TRAC *Technology and Resource Assessment Corporation*

3800 Arapahoe Avenue, Suite 225
Boulder, Colorado 80303
(303) 443-3700
FAX No. (303) 443-8626

DIALOGS BY YURI V. DUBLYANSKY REGARDING "FLUID INCLUSION STUDIES OF CALCITE VEINS FROM YUCCA MOUNTAIN, NEVADA, TUFFS: ENVIRONMENT OF FORMATION"

SPECIAL REPORT No.15
CONTRACT No. 94/96.0003

SPECIAL REPORT Submitted to the
Nuclear Waste Project Office
State of Nevada

July, 1994

Assembled by:

Jerry Szymanski

DIALOGS BY YURI V. DUBLYANSKY REGARDING "FLUID INCLUSION STUDIES OF CALCITE VEINS FROM YUCCA MOUNTAIN, NEVADA, TUFFS: ENVIRONMENT OF FORMATION"

REPORT ORGANIZATION

PART 1

Review of the paper: "Fluid Inclusion Studies of Calcite Veins fromYucca Mountain, Nevada, Tuffs: Environment of Formation" by E. Roedder, J. F. Whelan, and D. T. Vaniman

Y. V. Dublyansky

PART 2

Paper "Fluid Inclusion Studies of Calcite Veins fromYucca Mountain, Nevada, Tuffs: Environment of Formation" - in proceedings of the Fifth Annual International Conference on HLRW

E. Roedder, J. F. Whelan, and D. T. Vaniman

PART 3

Letter from R. M. Nelson to R. R. Loux containing fluid inclusion data discussed in Roedder et al., 1994.

D. O. E.

PART 1

Review of the paper: "Fluid Inclusion Studies of Calcite Veins from Yucca Mountain, Nevada, Tuffs: Environment of Formation" by Y. V. Dublyansky, Academy of Sciences of Russia

Review of the paper:

Fluid Inclusion Studies of Calcite Veins from Yucca Mountain, Nevada, Tuffs: Environment of Formation

by Edwin Roedder, Joseph F.Whelan and David T.Vaniman

Introduction

The author's understanding of genesis of Yucca Mountain calcite is given as the following: "The unsaturated zone calcite appears to have precipitated from rainwater that have descended along interconnected fractures carrying dissolved carbonate from the overlying soil environment; CO_2 escape from the fluid is a likely mechanism for the precipitation of this calcite within the unsaturated zone tuffs" (p.1854). The paper is an attempt to prove this model.

The text contains many solid theoretical arguments pertaining to fluid inclusions and various methods of their study, as well as detailed descriptions of methods used. The information on obtained results, however, is amazingly meager. For instance: about 35 % of the text's length are dedicated to theoretical and methodic aspects of thermometry by fluid inclusions, but no single datum on homogenization temperature is given.

Moreover, some data given by the authors are in contradiction with their own model. At least two lines of evidence: textures of calcite and fluid inclusions do not favor "descending" model, so the later doesn't look convincing. In the following text I shell argue my opinion.

I. Textural features of Yucca Mountain calcite

The authors describe textures encountered in unsaturated zone below 15 m as the following: "...calcite is sparry and locally coats fractures and forms drusy masses within litophysal cavities". This calcite is further interpreted as a film water precipitate. However, sparry and drusy textures are not typical of film precipitates. The environment where calcite deposited from gravitation-driven water films most often found (and thus, studied in detail) in the caves of vadose zone. The speleothemic coatings formed from water films have normally mamilliary laminated textures. The thicknesses of individual laminas are rarely exceed 1 mm. Sparry and drusy textures are virtually unknown in vadose (subaerial) cave environment (except some specific and rare cases like drip-splash crystals on tops of stalagmites or same aerosol formations). Instead, such textures rather suggestive of phreatic (subaqueous) environment.

In saturated zone: "...calcite occurs as veins, often with chlorite and quartz or chalcedony, and as a replacement cement of altered tuffs" (p.1854). Quartz, chalcedony and opal also occur in unsaturated zone of Yucca Mountain. The declaration that calcite in saturated zone "...is part of an alteration mineralogy formed during a low-temperature hydrothermal event that occurred ~10,4 ma..." is not necessarily true. This age was determined by means of K/Ar technique by illite/smectite (Bish & Aronson, 1993). The only date obtained for calcite in saturated zone by U-series is >400 ka (Szabo & Kyser, 1990).

II. Thermometry by fluid inclusions in calcite

Calcite is a mineral rather difficult for fluid inclusion studies. It is very cleavable and susceptible for re-crystallization even at low temperatures. This causes many problems on the stage of sample preparation. Besides, it is extremely difficult to distinguish primary, pseudo-secondary and secondary character of inclusions on the basis of petrographic observations. The existing criteria for distinguishing the origin of inclusions "...are not absolute, and many are merely suggestive... they must be applied with care and with awareness of the considerable ambiguity that exists" (Roedder, 1984, p.12; emphasis by Roedder). This is especially true when dealing with calcite.

Fluid inclusion is called **primary** if it was trapped during growth of a studied part of a crystal or a mineral body. It is classified as **pseudosecondary** if it was trapped after the studied part of a crystal was crystallized but before the growth of a whole crystal (mineral body) ceased. The inclusion is called **secondary** if it was trapped after the growth of mineral ceased. Primary and pseudosecondary inclusions characterize different temporal stages in evolution of mineral-forming environments, while secondary inclusions are characteristic of post-mineralization environments. Thus, the T_{hom} measured by fluid inclusions may characterize temperatures of fluids in which the crystal studied was bathed during or after its growth.

In case of Yucca Mountain it is unimportant what type of inclusion was used for thermometry: In either case high T_{hom} would mean that the rocks of Yucca Mountain were flooded with thermal water on a certain stage of its history.

To apply this approach, however, we must be sure that inclusions studied (a) were trapped as homogeneous phase, and (b) they were not damaged (shrinked or opened and leached) after the entrapment. This is hard to prove if one deal with a single inclusion but much easier when dealing with groups of inclusions. If such a group consist of two-phase inclusions with uniform V/L ratio, it gives us a strong indication that this particular group may provide reliable and meaningful thermometric information. Inclusions in such groups yield normally T_{hom} varying within 1-2 °C interval.

As it is obvious from the citations below, such groups of inclusions have been found in calcite from unsaturated zone in Yucca Mountain: "Suitable primary liquid-filled inclusions, containing a shrinkage vapor bubble, were found in only a few samples" (p.1857) and: "Most of the suitable inclusions occurred in groups, with an apparently uniform and small V/L ratio..." (p.1858). Surprisingly, the authors give us no numerical information on T_{hom} measured on these suitable inclusions (we may deduce that these have been measured from another quotation: "The meager T_h data indicate that at the time of growth of host calcite the ambient temperature was equal to the measured T_h..." (p.1585)). The authors only mention that "...small V/L ratio... visually indicated that the inclusions had formed at low temperatures, probably $< \sim 100$ °C" (p.1858). Such an approach, i.e., visual estimation instead of instrumental is quite astonishing by itself and I will discuss it latter. But there is something else that can be deduced from this short author's description. The minimal temperatures of entrapment could not have been lower than approx. 40 °C, otherwise the shrinkage bubbles simply would not have nucleated. (The physical mode of a gas bubble nucleation is described by the authors quite thoroughly on p.1858. However, their statement that "Inclusions in the 10-20 micrometer range, particularly if trapped at <100 °C, almost never nucleate a bubble..." is not correct. My 14-year experience of work with low-temperature hydrothermal calcite shows that inclusions of 5 to 25 mcm in size do nucleate bubbles yielding T_{hom} of 100-40 °C).

Thus, even being not provided with numerical data we may conclude that at a certain stage of its history the calcite studied was bathed in (and, quite probably, deposited from) fluids of approx. 40 to 100 °C. Obviously, these temperatures at depth -130-314 m can not be attributed to the "normal" geothermal gradient of ~ 34 °C/km (Sass e.a., 1980) in unsaturated zone.

Visual method of thermometry by fluid inclusions

Visual method has been designed by Nikolay Yermakov (1944). The *rationale* of this method was given by the author as the following: "...the homogenization method requires a special apparatus for heating minerals to high temperatures under the microscope. This is not always possible at any given place and time. We attempted therefore to produce empirical curves for the most common vein minerals that would help an investigator, equipped with any kind of microscope, in drawing tentative conclusion in regards to the temperature minima at which a given hydrothermal mineral may have been formed" (Yermakov, 1965, p.108), and: "The curves we have derived are suited only for approximate determination of the anticipated homogenization temperatures of inclusions. One may resort to them only in the absence of microthermochamber (thermostage, YuD)" (Ibid, p.116).

Author's interpretation of data

I have shown that (1) the authors were awared of the presence of two-phase fluid inclusions in calcite from unsaturated zone of Yucca Mountain, and (2) these inclusions imply temperatures higher than those that could have been induced by normal geothermal gradient. How are these data interpreted in the authors model developed in final section "ENVIRONMENT OF FORMATION OF THE CALCITE VEINS"? They are simply ignored. The authors even deny their own previous statements implying "...the absence of two-phase, liquid+vapor inclusions in the upper thousand feet of the USW G-1 borehole..." (p.1859; *cf.* with quotations above). This statement is also in contradiction with data on T_{hom} measured in unsaturated zone calcite from the same drill hole: 81 °C at -221 m (YMP, 1993), and other drill holes of the area: 78 to 227 °C in USW G-2 and G-3 (Bish, 1989 and Bish & Aronson, 1993). Obviously, these data can not be explained satisfactory within the model of deposition of calcite from thin films of rainwater seeping through the unsaturated zone.

III. Gases in inclusions

Crushing technique

The method of formation temperature estimation according to amount of immersion oil entering the inclusion on crushing seems to be very hard to calibrate. There are many variables that may play a role in the behaviour of an inclusion.

1. ***Solubility and diffusion***. If we deal with a gas phase consisted of a mixture of non-condensable gases like CO_2, O_2, N_2 and CH_4 we should be aware that (a) every gas is soluble to some extent in the crushing oil and (b) the gases may migrate from gas bubble into the oil and from oil into the bubble due to diffusion. Normally we do not know: - the real composition and partial pressures in a gas phase; - the solubility of these gases in the oil; - the amount of gases already dissolved in the oil (that influence the concentration gradients between the gas phase and crushing oil and control the rate of diffusion); and - the diffusion coefficients for our gases in this particular crushing oil. The diffusion coefficients are often extremely temperature-sensitive (for instance, for glycerol $D \sim \ln(\ln T)$, where D - diffusion coefficient, and T - temperature). Thus, the slightest change in ambient temperature may influence the result.

2. ***Gas bubble size.*** Detailed studies of the dynamics of gas bubble dissolution on crushing were performed in Laboratory of fluid inclusions of Institute of Mineralogy and Petrography, Novosibirsk in 80-ies. It was found that this process is non-linear and may be subdivided on three stages: (1) very fast but exponentially slowing decrease of a bubble during first 1-2 seconds due to both solution and diffusion; (2) slow decrease; and (3) exponentially accelerating decrease and collapse of a bubble when it reaches a certain "critical" size due to increase of internal pressure. Empirically, the "collapse diameter" was found to be approx. 3-5 mcm. It means that small bubbles (with original diameter $<$6-8 mcm) may collapse immediately after crushing even if they contain essentially "insoluble" gases.

3. ***Geometry of inclusions***. Fluid inclusions are three-dimensional vacuoles often with irregular shape. So, any estimations of volume phase relationships may not be too accurate.

Thus, the method suggested by the authors is not a "straight forward" one, and the possibility of obtaining reliable data this way is somewhat doubtful.

Mass-spectrometric data

Qualitative mass-spectrometric analysis has revealed N_2, O_2, CO_2, and CH_4 (methane is referred as "major" in the abstract; p.1854). Most unfortunately, no data on sample preparation, method of gas extraction and laboratory procedures have been given. Thus, there is no possibility to assess the reliability of the data. One should be aware, however, about some general problems with gas analyses by destructive methods:

(1) The gases are extracted from a certain amount of calcite. It means that these gases derived from different assemblages of inclusions, that represent different stages of mineral growth, and may even be trapped after the growth ceased (secondary inclusions). There is no way to estimate more or less accurately the ratio of these gases in a final mixture which is analyzed by mass-spectrometry or gas chromatography.

