Department of Energy
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114-4100

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JUN 26 1986

Those on Attached List

FINAL SUMMARY OF WORKSHOP ON FAULT-RELATED CALCITE-SILICA DEPOSITS NEAR YUCCA MOUNTAIN HELD ON APRIL 28, 1986

This letter transmits the final summary of the workshop on calcite-silica deposits held at Science Applications International Corporation (SAIC) on April 28, 1986. Corrections, comments, and additions received via telephone conversations and letters have been incorporated into the enclosed text.

Resolution of the remaining questions regarding the origin and regulatory implications of the calcite-silica deposits is a topic of great importance to the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. An External Peer Review Meeting will be held in order to assess the work plans directly related to the calcite-silica deposits. This meeting will review the proposed work for scientific merit and pertinence to the regulatory guidelines.

Please contact Steve Mattson, SAIC, FTS 575-1764, regarding plans for the External Peer Review Meeting.

Maxwell Blanchard
Maxwell B. Blanchard, Chief
Regulatory and Site Evaluation Branch
Waste Management Project Office

WMPO:MBB-1490

Enclosure:
As stated

WM Record File 102.2
WM Project 11
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FINAL SUMMARY OF DISCUSSIONS AT WORKSHOP ON CALCITE-SILICA DEPOSITS

APRIL 28, 1986

An attendance list for the workshop is presented in Enclosure 1. This meeting builds upon the workshop on Calcite-Silica Deposits held on February 28, 1986.

Max Blanchard (DOE/WMPO) called the meeting to order. Max stressed that the purpose of the workshop is to decide what would be a good field program to present to an outside peer review group. Max then turned the meeting over to Steve Mattson (SAIC). A general agenda for the meeting was presented (Enclosure 2).

Proposed investigation plans were submitted and presented by John Stuckless of the USGS, Emily Taylor of the USGS, and Dave Vaniman of Los Alamos.

John Stuckless presented an overall outline of proposed investigative plans. His presentation was divided into the following headings: statement of problem, surface investigations, trench mapping objectives, angle drill-hole objectives, mineralogy background, mineralogy objectives, geochemistry objective, tracer isotopes background, tracer isotopes objectives, isotopic dating objectives, stable isotopes objectives, and fluid inclusion objectives. (see Enclosure 3.)

A list of ongoing and proposed future studies was circulated by Emily Taylor (Enclosure 4). The proposed investigation plans were to resolve the timing and frequency of Quaternary faulting along the Bow Ridge Fault, on the East side of Yucca Mountain, NTS and 2) the origin of fault-filling $CaCO_3$ and opaline SiO_2. This submittal listed fifteen ongoing and planned studies. It was noted that much of the previously initiated work has been halted due to the stop-work order currently in effect at the USGS.

Dave Vaniman presented and distributed a list of possible analog deposit sites including Moapa, Nevares, Amargosa, Bailey, Steamboat, and Sou (Enclosure 5). In discussion, it was suggested that vein deposits in the Tonopah-Goldfield area be considered for inclusion in the analog studies. Dave said he was not familar with them, and Charlotte Abrams (NRC) provided two references (Berger and Eimon, 1983, "Conceptual Models of Epithermal Precious Metal Deposits", in Cameron Volume on Unconventional Mineral Deposits, 1983, W.C. Shanks III, ed., p. 191-205; and F. J. Sawkins, Metal Deposits in Relation to Plate Tectonics, Pages 38-55).

John Stuckless' submittal (Enclosure 3) was then discussed in detail.

- "Multiple Origins?" was added to the "Statement of Problem" (page 1, Enclosure 3) as an alternative hypothesis. Enclosure 3, page 1 was adapted by the group as the main outline of goals.

- "Angle Drill-Hole Objectives" elicited significant debate. It was felt that one angled drill hole may not intersect the fault-filling material. Problems concerning core recovery in fault zone were also discussed. Alternate suggestions were to drill a series of shallow, vertical holes or to deepen the trench for an initial investigation and to drill dry, vertical holes if needed. There was no further discussion on this topic at this point in the meeting.

