Enclosure 2

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

JUN 3 1986

MEMORANDUM FOR: King Stablein
Program Manager, NNWSI, WMRP

THROUGH: Paul Prestholt
OR, NNWSI

FROM: Charlotte Abrams
Geology/Geophysics Section, WMGT

SUBJECT: Trip report, 4-28-86, to SAIC Offices, Las Vegas, Nevada

PURPOSE OF TRIP: To attend a calcite-silica deposits working group meeting. An attendance list for the meeting is attached (attachment 1). The purpose of the meeting was to determine what work or investigations need to be done to resolve the origin and implications of the calcite-silica deposits located in the area of the proposed HLW repository at Yucca Mountain (see meeting notice, attachment 2).

Max Blanchard (WMPO) called the meeting to order and made some introductory remarks. Steve Mattson (SAIC) then took charge of the meeting. A preliminary agenda is attached (attachment 3).

John Stuckless (USGS) presented view graphs (attachment 4) which stated the problem with respect to the deposits, objectives and necessary investigations. His statement of the problem (see attachment 4, view graph 1) was adopted over the flow chart in the agenda (see agenda, attachment 3) with the addition of a category termed "multiple origins." Stuckless suggested that surface investigations should include: 1) a trench through the unfaulted colluvium-bedrock contact; 2) an additional trench parallel to trench 14; and 3) compilation of a regional map showing the location of other calcite-silica deposits. There was some question as to the value of such a map since it is doubtful that most secondary deposits would show as surface exposures.

With the current USGS work stop no new work is presently being initiated. Samples from some spring deposits have been collected and work will begin on those samples at the suspension of the work stop.

A drill hole is proposed to determine the vertical extent of the deposits and to enable workers to investigate the chemical, isotopic and mineralogical changes in the deposits with depth. A 600' drill hole was proposed. Steve Mattson (SAIC) raised the question of what would happen if the drill fails to intersect the veins. A lengthly discussion ensued as to whether the drill hole should be vertical or inclined; if multiple, shallow holes would provide more

information than one deeper hole; how many holes should be drilled; what sort of grid should be set up for drilling; and what diameter the core should be. The final consensus was that decisions about additional drill holes and their depth and placement should be based on the outcome of information from the initial hole and, therefore, these decisions should be made by the workers. Dry drilling was suggested as the presence of drill mud might alter the geochemical results.

Dave Vaniman (Los Alamos) will be looking at possible analogs from local spring, hydrothermal and pedogenic deposits. He will compare geochemical results from these analogs with the results from trench 14 samples. Attachment 5 gives a comparison of the mineralogy from some selected cold and hot springs studied at Los Alamos.

Planned mineralogical studies of the deposits in trench 14 and analog deposits will possibly:

1) provide a comparison between deposits of known origin (pedogenic, hydrothermal, and spring) with those in trench 14;

2) determine a temperature of deposition for the calcite-silica deposits in trench 14; and

3) give some evidence for or against hydrothermal alteration by an investigation of wall rocks and blocks included in the zone of secondary (calcite-silica) mineralization.

Planned isotopic dating should determine ages of deposits at and near the NTS. Comparison of ages from trench 14 to those of analog deposits of known origins and trace isotope work to provide information on paleopaths of water are also planned.

Stable isotope work will be conducted to determine the temperature of deposition and paleoisotopic composition of the ground water. Fluid inclusion studies have been done and will continue in order to determine the chemistry of the depositing fluid and the temperature of precipitation and homogenization.

Dave Vaniman listed possible analogue deposits to be studied. These included cold springs deposits of Mopa, Nevares, and in Amargosa Valley and hot springs at Bailey, Sou, and Steamboat Springs, Nevada. Cane Springs at the NTS was also suggested. C. Abrams (NRC) suggested vein deposits (paleohydrothermal) at Tonopah and Goldfield, Nevada, also be examined as possible analogs. Other sites suggested for analogue study are springs in Oasis Valley, at Wahmonie, and in Crater Flat; deposits at Busted Butte; and any deposits that should be

encountered in the proposed new trench parallel to trench 14. All possible analogue sites will be sampled for detailed major and trace element geochemistry, isotope studies, fluid inclusion work, mineralogy, and petrography. It was proposed that for continuity the same samples will be used for all analyses; therefore, all workers on the project should early on be in agreement as to what should be collected. In addition, trench 14 should be sampled for uranium dating.

Two references for hydrothermal veins were given to the DOE and their representatives by NRC representatives. These are:

Sawkins, F. J., 1984, Vein deposits and precious metal deposits of the Western United States in Metal Deposits in Relation to Plate Tectonics: Spring-Verlag, New York, p. 38-55.