(2) Both most common methods of release of a gas for analysis - decrepitation and crushing - cause significant change in component ratio due to gas reactions at high temperatures and adsorption on mineral surfaces freshly created by crushing.

(3) The gases in calcite may reside not only in inclusions, but also in lattice defects and, most important, they may be adsorbed on clay particles trapped as solid inclusions (these particles have extremely high specific surface). Greyish-white and light-brown color of Yucca Mountain calcite (Whelan e.a., 1994) might indicate the

presence of such clay contaminants. Our studies have shown that the amount of gases recovered by gas chromatography may differ by one to two orders of magnitude for zones with and without clay admixtures in a single calcite crystal (Dublyansky, 1990). Also, at least a part of methane might be related to organic impurities, reported for this calcite (Whelan e.a., 1994). In general, trace amounts of methane are common in low-temperature hydrothermal calcite from elsewhere (Dublyansky, 1990; Dublyansky & Reutski, 1993).

It is a sensible approach, thus, to keep in mind the opinion of the senior author of the reviewed paper given in his excellent treatise earlier: "Although it might seem extreme, I believe that the possibilities of major errors in inclusion analyses are sufficiently numerous that one should simply discount all analytical reports that do not give details on sample size, and the selection, cleaning, and extraction procedures used, as well as the usual statements of analytical methods, sensitivity, accuracy, precision, blanks, standardization, etc." (Roedder, 1984, p.110).

Origin of vapor-rich inclusions

"Vapor-filled inclusions provide, by their very existence, evidence of the presence of a vapor phase along with the liquid phase from which the host crystal grew" (p.1854). This is correct, provided these are undoubtedly primary inclusions. The difficulty of proof of that has already been discussed. So, it would be safer to say that such inclusions evidence the presence of a vapor phase during inclusion entrapment. Several alternative models may be proposed to explain the origin of vapor-rich inclusions. For instance the effervescence of CO_2 is quite typical in ascending hydrothermal solutions due to decrease of both pressure and CO_2 solubility (Malinin, 1979). Exsolving CO_2 (or any other gases) would form vapor bubbles and leave the system. However, if the velocity of upwelling water is high enough, the system would remain heterogeneous and calcite forming would trap vapour-rich inclusions along with liquid-rich ones (possibility 3, discussed by the authors on p.1859). And finally, the possibility that vapor-rich inclusions were trapped on the latter stages of calcite history during its residence in unsaturated zone should also be considered.

REFERNCES

Bish D.L., 1989, *Evaluation of Past and Future Alterations in Tuff at Yucca Mountain, Nevada, Based on Clay Mineralogy of Drill Cores USW G-1, G-2, and G-3.* Los Alamos National Laboratories, Report LA-10667-MS, 40 pp.

Bish D.L. and **Aronson, J.L., 1993,** *Paleogeothermal and Paleohydrologic Conditions in Silicic Tuff from Yucca Mountain, Nevada.* Clays and Clay Minerals, v.41, no.2, pp.148-161.

Dublyansky Yu.V., 1990, *Regularities of formation and modelling of hydrothermal karst.* Novosibirsk: Nauka, - 150 p. (In Russian)

Dublyansky Yu.V. and Reutsky V.N., 1993, *Hydrothermal system of some karst massifs of Hungary (by inclusion in minerals).* Report submitted to Hungarian National Authorities for Nature Conservation, Budapest, 128 p.

Malinin S.D., 1979, *Physical chemistry of hydrothermal systems with carbon dioxyde.* Moscow:Nauka, 111 p.

Roedder E., 1984, *Fluid Inclusions.* Reviews in Mineralogy, v.12. 644 pp.

Sass J.H., Lachenbruch A.H., and Mase C.W., 1980, *Analysis of thermal data from drill holes UE25 a#3 and UE25 a#1, Calico Hills and Yucca Mountain, Nevada Test Site,* USGS Open File Report 80-826, 25 p.

Szabo B.J., and Kyser T.K., 1990, *Ages and stable isotope compositions of secondary calcite and opal in drill cores from Tertiary volcanic rocks of the Yucca Mountain area, Nevada.* GSA Bull, 102:1714-1719.

Yermakov N.P., 1944, *The temperatures of formation of the deposits of optical minerals in Central Asia.* Soviet Geology, 1:34-36 (In Russian)

Yermakov N.P., 1965, *Studies of mineral-forming solutions.* In:D.E.Ingerson, editor. Research on the nature of mineral-forming solutions. International Series of Monographs in Earth Sciences, 22. New York: Pergamon Press. 348 p.

YMP, 1993, *Data released by Yucca Mountain Characterization Project Office.* December, 1993

Dr. Yuri V.Dublyansky
Senior scientist

July 8th, 1994.

Laboratory of fluid inclusions
Institute of Mineralogy & Petrography
Academy of Sciences of Russia, Siberian Division
University ave.,3 Novosibirsk
630090, RUSSIA
e-mail: dublyan@diamond.nsk.su

PART 2

Paper "Fluid Inclusion Studies of Calcite Veins from Yucca Mountain, Nevada, Tuffs: Environment of Formation" by R. Roedder, J. F. Whelan, and D. T. Vaniman

Fluid Inclusion Studies of Calcite Veins from Yucca Mountain, Nevada, Tuffs: Environment of Formation

Edwin Roedder
Dept. Earth and Planet. Sci.
Harvard University
Cambridge, MA 02138
(508)281-6193

Joseph F. Whelan
U.S. Geological Survey
Box 25046, Federal Center
Denver, CO 80225
(303)236-7671

David T. Vaniman
Group EES-1, MS D462
Los Alamos Nat'l Laboratory
Los Alamos, NM 87545
(505)667-1863

ABSTRACT

Calcite vein and vug fillings at four depths (130-314m), all above the present water table in USW G-1 bore hole at Yucca Mountain, Nevada, contain primary fluid inclusions with variable vapor/liquid raitos: most of these inclusions are either full of liquid or full of vapor.

The liquid-filled inclusions show that most of the host calcite crystallized from fluids at <100°C. The vapor-filled inclusions provide evidence that a separate vapor phase was present in the fluid during crystallization. Studies of these vapor-filled inclusions on the microscope crushing stage were interpreted in an earlier paper as indicating trapping of an air-water-CO_2 vapor phase at "<100°C"[1]. Our new studies reveal the additional presence of major methane in the vapor-filled inclusion, indicating even lower temperatures of trapping, perhaps at near-surface temperatures. They also show that the host calcite crystals grew from a flowing film of water on the walls of fractures open to the atmosphere, the vapor-filled inclusions representing bubbles that exsolved from this film onto the crystal surface.

I. INTRODUCTION

The origin of secondary calcite within Yucca Mountain has been addressed by stable isotope[2], trace element[3], and radiogenic isotope studies[4]. Within the thick (500 to 700 m) unsaturated zone above water table, fractures and other open spaces often contain calcite. Near the surface, this calcite is texturally and mineralogically similar to the pedogenic calcite found in the overlying soils; below ~15 m, the calcite is sparry and locally coats fractures and forms drusy masses within lithophysal cavities. The unsaturated zone calcite appears to have precipitated from rainwaters that have descended along interconnected fractures carrying dissolved carbonate from the overlying soil environment; CO_2 escape from the fluid is a likely mechanism for the precipitation of this calcite within the unsaturated zone tuffs[2]. Below the present water table, calcite occurs as veins, often with chlorite and quartz or chalcedony, and as a replacement cement of altered tuffs. This calcite is part of an alteration mineralogy formed during a low-temperature hydrothermal event that occurred ~10.4 ma at temperatures up to ~250°C, based on earlier fluid inclusion studies[5]. Calcite $\delta^{13}C$ values indicate that the fluids responsible for this alteration came from the underlying Paleozoic marine carbonate aquifer[2].

Vein and vug fillings of secondary calcite at four depths (130, 204, 292, and 314 meters), all above the present water table in drill core USW G-1 from Yucca Mountain, Nevada (Figs. 1 and 2), show two principal types of primary fluid inclusions: either full of liquid or full of vapor. These range in size from about 100 to less than 2 micrometers. Each of the two types provides different, useful data on the preexisting environments under which they were formed, i.e., trapped:

- Liquid-filled inclusions provide, by their very existence, semi-quantitative bounds on the temperature of trapping. Those few liquid inclusions with vapor bubbles also provide an impression of trapping temperature through visual estimates of their vapor/liquid ratio (high vapor/liqiud ratios reflect high temperatures of trapping; low ratios indicate low temperatures of trapping).
- Vapor-filled inclusions provide, by their very existence, evidence of the presence of a vapor phase along with the liquid phase from which the host crystal grew. Studies of such vapor-filled inclusions on a microscope crushing stage can provide semi-quantitative bounds on the pressure at the time of trapping, as well as some rough qualitative information on the chemical composition of the vapor

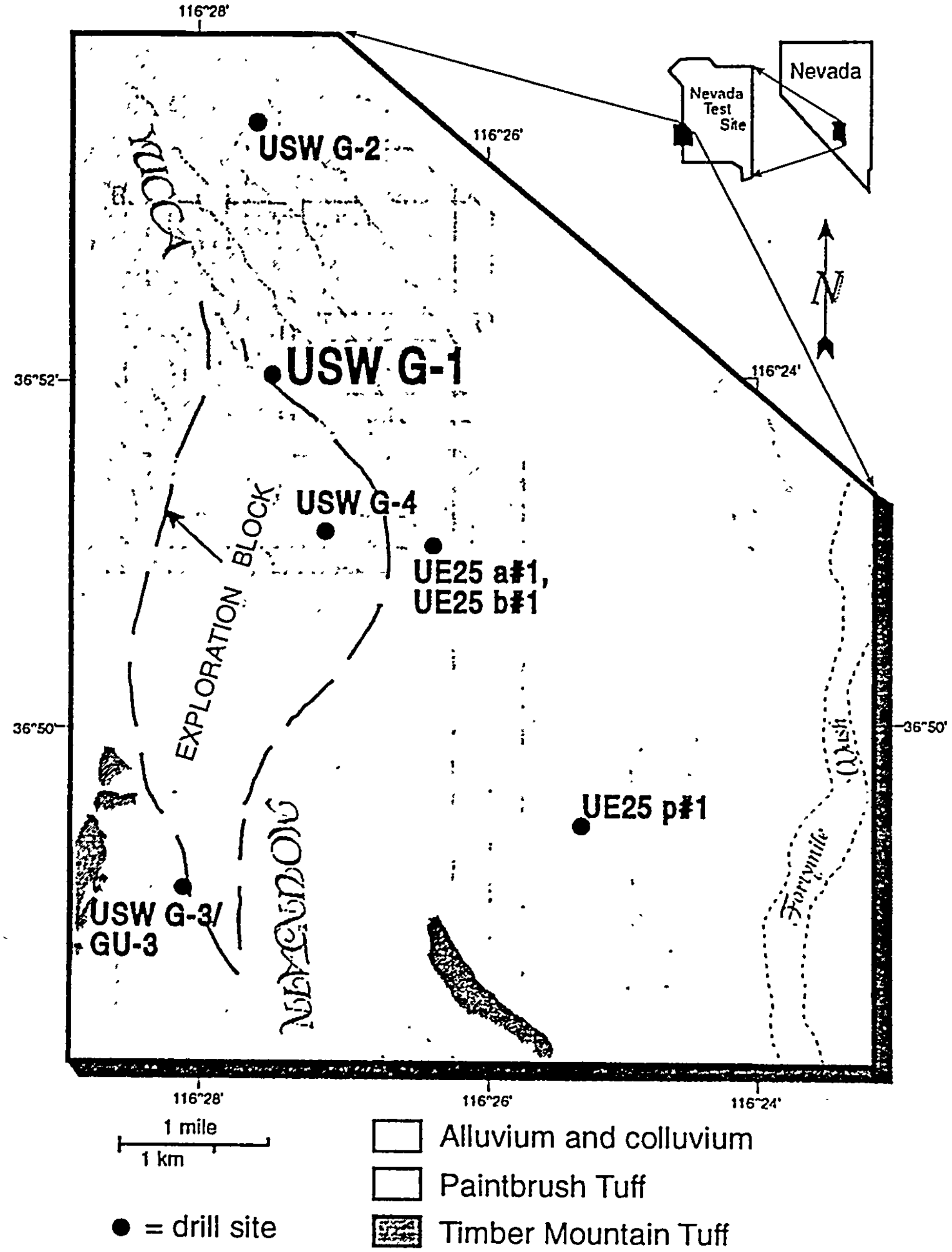

Figure 1: Location of bore hole USW G-1 at Yucca Mountain

itself. This latter can be used, in turn, to place some constraints on the environment in the vein at the time of crystallization of the host calcite.