- A question was raised as to what information would be gained from the fluid-inclusion studies in drusy quartz. Schon Levy (Los Alamos) responded that these studies would allow the acquisition of deuterium values and would enable a better evaluation of the water source.

Emily Taylor's list (Enclosure 4) was then discussed.

- A question was raised regarding the significance of studying the relationship of $CaCO_3$ and opaline SiO_2 (item 7 on enclosure 4): "Do they coprecipitate or is opaline SiO_2 replacing $CaCO_3$." Emily explained that if the driving process is pedogenic, there would be replacement textures, and, if the causative agent was a spring, there would be coprecipitation of phases.

- It was suggested by Maury Morgenstein (DRI) that microsampling across the calcite-silica interface using a Tandotron may give information regarding mode of origin of the deposits.

- A question was raised as to why investigations were continuing on the origin of drusy quartz in bedrock (item 15). Schon Levy responded that there have been some ambiguous results in the previous studies. Thin section and stereo microscopy studies have been done. Some initial work on fluid inclusions filling temperatures has been done. The fluid inclusions indicate that the drusy quartz had a high temperature of formation; however, oxygen-18 isotope studies suggest a low temperature of formation. The age of the drusy quartz is believed to be of the same age as the tuff. Electron Spin Resonance (ESR) dating is now in progress. If ESR is successful in dating the drusy quartz, then it may be used for dating other silicas.

Jerry Szymanski (DOE/WMPO) suggested a possible schedule for the resolution of the problem (Enclosure 6). The schedule was discussed and dates were agreed upon. The work plan is to be drafted, peer reviewed, and finalized by January 1987. A draft report on the deposits is to be completed by June 1988 and will be peer-reviewed and finalized by August 1988.

Dave Vaniman's list of possible analog studies was then discussed (Enclosure 5)

- A comment was made that there would be difficulties in sampling Nevares Spring, as it is in Death Valley National Monument, so it was eliminated from consideration for further studies.

- Dave Vaniman stressed that he wanted to examine modern springs that were analogous to the environment in Trench 14a (i.e., the modern springs should have tuff host rock, deposits of both calcite and silica, and some of the springs should be hot and some cold, for comparative purposes).

- Maury Morgenstein suggested that these studies should involve both examinations of the deposits and the spring waters, and that the stratigraphy of the spring deposits be sampled.

- Steve Mattson suggested studies of all the springs may not be needed. In discussion, Bailey, Steamboat, and Oasis Valley springs were chosen for detailed studies. Harold Wollenberg (LBL) suggested Art White should be contacted for information regarding Oasis Valley springs. It was agreed that these studies will include: detailed mineralogy, through the use of X-ray diffraction; tracer isotopes, including lead and strontium, and oxygen-18; major and trace elements; degree of crystallinity of opal, if present; physical characteristics; morphology/field occurrence; host rock; and host-rock mineralogy.

- Larry McKague (LLNL/NRC) suggested that the comprehensive Trench-14a studies should be done first. Then a literature review should be conducted, to rule out unnecessary analogs, and then the similar analogs should be examined.

Steve Mattson requested that a summary of the work plans be submitted for circulation. Bill Dudley (USGS) said that the USGS will take the lead in writing the summary and will coordinate this with Dave Vaniman on the mineralogy aspects of the investigations.

The group agreed that the most important aspects of the initial studies were: 1) the deepening of trench 14 to determine its lateral and vertical extent, 2) isotope studies to determine possible sources, temperatures of formation, and general isotope character, 3) field relationships relating to the deposits' occurrence/paragenesis, and 4) comparisons to analog deposits of known origin. A new trench, that will be excavated in unfaulted deposits, will be used for examinations of pedogenic deposits and isotopic chemistry. This work will, in large part, influence where new work will be concentrated.

Emily Taylor asked whether it would be better to widen Trench-14a to the north or to the south when it is deepened. The group consensus was to widen it to the north. While this will destroy the surface that exposes the questionable

deposits, it has several benefits. The surface that will be destroyed has been exhaustively documented through mapping, sketching, photography, and sampling. Moving the south wall back will allow a more comprehensive evaluation of the deposits as they trend to the south. This three-dimensional examination will be valuable in assessing the mode of origin of the deposits in Trench 14.

