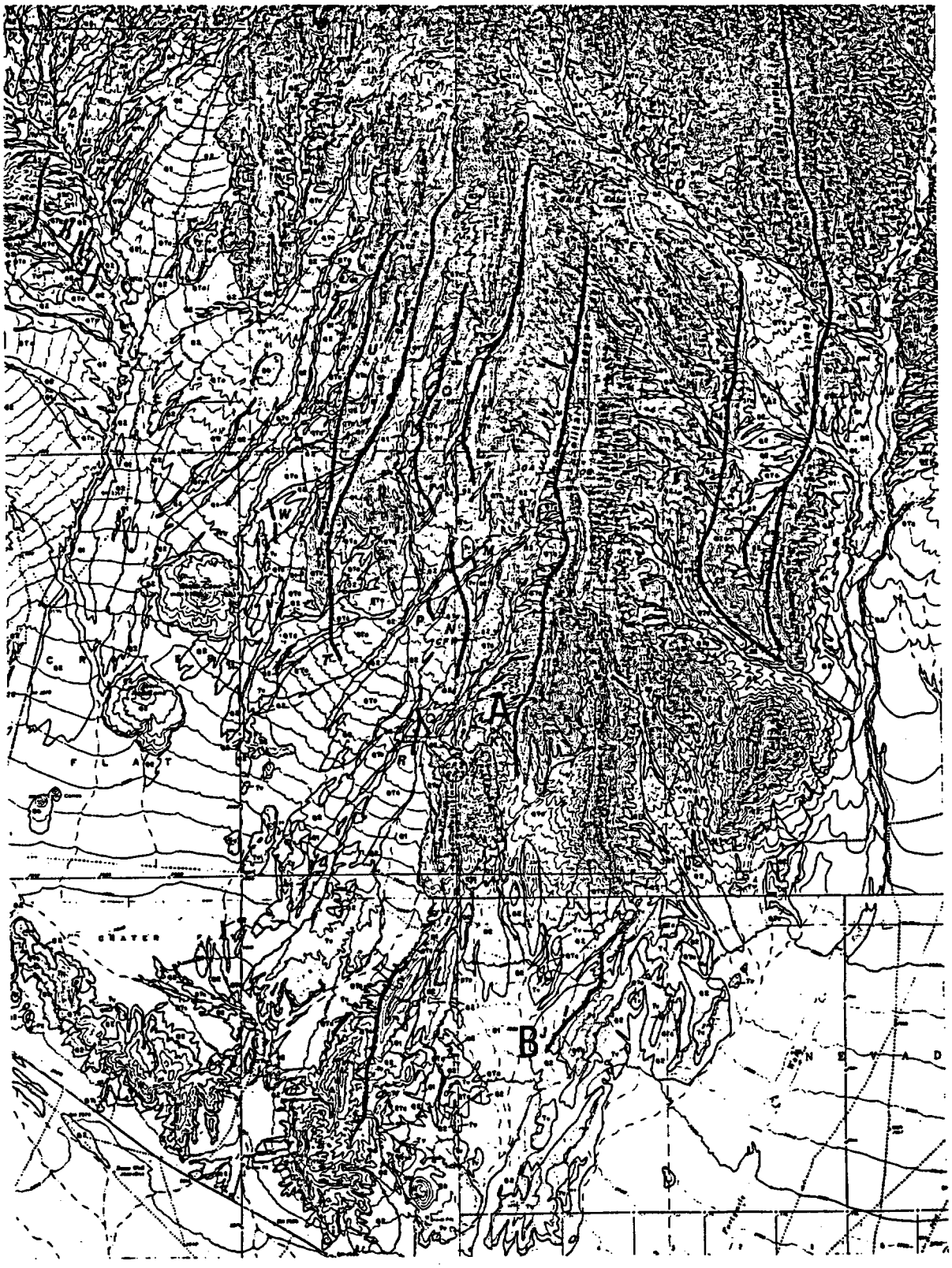
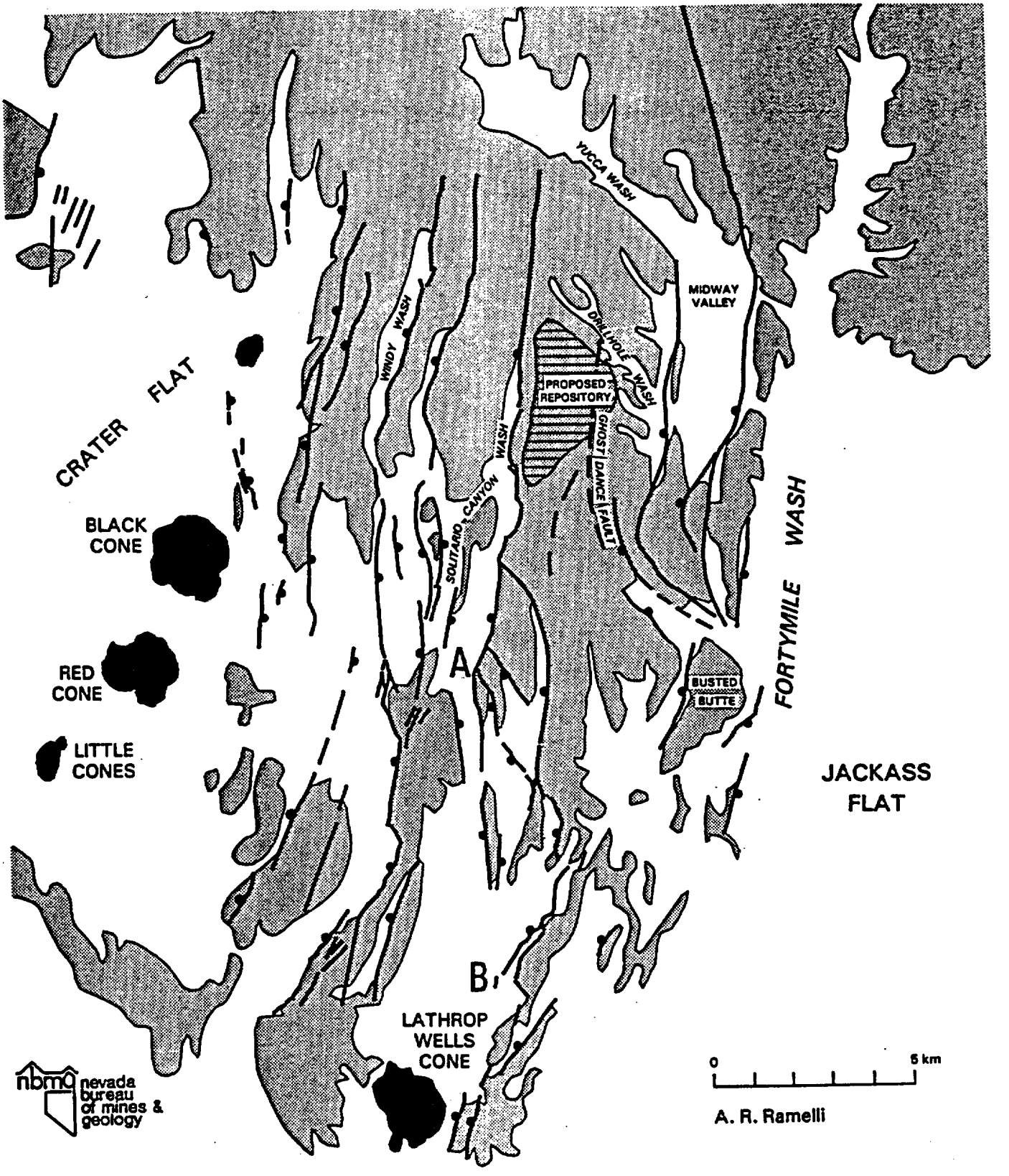
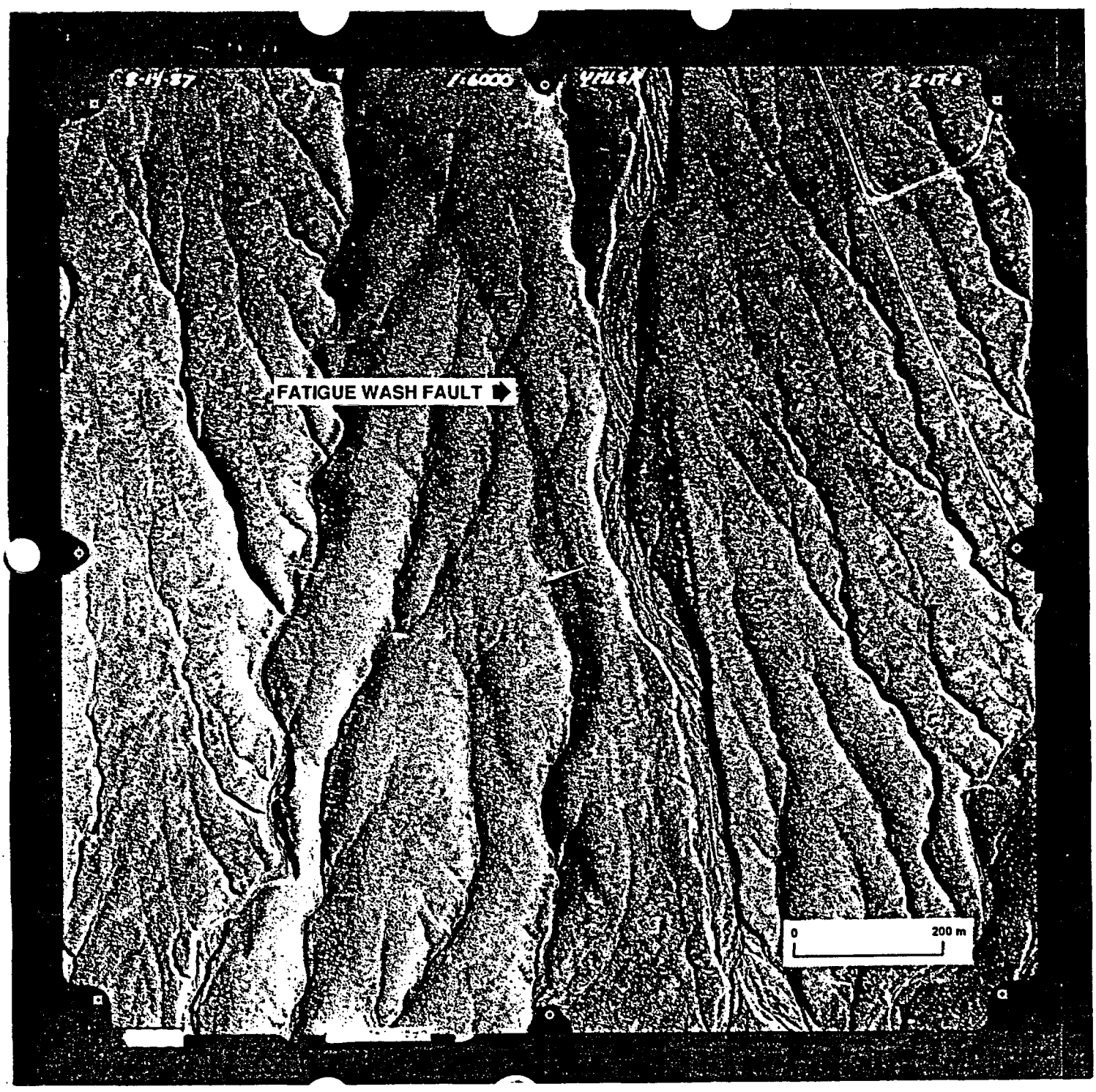
CURRENT DOE FAULT REPRESENTATION (Swadley and others, 1984)

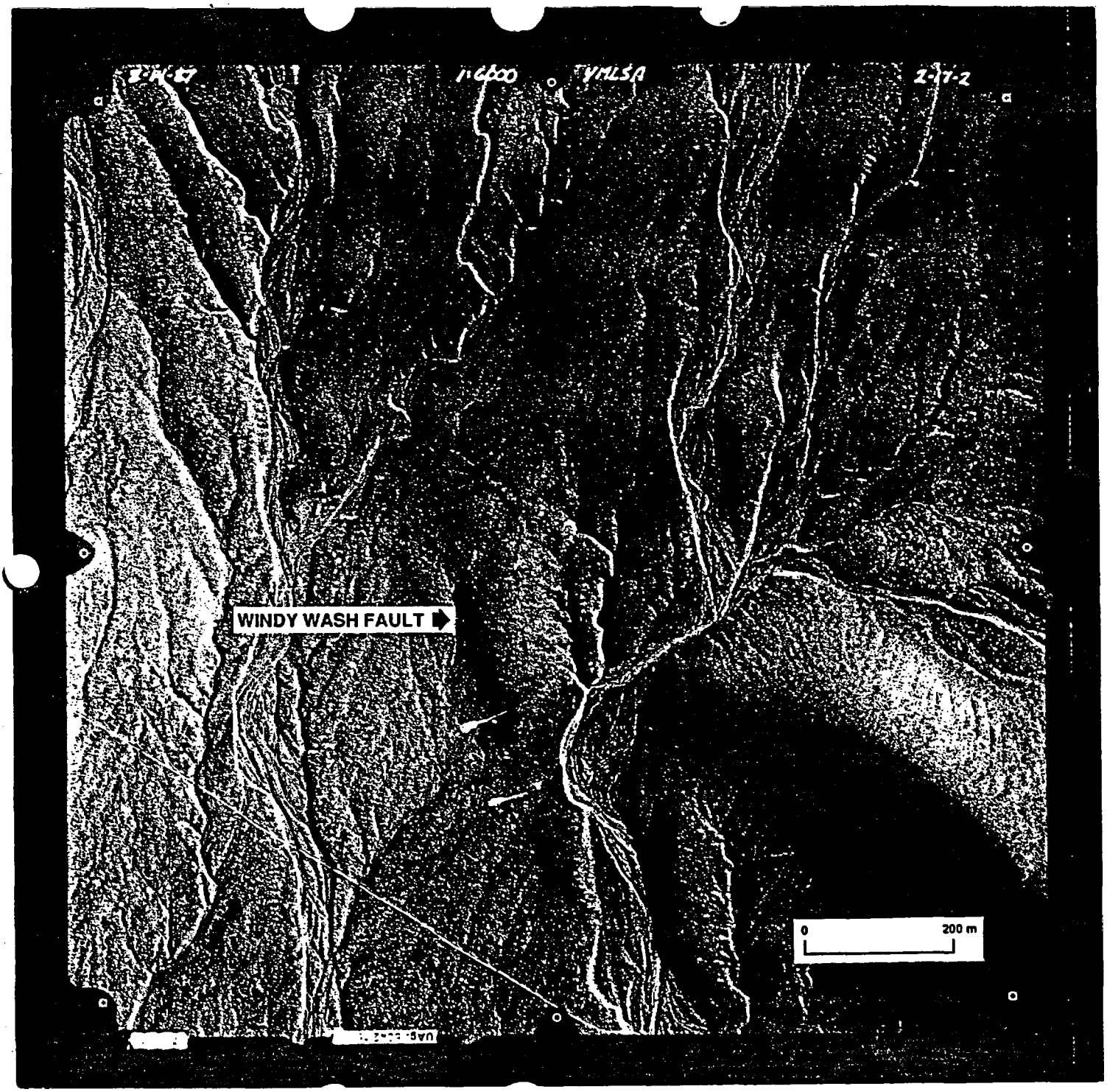


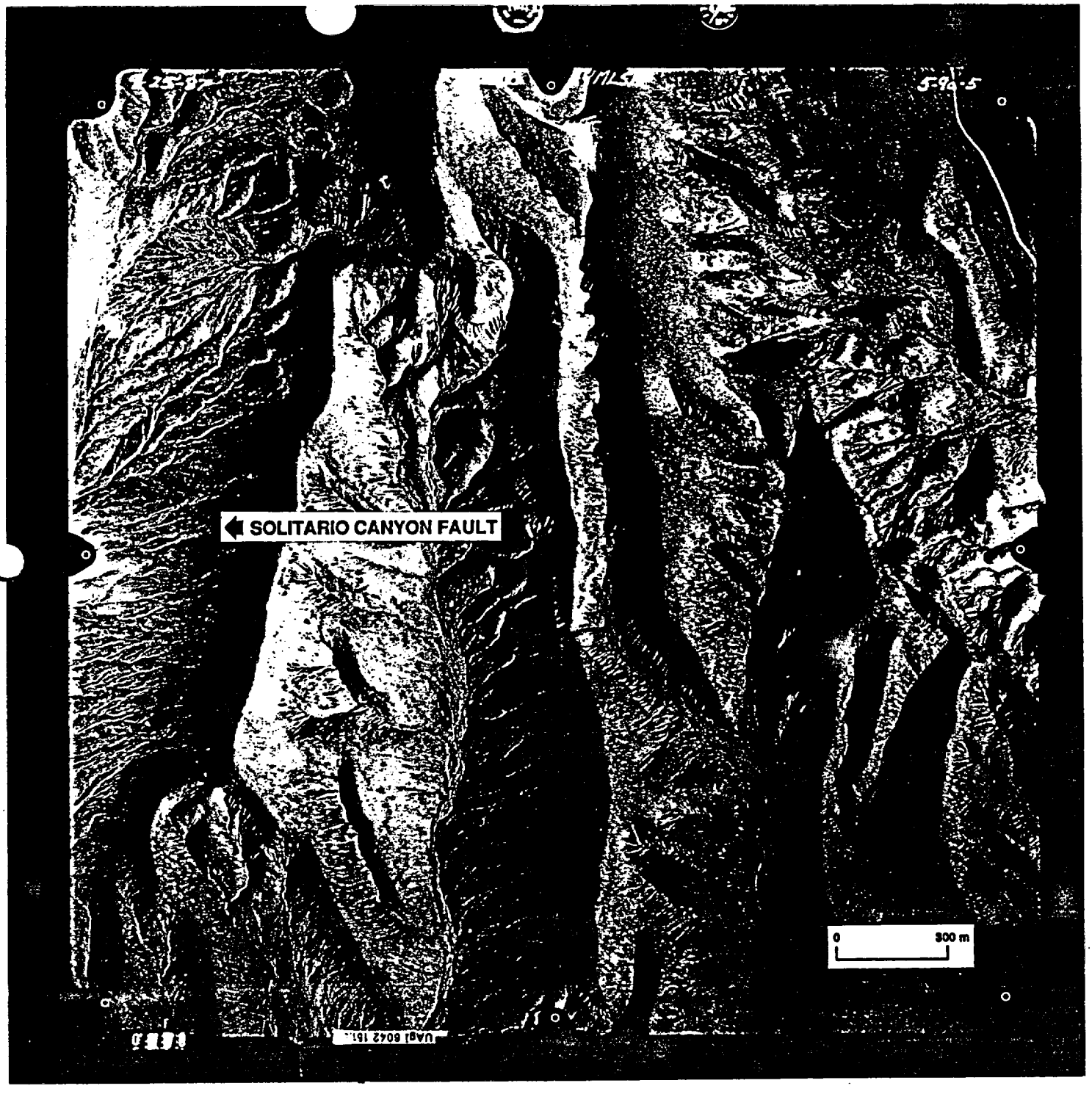
QUATERNARY FAULTS AT YUCCA MOUNTAIN

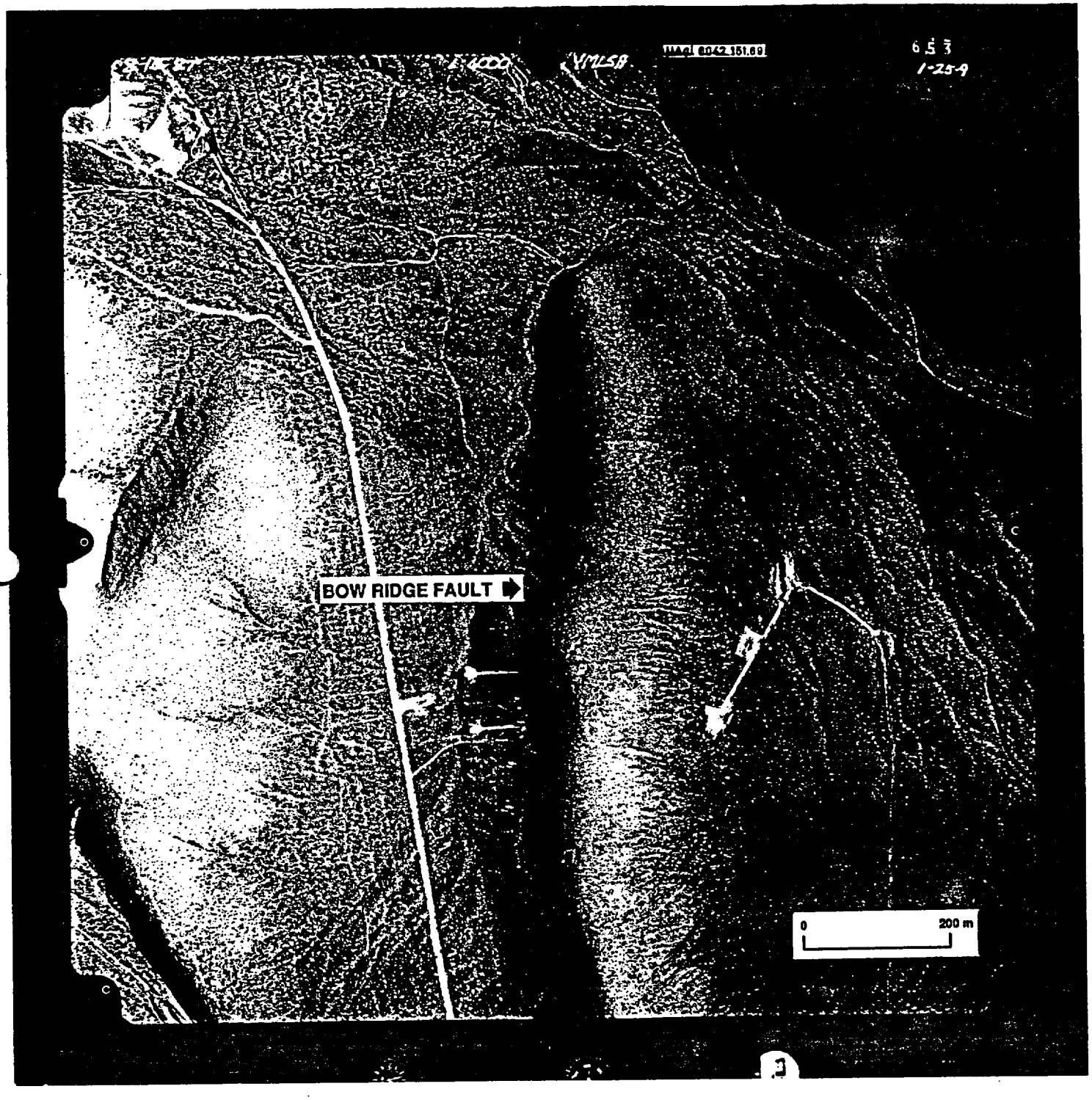


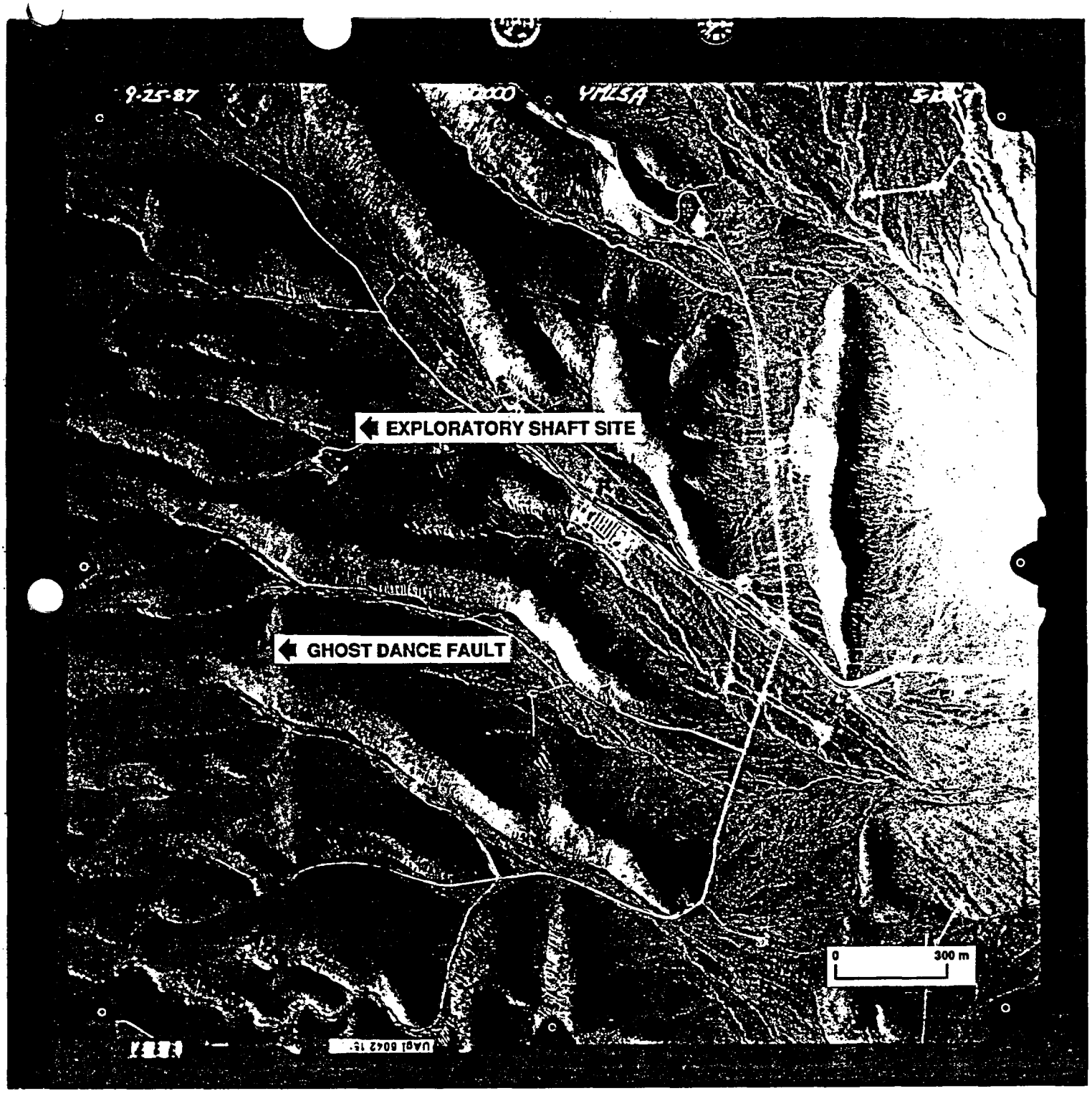

FATIGUE WASH FAULT
0
200 m

UAGI 8042 151
WINDY WASH FAULT
FATIGUE WASH FAULT
0
300 m


WINDY WASH FAULT
0
200 m


SOLITARIO CANYON FAULT
0
300 m


BOW RIDGE FAULT
0
200 m


9-25-87
YMSA
EXPLORATORY SHAFT SITE
GHOST DANCE FAULT
0
300 m

PALEOSEISMIC HISTORY

●Complex, distributive faulting
Map and field evidence suggests faults are interconnected

●Recency of faulting
Geologic evidence suggests recent activity

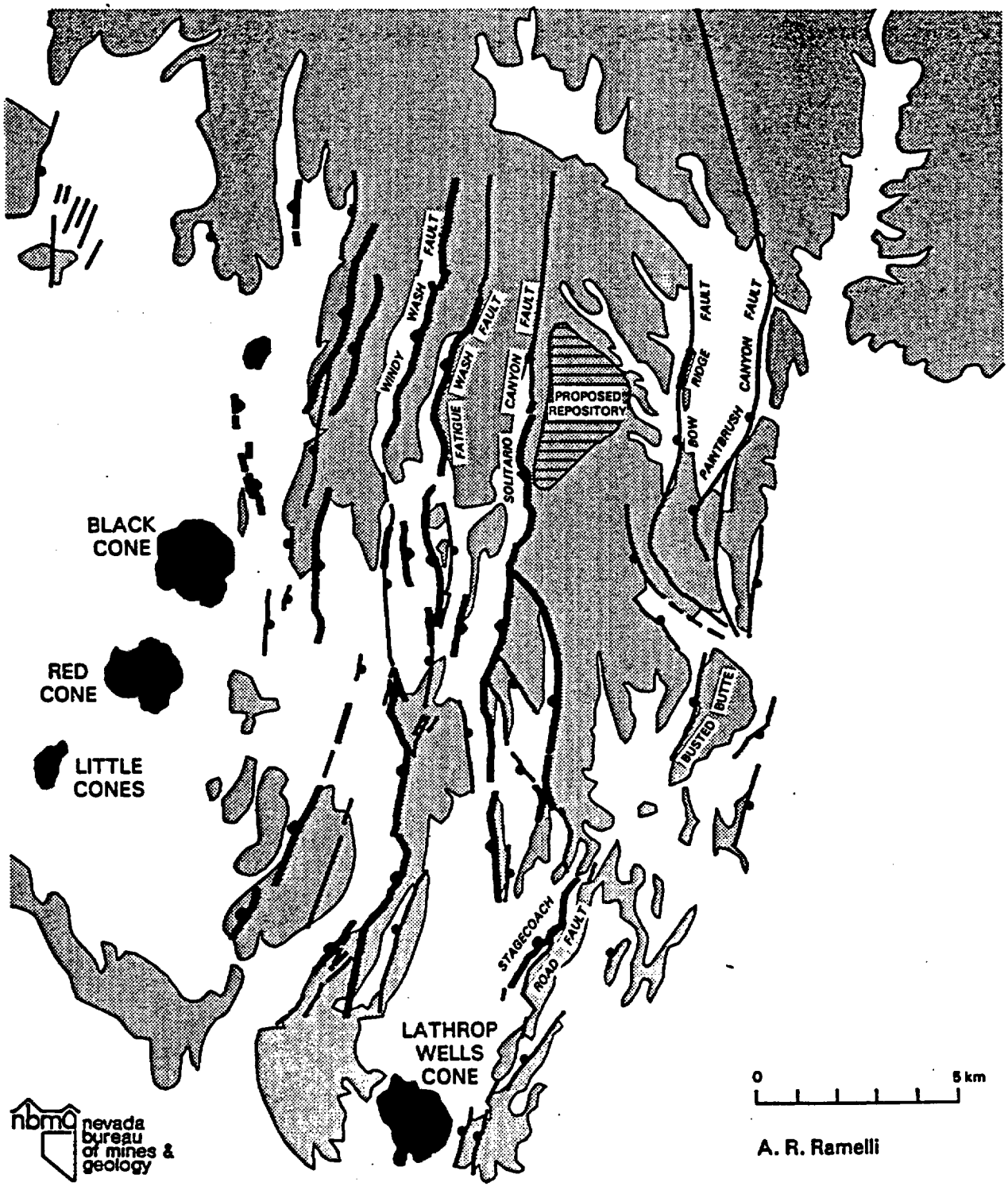
●Ages of faulted and faulted deposits
Timing of Quaternary events is poorly constrained

●Magnitudes of paleoevents
Magnitudes may be 7 or greater

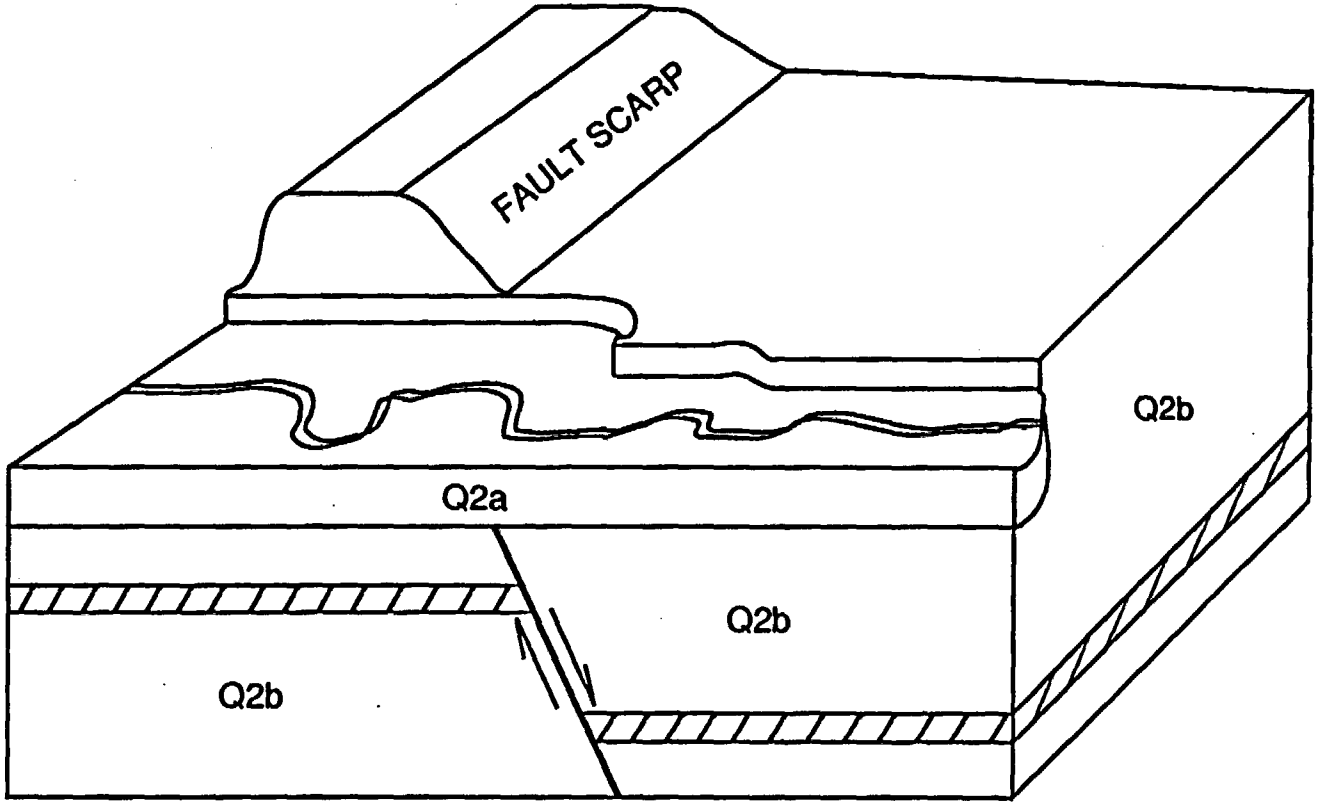
●Strike-slip displacement
Geologic and seismologic evidence suggests strike-slip component

●Synthesis of data
Reasonable conservatism should be used to define paleoseismic history

FAULTS WITH YOUNG SCARPS



FAULTED AND UNFAULTED DEPOSITS



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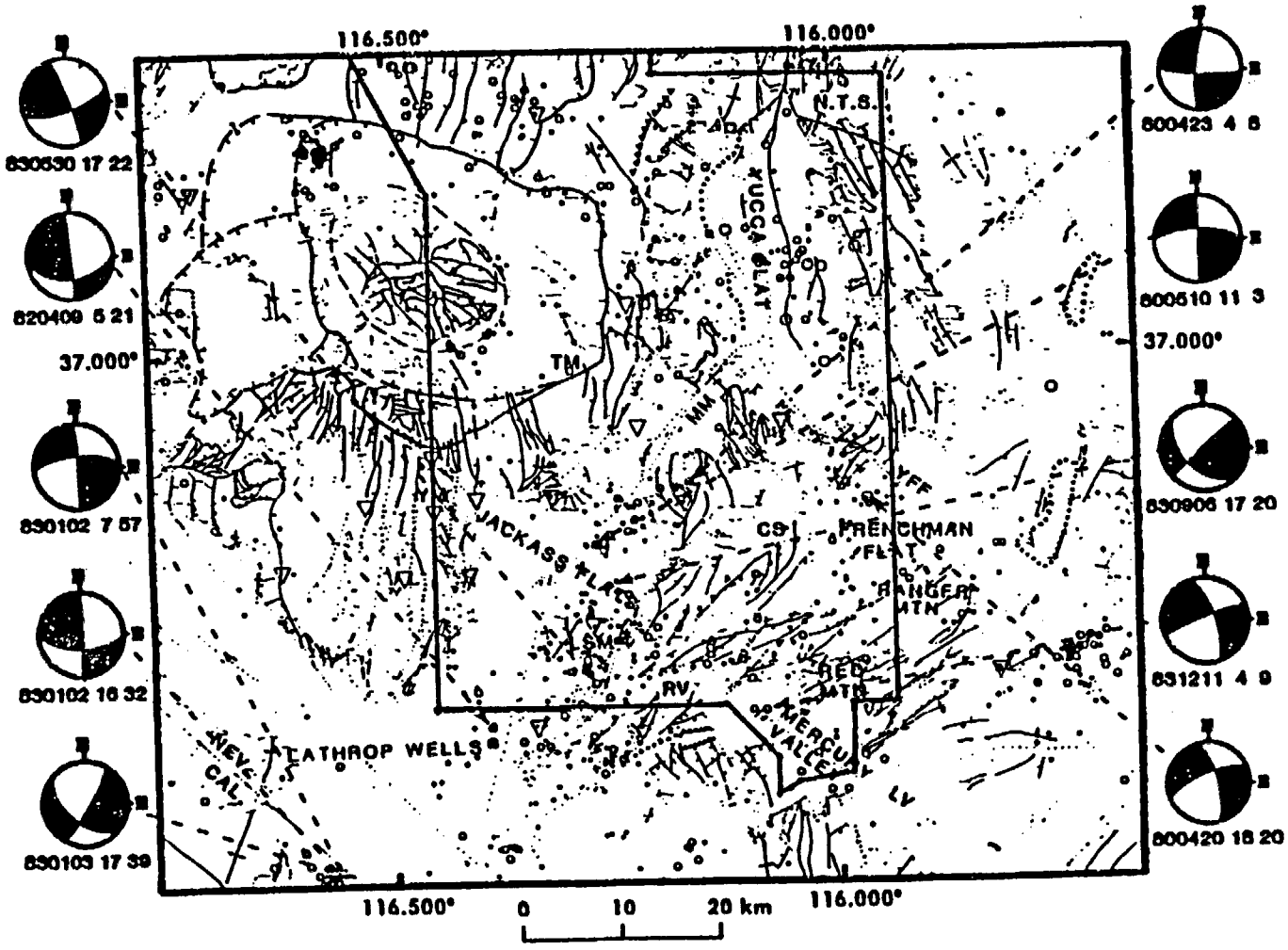
FOCAL MECHANISMS IN THE NTS REGION (Rogers and others, 1987)