The crushing test[6] provides a qualitative estimate of the gas pressure within a vapor inclusion at the time of crushing. It involves immersing the host grain in oil at 1 atmosphere under the microscope and stressing it until a crack reaches the inclusion. An inclusion filled with air at one atmosphere would not change when the crack reaches it, and on complete crushing, the original host grain would yield a bubble of the same volume as the original inclusion. An inclusion originally formed by the trapping of water vapor as a steam bubble would instantly fill with oil, once a crack reaches it, as the entrance of the oil at 1 atmosphere would collapse the very low-pressure water vapor completely. The present inclusions filled only partly (Fig. 3), suggesting that they contained, at room temperature, less than one atmosphere gas pressure; as a result of trapping a mixture of water vapor plus non-condensable gases such as air and/or CO_2.

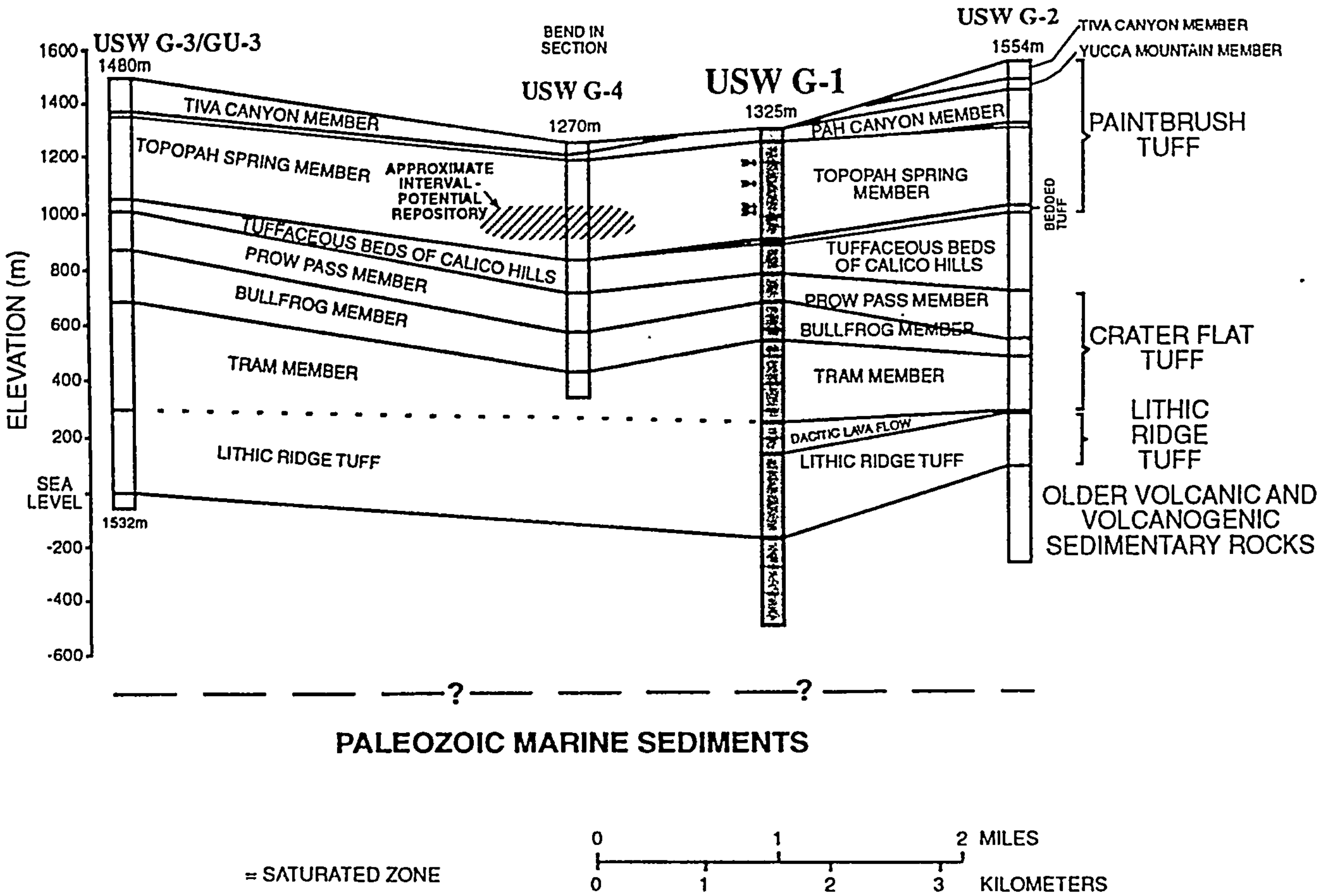

Figure 2: Roughly north-south cross-section of Yucca Mountain tuffs showing approximate locations of USW G-1 samples referred to in text (➛) and water table elevations.

II. PROCEDURES

A. Determination of the Th of Two-Phase Inclusions

Doubly-polished thin sections of calcite, mounted with acetone-soluble "superglue" resin, are made with a minimum of stressing of the sample and without any use of heat, and the entire slide is photographed at low magnification to provide a record and relocating guide. One or more suitable primary fluid inclusions, preferably >20 micrometers in diameter, are found by petrographic study and photographed. Primary refers to those inclusions trapped at the same time as the surrounding host mineral, using the criteria given by Roedder[7 a]. The location of the group is marked on the record photograph and on the upper polished surface of the doubly-polished plate. Marking on the slide is best done with a fine-tipped pen, using acetone-insoluble ink. After the ink has dried, the slide is turned over onto a firm but non-scratching white surface (permitting the ink marks to be seen) and a diamond pencil is used to score the slide on two (or three) sides of the marked area. The glass slide and its attached doubly-polished plate are then carefully broken along the scribed lines to yield a sample small enough and shaped appropriately for use in the microscope heating stage, where the temperatures of homogenization (Th) of the vapor bubbles are determined by standard procedures[7,b]. The low Th in most of these samples permit leaving the polished plate on the glass; if the homogenization temperatures are high, the plate may have to be removed from the glass slide with acetone solvent before inserting in the microscope heating stage.

B. Determination of Behavior in the Microscope Crushing Stage;

After a suitable single vapor-filled inclusion, preferably >20 micrometers in diameter, has been located and marked, as above, the doubly-polished thin section is freed from the glass slide and then remounted in a high-viscosity index oil. Via a series of steps involving a needle and some manual

[a] Chapter 2, pp. 43-45.

[b] Chapter 7

Figure 3: Series of photographs of a typical crushing experiment showing the initial vapor-rich inclusion, the inclusion after rupture along a cleavage fracture, and partial filling of the inclusion by the immersion oil.

dexterity, a fragment of calcite about 0.5 mm in size, containing the inclusion, is broken free and transferred to the microscope crushing stage where it is crushed in oil, following the procedures given by Roedder[6]. Optical measurements are made to establish the approximate volume of the inclusion before crushing, and the volume of gas remaining after crushing, as volume percent of the original volume.

III. RESULTS

A. Homogenization Runs

Suitable primary liquid-filled inclusions, containing a shrinkage vapor bubble, were found in only a few samples. As in all fluid inclusion studies, the most important step is that of sample selection[7]. Such selection of "suitable" inclusions must be done with considerable care or the data obtained will be invalid and misleading. In these samples, two-phase, vapor-liquid (V/L) inclusions were not rare, but most were "unsuitable" on the basis of petrographic evidence that they fell in one or another of the following categories:

1. Inclusions of non-primary (i.e., secondary) origin, using the criteria given by Roedder[7].
2. Inclusions with highly variable V/L ratios (on a visual basis) from the trapping of small amounts of liquid along with the vapor bubble.
3. Inclusions with highly variable V/L ratios (on a visual basis) that were intersected by a visible fracture, natural or from sample preparation, and thus were presumed to have lost some liquid by leakage.
4. Inclusions whose V/L ratio increased visibly during, or after, the homogenization run, indicating leakage of liquid.
5. Inclusions whose Th during a rerun were more than 2°C above the original values, indicating stretching or leakage.

6. Inclusions that decrepitated before homogenization occurred.

Most of the suitable inclusions occurred in groups, with an apparently uniform and small V/L ratio, which visually indicated that the inclusions had formed at low temperatures, probably ≤~100°C.

B. Crushing Runs

The very small number of suitable inclusions in the slides, and the numerous losses along the way from the vagaries of the various steps involved resulted in only ten inclusions being successfully crushed; i.e., conditions were such that optical observation of the behavior of the inclusion could be made at the moment of crushing. In each of these, oil entered the inclusion, suggesting at first that the gas pressure within the inclusion at room temperature was less than atmospheric (Fig. 3). Later experiments using glycerol instead of oil showed that the vapor inclusions were at essentially atmospheric internal pressure (see section IV.B.2).

IV. SIGNIFICANCE OF THE DATA

A. Homogenization Data

The meager Th data indicate that at the time of growth of the host calcite the ambient temperature was equal to the measured Th (as shown in section V, no "pressure correction" is needed).

Most of the samples contain all-liquid inclusions, i.e., without vapor bubbles, ranging in size from approximately 100 micrometers down to less than 2 micrometers. These tell us that there was a liquid phase at the growing surface of the calcite crystal, but as they have no vapor bubble, no quantitative temperature data can be obtained from them. However, they do permit some qualitative bounds to be placed on the temperature at the time of trapping, based on well-known limitations on the nucleation of a vapor phase[7,8,c]. The smaller the inclusion, the less likely is the nucleation of any new phase, for two reasons: 1) The smaller the system, the less likely that a suitable nucleation site, a "mote", will be present, either as some appropriate irregularity of the inclusion cavity walls, or as a minute grain of a foreign substance, that will aid heterogeneous nucleation. 2) Fluid inclusions are small systems, so small that the probability statistics involved in the process of homogeneous nucleation by random molecular movement become significantly influenced by size and, hence, actual numbers of molecules involved.

[c] Chapter 10

On cooling from the temperature of trapping of a liquid inclusion, the point representing the system follows down an isochore in pressure-temperature space until it reaches the V/L two-phase line, where a bubble of vapor should nucleate. (This is the same point at which the bubble will disappear on heating during an homogenization run.) In practically all cases, however, nucleation does not occur at this point on cooling. Further cooling merely moves the all-liquid inclusion along the metastable extension of the isochore, into the field for vapor. Under these conditions, the liquid is an undercooled, "stretched" liquid, with a metastably lower density than it should have. When the first minute bubble of vapor nucleates, it instantly expands, the liquid shrinks to its correct density, and the system — now stable, not metastable— returns to the two-phase V/L line.

High temperatures at the time of trapping and large inclusion size both tend to minimize the amount of undercooling needed to induce nucleation of vapor. Extensive studies of samples from many environments show that inclusions >100 micrometers, trapped at temperatures >100°C, usually nucleate a bubble with only a few degrees of supercooling. Inclusions <100 micrometers in size, particularly if trapped at <100°C, frequently will not nucleate a bubble. Inclusions in the 10-20 micrometer range, trapped at <100°C, almost never nucleate a bubble, even after millions of years of metastability at near-surface temperature. As the samples studied here have many primary all-liquid inclusions as much as 100 micrometers in size, we can presume that they were trapped at temperatures well under 100°C.

B. Crushing Data

1. Formation of vapor-filled inclusions. The vapor-filled inclusions can have formed in various ways:

a. The host crystals may have grown from a vapor phase. For several reasons, this is very unlikely for these samples: the solubility of $CaCO_3$ would probably be very low unless the temperatures were high, yet the all-liquid inclusions indicate that the temperatures were very low.

b. They may have been liquid-filled inclusions that leaked and lost all their liquid through cracks (e.g., cracks formed during the borehole drilling). Such cracks can be below the limit of optical visibility. The inclusions would now be filled with air at one atmosphere.

c. They may have trapped a bubble of a vapor phase present in a heterogeneous, two-phase system of vapor plus liquid, as is known to have occurred in many other geological systems. This vapor phase may have consisted of:

(1) Steam, i.e., from boiling of a liquid water phase. On cooling, such inclusions would precipitate an invisibly thin layer of liquid on the walls, and leave the inclusion filled with a low pressure water vapor phase, almost a vacuum.