Steve Mattson then requested that the group review the concerns that were voiced at the last meeting (February 28, 1986, Calcite-Silica Deposits Workshop), in order to ascertain if all the concerns involved in that meeting had been addressed in the proposed plans discussed at the current meeting.

- The group concurred that topics #1 through #6 of the workshop minutes of February 28, 1986 had been covered.

- The question arose as to whether concern #7 ("Consider possible hydromechanical mechanisms") had been covered. The following possible mechanisms were discussed:

  ground-water table rise;
  perched water table discharge;
  seismic pumping; and
  lateral movement of a high ground-water gradient.

- The consensus was that these mechanisms represent a set of hypotheses (not all inclusive) and that the data will be used to differentiate between these mechanisms.
- The group concurred that #8 through #15 had been covered. Item number 16 ("Map slickensides in Trench 14 for stress analysis") was discarded as it did not have a bearing on the origin of the deposits. Item number 17 ("Compare bedrock silica cements to silica cements in soils") will be incorporated under mineralogy and geochemistry. Item number 18 ("Remove more surface material from Trench 14") was discussed previously.

Maury Morgenstein (DRI) suggested that soil-water sampling should be done at different times of the year, after rainfall or snowfall events. This will allow an analysis of shallow vadose zone water chemistry. Bill Dudley (USGS) agreed that this could be done.

Steve Mattson requested that the USGS and Los Alamos submit preliminary plans for resolution of the issue. This will be considered by an outside peer review committee. These should include the standard scientific considerations in a research proposal:

principal investigator
purpose of research
objectives
methodology
QA procedures
schedule of completion

Bill Dudley stated that the time frame for the preliminary work plans to be sent to peer review would be within 3 to 4 weeks.

Steve Mattson requested candidates for the Peer Review Committee. The Peer Review Committee will consist of 4 to 5 individuals external to the working group. The list of possible committee members is as follows:

Glen Roquermore	(NWC) Quarternary Geologist
Art White	(LBL) Spring Deposits
John Hawley	(NM Inst. Mining and Tech.) Soils
Gil Hanson	(Stoneybrook) Isotopes
J.C. Laul	(BNL) Geochemist, Neutron Activation Analysis
Byron Berger	(USGS)
R. Sibson	(U.C. - Santa Barbara) Seismic Pumping
H. Kanamori	(Caltech) Seismologist
Roger Phillips	(Southern Meth. University) Geophysics
Pete Birkeland	(Univ. Colorado) Quarternary Geologist
K. Sieh	(Caltech) Active Faulting
Cerling	(Utah) Paleohydrology
Dick Hutchinson	(Colorado School of Mines) Economic Geology
Phil Bethke	(USGS) Hydrothermal Deposits
Robert Schafer	(Billiton) Hydrothermal Deposits
A. H. Truesdell	(USGS) Geochemistry/Hydrothermal
R. O. Fourier	(USGS) Geochemistry/Hydrothermal
Fred Peterson	(UN) Soil Scientist
Roy Schlemon	Quarternary Geologist
Russ Harmon	(SMU) Isotopes, Geochemistry
Paul Aharon	(LSU) Stable Isotopes
Ajoy Baski	(LSU) Isotopes, Geochemistry
Steven G. Wells	(Univ. NM) Geomorphologist (Pedogenic Processes)
Les McFadden	(Univ. NM) Quarternary Geologist

Steve stated that the list would be left open for one week for any other suggestions.