Berger, B. R., and Eimon, P. I., 1983, Conceptual Model of epithermal precious metal deposits in Shanks, W. C., III, ed., Cameron Volume on Unconventional Mineral Deposits: Society of Mining Engineers, New York, p. 191-205.

Emily Taylor (USGS) presented a trench 14 status report (attachment 6). Much of her presentation is covered in attachment 6 or was mentioned in discussions by Dave Vaniman. Additional comments not covered under her "Research activity, Status of work" heading on attachment 6 are as follows: (Comment numbers correspond to the specific comment numbers in attachment 6.)

1) Mapping of the north wall of trench 14 will include only the first 30' from the east end. All walls will be photographed.

2) Dating of Quaterrary deposits of trench 14 is complete. This was questioned due to problems with QA and it was recognized that some confirmitory sampling may have to be done.

3) A surficial map of Yucca Mountain will be complete in approximately two years. Scale will be 1:24,000. A map of the Exile Hill area can be completed sooner.

12) Samples taken for analyses of bedrock alteration may also be compared with analogs.

15) Schon Levy (Los Alamos) has done an examination of drusy quartz from the bedrock in trench 14. She examined the quartz in thin section and fluid inclusion study of heating and filling temperatures yielded one oxygen isotope value. More fluid inclusion work is now in progress.

It was decided to deepen trench 14. This will be completed before any drilling is done. The question arose as to which wall of trench 14 should be preserved when the trench is widened. The USGS was encouraged to preserve the wall with the more pronounced veins (south wall) if possible.

Jerry Szymanski (DOE) stressed that some resolution of the vein deposits problem needs to happen soon and suggested a four to six month resolution schedule would be best. Due to the nature of proposed investigations that time frame is not reasonable. Also, until the work stop is lifted no new work can be initiated. Szymanski suggested that a work plan be developed and a schedule be adopted. The suggested schedule is as follows:

1) Develop a work plan.
2) Peer review
3) Final work plan - January 1987
4) Report (genesis, implications, recommendations) - June 1988
5) Peer review
6) Final report to NRC, workshop, RESOLUTION - August 1988

The work plan will include a statement of purpose, scope of work, a schedule, organization, and a QA plan. Work considered to be of highest priority includes deepening of trench 14, isotope work, and work on analogues. Suggestions for possible peer review committee members were taken from attendees of the meeting (attachment 7).

Charlotte Abrams

Charlotte Abrams
Geology/Geophysics Section

*Prestholt's concurrence by phone

SAIC
Science Applications International Corporation

L86-GEO-SRM-043

April 14, 1986

TO: Distribution

Subject: Meeting Notice on Workshop on Calcite-Silica Deposits

This letter is a reminder of the letter from Maxwell Blanchard (WMPO:MBB-976 dated March 31, 1986) announcing the upcoming workshop on Calcite-Silica Deposits. The workshop is to be held on Monday April 28, 1986, at SAIC, Las Vegas in Room 450 beginning at 8:30 a.m.

The purpose of the workshop is to finalize the strategy for resolving the remaining problems and questions about the calcite-silica deposits. The list of potential activities for resolving the questions covered at the end of the February 28, 1986, meeting included: determining oxygen, hydrogen, carbon, and strontium/lead isotopes; assessing the regional distribution, geography, and ages of the deposits; determining the origin of "silica plates" in the deposits; investigating trace elements occurring in minerals from these deposits and possible analog deposits; determining vertical extent of deposits; investigating trace elements occurring in minerals from these deposits and possible analog deposits; determining vertical extent of deposits; investigating use of radiogenic isotopes and/or stable isotopes for determining sources; determining extent of mineral segregations; considering possible hydromechanical mechanisms; expanding fluid inclusion studies; expanding field studies by deepening Trench 14A, and constructing a new trench between 14 and 14A; evaluating literature with regard to analog deposits; revisiting Wahmonie deposits to (a) compare characteristics, (b) determine ages, and (c) determine the depth to the water table; focusing attention on geologic mapping, field occurrence,and time relationships; detailing mapping to match laminae across zones within the faults; drilling slant hole at Trench 14; obtaining samples of spring deposits at Oasis Valley for comparison; mapping slickensides in Trench 14 for stress analysis; comparing bedrock silica cements to silica cements in soils; and removing surface material between Trenches 14 and 14A to expose fault trace for investigations of lateral continuity of deposits.