(2) Air. Air could have been trapped at 1-atmosphere pressure, if the system were open to the surface, or at >1-atmosphere pressure, if trapping occurred from air bubbles under some hydrostatic head.

(3) CO_2. Carbon dioxide gas bubbles could exsolve from water solutions and become trapped as inclusions. Unlike boiling of the water, which requires temperatures of at least 100°C, such effervescence of a CO_2 vapor phase can occur at any temperature. This CO_2 phase would be in equilibrium with liquid water, so it would also contain water vapor at the partial pressure appropriate for the temperature of trapping.

2. Crushing test rationale. The crushing test[6] provides a qualitative estimate of the gas pressure within an inclusion at the time of crushing, unless a gas is present that is soluble in the crushing oil. It involves breaking an inclusion open under the microscope while the host mineral grain is immersed in oil at 1-atmosphere pressure. An inclusion filled with a gas having a pressure greater than atmospheric, or one filled with a fluid having a vapor pressure greater than atmospheric (e.g., light hydrocarbons) would instantly expand, or "boil", into the oil. If filled with liquid water containing CO_2 at >1-atmosphere pressure, a vapor bubble would form, just as in opening a bottle of beer. An inclusion filled with air at 1-atmosphere wouldn't change, i.e., would yield a bubble of the same volume as the original inclusion. An inclusion formed by trapping of a steam bubble, since it would have a pressure of only about 30 mm after cooling to room temperature (above possibility c-1), would instantly fill with oil. Inclusions containing CO_2 (above possibility c-3) would have a more complex behavior; the vapor would expand or collapse by an amount controlled by the pressure, temperature and composition of the system at the time of trapping.

If the gas phase trapped in the vapor inclusion consisted of a bubble of non-condensable gases such as air and/or CO_2 in equilibrium with the aqueous fluid from which the calcite crystallized, there would also be an amount of water vapor in the trapped gas corresponding to the partial pressure of water at the temperature of trapping. On cooling to room temperature, condensation of this water vapor would create a partial vacuum in the inclusion. On crushing, the surrounding immersion oil would enter such an inclusion in an amount corresponding to the partial pressure of water vapor during trapping. This logic was used to estimate the temperature of trapping of some inclusions from these samples; these temperatures were estimated be "<100°C"[1].

The temperature values obtained by this method are actually only maximum values, as a result of a caveat not mentioned in the previous study[1] — if a gas in the vapor inclusion is highly soluble in the oil used in the crushing procedure, oil will dissolve this gas and enter the inclusion just as though it was a partial vacuum at the time of crushing. Since the previous report[1] we have obtained preliminary qualitative Quadrupole™ mass spectrometer analyses of the gases in the inclusions in these samples, through the courtesy of Dr. Gary P. Landis of the USGS. These analyses show that the gases are mixtures of nitrogen and oxygen (at near "air" ratios), CO_2, and methane. Methane is highly soluble in the immersion oil used, and we now believe that most or even all of the collapse of the gas inclusions that was found on crushing stems from dissolution of the methane. As such, the temperatures calculated for trapping are well under the "<100°C" reported earlier, and could have been near surface temperatures. Some corroboration of this interpretation was obtained by crushing additional vapor inclusions in glycerol, a fluid that is not a good solvent for methane. Neither collapse nor expansion occurred in glycerol, suggesting that the contribution of water vapor to the collapse in oil was minimal and that trapping occurred at near-surface temperatures.

V. ENVIRONMENT OF FORMATION OF THE CALCITE VEINS

The presence of all-liquid inclusions, and the absence of two-phase, liquid + vapor, inclusions in the upper thousand feet of the USW G-1 borehole together establish that these calcites have formed at low temperatures, <100°C, possibly comparable to modern ambient temperatures. The higher temperatures found on homogenization of the few two-phase inclusions present in deeper parts of the core corroborate published research documenting a deep hydrothermal system at 10.4ka, coincident with the formation of the Timber Mountain caldera just to the north of Yucca Mountain[5].

The phase relations at the point and time of trapping can be deduced, with relatively little ambiguity, from the inclusion evidence. The all-liquid inclusions tell us only that a liquid phase was present. It could have been merely a film of water flowing down the walls of the fracture, or the entire vein could have been filled. However, a vapor phase was also present. Such mixture of all-liquid and all-vapor inclusions might be expected from a thin, flowing film of water in which small vapor bubbles occasionally form on the crystal faces and are trapped, or in calcite growing into a vein filled with liquid, out of which small amounts of gas was exsolving as bubbles. The inclusion evidence favors the water film environment, as the vapor inclusions show essentially atmospheric internal pressure (when crushed in glycerol), even in samples as deep as 314 m. If the vein were filled with water to this depth, these vapor inclusions would have been trapped at pressures ≤30 atmospheres. Thus, these inclusions were formed in the unsaturated zone. (If crushing experiments show similar low pressures for the samples for which Th were determined, there would be no need for a "pressure correction" to be added to the homogenization temperatures to obtain trapping temperatures.)

Although the above arguments seem to establish that the calcite crystallized from a descending film of water on the walls of a vein that was open to the atmosphere, the origin of the gases in the inclusions is not as clear. The gases could simply be "air", pumped in and out of the vein by barometric pressure changes. The CO_2 and methane could be of bacterial origin, carried down with the water and exsolved as temperatures rise slightly. Alternatively, all gases ("air", CO_2, and methane) could have been exsolved into the vein system from deeper circulating ground waters. We have not as yet found any inclusion evidence for the age of formation of the host calcite.

ACKNOWLEDGEMENTS

The authors greatly appreciate the training and use of the Quadrupole Gas Analysis Laboratory provided by Gary Landis of the USGS. This paper benefitted from the thoughtful reviews of Robert O. Rye, Craig Johnson, and Richard Moscati of the USGS. Polished plates for fluid inclusion study were prepared by David Mann of LANL.

References

1. ROEDDER, EDWIN, J.F. WHELAN, and D.T. VANIMAN, "Environment of formation of calcite veins from Yucca Mountain (NV) tuffs as evidenced by fluid inclusion crushing studies", Abs. with Program, GSA Annual Meeting, p. A-184 (1993).

2. WHELAN, J.F., and J.S. STUCKLESS, "Paleohydrologic implications of the stable isotopic composition of secondary calcite within the Tertiary volcanic rocks of Yucca Mountain, Nevada", in *IHLRWM Proc.*, ASCE and ANS, 3rd Internat. Conf., Las Vegas, Nevada, 1572-1581 (1992).

3. VANIMAN, D.T., "Calcite deposits in fractures at Yucca Mountain, Nevada", in *IHLRWM Proc.*, ASCE and ANS, 4th Internat. Conf., Las Vegas, Nevada, 1935-1939 (1993).

4. PETERMAN, Z.E., J.S. STUCKLESS, B.D. MARSHALL, S.A. MAHAN, and K.A. FUTA, "Strontium isotope geochemistry of calcite fracture fillings in deep core, Yucca Mountain, Nevada - a progress report", in *IHLRWM Proc.*, ASCE and ANS, 3rd Internat. Conf., Las Vegas, Nevada, 1582-1586 (1992).

5. BISH, D.L., and ARONSON, J.L., "Paleogeothermal and paleohydrologic conditions in silicic tuff from Yucca Mountain, Nevada", Clays and Clay Minerals, 41, 148-161 (1993).

6. ROEDDER, EDWIN, "Application of an improved crushing microscope stage to studies of the gases in fluid inclusions", Schweiz. Mineral. Petrog. Mitteil., 50, p. 41-58 (in English) (1970).

7. ROEDDER, EDWIN, *Fluid Inclusions*, 12, Reviews in Mineralogy, Mineralogical Society of America, Washington, D.C., 644 p. (1984).

8. ROEDDER, EDWIN, and H.E. BELKIN, "Significance of monophase fluid inclusions in minerals", Comptes rendus Acad. Sci. (Paris), 306, p. 283-287 (in English) (1988).

PART 3

Letter from R. M. Nelson (DOE) to R. R. Loux containing fluid inclusion data discussed in Roedder et al., 1994

Department of Energy
Yucca Mountain Site Characterization
Project Office
P. O. Box 98608
Las Vegas, NV 89193-8608

WBS 1.2.5.3
QA: N/A

DEC 2 0 1993

Robert R. Loux
Executive Director
Agency for Nuclear Projects
State of Nevada
Evergreen Center, Suite 252
1802 North Carson Street
Carson City, NV 89710

SECOND INSTALLMENT OF DATA REPORTED IN U.S. GEOLOGICAL SURVEY (USGS) MONTHLY REPORTS (SCP: N/A)

References: (1) Ltr, Loux to Gertz, dtd 8/31/93
(2) Ltr, Gertz to Loux, dtd 10/1/93

Enclosed is the second installment of information requested by the State of Nevada for data, data sets, and preliminary interpretations mentioned in the USGS monthly reports of ongoing work (Reference 1). The data noted by Y[5] in the table entitled "Data Request" are enclosed. The data tracking numbers associated with data enclosed with this letter are GS931008315215215.030, GS931008315215215.034, and GS931008315215215.035.

The data denoted by N[6] are scheduled to be sent to the USGS Local Records Center on January 31, 1994. Within 15 days of this date, data will be furnished to the U.S. Department of Energy (DOE) and within another 15 days, DOE will release the data to the state.

If you have any questions, please contact either Ardyth M. Simmons at (702) 794-7998 or Thomas W. Bjerstedt at (702) 794-7950.

Robert M. Nelson, Jr.
Acting Project Manager

RSED:AMS-1160

Enclosure:
Partial Transmittal of
Requested Data

cc w/encl:
A. B. Benson, HQ (RW-5.2) FORS
S. J. Brocoum, HQ (RW-22) FORS
L. J. Desell, HQ (RW-331) FORS
C. E. Einberg, HQ (RW-331) FORS
A. A. Boulton, SAIC, Denver, CO
B. E. Reilly, SAIC, Las Vegas, NV
P. W. McKinley, USGS, Denver, CO

RECEIVED
DEC 2 1 1993
WASTE PROJECT OFFICE

DATA REQUEST

(Summary)

Agency for Nuclear Projects, Nuclear Waste Project Office

Request Dated: August 31, 1993

Request Received: September 9, 1993

Item Number	Requested Data	Source	Data Included (Y/N)
	Strontium		
1	Location and analysis of carbonate-rich samples	[a] 01/93, p. 64	N[b]
2	Locations and alpha-spectrometry results from Nevares Spring tufa mound	[a] 10-11/93, p. 64	N[b]
3	Sr isotope data for VH-2 and elsewhere in Tertiary aquifer	[a] 08/92, p 94	Y
4	XRF mass spec. analyses and SR/SR ratios of VH-1	[a] 08/92, p. 94	Y
5	Sr/Sr ratios from Franklin Lake Playa	[a] 08/92, p. 94	Y
6	Sr concentrations for Nevares Spring tufa	[a] 08/92, p. 95	Y
7	Sr content and isotopic comp. of high-Si rhyolite samples from UE25A#1	[a] 09-92, p. 13	Y
8	Sr composition from Nevares Spring	[a] 09/92, p. 8	Y
9	Sr composition from Pyramid Lake	[a] 09/92, p. 89	N[c]
10	Sr isotopes for precip. sample from Yucca Crest	[a] 01/93, P. 63	Y
11	Sr/Sr and Rb/Sr rations of rhyolite in G-4	[a] 10-11/93(?), p. 16	Y
12	Sr/Sr ratios of precip. samples for 08/11/92, 03/92, and 02/92	[a] 10-11/93(?), p. 90	Y