REGIONAL ANALOGUES

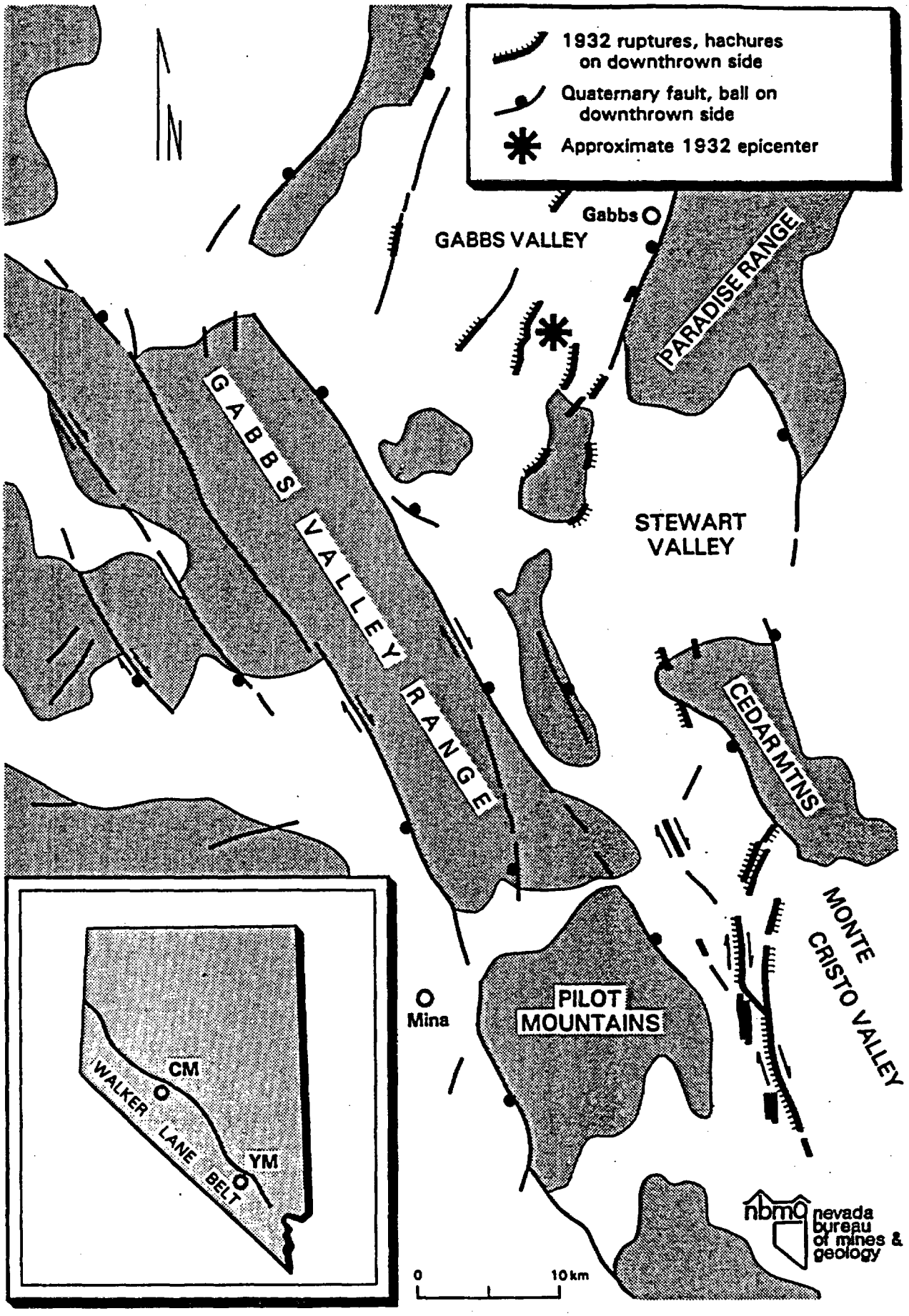
- **1932 Cedar Mountain earthquake should be used as a principal analogue**

Walker Lane tectonic setting

Predominantly strike-slip event

Distributive fault pattern with small vertical displacements

1932 CEDAR MTN. EARTHQUAKE RUPTURES



COUPLED PROCESSES

- **Volcano-tectonic events**

Volcanic ash found in four faults

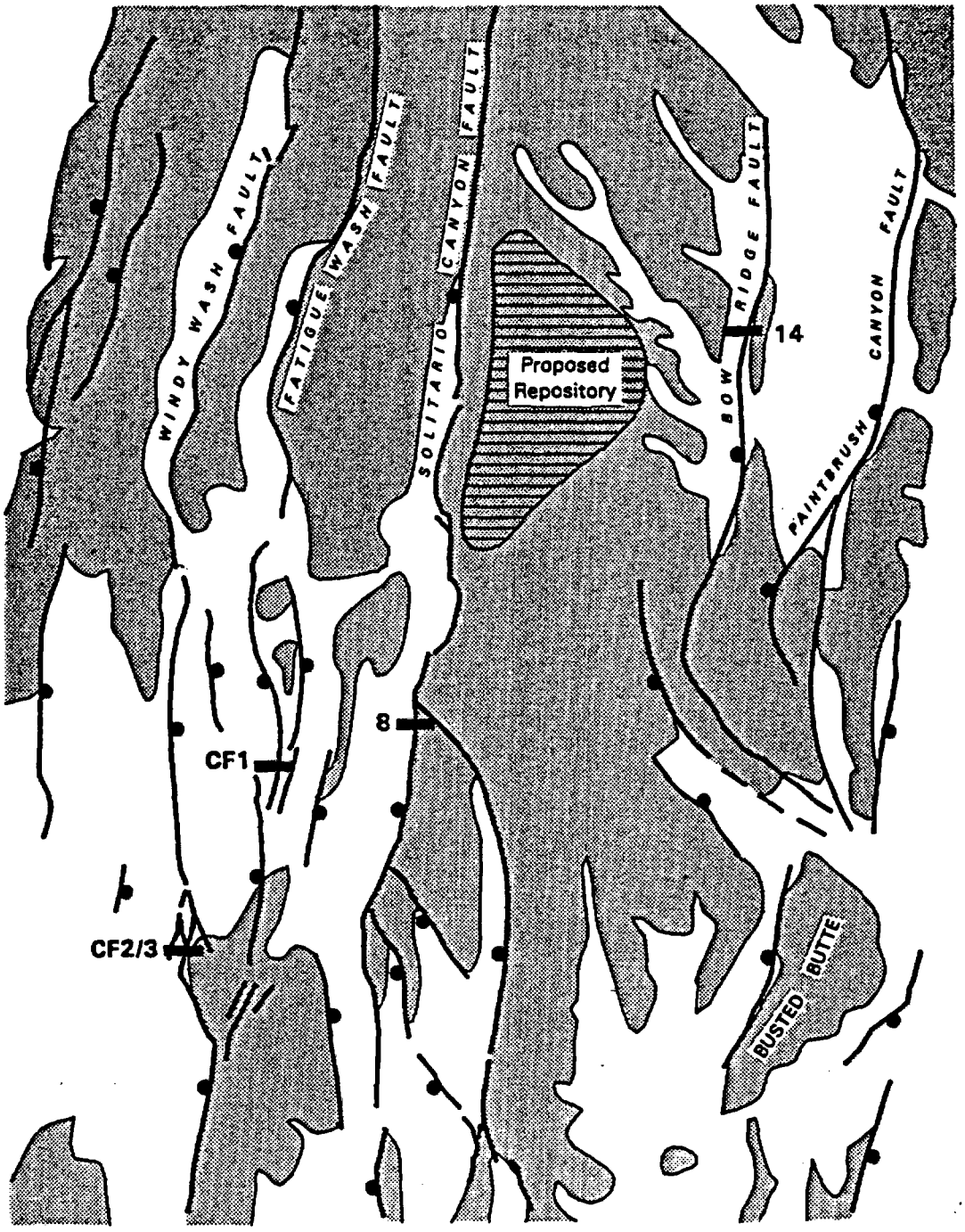
Suggestive of simultaneous volcanic and faulting events

- **Hydrologic effects**

Water level fluctuations

Extensive fracturing associated with faulting

TRENCHES EXPOSING BASALTIC ASH IN FAULTS



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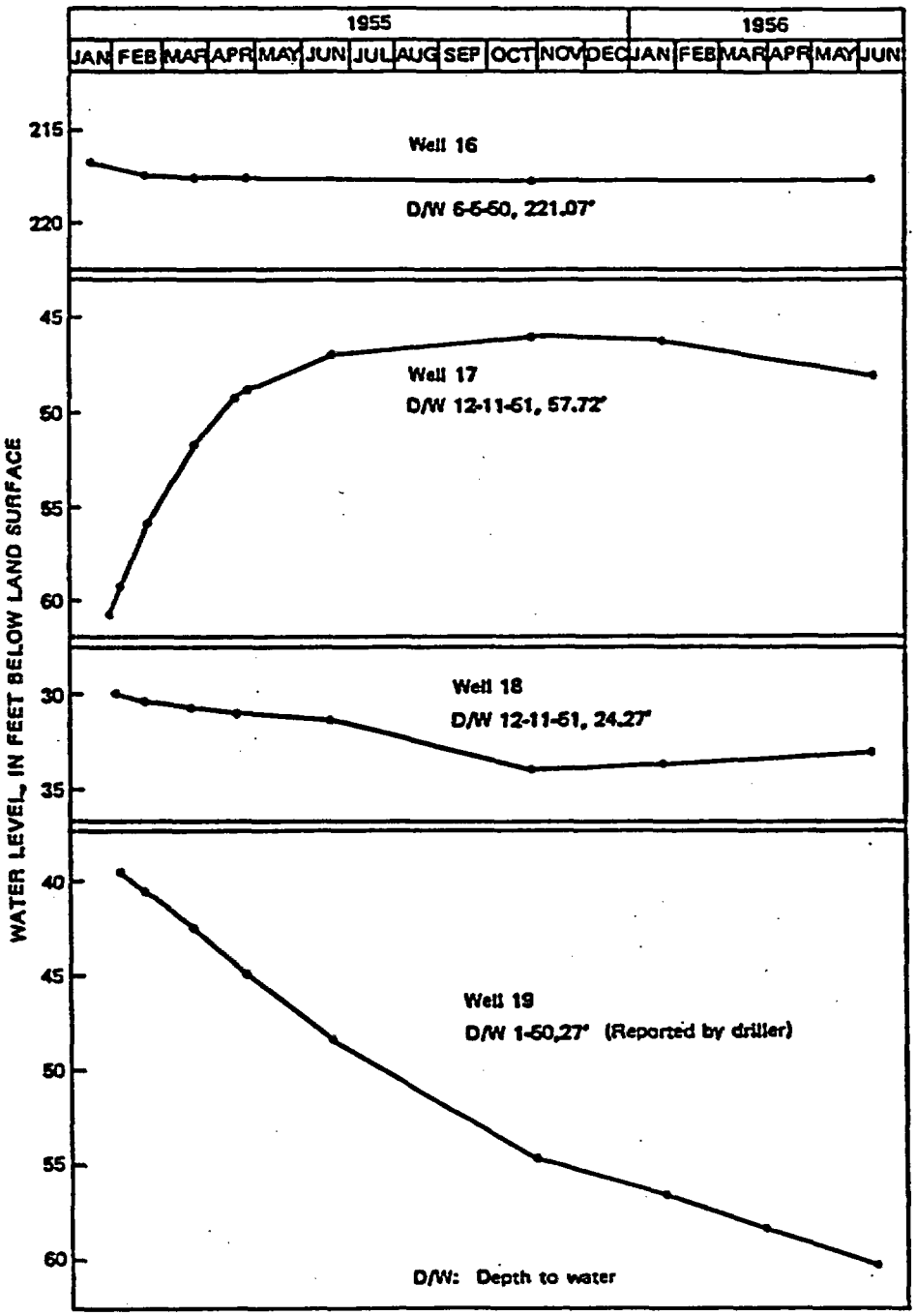
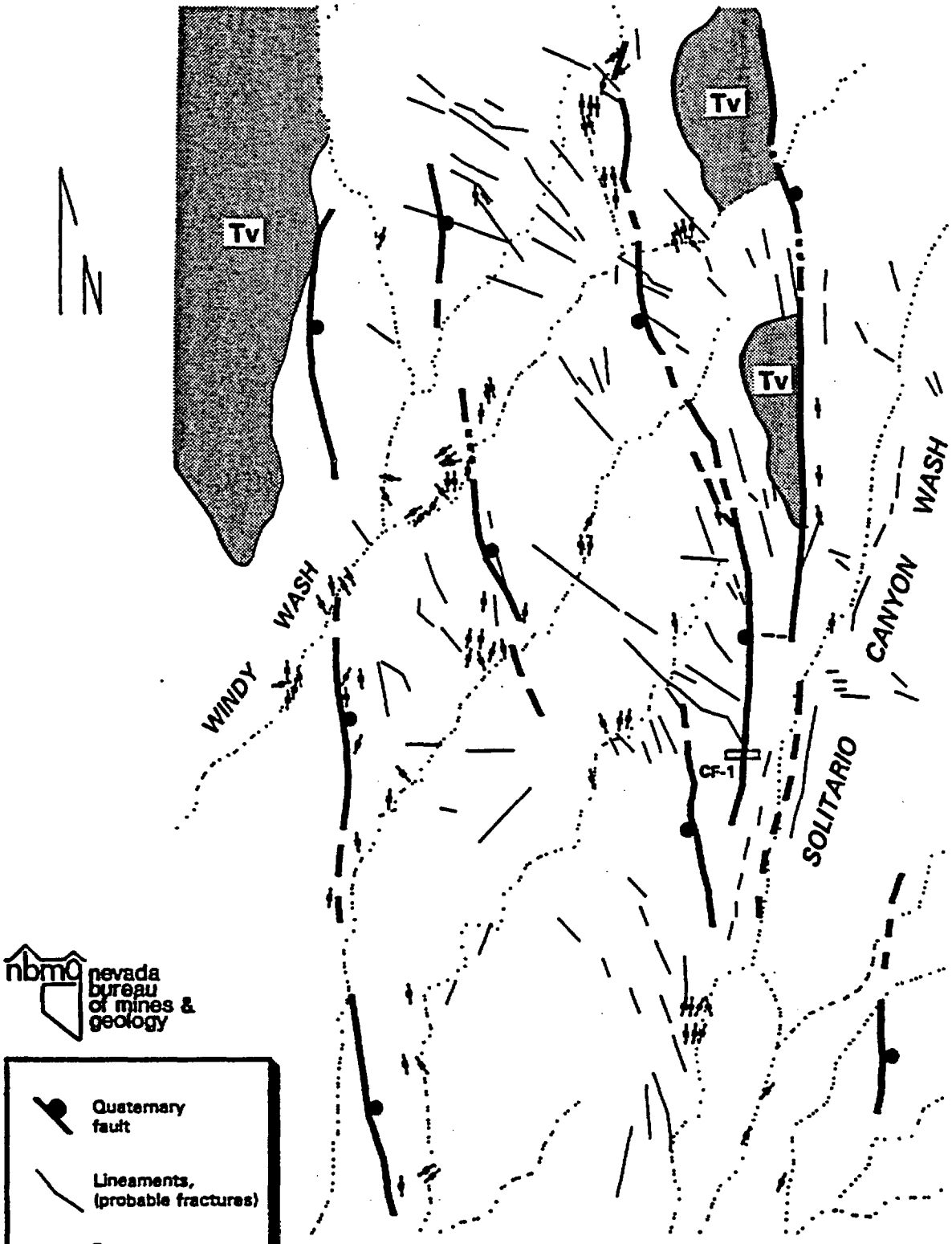
0 1 2 3 km

A. R. Ramelli

HYDROGRAPHS OF SELECTED WELLS IN FAIRVIEW VALLEY AFFECTED BY THE 1954 DIXIE VALLEY-FAIRVIEW PEAK EARTHQUAKES (Raney, 1988, for the N.R.C.)



Redrawn from Zones, 1957



QUATERNARY FAULTS AND FRACTURES IN ALLUVIUM IN THE VICINITY OF TRENCH CF-1

SUMMARY OF QUATERNARY FAULTING CONCERNS

- Distribution of Quaternary faults
- Style, age and magnitude of faulting
- Regional analogues
- Coupled processes
- Interpretation of future events

JOHN W. BELL

Professional Summary

PERSONAL

Born [redacted]

Business address: Nevada Bureau of Mines and Geology
University of Nevada-Reno
Reno, NV 89557-0088

Business telephone: (702) 784-6691
Home telephone: [redacted]
FAX: [redacted]

EDUCATION

B.A. Geology, Augustana College, 1968
M.S. Geology, Arizona State University, 1974

REGISTRATION

Registered Geologist, State of California

AREAS OF EXPERTISE

Quaternary geology; alluvial and soil stratigraphy
Neotectonics
Earthquake hazards
Engineering and urban geology

PROFESSIONAL WORK EXPERIENCE

A. Research Faculty, Nevada Bureau of Mines and Geology
Mackay School of Mines, University of Nevada-Reno
(1976-present)

Assistant Engineering Geologist (1976-1979)
Associate Engineering Geologist (1979-1988)
Engineering Geologist (1988-present)
Tenured 1981

Responsible for basic and applied research in Quaternary and surficial geology as related to engineering geology; specialized in neotectonics.

B. Geologist, Earth Resources Technology, Inc. (formerly Fugro, Inc.), Long Beach, California
(1973-1976)

Conducted Quaternary and engineering geology studies for nuclear power plant sites in Arizona and California.

C. Geologist (WAE), U.S. Geological Survey, Alaskan Geology Branch, Menlo Park, California
(1972-1974).

Conducted environmental geology research in the Fairbanks area, Alaska.

D. Consulting Geologist, Arizona Atomic Energy Commission, Phoenix, Arizona
(1972)

Conducted Quaternary geology study for proposed nuclear power/desalinization plant.

E. U.S. Army
(1969-1971)

Surveyor; included service in Vietnam.

PROFESSIONAL SOCIETIES

Geological Society of America
Association of Engineering Geologists
International Association of Engineering Geologists
Seismological Society of America

HONOR SOCIETIES

Society of Sigma Xi

PUBLICATIONS

Peer-Reviewed Reports Published by Geological Surveys

Bell, J.W., and Bonham, H.F., Jr., 1987, Geologic map, Vista quadrangle: Nevada Bureau of Mines and Geology Map 4Hg.

Bell, J.W., and Garside, L.J., 1987, Geologic map, Verdi quadrangle: Nevada Bureau of Mines and Geology Map 4Gg.

Bell, J.W., and Katzer, T.L., 1987, Surficial geology, hydrology, and late Quaternary tectonics of the IXL Canyon area, Nevada, as related to the 1954 Dixie Valley earthquake: Nevada Bureau of Mines and Geology Bulletin 102, 52 p.

Matti, J.C., Bachhuber, F.W., Morton, D.M., and Bell, J.W., 1987, Geologic map, Las Vegas NW quadrangle: Nevada Bureau of Mines and Geology Map 3Dg.

Bell, J.W., 1984, Quaternary fault map of Nevada--Reno sheet: Nevada Bureau of Mines and Geology Map 79.

Bell, J.W., 1981, Subsidence in Las Vegas Valley, Nevada: Nevada Bureau of Mines and Geology Bulletin 95, 84 p.

Bell, J.W., and Trexler, D.T., 1980, Earthquake hazards map, New Empire quadrangle: Nevada Bureau of Mines and Geology Map 1Bi.

Bell, J.W., and Smith, E.I., 1980, Geologic map, Henderson quadrangle: Nevada Bureau of Mines and Geology Map 67.

Trexler, 1980, Earthquake hazards map, South Lake Tahoe quadrangle: Nevada Bureau of Mines and Geology Map 2Ai.

Trexler, D.T., and Bell, J.W., 1980, Earthquake hazards map, Carson City quadrangle: Nevada Bureau of Mines and Geology Map 1Ai.

Bell, J.W., 1978, Geologic constraints map, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Map 3am.

Papke, K.C., and Bell, J.W., 1978, Energy and mineral resources map, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Map 3Ah.

Pewe, T.L., Bell, J.W., Williams, J.R., and Paige, R.A., 1976, Geologic map of the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map I-949.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map I-942.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 SW quadrangle, Alaska: U.S. Geological Survey Map I-829A.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map I-950.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1975, Geologic map of the Fairbanks D-2 NW quadrangle, Alaska: U.S. geological Survey Map I-907.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671B.

Pewe, T.L., and Bell, J.W., 1975, Map showing distribution of permafrost in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669B.

Pewe, T.L., and Bell, J.W., 1975, Map showing permafrost in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670B.

Pewe, T.L., and Bell, J.W., 1975, Map showing distribution of permafrost in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map 668D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map 668C.

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State of Nevada Briefing to the Nuclear Waste Technical Review Board (NWTRB)

Subject: Vadose (Unsaturated) Zone Hydrologic Concerns of the Proposed Nuclear Waste Repository, Yucca Mountain, Nevada

Date: 26 June 1989

Presenter: Dr. Martin D. Mifflin

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Vadose (Unsaturated) Zone Hydrogeology at Yucca Mountain

General Concerns

- The DOE site-selection and investigative program to date has been based on unconservative assumptions with respect to the vadose zone.
- Vadose-zone hydrology remains essentially unknown. The database released by DOE is extremely sparse, and does not establish hydrologic processes at the site.
- The vadose zone is highly fractured from the uppermost welded tuffs to the water table. This promotes rapid vertical travel times for liquid and gas phase fluids.
- Vadose-zone hydrology at the site is probably extremely complex and can not be confidently characterized in the absence of site-specific data.
- To date, the DOE has not demonstrated data collection techniques suitable for confidently characterizing the hydrology of the vadose zone at the site.
- Moisture available for recharge occurs at the site, but it is not equally distributed in time or space. Confident recharge estimates can not be established at the Yucca Mountain site with the existing database and available methods.

SPECIFIC FIELD DATA COLLECTION CONCERNS

- Normal drilling and coring techniques introduce water-based drilling fluids which mask vadose-zone saturation and fracture flow.
- The DOE program has not demonstrated to date drilling methods capable of establishing reliable hydrologic process data throughout the entire vadose zone.
- There is no database or demonstrated methods that allows for confident estimation of the recharge rate on a Yucca Mountain site-specific basis.
- There has been essentially no release of water chemistry or isotopic data from either rock-matrix water or free water in the vadose zone that has been encountered in the drilling programs.
- There are some indications that former drilling and pump-testing programs have significantly disturbed the natural vadose system by adding large amounts of water or water-based drilling fluid to the vadose zone.

Database with Respect to Fracture Flow

- Core data indicates each stratigraphic unit is highly fractured in the vadose zone.
- There is evidence of active soil-gas circulation within the vadose zone at Yucca Mountain. Blowing wells on a seasonal basis indicate high degrees of fracture network continuity with large volumes of fracture porosity at depth and very rapid transport times of soil air.
- Hydraulic conductivity data from core indicate variable but very small hydraulic conductivities for the rock matrix of welded volcanic tuffs, and much larger hydraulic conductivities for the bedded tuffs.
- Moisture content of core samples suggests fracture flow.
- Saturation encountered in drilling suggests perched water and fracture flow.

Database with Respect to Recharge

- The climate is characterized by infrequent short term precipitation events, some of high intensities. These events concentrate moisture in time and space for recharge.
- Methods for establishing confident site specific recharge estimates at Yucca Mountain have not been developed.
- There is evidence that important recharge takes place along the ephemeral drainages and occurs by fracture flow.

Properties of Hydrogeologic Units Within the Unsaturated Zone*

Yucca Mountain, Nevada

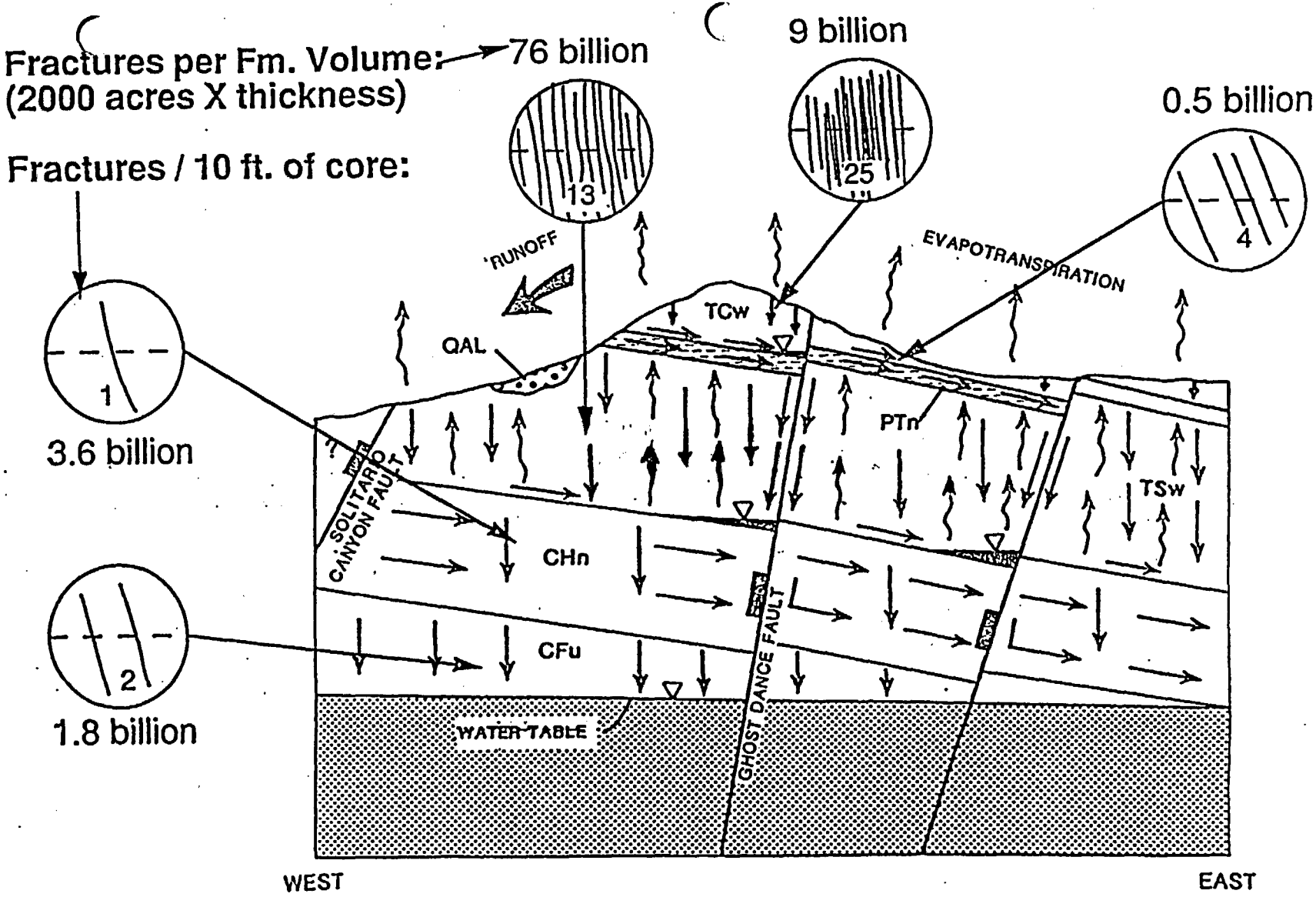
Hydrogeologic Unit	Thickness Range, m	Porosity	Saturated Hydraulic Conductivity mm/yr	Saturation (percent)
Tiva Canyon welded	0 - 150	0.12	0.73	67
Paintbrush nonwelded	20 - 100	0.46	3285	61
Topopah Spring welded	290 - 360	0.14	1.10	65
Calico Hills nonwelded (vitric)	100 - 400	0.37	1460	90
Calico Hills nonwelded (zeolitic)		0.31	2.92	91
Crater Flat unit (undifferentiated)	0 - 200	0.23	18.25	88

*Table 1 of P. Montazer & W.E. Wilson, 1984, USGS, WRIR84-4345.

APPARENT FLOW REGIMENS WITH ASSUMED STEADY RECHARGE RATES

Hydrogeologic Unit	Saturated Hydraulic Conductivity mm/yr.			Assumed Steady Recharge Rate mm/yr. matrix flow (M) fracture flow (F)			
				0.5	1.0	5.0	10.0
Tiva Canyon, welded	0.31 [c]	0.73 [b]	1.0 [a]	M/F	M/F	F	F
Paintbrush, nonwelded	109 [b]	3,300 [a]	12,300 [c]	M	M	M	M
Topopah Spring, welded	0.05 [c]	0.06 [b]	0.70 [a]	M/F	F	F	F
Calico Hills, nonwelded (vitric)	55 [b]	85 [c]	107 [a]	M	M	M	M
Calico Hills, nonwelded (zeolitic)	0.01 [b]	0.50 [a]	0.63 [c]	M/F	F	F	F
Crater Flat unit (Undifferentiated)	18.25 [b]	22.0 [a]	88.0 [a]	M	M	M	M

DATA SOURCES:
[a] Environmental Assessment, 1986, DOE/RW-0073.
[b] USGS, WRIR84-4345, 1984.
[c] SAND 84-1471, 1984.



QAL	ALLUVIUM
TCw	TIVA CANYON WELDED UNIT
PTn	PAINTBRUSH NONWELDED UNIT
TSw	TOPOPAH SPRING WELDED UNIT
CHn	CALICO HILLS NONWELDED UNIT
CFu	CRATER FLATS (Undifferentiated) UNIT

LIQUID-WATER FLOW

WATER-VAPOR FLOW

NORMAL FAULT

WATER TABLE

POSSIBLE PERCHED-WATER ZONE

Modified from the SCP (DOE, 12/88)

SUMMARY

- Fracture flow or perched water (local saturation) is likely to occur at any zone where the vertical water flux is greater than the saturated hydraulic conductivity of the rock matrix.
- Fracture flow indicates very rapid travel times within the vadose zone measured in months, years, or tens of years.
- The physics of vadose flow processes, involving both vapor and liquid flow in nonisothermal environments, are too complex to model in a fractured and porous rock environment. Only abundant site-specific data can establish site-specific processes.

Conclusions

- The arid climate does not ensure waste isolation.
- Vadose-zone hydrology at Yucca Mountain is highly complex, but little documented or understood.
- Fracture flow occurs and could be a common process.
- Soil-air travel time in the vadose zone is rapid to the accessible environment (land surface).
- Travel time to the underlying saturated zone could also be rapid with fracture flow.
- An abundant site specific database of appropriate parameters is necessary within the repository block.

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VITAE

MARTIN D. MIFFLIN

EDUCATION:

Ph.D., 1968, University of Nevada, in Hydrogeology.
M.S., 1963, Montana State University, in Applied Science.
B.S., 1960, University of Washington, in Geology.
Washington State University, Eastern Washington.

PROFESSIONAL EXPERIENCE:

President and Senior Hydrogeologist of Mifflin & Associates, Inc., a consulting firm which conducts hydrogeologic and geologic investigations, July, 1986 to Present.

Research Professor, Water Resources Center, Desert Research Institute, University of Nevada System. Research in ground-water problems in arid-zone hydrology. Specific areas of activity: carbonate-rock hydrology, ground-water exploration and development, exploratory-drilling techniques, vadose-zone moisture conditions, and recharge in arid terrane. During this period of time, major ground-water exploration and development programs were established for the State of Nevada (Jean Prison water supply, Valley of Fire State Park), the U.S. Air Force (Tonopah Test Range, Tolicha Peak), and Nevada Power Company (Meadow Valley Well Field development, monitoring, and modeling; carbonate-rock ground-water exploration program near Moapa). Program Director of the Yucca Mountain Candidate High-Level Nuclear Waste Repository technical support program for the State of Nevada (1983-1986), Sept., 1977 to July, 1986.

Senior Hydrogeologist, UNDP, Chile. Leave of absence from the Desert Research Institute for service in Region 4, Chile United Nations Development Program (UNDP) project. Water-resource assessment project in semi-arid region of Chile, chief resident administrative responsibility for the UNDP of the project, March, 1978 to March, 1979.

Water Resources Center Associate Director and Research Professor, Desert Research Institute, Las Vegas, Nevada. Head administrator for the Water Resources Center of the Desert Research Institute in the Las Vegas branch office. General responsibilities included research funding, direction, and execution of program of the Water Resource Center in Southern Nevada. Areas of research interest during this period included land subsidence caused by fluid withdrawals and associated earth fissures and faults in Las Vegas Valley and Mexico, deep carbonate-rock aquifers in Nevada as a potential water-supply alternative for Eastern and Southern Nevada, and waste-water treatment by natural marsh systems in Las Vegas Valley. Expert testimony on the Cross Florida Barge Canal ground-water hydrology was given to the State of Florida Bureau of Planning and Florida Cabinet in July, 1976; as well as serving on the board of review for the Water Element of the State Plan of Florida from 1976 to 1977. Periodic consulting 1975, 1976, 1977 for the Comision del Plan Nacional Hidraulico, in the area of ground-water policy and executed programs of resource evaluation and advanced training of personnel, July, 1975 to Sept., 1977.

Resident Consultor, International Bank for Reconstruction and Development (World Bank). Leave of Absence from the University of Florida in order to accept an 18-month position as World Bank Resident Consultor in ground water to the Plan Nacional Hidraulico (PNH), a newly-created planning organization within the Mexican government. Held additional position of Jefe de Aguas Subterraneas (chief in charge of ground-water planning and associated investigations within PNH). Responsibilities involved training and development of professional staff, development of procedures and policy, and direction of ground-water studies designed for both short and long-term planning of ground-water exploitation and management. PNH was a joint effort by the United Nations Development Programs (UNDP) and the Mexican Government. The effort of the UNDP was executed by the World Bank (International Bank for Reconstruction and

Development) and the procedure was to supply five resident consultors who were expert in various disciplines in water-resource planning and development. I was also appointed to a Mexican government management role, and maintained the Bank title. Subsequently, the experimental program was judged successful by the UNDP, World Bank, and the Mexican Government formalized the organization into the continuing national planning agency for water-resource development in Mexico (Comision del Plan Nacional Hidraulico, ASRH), Sept., 1973 to July, 1975.

Associate Professor Geology, University of Florida. Teaching responsibilities in the following courses: Physical Geology, Introductory Geosciences, Geomorphology, Structural Geology, Ground-Water Geology and Hydrogeology. Research was more or less limited to local problems of ground-water pollution and continued work (summers of 1970, 1972) on isostatic rebound in the Lahontan Basin of the Great Basin. Member of the University of Florida Graduate Faculty, served on graduate committees (M.S. and Ph.D.) for Geology, Environmental Engineering, Coastal Engineering, and Civil Engineering graduate students. Considerable involvement in ground-water pollution aspects of the Cross Florida Barge Canal controversy, with testimony given to Florida Legislative committees, the State of Florida Cabinet, and the U. S. Presidential Council on Environmental Quality. Principal expert witness in ground water for EDF and the Department of Interior in court proceedings (U.S. Government vs. Florida Canal Authority) in August, 1973, Sept., 1969 to July, 1975.

Research Associate, Desert Research Institute and Nevada Center for Water Resources Research. Activities primarily research in ground water and hydrogeology. Principal Investigator or co-investigator in research dealing with the following: hydrologic safety, AEC underground nuclear detonation; investigation of land subsidence in Las Vegas Valley and the development of the theory of mechanics; investigation of the hydrogeology of Las Vegas Valley for feasibility of artificial recharge; delineation of ground-water flow systems using studies of fluid potential, water chemistry, isotopes, and other methods: paleohydrologic investigations in Nevada (surface and ground water); stratigraphic studies of alluvial basins; documentation of mudlump formation and hydrologic relationships causing formation, and developing a theory for mechanics of formation; investigations of carbonate-terrain hydrology in Nevada using tritium and hydrogeochemical techniques; exploration and development of ground water in a number of arid areas for federal, state, and private agencies; investigation of techniques for delineation of ground-water flow systems. Other activities included guest and substitute lecturing in ground water, hydrogeology, and physical geology, and direction of graduate student research in the Great Basin on hydrologic problems, July, 1963 to Sept., 1969.

Graduate Research Assistant, Montana State University (the Montana State University experience consisted of 1/2-time teaching of geology laboratories and two winters of snow avalanche research), Sept., 1962 to June, 1963.

