

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

OFC	:WMGT	:OR	:WMGT	:WMGT	:	:	:
NAME	:CAbrams	:PPrestholt*	:JTrapp	:PJustus	:	:	:
DATE	:86/05/	:86/05/	:86/05/	:86/05/	:	:	:

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: Springer-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 Quaternary deposits of trench 14 is complete. This was questioned due to problems with QA and it was recognized that some confirmatory 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.

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NAME	:CAbrams	:PPrestholt*	:JTrapp	:PJustus	:	:	:
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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).

151
Charlotte Abrams
Geology/Geophysics Section

*Prestholt's concurrence by phone

DFC	: WMGT	: OR	: WMGT	: WMGT	:	:	:
NAME	: CAbrams	: PPrestholt*	: JTrapp	: PJustus	:	:	:
DATE	: 86/06/2	: 86/05/28	: 86/05/02	: 86/05/02	:	:	:

☼ CALCITE-SILICATE DEPOSITS

STEVE MATSON	SAIC
Heather Huckins	F+S
Emily Taylor	USGS
Schön Levy	LANL
Dave Vaniman	LANL
UEL S CLANTON	DOE/OMWD
SZYMAŃSKI	DOE/NU
Bill Dudley	USGS
John Stuckless	USGS
BOB RAUP	USGS
Joe D'Luogozz	DOE
Ken CYSINSKI	WESTON
Charlotte Abrams	URC
LARRY MCKAGUE	LLNL LLNL URC
Kevin Krauss	LLNL
Harold Woffenberg	LBL
CARL JOHNSON	STATE OF NEVADA
MADRY MORVENSTEIN	DRI
LINDA LEHMAN	STATE OF NEVADA
CADY JOHNSON	DCI
Terrence Gerlach	SANDIA
TERRY GRANT	SAIC
AUGUST MATTHUSEN	SAIC

~~8~~ CALCITE-SILICATE DEPOSITS WORKSHOP 2

STEVE MATSON	SAIC	FTS 575-1764
Heather Huckins	F+S	" 295-6519
Emily Taylor	USGS	" 776-1141
Schön Levy	LANL	" 843-9504
Dave Vaniman	LANL	" 843-1165
UEL S CLANTON	DOE/OMPD	" 575-1589
SZYMAŃSKI	DOE/NV	-4 - 575-1503
Bill Dudley	USGS	776-4921
John Stuckless	USGS	776-7886
BOB RAUP	USGS	776-1273
Joe D'Luose	DOE	FTS-575-1862
Ken Cysinski	WESTON	301 963-5213
Charlotte Abrams	NRC	FTS 427.439
LARRY MCKAGUE	LLNL/ DOE /NRC	FTS 532-649
Kevin Krauss	LLNL	FTS 532-1372
Harold Wolfentz	LBL	FTS-458-5344
CARL JOHNSON	STATE OF NEVADA	702 885-3741
MARY MORDEWSTEIN	DRI	(702) 798-8882
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Terrence Gutlach	SANDIA	FTS - 844-5929
TERRY GRANT	SAIC	FTS 575-0067
AUGUST MATTHUSEN	SAIC	FTS 575-1409

attachment 2



Science Applications International Corporation

*All memo to
Ablein from
Abrams 6/3/86*

L86-GEO-SRM-043

102

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

A handwritten signature in cursive script that reads "Michael D. Voegle".

Michael D. Voegle
Technical Director
Technical Programs Division

Valley Bank Center, 101 Convention Center Drive, Suite 407, Las Vegas, Nevada 89109, (702) 295-1204

Technical & Management Support Services Contractor Nevada Nuclear Waste Storage Investigations

Other SAIC Offices: Albuquerque, Chicago, Dayton, Denver, Huntsville, Los Angeles, Oak Ridge, Orlando, San Diego, San Francisco, Tucson and Washington, D.C.

Distribution
April 14, 1986
Page Two

MDV:SRM:1ab

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Larry McKague, LLNL, Livermore, CA
P. T. Prestholt, NRC, Las Vegas, NV
J. W. Whitney, USGS, Denver, CO
W. E. Wilson, USGS, Denver, CO
W. B. Meyers, USGS, Denver, CO
John Stuckless, USGS, Denver, CO
W. W. Dudley, USGS, Denver, CO
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Dan Muhs, USGS, Denver, CO
E. M. Taylor, USGS, Denver, CO
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J. L. Younker, SAIC, Las Vegas, NV
S. R. Mattson, SAIC, Las Vegas, NV
M. D. Teubner, SAIC, Las Vegas, NV
D. B. Jorgenson, SAIC, Las Vegas, NV

cc:

M. Spaeth/W. Macnabb/W. Devlin
J. LaRiviere/B. Sweeney
S. Klein/S. Metta
M. Foley
J. Donnell
Project File 3.3.1

attachment 3

cc: Kevin Knuss
Jeff Wagoner
Larry McKeague

RECEIVED BY

APR 23 1986

LLNL-NAWSI PROJECT..