Item Number	Requested Data	Source	Data Included (Y/N)
13	Sr isotopic anal. of outcrop samples, Southern Yucca Mtn.	[b] 04/15/92	Y
14	Sr content and isotopic comp. from high-Si rhyolite from UE25a#1	[b] 10/16/92	Y
	Fluid Inclusion		
15	Results from fluid inclusion studies for USW - G-1 and G-2	[a] 01/93, p. 87	Y
16	Results of fluid inclusion studies of calcite from USW G-2, GU-3, G-4, UE25UZ-16, A-4, A-5, A-7	[a] 01/93, p. 70	Y
	Carbon and Oxygen		
17	^{13}C and $^{18}0$ values of calcite from site 106	[a] 07/92, p. 105	Y
18	^{13}C and ^{18}O values from Site 199	[a] 07/92, p. 106	Y
19	^{13}C and ^{18}O values from trenches CFS-E, CF-1, 2, and 8	[a] 07/92, p. 106	Y
20	^{13}C and ^{18}O values from Tonopah RR in Ash Meadows	[a] 07/92, p. 106	Y
21	^{13}C and ^{18}O values from Trench 14 calcites and calcrete	[a] 07/92, p. 106	Y
22	^{13}C and ^{18}O values from Nevares Spring	[a] 07/92, p. 107	Y
23	^{18}O results from Trench-14	[a] 08/92, p. 100	Y
24	^{18}O values of opal/chalcedony from drill core	[a] 08/92, p. 100	Y
25	^{14}C ages of calcites from USW G-1 and other drill holes.	[a] 01/93, p. 71	Y
26	^{13}C and ^{18}O values from Site 106 and Wahmonie	[a] 10-11/93 (?), p. 92	Y

Item Number	Requested Data	Source	Data Included (Y/N)
27	^{13}C and ^{18}O values from Travertine, Nevares, and Grapevine springs	[a] 10-11/ 93(?), p. 92	Y\5
28	^{13}C and ^{18}O values from Busted Butte, Eleanna Trench, Trenches 1 and 16, Yucca Crest	[a] 10-11/ 93(?), p. 92	Y\5
29	^{13}C and ^{18}O values from Site 106 and Wahmonie	[a] 12/93, p. 68	Y\5
30	^{13}C and ^{18}O values from Nevares and Grapevine springs	[a] 12/93, p. 68	Y\5
31	^{13}C and ^{18}O values from UE25-RF-9	a 12/93, p. 68	Y\5
32	^{13}C and ^{18}O values from Yucca Crest	a 12/93, p 68	Y\5
33	^{13}C and ^{18}O values from Sites 106 and 199, Trenches CFS-E, CF-1, 2, and 8, Tonopah RR, Trench 14, and Nevares Spring	[b] 08/11/92	Y\5
34	^{13}C and ^{18}O values from USW G-1 and 2, UE-25 A-5, RF-3, and USW GU-3	[b] 03/10/93	Y\5
	Other Data		
35	Nd/Nd values of calcite fracture-fillings from USW G-2, 3, and 4	[a] 01/92, p. 83	N\2
36	Results of XRF trace-element analyses	[a] 10-11/93, p. 15	N\3
37	Location and results of isotope analysis on samples from Raven Canyon and results from JF-3	[a] 10-11/93, p. 15	Y
38	Results from tufa mound samples at Nevares Spring	[a] 0-11/93, p. 89	N\6
39	Chemistry results from VH-2	[a] 10-11/93, p. 94	Y
40	Vapor-phase inclusion results from USW G-1	[a] 10-11/93, p. 93	Y\5
41	Analyses of faunal samples from Modern Springs	[b] 03/11/92, p. 6	N\4

Item Number	Requested Data	Source	Data Included (Y/N)
42	Isotopic composition of carbonate from Site 106, Wahmonie, Nevares, and Grapevine springs, UE25 RF-9, UEA-6, Yucca Crest, and USW G-4	[b] 01/13/93	Y \5

[a] USGS, YMP, Monthly Highlights and Status Report
[b] Letters to Carl Gertz from U.S. Department of Interior

\1 Unable to respond to this request. This study by Larry Benson (USGS-WRD, Boulder, CO) was funded from a Geologic Division account.
\2 No data available. Samples were originally obtained from LANL and had been irradiated for neutron activation analysis. The neodymium isotopic compositions had been affected by the irradiation, and the analyses were determined to be invalid.
\3 Request cannot be met - unable to specifically identify the data wanted from the wording in the request.
\4 Octracodes were observed in the samples as described on page 11 of the data request, however no identification of species was made.
\5 Available December 7, 1993
\6 Available February 15, 1994

HD #	Drill Hole	SPC #	Depth (ft)	Tcrush (C)	Thomog (C)
HD-318	G1	00016017	425.5	95,90,-90	
HD-319	G1	00016018	491.8	-60,60	
HD-322	G1	00016021	669.2	-100,99.5,76,92	81
HD-325	G1	00016024	959.8	94,-82	
HD-326	G1	00016025	1029.0	82,82,82,-82	
HD-338	G1	00016037	3588.5		99,10[illegible].114
HD-343	G1	00016042	3867.3		74,86
HD-348	G1	00016047	5348.6		87,96,92,91
HD-359	G2	00016060	858.2		57,59
HD-368	G2	00016068	1137.6		81>72
HD-369	G2	00016069	1169.8		104,103
HD-274	G2	00004688	1562.2	94,92	
HD-579	G2	00016083	4162.8		78,-80,82,80,79
HD-582	G2	00016086	4912.8		org(?)-240-260
HD-583	G2	00016087	5107.3		215,216,242-245

Request numbers 15 and 16 for fluid inclusion are a part of TDIF.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-150-1	Site 106		359-C-7	-3.6	22.7	00002931
☒ Yes	HD-150-1A	Site 106		2C1	-3.8	22.5	00002931
☒ Yes	HD-151-2	Site 106		359-C-8	-3.9	22.7	00002932
☒ Yes	HD-151-2A	Site 106		2C2	-4.1	22.5	00002932
☒ Yes	HD-151-3A	Site 106		2C3	-4.1	22.1	00002932
☒ Yes	HD-153-1	Site 106		359-C-9	-4.7	21.4	00002934
☒ Yes	HD-153-1A	Site 106		2C5	-5.1	20.4	.00002934
☒ Yes	HD-153-1JFW	Site 106		394-C-9	-4.9	20.8	00002934
☒ Yes	HD-153-1RJM	Site 106		395-C-1	-5.2	20.4	00002934
☒ Yes	HD-153-1RJM	Site 106		13C-10	-5.1	20.2	00002934
☒ Yes	HD-153-1RJM	Site 106		17C-9	-5.0	20.8	00002934
☒ Yes	HD-155-1	Site 106		359-C-10	-4.2	22.5	00002936
☒ Yes	HD-155-1A	Site 106		2C6	-4.3	22.1	00002936
☒ Yes	HD-156-1A	Site 106		2C7	-4.5	21.7	00002937
☒ Yes	HD-156-2A	Site 106		2C8	-4.6	21.8	00002937
☒ Yes	HD-159-1	Site 106		360-C-1	-3.7	23.9	00002940
☒ Yes	HD-159A	Site 106		2C10	-3.8	23.5	00002940
☒ Yes	HD-160-1	Site 106		360-C-2	-4.1	23.5	00002941
☒ Yes	HD-160A	Site 106		3C1	-4.3	23.2	00002941
☒ Yes	HD-161A	Site 106		3C2	-5.6	30.7	00002942
☒ Yes	HD-162-1	Site 106		360-C-4	-4.4	24.3	00002943
☒ Yes	HD-162-1JFW	Site 106		394-C-7	-4.6	23.8	00002943
☒ Yes	HD-162-1RJM	Site 106		394-C-8	-4.6	24.1	00002943
☒ Yes	HD-163-1	Site 106		360-C-5	-3.8	22.1	00002944
☒ Yes	HD-163A	Site 106		3C5	-4.0	22.2	00002944

Request numbers 17, 26, 33 and 42.

C-13 and O-18 values of calcite from site 106.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
⊠ Yes	HD-164-2	Site 199		360-C-6	-2.8	18.9	00002945
⊠ Yes	HD-164-2A	Site 199		3C6	-2.8	18.8	00002945
⊠ Yes	HD-166-1	Site 199		360-C-7	-1.3	20.5	00002947
⊠ Yes	HD-166-3A	Site 199		3C7	-1.0	20.4	00002947
⊠ Yes	HD-167A	Site 199		3C8	-2.1	20.1	0000294[illegible]
⊠ Yes	HD-168-1A	Site 199		3C9	-1.5	21.5	00002949
⊠ Yes	HD-169-1	Site 199		360-C-8	-1.1	21.3	0000[illegible]950
⊠ Yes	HD-169-1A	Site 199		3C10	-1.6	21.4	0000[illegible]950

Request number 18 and 33.

C-13 and O-18 data from site 199.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-171A	Trench CFS-E		4C9	-3.7	19.6	00002952

Request number 19 and 33.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-209-1A	Trench CF2		7C9	-5.3	23.0	00002995

Request number 19 and 33.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-181-1A1	Trench 8		5C7	-5.5	19.3	00002967
☒ Yes	HD-181-2A1	Trench 8		5C8	-5.7	19.2	00002967
☒ Yes	HD-181-3A1	Trench 8		5C9	-5.3	19.4	00002967
☒ Yes	HD-181-4A1	Trench 8		5C10	-5.6	19.2	00002967
☒ Yes	HD-181-6A1	Trench 8		6C2	-6.0	21.8	00002967
☒ Yes	HD-184-1	Trench 8		6C3	-5.8	21.0	[illegible]
☒ Yes	HD-186-1	Trench 8		6C5	-5.5	21.8	00002972
☒ Yes	HD-189A	Trench 8		6C7	-5.9	19.4	00002975
☒ Yes	HD-190A	Trench 8		6C8	-6.2	19.3	00002976
☒ Yes	HD-191A	Trench 8		6C9	-6.3	19.8	00002977

Request number 19 and 33.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
⊠ Yes	HD-175-2	Tonopah Railroad		5C1	-0.9	16.7	00002961
⊠ Yes	HD-176-2A	Tonopah Railroad		5C2	0.3	22.2	00002962
⊠ Yes	HD-177A	Tonopah Railroad		5C3	-0.9	16.3	00002963
⊠ Yes	HD-178A	Tonopah Railroad		5C4	-1.1	17.5	00002964
⊠ Yes	HD-179A	Tonopah Railroad		5C5	-0.7	15.7	00002965

Request number 20 and 33.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-1	Trench 14		283-C-8	-6.7	20.8	00003618
☒ Yes	HD-1	Trench 14		320-C-1	-6.2	21.1	00003618
☒ Yes	HD-1	Trench 14		321-C-1	-6.1	21.2	00003618
☒ Yes	HD-10	Trench 14		284-C-2	-5.6	19.7	00003626
☒ Yes	HD-10	Trench 14		321-C-5	-5.6	19.6	00003626
☒ Yes	HD-11	Trench 14		321-C-6	-5.9	20.4	00003627
☒ Yes	HD-12	Trench 14		321-C-7	-6.0	20.2	00003628
☒ Yes	HD-15-3-2	Trench 14		1C3	-5.3	19.5	00003695
☒ Yes	HD-15-3-3	Trench 14		1C4	-4.5	20.3	00003695
☒ Yes	HD-15-3-4	Trench 14		1C5	-6.4	19.5	00003695
☒ Yes	HD-2	Trench 14		283-C-9	-6.9	20.5	00003617
☒ Yes	HD-2	Trench 14		286-C-4	-6.9	20.3	00003617
☒ Yes	HD-2	Trench 14		320-C-2	-6.9	20.3	00003017
☒ Yes	HD-20-1	Trench 14		285-C-3	-7.6	20.0	00003698
☒ Yes	HD-20-1	Trench 14		322-C-4	-7.5	20.2	00003698
☒ Yes	HD-20-2	Trench 14		285-C-2	-6.4	21.2	00003698
☒ Yes	HD-22-1	Trench 14		285-C-1	-6.9	19.8	00003634
☒ Yes	HD-22-3	Trench 14		284-C-9	-6.1	19.9	00003634
☒ Yes	HD-22-4	Trench 14		284-C-10	-7.1	19.5	00003634
☒ Yes	HD-22-4	Trench 14		322-C-5	-7.1	19.6	00003634
☒ Yes	HD-23-1A	Trench 14		1C6	-5.3	20.3	00003635
☒ Yes	HD-24-1A	Trench 14		1C7	-5.5	20.3	00003636
☒ Yes	HD-25-1A	Trench 14		1C8	-5.6	20.9	00003637
☒ Yes	HD-26-1A	Trench 14		1C9	-5.6	20.4	00003638
☒ Yes	HD-27-1A	Trench 14		1C10	-5.9	19.6	00003639
☒ Yes	HD-28-2	Trench 14		285-C-6	-6.0	19.5	00003640
☒ Yes	HD-3	Trench 14		320-C-3	-6.1	20.6	00003619
☒ Yes	HD-31-1	Trench 14		285-C-7	-6.5	19.9	00003643
☒ Yes	HD-31-2	Trench 14		286-C-6	-6.1	20.4	00003643
☒ Yes	HD-39-2	Trench 14		285-C-8	-6.6	20.4	00003649
☒ Yes	HD-4	Trench 14		322-C-1	-6.1	19.9	00003620
☒ Yes	HD-41-1-A	Trench 14		287-C-1	-7.4	19.7	00003650
☒ Yes	HD-41-1-B	Trench 14		287-C-3	-7.2	20.0	00003650
☒ Yes	HD-42-10	Trench 14		282-C-3	-6.1	20.3	00003651
☒ Yes	HD-42-10	Trench 14		284-C-3	-6.1	20.6	00003651
☒ Yes	HD-42-10	Trench 14		286-C-5	-6.1	20.5	00003651
☒ Yes	HD-42-11	Trench 14		284-C-4	-6.7	20.3	00003651
☒ Yes	HD-42-12	Trench 14		284-C-5	-7.1	20.0	00003651
☒ Yes	HD-42-13	Trench 14		283-C-1	-7.0	19.7	00003651
☒ Yes	HD-42-13	Trench 14		284-C-6	-7.0	19.9	00003651
☒ Yes	HD-42-14	Trench 14		282-C-9	-6.1	20.5	00003651
☒ Yes	HD-42-15	Trench 14		283-C-6	-6.5	20.5	00003651
☒ Yes	HD-42-16	Trench 14		284-C-7	-6.5	20.7	00003651