ENCLOSURE 1

CALCITE-SILICA DEPOSITS WORKSHOP
APRIL 28, 1986

STEVE MATTSON	SAIC
HEATHER HUCKINS	F&S
EMILY TAYLOR	USGS
SCHON LEVY	LANL
DAVE VANIMAN	LANL
UEL CLANTON	DOE/WMPO
JERRY SZYMANSKI	DOE/WMPO
BILL DUDLEY	USGS
JOHN STUCKLESS	USGS
BOB RAUP	USGS
JOE D'LUGOSZ	DOE/WMPO
KEN CZYSCINSKI	WESTON
CHARLOTTE ABRAMS	NRC
LARRY MCKAGUE	LLNL/NRC
KEVIN KNAUSS	LLNL
HAROLD WOFFENBERG	LBL
CARL JOHNSON	STATE OF NEVADA
MAURY MORGENSTEIN	DRI
LINDA LEHMAN	STATE OF NEVADA
CADY JOHNSON	DRI
TERRENCE GERLACH	SANDIA
TERRY GRANT	SAIC
AUGUST MATTHUSEN	SAIC

ENCLOSURE 1

CALCITE-SILICA DEPOSITS WORKSHOP
APRIL 28, 1986

STEVE MATTSON	SAIC	FTS 575-1764
HEATHER HUCKINS	F&S	295-6519
EMILY TAYLOR	USGS	776-1141
SCHON LEVY	LANL	843-9504
DAVE VANIMAN	LANL	843-1165
HEL CLANTON	DOE/WMPO	575-1589
JERRY SZYMANSKI	DOE/WMPO	575-1503
BILL DUDLEY	USGS	776-4921
JOHN STUCKLESS	USGS	776-7886
BOB RAUP	USGS	776-1273
JOE D'LUGOSZ	DOE/WMPO	575-1862
KEN CZYSCINSKI	WESTON	301 963-5213
CHARLOTTE ABRAMS	NRC	427-4390
LARRY MCKAGUE	LLNL/NRC	532-6494
KEVIN KNAUSS	LLNL	532-1372
HAROLD WOFFENBERG	LBL	451-5344
CARL JOHNSON	STATE OF NEVADA	702 885-3744
MAURY MORGENSTEIN	DRI	702 798-8882
LINDA LEHMAN	STATE OF NEVADA	612 894-0357
CADY JOHNSON	DRI	702 798-8882
TERRENCE GERLACH	SANDIA	844-5929
TERRY GRANT	SAIC	575-0067
AUGUST MATTHUSEN	SAIC	575-1409

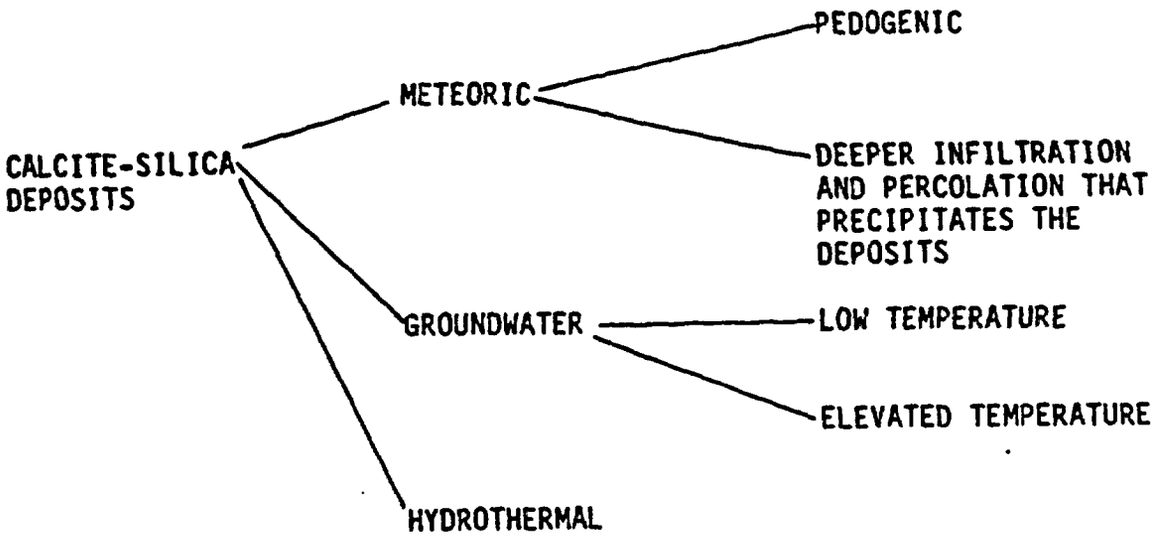
ENCLOSURE 2

EXAMPLE OF FORMAT

PRIORITIZED LIST

RANKING 1 - 10 (High - Low)	ACTIVITY	OBJECTIVES	TIME FRAME 6MO-1YR 1YR-3YR
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.		