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
101 Convention Center Drive #407
Las Vegas, Nevada 89109

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Machines: FTS 575-1206
702 295-1206
FTS 575-1552
702 295-1552
Verify: FTS 575-1550
702 295-1550

FROM: Steve Mattson

TO: L.D. Ramspoth / LLNL

TO: P.T. Presthott / NRC - LV.

W.W. Dudley - USGS
TO: D.T. Oakley - LANL
D.T. Vaniman

Jerrane Gorlock - SNL
TO: Heather Hutchins - FTS

Carl Johnson - State of NV.

TO: W.S. Juwendofel - SAIC - Lakewood, CO.

T.O. Hunter - SNL
TO: A. Jelacic - DOE / HQ
Blanchard - WMAP.

Number of pages excluding cover 4

Date 4/23/86

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
Steve

STEVEN R. MATTSO
FTS 575-1764

2.1

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:

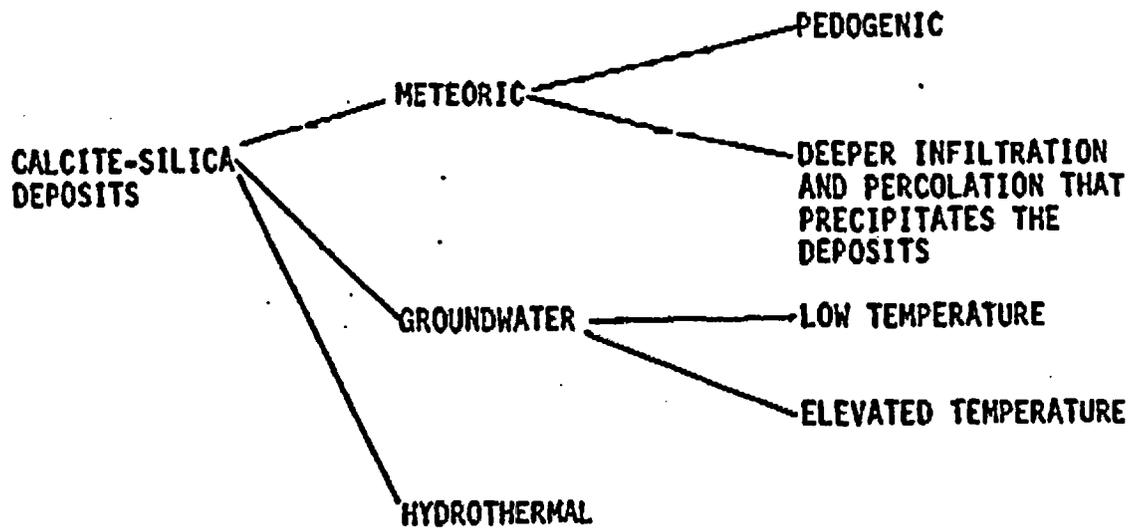
1:00 - 2:00 p.m. Group discussion on ranking of activities and finalization of the acceptance or rejection of activities on the prioritized list.

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

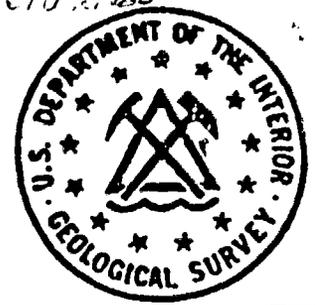
PRIORITIZED LIST

RANKING 1 - 10 (High - Low)	<u>ACTIVITY</u>	<u>OBJECTIVES</u>	TIME FRA <u>6MO-1YR 1YR-3</u>
1	Complete field mapping. Petrologic information on excavations and other field occurrences 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.		

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STATEMENT OF PROBLEM



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 ?

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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



1. Characterize in detail the morphology of fault-related deposits.
2. Determine relative age relationships within the calcite-silica deposit.

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ANGLE DRILL-HOLE

Objectives



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

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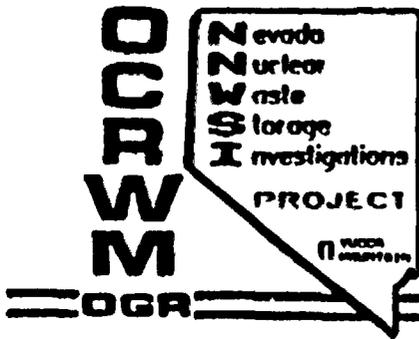
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MINERALOGY

Background

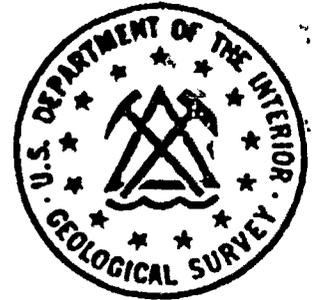


Presence or absence of certain minerals, degree of crystallinity, chemical composition of some minerals, and crystal morphology all vary as a function of temperature and mode of origin.