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-5	Trench 14		283-C-3	-5.5	20.7	00003621
☒ Yes	HD-54-1	Trench 14a		286-C-7	-6.9	21.4	00003659
☒ Yes	HD-54-1	Trench 14a		322-C-6	-6.9	21.5	00003659
☒ Yes	HD-54-3	Trench 14a		286-C-1	-7.1	20.3	00003659
☒ Yes	HD-54-5	Trench 14a		283-C-4	-6.4	2[illegible].1	00003659
☒ Yes	HD-6	Trench 14		283-C-10	-5.[illegible]	19.8	00003622
☒ Yes	HD-7	Trench 14		321-C-2	-5.8	19.8	00003623
☒ Yes	HD-8	Trench 14		321-C-3	-5.6	19.8	00003624
☒ Yes	HD-9	Trench 14		282-C-1	-5.9	20.1	00003625
☒ Yes	HD-9	Trench 14		284-C-1	-5.9	20.4	00003625
☒ Yes	HD-9	Trench 14		321-C-4	-5.9	20.3	0000362[illegible]
☒ Yes	HD-[illegible]63-03A	Trench 14c		119C-7	-6.4	20.3	00005405
☒ Yes	HD-963-03B	Trench 14c		119C-8	-5.4	20.1	00005405
☒ Yes	HD-963-04A	Trench 14c		119C-10	-6.2	20.4	00005406
☒ Yes	HD-963-04C	Trench 14c		120C-1	-5.9	19.2	00005406
☒ Yes	HD-963-05A	Trench 14c		120C-3	-5.7	20.1	00005407
☒ Yes	HD-963-06A	Trench 14c		120C-5	-6.6	20.3	00005408
☒ Yes	HD-963-07A	Trench 14c		120C-6	-6.5	19.6	00005409
☒ Yes	HD-963-08A	Trench 14c		120C-7	-6.9	19.9	00005410
☒ Yes	HD-963-08B	Trench 14c		121C-1	-6.3	19.4	00005410
☒ Yes	HD-963-09A	Trench 14c		121C-2	-6.3	20.8	00005411
☒ Yes	HD-963-09B	Trench 14c		121C-3	-6.4	20.7	00005411
☒ Yes	HD-963-10A	Trench 14c.		121C-5	-6.7	20.3	00005412
☒ Yes	HD-963-11A	Trench 14c		121C-6	-6.9	19.7	00005413
☒ Yes	HD-963-15A	Trench 14c		122C-1	-5.4	20.5	00005417
☒ Yes	HD-963-16A	Trench 14c		122C-2	-6.3	20.2	00005418
☒ Yes	HD-963-17A	Trench 14c		122C-3	-5.8	19.6	00005419
☒ Yes	HD-963-18A	Trench 14c		122C-4	-5.8	19.6	00005551
☒ Yes	HD-963-19A	Trench 14c		122C-5	-6.1	20.5	00005552
☒ Yes	HD-963-20A	Trench 14c		123C-3	-5.7	20.5	00005553

Request numbers 21 and 33.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-494-A	Nevares Spring		17C-5	-1.0	25.1	00003730
☒ Yes	HD-495A	Nevares Spring		7C10	-2.5	15.4	00003731
☒ Yes	HD-496-A	Nevares Spring		18C-4	-2.5	15.6	00003732
☒ Yes	HD-496-A	Nevares Spring		18C-8	-2.1	15.6	00003732
☒ Yes	HD-499-A	Nevares Spring		18C-9	-1.5	17.6	00003735
☒ Yes	HD-500-A	Nevares Spring		19C-1	-1.3	18.9	00003736
☒ Yes	HD-501-A	Nevares Spring		19C-2	-1.6	17.0	00003737
☒ Yes	HD-502-A	Nevares Spring		19C-3	-1.9	15.8	00003738
☒ Yes	HD-502A	Nevares Spring		21C-10	-1.9	15.9	00003738
☒ Yes	HD-503-A	Nevares Spring		19C-4	-1.4	15.3	00003739
☒ Yes	HD-503-A	Nevares Spring		19C-5	-1.4	15.3	00003739

Request number 22, 27, 33 and 42.

Sample #	Locality	SPC #	Depth (ft)	Yield (umole/mg)	d18O smow
HD-306C	UE-25 a#1	00016005	253	18.51	18.60
HD-351B	USW G-2	00016051	92.2	16.80	26.60
HD-355A	USW G-2	00016055	236.7	16.46	20.70
HD-355A	USW G-2	00016055	236.7	16.92	20.50
HD-356A	USW G-2	00016056	240.7	17.22	21.70
HD-358A	USW G-2	00016058	257.8	17.15	24.10
HD-362A	USW G-2	00016062	280.2	17.10	21.20
HD-929A	UE-25 A-5	00019109	92.2	17.16	23.30
HD-926A	UE-25 A-5	00019106	85.2	16.65	21.90
HD-941A	Beatty	00005451		16.45	24.60
HD-700A	USW G-4	00005542	74.2	17.10	24.10

Request number 24.

HD #	Drill Hole	SPC #	Depth (ft)	LLNL #	GRPT #	14C Age	Age error	Fm	Fm error	mg of Carbon
HD-325c	G1	00016024	579.4	CAMS-4056	219	39,970	1,940	0.0069	0.0017	0.51
HD-674d	G4	00004866	352.4	CAMS-4677	292	41,950	950	0.0054	0.0006	0.77
HD-388a	GU3	00016108	204.9	CAMS-4678	293	33,360	360	0.0157	0.0007	0.46
HD-359a	G2	00016060	858.2	CAMS-4679	295	45,260	1850	0.0036	0.0008	0.88
HD-322c	G1	00016021	669.2	CAMS-4925	327	20,910	90	0.0740	0.0007	0.50
HD-676a	G4	00004864	554	CAMS-4926	328	>54,000		0.0002	0.0005	0.79
HD-385a	GU3	00016105	149.6	CAMS-4927	329	37,390	470	0.0095	0.0006	0.55
HD-320c	G1	00016019	579.4	CAMS-4928	330	>51,000		0.0008	0.0005	0.88
HD-351a	G2	00016051	302.5	CAMS-4929	333	43,500	970	0.0044	0.0005	0.85
HD-272a	G2	00004686	1448	CAMS-4930	334	39,510	610	0.0073	0.0005	0.92
HD-702a	G4	00005540	259.4	CAMS-4931	336	38,950	580	0.0078	0.0006	0.90
HD-328b	G1	00016027	1134.1	CAMS-4932	337	40,300	660	0.0066	0.0005	0.76
HD-383a	GU3	00016103	47.7	CAMS-4933	338	40,260	680	0.0067	0.0006	0.67
HD-352a	G2	00016052	314.5	CAMS-4934	340	>51,000		0.0008	0.0005	0.75
Harding				CAMS-4689	273	49,290	380	0.0022	0.0001	1.03
Harding				CAMS-4913	331	55,870	1550	0.0010	0.0002	0.91
Harding				CAMS-4690	274	48,330	480	0.0024	0.0001	0.86
Harding				CAMS-5341	401	54,600	880	0.0011	0.0001	0.85
Harding				CAMS-4914	332	50,090	590	0.0020	0.0001	0.78
Harding				CAMS-4057	222	46,520	3280	0.0031	0.0012	0.63
Harding				CAMS-4686	294	48,190	470	0.0025	0.0001	0.61
Harding				CAMS-4688	291	45,750	390	0.0034	0.0002	0.60
Harding				CAMS-4687	290	48,780	500	0.0023	0.0001	0.59
Harding				CAMS-5340	400	49,450	1120	0.0021	0.0003	0.47
Harding				CAMS-5343	406	44,500	2700	0.0039	0.0013	0.26
Harding				CAMS-5342	402	30,280	580	0.0231	0.0017	0.08

Request number 25

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-443-4-A	Wahmonie		13C-2	-5.0	18.1	00001981
☒ Yes	HD-443-5-A	Wahmonie		13C-3	-4.8	23.6	00001981

Request number 26.

Site 106 data can be found under request number 17.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-505-1	Grapevine Spring		19C-7	0.4	15.5	00003741
☒ Yes	HD-505-2	Grapevine Spring		19C-8	0.5	14.7	00003741
☒ Yes	HD-505-3	Grapevine Spring		19C-9	0.3	13.9	00003741
☒ Yes	HD-505-3	Grapevine Spring		19C-10	0.3	13.7	00003741
☒ Yes	HD-505-3	Grapevine Spring		22C-1	0.2	13.6	00003741
☒ Yes	HD-505-4	Grapevine Spring		20C-1	0.0	14.1	00003741
☒ Yes	HD-505-5	Grapevine Spring		20C-2	0.0	14.0	00003741
☒ Yes	HD-505-5	Grapevine Spring		43C-3	0.1	14.1	00003741
☒ Yes	HD-506-1	Grapevine Spring		20C-3	-0.2	15.9	00003741
☒ Yes	HD-506-1	Grapevine Spring		43C-4	-0.2	16.1	00003742
☒ Yes	HD-506-2	Grapevine Spring		20C-4	-0.7	16.0	00003742
☒ Yes	HD-507-1-A	Grapevine Spring		20C-5	-0.1	17.1	00003742
☒ Yes	HD-507-1-A	Grapevine Spring		22C-3	-0.1	17.2	00003743
☒ Yes	HD-507-1-A	Grapevine Spring		43C-5	-0.1	17.2	00003743
☒ Yes	HD-507-1-B	Grapevine Spring		22C-4	-0.5	17.1	00003743
☒ Yes	HD-507-2-C	Grapevine Spring		20C-8	0.1	16.6	00003743
☒ Yes	HD-507-2-C	Grapevine Spring		20C-9	0.1	16.5	00003743
☒ Yes	HD-507-3-D	Grapevine Spring		21C-1	0.7	16.9	00003743
☒ Yes	HD-507-3-D	Grapevine Spring		22C-5	0.7	16.9	00003743
☒ Yes	HD-507-3-D	Grapevine Spring		43C-6	0.7	16.8	00003743
☒ Yes	HD-507-3-E	Grapevine Spring		21C-2	0.2	14.6	00003743
☒ Yes	HD-507-4-F	Grapevine Spring		21C-3	-0.6	15.5	00003743
☒ Yes	HD-507-4-G	Grapevine Spring		21C-4	-0.1	14.2	00003743
☒ Yes	HD-508-1	Grapevine Spring		21C-5	0.1	13.8	00003744
☒ Yes	HD-508-1	Grapevine Spring		22C-6	0.1	14.3	00003744
☒ Yes	HD-508-2	Grapevine Spring		21C-6	-0.1	15.8	00003744
☒ Yes	HD-508-2	Grapevine Spring		20C-7	-0.1	15.7	00003744
☒ Yes	HD-508-2	Grapevine Spring		43C-9	0.0	16.0	00003744
☒ Yes	HD-510-1	Grapevine Spring		22C-7	-0.7	17.6	00003746
☒ Yes	HD-510-2	Grapevine Spring		22C-8	-4.5	18.9	00003746
☒ Yes	HD-510-3	Grapevine Spring		22C-9	-3.6	18.4	00003746
☒ Yes	HD-510-4	Grapevine Spring		22C-10	-3.4	18.6	00003746
☒ Yes	HD-510-5	Grapevine Spring		23C-1	-4.4	17.8	00003746
☒ Yes	HD-510-5	Grapevine Spring		45C-7	4.4	17.9	00003746
☒ Yes	HD-511	Grapevine Spring		43C-10	-0.5	18.8	00003747
☒ Yes	HD-511-A	Grapevine Spring		23C-2	-0.6	18.7	00003747

Request number 27.