We expect to limit attendance to two or three key individuals from each organization who have the responsibility for reaching preliminary agreement on plans for resolving the remaining questions.

If you have any questions, please contact Steve Mattson (SAIC) at 295-1764 or FTS 575-1764.

Sincerely,

SCIENCE APPLICATIONS
INTERNATIONAL CORPORATION

Michael Voegele

Michael D. Voegele
Technical Director
Technical Programs Division

MDV:SRM:lab

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Project File 3.3.1

attachment 3

cc: Kevin Kreuss
Jeff Wagoner
Larry LeRoque

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APR 23 1986
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FROM: Steve Mattson

TO: L.D. Ramspott / LLNL

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W.W. Dudley - USGS
TO: D.T. Oakley - LANL
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Carl Johnson - State of NV.
TO: W.S. Twenhofel - SAIC - Lakewood, CO.
T.O. Hunter - SNL
TO: A. Jelacic - DOE / HQ
Blanchard - WMPO.

Number of pages excluding cover 4

Date 4/23/86

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ENCLOSED IS THE PROPOSED AGENDA FOR THE UPCOMING CALCITE-SILICA DEPOSITS WORKSHOP, APRIL 28, 1986. PLEASE DISTRIBUTE THE AGENDA TO THOSE PARTICIPANTS WHO WILL BE ATTENDING.

THANK YOU

STEVEN R MATTSON

FTS 575-1764

# PRELIMINARY AGENDA FOR FINAL WORKSHOP ON CALCITE-SILICA DEPOSITS

## Location and Date:

Monday, April 28, 1986
Science Applications Intl. Corp.
Valley Bank Center Building
101 Convention Center Drive
Las Vegas, NV 89109
Room 450, 8:30 a.m.

## Purpose of Workshop:

8:30 - 8:45 a.m. (Max Blanchard) To finalize the strategy for resolution of the remaining problems and questions about the calcite-silica deposits necessary for issue resolution and to satisfy guidance.

The origin(s) and mechanisms involved in the deposition or emplacement of the calcite-silica deposits is of prime importance. Enclosure 1 provides a flow chart of the possible origin(s) of these deposits. The flow chart is not intended to favor a particular origin of the deposits, but is included to be complete.

## Establishment of Priorities:

8:45 - 11:45 a.m. Group discussion that focuses on establishing a prioritized list of activities necessary to accomplish the purpose stated above. Priority of activities should be based upon the possible strength of the evidence to be acquired, the time frame of the procurement of the evidence, and the relative cost/benefit ratio of the proposed activity. Detailed outlines of the objectives of the activity should be established. The level of detail of an objective should be commensurate with that necessary to state an objective concisely and clearly.

The format presented in Enclosure 2 is suggested to be adopted by the group. This format includes a list of activities, a statement of objectives, an estimation of the time frame and a ranking of the activities in order to access their priority.

## Consensus of Priority List:

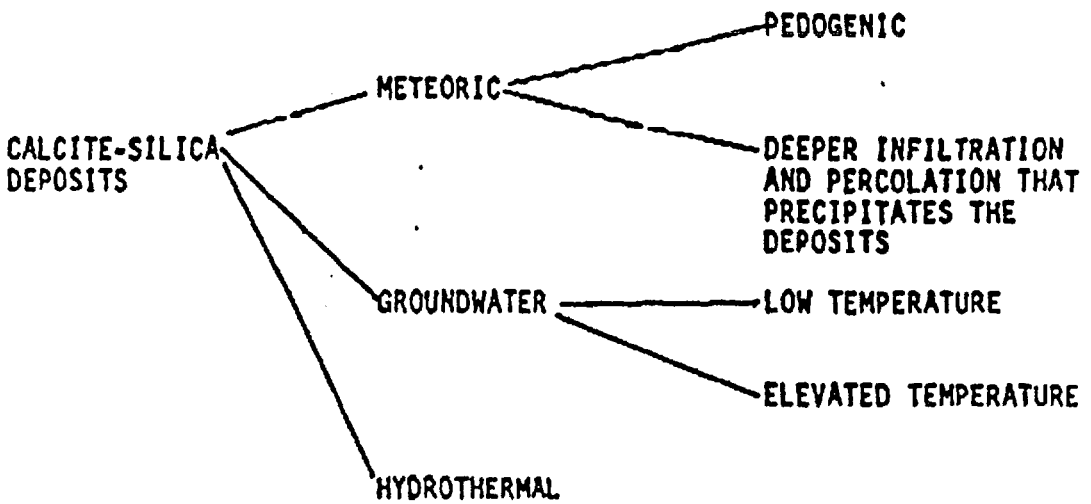
1:00 - 2:00 p.m. Group discussion on ranking of activities and finalization of the acceptance or rejection of activities on the prioritized list.