Geologist, GS-7, U.S. Geological Survey, field mapping in the Lemhi Range and Beaverhead Range, Idaho and Montana, May, 1962 to Sept., 1962.

Graduate Teaching Assistant, Montana State University, Sept., 1960 to June, 1962.

Apprentice Geologist, Pan Petroleum Corp., Field-reconnaissance mapping in Western Alaska, April, 1959 to Aug., 1959.

PROFESSIONAL AFFILIATIONS

Geological Society of America
National Water Well Association
Sigma Xi

PROFESSIONAL HONORS AND OTHER PROFESSIONAL ACTIVITIES:

DRASTIC Advisory Board Member, National Water Well Assoc., 1986-1987

Invited Speaker, 15th Annual Rocky Mountain Groundwater Conference on Today's Groundwater Issues, Phoenix, Arizona, Sept. 1986, "Total Basin Concept - Groundwater Flow Systems"

Invited Speaker, International Workshop on Regional Aquifers, Sponsored by the Institute of

Geophysics, UNAM, Mexico City, Feb., 1985, "Hydrogeology of regional systems in the Great Basin"

Co-Leader, Field trip, White River Hydrological (Karst) System, S.E. Nevada, 6th Conference on Karst Hydrogeology and Speleology (Friends of the Karst), Sept. 1979

Moderator, Water Supply Planning Session, AWRA Conference "Water Resource Management in a Changing Society," Sept., 1979, Las Vegas

Geological Society of America Meinzer Award Committee, term 1977-1980

Elected to DRI Faculty Senate, 1975-1978

Moderator, Special Session on Ground-Water Quality, Las Vegas Valley, NWWA Tech. Meeting, Las Vegas, 1976

Selected as resident international consultant in the field of ground water to the Mexican Government by the World Bank and UNDP, 1973-1975

Trustee: Florida Defenders of the Environment (1970-1977) FDE Scientific Committee Co-Chairman (1971-1974)

Appointed Chairman, Environmental Impact Committee City of Gainesville-Alachua Co. joint committee (Jan. 1973; resigned Aug., 1973)

Elected Foundation Advisory Member, Environmental Information Center, Florida Conservation Foundation, Inc., 1972

Elected member University of Florida Presidential Faculty Concerns Committee, 1971

Appointed member of University of Florida Ad Hoc Com. on Environmental Programs, 1971

Designated Program Moderator (1970 Nat. GSA Evening Discussion of Hydrology Section)

Member of the U.S. delegation to the Inter. Assoc. of Sci. Hydrol., Symposium Hydrology of Deltas, Bucharest, Rumania, 1969

Granted first sabbatical leave offered to DRI faculty, 1969

Elected to DRI Faculty Organization, 1968 to 1969

Program Chairman, Sigma Xi Luncheon Lecture Series at University of Nevada, 1965 to 1966

Co-Author of scientific paper nominated for the G.S.A. Meinzer Award, 1965

NSF Basin and Range Field Conference Co-leader, 1965

INQUA Great Basin Field Conference Co-leader, 1965

Sigma Xi (Nominated at Montana State University for M.S. thesis).

CONSULTING EXPERIENCE:

Consultant to the U.S. Nuclear Regulatory Commission on Yucca Mountain, Nevada, 1982 to 1984.

Consultant to Government of Ecuador, ground-water development for irrigation, Rio Guayas Basin, 1982 to 1983.

Consultant to USAID, University of Wisconsin, and OTDC, Government of Tunisia, on design and feasibility of potable water development for dispersed populations in Central Tunisia, Feb.-Mar., 1980.

Consultant for the organization, and participant in "Seminar on Development and Rational Management of Groundwater of the Yucatan Peninsula" sponsored by the Banco de Mexico, S.A., Dec. 3-7, 1979, Merida, Yucatan, Mexico, 1979.

Consultant to Mexico, reviewer of all ground-water studies by CPNH 1973-77, Comision del Plan Nacional Hidraulico, ASRH, July 1977. State of Florida, Div. of State Planning, Water Element of State Comprehensive Plan, Panel of Experts, review of water element, 1977.

State of Florida, Dept. of Planning: testimony to the Florida Cabinet on hydrologic impacts of Cross Florida Barge Canal, June, 1976.

Ground-water consultant to Arthur D. Little, Inc. on bi-national water-resource development project for Colombia and Venezuela. Consultant to Mexico, organization of PNH-sponsored symposium entitled "La Soreexplotacion de Agua Subterranea en Algunas Partes del Mundo," Mexico City, Dec., 1975.

Nevada and California (1969-1973): runoff/erosion studies with respect to timbering activities in the Sierra Nevada (1972, major lumber company). Florida: lake dewatering hydrogeological studies for Lake Apopka (1970, Citrus Growers). Numerous

hydrogeological studies for land developers as senior hydrologic consultant for the firms Eco Impact, Inc. and Environmental Science Engineering, Inc. (1972-73). Solid-waste disposal and site suitability for Alachua County (1972). Three landfill sites located, evaluated, and subsequently adopted by the County. Landfill monitoring, Alachua County (1972-73). OffShore Nuclear Power Plant site evaluation - aspects of tectonic history and seismic hazards (major engineering firm, 1973).

Nevada and California (1963-1969): ground-water exploration and water supply development in arid terrain for U.S. Fish and Wildlife Service, Nevada State Parks, and several development and mining firms; ground-water supply and contamination studies, U.S. Gypsum.

PUBLICATIONS AND REPORTS:

Mifflin, M. D., Johnson, C. L., and Johnson, R. J., 1989, Hydrogeologic assessment, Upper Muddy River Valley, Nevada: Mifflin & Associates, Inc., 46 p., Appendices.

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Mifflin, M. D. and M. E. Morgenstein, Eds., 1985, Technical review comments on the draft environmental assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada: WRI-DRI, 169 p.

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STATE OF NEVADA
NUCLEAR WASTE PROJECT OFFICE

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: REGIONAL WATER CONCERNS RELATED TO THE PROPOSED HIGH LEVEL NUCLEAR WASTE REPOSITORY, YUCCA MOUNTAIN, NEVADA

DATE: JUNE 26, 1989

PRESENTER: JOHN W. FORDHAM

TITLE/ORGANIZATION: PROJECT MANAGER
WATER RESOURCES CENTER
DESERT RESEARCH INSTITUTE
UNIVERSITY OF NEVADA SYSTEM
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CONCERNS

- THE RELATIONSHIP OF YUCCA MOUNTAIN TO THE REGIONAL FLOW SYSTEM
- POSSIBLE CONTAMINATION OF THE DOWN-GRADIENT FLOW SYSTEM
- IMPACTS ON FUTURE WATER SUPPLY DEVELOPMENT

REQUIRED ANALYSIS

- **DETERMINE THE PROBABLE FLUID FLOW PATHS TO THE ASSESSIBLE ENVIRONMENT**

  THIS REQUIRES A THOROUGH UNDERSTANDING OF THE SATURATED ZONE FLOW SYSTEM AT REGIONAL, SUB-REGIONAL AND SITE SCALES

- **EVALUATE CONSEQUENCES OF PRE AND POST CLOSURE SYSTEM DYNAMICS**

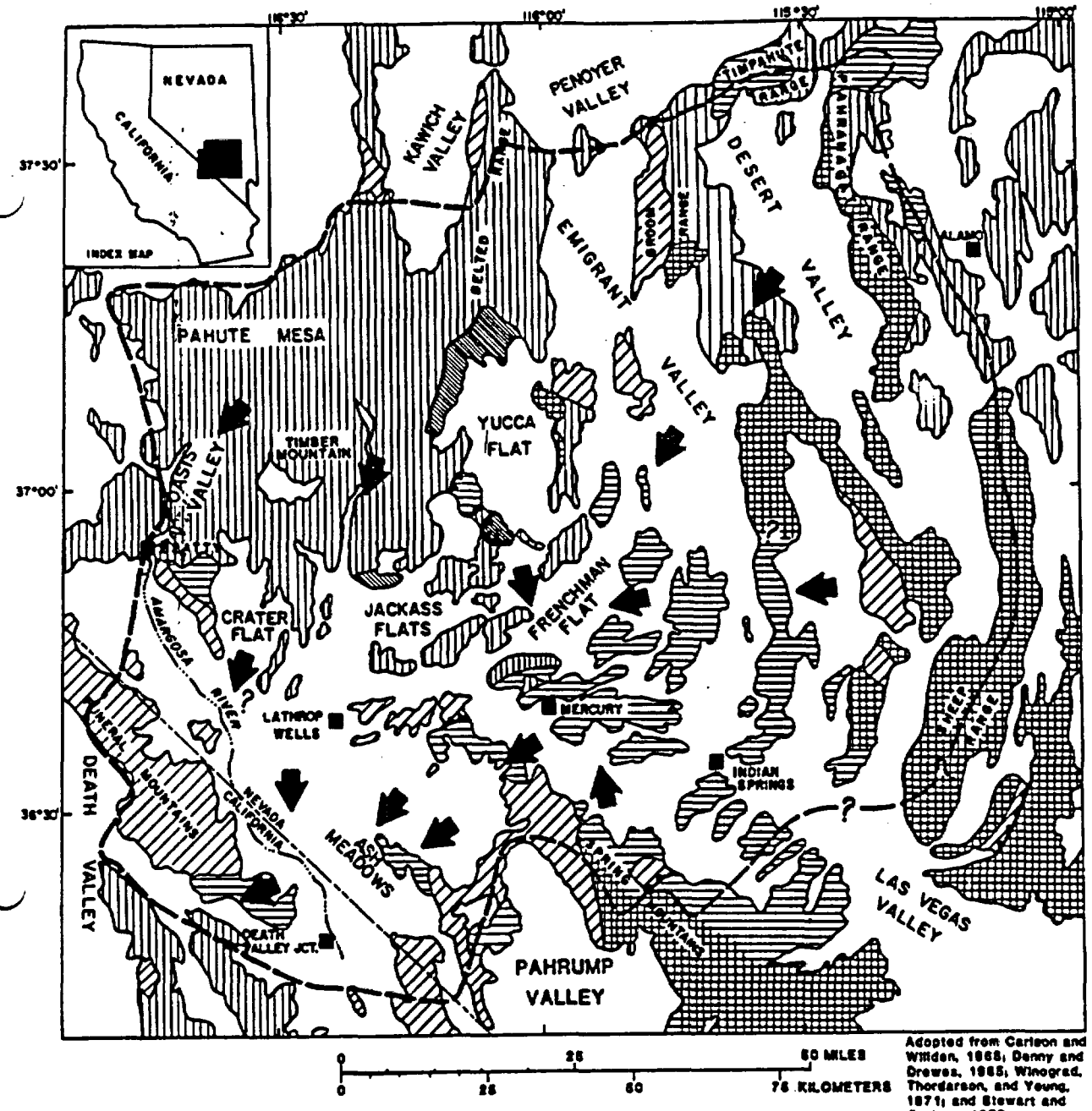
  INCREASED REGIONAL WATER USE – IRRIGATION
  MINERAL
  URBAN

  CLIMATIC CHANGE EFFECTS – WATER LEVELS
  DISCHARGE LOCATIONS

  STRUCTURAL CHANGES – FAULTING

REGIONAL FLOW SYSTEM

- CURRENT UNDERSTANDING ORIGINALLY BASED ON WORK BY WINOGRAD AND THORDARSON (1975)
- UPDATED, REVISED, AND MODELED BY WADDELL (1982)
- FURTHER REFINED BY CZARNECKI AND WADDELL (1984) (SUB–REGIONAL)
- ADDITIONAL WORK BY DRI AND USGS RELATED TO THE REGIONAL CARBONATE AQUIFER



Adopted from Carlson and Winden, 1968; Denny and Drewes, 1965; Winograd, Thordarson, and Young, 1971; and Stewart and Carlson, 1978.

EXPLANATION

QUATERNARY

Alluvium, lake beds, and minor volcanic rocks

TERTIARY

Tuff, rhyolite, and associated volcanic rocks

MESOZOIC (Minor--not shown)

PALEOZOIC

Undifferentiated upper clastic aquitard, and lower and upper carbonate aquifers

Upper clastic aquitard

Lower carbonate aquifer

PALEOZOIC (CAMBRIAN)-PRECAMBRIAN

Lower clastic aquitard

SYMBOLS

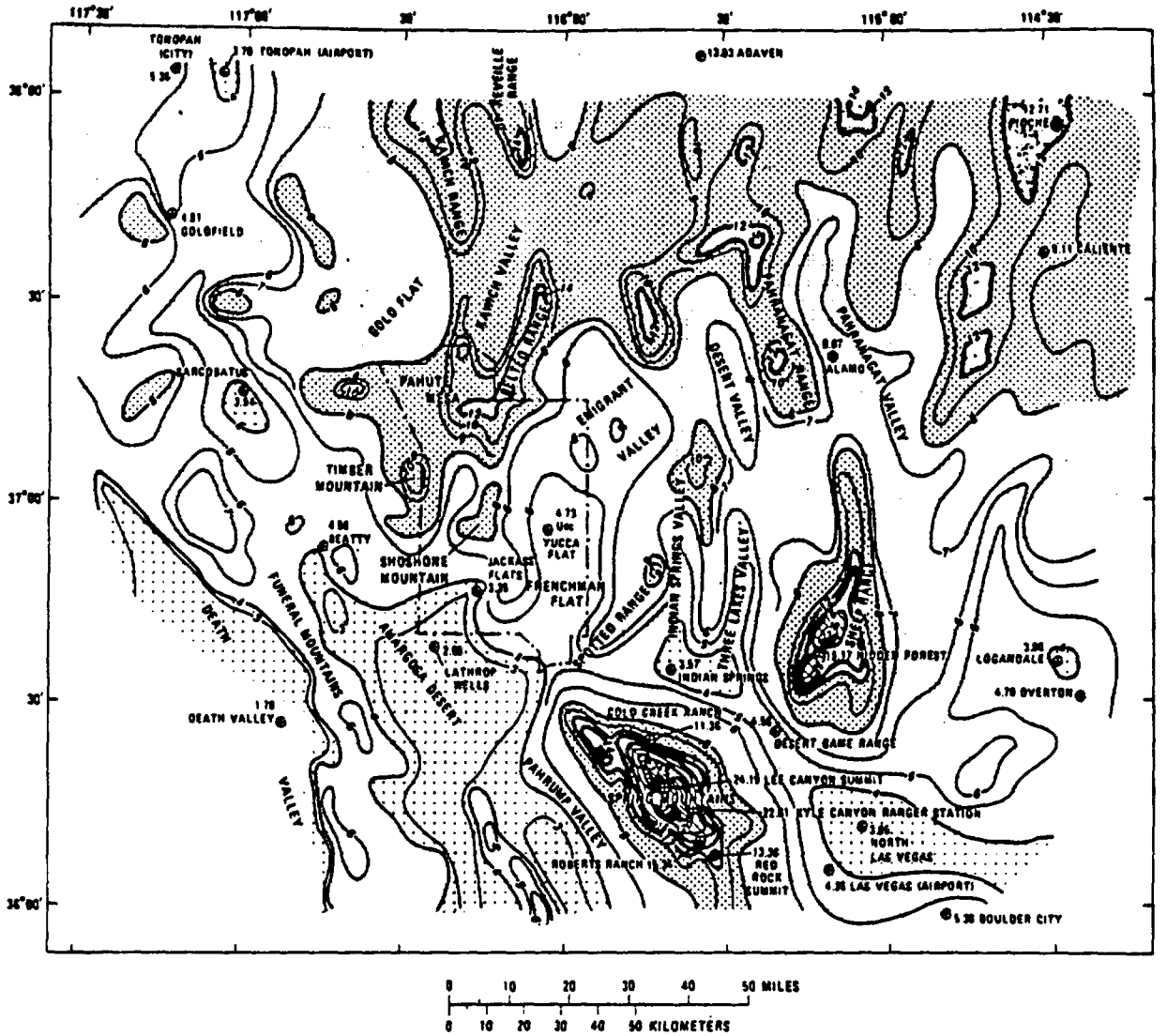
Contact

Thrust fault

Approximate boundary of ground-water system

Approximate direction of ground-water flow

Generalized geology.



EXPLANATION

RANGE OF ANNUAL PRECIPITATION, IN INCHES

Less than 4 | 4-8 | 8-12 | 12-16 | 16-20 | 20-24 | 24-28 | Greater than 28

CONTOUR SHOWING MEAN ANNUAL PRECIPITATION Contour interval, in inches, is variable

ADAVER SITE AND NAME OF WEATHER STATION Number is mean annual precipitation, in inches, adjusted to 30 year period, 1931-60

NEVADA TEST SITE BOUNDARY

Mean annual precipitation

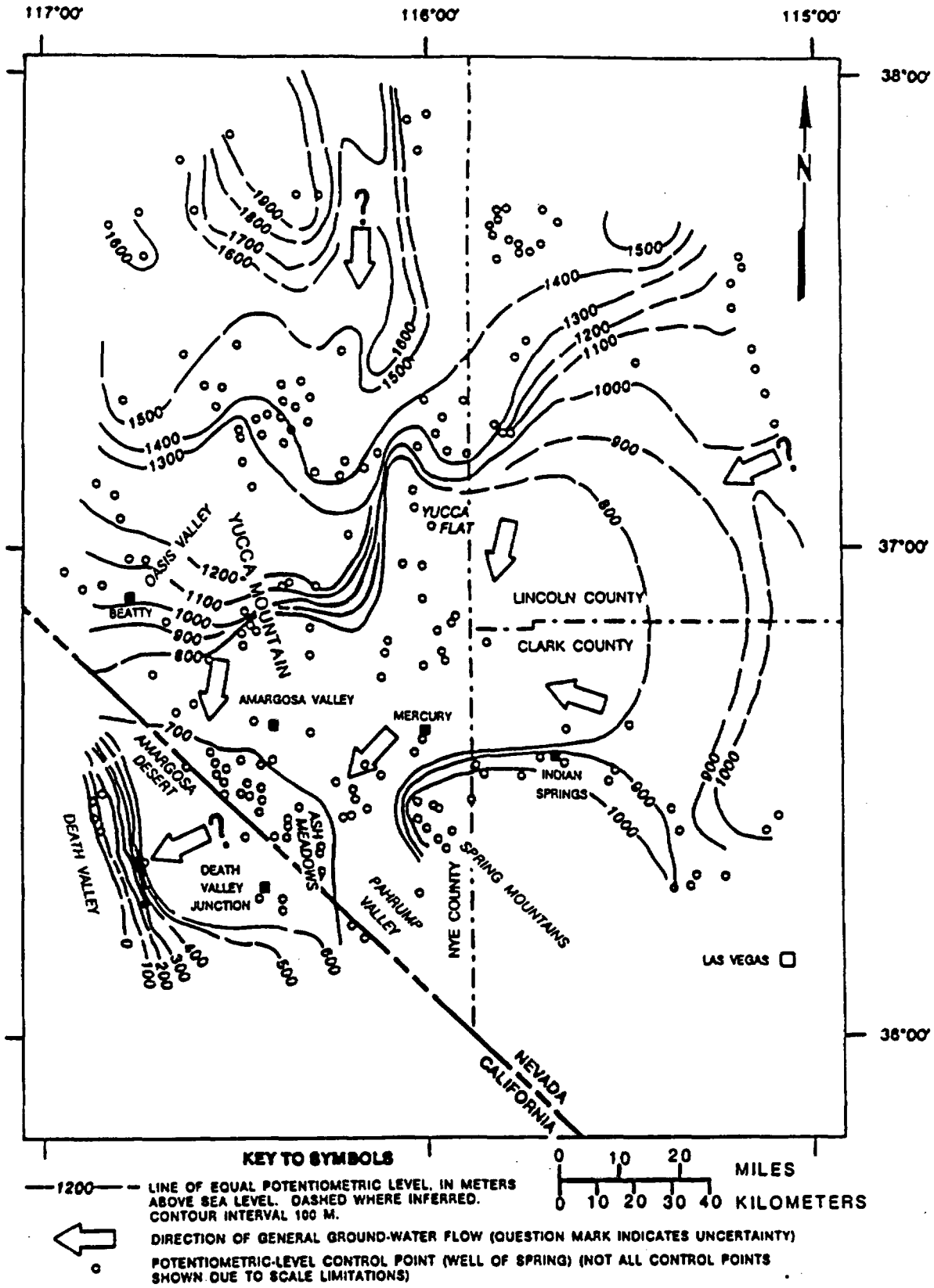


Figure 3-10. Regional ground-water flow paths. Modified from Waddell et al. (1984).

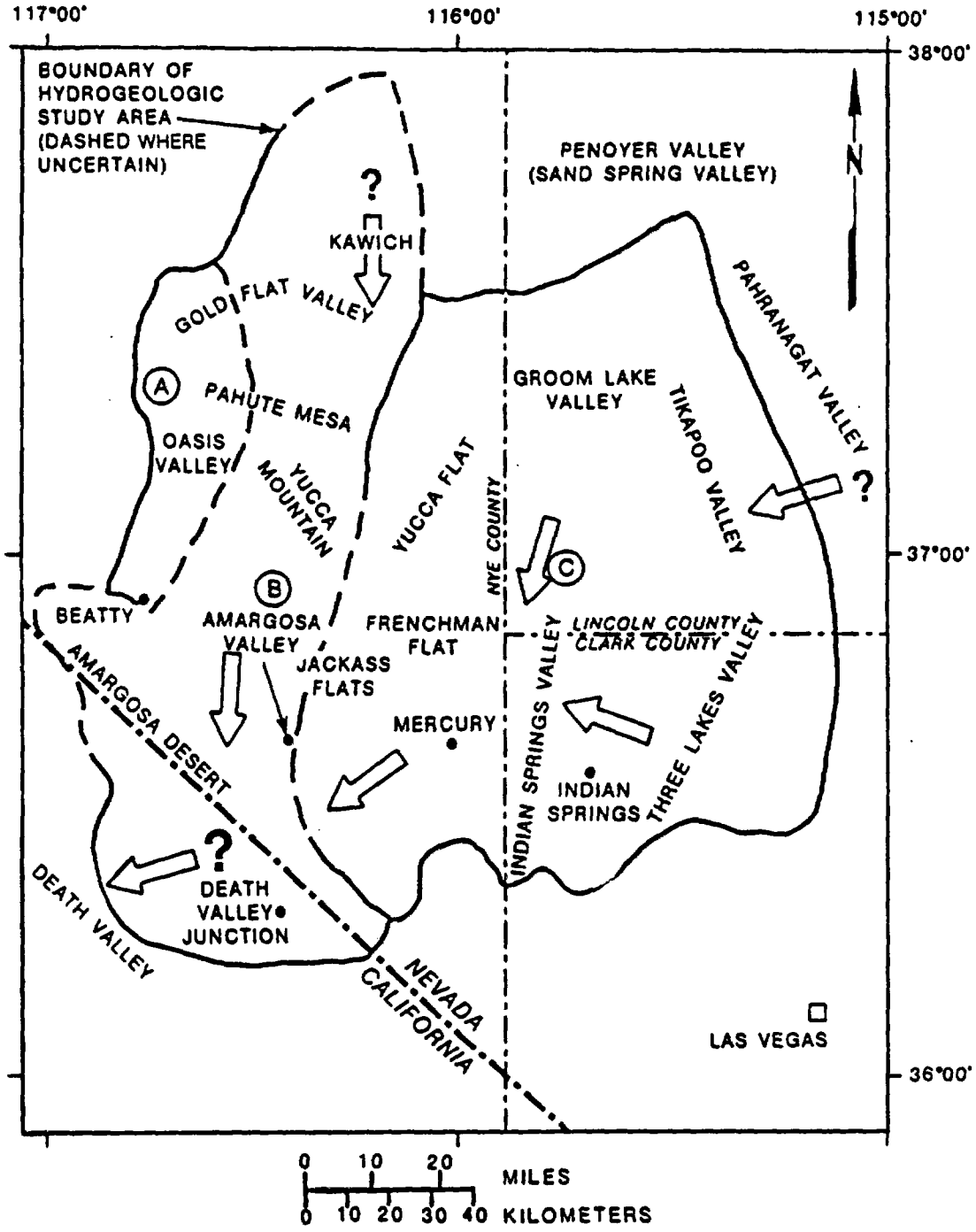


Figure 3-2. Hydrogeologic study area, showing three ground-water subbasins. Modified from Rush (1970), Blankennagel and Weir (1973), Winograd and Thordarson (1975), Dudley and Larsen (1976), Waddell (1982), and Waddell et al. (1984).

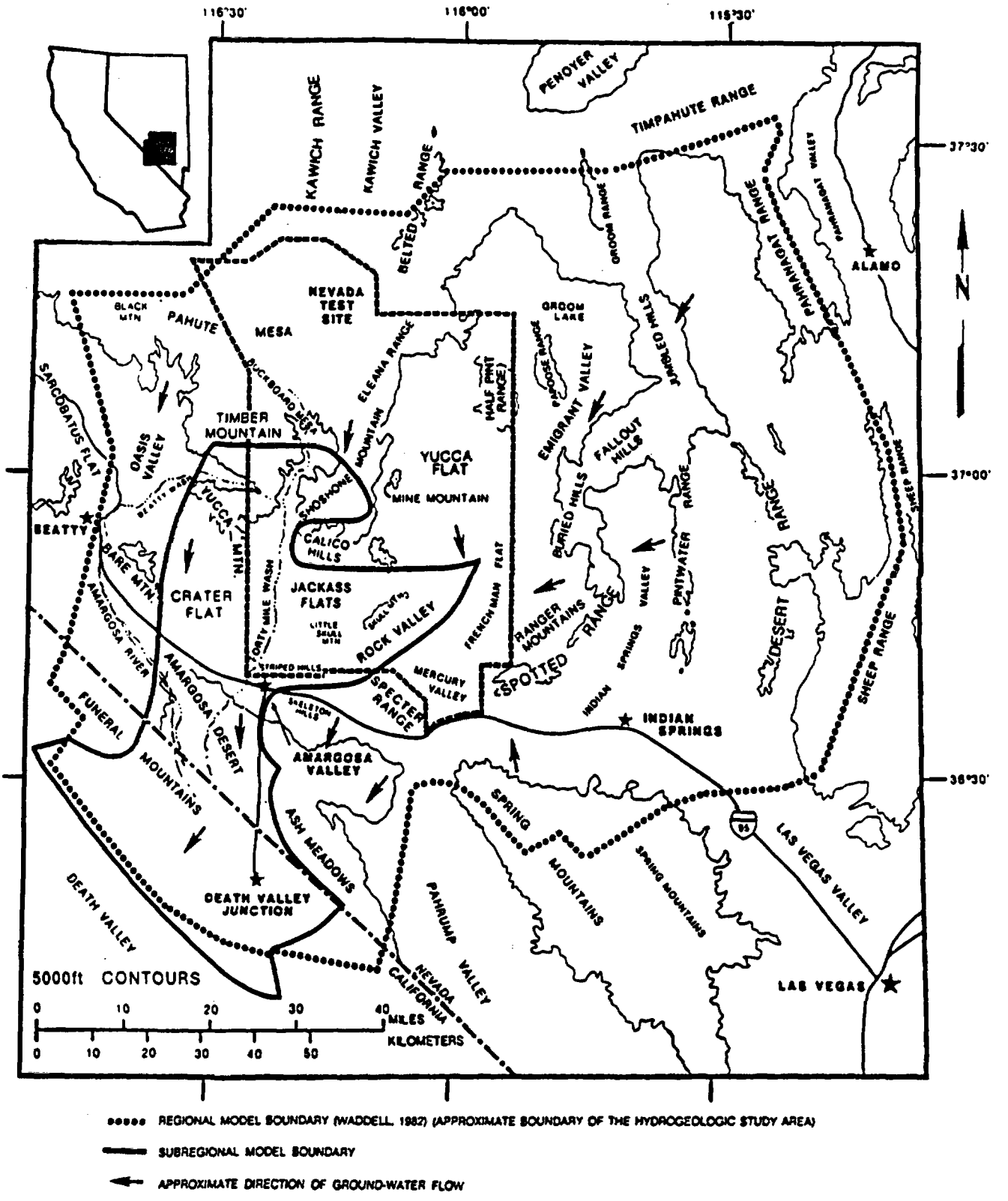
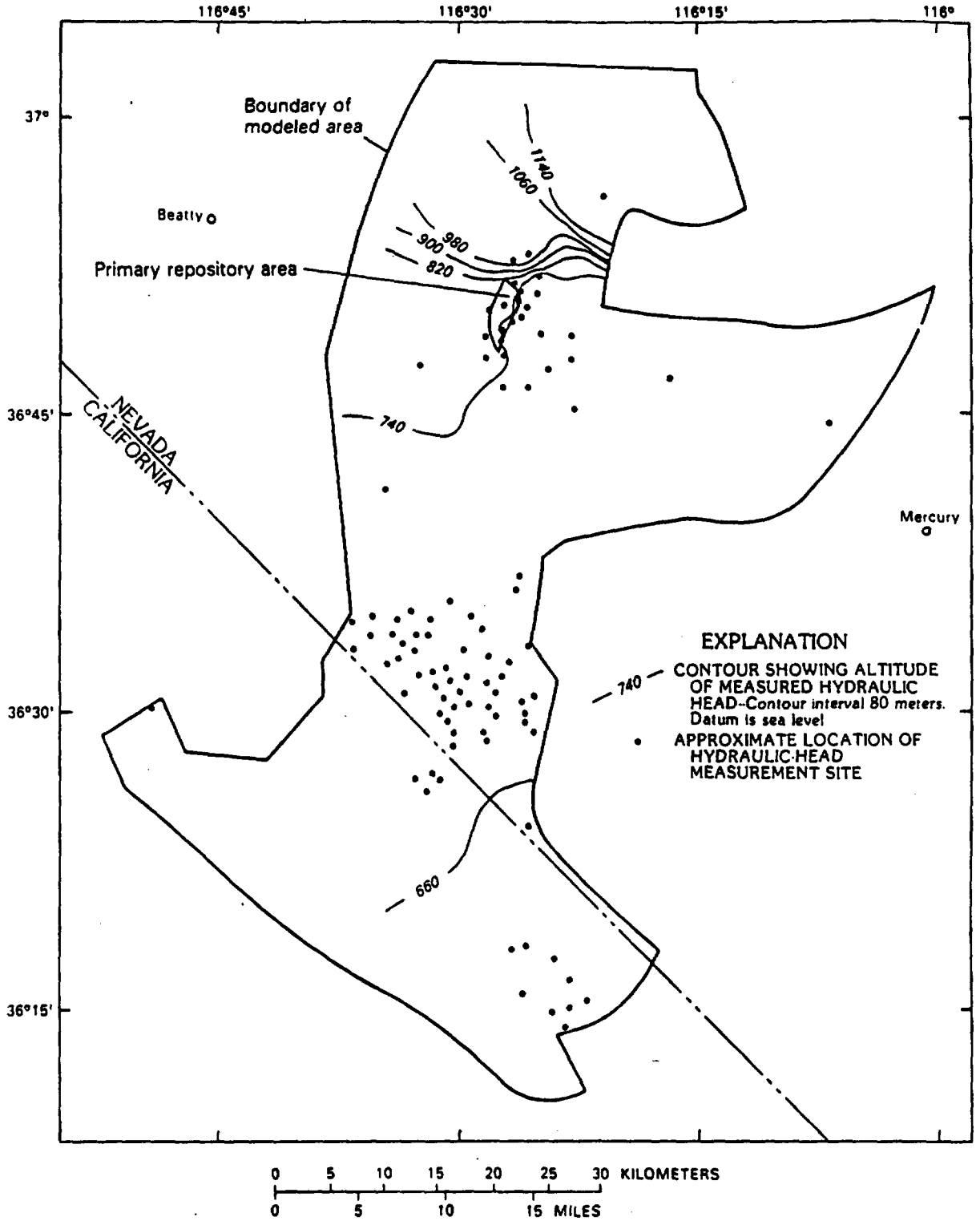
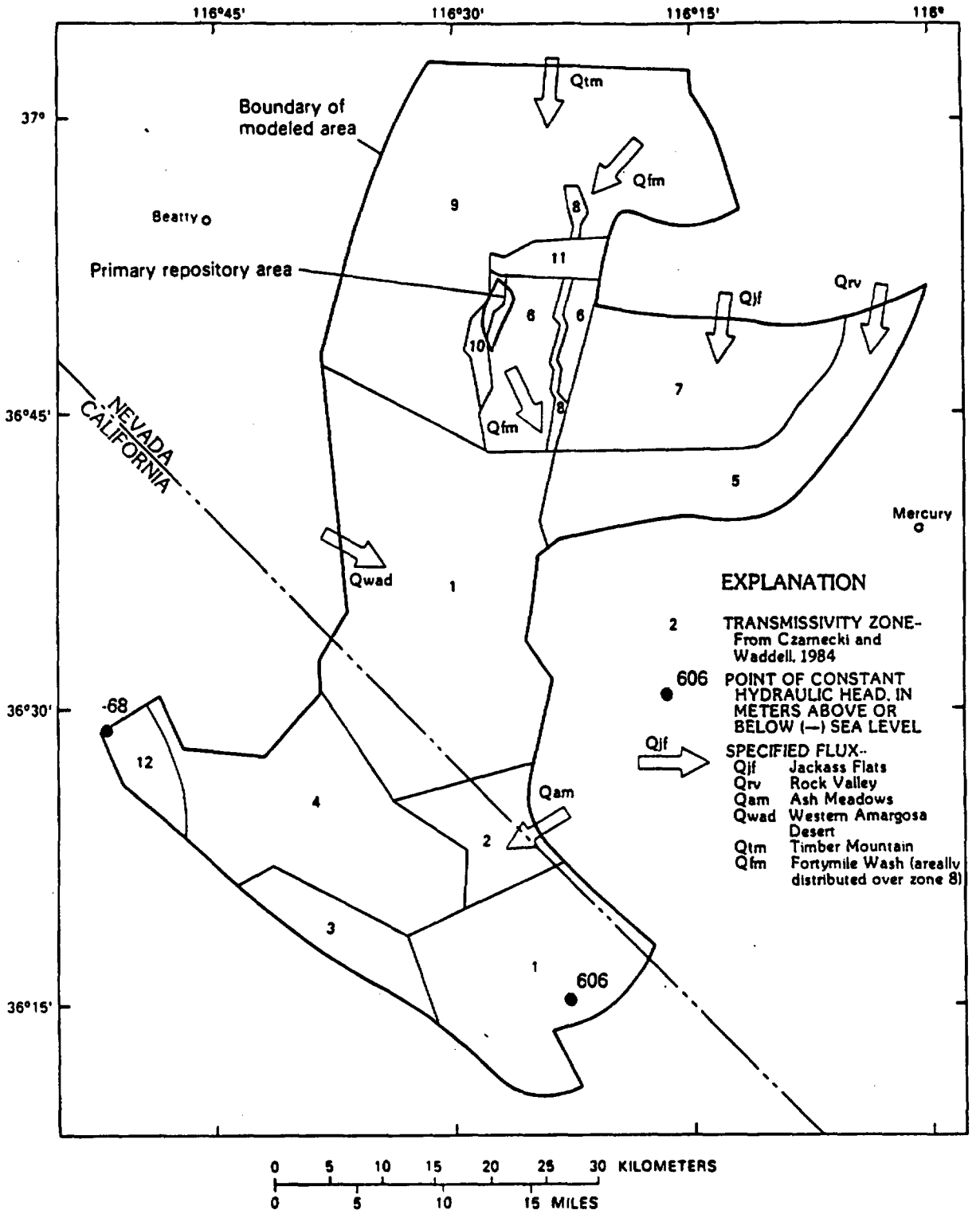


Figure 3-43. Location of regional and subregional modeled areas, with generalized ground-water flow directions. Modified from Czarnecki and Waddell (1984)



Measured hydraulic head and location of measurement sites.



Model boundary fluxes, constant-head nodes, and transmissivity zones.

A REFINED ACCURATE REGIONAL/SUB-REGIONAL MODEL WHICH WILL DEFINE THE PRESENT SYSTEM AND WHICH CAN BE USED TO EVALUATE POSSIBLE FUTURES IS REQUIRED

- A MORE EXTENSIVE DATA BASE IS NEEDED TO DEFINE THE SATURATED ZONE FLOW REGIME
  - FRACTURE FLOW IMPORTANCE
  - BARRIERS/CONDUITS
  - INTERACTION WITH REGIONAL CARBONATE SYSTEM (i.e., VERTICAL FLOW COMPONENTS)
- EVALUATE THE IMPACT OF PERTABATIONS TO THE EXISTING FLOW SYSTEM
  - CLIMATE
  - INCREASED USE
  - STRUCTURAL CHANGES

CLIMATE CHANGE

(INCREASED RECHARGE)

RISE IN WATER TABLE

SHORTENED FLOW PATHS

[IF ONE LOOKS AT GWTT UNDER THIS OR SIMILAR CONDITIONS TOGETHER WITH INCREASED SITE FLUX – GWTT COULD BE VERY SHORT.]