Nevares Spring data is listed with request number 22.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-483-1-A	Travertine Point		17C-1	0.2	15.0	00003719
☒ Yes	HD-483-A	Travertine Point		16C-10	0.2	15.7	00003719
☒ Yes	HD-484-A	Travertine Point		17C-2	0.5	16.6	00003720
☒ Yes	HD-485-A	Travertine Point		17C-3	1.3	15.4	00003721

Request number 27.

Nevares Spring data is listed with request number 22.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-444-A	Eleanna Trench		13C-4	-6.1	18.7	00001982
☒ Yes	HD-445-A	Eleanna Trench		13C-5	-4.8	19.5	00001983

Request number 28 data are listed on next 6 pages.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-1178A	Busted Butte		114C-7	-3.8	24.1	00005184
☒ Yes	HD-1179A	Busted Butte		114C-8	-3.7	20.4	00005183
☒ Yes	HD-1450A	Busted Butte		117C-2	-5.4	19.1	00500387
☒ Yes	HD-1450B	Busted Butte		117C-3	-5.8	18.5	00500387
☒ Yes	HD-1450C	Busted Butte		117C-4	-5.8	18.4	00500387
☒ Yes	HD-1454-LA	Busted Butte		117C-9	-5.3	20.0	00500391
☒ Yes	HD-1454-LB	Busted Butte		117C-10	-5.7	21.5	00500391
☒ Yes	HD-1454-UA	Busted Butte		117C-6	-6.6	21.8	00500391
☒ Yes	HD-1454-UB	Busted Butte		117C-7	-5.5	20.8	00500391
☒ Yes	HD-1454-UC	Busted Butte		117C-8	-6.3	21.9	00500391
☒ Yes	HD-1456-LA	Busted Butte		118C-7	-5.4	20.0	00500393
☒ Yes	HD-1456-LA	Busted Butte		12C-7	-5.5	19.9	00500393
☒ Yes	HD-1456-LB	Busted Butte		118C-8	-4.9	20.1	00500393
☒ Yes	HD-1456-LB	Busted Butte		122C-8	-5.0	20.0	00500393
☒ Yes	HD-1456-LC	Busted Butte		118C-9	-4.2	19.5	00500393
☒ Yes	HD-1456-LC	Busted Butte		122C-9	-4.1	19.7	00500393
☒ Yes	HD-1456-UA	Busted Butte		118C-10	-4.7	20.2	00500393
☒ Yes	HD-1456-UA	Busted Butte		123C-1	-4.7	20.2	00500393
☒ Yes	HD-1456-UB	Busted Butte		119C-1	-5.2	19.4	00500393
☒ Yes	HD-240-01-A	Busted Butte		395-C-5	-5.0	19.8	00003025
☒ Yes	HD-240-01-B	Busted Butte		395-C-6	-4.9	20.2	00003025
☒ Yes	HD-240-02-A	Busted Butte		395-C-7	-4.2	20.4	00003025
☒ Yes	HD-240-02-A	Busted Butte		13C-9	-4.3	20.5	00003025
☒ Yes	HD-240-03-A	Busted Butte		395-C-9	-2.2	21.4	00003025
☒ Yes	HD-240-03-A	Busted Butte		13C-8	-2.2	21.4	00003025
☒ Yes	HD-240-04-A	Busted Butte		395-C-10	-5.4	19.6	00003025
☒ Yes	HD-241-01-A	Busted Butte		396-C-1	-3.3	21.0	00003026
☒ Yes	HD-241-01-A	Busted Butte		15C-4	-3.3	21.3	00003026
☒ Yes	HD-241-01-A	Busted Butte		18C-1	-3.1	21.3	00003026
☒ Yes	HD-241-02-A	Busted Butte		12C-2	-3.9	20.9	00003026
☒ Yes	HD-241-02-A	Busted Butte		12C-3	-3.8	20.8	00003026
☒ Yes	HD-241-03-A	Busted Butte		12C-4	-3.6	19.6	00003026
☒ Yes	HD-241-03-B	Busted Butte		12C-6	-4.9	20.5	00003026
☒ Yes	HD-243-02-A	Busted Butte		12C-8	-4.6	20.4	00003028
☒ Yes	HD-243-03-A	Busted Butte		12C-9	-3.9	20.1	00003028
☒ Yes	HD-446-1-A	Busted Butte		15C-5	-3.7	21.6	00001984
☒ Yes	HD-446-3A	Busted Butte		9C1	-4.0	21.2	00001984
☒ Yes	HD-446-4A	Busted Butte		9C2	-5.2	20.3	00001984
☒ Yes	HD-446-A	Busted Butte		13C-6	-4.9	20.7	00001984
☒ Yes	HD-447A	Busted Butte		9C3	14.4	21.0	00001985
☒ Yes	HD-448A	Busted Butte		9C4	-3.6	21.5	00001986
☒ Yes	HD-451A	Busted Butte		9C7	-4.8	21.5	00001989
☒ Yes	HD-56-5	Busted Butte		285-C-4	-5.1	19.6	00003661

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-56-6	Busted Butte		321-C-8	-5.7	20.2	00003661
☒ Yes	HD-56-7	Busted Butte		286-C-2	-5.1	19.9	00003661
☒ Yes	HD-56-7	Busted Butte		321-C-9	-5.0	19.9	00003661
☒ Yes	HD-56-8	Busted Butte		282-C-6	-6.1	19.3	00003661
☒ Yes	HD-56-8	Busted Butte		283-C-7	-6.2	19.3	00003661
☒ Yes	HD-56-9	Busted Butte		285-C-5	-5.8	19.7	00003661
☒ Yes	HD-57	Busted Butte		323-C-3	-5.2	20.4	00003662
☒ Yes	HD-58	Busted Butte		323-C-4	-4.8	22.1	00003663
☒ Yes	HD-63-3	Busted Butte		282-C-10	-3.1	21.4	00003667
☒ Yes	HD-63-4	Busted Butte		285-C-9	-3.7	21.1	00003667
☒ Yes	HD-74-1-A	Busted Butte		287-C-2	-7.0	19.6	0000367.
☒ Yes	HD-75	Busted Butte		323-C-5	-4.8	20.2	00003676
☒ Yes	HD-76	Busted Butte		323-C-6	-4.6	22.1	00003679
☒ Yes	HD-954B	Busted Butte		114C-9	-5.1	20.5	00005594
☒ Yes	HD-955AB	Busted Butte		115C-1	-5.7	19.5	00005595
☒ Yes	HD-955B-B	Busted Butte		123C-2	-5.6	19.8	00005595
☒ Yes	HD-955BB	Busted Butte		115C-2	-5.5	20.1	00005595
☒ Yes	HD-956A	Busted Butte		115C-6	-4.8	20.6	00005596
☒ Yes	HD-956B	Busted Butte		115C-7	-4.8	21.4	00005596
☒ Yes	HD-957A	Busted Butte		115C-8	-4.7	20.8	00005597
☒ Yes	HD-957B	Busted Butte		115C-9	-4.5	20.7	00005597
☒ Yes	HD-957C	Busted Butte		115C-10	-4.0	19.9	00005597
☒ Yes	HD-958A	Busted Butte		115C-3	-8.8	22.1	00005598
☒ Yes	HD-959B	Busted Butte		115C-4	-5.3	20.3	00005599
☒ Yes	HD-960A	Busted Butte		116C-1	-4.3	21.1	00005600
☒ Yes	HD-960B	Busted Butte		116C-5	-4.8	20.0	00005600
☒ Yes	HD-961-B	Busted Butte		119C-2	-5.2	19.9	00005401
☒ Yes	HD-961A	Busted Butte		116C-6	-4.9	19.7	00005401
☒ Yes	HD-961B	Busted Butte		116C-7	-5.3	19.3	00005401
☒ Yes	HD-961C	Busted Butte		116C-8	-5.4	18.8	00005401
☒ Yes	HD-961D	Busted Butte		116C-9	-4.8	19.7	00005401
☒ Yes	HD-962-B	Busted Butte		119C-3	-5.7	20.4	00005402
☒ Yes	HD-962A	Busted Butte		116C-10	-6.3	20.0	00005402
☒ Yes	HD-962B	Busted Butte		117C-1	-5.2	20.4	00005402

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-453A	Yucca Crest		9C8	-5.8	18.8	00001990
☒ Yes	HD-454A	Yucca Crest		9C9	-6.6	20.0	00001991
☒ Yes	HD-455A	Yucca Crest		9C10	-5.8	19.9	00001992
☒ Yes	HD-456A	Yucca Crest		15C-6	-5.8	20.4	00001993
☒ Yes	HD-462-2-A	Yucca Crest		16C-4	-6.5	20.1	00001999
☒ Yes	HD-463-B	Yucca Crest		16C-5	-6.0	21.4	00002000
☒ Yes	HD-464-A	Yucca Crest		16C-7	-5.3	21.3	00004656

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-457-A	Trench One		15C-7	2.2	19.8	00001994
☒ Yes	HD-458-A	Trench One		15C-10	-6.4	17.0	00001995
☒ Yes	HD-460-A	Trench One		16C-1	-5.6	19.8	00001997
☒ Yes	HD-461-A	Trench One		16C-2	-6.3	19.0	00001998

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-254-2	Trench 16		395-C-3	-5.3	21.4	00003035
☒ Yes	HD-254-1	Trench 16		395-C-2	-5.6	19.6	00003035

See request number 27 for data form request numbers 29 and 30.

See request number 28 for data from request number 32.