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.

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U.S. DEPARTMENT OF ENERGY

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



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



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

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ISOTOPIIC DATING

Objectives



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



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

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OGA

FLUID INCLUSIONS

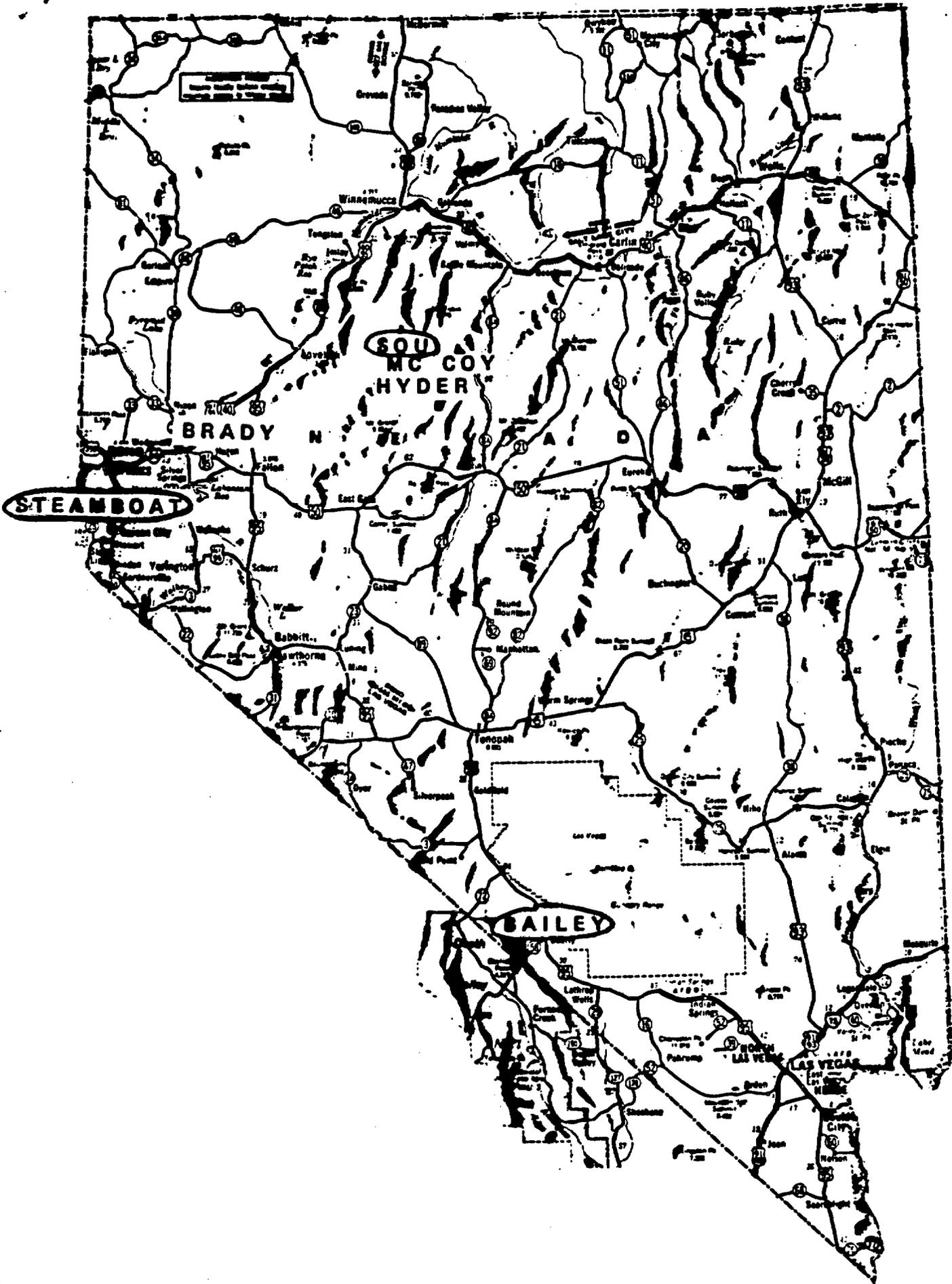
Objectives



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

COLD SPRINGS

	<u>Moapa</u>	<u>Navares</u>	<u>Amargosa</u>
Calcite	x	x	x
Dolomite			x
Sepiolite			x
Smectite	tr.	tr.	x
Quartz			tr.
Chalcedony			tr.