INCREASED REGIONAL WATER USE

- EFFECTS OF INCREASED IRRIGATION (AMARGOSA DESERT)
- EFFECTS OF INCREASED MINING OPERATIONS SUCH AS SAGA MINERALS; BOND GOLD
- EFFECTS OF INCREASED URBAN WATER USE – i.e., DEVELOPMENT OF THE REGIONAL CARBONATE AQUIFER FOR THE LAS VEGAS AREA

STRUCTURAL CHANGES

- REGIONAL CHANGES IN POTENTIAL AND DISCHARGE LOCATIONS
- SITE CHANGES IN POTENTIAL
- NEW BARRIERS OR CONDUITS

RECOMMENDATIONS

CONCENTRATED EFFORT TO REFINE REGIONAL/SUB-REGIONAL AND SITE FLOW MODELS

- REGIONAL SYSTEM BOUNDARIES NEED BETTER DEFINITION – LITTLE REFINEMENT HAS BEEN MADE SINCE ORIGINAL WORK IN THE EARLY 70'S
- DEFINITION OF RECHARGE AREAS QUESTIONS WILL REMAIN RELATED TO UNDERFLOW FROM THE NORTH AND THE IMPORTANCE OF WASH SYSTEM RECHARGE TO THE REGIONAL AND SUB-REGIONAL SYSTEMS (e.g., AMARGOSA RIVER)
- STUDIES TO DEFINE THE MECHANISMS FOR AND IMPORTANCE OF AREAS WITH STEEP GRADIENTS – NEAR DEATH VALLEY, EAST OF MERCURY, NORTH OF YUCCA FLAT
- NEED TO BETTER UNDERSTAND THE SOURCE AND CONTROLS ON DISCHARGE FOR THE SPRINGS NEAR FURNACE CREEK RANCH

- NEED TO DEFINE THE INFLUENCE OF ANISOTROPY ON LOCAL FLOW PATHS
- TESTING SHOULD BE EXPANDED BEYOND THE SITE TO THE SUBREGIONAL SYSTEM
- IMPORTANCE OF VERTICAL GRADIENTS NEEDS ADDITIONAL STUDY - SHOULD DEVELOP ADEQUATE DATA FOR A 3-D MODEL TO ANSWER QUESTIONS CONCERNING THE CARBONATE AQUIFER AND DISCHARGE TO DEATH VALLEY
- THOROUGH EVALUATION OF POSSIBLE FUTURE CONDITIONS NEEDS TO BE UNDERTAKEN ONCE ADEQUATE REVISED MODELS ARE AVAILABLE

EXAMPLE OF FUTURE CONDITIONS

CZARNECKI (1985)

CHANGE:
- Δ PRECIP = 100%
- Δ RECHARGE = 15 TIMES

RESULTS:
- ΔWT = 130 M RISE
- FLOW PATH SHORTENED BY 2/3

IF A SCENARIO SUCH AS THIS WERE TO OCCUR: 1) THE UNSATURATED ZONE WOULD BE REDUCED TO 20 M IN THE TOPOPAH SPRING UNIT (DISTURBED ZONE TO WATER TABLE); AND 2) SATURATED ZONE FLOW PATH WOULD BE $\approx$ 14 KM TO NEW DISCHARGE POINTS

TRAVEL TIME COULD BE <1,000 YEARS

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EXPERIENCE

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Senior Research Engineer, Water Resources Center, Desert Research Institute, University of Nevada System, Reno. Research in water resources evaluation, hydrologic modeling, and environmental assessment.

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Assistant Project Manager, "Environmental Impact Analysis - Groom Mountain Withdrawal," U.S. Air Force, 1985-86.

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Co-Investigator, "Environmental Assessment Hi-Shear Technology Corp. - Moapa Indian Reservation," Hi-Shear Technology Corp., 1985.

Principal Investigator, "Analysis of Digital Spectral Satellite Data for Hydrologic Mapping," U.S. Department of Energy, 1984-85.

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Department of Civil Engineering, University of Nevada, Reno. Engineering Hydrology - CE 364-564; Advanced Hydrology 1-CE 718.

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Co-principal Investigator, "Development of Methodology for Evaluating Integrated Water Reuse/Water Supply/Waste Treatment Alternatives," 1979-1982.

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Co-principal Investigator, "Banking Colorado River Allotment Water in Las Vegas Valley, Nevada," 1978-1979.

Co-principal Investigator, "Water and Related Resource Problems and Research Needs in the Arid Southwest," 1978.

Co-investigator, "Institutional Constraint Evaluation of Land Application Sites and Water Right Availability for Reno-Sparks," 1978.

Co-principal Investigator, "Application of Numerical Simulation Techniques to Flood Plain Management," 1977-1978.

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1974-1976 Acting Deputy Director, Water Resources Center. Responsible for information dissemination program and Center day to day operations. Procurement of grant and contract funds through various agencies, including state, local and Federal governments. Center operating authority during frequent absence of Director. Research on water resources systems engineering and hydrological modeling.

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Co-investigator, "Island Park Dam Rehabilitation Environmental Assessment," USBR, 1976.

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Co-principal Investigator, "Time Variant Characteristics of Water Quality Control Plants in Nevada," 1972–1973.

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Co-investigator, "The Optimum Release Policy for a Multipurpose Reservoir Using Stochastic Hydrology," 1968–1970.

Principal Investigator, "Application of Watershed Simulation Model to Truckee River Basin," 1969.

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MEMBERSHIPS

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CONSULTING ACTIVITIES

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While employed by IECO 1973-74

a. Eyser Engineering, Madrid, Spain, Rio Rubi Flood Studies (Design Flood).

b. Seattle City Light, Seattle, Washington, PMF for Boundry Dam (Safety of Dams).

c. Electrobras, Rio de Janeiro, Brazil, Basic hydrologic and reservoir operation studies - Itaipu Dam.

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A REALIST'S VIEW OF FLUID TRANSPORT MODELING AT YUCCA MOUNTAIN

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WHY MODEL TRANSPORT

- Complexity of Processes
- Regulatory Requirements
- Uncertainties May Be Estimated
- Experiments/Data Collection May Be Optimized

WHAT IS A MODEL

- Model is a Conceptual Approach to the Coupled Transport in Hetergeneous Media Under Influences of:
  - A. Gravity Forces
  - B. Surface Forces
  - C. Bouyancy Forces
  - D. Thermal Forces
  - E. Tectonic Forces
  - F. Osmotic Forces
  - G. Others ?
- Model is NOT a Computer Program!!

WHAT PROCESSES (Currently Known) NEED TO BE MODELED TO ESTIMATE TRAVEL TIME

- Liquid Flow in Both Porous and Fractured Media
- Chemical Transport (Advection, Diffusion, Sorption, Decay) in Liquid Phase
- Gaseous Transport (Diffusion, Advection, Convection)
- Heat Transport (Conduction, Convection)
- Rock Mechanics (Stress/Strain, Hydrofracturing)

All Five Processes Are Highly Coupled!

SCP PERFORMANCE ASSESSMENT METHODOLOGY

"Darcian flow with dispersion in fractured porous media is the process that will be used as a baseline case to describe water movement through unsaturated and saturated hydrogeologic units."

SCP 8.3.5.12-11

Let's Examine the Baseline Understanding

UNCERTAINTIES IN FLOW

"The ability to characterize and model media composed of both a matrix and a fracture component is in the development stage."

Evans and Nicholson (1987)
AGU Monograph 42

"A major problem that must be faced is that of determining the location of all fractures and describing their properties. We can at most hope to describe the fractures and derive the properties of the network in a stochastic sense."

Witherspoon and Long (1987)
Symposium on Rock Mechanics

UNCERTAINTIES IN FLOW
(continued)

"Field experiments . . . . . called attention to the fact that the parallel plate assumption of a single fracture may be incorrect in describing the fluid moving through it."

Tsang and Tsang (1987)
WRR 23(3)

". . . The theoretical analysis has clearly shown that, in general, channel geometry and the frequency of channels have a very strong impact on the transport of dissolved species. Such data are largely not available."

Rasmussen and Neretnieks (1986)
WRR 22(8)

UNCERTAINTIES IN FLOW
(continued)

"One of the more important directions of future research is to explore the validity of the model assumptions and preferentially substitute them with more realistic ones."

Andersson and Dverstorp (1987)
WRR 23(10)

"A major message of this paper is our belief that present work on flow and transport lacks a unified approach that includes all pertinent physical, chemical, and biological processes operative in the unsaturated zone."

Nielsen, van Genuchten &
Biggar (1986)
WRR 22(9)

UNCERTAINTIES IN TRANSPORT

"The last decade (1976–1986) has seen rapid developments in theoretical research treating groundwater flow in a probabilistic frame work, but actual field application has been very limited.".....

"New theoretical approaches will also be required to treat the extreme heterogeneity of some natural permeable media."

L. Gelhar
WRR 22(9)

"The conclusions show that the estimated dispersivity value is significantly affected by sampling procedures, sampling frequency, and monitoring network and that the classical advective dispersion equation provides adequate representation of column and field scale experimental data."

Moltyaner and Killey (1988)
WRR 24(10)

UNCERTAINTIES IN TRANSPORT
(continued)

"The stochastic convection–dispersion model has not yet proved useful in shedding fundamental light on the scale effect (of dispersion) . . . . The assumption of homogeneity and ergodicity in the random hydraulic conductivity function need more experimental verification. . . ."

Sposito, Jury & Gupta (1986)
WRR 22(1)

". . . . Inspection of the concentration (contaminants) spatial distributions in the two examples mentioned leads to the conclusion that it is extremely difficult, if not impossible, to predict accurately the point value of concentrations."

G. Dagan (1988)
WRR 24(9)

CONCLUSIONS

1. Current directions in flow and transport research are toward stochastic or probabilistic methods.

2. Stochastic methods require a detailed understanding of hydraulic property variation within the simulated region. Particular emphasis is on spatial correlation of properties.

3. Current theoretical approaches have not been significantly tested due to lack of controlled field experiments.

SCP DATA COLLECTION FOR GROUND WATER TRAVEL TIME

- 11 deep boreholes in the repository block for unsaturated zone data.
- 16 boreholes for the saturated zone for detailed hydraulic property data.
- 3 unsaturated boreholes in the Calico Hills unit beneath the repository block.
- 1 (2?) multiwell field tracer equipment (<100 meter scale) in the saturated zone.

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SCOTT W. TYLER

EDUCATION

B.S. Mechanical Engineering, University of Connecticut; Storrs, Connecticut - 1978

M.S. Hydrology, New Mexico, Institute of Mining and Technology; Socorro, New Mexico - 1983

MEMBERSHIPS

Pi Tau Sigma Honorary Society
American Geophysical Union
Soil Science Society of America
Chairman USDA Western Regional Research Project and Nevada Representative

EXPERIENCE

1983 - Present

Assistant Research Soil Scientist, Water Resources Center, Desert Research Institute. Specializing in water and contaminant transport through the vadose zone. Concurrently pursuing a doctoral degree in Hydrology at the University of Nevada, Reno.

Mr. Tyler is currently involved with the application of fractal mathematics to the understanding of transport behavior in heterogeneous soils and aquifers.

As task leader for DRI unsaturated zone studies at the Nevada Test Site, involved with research programs dealing with many forms of radionuclide migration in the vadose zone. These studies include subsidence crater moisture studies, flow and transport through fractured tuff and large scale tracer studies in unsaturated alluvium. These studies include the use of innovative drilling and sampling systems as well as detailed laboratory analysis.

Also involved with the assessment of radioactive waste disposal at Yucca Mountain in southern Nevada, the water supply potential and development programs for several clients in southern Nevada and subsurface monitoring in the vadose zone for hazardous waste and leaking underground storage tanks.

1982 - 1983

Research Engineer, Battelle Pacific Northwest Laboratory. Conducted research in the fields of waste disposal on ground-water quality. The following studies were completed at Battelle.

Project Manager of a two-year study for the evaluation of leachate production from closed hazardous waste landfills for the U.S. Environmental Protection Agency. The study included analytical and numerical analysis of the fluid flow characteristics of landfills as well as extensive field studies at operating landfills. This study provided data on the effectiveness of the regulations under the Resource Conservation and Recovery Act of 1976.

Also developed a set of analytical solutions to ground-water flow for verification and benchmarking of three-dimensional numerical ground-water flow codes. These solutions were prepared for use in the Basalt Waste Isolation Project (BWIP).

In order to simplify data input to saturated/unsaturated numerical ground-water flow codes, procedures and computer codes were prepared. The package allows the user to fit functional representations to experimental soil water characteristic data as well as generate partially saturated hydraulic conductivity data.

In support of the Uranium Mill Tailings Remedial Action Program (UMTRAP), prepared a document describing methodologies applicable to the design of leak detection and leak monitoring at line uranium mill tailings disposal sites. In addition, several uranium mill tailings pond liner and substrata designs to enhance lateral spreading of fluids for leak detection systems are discussed.

1978 - 1980 Sanitary Engineer, Connecticut Department of Health Services. Conducted investigations and overseeing of clean-up operations of public and private drinking water supplies contaminated by petroleum fluids, chlorinated organic compounds, and heavy metals. These contaminations were the result of industrial discharges, sanitary landfill leachates, and leaking chemical storage tanks. In addition, duties included inspection and sampling of public water supplies in compliance with the Safe Drinking Water Act. While with the State of Connecticut, participated and completed the U.S. Environmental Protection Agency's Surface Impoundment Program for the State.

PUBLICATIONS

Iannacelli, D., S.W. Tyler and D. Grower, 1979. Surface Impoundment Assessment, The Connecticut State Report. Prepared for the U.S. Environmental Protection Agency under the Surface Impoundment Assessment Project.

Myers, D.A., S.W. Tyler, P. Gutnecht and D. Mitchell, 1983. Leak Detection Systems for Uranium Mill Tailings Impoundments With Synthetic Liners. PNL-4694, Pacific Northwest Laboratory, Richland, Washington.

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Tyler, S.W. and R.K. Kirkham, 1984. "Leachate Production from Closed Hazardous Waste Landfills," in Proceedings of the Seventh Annual National Ground-Water Quality Symposium, September 1984, Las Vegas, Nevada.

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Tyler, S.W., 1987. Review of Soil Moisture Flux Studies at the Nevada Test Site, Nye County, Nevada, (DOE/NV/10384-17). Desert Research Institute, Publication No. 45058.

PAPERS PRESENTED

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STATE OF NEVADA
NUCLEAR WASTE PROJECT OFFICE

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: UNCERTAINTY IN MODELING AND PERFORMANCE ASSESSMENT

DATE: JUNE 26, 1989

PRESENTER: LINDA L. LEHMAN

PRESENTER'S TITLE AND ORGANIZATION: PRESIDENT
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UNCERTAINTY IN MODELING

I. Sources of Uncertainty

II. Data Limitations

III. Recommendations

I. SOURCES OF UNCERTAINTY

Cranwell and Helton 1981 (NUREG/CP-0022) identify:

- o Process Modeling Uncertainty
- o Input Data Uncertainty
- o Scenario Uncertainty

as primary components of uncertainty

BROAD CLASSES OF UNCERTAINTY

Eisenburg, et al 1987 identify five (5)

- Systematic and Random Error in Measurement
- Spatial Variations in Geologic Parameters
- Conceptual Models
- Physicochemical Process Modeling
- Future States of Nature

Schalla and Leonhart, 1981
NUREG/CP-0022 identify:

- Data limitations as a source of uncertainty in formulating conceptual hydrologic models

Kocher, Sjoreen and Bard, 1983
NUREG/CR-2506 identify:

- Insufficient Site Characterization as a source of uncertainty in estimating ground water transport times

WATER CONDUCTING ELEMENTS IN TUFF

- Fractures or other voids in rock
- Matrix pores

Large permeability heterogenities necessitate using average properties.

TRANSPORT MECHANISMS

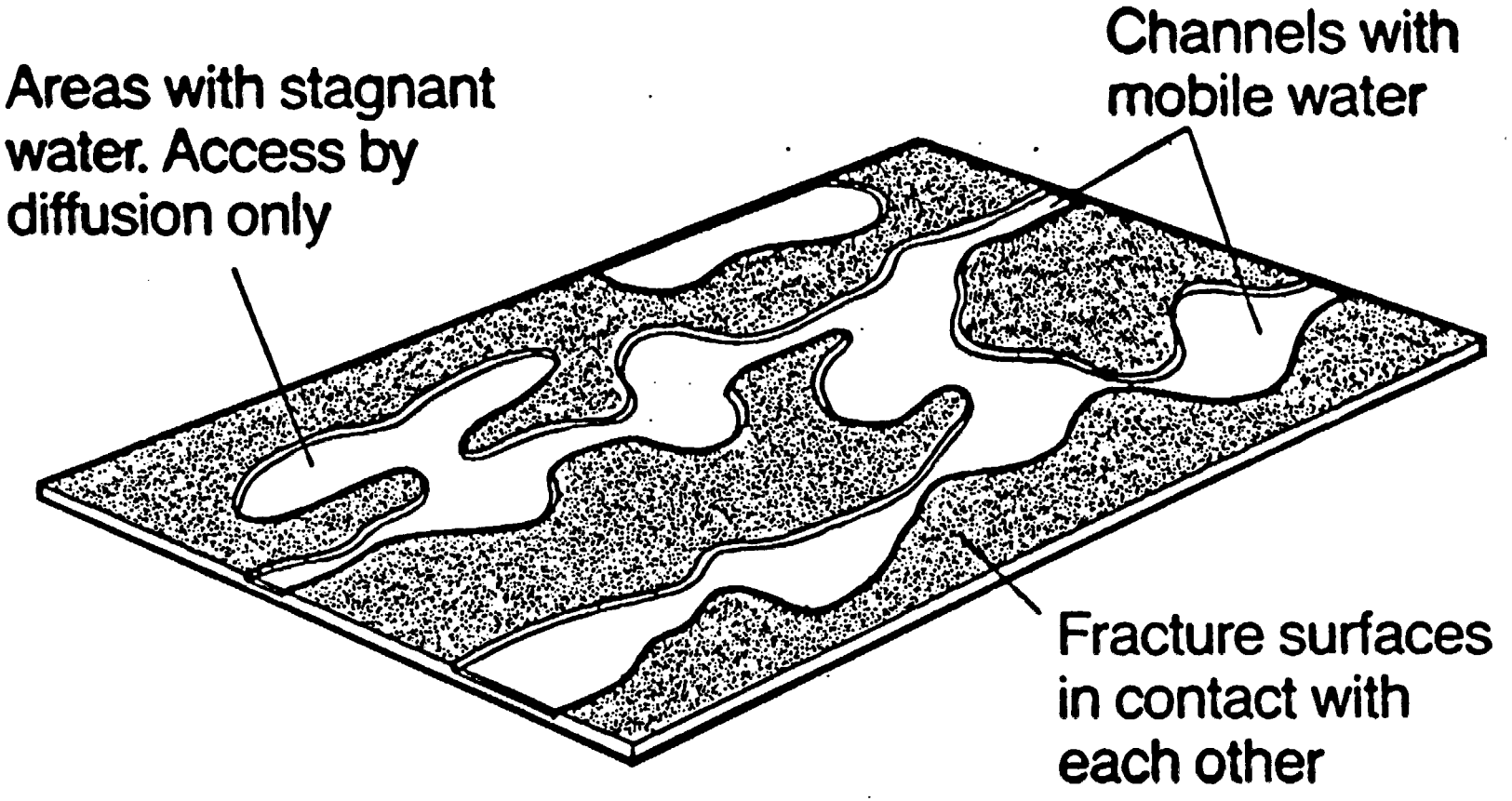
- Advection
- Dispersion
- Sorption
- Matrix diffusion
- Chain decay
- Colloids

To what extent do they occur?

* Heterogeneity - Uncertainty in describing spatial structure

SPATIAL STRUCTURE

- Homogeneous porous medium
- Homogeneous porous medium with fracture zones
- Heterogeneous porous medium
- Discrete fracture network
- Channel network
- Fractal geometry


Areas with stagnant water. Access by diffusion only
Channels with mobile water
Fracture surfaces in contact with each other

CRITICAL QUESTIONS WITH REGARD TO BARRIER FUNCTIONS - LARGE UNCERTAINTY

1) What is a proper description of the spatial variability of the rock; is it a system of poorly connected fast channels or not?

2) How much capacity for sorption and matrix diffusion are generally available?

3) Are colloids an important transport mechanism?

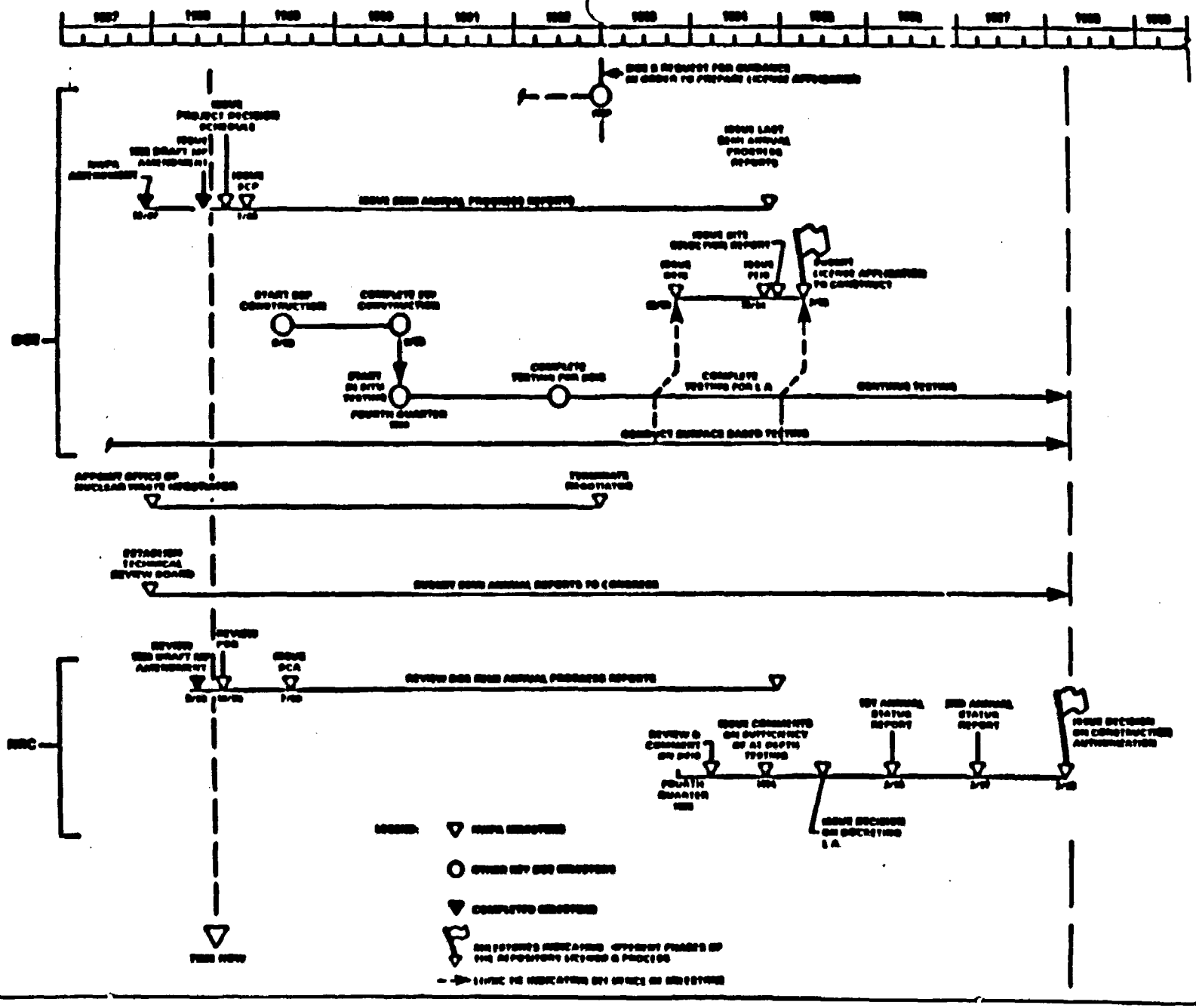
4) Will the coupling between ground water flow, rock stress and rock deformation seriously affect the long-term function of the repository?

II. DATA LIMITATIONS

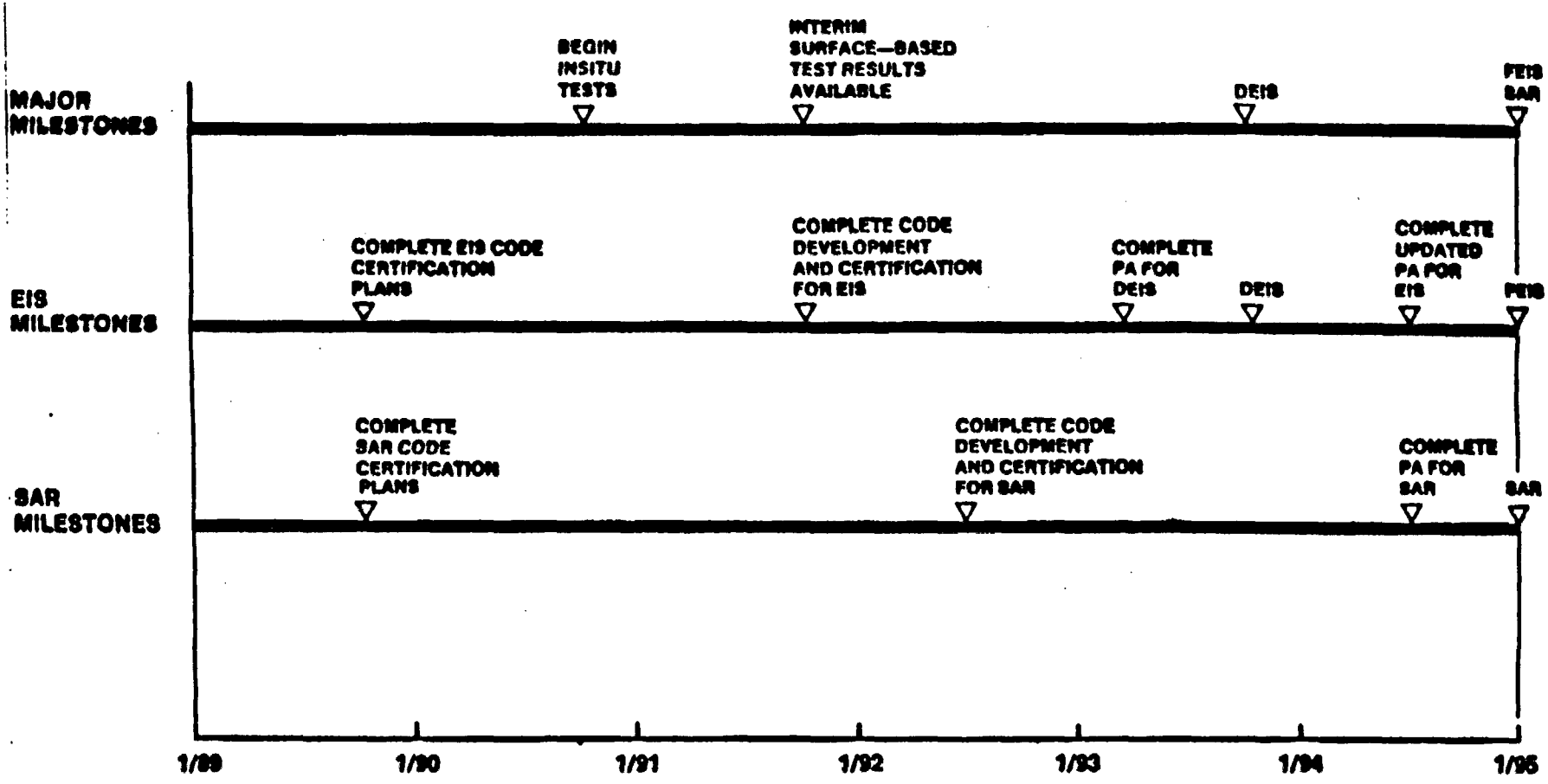
- General limitations
- Data limitations due to insufficient Site Characterization

TIMELINE OF LEVEL I NRC & DOE NWPA MAJOR REPOSITORY MILESTONES

ENCLOSURE 3



PERFORMANCE ASSESSMENT (PA) MILESTONES FOR LICENSING



GENERAL DATA LIMITATIONS

- Many hydrogeologic parameters are obtained from inference
- Many parameters are assumed correlated to other parameters
- Representativeness of samples collected
- Number of samples
- Sample disturbance during sampling
- Measurement and interpretation error

TIME DEPENDENT LIMITATION

(i.e., time allocated for data acquisition)

This limitation <u>is</u> correctable.

At what point does the schedule go from "ambitious" to "unrealistic"?

QUESTIONS

(1) What data will actually be used in the License Application?

(2) What will be its quality?

(3) How long does it take to generate data?

HYDROLOGY DATA - SATURATED ZONE

Type of Data	Period of Record		Date Released	Quality
Water Level - Pressure Transducer (15 wells)	(1983 - Feb. 1987)	Non QA'd QA'd	Mar. 1987 ?	poor
Water Level - other (28 wells)	(1981 - 1987)		Jan. 1989	fair
Drawdown and recovery (10 wells)	(Oct. 1980 - 1984)	Non QA'd	Apr. 1987	?

HYDROLOGY DATA - UNSATURATED ZONE

Types of Data	Period of Record	Date Released	Quality
Matric Potential vs. depth (UZ-1) instrumented	(Nov. 1983 - 1989)	not released	Suspect as per USGS
Saturation vs. depth Laboratory analysis of cores, cuttings, neutron probes (8 wells)	(1983, 1984, 1985)	(Preliminary results presented Nov. 1985) raw data not released	?

Historically, reliable, good quality data are not available for at least two (2) years after a test is finished.

This means that for in-situ tests requiring more than two (2) years, the data will not be available for the License Application.

- **prototypes**
- **USGS internal reviews**

License Application will be based largely on sparse, surface-based testing

III. RECOMMENDATIONS

To ensure a high quality and complete LA, DOE/NRC should move immediately to correct this time-limited data deficiency.

- Determine immediately how much in-situ data will be required in the LA and its quality.
- Extend deadlines to allow these data to be reliably collected, and interpreted.
- Stop compressing the data collection phase (deadlines must be moved commensurate with delays).

RECOMMENDATIONS - continued

Expand research into basic processes needed to address critical questions

- Unsaturated flow in fractured/porous media
- Analog studies
- Tectonic coupling to flow field

IN SUMMARY

- Performance Assessment and Modeling Uncertainties are extremely large
- Data limitations are severe - some are correctable
- Even with good data, we will not be able to reliably model and predict the unsaturated zone (processes)
- Schedule compression must stop (Quality of License Application is at risk)
- Deadlines moved commensurate with delays
- License Application will be based on sparse, low-quality surface-based test data

RESUME

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EDUCATIONAL BACKGROUND:

University of South Florida, M.S., 1978, Hydrogeology
Florida Atlantic University, B.S., 1975, Geology
University of Minnesota, Ph.D. candidate/Hydrogeology, 1989

WORK HISTORY:

President/Principal Hydrogeologist
L. Lehman & Associates, Inc.; 1985 - Present

Private Consultant
Hydrogeology; 1983 - 1985

Hydraulic Engineer
U.S. Nuclear Regulatory Commission; 1979 - 1982

Hydrogeologist
Parsons, Brinkerhoff, Quade & Douglas, Inc.; 1977 - 1979

EXPERIENCE:

Ground Water Modeling

- Currently developing modeling efforts as the representative of the State of Nevada at the international flow and transport model validation effort for nuclear waste repository performance codes (INTRAVAL).
- Directed the development of conceptual flow models at solid and hazardous waste sites contaminated with volatile organic contaminants and other pollutants.
- Performed ground water flow and contaminant transport modeling of high-level nuclear waste sites (the Hanford Site Washington).
- Performed time series analyses using computerized data bases to establish baseline ground water conditions at high-level nuclear waste sites.

Expert Witness Testimony

- Served as primary technical expert regarding the ground water contamination at the Flying Cloud Landfill under litigation procedures, public hearings, and formal governmental agency meetings at various levels.

- Hydrogeologic expert for a class-action suit in Fernald, Ohio regarding ground water contaminants from defense-related nuclear operations.

- Provided the primary expert testimony regarding potential ground water contamination and site suitability for a solid waste landfill in McHenry County, Illinois.

- Provided expert testimony concerning potential ground water contamination from sewage sludge land application and agricultural runoff.

Hydrogeologic Investigations

- Directed the development of site characterization studies, environmental sampling and analytical program as part of the Remedial Investigation/Feasibility Study (RI/FS) for the Union Scrap Superfund Site.

- Technical review and analysis of the RI/FS at the Flying Cloud Landfill regarding ground water contamination and design of the ground water pump-out system.

- Directed staff in hydrogeological studies of potential solid waste disposal sites in Minnesota and Illinois.

- Directed the evaluation of the RI/FS for the Fernald nuclear defense facility in Ohio with regard to ground water contamination at that site.

Technical Program Management

- Provided overall project direction to the Yakima Indian Nation regarding the disposal of high-level nuclear waste and defense wastes at the Hanford reservation, including scientific and engineering efforts related to waste disposal design and siting issues.

- Served as prime contractor to the Minnesota Governor's Nuclear Waste Council for high-level nuclear waste Crystalline Repository Project and provided technical assistance in the areas of hydrology, geology, ground water modeling and regulatory/program analysis.

- Provided technical management assistance to the Nevada Governor's office in regards to scientific and engineering contractor support regarding the high-level nuclear waste repository at the Nevada Test Site.

Regulatory Development and Analysis

- Directed the development of rules to regulate the siting, design, construction, operation and closure of a low-level radioactive waste storage or disposal facility in the State of Maine.
- Participated in the development of siting criteria for the Federal Regulation (10 CFR 60) for high-level nuclear waste repositories.
- Provided formal review and comment efforts for various clients in regards to ground water and waste management regulations related to solid waste, hazardous waste, high-level and low-level nuclear waste, U.S. defense wastes, agricultural impacts on ground water, and ground water quality standards.
- Developed site suitability and selection criteria for radioactive waste disposal facilities keyed to various federal and state statutes.

PROFESSIONAL ACTIVITIES:

President, Minnesota Ground Water Association (1988)
Chairwoman, Subcommittee on Ground Water Protection Strategies; Environmental Quality Board Advisory Committee on Ground Water Protection (1988)
Member, Minnesota Pollution Control Agency Joint Hydrology Task Force

Certifications

Registered Geologist, State of Indiana
Professional Hydrogeologist, American Institute of Hydrology

Associations

International Association of Hydrogeologists
National Water Well Association
American Geophysical Union
Engineers Club of Minneapolis
American Institute of Hydrology

SELECTED PUBLICATIONS:

Nguyen, V.V., G.V. Abi-Ghanem and L.L. Lehman; Fractal Mixing in a Class of Composite Media; Preprints of Proceedings of the Stochastic Approach to Subsurface Flow, Montvillargenne, France; 6/85.

Lehman, L.L.; Factor Analysis of Groundwater Flow Paths in the Central Columbia Plateau; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L., GeoTrans, Inc.; Preliminary Sensitivity Analysis of Rockwell Flow Path Using SWIFT; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L.; Model Comparison; Comments of the Yakima Indian Nation on the Draft Environmental Assessment for the Hanford Site, Washington under the Nuclear Waste Policy Act, Volume 2; 3/85.

Lehman, L.L., V.V. Nguyen; Regional Correlation Between Precipitation and Piezometric Potential in Basalts: Analysis and Application; 3/88.

Lehman, L.L., Eric Hansen; Secondary Concentration of Air-Released Uranium through Watershed Runoff at the Feed Materials Production Center, Fernald, Ohio; 3/88.

Nguyen, V.V., L.L. Lehman; Interscale Transfer of Information in Nuclear Waste Repository Multibarrier Systems; Proceedings of Western Regional Conference Society of Groundwater Scientists and Engineers; 1/85.

Bennett, R.H., L.L. Lehman, et.al.; Interrelationships of Organic Carbon and Submarine Sediment Geotechnical Properties; Marine Geotechnology, Volume 6, Number 1; 3/84.

Upchurch, S.B., M. Dalton and L.L. Lehman; Groundwater Mixing in the Lower Floridan Aquifer in the Southern Peace River Basin; Florida Scientist, Volume 41, Supplement 1; 1978.

State of Nevada Briefing to the Nuclear Waste Technical Review Board (NWTRB)

Subject: Geochemical Concerns of the Proposed Nuclear Waste Repository, Yucca Mountain, Nevada

Date: 26 June 1989

Presenter: Dr. Maury E. Morgenstein

Title: Senior Geologist, Geochemical Program Manager

Organization: Mifflin & Associates, Inc.
2700 East Sunset Road, Suite C25
Las Vegas, Nevada 89120

Telephone: (702)798-0402

Problem

To determine the Ability of the Surface Volcanic Tuffs to Isolate Radionuclides from the Accessible Environment.

Retardation Credit

- Retardation credit is needed for radionuclides that require isolation in the host rock in order for the Repository to meet Regulatory critera. These radionuclides that require isolation are considered *Key Radionuclides*.
- Isolation can be accomplished by: Sorption, Precipitation, Ion Exclusion, and Diffusion mechanisms.

Key Radionuclides

Key Radionuclides	Mechanism of Possible Release
Actinides*: • Plutonium • Americium • Neptunium	Ground Water Travel
Technetium*	Ground Water Travel
Carbon-14	Gas Transport

* After A.D. Kelmers, ORNL-WS 41476.

Mineralogy-Related Parameters Necessary for a Retardation Barrier

Parameter	Comments
Suitable Mineralogy	Zeolites*, Clays, Fe & Mn Oxyhydroxides
Mineral Stability	Ambient Temperatures, low Na water, high Silica activity
Mineral Accessibility	**Open pores lined with suitable minerals in likely path of travel combine with:** • A significant volume of sorbing minerals • Mineral crystals oriented so that sorbing crystal faces are exposed to passing liquids. **This is a function of:** • Crystal orientation • No nonsorbing mineral overgrowths

* Sorbing zeolites such as clinoptilolite, mordenite, and heulandite.