## Elements to be included in the package sent to the external review committee:

2:00 - 3:00 p.m.

1) Statement of intent and rationale for workshop
2) Meeting minutes from February 28, 1986
3) Meeting minutes from April 28, 1986
4) Compiled prioritized list with extended statements of objectives and estimated date of completion.

ENCLOSURE 1




MULTIPLE ORIGINS ARE ALSO POSSIBLE.

ENCLOSURE 2

EXAMPLE OF FORMAT

PRIORITIZED LIST

| RANKING 1 - 10 (High - Low) | ACTIVITY | OBJECTIVES | TIME 6MO-1YR | TIME 1YR-3 |
|---|---|---|---|---|
| 1 | Complete field mapping. Petrologic information on excavations and other field occurences already started. | Details of occurrence, mineralogy, field setting, paragenesis, and distribution and extent of deposits, etc. | | |
| 3 | Literature review of possible analog deposits. | Literature review of deposits with known origins with those occurring at Yucca Mtn. for comparative purposes, etc. | | |
| 3 | Analog deposits: known hydrothermal and pedogenic deposits for comparative purposes. | | | |
| | a) Trace elements (REE) | Determination of trace elements from known deposits for comparative purposes. Can known or determined distribution coefficients account for trace elements characteristics found in the minerals or whole rocks found at Yucca Mountain, etc. | | |
| 2 | b) Isotopic studies | Determination of stable isotopes (O,C,H) in analog deposits and Yucca Mtn. in order to characterize the deposits for known processes Localities for study are Oasis Valley, Wahmonie, and Yellowstone, etc. | | |
| | Investigations of possible spring deposits near Yucca Mountain. | | | |
| 1 | a) Field characteristics | To provide information and samples in order to compare these deposits to Yucca Mtn and analog deposits, etc. | | |
| 2 | b) Trace elements | Determination of trace elements on minerals and whole rocks in order to compare these deposits with those of Yucca Mtn and analog deposits, etc. | | |
| 2 | c) Isotope characteristics | (O,H,C,Sr, etc.) as described under analog deposits. Etc. | | |

OCRWM Nevada Nuclear Waste Storage Investigations PROJECT

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# STATEMENT OF PROBLEM

U.S. DEPARTMENT OF THE INTERIOR · U.S. GEOLOGICAL SURVEY

1. Do the calcite-silica deposits indicate increased potential for water at repository depth ?

2. What is the origin of the calcite-silica ?
   A. Ascending water ?
      - cold springs ?
      - hydrothermal ?
   B. Descending water ?
      - pedogenic ?
      - to what depth ?
   C. MULTIPLE ORIGINS ?

attachment 4

# SURFACE INVESTIGATIONS

1. Trench of unfaulted, bedrock-coluvium contact for comparison to Trench 14.

2. Trenching parallel to Trench 14 to reveal extent and morphology of deposit.

3. Regional map compilation of similar calcite-silica deposits.

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# TRENCH MAPPING

## Objectives

U.S. DEPARTMENT OF THE INTERIOR · U.S. GEOLOGICAL SURVEY

1. Characterize in detail the morphology of fault-related deposits.

2. Determine relative age relationships within the calcite-silica deposit.

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Nevada Nuclear Waste Storage Investigations PROJECT

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# ANGLE DRILL-HOLE

## Objectives

U.S. DEPARTMENT OF THE INTERIOR · GEOLOGICAL SURVEY

1. Determine vertical extent of calcite-silica deposit.
2. Investigate chemical, isotopic, and mineralogic changes with depth.

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# MINERALOGY

## Background

U.S. DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY

Presence or absence of certain minerals, degree of crystallinity, chemical composition of some minerals, and crystal morphology all vary as a function of temperature and mode of origin.

# MINERALOGY

## Objectives

1. Provide comparison to deposits of known origin.
2. Determine qualitative temperature of deposition for calcite-silica material in Trench 14.
3. Investigate wall rocks and included blocks for evidence of hydrothermal alteration.

# GEOCHEMISTRY

## Objectives

1. Compare major and minor element compositions of Trench 14 deposits to spring, lake, and pedogenic deposits at and near NTS.

2. Compare to published data elsewhere.

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# TRACER ISOTOPES
## Background

U.S. DEPARTMENT OF THE INTERIOR · GEOLOGICAL SURVEY

The isotopic compositions of Pb and Sr vary widely in different geologic material as a function of time and differing U/Pb or Rb/Sr.