ENCLOSURE 2



MULTIPLE ORIGINS ARE ALSO POSSIBLE.

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 ?

ENCLOSURE 3

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.

TRENCH MAPPING

Objectives

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

ANGLE DRILL-HOLE

Objectives

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

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.

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.

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.

TRACER ISOTOPES
Objectives

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

ISOTOPIC 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.

STABLE ISOTOPES
Objectives

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

FLUID INCLUSIONS

Objectives

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

ENCLOSURE 4

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.

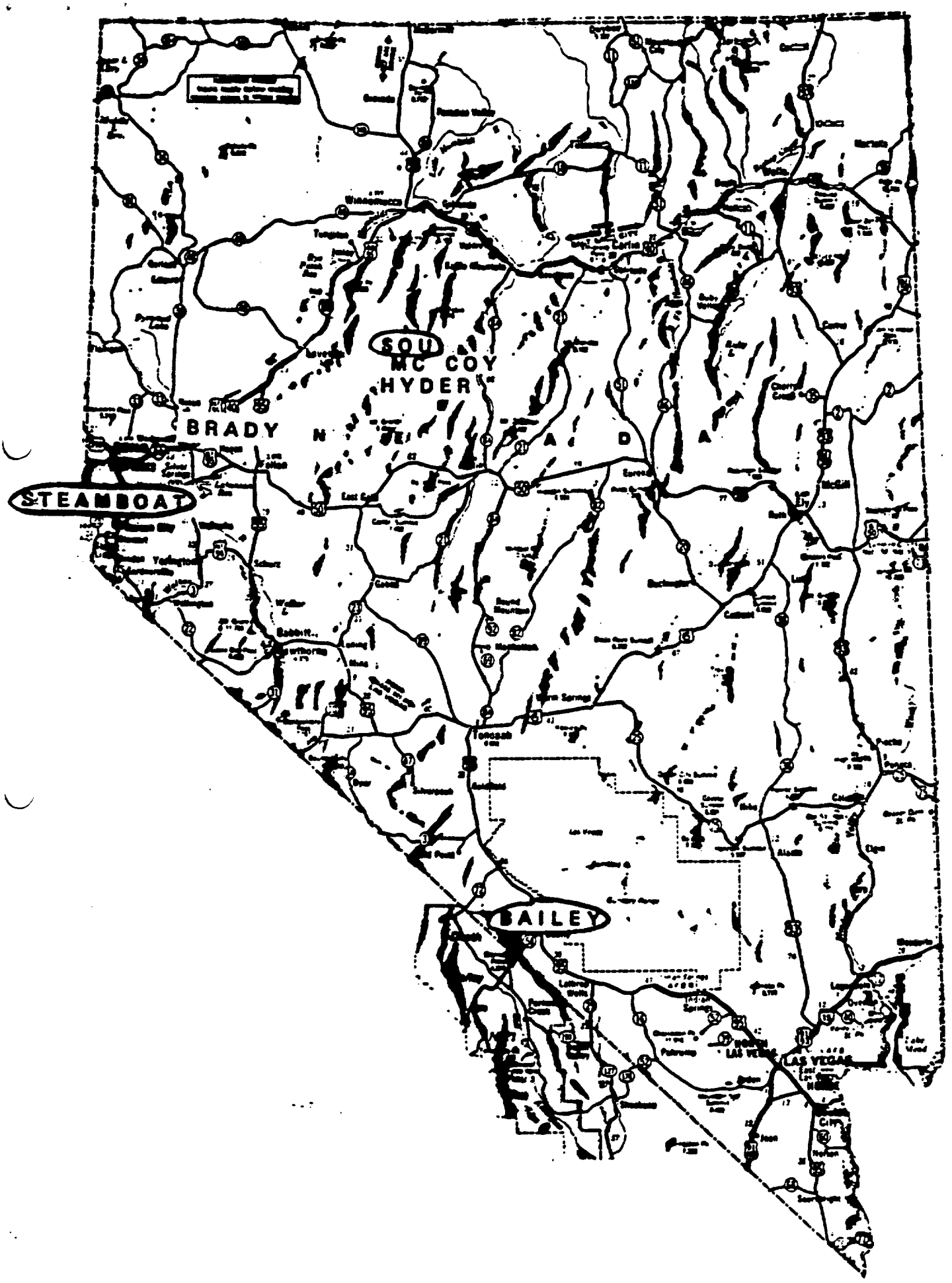
ENCLOSURE 5

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	

COLD SPRINGS

	Moapa	Navares	Amargosa
Calcite	x	x	x
Dolomite			x
Sepiolite			x
Smectite	tr.	tr.	x
Quartz			tr.
Chalcedony			tr.


SOU
MC COY
HYDER
BRADY
STEAMBOAT
BAILEY
LAS VEGAS

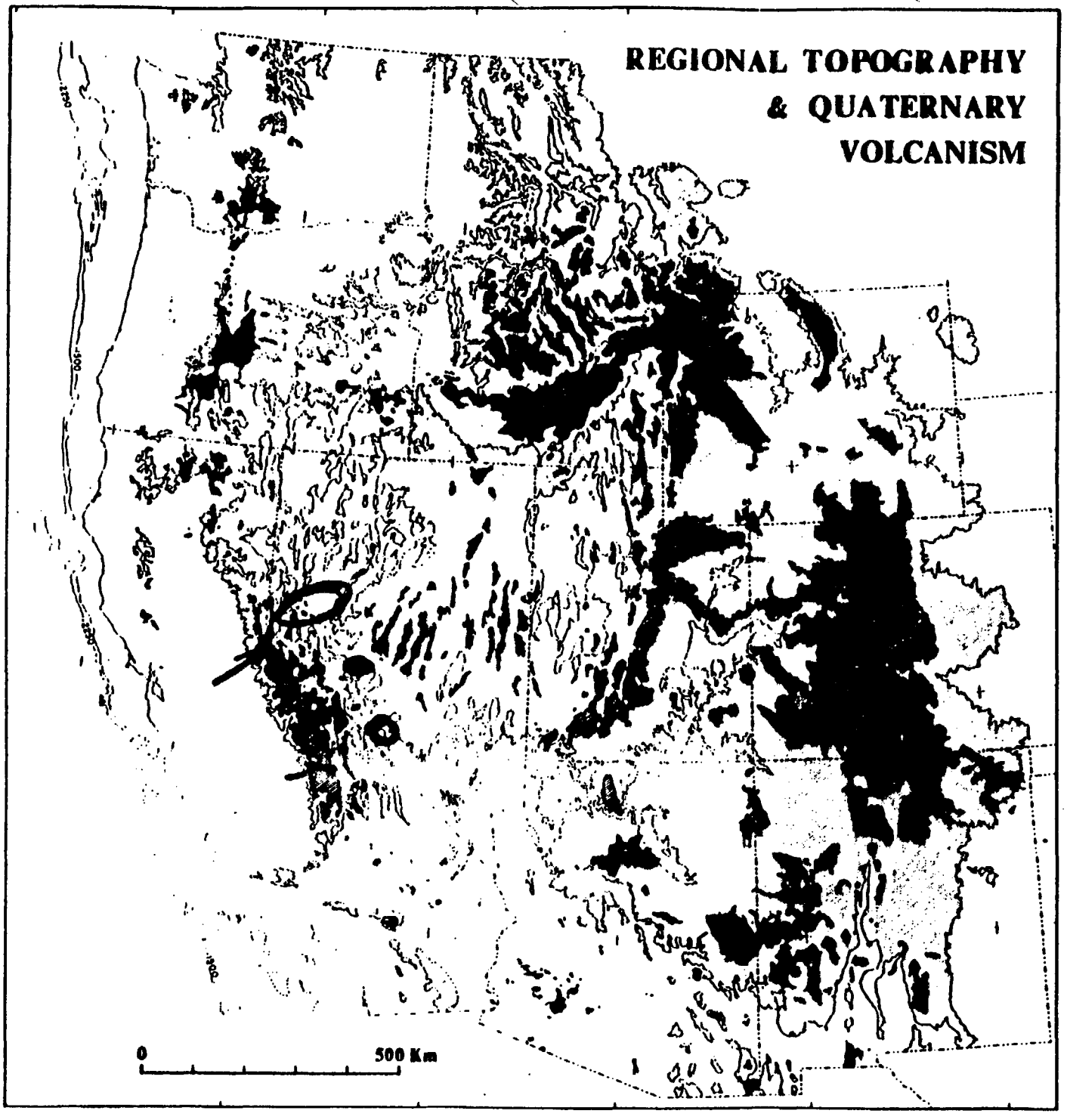
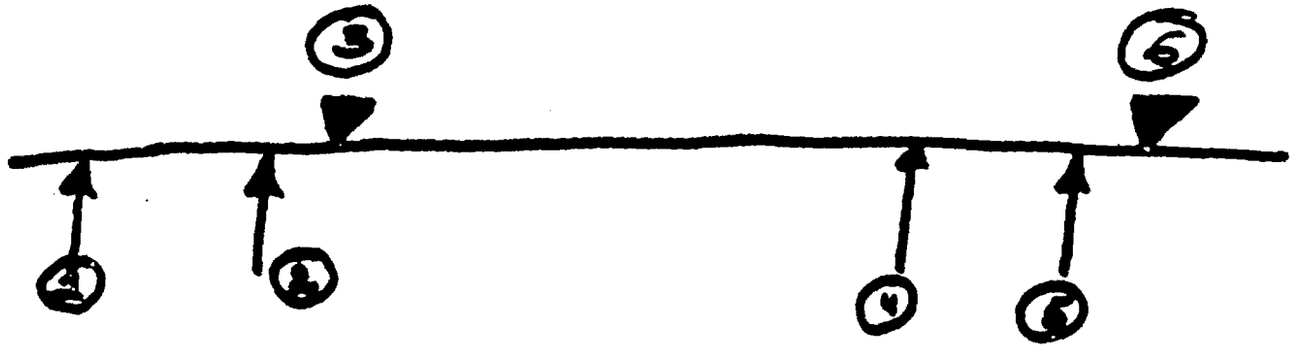