Zeolite Stability

- As the concentration of sodium in water that contacts clinoptilolite increases, the stability of clinoptilolite as a function of temperature decreases. Clinoptilolite converts to the nonsorbing zeolite analcime. Silica activity also affects clinoptilolite stability.

- If the sodium concentration is held constant and at the level of J-13 water at Yucca Mountain, then the clinoptilolite conversion to analcime will probably take place at a temperature of about 90 degrees Centigrade. At temperatures between 60 and 90 degrees Centigrade, there would be a reduction of the clinoptilolite unit cell volume and therefore a partial loss of sorption capabilities, therefore retardation would be affected.

- Heulandite is not stable in the present day Yucca Mountain saturated zone as indicated by recent studies by Los Alamos on J-13. Repository induced changes to Yucca Mountain will affect minerals that are presently stable.

Other Parameters Affecting A Retardation Barrier

Parameter	Comments
Mass Action Competition	Clinoptilolite Exchange Preferences: Cs > K > Sr = Ba > Ca >> Na > Li Mordenite Exchange Preferences: Cs > K > NH4 > Na > Ba > Li NOTE: Cation exchange and thermal stability are both affected by cations present in the structures.
Colloid Formation	Example: Actinide transport
Multiple Speciation	Example: Actinides of various oxidation states.
Fracture Flow Predominant	Insignificant exposure to sorbing minerals. Low unit per unit residence time.
Nonsorbing Radionuclides	Most probably the actinides and Technetium.
Soil Gas Circulation	Known pressure differential in vadose zone create blowing wells - Radionuclide gas transport through open fractures and faults.

If

- Sorption credit is to be taken

The Most Likely Path of Travel

Must Be:

- Geochemically Stable
- Composed of actively sorbing minerals
- A slow path of travel

If the Most Likely Path of Travel is:

IF	THEN
Fracture Flow	No sorption is expected because there are not enough sorbing minerals present along fracture pathways. Sorption credit is needed for site licensing.
Matrix Flow	Sorption is expected for non-key radionuclides. Transport is generally so slow that sorption credit for these radionuclides are not needed for licensing.
Selective Matrix Flow (preferential pathways)	Limited sorption is expected for non-key radionuclides. Transport may be rapid and sorption credit is needed for licensing.

A TENTATIVE CONCLUSION might be that when sorption/ retardation is really needed, it is not available and when it is not needed it is available on a limited basis.

Conclusions

The ability to determine whether or not there will be sufficient isolation of radionuclides from the accessible environment rests on the following concerns:

- Actinides do not appear to respond to sorption as a mechanism for retardation. Precipitation on the canisters or repository tuffs will depend upon unknown local conditions. Colloid formation is expected. It is doubtful that actinide retardation can be adequately characterized on a site-specific basis.
- Technetium is expected to stay in solution.
- Sorption of the other radionuclides (except actinides and vapor phase radionuclides) probably can be significant under idealized conditions at the Calico Hill Formation (below the proposed repository horizon) if the following conditions are met: There is no fracture flow, low sodium and high silica concentrations in the pore waters, and temperatures are at or below 60 degrees C. Transport by preferred channeling (selective matrix flow) may reduce sorption capacity by reducing exposure to sorbing minerals.
- Vapor phase radionuclide transport of C-14 is expected. No retardation mechanism has been identified yet.

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- Kelmers, A.D., 1985. Applications of Radionuclide Sorption Information for Prediction of Retardation in Fracture-Flow Geologic Systems (ORNL-WS 41476).

VITAE

MAURICE E. MORGENSTEIN

EDUCATION:

Ph.D., 1974, University of Hawaii, in Geology and Geophysics.
M.S., 1969, Syracuse University, in Geology.
B.A., 1967, Queens College, City University of New York, in Geology,
New Mexico Institute of Mining and Technology (NMIMT).

PROFESSIONAL EXPERIENCE:

Chairman and Research Scientist, Mifflin & Associates, Inc., Las Vegas, Nevada, June 1986 to present.
Consultant, Desert Research Institute, Water Resources Center, University of Nevada System, 1984-June 1986.
Senior Geologist, Geophysicist, Director of Operations, Brim Partnership, placer gold mining operation, Lake Havasu, Arizona, 1982-1984.
President, Hawaii Marine Research, Corporation, Honolulu, Hawaii, 1974-1982.
Consultant, Altman & Vanairsdale, Attorneys-at-Law, Hilo, Hawaii, Economic Geology, 1978 to present.
Affiliate Faculty of the Graduate School of the University of Hawaii, 1976-1979.
Consultant, State of Hawaii, Department of Land and Natural Resources, Division of State Parks, 1977.
Aquatic Biologist, State of Hawaii, Department of Fish and Game, Honolulu, Hawaii, 1976-1977.
Consultant, Energy Resources, Pacific Marine and Supply Co., Honolulu, Hawaii.
Director of Research, Commercial Division, Pacific Analysis Corporation, Honolulu, Hawaii, 1976.
Assistant Oceanographer, University of Hawaii, 1975.
Assistant Researcher, Research Corporation of the University of Hawaii, 1974-1975.
Ferromanganese Program Coordinator, State Program, University of Hawaii, 1973-1975.
Research Assistant, Research Corporation of the University of Hawaii, 1972-1974.
Chief Scientist - R/V Kana Keoke, 1972-1974.
Lecturer - University of Hawaii, 1972.
Chief Scientist - R/V Teritu, 1970-1974.
Assistant in Geophysics, University of Hawaii, 1969-1972.
Lecturer - Utica College, 1968-1969.
Lecturer - Department of Geology, Rutgers University, NSF Summer Institute, 1967.
Teaching Assistant - Syracuse University, 1967-1969.
Chief Geologist - R/V Conrad, 1965-1969.
Assistant in Research, Lamont-Doherty Geological Observatory of Columbia University, 1964-1969.

PROFESSIONAL AFFILIATIONS:

American Association for the Advancement of Science
Hawaii Association of Professional Geologists
International Association of Sedimentologists
Sigma Xi

PUBLICATIONS:

Blundy, J. D., R. G. Burns, and M. Morgenstein, Authigenic Minerals in Rhyolite Tuff at Yucca

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Landmeisser, C. W. and M. Morgenstein, Survey and Mapping of Manganese Deposits in the Hawaiian Archipelago, In: The Origin and Distribution of Manganese Nodules in the Pacific and Prospects for Exploration (Ed: M. Morgenstein), Honolulu, Hawaii, p. 93-101, 1973).
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Morgenstein, M., Authigenic Cementation of Scoriaceous Deep-sea Sediments West of the Society Ridge, South Pacific, Sedimentology, vol. 9, p. 105-118, 1967.
Morgenstein, M., The Composition and Development of Palagonite in Deep-sea Sediments from the Atlantic and Pacific Oceans, Syracuse University, New York, 137 p., 1969 (Master's Thesis).

CONSULTANT PUBLICATIONS:

Morgenstein, Fein, Andrews, Deepsea Ocean Mining for AMAX, Denver, Colorado.
Morgenstein, Kapuku Plan for Resource Management, State of Hawaii, for Department of Fish and Game.
Morgenstein and HMR archaeologists, various publications Geoarchaeology of Kaho'olawe, Maui County, Hawaii, for State of Hawaii, Department of Parks.
Morgenstein and HMR archaeologists, various publications Geoarchaeology of Kaho'olawe, Maui County, Hawaii, for U.S. Navy, Third Fleet.
Morgenstein, Shallow Seismic Survey (Reflection and Refraction) of Groundwater, (KUOU II well site) Kaneohe, Hawaii, for State of Hawaii, Department of Land and Natural Resources. Circular C86, DLNR, State of Hawaii, 1981.
Morgenstein, Petrology of Oahu Volcanics, for Hydraulic Studies, Dam Construction, Oahu, for U.S. Army Corps of Engineers.
Morgenstein, Micropaleontology and Chemical Stratigraphy for Paleotaro Fields, Oahu, for U.S. Army Corps of Engineers.
Morgenstein, Geoarchaeology, Chemical Stratigraphy, Micropaleontology, Hydration-rind Dating, various publications, Society Islands, Hawaiian Islands, Samoa, Easter Island, etc., Bernice Pauahi Bishop Museum, Honolulu, Hawaii.
Morgenstein, Geoarchaeology, Hydration-rind Dating, Micropaleontology with various archaeologists, various publications, Maui, Oahu, Hawaii, Molokai, Kauai, archaeological sites for U.S. Army Corps of Engineers and for State of Hawaii, Department of Parks.
Morgenstein, Age Determinations of Land Boundary Markings for Land Dispute Case, Law Firm in Honolulu, Hawaii - Witchman, Witcham and Case. Data not used in court.
Morgenstein,Uranium Mining, Grants, New Mexico Geologic and Sedimentologic Assessments with other geologists for Law firm in Hilo, Hawaii, Altman & Vanairsdale.
Morgenstein, Glass Hydration, Authigenic Mineralogy, Geochemistry Reports dealing with Yucca Mountain Proposed High-Level Nuclear Waste Repository, for DRI, University of Nevada System.
Morgenstein, Glass Hydration, Authigenic Mineralogy, Geochemistry Reports dealing with Yucca Mountain Proposed High-Level Nuclear Waste Repository, for State of Nevada.
Morgenstein, Reviews of various DOE and DOE contractors, NRC, USGS, and other publications and reports.

PATENTS:

2 U.S. Patents in Deep-Sea Mining Equipment, concepts:
1) Morgenstein, Elevator Apparatus; and
2) Andrews and Morgenstein, Concept of Full Mining System.

State of Nevada Briefing to Nuclear Waste Technical Review Board

Subject	Geochemical Concerns Regarding the Disturbed Zone at the Proposed Nuclear Waste Repository, Yucca Mountain, Nevada.
Date	June 26, 1989
Presenter	Dr. Don L. Shettel, Jr.
Title	Senior Geochemist, Geochemical Program Co-Manager
Organization	Mifflin & Associates, Inc. 2700 East Sunset Road, Suite C25 Las Vegas, NV 89120
Telephone	(702) 798-0402

Definition of the Disturbed Zone

"the portion of the controlled area the physical or chemical properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository." 10 CFR Part 60.2

NRC considers changes in permeability and porosity define the Disturbed Zone.

This ignores changes in state of the pore (and fracture) fluid and associated effects.

Geochemical Concerns Regarding the Disturbed Zone

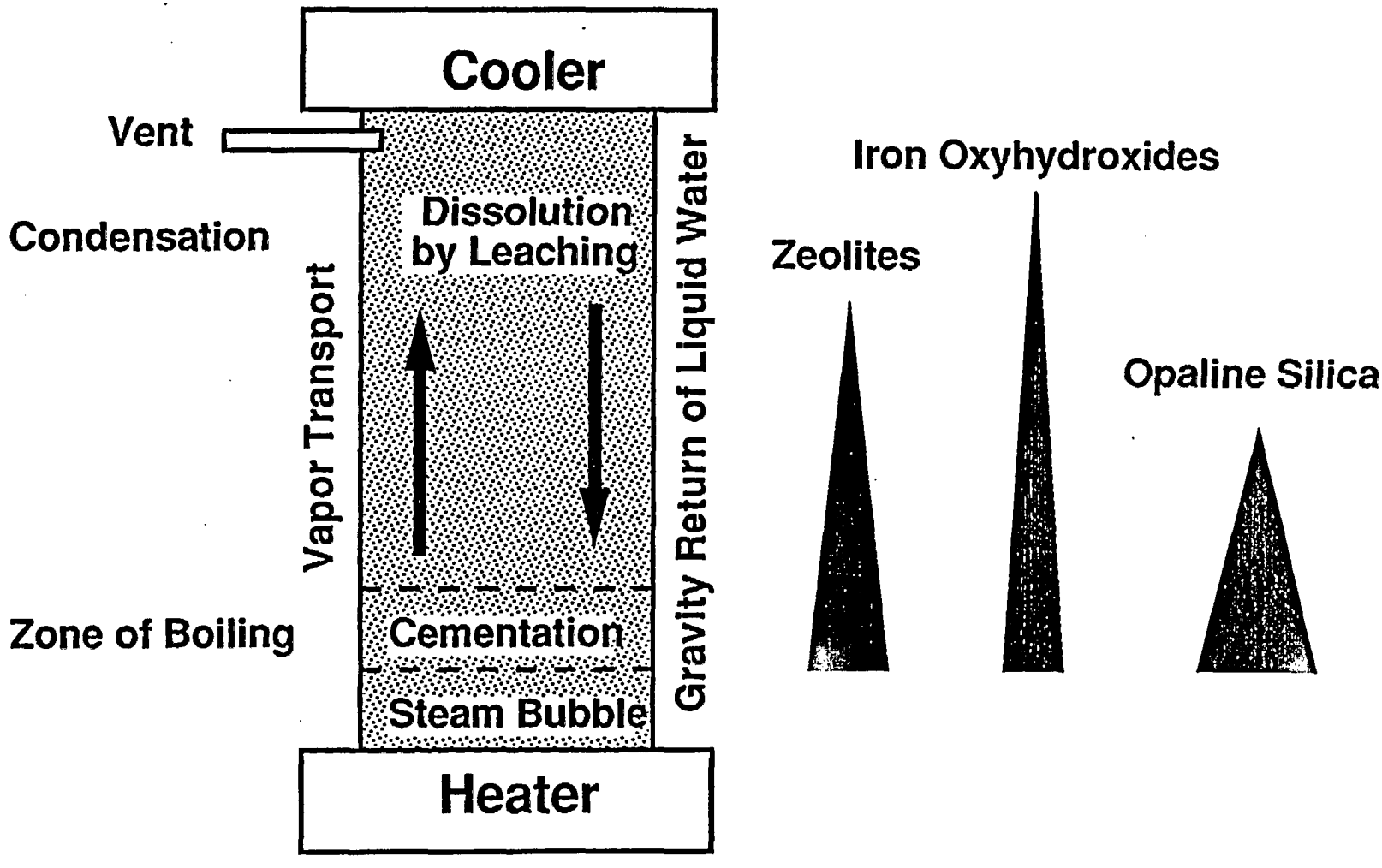
- Mass Transport (dissolution) in a Thermal Gradient
- Changes in Vadose Zone Water Chemistry:
  - Corrosion of Canisters
  - Leaching of Waste Forms
- Local Saturation Surrounding Dried Out Zone:
  - Perched Water Bodies above Repository
  - Saturated Fractures
- Thermal Fracturing of Repository Horizon Rock:
  - Boiling of Pore Water during Heating Phase
  - Massively Cemented Zones during Cooling

Vadose Zone, Yucca Mountain, Nevada

Hydrogeologic Unit	Thickness Range, m	Remarks
Tiva Canyon, welded	0 - 150	
Paintbrush nonwelded	20 - 100	Partially Zeolitic
Topopah Spring welded	290 - 860	Repository Horizon
Calico Hills nonwelded (vitric)	100 - 400	Potential Retardation
Calico Hills nonwelded (zeolitic)		Standing Water Level
Crater Flat unit: Prow Pass, Bullfrog, Tram members	0 - 200	

Mass Transport

Thermal Gradient Reactor Experiment



Changes in Vadose Water Chemistry within the Disturbed Zone

- **Boiling of Vadose Zone Water Produces:**

  High pH waters (pH jumps to 9 with small amounts of boiling, and is over 10 near dryness)
  Mineral Precipitates of Calcite, Amorphous Silica, Albite, and Talc

- **Condensation of Boiled Gases Produces:**

  Carbonic Acid Liquid with pH of 6 at 100°C (4.6 at 25°C)
  Series of Mineral Assemblages (when reacted with welded tuff) that include Alkali Feldspar, Zeolites, Hematite, Amorphous Silica, Laumontite, and Pyrophyllite.

Stability of Sorbing Minerals Example: Clinoptilolite

Stability of Clinoptilolite decreases with increasing
- Temperature (=> Kaolinite)
- Aqueous Al activity (=> Kaolinite ± Pyrophyllite)
- Aqueous activity ratio of Na+/H+ (=> Albite)
- Aqueous activity ratio of Ca2+/H+ (=> Calcite ± Epistilbite ± Scolecite)

Stability increases with increasing aqueous Silica activity.

CONCLUSION: Clinoptilolite will become unstable within the Disturbed Zone as boiling of vadose waters proceeds.

Redistribution of Water Within Disturbed Zone

Water in Topopah Spring matrix = Porosity * Mean Saturation
= 0.11 * 0.65
= 0.0715 (7.15% by volume)

Initial areal power density of 57 kw/acre, 95°C isotherm will reach maximum extent of 20m (10m above and below midline of repository) in approximately 90 years.

Volume of displaced liquid water = 2,000 acres * 20m * 0.0715
= 9,381 acre-feet

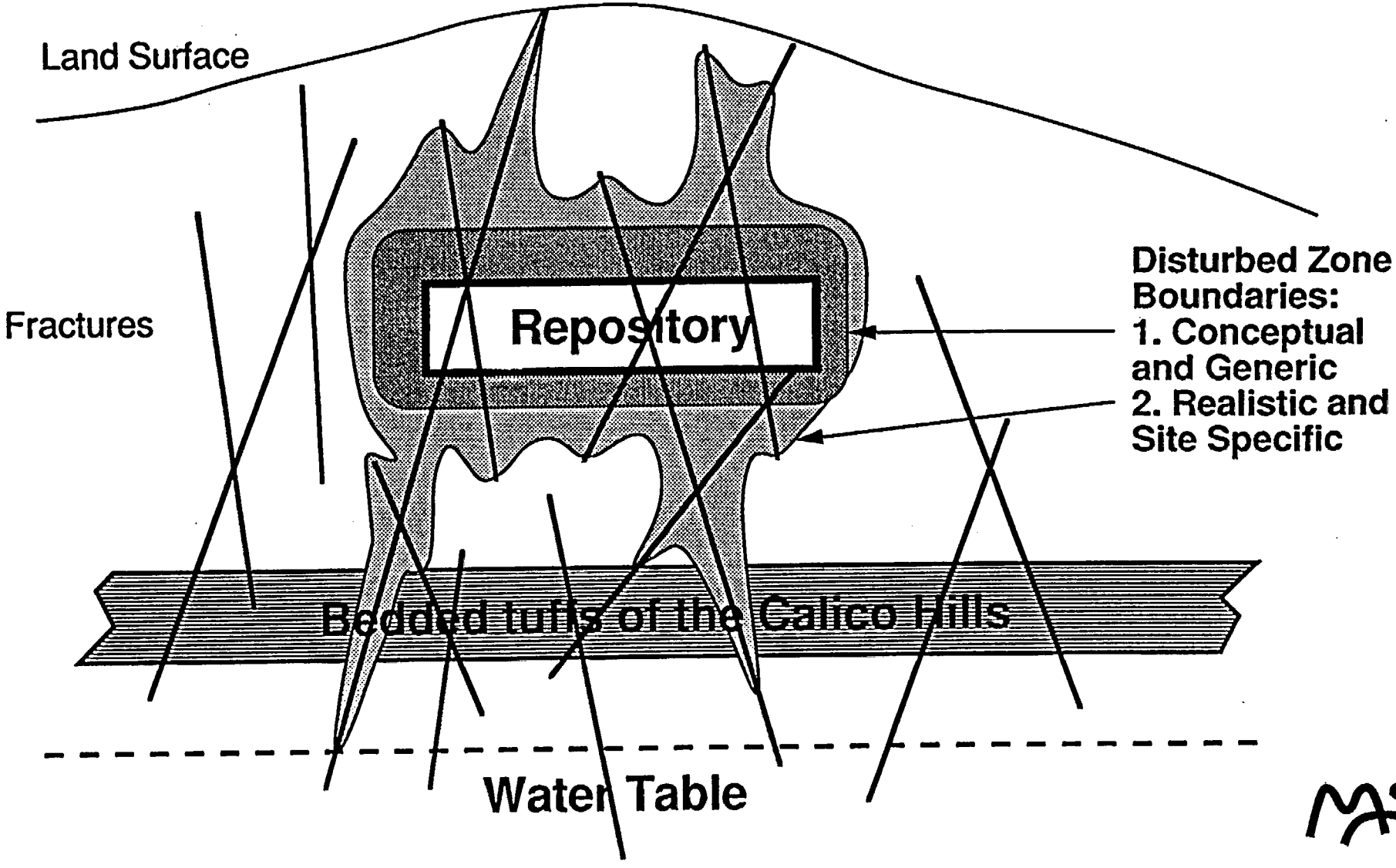
RESULT: Extensive envelope of fracture (and perhaps matrix) saturation totally surrounds repository. Recharge flux also accumulates.

A Site Specific, Realistically Defined Disturbed Zone

Is Required to be able to calculate:

- Travel Time
- Colloid and Particulate Transport
- Mineral Stability
- Changes in Vadose Water Chemistry

Schematic Diagram
Disturbed Zone Boundary



Conclusions Regarding the Disturbed Zone

- Significant Mass Transport may occur that could:
  - Affect the mechanical stability of the repository horizon
  - Cause local changes in permeability and porosity.

- Irreversible alteration of potentially sorbing minerals.

- Significant changes in Vadose Water Chemistry would affect
  - Corrosion rates of canisters, and
  - Dissolution rates of the waste form.

- Redistribution of water within and near the Repository by the thermal pulse may result in:
  - Thermal fracturing of repository-level host rock, and
  - Formation of locally saturated zones by condensation.

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VITAE

DON L. SHETTEL, JR.

EDUCATION:

Ph.D., 1978, Pennsylvania State University, in Geochemistry and Mineralogy.
M.Sc., 1974, Pennsylvania State University, in Geochemistry.
B.Sc., 1971, University of Michigan, in Geology (with honors).

PROFESSIONAL EXPERIENCE:

Senior Geochemist, Treasurer, and Associate, Mifflin & Associates, Inc., Las Vegas, Nevada. As a technical consultant to the State of Nevada's Nuclear Waste Project Office, monitored and evaluated federal environmental assessment and site characterization efforts at the Yucca Mountain proposed nuclear waste repository. Conducted geochemical research on suitability of Yucca Mountain as the nation's first nuclear waste repository. Performed geochemical and hydrogeological modeling of vadose zone to determine extent of "disturbed zone." Oversaw development of quality assurance and quality control program for drilling and sampling of the vadose zone in the vicinity of Yucca Mountain. Reviewed technical documents of DOE and their subcontractors pertaining to the nuclear waste repository. 1986 to present.

Senior Research Geochemist, Reservoir Diagenesis Section, Exxon Production Research Company, Houston, Texas. Improved porosity prediction by investigating sandstone diagenesis by geochemical modeling (EQ3/6), isotopic methods, mass balance calculations, and microscopy. Developed model for carbonate cementation in sandstones based in part on stable isotope geochemistry and microscopy of sandstones from around the world. Established stable isotope laboratory for carbon and oxygen isotopic measurements on carbonates in rocks and calcareous microfossils that resulted in improved turn-around time and quality control of isotope analyses. Supervised and trained a technician to operate laboratory, 1982 to 1986.

Staff Geoscientist, Data Integration Group, Geology Division, Bendix Field Engineering Corporation, Grand Junction, Colorado. Improved uranium resource assessment by developing computer software and standardizing statistical analysis procedures for the interpretation and display of geochemical exploration data. Interpreted over 250,000 hydrogeochemical and stream-sediment samples consisting of over 5 million analyses and reported results. Combined solution-mineral equilibria computer models (PHREEQE and WATEQF) with standard interpretation techniques of geochemical data that aided uranium resource assessment. Supervised three professionals and one technician to develop and use software for interpretation of geochemical exploration data, 1978 to 1982.

Faculty Research Associate (Geochemistry Section), Arizona State University, Department of Chemistry, Tempe, Arizona. Designed and tested a mixing cell for performing calorimetry on geothermal brines, 1977 to 1978.

Research Assistant, Department of Geosciences, Pennsylvania State University, University Park, Pennsylvania. Conducted hydrothermal experiments and stable isotope mass spectrometry that resulted in a new model for low 18-O magmas. Built fluorination line for oxygen isotopic analyses of silicates and trained other research assistants in its use which enabled completion of research. Developed computer software for geochemical calculations of fluid and isotopic equilibria and mineral stability, 1971 to 1977.

Assistant Field Geologist, Mineral Exploration Division, Humble Oil & Refining Company, Bangor, Maine. Conducted reconnaissance geologic mapping and geochemical and geophysical surveys that resulted in prospects for drilling, Summer1971.

PROFESSIONAL AFFILIATIONS:

American Association for the Advancement of Science
American Geophysical Union
Apple Programmers and Developers Association
Association of Ground Water Scientists and Engineers (a division of NWWA)
Computer Oriented Geological Society
Geochemical Society
International Association of Geochemistry and Cosmochemistry
International Association of Mathematical Geologists

PUBLICATIONS:

Rimstidt, J.D., W.D. Newcomb, and D.L. Shettel, Jr., 1989, An experiment to simulate mass transport near the Yucca Mountain High Level Radioactive Waste Repository (in preparation for submittal to Applied Geochemistry).

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Zinkl, R. J., D. L. Shettel, Jr., and R. F. D'Andrea, Jr., 1982a, PLTLBL: A FORTRAN computer program for labeling geochemical sample locations: U.S. Dept. of Energy Open-File Report GJBX-192(82).

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Corp. Rept. No. GJBX-204(81), 132 p., 5 pl., August, 1981.

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Petrography and Mineralogy of Sidewall Cores from the Lower Frio Marine Sands - K.R. Alazan No. 400 Well, North Alazan Field, Kleberg County, Texas: October 1983, EPR.222ES.83. [with S. T. Paxton and A. L. Kidwell].

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Isotope Geochemistry of Anhydrite Core Samples from the Exxon #1 Southern Minerals and Exxon #1 State Lease 538-1 Wells: July, 1985, EPR.143ES.85.

Stable Isotope Geochemistry of Core Samples from the Means San Andres Unit, Andrews County, Texas: September, 1985, EPR.177ES.85.

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Preservation of Primary Porosity in Deep Tuscalosa Sandstones: A New Play Concept: April 1986, EPR.53EX.86 [contributing author with S. T. Paxton, J. O. Szabo, F. W. Stapor, K. O. Stanley, and R. A. McCallister].

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R. E. Klimentidis].

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Reservoir Quality of the East Texas Frio Formation: 1986, in prep. [with A.Cochran, C. S. Calvert, and R. E. Klimentidis].

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NEVADA NUCLEAR WASTE PROJECT OFFICE
PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: VOLCANIC RISK STUDIES

DATE: JUNE 26, 1989

PRESENTER: DR. EUGENE I. SMITH
PROFESSOR OF GEOLOGY

ORGANIZATION CENTER FOR VOLCANIC AND TECTONIC STUDIES
DEPARTMENT OF GEOSCIENCE
UNIVERSITY OF NEVADA
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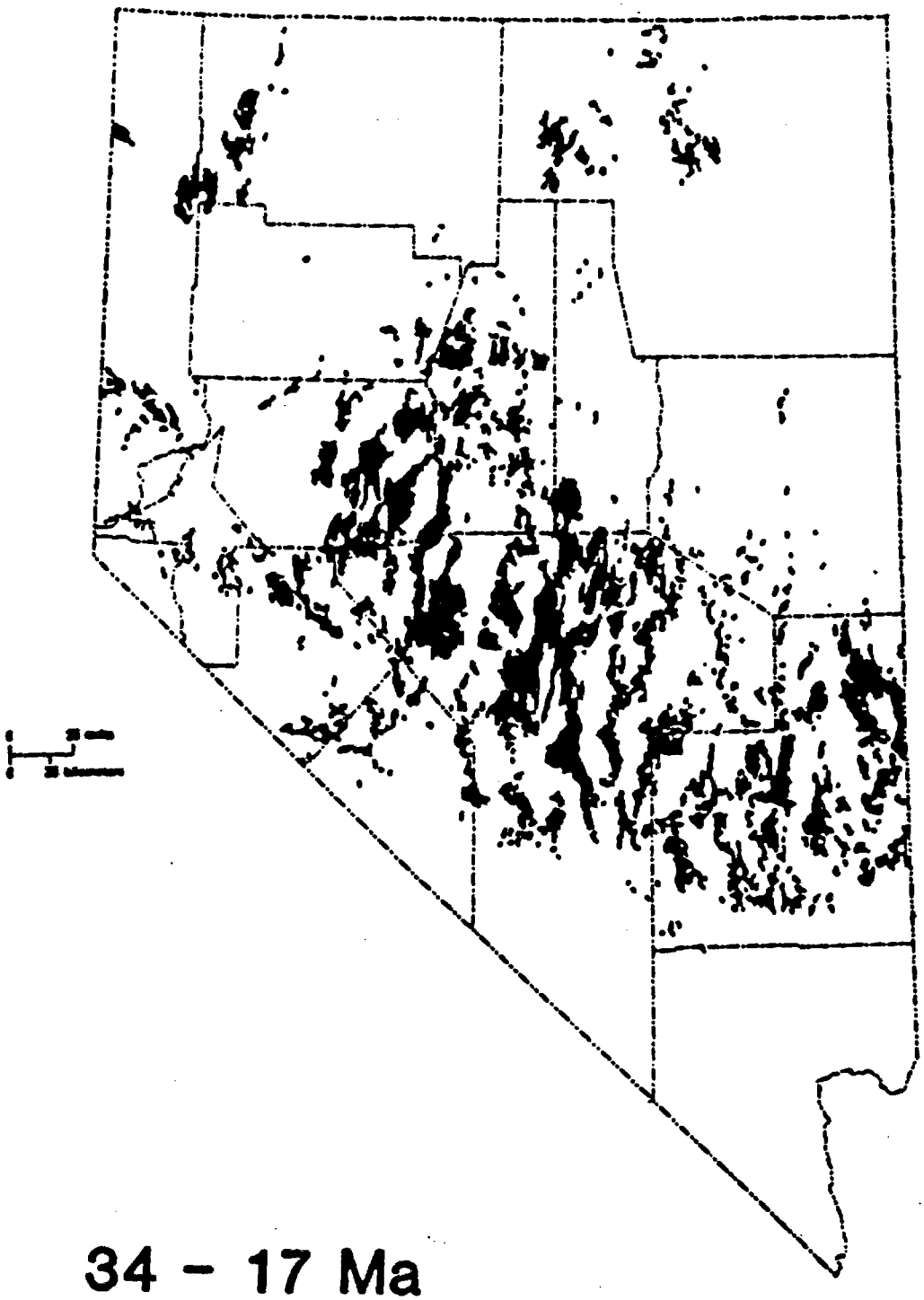
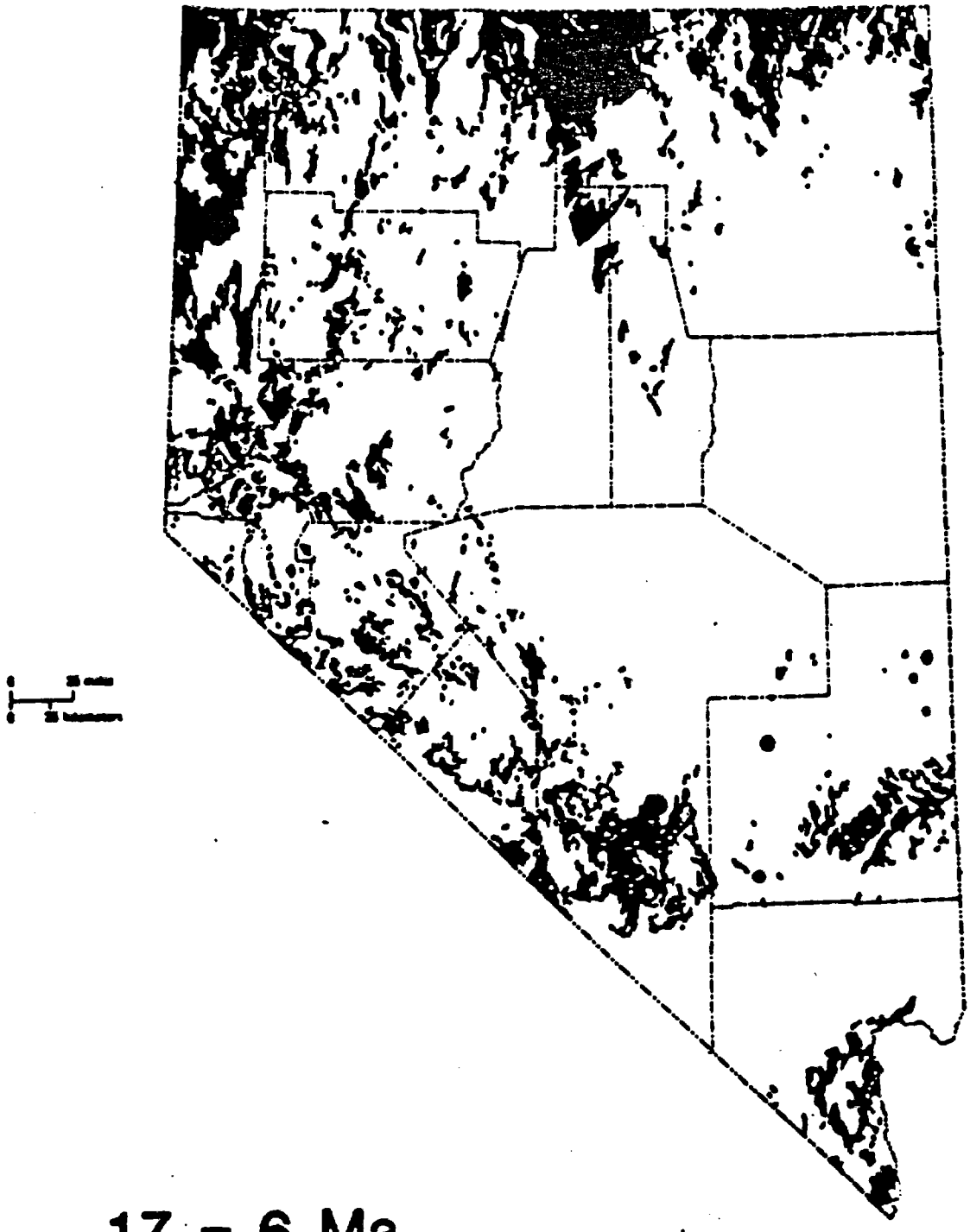