Waters in contact with various geologic materials acquire the isotopic composition of those materials.

These compositions are then passed to chemical precipitates from those waters.

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# TRACER ISOTOPES
## Objectives

U.S. DEPARTMENT OF THE INTERIOR · GEOLOGICAL SURVEY

To determine sources of water-precipitated deposits and hence, paleo ground water paths

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# ISOTOPIC DATING

## Objectives

U.S. DEPARTMENT OF THE INTERIOR · U.S. GEOLOGICAL SURVEY

1. Determine absolute ages of spring, lake, and pedogenic deposits at and near NTS.

2. Detailed dating of Trench 14 to :
   - compare ages to deposits of known origin.
   - determine history of calcite-silica development.

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# STABLE ISOTOPES
## Objectives

U.S. DEPARTMENT OF THE INTERIOR · GEOLOGICAL SURVEY

1. To determine temperature of deposition for spring deposits.
2. To determine paleo isotopic composition of ground water.

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# FLUID INCLUSIONS

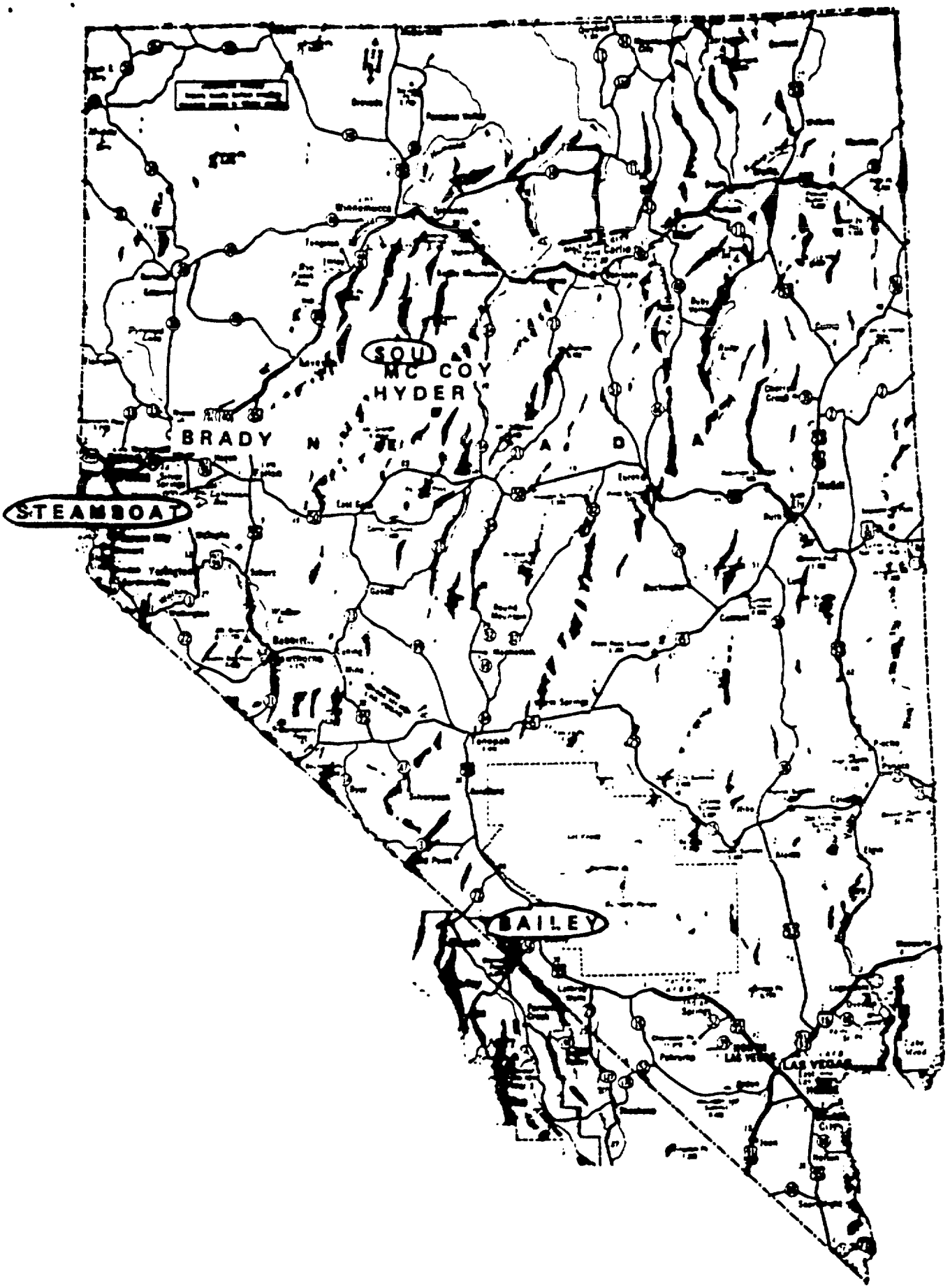
## Objectives

U.S. DEPARTMENT OF THE INTERIOR · U.S. GEOLOGICAL SURVEY

1. Determine chemistry of depositing fluid.
2. Determine temperature of precipitation.
   - homogenization temperature.
   - isotopic analysis.

# COLD SPRINGS

| | Moapa | Navares | Amargosa |
|---|---|---|---|
| Calcite | × | × | × |
| Dolomite | | | × |
| Sepiolite | | | × |
| Smectite | tr. | tr. | × |
| Quartz | | | tr. |
| Chalcedony | | | tr. |


SOU
MC COY
HYDER
BRADY
STEAMBOAT
BAILEY
LAS VEGAS

# HOT SPRINGS

| | Bailey | Steamboat | Sou |
|---|---|---|---|
| Opal A | x | x | |
| Quartz | x | x | |
| kaolinite | x | x | x |
| Smectite | | x | x |
| Alunite | x | x | |
| Calcite | x | | |
| Gypsum | x | | x |
| Sulfur | | x | |