Fig. 3. Regional topography and Quaternary volcanism of the Western United States. Light gray, screened regions lie between 1.5 and 2.25 km; dark gray, lined regions lie in excess of 2.25 km. Submarine contours are given at −1.5 km and −2.25 km and generally lie within the continental slope. Black specks 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.

ENCLOSURE 6

18 month.



1. Draft Work Plan -
2. Peer Review. 2 weeks.
3. Final Work Plan. - Jan 1987. ←
4. Genesis, Implications, Recommendation.
   REPORT June 1988.
5. Peer Review.
6. Final Report to NRC - workshop etc.
   Resolution. Aug 1988.

JUN 26 1986

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W. B. Meyers, USGS, Denver, CO
W. W. Dudley, USGS, Denver, CO
R. B. Raup, USGS, Denver, CO
E. M. Taylor, USGS, Denver, CO
J. S. Downey, USGS, Denver, CO
D. T. Vaniman, Los Alamos, NM
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Kenneth Czyscinski, Weston, Rockville, MD
Harold Wollenberg, LBL, Berkley, CA
Heather Huckins, F&S, Mercury, NV
Carl Johnson, State of Nevada, Carson City, NV
Linda Lehman, State of Nevada, Carson City, NV
Maury Morgenstein, DRI, Reno, NV
Cady Johnson, DRI, Reno, NV
W. S. Twenhofel, SAIC, Lakewood, CO
M. D. Teubner, SAIC, Las Vegas, NV
J. C. Rotert, WMPO, DOE/NV
J. D. D'Lugosz, WMPO, DOE/NV
U. S. Clanton, WMPO, DOE/NV
D. E. Livingston, WMPO, DOE/NV

cc w/encl:
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