34 - 17 Ma

After Stewart, 1980

CVTS



17 - 6 Ma

After Stewart, 1980

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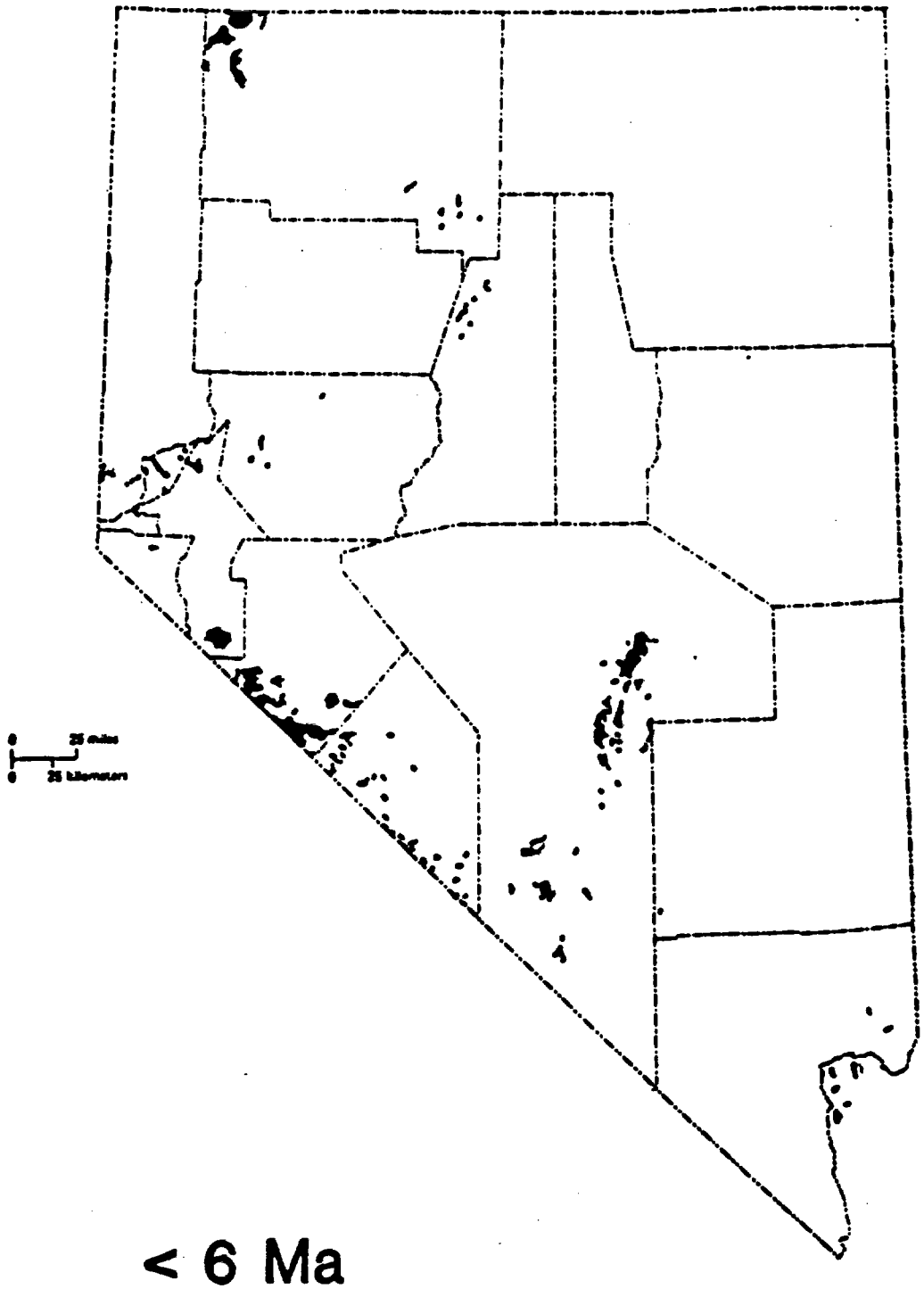
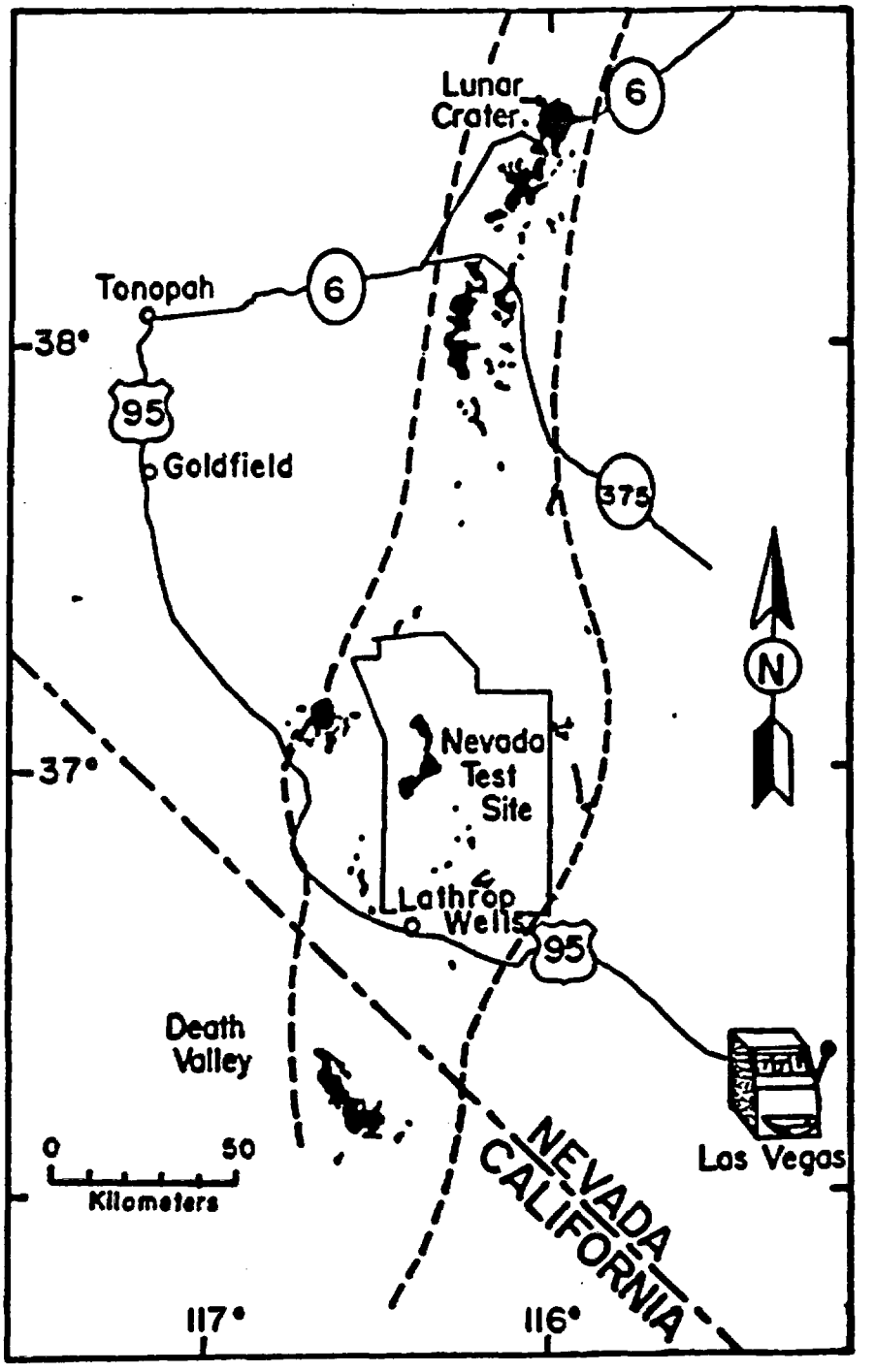


< 6 Ma

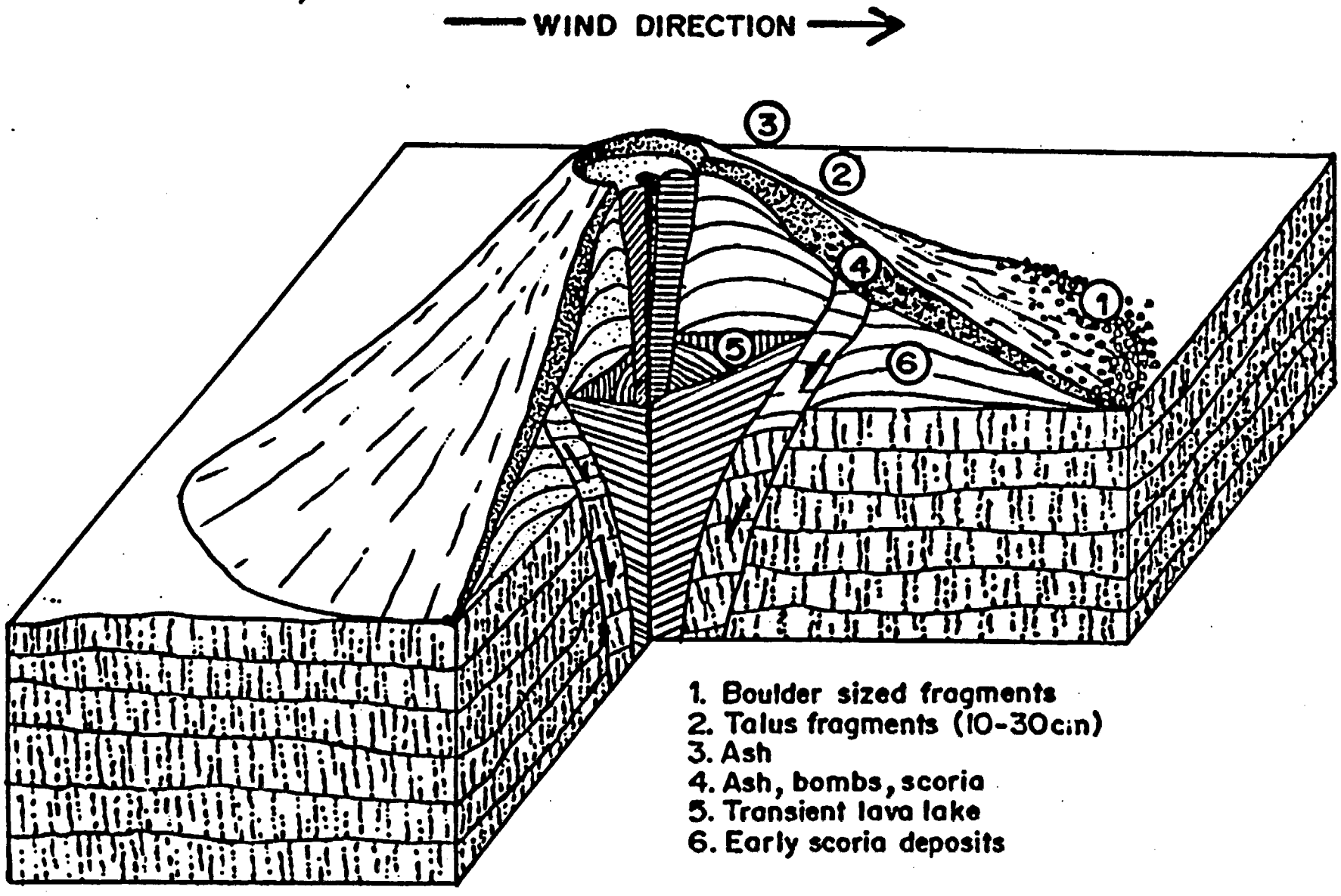
After Stewart, 1980

CVTS


Lunar Crater
6
Tonopah
6
38°
95
Goldfield
375
N
Nevada Test Site
37°
Lathrop Wells
95
Death Valley
0
50
Kilometers
NEVADA
CALIFORNIA
Las Vegas
117°
116°

CVTS

(after McGetchin et al, 1974)



CVTS

VOLCANIC RISK STUDIES

IMPORTANT ISSUES AND QUESTIONS

1. STRUCTURAL CONTROL

   WHERE WILL VOLCANISM OCCUR?

   WILL VOLCANISM BE CONTROLLED BY EXISTING GEOLOGIC STRUCTURES?

   WILL FUTURE ERUPTIONS OCCUR AT SITES OF PAST ERUPTIONS?

2. LENGTH AND NATURE OF AN ERUPTION

   HOW LONG WILL AN ERUPTION LAST?

   WILL THE ERUPTION BE SIMPLE OR COMPLEX?

3. CRITERIA FOR IDENTIFYING AN EXTINCT VOLCANIC FIELD

   ARE THERE RELIABLE CHEMICAL CRITERIA THAT INDICATE THAT A VOLCANO IS EXTINCT?

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STRUCTURAL CONTROL

CINDER CONES MAY NOT BE CONTROLLED BY FAULTS----DIKES AND CONDUITS MAY AVOID FAULT ZONES

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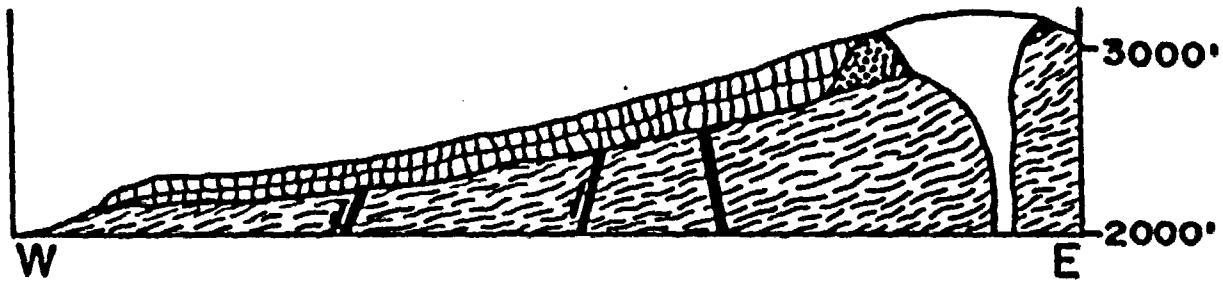
LAVA CASCADE, NW ARIZONA



BASALT

PLUG

SCORIA

PRECAMBRIAN BASEMENT

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STRUCTURAL CONTROL

FUTURE ERUPTIONS MAY OCCUR AT OR NEAR SITES OF PAST ERUPTIONS

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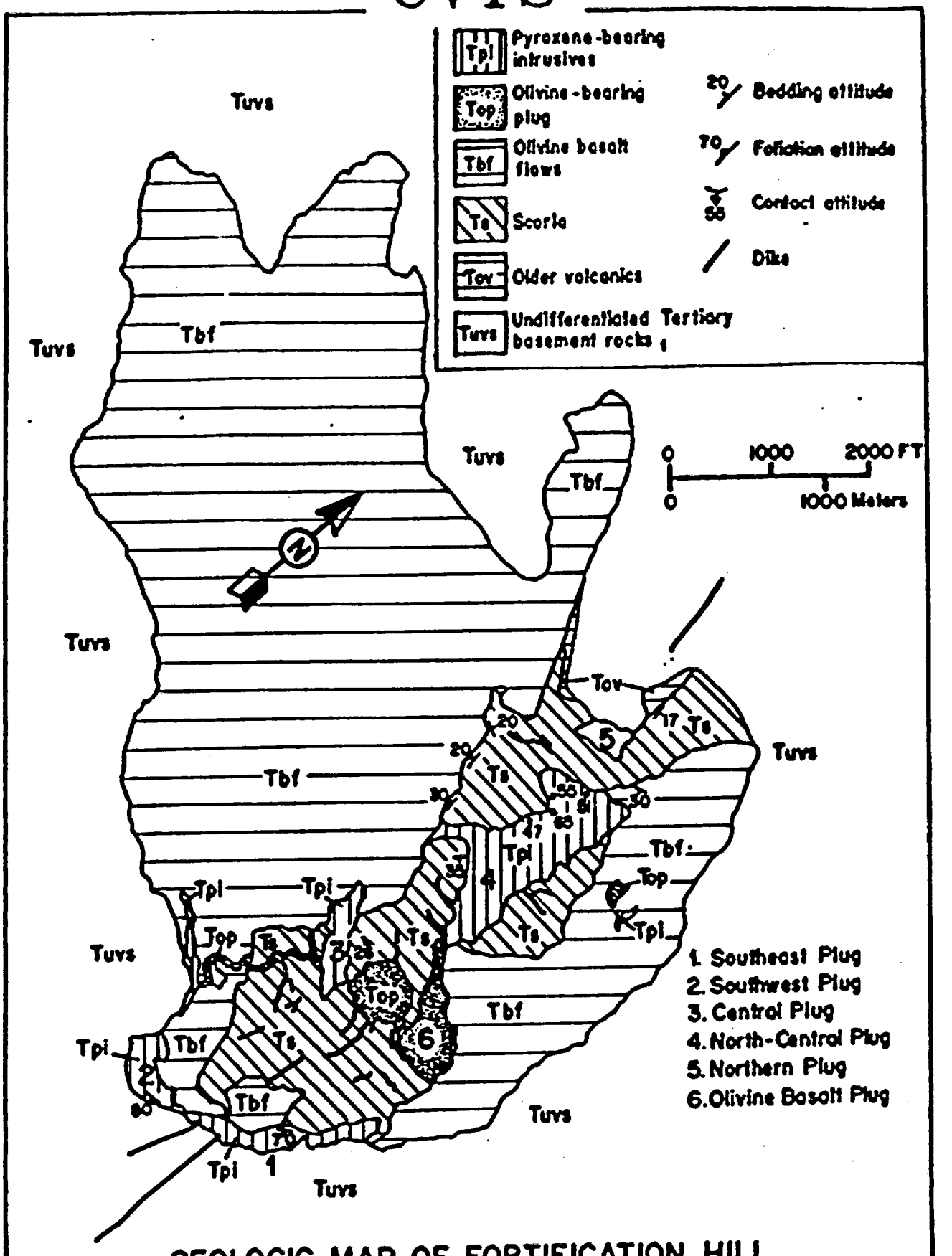

GEOLOGIC MAP OF FORTIFICATION HILL

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LENGTH AND NATURE OF AN ERUPTION

FORTIFICATION HILL 470,000 +/− 160,000 YEARS

LAVA CASCADE 420,000 +/−130,000 YEARS

CINDER CONES IN THE CENTRAL GREAT BASIN
"SEVERAL HUNDRED THOUSAND YEARS"
CROWE ET AL. (1988)

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LENGTH AND NATURE OF AN ERUPTION

ERUPTIONS AT A CINDER CONE COMPLEX MAY LAST AS LONG AS 10^5 YEARS

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LENGTH AND NATURE OF AN ERUPTION

ERUPTIONS MAY BE COMPLEX AND INVOLVE ERUPTIVE PULSES RANGING FROM RELATIVELY QUIET LAVA FOUNTAINING TO MODERATELY EXPLOSIVE STROMBOLIAN OR HYDROMAGMATIC

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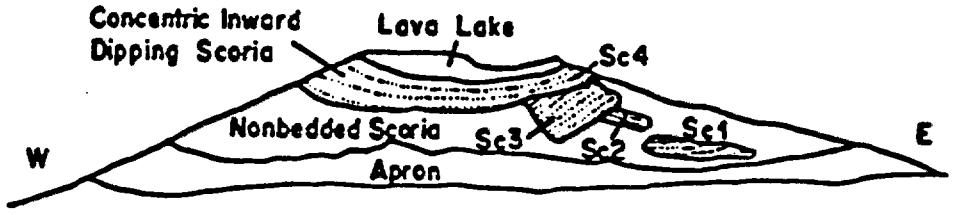
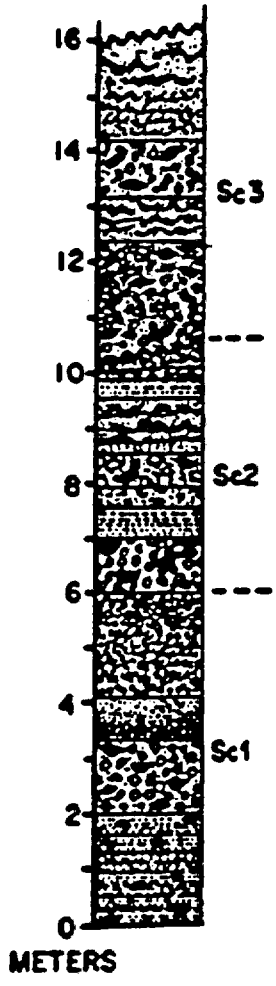
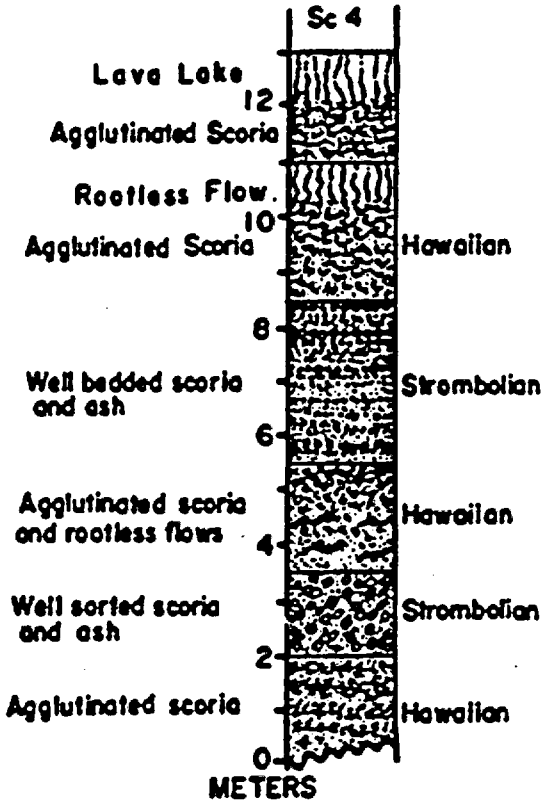
BLACK CONE (CRATER FLAT, NEVADA)



52 eruptive pulses observed





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LENGTH AND NATURE OF AN ERUPTION

MORE FELSIC AND POSSIBLY MORE EXPLOSIVE ACTIVITY MAY OCCUR DURING OR BETWEEN ERUPTIONS OF BASALT

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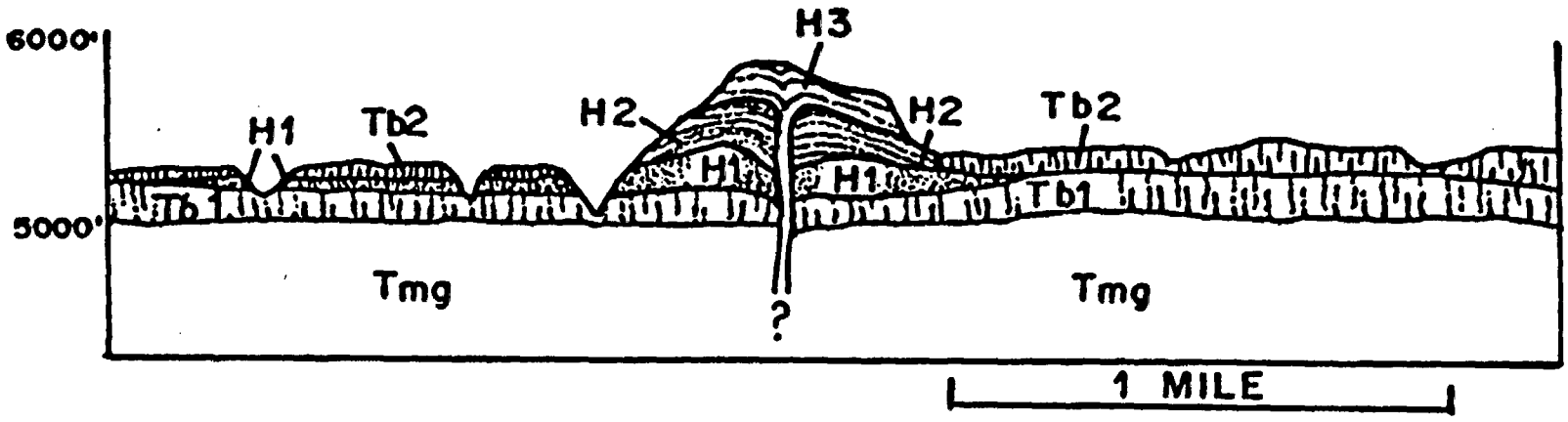

Tb2	EPISODE 2 BASALT (4Ma)
H3	TRISTANITE LAVA (59% SiO_2) (4Ma)
H2	TRACHYTE LAVA (60% SiO_2)
H1	PYROCLASTIC SURGE AND FALL
Tb1	EPISODE 1 BASALT (5Ma)
Tmg	MONOTONY TUFF (25Ma)

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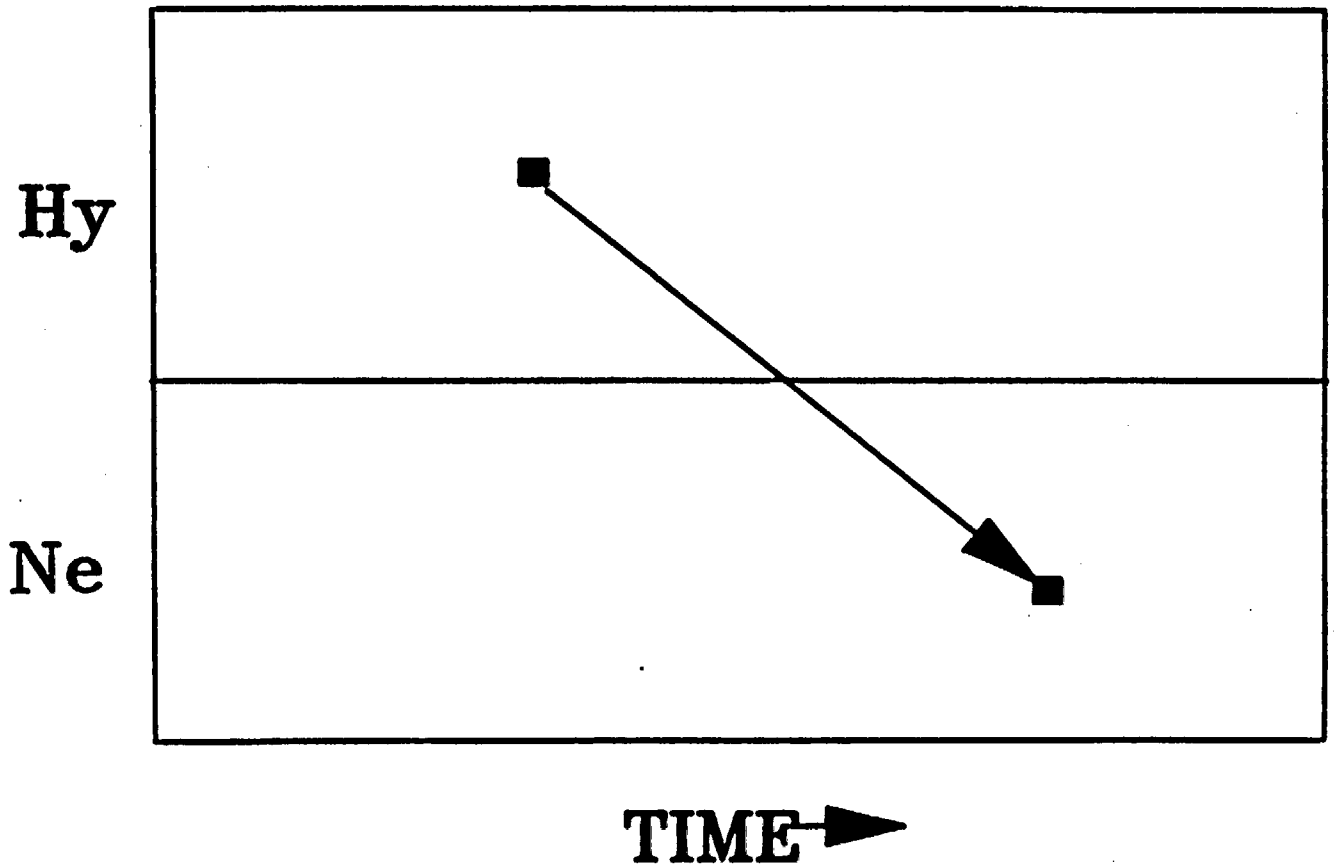
CRITERIA FOR IDENTIFYING AN EXTINCT VOLCANIC FIELD

THE ERUPTION OF ALKALIC BASALTS (NEPHELINE BEARING)

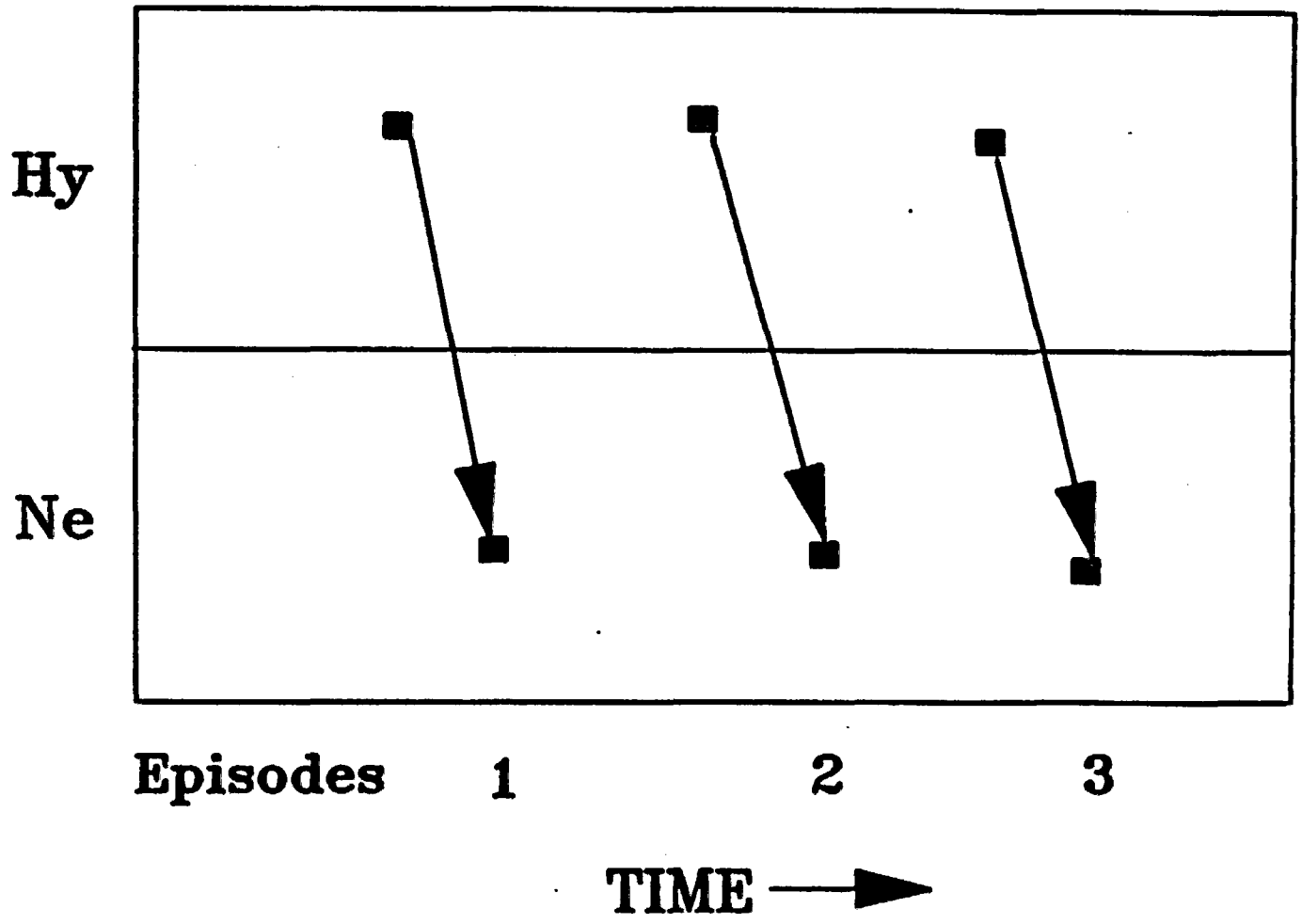
MAY NOT REFLECT THE TERMINATION OF

VOLCANISM IN A PARTICULAR VOLCANIC FIELD

APPARENT TWO SAMPLE VARIATION



VARIATION BASED ON DETAILED SAMPLING



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VOLCANIC RISK STUDIES

IMPORTANT ISSUES AND ANSWERS

1. STRUCTURAL CONTROL

   CINDER CONES MAY NOT BE CONTROLLED BY FAULTS----DIKES AND CONDUITS MAY AVOID FAULT ZONES

   FUTURE ERUPTIONS MAY OCCUR AT OR NEAR SITE OF PAST ERUPTIONS

   NO CONSISTENT MIGRATION PATTERNS FOR PLIOCENE VOLCANISM

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VOLCANIC RISK STUDIES

IMPORTANT ISSUES AND ANSWERS

2. LENGTH AND NATURE OF AN ERUPTION

ERUPTIONS AT A CINDER CONE COMPLEX MAY LAST AS LONG AS 10^5 YEARS

ERUPTIONS MAY BE COMPLEX AND INVOLVE ERUPTIVE PULSES RANGING FROM RELATIVELY QUIET LAVA FOUNTAINING TO MODERATELY EXPLOSIVE STROMBOLIAN OR HYDROMAGMATIC

MORE FELSIC AND POSSIBLY MORE EXPLOSIVE ACTIVITY MAY OCCUR DURING OR BETWEEN ERUPTIONS OF BASALT

CVTS

VOLCANIC RISK STUDIES

IMPORTANT ISSUES AND ANSWERS

3. CRITERIA FOR IDENTIFYING AN EXTINCT VOLCANIC FIELD

AT THE PRESENT THERE ARE NO RELIABLE CHEMICAL CRITERIA THAT INDICATE THAT A VOLCANO IS EXTINCT

TRENDS TOWARD ALKALIC VOLCANISM MAY NOT SIGNIFY THE DEATH OF A VOLCANIC FIELD

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EUGENE I. SMITH

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Educational Background:

University	Degree	Year
University of New Mexico	Ph.D.	1970
University of New Mexico	M.S.	1968
Wayne State University	B.S.	1965

Specialties: Igneous Petrology, Volcanology, Geochemistry, Tectonics, Planetary Geology

Professional Experience:

8/88 to present:	Professor of Geology, University of Nevada.
9/80 to 8/88:	Associate Professor of Geology, University of Nevada
9/76-8/80:	Associate Professor of Earth Science, University of Wisconsin-Parkside
9/78-8/79:	Visiting Associate Professor of Geology, University of Nevada
9/72-9/76:	Assistant Professor of Earth Science, University of Wisconsin-Parkside
9/70-6/72:	Post-doctoral Research Associate to Professor W.E. Elston, Department of Geology, University of New Mexico
9/68-8/70:	Graduate Research Assistant to Professor W.E. Elston, Department of Geology, University of New Mexico
8/68-8/80:	Geologist WAE, U.S. Geological Survey, Flagstaff, AZ
6/66-7/68:	Geological Field Assistant WAE, U.S. Geological Survey, Flagstaff, AZ
6/64-9/64:	Undergraduate Research Assistant to Professor A.J. Mozola, Department of Geology, Wayne State University, Detroit, MI

Teaching Experience:

Courses: Petrology, Optical Mineralogy, Petrography, Geochemistry, Crystallography and X-ray crystallography, Mineralogy, Structural Geology, Lunar and Planetary Geology, Volcanology, Economic Geology, Introductory Geology, Instrumental Techniques, Advanced Geochemistry, Igneous Petrology

Professional Society Memberships:

Sigma Xi
Sigma Gamma Epsilon
Phi Kappa Phi
Geological Society of America
American Geophysical Union
AAAS

Honors:

National Defense Education Act (NDEA) Title IV Fellowship, 9/65-6/68

Grants:

NASA Grant NGR 50-009-001 for the study of volcanic features and craters on Mars, Mercury, Moon and Earth (6 years of funding).

Four University of Wisconsin research grants to support the study of Precambrian igneous rocks of south-central Wisconsin.

UNLV Research Council grant to support the study of Tertiary volcanic rocks in Clark County, Nevada.

Grant from Nevada Nuclear Waste Project Office (NWPO) and DOE to study late-Miocene and younger volcanic activity in southern Nevada (3 years of funding).

Current Research:

1. Geochemical, petrological and structural studies of the Tertiary volcanic and plutonic rocks of the Lake Mead area, Nevada and Arizona.

2. Study of volcanic rocks in the McCullough Range, Nevada

3. Study of the late-Miocene Fortification Hill Basalt.

PUBLICATIONS:

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State of Nevada Briefing to the Nuclear Waste Technical Review Board (NWTRB)

Subject: Climate Change Concerns of the Proposed Nuclear Waste Repository, Yucca Mountain, Nevada

Date: 26 June 1989

Presenter: Dr. Martin D. Mifflin

Title: Senior Hydrogeologist, Yucca Mountain Technical Support Program Director

Organization: Mifflin & Associates, Inc.
2700 East Sunset Road, Suite C25
Las Vegas, Nevada 89120

Telephone: (702)798-0402

Climate Change

GENERAL CONCERNS

- A vadose-zone repository at Yucca Mountain will experience major hydrologic impacts from a climate change similar to the last pluvial climate which occurred about 16,000 to 10,000 years before the present.

- Anticipated hydrologic changes from a pluvial climate acting on Yucca Mountain is about 10 x more effective moisture--more recharge, more fracture flow, more perched water, and a rise in the water table to a level below the repositry horizon.

REGIONAL EVIDENCE

- Former extent of pluvial lakes in the Great Basin.

- Change in effective moisture (runoff and recharge) was about a one order of magnitude increase (10x modern).

- Extensive areas of ground-water discharge deposits in the Yucca Mountain region indicate greater discharge flux and rise in water tables up to several hundred feet.

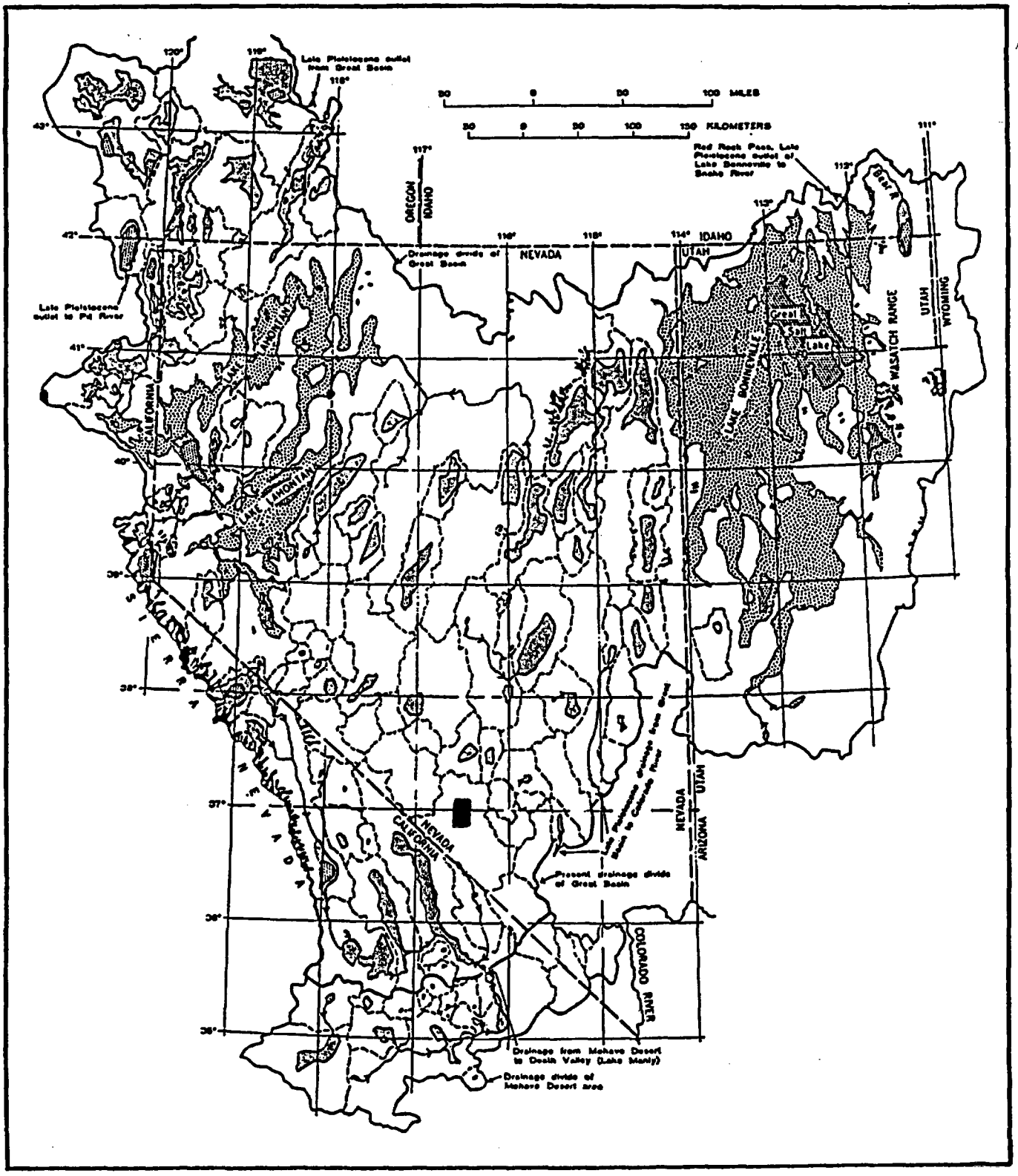


Figure 3. Plenipluvial Pleistocene lakes in the Great Basin (after Morrison, 1965; modifications from Mifflin and Wheat, 1979).