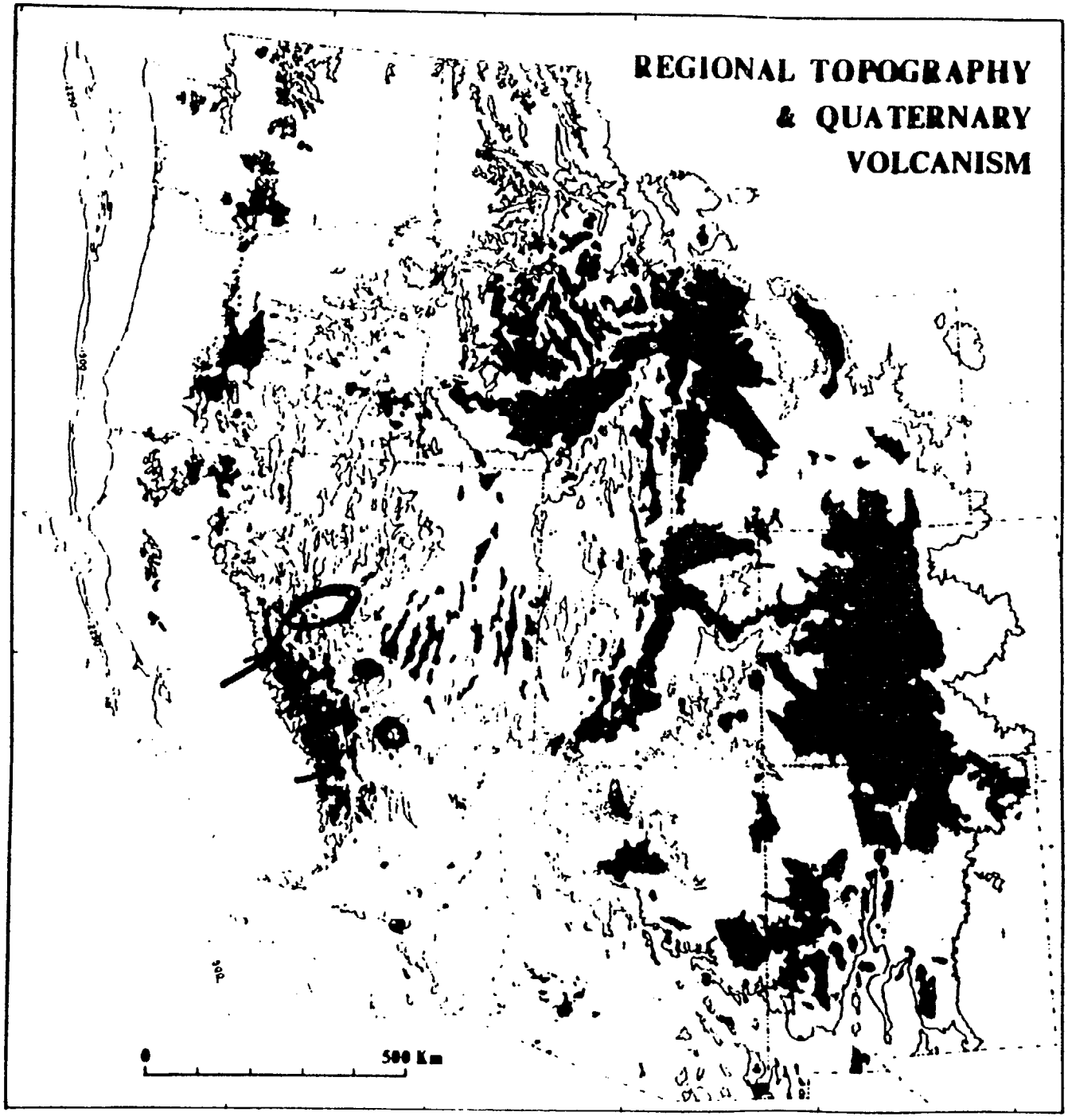



Fig. 3. Regional topography and Quaternary volcanism of the Western United States. Light gray, screened regions lie between 1.5 and 2.25 km; dark gray, lined regions lie in excess of 2.25 km. Submarine contours are given at −1.5 km and −2.25 km and generally lie within the continental slope. Black spots and splotches are not spilled ink but regions of Quaternary and presumed Quaternary volcanism. Topography is compiled from state and regional maps published by the U.S. Geological Survey (1:500,000 and 1:250,000). Volcanism is compiled with only minor modification from the standard state and regional geologic maps published by state and federal geological surveys. The age of many of the volcanic rocks is not well known in general, and a variety of map units are used in the published sources (for example *Qv*, *QRv*, *QTv*). The regional patterns of volcanism of interest to us here are insensitive to these chronologic problems.

4/28/86

# Trench 14--Status Report

## Purpose of Research

(1) To establish the timing and frequency of Quaternary faulting on the Bow Ridge Fault, on the east side of Yucca Mountain, NTS.

(2) To establish the origin of fault-filling $CaCO_3$ and opaline $SiO_2$.

## Research Activity

### Status of Work

(1) Map trench walls.

The south wall is completed for its full 56 m length. The north wall has been mapped from the east end, through the bedrock and main fault zone. The floor has been scraped, but needs to be cleaned to map the transition between the north and south walls.

(2) Date the Quaternary deposits exposed in trench.

U-trend dates have placed a minimum age on the lower colluvial unit of 590±90 ka, and an average age of 40 ka on the argillic B horizon. A U-series date of >500 ka has been obtained on an opaline $SiO_2$ stringer in the platy K horizon, near the main fault zone.