HOT SPRINGS

	<u>Bailey</u>	<u>Steamboat</u>	<u>Sou</u>
Opal A	x	x	
Quartz	x	x	
Kaolinite	x	x	x
Smectite		x	x
Alunite	x	x	
Calcite	x		
Gypsum	x		x
Sulfur		x	

REGIONAL TOPOGRAPHY & QUATERNARY VOLCANISM

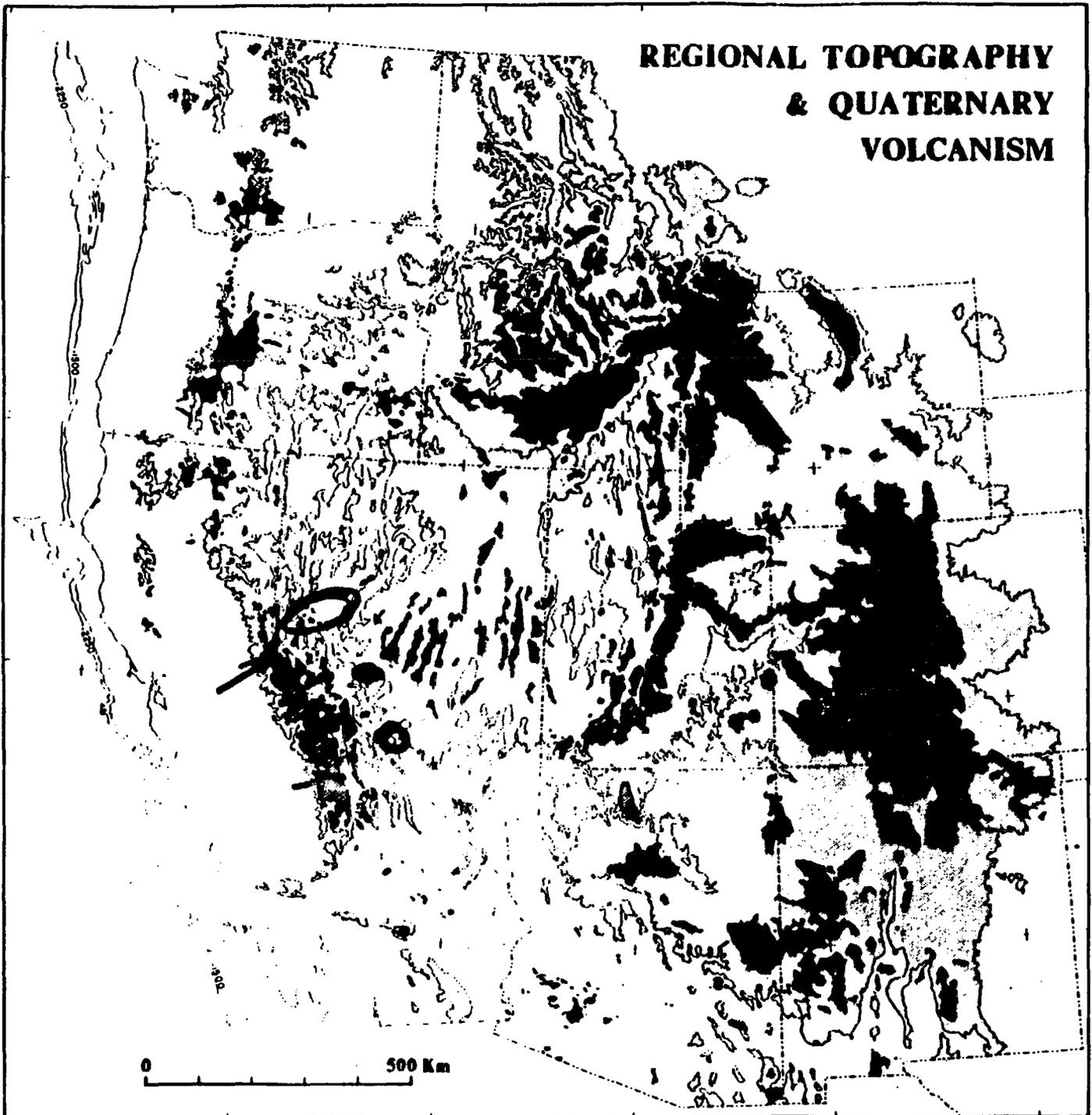


Fig. 3.
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4/28/86

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), $\% \text{CaCO}_3$, 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 °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 deuterium/¹⁸O ratio has been determined for meteoric water. This ratio will be measured for the CaCO₃ and opaline SiO₂ to establish if deviations from the meteoric water line exist.

Crystal order (XRD) of opaline SiO₂ 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 CaCO₃ and opaline SiO₂ 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 is 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