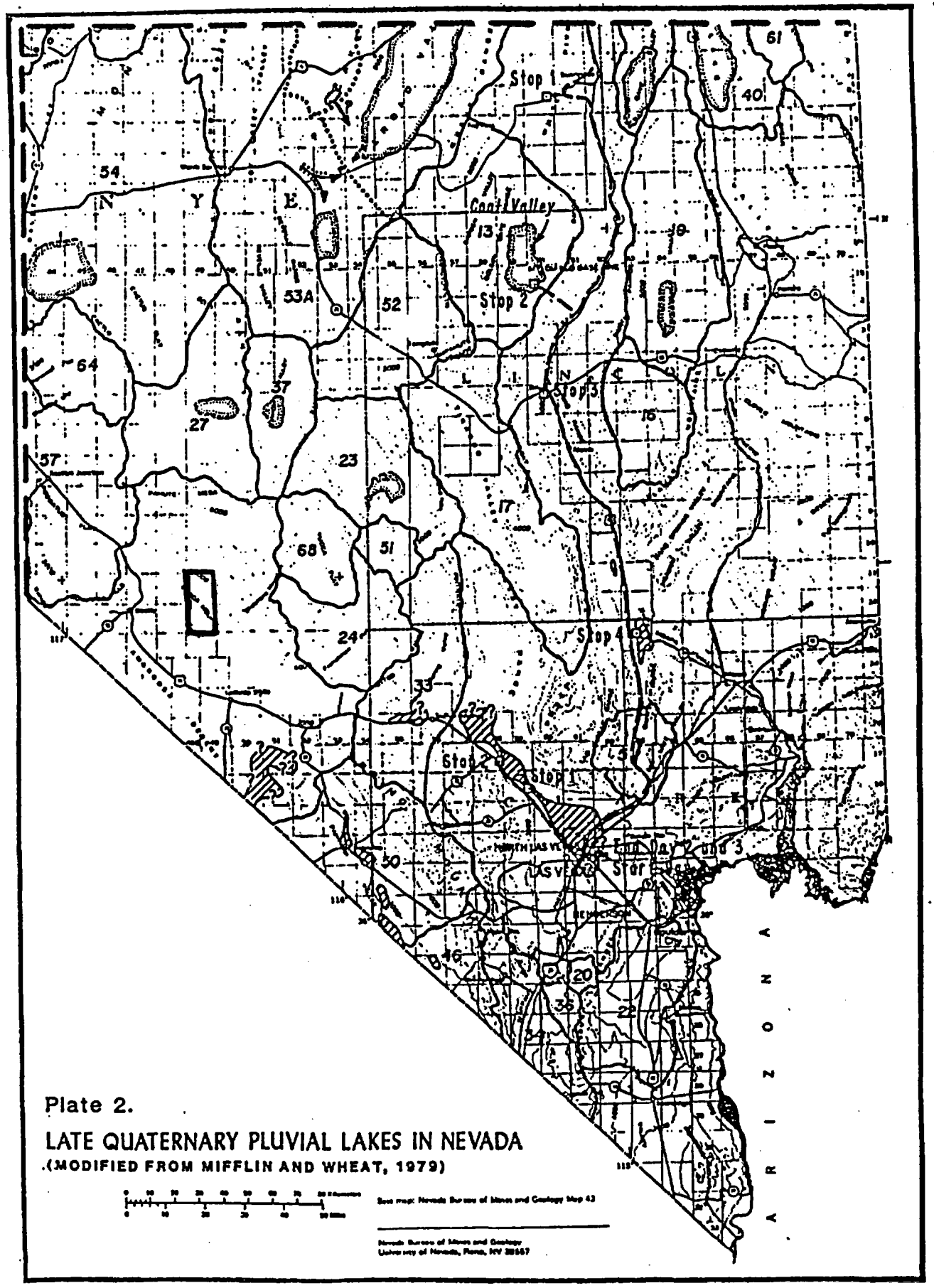


Plate 2.

LATE QUATERNARY PLUVIAL LAKES IN NEVADA

(MODIFIED FROM MIFFLIN AND WHEAT, 1979)

Base map: Nevada Bureau of Mines and Geology Map 43

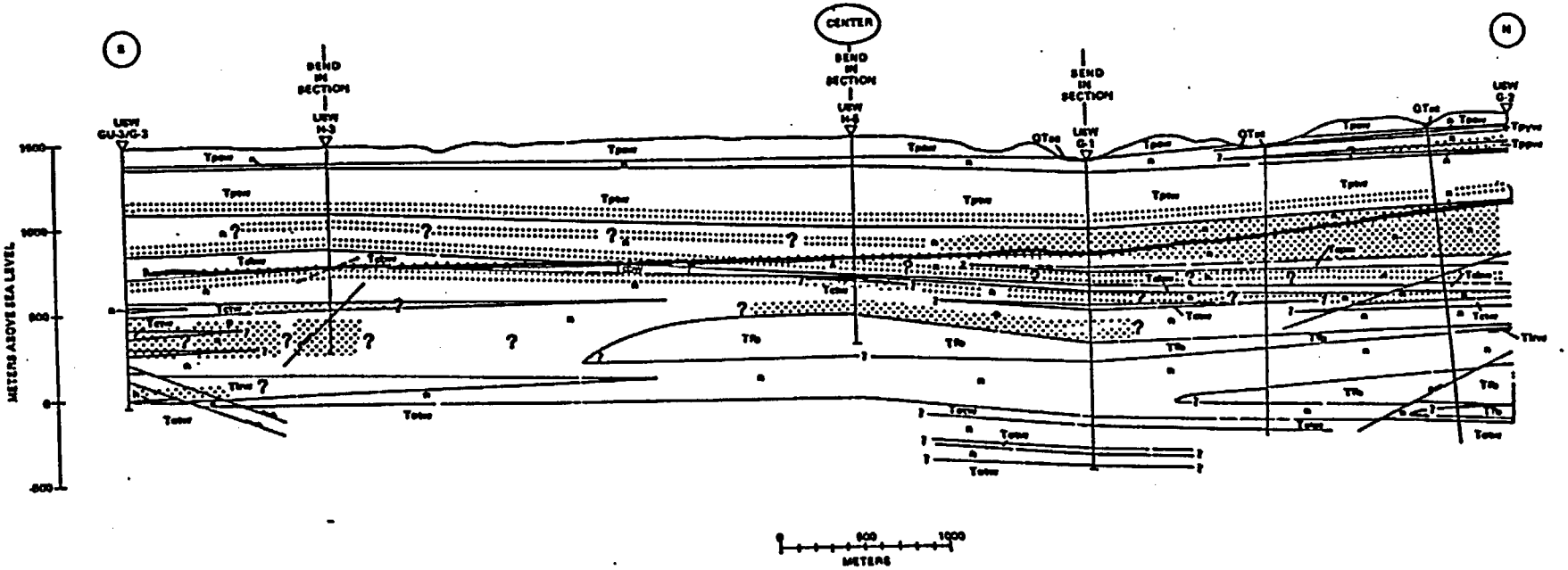
Nevada Bureau of Mines and Geology
University of Nevada, Reno, NV 89557

SITE-SPECIFIC EVIDENCE

- Glass alteration occurs well above the present water table. Some appears to be related to a paleowater table and some, well above the zone of complete alteration, to perched water.

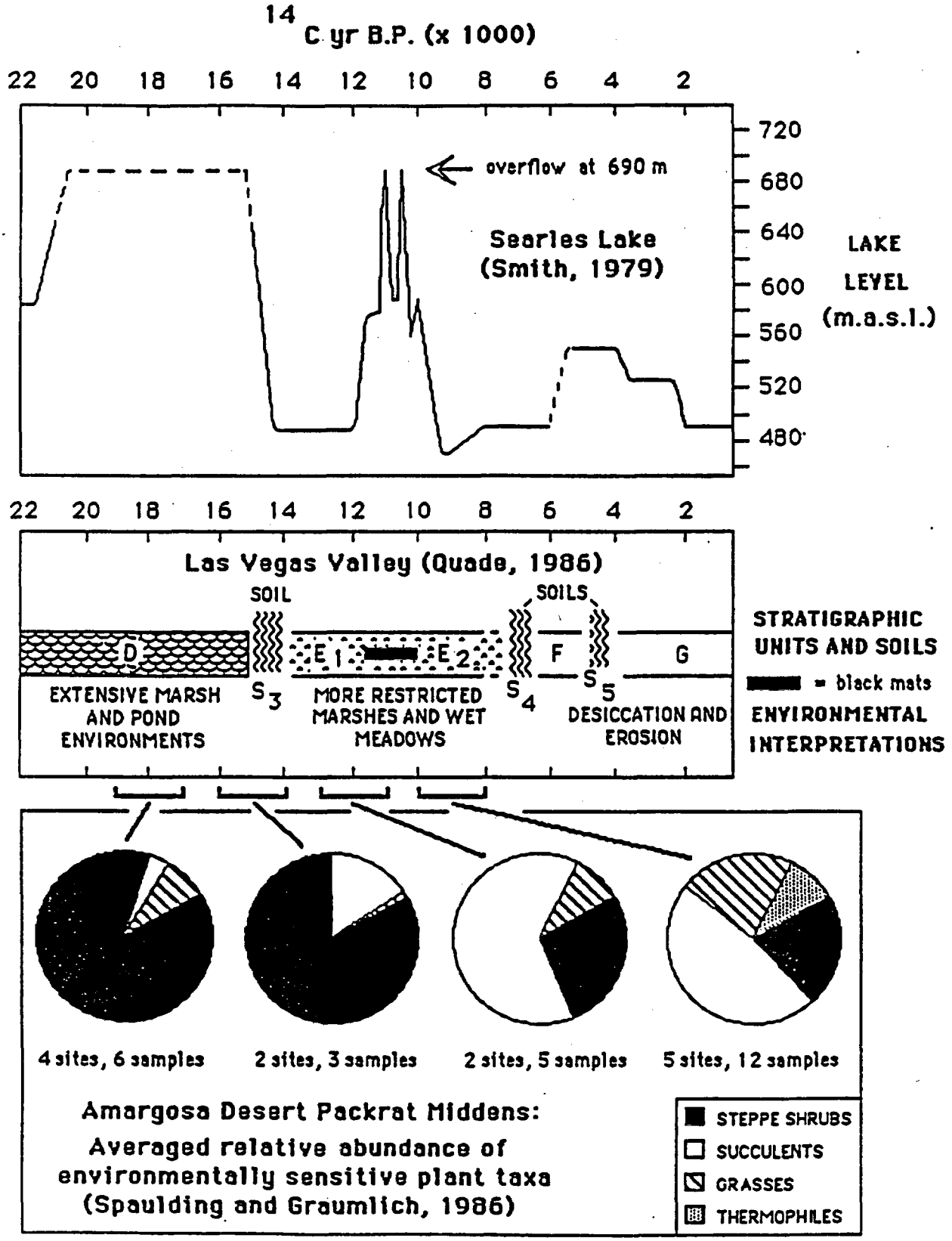
- Fractures have secondary mineral coatings and fillings precipitated from aqueous solutions.

- The macro-fossil evidence (packrat middens) reflects the timing of vegetation community changes, the approximate climate related, and, locally, phreatophytic plant fossils which require perennial saturation at root level.



Major Clinoptilolite / Mordenite Intervals

Modified from Bish & Vaniman (1985) LA-10543-MS


14 C yr B.P. (x 1000)
22 20 18 16 14 12 10 8 6 4 2
720
680
640
600
560
520
480
LAKE LEVEL (m.a.s.l.)
overflow at 690 m
Searles Lake (Smith, 1979)
Las Vegas Valley (Quade, 1986)
SOIL
SOILS
D
E1
E2
F
G
S3
S4
S5
EXTENSIVE MARSH AND POND ENVIRONMENTS
MORE RESTRICTED MARSHES AND WET MEADOWS
DESICCATION AND EROSION
STRATIGRAPHIC UNITS AND SOILS
= black mats
ENVIRONMENTAL INTERPRETATIONS
4 sites, 6 samples
2 sites, 3 samples
2 sites, 5 samples
5 sites, 12 samples
Amargosa Desert Packrat Middens:
Averaged relative abundance of environmentally sensitive plant taxa (Spaulding and Graumlich, 1986)
STEPPE SHRUBS
SUCCULENTS
GRASSES
THERMOPHILES

SUMMARY

- It is important to confidently predict future climate changes when characterizing a repository in fractured rock within the vadose zone because of hydrologic sensitivity to increases in effective moisture.

- A change to the full pluvial climate would markedly increase fracture flow and perched-water conditions.

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VITAE

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EDUCATION:

Ph.D., 1968, University of Nevada, in Hydrogeology.
M.S., 1963, Montana State University, in Applied Science.
B.S., 1960, University of Washington, in Geology.
Washington State University, Eastern Washington.

PROFESSIONAL EXPERIENCE:

President and Senior Hydrogeologist of Mifflin & Associates, Inc., a consulting firm which conducts hydrogeologic and geologic investigations, July, 1986 to Present.

Research Professor, Water Resources Center, Desert Research Institute, University of Nevada System. Research in ground-water problems in arid-zone hydrology. Specific areas of activity: carbonate-rock hydrology, ground-water exploration and development, exploratory-drilling techniques, vadose-zone moisture conditions, and recharge in arid terrane. During this period of time, major ground-water exploration and development programs were established for the State of Nevada (Jean Prison water supply, Valley of Fire State Park), the U.S. Air Force (Tonopah Test Range, Tolicha Peak), and Nevada Power Company (Meadow Valley Well Field development, monitoring, and modeling; carbonate-rock ground-water exploration program near Moapa). Program Director of the Yucca Mountain Candidate High-Level Nuclear Waste Repository technical support program for the State of Nevada (1983-1986), Sept., 1977 to July, 1986.

Senior Hydrogeologist, UNDP, Chile. Leave of absence from the Desert Research Institute for service in Region 4, Chile United Nations Development Program (UNDP) project. Water-resource assessment project in semi-arid region of Chile, chief resident administrative responsibility for the UNDP of the project, March, 1978 to March, 1979.

Water Resources Center Associate Director and Research Professor, Desert Research Institute, Las Vegas, Nevada. Head administrator for the Water Resources Center of the Desert Research Institute in the Las Vegas branch office. General responsibilities included research funding, direction, and execution of program of the Water Resource Center in Southern Nevada. Areas of research interest during this period included land subsidence caused by fluid withdrawals and associated earth fissures and faults in Las Vegas Valley and Mexico, deep carbonate-rock aquifers in Nevada as a potential water-supply alternative for Eastern and Southern Nevada, and waste-water treatment by natural marsh systems in Las Vegas Valley. Expert testimony on the Cross Florida Barge Canal ground-water hydrology was given to the State of Florida Bureau of Planning and Florida Cabinet in July, 1976; as well as serving on the board of review for the Water Element of the State Plan of Florida from 1976 to 1977. Periodic consulting 1975, 1976, 1977 for the Comision del Plan Nacional Hidraulico, in the area of ground-water policy and executed programs of resource evaluation and advanced training of personnel, July, 1975 to Sept., 1977.

Resident Consultor, International Bank for Reconstruction and Development (World Bank). Leave of Absence from the University of Florida in order to accept an 18-month position as World Bank Resident Consultor in ground water to the Plan Nacional Hidraulico (PNH), a newly-created planning organization within the Mexican government. Held additional position of Jefe de Aguas Subterraneas (chief in charge of ground-water planning and associated investigations within PNH). Responsibilities involved training and development of professional staff, development of procedures and policy, and direction of ground-water studies designed for both short and long-term planning of ground-water exploitation and management. PNH was a joint effort by the United Nations Development Programs (UNDP) and the Mexican Government. The effort of the UNDP was executed by the World Bank (International Bank for Reconstruction and

Development) and the procedure was to supply five resident consultors who were expert in various disciplines in water-resource planning and development. I was also appointed to a Mexican government management role, and maintained the Bank title. Subsequently, the experimental program was judged successful by the UNDP, World Bank, and the Mexican Government formalized the organization into the continuing national planning agency for water-resource development in Mexico (Comision del Plan Nacional Hidraulico, ASRH), Sept., 1973 to July, 1975.

Associate Professor Geology, University of Florida. Teaching responsibilities in the following courses: Physical Geology, Introductory Geosciences, Geomorphology, Structural Geology, Ground-Water Geology and Hydrogeology. Research was more or less limited to local problems of ground-water pollution and continued work (summers of 1970, 1972) on isostatic rebound in the Lahontan Basin of the Great Basin. Member of the University of Florida Graduate Faculty, served on graduate committees (M.S. and Ph.D.) for Geology, Environmental Engineering, Coastal Engineering, and Civil Engineering graduate students. Considerable involvement in ground-water pollution aspects of the Cross Florida Barge Canal controversy, with testimony given to Florida Legislative committees, the State of Florida Cabinet, and the U. S. Presidential Council on Environmental Quality. Principal expert witness in ground water for EDF and the Department of Interior in court proceedings (U.S. Government vs. Florida Canal Authority) in August, 1973, Sept., 1969 to July, 1975.

Research Associate, Desert Research Institute and Nevada Center for Water Resources Research. Activities primarily research in ground water and hydrogeology. Principal Investigator or co-investigator in research dealing with the following: hydrologic safety, AEC underground nuclear detonation; investigation of land subsidence in Las Vegas Valley and the development of the theory of mechanics; investigation of the hydrogeology of Las Vegas Valley for feasibility of artificial recharge; delineation of ground-water flow systems using studies of fluid potential, water chemistry, isotopes, and other methods: paleohydrologic investigations in Nevada (surface and ground water); stratigraphic studies of alluvial basins; documentation of mudlump formation and hydrologic relationships causing formation, and developing a theory for mechanics of formation; investigations of carbonate-terrain hydrology in Nevada using tritium and hydrogeochemical techniques; exploration and development of ground water in a number of arid areas for federal, state, and private agencies; investigation of techniques for delineation of ground-water flow systems. Other activities included guest and substitute lecturing in ground water, hydrogeology, and physical geology, and direction of graduate student research in the Great Basin on hydrologic problems, July, 1963 to Sept., 1969.

Graduate Research Assistant, Montana State University (the Montana State University experience consisted of 1/2-time teaching of geology laboratories and two winters of snow avalanche research), Sept., 1962 to June, 1963.

Geologist, GS-7, U.S. Geological Survey, field mapping in the Lemhi Range and Beaverhead Range, Idaho and Montana, May, 1962 to Sept., 1962.

Graduate Teaching Assistant, Montana State University, Sept., 1960 to June, 1962.

Apprentice Geologist, Pan Petroleum Corp., Field-reconnaissance mapping in Western Alaska, April, 1959 to Aug., 1959.

PROFESSIONAL AFFILIATIONS

Geological Society of America
National Water Well Association
Sigma Xi

PROFESSIONAL HONORS AND OTHER PROFESSIONAL ACTIVITIES:

DRASTIC Advisory Board Member, National Water Well Assoc., 1986-1987

Invited Speaker, 15th Annual Rocky Mountain Groundwater Conference on Today's Groundwater Issues, Phoenix, Arizona, Sept. 1986, "Total Basin Concept - Groundwater Flow Systems"

Invited Speaker, International Workshop on Regional Aquifers, Sponsored by the Institute of

Geophysics, UNAM, Mexico City, Feb., 1985, "Hydrogeology of regional systems in the Great Basin"

Co-Leader, Field trip, White River Hydrological (Karst) System, S.E. Nevada, 6th Conference on Karst Hydrogeology and Speleology (Friends of the Karst), Sept. 1979

Moderator, Water Supply Planning Session, AWRA Conference "Water Resource Management in a Changing Society," Sept., 1979, Las Vegas

Geological Society of America Meinzer Award Committee, term 1977-1980

Elected to DRI Faculty Senate, 1975-1978

Moderator, Special Session on Ground-Water Quality, Las Vegas Valley, NWWA Tech. Meeting, Las Vegas, 1976

Selected as resident international consultant in the field of ground water to the Mexican Government by the World Bank and UNDP, 1973-1975

Trustee: Florida Defenders of the Environment (1970-1977) FDE Scientific Committee Co-Chairman (1971-1974)

Appointed Chairman, Environmental Impact Committee City of Gainesville-Alachua Co. joint committee (Jan. 1973; resigned Aug., 1973)

Elected Foundation Advisory Member, Environmental Information Center, Florida Conservation Foundation, Inc., 1972

Elected member University of Florida Presidential Faculty Concerns Committee, 1971

Appointed member of University of Florida Ad Hoc Com. on Environmental Programs, 1971

Designated Program Moderator (1970 Nat. GSA Evening Discussion of Hydrology Section)

Member of the U.S. delegation to the Inter. Assoc. of Sci. Hydrol., Symposium Hydrology of Deltas, Bucharest, Rumania, 1969

Granted first sabbatical leave offered to DRI faculty, 1969

Elected to DRI Faculty Organization, 1968 to 1969

Program Chairman, Sigma XI Luncheon Lecture Series at University of Nevada, 1965 to 1966

Co-Author of scientific paper nominated for the G.S.A. Meinzer Award, 1965

NSF Basin and Range Field Conference Co-leader, 1965

INQUA Great Basin Field Conference Co-leader, 1965

Sigma Xi (Nominated at Montana State University for M.S. thesis).

CONSULTING EXPERIENCE:

Consultant to the U.S. Nuclear Regulatory Commission on Yucca Mountain, Nevada, 1982 to 1984.

Consultant to Government of Ecuador, ground-water development for irrigation, Rio Guayas Basin, 1982 to 1983.

Consultant to USAID, University of Wisconsin, and OTDC, Government of Tunisia, on design and feasibility of potable water development for dispersed populations in Central Tunisia, Feb.-Mar., 1980.

Consultant for the organization, and participant in "Seminar on Development and Rational Management of Groundwater of the Yucatan Peninsula" sponsored by the Banco de Mexico, S.A., Dec. 3-7, 1979, Merida, Yucatan, Mexico, 1979.

Consultant to Mexico, reviewer of all ground-water studies by CPNH 1973-77, Comision del Plan Nacional Hidraulico, ASRH, July 1977. State of Florida, Div. of State Planning, Water Element of State Comprehensive Plan, Panel of Experts, review of water element, 1977.

State of Florida, Dept. of Planning: testimony to the Florida Cabinet on hydrologic impacts of Cross Florida Barge Canal, June, 1976.

Ground-water consultant to Arthur D. Little, Inc. on bi-national water-resource development project for Colombia and Venezuela. Consultant to Mexico, organization of PNH-sponsored symposium entitled "La Soreexplotacion de Agua Subterranea en Algunas Partes del Mundo," Mexico City, Dec., 1975.

Nevada and California (1969-1973): runoff/erosion studies with respect to timbering activities in the Sierra Nevada (1972, major lumber company). Florida: lake dewatering hydrogeological studies for Lake Apopka (1970, Citrus Growers). Numerous

hydrogeological studies for land developers as senior hydrologic consultant for the firms Eco Impact, Inc. and Environmental Science Engineering, Inc. (1972-73). Solid-waste disposal and site suitability for Alachua County (1972). Three landfill sites located, evaluated, and subsequently adopted by the County. Landfill monitoring, Alachua County (1972-73). OffShore Nuclear Power Plant site evaluation - aspects of tectonic history and seismic hazards (major engineering firm, 1973).

Nevada and California (1963-1969): ground-water exploration and water supply development in arid terrain for U.S. Fish and Wildlife Service, Nevada State Parks, and several development and mining firms; ground-water supply and contamination studies, U.S. Gypsum.

PUBLICATIONS AND REPORTS:

Mifflin, M. D., Johnson, C. L., and Johnson, R. J., 1989, Hydrogeologic assessment, Upper Muddy River Valley, Nevada: Mifflin & Associates, Inc., 46 p., Appendices.

Mifflin, M. D. and J. Quade, 1988, Hydrogeology and paleohydrology of the Carbonate Rock Province of the Great Basin: Geol. Soc. Amer. Field Trip Guidebook, 1988 GSA Centennial, Annual Meeting.

Mifflin, M. D., 1988, Region 5, Great Basin, in Back, W., Rosenshein, J. S., and Seabar, eds., Hydrogeology: Boulder, Colorado, Geological Society of America, The Geology of North America, vol. 0-2, p. 69 to 78.

Mifflin, M. D., Ed., 1988, Review of consultation draft of the site characterization plan, Yucca Mountain Site, Nevada research and development area, Nevada (DOE/RW-0160), January 1988): Mifflin & Associates, Inc., 247 p.

Mifflin, M. D. and J. Quade, 1987, Estimating climate change from hydrologic response: Water Forum '86, ASCE Proceedings, Aug. 4-6, 1986, Long Beach, California.

Mifflin, M. D., et al., 1987, Technical review comments on the environmental assessment: Yucca Mountain site, Nevada Research and Development Area, Nevada (May 1986, Vols.I, II, III [DOE/RW-0073]): Mifflin and Assoc., Inc., 187 p.

Mifflin, M. D. and M. E. Morgenstein, Eds., 1985, Technical review comments on the draft environmental assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada: WRI-DRI, 169 p.

Mifflin, M. D. and D. E. Zimmerman, 1984, Ground-water availability in the lower Meadow Valley Wash near Glendale, Nevada: WRC-DRI, 52 p.

Glancy, P. A., R. L. Jacobsen, and M. D. Mifflin, 1984, The hydrogeology of the Carson and Truckee River Basins, Nevada: in Western Geological Excursions, 1984 Annual Meeting, Geol. Soc. Amer., vol. 3, Lintz, J. (Ed.), p. 52-146.

Woessner, W. W., M. D. Mifflin, D. E. Zimmerman, and K. E. Sullivan, 1983, Meadow Valley Wash exploration program, October and November: WRC-DRI, 47 p.

Mifflin, M. D.; A. Elzeftawy, S. W. Wheatcraft, and J. W. Hess, 1982, Henderson, Nevada rapid infiltration basin siting and monitoring study: WRC-DRI Project Report, 100 p.

Mifflin, M. D., 1982, Preliminary report on the Jean Correctional Facility test/production well: WRC-DRI Memo. Rept. to Nevada Legislature Intrium Finance Committee, 5 p.

Elzeftawy, A. and M. D. Mifflin, 1982, Soil sample analyses from borings of the RIB site for the City of Henderson: WRC-DRI Letter Report to URS/City of Henderson, 8 p.

Mifflin, M. D., 1982, Exploration and development of a ground-water supply for the southern Nevada Correctional Center, Jean, Nevada: WRC-DRI, 43 p. and Appendices.

Zimmerman, D. E., M. D. Mifflin, and K. E. Sullivan, 1982, Construction and testing of wells NPC-2, NPC-11, NPC-25, and NPC-34, Meadow Valley Wash Field: WRC-DRI, 203 p.

Mifflin, M. D. and A. Elzeftawy, 1982, Lateral hydraulic conductivity of the alluvial sediments near the RIB site: WRC-DRI Letter Report to City of Henderson, 6 p.

Mifflin, M. D., 1982, Preliminary results of additional test holes for the determination of the useful life of the test/production well, Jean Correctional Facility: WRC-DRI Memo. Rept. to Nevada Legislature Intrium Finance Committee, 4 p.

Elzeftawy, A., M. D. Mifflin, R. L. Skaggs, and M. J. Miles, 1981, TIMET waste leach liquor as a soil stabilizer: WRC-DRI Project Report, 64 p.

Woessner, W. W., M. D. Mifflin, R. H. French, A. Elzeftawy, and A. Zimmerman, 1981,

Hydrologic and salinity analysis of the lower Virgin River Basin, Nevada and Arizona: WRC-DRI Project Report, 171 p.
Mifflin, M. D. and A. Elzeftawy, 1981, Soils, geology and hydrogeology of the Laughlin area, Nevada: WRC-DRI Project Report, 75 p.
French, R. H., M. D. Mifflin, and J. Edkins, 1981, Salt storage in the lower Las Vegas Valley: WRC-DRI Project Report, 270 p.
Mifflin, M. D. and J. Harrill, 1981, Hydrogeologic characteristics of the Great Basin: Geol. Soc. Amer. Abstracts with Programs, vol. 13, no. 7.
Dickson, B. H., M. D. Mifflin, and M. E. Vollbrecht, 1980, Potable water for dispersed populations in central Tunisia: Regional Planning and Area Development Project, University of , 101 p. (in English and French).
Mifflin, M. D., 1980, Ground-water aquifer system assessment in carbonate terrane of the Great Basin: Symposium on Regional Aquifer Analysis, Amer. Geophy. Union, Fall Annual Meeting, San Francisco (Abst.).
Mifflin, M. D. and M. Wheat, 1979, Pluvial lakes and estimated pluvial climates of Nevada: Nevada Bur. of Mines and Geol. Bull. 94, 57 p.
Mifflin, M. D. and J. W. Hess, 1979, Regional carbonate flow systems in Nevada: in Maxey Memorial Volume 43, Jour. Hydrology, p. 217-237.
Mifflin, M. D., 1979, Ground water of the Rio Elqui Valley, Region IV, Chile: UNDP, Project Chi/69/535.
Hess, J. W. and M. D. Mifflin, 1978, A feasibility study of water production from deep carbonate aquifers in Nevada: Desert Research Institute, Water Resources Center, Pub. No. 4i054, 125 p.
Hess, J. W. and M. D. Mifflin, 1976, Water-quality investigation of Fort Churchill State Historical Monument, Lyon County, Nevada: Desert Research Institute, WRC, Project Report No. 45, 34 p.
Mifflin, M. D. and M. Wheat, 1971, Isostatic warping in Lahontan Basin, Northern Great Basin: Geol. Soc. Amer. Annual Meeting, Program and Abstracts, p. 467.
Mifflin, M. D., 1970, Mudlumps and suggested genesis in Pyramid Lake, Nevada: Inter. Assoc. of Sci. Hydrol., Symposium Hydrology of Deltas, Bucharest, Rumania, May, 1969, Pub. No. 90, p. 75-88.
Mifflin, M. D., 1970, Hydrology and conclusions: in Environmental Impact of the Cross Florida Barge Canal: Florida Defenders Environment, p. 17-19, 64-72 and 114-115.
Mifflin, M. D. and M. Wheat, 1969, Distribution of Late Quaternary lakes in Nevada: Desert Research Institute, Unpubl.
Mifflin, M. D., 1968, Recognition of ground-water flow systems configuration by fluid potential measurements: Geol. Soc. Amer., Program 1968 Annual Meeting, p. 200-201 (Abst.).
Mifflin, M. D., 1968, Delineation of ground-water flow systems in Nevada: University of Nevada Ph.D. Dissertation: Desert Research Institute, CWRR, Tech. Rept. Series H-W, No. 4, 11 p.
Mifflin, M. D., 1967, Hydrogeology: in A Reconnaissance of the Technology for Recharging Reclaimed Waste Water into the Las Vegas Ground-Water Basin: Desert Research Institute, Tech. Rept. Series H-W, Pub. No. 2, p. 14-29.
Mifflin, M. D., 1967, Formation of mudlumps in Pyramid Lake, Nevada: Geol. Soc. Am., Program 1967 Annual Meeting, p. 149-150 (Abst.).
Mifflin, M. D., 1967, Strange things are rising in Pyramid Lake, Nevada: State Journal, Science in Nevada, July 2, 1967 Issue.
Maxey, G. B., M. D. Mifflin, P. A. Domenico, and A. McLane, 1966, Geology and water resources of Red Rock Ranch: Mim. Rept. to the Red Rock Ranch Stockholders, 48 p., 2 maps.
Maxey, G. B. and M. D. Mifflin, 1966, Occurrence and motion of water in carbonate rocks of Nevada: Annual Meeting of the Amer. Assoc. for the Advancement of Science, Berkeley, California, Dec. 28-29, 1965. Published in Natl. Speleol. Soc. Bull., vol. 28, no. 3, July, 1966.
Morrison, R. B., M. D. Mifflin, and M. Wheat, 1965, Rye Patch Dam Pleistocene stratigraphy: INQUA VII Congress, Northern Great Basin and California Guidebook, p. 28-33.

Morrison, R. B., M. D. Mifflin, and M. Wheat, 1965, Pleistocene stratigraphy at the Badland Amphitheater on the Truckee River north of Wadsworth: INQUA VII Congress, Northern Great Basin and California Guidebook, p. 38-43.

Domenico, P. A. and M. D. Mifflin, 1965, Water from low-permeability sediments and land subsidence: Am. Geophy. Union, Water Resources Research, vol. 1, no. 4, p 563-576.

Domenico, P. A., M. D. Mifflin, and A. Mindling, 1965, Geologic controls on land subsidence, Las Vegas Valley, Nevada: Proceedings 4th Annual Symposium on Engineering Geology and Soils Engineering, Moscow, Idaho, p. 113-121.

Mifflin, M. D. and P. A. Domenico, 1964, Part II, Hydrogeology: in Seismology, Hydrogeology and Meteorology of the Proposed Nuclear Power Plant Site in Mason Valley, Nevada: Desert Research Institute Mim. Report to Sierra Pacific Power Co., 14 p.

Mifflin, M. D., G. B. Maxey, P. A. Domenico, D. A. Stephenson, and J. R. Hardaway, 1964, Hydrological investigations of the Sand Springs Range, Fairview Valley and Fourmile Flat, Churchill County, Nevada: VELA UNIFORM, Project SHOAL, AEC Report VUF-1001, p. 239-364.

Mifflin, M. D. and G. B. Maxey, 1964, Lahontan 16-inch well, construction pump tests, and recommendations: Desert Research Institute Letter Report to Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, 8 p.

Mifflin, M. D., 1964, Lahontan well #3 step-drawdown test and interpretations: Desert Research Institute Letter Report to Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, 8 p.

Mifflin, M. D., 1964, Hydrology of the Lahontan Basin, Northwestern Nevada: INQUA VII Congress, Northern Great Basin and California Guidebook, p. 25-28.

Mifflin, M. D., 1963, Preliminary report on the ground-water possibilities in the Valley of Fire State Park, Nevada: Desert Research Institute Letter Report of Sept. 19, 1963, to Dean L. Kastens, Director of the Nevada State Park Service, 6 p.

Mifflin, M. D., 1963, A discussion of the hydrology and hydrogeology in the Sand Springs Range, Churchill County, Nevada: Northwest Science, Spokane, Washington Meeting, Dec. 1963 (Abst.).

Mifflin, M. D. and G. B. Maxey, 1963, Preliminary report of the geology and hydrology of the Settlemeyer Site, Carson Valley, Nevada: Desert Research Institute Mim. Rept. to Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, 13 p.

Mifflin, M. D., 1963, Geology of a part of the southern margin of the Gallatin Valley, Southwest Montana: M.S. Thesis, Montana State University, Bozeman, Montana, 111 p.; Program of the 16th Annual Meeting, Geol. Soc. Am., Rocky Mtn. Sect. (Abst).

STUDIES DIRECTED AND/OR COAUTHORED IN MEXICO (In Spanish by Plan Nacional Hidraulico, Secretary of Water Resources, Mexico):

Ground-Water Reconnaissance and Availability, Region Closed Basins, No. Central Mexico, 1976.

Ground-Water Reconnaissance of Region Rio Lerma Basin, Central Mexico,1976.

Ground-Water Reconnaissance and Availability, Region Rio Bravo , 1975.

Ground-Water Reconnaissance and Availability, Region NW Pacific coast, NW Mexico, 1975.

Ground-Water Availability, Exploitation and Policy, National Water Plan of Mexico, in Plan Nacional Hidraulics de Mexico (1974) (1975), 1975.

Ground-Water Reconnaissance and Availability, Region Papaloapan, SE Mexico, 1974.

NNWPO PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: Mineral Resource Potential, Yucca Mountain Area, Nevada

DATE: June 26, 1989

PRESENTER: Lawrence T. Larson, Ph.D.

AFFILIATION: Professor and Chair,
Department of Geological Sciences,
Mackay School of Mines, University of Nevada at Reno

TELEPHONE: (702) 784-4002

MAIN ISSUES

» IS THERE POTENTIAL FOR MINERAL RESOURCES?

Potentially adverse conditions [10 CFR 60.122 (2) (c), 10 CFR 960.4-2-8-1 (c) (1)]

Presence of, or indications of mineral resources, identified or undiscovered, ...