(3) Map the lateral extent of deposits exposed in Trench 14.

Detailed field mapping in progress.

(4) Age of most recent faulting.

The basaltic ash thought to be correlative with either the 290 ka or 1.2 My ash from Crater Flats will be K-Ar dated. This ash fills the fracture that cross cuts all other fractures, and thus appears to represent the most recent faulting event. The paleomagnetic orientation of ash will be determined. If it is the older of the two ashes its orientation should be reversed.

Carbonate fracture fill with slickensides from the east (bedrock) end of the trench has been submitted for U-series dating to obtain a maximum age for movement on that fracture, and estimated age for fracture filling in bedrock. Particle size distribution (PSD), $\%CaCO_3$, and bulk density are being measured to compare to the colluvium and the laminar fault-filling.

(5) Evaluate the morphology of fracture-fill in similar aged and younger colluvial deposits that are not immediately adjacent to bedrock.

Two backhoe trenches within 100 m south of Trench 14 have been excavated. The main fault is exposed in similar aged and younger depositional units.

(6) Evaluate the $CaCO_3$ and opaline $SiO_2$ morphology in deposits associated with increased runoff at unfaulted bedrock colluvial contacts.

A trench will be excavated across the valley to the west from Trench 14, to determine the amount and nature of $CaCO_3$ and opaline $SiO_2$ in deposits related to an unfaulted bedrock/colluvial contact.

(7) Relationship of $CaCO_3$ and opaline $SiO_2$--do they coprecipitate or is opaline $SiO_2$ replacing $CaCO_3$?

A plate from the K horizon containing a "sandwich" of opaline $SiO_2$ between dense $CaCO_3$ has been submitted for U-series dating. Thin sections are being prepared, and samples have been submitted to lab for particle size distribution (PSD), %$CaCO_3$, %opaline $SiO_2$, and bulk density.