» WILL THERE BE HUMAN INTERFERENCE AT YUCCA MT. IN SEARCH FOR MINERAL RESOURCES?

Safety Analysis Report [10 CFR 60.21 (c)]

Requires identification and evaluation of natural resources .., the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes...

EXISTING DATA ARE INSUFFICIENT

SUMMARY

1) YUCCA MTN. IS WITHIN AN AREA OF WIDESPREAD BASE/PRECIOUS METAL MINERALIZATION

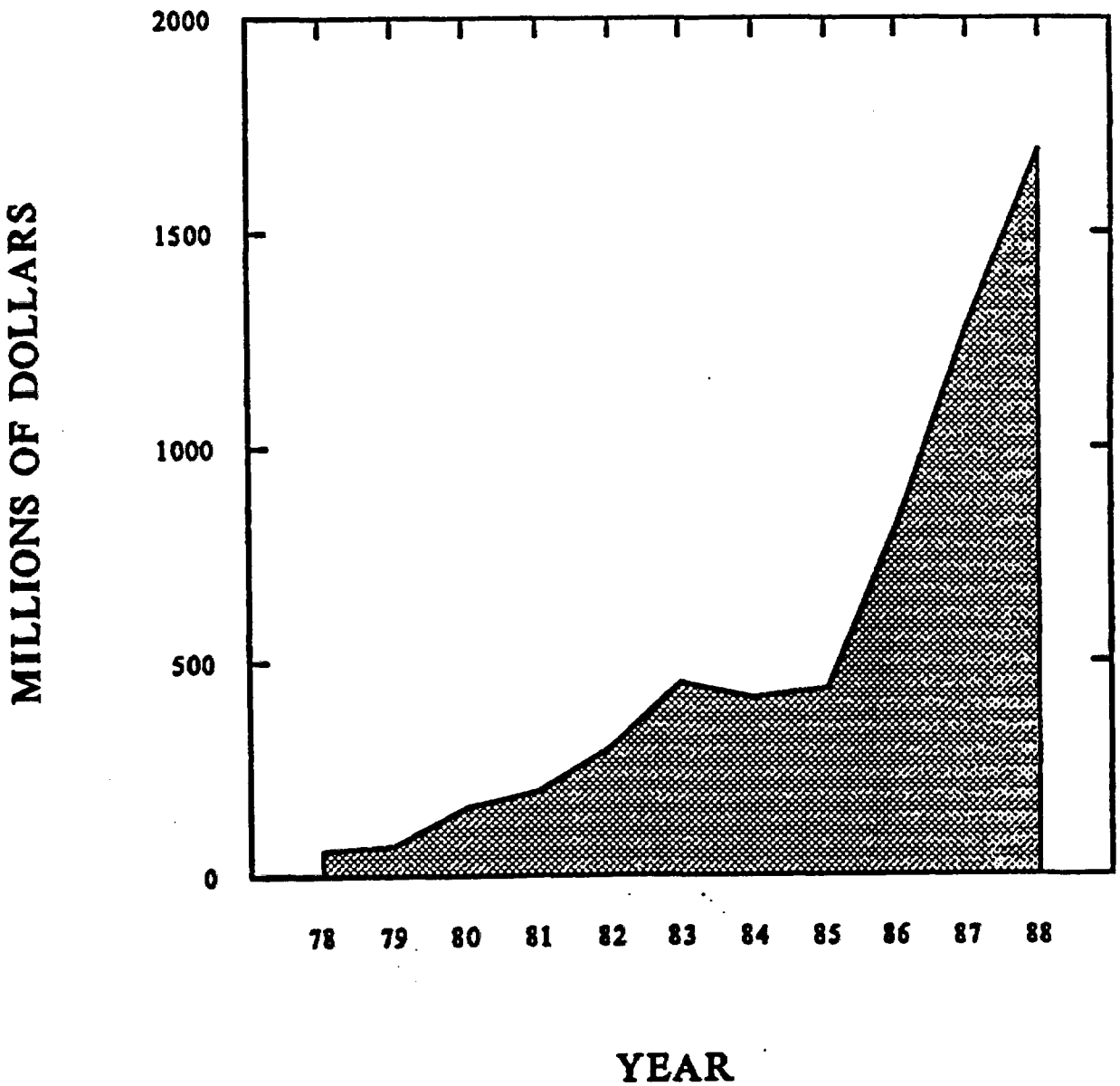
2) CURRENTLY THERE IS INTENSE MINERAL EXPLORATION AND DEVELOPMENT IN ALL AREAS SURROUNDING YUCCA MTN. THAT ARE OPEN TO MINERAL ENTRY

3) EXISTING INFORMATION IS INADEQUATE TO EVALUATE THE POTENTIAL FOR MINERAL RESOURCES IN YUCCA MTN. OR IMMEDIATE VICINITY

4) IT IS *IMPOSSIBLE* AT PRESENT TO RULE OUT THE PRESENCE OF MINERAL DEPOSITS IN YUCCA MTN.

5) HISTORICALLY, WHERE KNOWN OR *PERCEIVED* MINERALIZATION EXISTS, EXPLORATION/HUMAN INCURSION TAKES PLACE

NEVADA Au+Ag PRODUCTION



ACTIVE Au-Ag MINES NEAR YUCCA MOUNTAIN

(15 - 40 kilometers of the proposed repository)

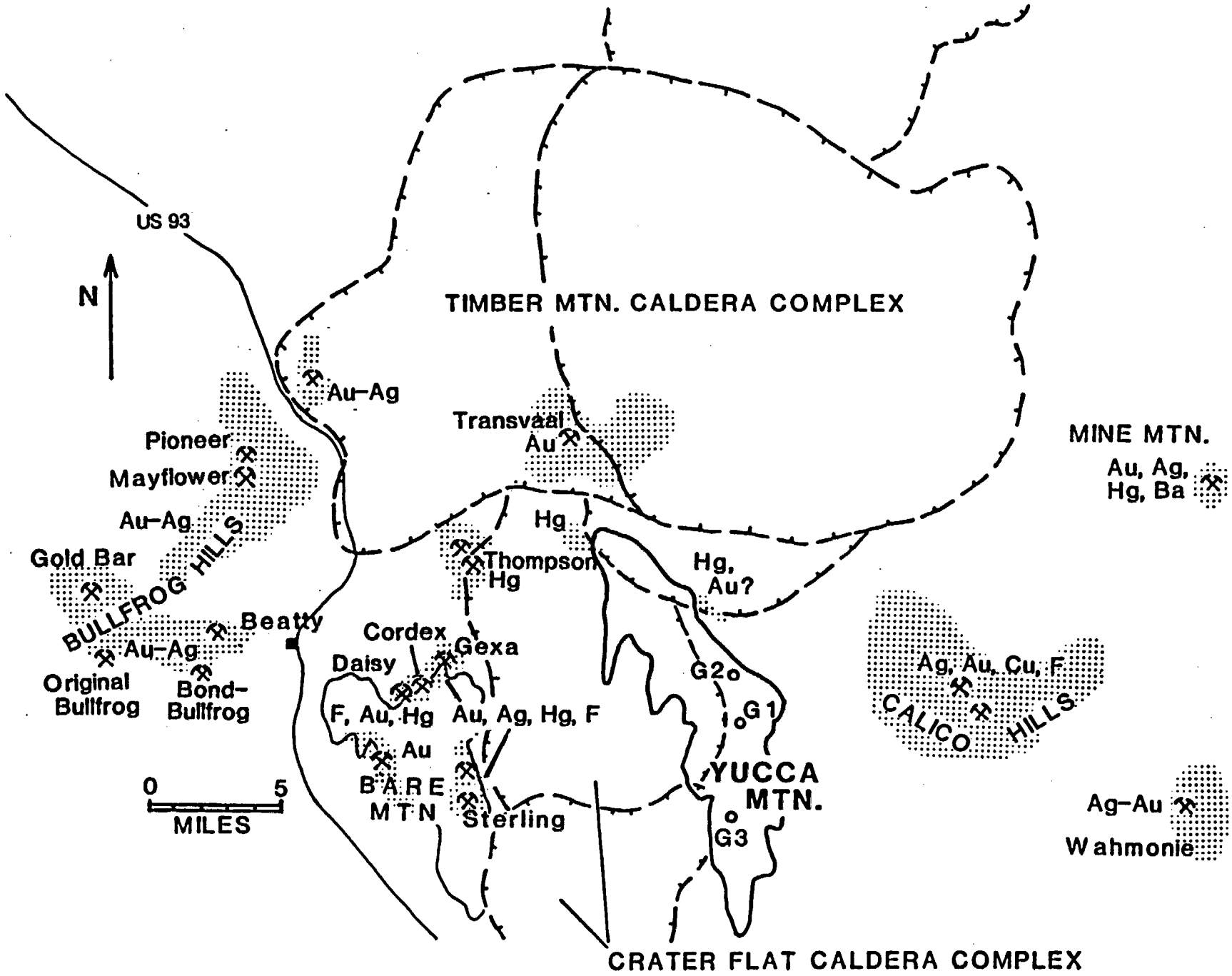
Au RESERVES

		ounces	approx. 1988 $$
»	STERLING MINE	75,000	30 million
»	GOLD BAR MINE	62,000	25 million
»	BOND-BULLFROG MINE	3,200,000	1.3 *billion*
»	GEXA MINE	250,000	100 million

COMMON GEOLOGIC FEATURES OF NEVADA ORE DEPOSITS

- » ROCK ALTERATION *e.g.,* Silicification, Adularization, Argillization
- » GEOCHEMICAL SIGNATURE *e.g.,* Au, Ag, As, Hg, Sb, Tl, Mo, Zn, Ba, F
- » FAULTS, BRECCIAS
- » FELSIC ("GRANITIC") DIKES, PLUGS, SILLS, AND STOCKS
- » LATE-STAGE BARITE ± FLUORITE VEINS

MINES, PROSPECTS, AND AREA OF HYDROTHERMAL ALTERATION NEAR YUCCA MOUNTAIN, SW NEVADA VOLCANIC FIELD



FEATURES OF MINES/PROSPECTS IN AREA OF YUCCA MTN.

» MINERALIZATION TYPES:

DISSEMINATED, VEINS, SKARN
Au-Ag, Hg, Cu-Zn-Mo-W, F, Ba

» HOST ROCKS:

DACITIC TO RHYOLITIC VOLCANIC ROCKS
PALEOZOIC SEDIMENTARY ROCKS

» HYDROTHERMAL ALTERATION:

SILICIFICATION
ADULARIA (HYDROTHERMAL POTASSIUM FELDSPAR)
ARGILLIZATION ± SERICITE ± ALUNITE

» CHEMICAL SIGNATURES

ELEVATED CONCENTRATIONS OF (ONE OR MORE):
Au, Ag, Ba, As, Sb, Pb, Cu, Zn, Mo, Hg, F

» FAVORABLE STRUCTURES:

FAULTS, BRECCIAS, CONTACTS

» PRESENCE OF DIKES, PLUGS, STOCKS

MINERAL POTENTIAL OF YUCCA MTN. AREA

» FAVORABLE GEOLOGIC ENVIRONMENT FOR HYDROTHERMAL MINERALIZATION

REPEATED MAGMATIC AND VOLCANIC ACTIVITY

ABUNDANT FAULTS, COMPLEX STRUCTURAL HISTORY

» PRODUCING MINES:

GOLD BAR MINE

STERLING MINE

DAISY MINE

» MINES IN DEVELOPMENT STAGE:

BOND-BULLFROG MINE

GEXA (MOTHER LODE)

» PROSPECTS WITH FAVORABLE GEOCHEMISTRY/GEOLOGY:

CORDEX-BERMUDA TRIANGLE (BARE MTN.)

TRANSVAAL

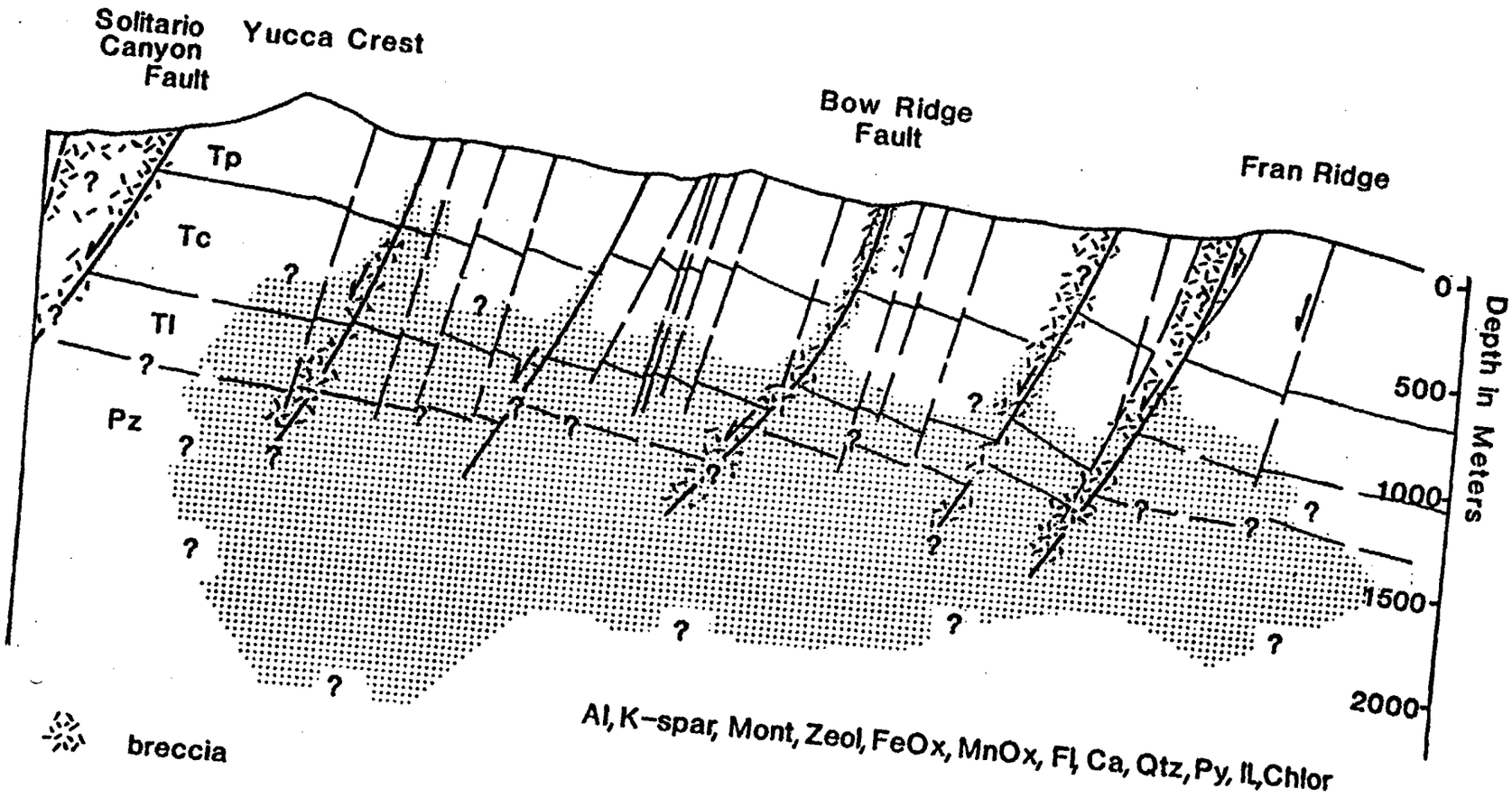
THOMPSON MINE (NW YUCCA MTN.)

CALICO HILLS (NTS)

WAHMONIE (NTS)

MINE MTN. (NTS)

GENERALIZED SECTION SHOWING POSSIBLE DISTRIBUTION OF HYDROTHERMAL ALTERATION, YUCCA MTN.



breccia

Tp Paintbrush Tuff

Tc Crater Flat Tuff

Tl Lithic Ridge Tuff and older volcanic rocks

Pz Paleozoic sedimentary rocks

FEATURES PRESENT AT YUCCA MTN. PERTINENT TO MINERAL POTENTIAL

» AREALLY EXTENSIVE HYDROTHERMAL ALTERATION IN SUBSURFACE
HYDROTHERMAL MINERAL ASSEMBLAGES INCLUDE:
Quartz, Illite, Albite, K-feldspar, Chlorite, Calcite, Barite, Pyrite (Zeolites are in part hydrothermal, not diagenetic)

» VERY LIMITED DATA SHOWS ELEVATED *F, Ba, Zn, Au?* IN SUBSURFACE AND
ELEVATED *As, Hg, Au, Mo, Zn, Ag* AT SURFACE:
N. Yucca Mtn. (Prow Pass, Claim Canyon), Trench 14

SUGGEST THAT HYDROTHERMAL SYSTEM(S) WAS METAL-BEARING

» AGE OF HYDROTHERMAL ACTIVITY IN YUCCA MTN.: 11-10 Ma

SAME AGE AS HYDROTHERMAL ACTIVITY AND MINERALIZATION IN BULLFROG HILLS, N. BARE MTN., TRANSVAAL, CALICO HILLS, MINE MTN.?

» VOLCANIC ROCK UNITS OF YUCCA MTN. HOST Au-Ag ORE AT GOLD BAR, BOND-BULLFROG, CORDEX PROSPECT, GEXA(?)

» PRESENCE OF NUMEROUS FAULTS AND BRECCIAS: HIGH-PERMEABILITY CHANNELS FOR HYDROTHERMAL FLUID CIRCULATION

CONCLUSIONS

- *RECENT DISCOVERIES AND NEW GEOLOGIC AND CHEMICAL DATA SUGGEST GREATER MINERAL POTENTIAL THAN PREVIOUSLY RECOGNIZED.*

- *HISTORIC AND CURRENT HIGH LEVELS OF EXPLORATION ACTIVITY IN SW NEVADA AND PRESENCE OF WIDESPREAD HYDROTHERMAL ALTERATION AND MINERALIZATION ASSURE HUMAN INTERFERENCE IF NTS AREA BECOMES ACCESSIBLE TO PUBLIC.*

- *EXISTING DATA DO NOT EXCLUDE POSSIBILITY OF ECONOMIC MINERALIZATION IN OR NEAR YUCCA MOUNTAIN.*

- *RESOLUTION OF THIS ISSUE REQUIRES FUNDAMENTAL GEOLOGIC, CHEMICAL AND GEOPHYSICAL INVESTIGATIONS CONDUCTED FROM EXPLORATION PERSPECTIVE.*

TRENCH 14

(PPM)

Au	*Ag*	*As*	*Hg*	*Sb*	*Cu*	*Mo*	*Pb*	*Zn*
0.004	0.034	7.93	0.122	<.247	7.16	0.587	7.75	23.8
0.005	0.423	110	0.799	24.6	27.9	65.3	154	33.2
0.002	0.031	7.31	0.147	<.245	4.52	0.422	5.31	19.0
0.004	0.048	15.6	0.373	10.1	11.1	1.23	16.4	90.8
0.001	<.015	5.89	0.349	2.90	2.71	1.80	10.7	147
0.001	0.048	11.2	0.553	6.36	4.11	2.29	14.8	75.5
0.002	0.049	11.2	2.02	2.89	2.95	1.58	46.6	892
0.001	0.141	14.1	3.08	8.69	14.4	2.54	78.6	344

Analyses by ICP methods

CLAIM CANYON AND NORTHWESTERN YUCCA MTN

(PPM)

Au	*Ag*	*As*	*Hg*	*Sb*	*Pb*	*Zn*
0.009	0.063	9.81	0.692	0.918	33.7	37.1
0.055	0.063	16.1	0.479	1.02	31.8	33.2
0.010	0.052	5.16	0.869	0.697	10.5	9.0
0.010	0.05	12.3	0.618	0.730	10.0	8.10
0.001	0.028	3.01	0.452	0.260	7.24	6.63
0.001	0.054	5.89	0.486	0.612	3.50	16.5
0.004	0.037	41.9	<.359	2.19	20.1	32.1
0.004	0.03	2.09	1.77	0.819	19.50	6.24
0.004	0.019	4.14	2.24	<.242	8.38	7.10
0.003	0.037	4.31	0.531	0.656	18.4	11.4

Analyses by ICP methods

VITA

LAWRENCE T. LARSON

GENERAL DATA

Date and place of birth: [redacted]

Marital Status: Married [redacted]

ADDRESSES

Office - Department of Geological Sciences
Mackay School of Mines
University of Nevada
Reno, NV 89557
Phone: (702) 784-4002

Home - [redacted]

PRESENT POSITION

Professor and Chairman - Geological Sciences (Geology, Geological Engineering, Geophysics, Geochemistry, Hydrology)

EDUCATION

B.S. - Geology (highest honors), University of Illinois, Urbana, 1957.
M.S. - Geology, University of Wisconsin, Madison, 1959.
Ph.D.- Economic Geology, University of Wisconsin, Madison, 1962.

PUBLICATIONS

See appended listing.

SCHOLASTIC HONORS, FELLOWSHIPS, ETC.

University Honors; Bronze Tablet - University of Illinois
Wisconsin Alumni Research Fellow - 1957-1959
Union Carbide Ore Company Research Fellow - 1959-1961
Phi Kappa Phi
Participant, NSF-AGI studies in Brazil, summer, 1966
Participant, NSF Institute, Sulphide Phase Equilibria, 1967
Fulbright Senior Professor, 1985-86

GRANTS AND CONTRACTS

National Science Foundation, 1969-1970. $12,000
Bendix - U.S. Dept. of Energy, 1977-1978. $125,000
Southland Royalty Corp. - U.S. Dept. of Energy, 1979-80. $154,000
Dept. of Interior, Office of Surface Mining, 1980-1983. $69,000
State of Nevada, Evaluation of Proposed Yucca Mountain Repository, Task III, 1987. $156,000
State of Nevada, Evaluation of Proposed Yucca Mountain Repository, Task III, 1988. $100,000
NATO, Division of Scientific Affairs, 1989. 390,000 Belgian Francs

COLLEGE/UNIVERSITY COMMITTEES

Faculty Development Committee, 1987-present
Sabbatical Leave Committee, 1982-85
Promotion and Tenure Committee - Univ. of Nevada, 1979-81
Ad hoc University Academic Master Plan Committee, 1980-81
Hydrology-Hydrogeology Interdisciplinary Committee, 1976-present
Mackay Mineral Research Institute Advisory Committee, 1979-present
Water Resource Center Technical Advisory Committee, 1977
International Studies Development and Review Board, UNR, 1978-80
Ad hoc Committee on Role and Function of Department Chairpersons, UNR, 1978-80
Governor's Committee on MX Missile siting in Nevada, 1981
Others

UNIVERSITY PROFESSIONAL RESPONSIBILITIES

1975-present:

Chairman and Professor of Economic Geology, Mackay School of Mines, University of Nevada, Reno, NV 89557. Responsibilities include direction and administration of the Department of Geological Sciences with a full and part time faculty of 18 to 20 professionals. Department student enrollment is composed of approximately 70 undergraduate majors and 110 graduate students pursuing degrees in geology, geological engineering, geophysics, geochemistry and hydrogeology/hydrology. From 1975-1979 geography (three faculty) degrees were also given in the Department. Administrative tasks include budget, course offerings and scheduling, graduate student admission, committee assignments, daily operation, faculty evaluation, recommendation for promotion and tenure, etc. Teaching responsibilities include graduate and undergraduate courses in economic geology, mining and exploration geology (including legal and environmental aspects of exploration

and mining), ore petrology and geochemistry. Additional significant teaching tasks include supervision of graduate student research and the teaching of individual tutorials and seminars in the area of ore deposits. Since 1976 I have also served as administrator and/or principal investigator of funded research projects resulting in published research articles (see bibliography and page 1, vita)

1961-1975:

Assistant (1961-1966), Associate (1966-1971) and Professor (1971-1975) of Geology, University of Tennessee, Knoxville, Tn. Responsibilities included teaching, research and graduate research supervision. Courses taught included Principles of Economic Geology; Metallic Mineral Deposits; Non-metallic Mineral Deposits; Geology of Fuels; Ore Microscopy; Regional Studies in Economic Geology; Introductory Physical Geology; Geology for Engineers, and various seminars in Sulphide Phase Equilibria; Massive Sulphide Deposits; Mississippi Valley Pb/Zn deposits; Geochemistry of Ore Forming Solutions, Metallogenic Provinces, etc. Directed the graduate research leading to two Ph.D. and 16+ M.S. degrees. Served on a number of Departmental, College and University committees. Performed publishable research (see bibliography).

CONTINUING EDUCATION/PREPARATION

1981-1982:

American Council on Education - Departmental Leadership and the Academic Chairperson. Two 4-day intensive training sessions by the ACE on planning management and leadership. Decision making, budgets, responsibilities, grievances, faculty evaluation(s), counseling, etc.

PROFESSIONAL ASSOCIATIONS

Fellow - Geological Society of America
Member - Society of Economic Geologists
Canadian Institute of Mining and Metallurgy
Northwest Mining Association
IAGOD - International Association on the Genesis of Ore Deposits
AGID - Association of Geologists for International Development
American Institute of Mining, Metallurgical and Petroleum Engineering
- Society of Mining Engineers
Member and Chairman (1978-79) Geochemical Committee
Member - Executive Committee, SME, 1981
Member - Jackling Award Committee, SME, 1980

Member - R. Peele Award Committee, SME, 1979
Registered Professional Geologist (#418) - State of Georgia

NON-ACADEMIC PROFESSIONAL ACTIVITIES

Co-Principal Investigator - Yucca Mt. Project Task III, 1987-present. Nuclear Waste Isolation, Nevada.
ABET - Visitor, Geological Engineering Programs, 1987- .
Consultant, Ranger Exploration, N.L., 1986-1988. Gold Exploration, Turkey.
Fulbright Senior Professor, 1985-86.
Consultant - British Petroleum Minerals, Brazil, 1983-1987.
General Chairman, Geological Society of America, 1984 Annual Meeting
Invited Speaker, Peruvian Geological Congress, July 1983
Administrator and Principal Investigator, USBM Grant to investigate Geochemical Exploration for precious metals using Fe/Mn oxide joint coatings, 1980-83.
Member, NSF Post Doctoral Fellowship Review Committee, 1982
Consultant - Sabine Production Company, 1980, 81, 82
Consultant - Freeport Exploration, R. Robinson and others, 1981, 1982, 1983
Consultant, Sandia Laboratories, 1981, 1982
Consultant - Westcoast Oil and Gas, Summer 1981
Consultant - United Nations Dev. Prog/World Health Org.- Feb. 1981
Chairman and Member of technical peer review committee- Nuclear Waste Isolation Program, U.S. Dept. Energy, 1979-83.
Consultant - Home Oil Corp., Canada. Gold Potential of properties in southeast and western U.S., Summer, 1980
Consultant - United Nations Dev. Program - Turkey. Zinc exploration and evaluation of resources and Turkish government exploration efforts. 1979
Administrator and Principal Investigator, Southland Royalty/U.S. DOE contract for Geothermal Reservoir Case Study, Nevada. Available time, 1979-80.
Consultant - Noranda Exploration Company. Uranium exploration in Nevada. Summer, 1978.
Principal Investigator and Administrator, Bendix Engineering/U.S. DOE contract for Uranium potential of the Great Basin. Available time, 1977-78.
Partner and geologic consultant - Applied Exploration Concepts. Designed and implemented copper exploration program for CONOCO, 1972-75.
Consultant - International Minerals and Chemical Corp. Copper exploration in Wyoming and Utah. Summer, 1971.
Consultant - Alcoa Corp. Copper/nickel exploration in Main. Summer, 1970.
Consultant - Duval Corp. and Placer Amex - Copper exploration, Montana/Idaho, 1969.
Consultant - Union Carbide Nuclear Corp-Oak Ridge National

Laboratories. Development of program to study reactor cladding products. Available time, 1963-1969.

Consultant - Tennessee Division of Geology. Study and mapping of mineral resources. Summers and available time, 1962-65, 1967.

Consultant - Several firms such as American Zinc, U.S. Borax and Chemical, Grealbeal Interests, etc. - Short (1 week to 1 month) contracts. 1961-present.

PUBLICATIONS * = reviewed publication

L. T. Larson - sole author unless otherwise indicated.

* Rotation Properties of Certain Anisotropic Ore Minerals: Econ. Geol., v. 56, pp. 569-583, 1961 (with others).

Geology and Mineralogy of Certain Manganese Oxide Deposits, Philipsburg, Montana: (Abs), GSA Special Paper 68, 1961, p. 215.

* Zinc-bearing Todorokite from Philipsburg, Montana: Amer. Mineralogist, v. 47, pp. 59-66, 1962.

* Geology and Mineralogy of Certain Manganese Oxide Deposits, Philipsburg, Montana: Econ. Geol., v. 59, pp. 54-78, 1964.

Field-trip guide to Corundum Hill, North Carolina: in Field Trip Guidebook, Joint ACA-MSA meeting, Gatlinburg, Tennessee, July 1965 (with F. S. Lesure).

* Mineral Resources Summary of the Waverly Quadrangle, Tennessee: Tenn. Div. of Geology, Geological Map and Mineral Resources Summary (MRS) 30-SE, 1965, 7 p.

* Mineral Resources Summary of the Standing Rock Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 29-MW, 1965, 15 p. (with R. H. Barnes).

* Mineral Resources Summary of the Bumpas Mills Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 28-SE, 1965, 17 p.

* Mineral Resources Summary of the Dover Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 29-NE, 1965, 12 p. (with R. H. Barnes).

* Mineral Resources Summary of the Hurricane Mills Quadrangle, Tennessee: Tenn. Div. of Geology, GM an;d MRS 31-NE, 1965, 4 p.

* Mineral Resources Summary of the Kimmins Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 41-NE, 1965, 17 p.

Mineral Resources Summary of the Cumberland Furnace Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 302-SE, 1966, 15 p.

Mineral Resources Summary of the McEwen Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 39-SE, 1966, 6 p.

Mineral Resources Summary of the Tharpe Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 28-SW, 1967, 17 p. (with others).

Mineral Resources Summary of the Ashland City Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 304-SE, 1967, 6 p.

Mineral Resources Summary of the Cheatham Dam Quadrangle, Tennessee: Tenn. Div. of Geology, GM and MRS 304-SW, 1967, 4 p.

* Determination of the Basal-Pole Orientation in Zirconium by Polarized Light Microscopy: Trans. Met. Soc. of AIME, v. 236, pp. 1104-1106, 1966.

* Equipment for the Quantitative Measurement of Reflectivity: Journ. of Scientific Instruments, v. 40, pp. 1088-1092, 1969.

* Reflectivity Measurements on Zirconium: Trans. Met. Soc. of AIME, v. 245, pp. 2047-2049, 1969.

* Cobalt and Nickel-bearing Manganese Oxides from the Fort Payne Formation, Tennessee: Econ. Geol., v. 65, pp. 952-962, 1970.

* Two Sources of Error in Low Temperature Inclusion Homogenization Determination, and Corrections on Published Temperatures for the East Tennessee and Laisvall Deposits: Econ. Geol., v. 68, pp. 113-116, 1973 (with others).

* Textural Study of Polycrystalline Pyrhotite by Reflectance Measurements and X-ray Pole Figures: Econ. Geol., v. 68, pp. 671-680, 1973.

A Short Course on Opaque Minerals: a Text Published for the 1973 S. E. Geol. Soc. of Amer. Meeting (with R. H. Carpenter), 203 p.

Geochemistry - a Review, 1976. Mining Engineering, Feb. 1977, 6 p.

The Great Basin Geologic Framework and Uranium Favorability. A Report to Bendix Corp., 3 vols. (226 p. Text and 696 p. Bibliography) plus Geologic, Geochemical, Geochronologic Map Folio 211 p. (189 maps + 22 stratigraphic columns) open filed, April, 1978. (Senior Author, with others).

* Uranium Potential of Zeolites in Volcanically Derived Sediments, Northern Reese River Valley, NV. AIME Preprint and Trans., 13 p., 1980 (with P. Basinski).

Geothermal Reservoir Assessment Case Study, Northern Basin and Range Province: U.S.-DOE Document, Contract No. DE-AC08-79E27006, 223 p. (with several other authors).

Geochemical Exploration for Precious Metals in the Great Basin Using Fe/Mn Oxide Joint Coatings. AIME Meeting and PREPRINT, Nov. 1981 (with W. Crone).

Overview of Energy and Mineral Resources for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, NV: U.S. Dept. of Energy Report, NVO-250, 64 p. + maps (with E. Bell).

Annotated Bibliography, Overview of Energy and Mineral Resources for the Nevada Nuclear Waste Storage Investigations, Nevada Test Site, Nye County, NV: U.S. Dept. of Energy Report NVO-251, 30 p. (with E. Bell).

<u>In</u> A Peer Review of the Nevada Nuclear Waste Storage Investigations: August 24-28, 1981: NVO 196-27 (DE84007255), Office of Scientific and Technical Information, U.S. Dept. of Energy, p. 38-43 and 144-155.

* A Comparison of Iron Oxide-rich Joint Coatings and Rock Chips as Geochemical Sampling Media in Exploration for Disseminated Gold Deposits: Journal of Geochemical Exploration, v. 20, pp. 161-178, 1984 (with others).

* Latest Miocene Hydro-Thermal Activity at the Willard and Scossa Mining Districts, Pershing County, North-western Nevada: Isochron/West, 1987, with D. C. Noble and E. H. McKee.

Geology and Gold Exploration in Western Turkey:, 1989. AIMME Preprint. 89-55, 5 pages, 9 illus.

ABSTRACTS (partial listing)

The Stratigraphic and Petrologic Controls of the Economics of a Pottsville Sandstone, Caryville, TN: GSA Special Paper, 1966 (with T. Freeman), National Distribution.

Preliminary Electron Microscope Studies of West Tennessee Ceramic Clays: Prog. for the 1967 annual meeting of S.E. Section of G.S.A. Regional Distribution.

Mineralogy of Certain West Tennessee Ceramic Clays: Prog. for the 1967 meeting of the S.E. Section of G.S.A. (with C. E. Merschat). Regional Distribution.

Geochemistry of Co and Ni in Southern Appalachian Massive Sulphide Ores: Prog. for the 1968 annual meeting of the S.E. Section of G.S.A., p. 51. Regional Distribution.

Cobalt and Nickel-bearing Manganese Oxides from the Fort Payne Formation, Tennessee: Prog. for the 1969 annual meeting, S.E. Section of G.S.A. Regional Distribution.

Textural Study of Polycrystalline Pyrrhotite by Reflectance Measurements and X-ray Pole Figures: Prog. for the 1970 National Meeting, G.S.A. National Distribution.

Disseminated Sulphides in Late Precambrian Metamorphic Rocks: Prog. of the S.E. Section of G.S.A., 1972 (with C.E. Merschat). Regional Distribution.

Basin Evolution and Mississippi Valley Type Ore Deposits: Abs. Northwest Mining Association, 1975. Regional Distribution.

Basin Evolution and the Distribution of Mississippi Valley Type Deposits: G.S.A., Southeast Section, 1975. Regional Distribution.

Geochemical Exploration for Precious Metals in the Great Basin Using Fe/Mn Oxide Joint Coatings. Abstracts with Program, AIME, Denver, 1981 (with W. Crone, R. Carpenter, and T.T. Chao).

Timber Mountain Magmato-Thermal Event: An Intense Widespread Culmination of Magmatic and Hydrothermal Activity at the S.W. Nevada Volcanic Field, 1987 (with Jackson, Noble and Weiss).

Hypersaline and Liquid CO2-bearing fluid inclusions suggest Candelaria sediment-hosted Ag deposit is related to a porphyry system, 1987 (with Foster and Noble).

STATE OF NEVADA

Presentation To

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SUMMARY - TECHNICAL CONCERNS

DATE: JUNE 26, 1989

PRESENTER: CARL A. JOHNSON

TITLE: ADMINISTRATOR OF TECHNICAL PROGRAMS

ORGANIZATION: NEVADA AGENCY FOR NUCLEAR PROJECTS
CARSON CITY, NEVADA

TELEPHONE: (702) 885-3744

SUMMARY

- FOUR GENERAL SITE SUITABILITY CONCERNS ARE INTERRELATED:

  1. SITE SUITABILITY TECHNICAL ISSUES
  2. REGULATORY POLICY ISSUES
  3. SITE DISTURBANCE ISSUES
  4. LONG-TERM POST-CLOSURE ISSUES

GENERAL OBSERVATIONS

1. SOUTHERN NEVADA AREA IS ACTIVE GEOLOGICALLY, TECTONICALLY, AND GEOHYDROLOGICALLY.

2. YUCCA MOUNTAIN IS TECTONICALLY AND GEOHYDROLOGICALLY COMPLEX.

3. COLLECTION OF ADEQUATE, RELIABLE, REPRESENTATIVE DATA TO RESOLVE SOME ISSUES MAY BE DIFFICULT TO IMPOSSIBLE WITH THE PRESENT STATE OF TECHNOLOGY

4. PREDICTION OF SITE PERFORMANCE OVER 10,000 YEARS WITH <u>REASONABLE ASSURANCE</u> MAY NOT BE POSSIBLE AT YUCCA MOUNTAIN

CONCLUSIONS

- YUCCA MOUNTAIN HAS NOT BEEN DETERMINED TO BE A SUITABLE SITE FOR ISOLATION OF HIGH-LEVEL RADIOACTIVE WASTE.
- IT IS QUESTIONABLE WHETHER DEMONSTRATION OF SUITABILITY AND REASONABLE ASSURANCE OF WASTE ISOLATION CAN BE ACHIEVED.