(8) Physical, chemical, micromorphologic, and mineralogic characteristics of the deposits and the vertical fault-filling $CaCO_3$ and opaline $SiO_2$ from Trench 14.

Samples to be submitted for total chemistry (INAA or PIXE), major oxides (XRF), PSD, %$CaCO_3$, %opaline $SiO_2$, pH, and bulk density. Thin sections have been submitted. X-ray diffraction (XRD) work will continue. Elements such as S, Se, As, or Hg, and the clay minerals kaolinite and alunite, would be suggestive of spring deposition.

(9) Physical, chemical, micromorphologic, and mineralogic characteristics of the pedogenic deposits and associated $CaCO_3$ and opaline $SiO_2$ in the Yucca Mountain area.

Samples to be submitted for total chemistry (INAA or PIXE) and major oxides (XRF). Data exists on PSD, %$CaCO_3$, %opaline $SiO_2$, pH, and bulk density. Some thin sections have been prepared, and XRD work will continue.

(10) Physical, chemical, micromorphological, and mineralogic characteristics of associated $CaCO_3$ and opaline $SiO_2$ in regional cool, warm, and hot spring deposits.

Sample localities will include Oasis Valley, Wahmonie, and Ash Meadows. A number of spring deposits, including those from Bailey, Soe, Steamboat, and Moapa, have already been analyzed. Samples will be submitted for total chemistry (INAA or PIXE), major oxides (XRF), PSD, %$CaCO_3$, %opaline $SiO_2$, pH, bulk density, thin sections, and XRD.

(11) Temperature of precipitation of $CaCO_3$ and opaline $SiO_2$ in Trench 14.

Initial oxygen isotope data suggests an ambient air temperature (15 $^{o}$C) for the precipitation of the $CaCO_3$ and opaline $SiO_2$. However, this temperature is debated because of the assumptions on the original isotopic composition of the solution.

Samples for oxygen isotope determination have been taken in the platy K horizon and the basal $CaCO_3$ stringer, at 8 m intervals with increasing distance from the fault; and within the laminated $CaCO_3$ and opaline $SiO_2$ fault-filling from top to bottom of Trench 14. Indications of temperature change up and away from the fault would be expected in a spring deposit, while pedogenic $CaCO_3$ and opaline $SiO_2$ should be deposited at a similar temperature. No assumption is made on the original isotopic composition of the solution because only relative change will be considered.

The Sr/Pb ratios have been measured for the Yucca Mountain tuffs, the crystalline basement, and the limestone. The deposits in Trench 14 will be measured to see how similar or dissimilar they are from these known values.

The deterium/$^{18}O$ ratio has been determined for meteoric water. This ratio will be measured for the $CaCO_3$ and opaline $SiO_2$ to establish if deviations from the meteoric water line exist.

Crystal order (XRD) of opaline $SiO_2$ may be used to establish temperature of precipitation.

(12) Evidence for hydrothermal alteration of bedrock in fault zone.
Samples will be submitted for total chemistry; thin sections will be prepared and compared to non-faulted bedrock.

(13) Origin of breccia cement.
Silica cemented breccia samples will be submitted for XRD of cement, and thin section preparation.

(14) Vertical extent of $CaCO_3$ and opaline $SiO_2$ fault filling.
A low angle drill hole has been proposed that will intersect the main fault around 250 ft.

(15) Origin of drusy quartz in bedrock.
Initial data from fluid inclusions and geochemistry suggest that the drusy quartz in probably covolcanic.

ATTACHMENT 7

SUGGESTED PEER REVIEW COMMITTEE MEMBERS (with affiliation and speciality)

Art White, National Research Council, Spring deposits
John Hawley, New Mexico Tech, Soils
Hans Claussen, USGS, Hydrogeochemistry
Gail Hanson, Sunnybrook, Isotopes
J.C. Laul, BNL, Geochemistry
Byron Berger, USGS, Hydrothermal deposits, geochemistry
Price or R. Simbson, U of CA Santa Barbara, Seismic pumping
R. Morrison, Quaternary geology
H. Kanamori, Cal Tech, Seismology
Roger Phillips, Southern Methodist, geophysics
Pete Birkeland, U of Colorado, Soils science
K. Sieh, Cal Tech, active faulting
Dick Hutchinson, Colorado School of Mines, Economic and hydrothermal geology
Cerling, Utah, Paleohydrology
Phillip Bethke, USGS, hydrothermal deposits
Robert Schafer, Billiton Exploration, Hydrothermal deposits
A. H. Truesdell, USGS, Hydrothermal geochemistry
R.O. Fournier, USGS, Hydrothermal geochemistry