Data for request number 33 are found with the following:

request number 17 for site 106
18 for site 199
19 for Trench CFS-E
19 for Trench CF-1
19 for Trench CF-2
19 for Trench 8
20 for Tonopah RR
21 for Trench 14
22 for Nevares Spring

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-863-A	UE-25 RF-9	16.4	24C-4	-4.3	19.4	00019196
☒ Yes	HD-864-A	UE-25 RF-9	18.3	24C-5	-5.4	19.1	00019197
☒ Yes	HD-865-A	UE-25 RF-9	20.1	24C-7	-5.0	21.2	00019198
☒ Yes	HD-865-A	UE-25 RF-9	20.1	44C-1	-5.0	21.2	00019198
☒ Yes	HD-866-A	UE-25 RF-9	22.0	44C-2	-6.3	16.6	00019199

Request number 31.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-280A	USW G-1	885.4	347-C-6	-9.5	14.2	00004694
☒ Yes	HD-280A	USW G-1	885.5	34C-9	-9.4	14.4	00004694
☒ Yes	HD-280A	USW G-1	885.4	46C-8	-9.5	14.0	00004694
☒ Yes	HD-317A	USW G-1	97.7	34C-10	-5.5	17.4	00016016
☒ Yes	HD-317A	USW G-1	97.7	46C-9	-5.7	16.9	00016016
☒ Yes	HD-317B	USW G-1	97.7	35C-1	-6.1	17.1	00016016
☒ Yes	HD-317B	USW G-1	97.7	46C-10	-6.1	17.1	00016016
☒ Yes	HD-318A	USW G-1	129.7	35C-2	-4.8	14.6	00016017
☒ Yes	HD-318A	USW G-1	129.7	47C-1	-4.9	14.5	00016017
☒ Yes	HD-318A	USW G-1	129.7	47C-1	-4.9	14.4	00016017
☒ Yes	HD-318B	USW G-1	129.7	38C-2	-6.8	16.2	00016017
☒ Yes	HD-318B	USW G-1	129.7	47C-2	-6.8	16.0	00016017
☒ Yes	HD-319A	USW G-1	149.9	38C-3	-5.4	14.6	00016018
☒ Yes	HD-319A	USW G-1	149.9	38C-3	-5.4	14.7	00016018
☒ Yes	HD-319A	USW G-1	149.9	38C-3	-5.4	14.7	00016018
☒ Yes	HD-319A	USW G-1	149.9	47C-4	-5.4	14.3	00016018
☒ Yes	HD-319B	USW G-1	149.9	38C-4	-2.4	14.2	00016018
☒ Yes	HD-319B	USW G-1	149.9	80C-3	-2.4	14.3	00016018
☒ Yes	HD-319C	USW G-1	149.9	38C-6	3.7	13.9	00016018
☒ Yes	HD-319C	USW G-1	149.9	38C-6	3.5	13.6	00016018
☒ Yes	HD-319C	USW G-1	149.9	47C-6	3.4	13.3	00016018
☒ Yes	HD-319D	US[illegible]	149.9	39C-4	2.0	13.7	00016018
☒ Yes	HD-319D	US[illegible]	149.9	39C-4	2.1	13.7	00016018
☒ Yes	HD-319D	USW G-1	149.9	47C-7	2.1	13.6	00016018
☒ Yes	HD-319E	USW G-1	149.9	38C-8	-1.4	15.3	00016018
☒ Yes	HD-319E	USW G-1	149.9	47C-8	-1.5	15.2	00016018
☒ Yes	HD-320A	USW G-1	176.6	38C-10	-6.8	15.2	00016019
☒ Yes	HD-320A	USW G-1	176.6	38C-10	-6.9	15.1	00016019
☒ Yes	HD-320A	USW G-1	176.6	38C-10	-6.7	15.5	00016019
☒ Yes	HD-320A	USW G-1	176.6	47C-10	-6.8	15.3	00016019
☒ Yes	HD-320B	USW G-1	176.6	39C-1	-6.9	16.4	00016019
☒ Yes	HD-320B	USW G-1	176.6	39C-1	-6.9	16.2	00016019
☒ Yes	HD-320B	USW G-1	176.6	39C-1	-6.8	16.6	00016019
☒ Yes	HD-320B	USW G-1	176.6	45C-8	-6.8	16.5	00016019
☒ Yes	HD-320B	USW G-1	176.6	48C-1	-6.8	16.4	00016019
☒ Yes	HD-320C	USW G-1	176.6	45C-9	-7.7	17.0	00016019
☒ Yes	HD-320C	USW G-1	176.6	48C-2	-8.0	17.0	00016019
☒ Yes	HD-322A	USW G-1	204.0	39C-2	-0.6	14.5	00016021
☒ Yes	HD-322A	USW G-1	204.0	39C-2	-0.7	14.5	00016021
☒ Yes	HD-322A	USW G-1	204.0	39C-2	-0.5	14.7	00016021
☒ Yes	HD-322A	USW G-1	204.0	48C-3	-0.7	14.5	00016021
☒ Yes	HD-322B	USW G-1	204.0	39C-5	-4.9	14.6	00016021
☒ Yes	HD-322B	USW G-1	204.0	48C-4	-5.1	14.5	00016021

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-322C	USW G-1	204.0	46C-2	-4.6	14.8	00016021
☒ Yes	HD-322C	USW G-1	204.0	48C-5	-5.2	15.0	00016021
☒ Yes	HD-325A	USW G-1	292.5	46C-3	-7.3	15.8	00016024
☒ Yes	HD-325A	USW G-1	292.5	48C-6	-7.3	15.8	00016024
☒ Yes	HD-326A	USW G-1	313.6	39C-6	-6.8	15.6	00016025
☒ Yes	HD-326A	USW G-1	313.6	48C-8	-6.8	15.6	00016025
☒ Yes	HD-327A	USW G-1	310.1	46C-5	-8.2	16.6	00016026
☒ Yes	HD-327A	USW G-1	310.1	48C-10	-7.9	16.6	00016026
☒ Yes	HD-327B	USW G-1	310.1	39C-10	-4.2	15.0	00016026
☒ Yes	HD-327B	USW G-1	310.1	49C-1	-4.5	14.8	00016026
☒ Yes	HD-327C	USW G-1	310.1	49C-2	-7.8	16.2	00016026
☒ Yes	HD-328A	USW G-1	345.7	49C-3	-7.5	16.3	00016027
☒ Yes	HD-328A	USW G-1	345.7	80C-4	-7.6	16.3	00016027
☒ Yes	HD-328B	USW G-1	345.7	49C-4	-7.1	15.5	00016027
☒ Yes	HD-329A	USW G-1	353.7	40C-2	-1.7	14.6	00016028
☒ Yes	HD-329A	USW G-1	353.7	49C-6	-1.6	14.2	00016028
☒ Yes	HD-330A	USW G-1	365.4	40C-3	-7.6	16.5	00016029
☒ Yes	HD-330A	USW G-1	365.4	49C-7	-7.5	16.5	00016029
☒ Yes	HD-330B	USW G-1	365.4	49C-8	-6.5	16.4	00016029
☒ Yes	HD-330B	USW G-1	365.4	52C-8	-6.4	16.8	00016029
☒ Yes	HD-331A	USW G-1	385.7	49C-9	-5.4	12.7	00016030
☒ Yes	HD-331A	US	385.7	80C-6	-5.5	13.1	00016030
☒ Yes	HD-334A	US[illegible]	895.3	50C-1	4.4	11.8	00016033
☒ Yes	HD-334A	USW G-1	895.3	80C-7	4.2	11.9	00016033
☒ Yes	HD-336A	USW G-1	1090.3	50C-2	1.9	10.3	00016035
☒ Yes	HD-337A	USW G-1	1090.7	50C-3	1.7	10.0	00016036
☒ Yes	HD-337B	USW G-1	1090.7	50C-4	1.9	10.3	00016036
☒ Yes	HD-338A	USW G-1	1093.8	50C-5	2.1	10.0	00016037
☒ Yes	HD-339A	USW G-1	1109.8	50C-6	3.3	11.9	00016038
☒ Yes	HD-339A	USW G-1	1109.8	52C-9	3.3	11.9	00016038
☒ Yes	HD-340A	USW G-1	1112.7	50C-7	2.1	10.2	00016039
☒ Yes	HD-341A	USW G-1	1120.7	50C-9	2.3	10.1	00016040
☒ Yes	HD-341A	USW G-1	1120.7	53C-5	2.3	10.0	00016040
☒ Yes	HD-342D	USW G-1	1164.9	50C-8	3.3	11.3	00016041
☒ Yes	HD-343B	USW G-1	1178.8	50C-10	2.3	10.7	00016042
☒ Yes	HD-343C	USW G-1	1178.9	51C-6	1.9	11.0	00016042
☒ Yes	HD-343D	USW G-1	1178.8	51C-7	2.5	10.2	00016042
☒ Yes	HD-344B	USW G-1	1187.4	51C-8	1.4	9.6	00016043
☒ Yes	HD-345B	USW G-1	1427.0	51C-9	0.5	3.9	00016044
☒ Yes	HD-345B	USW G-1	1427.0	80C-8	0.4	4.0	00016044
☒ Yes	HD-346A	USW G-1	1550.0	51C-10	-0.2	3.4	00016045
☒ Yes	HD-346A	USW G-1	1550.0	80C-9	-0.3	3.4	00016045
☒ Yes	HD-347A	USW G-1	1618.8	52C-2	0.1	9.5	00016046

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-347A	USW G-1	1618.8	80C-10	0.0	9.6	00016046
☒ Yes	HD-348A	USW G-1	1630.3	52C-3	0.1	2.4	00016047
☒ Yes	HD-348B	USW G-1	1630.3	52C-4	0.4	4.2	00016047
☒ Yes	HD-349A	USW G-1	1636.3	52C-5	0.4	1.3	00016048
☒ Yes	HD-350A	USW G-1	1654.6	52C-6	-0.4	6.9	00016050
☒ Yes	HD-350A	USW G-1	1654.6	52C-6	-0.[illegible]	[illegible] 9	00016050
☒ Yes	HD-350B	USW G-1	1[illegible]4.6	53C-6	0.2	8.2	0[illegible]016050

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-261A	USW G-2	1279.9	54C-4	0.0	4.1	00004675
☒ Yes	HD-261A	USW G-2	1279.9	71C-4	-0.1	3.9	00004675
☒ Yes	HD-261B	USW G-2	1279.9	350-C-4	-0.6	7.8	00004675
☒ Yes	HD-262A	USW G-2	1459.4	350-C-7	-1.5	7.8	00004676
☒ Yes	HD-262B	USW G-2	1459.4	350-C-8	-1.0	8.1	00004676
☒ Yes	HD-263A	USW G-2	1636.8	350-C-9	1.1	9.4	00004677
☒ Yes	HD-264A	USW G-2	1639.5	347-C-8	1.9	12.9	00004678
☒ Yes	HD-264B	USW G-2	1639.5	347-C-9	0.7	6.2	00004678
☒ Yes	HD-264C	USW G-2	1639.5	349-C-7	-0.4	8.9	00004678
☒ Yes	HD-265A	USW G-2	1756.3	351-C-1	-0.8	7.1	00004679
☒ Yes	HD-265B	USW G-2	1756.3	351-C-2	-0.4	8.6	00004679
☒ Yes	HD-265C	USW G-2	1756.3	351-C-3	-0.5	9.7	00004679
☒ Yes	HD-266A	USW G-2	1794.1	349-C-9	1.4	10.8	00004680
☒ Yes	HD-272A	USW G-2	441.4	348-C-5	-5.7	14.7	00004686
☒ Yes	HD-272B	USW G-2	441.4	348-C-6	-8.2	15.6	00004686
☒ Yes	HD-272B	USW G-2	441.4	349-C-6	-8.3	15.6	00004686
☒ Yes	HD-272B	USW G-2	441.4	71C-6	-8.4	15.4	00004686
☒ Yes	HD-272D	USW G-2	441.4	348-C-7	-3.6	14.5	00004686
☒ Yes	HD-273A	USW G-2	463.9	348-C-1	-7.9	17.1	00004687
☒ Yes	HD-273B	USW G-2	463.9	348-C-2	-6.0	15.1	00004687
☒ Yes	HD-273C	USW G-2	463.9	348-C-3	-7.9	17.3	00004687
☒ Yes	HD-273D	US[illegible]	463.9	348-C-4	-4.1	14.7	00004687
☒ Yes	HD-273E	US[illegible]	463.9	350-C-5	-6.8	15.5	00004687
☒ Yes	HD-273E	USW G-2	463.9	71C-10	-7.0	15.4	00004687
☒ Yes	HD-273F	USW G-2	463.9	350-C-6	-7.3	15.7	00004687
☒ Yes	HD-274A	USW G-2	476.1	348-C-8	-1.5	14.4	00004688
☒ Yes	HD-274B	USW G-2	476.1	348-C-9	-0.9	13.8	00004688
☒ Yes	HD-274C	USW G-2	476.1	348-C-10	-4.7	15.9	00004688
☒ Yes	HD-274D	USW G-2	476.1	349-C-1	-7.5	18.3	00004688
☒ Yes	HD-274E	USW G-2	476.1	349-C-2	-8.2	18.3	00004688
☒ Yes	HD-275B	USW G-2	477.3	350-C-1	-2.0	14.8	00004689
☒ Yes	HD-275C	USW G-2	477.3	350-C-2	-0.2	14.0	00004689
☒ Yes	HD-275D	USW G-2	477.3	53C-8	-1.7	14.1	00004689
☒ Yes	HD-351A	USW G-2	92.2	53C-9	-7.6	20.7	00016051
☒ Yes	HD-351C	USW G-2	92.2	53C-10	-6.8	20.5	00016051
☒ Yes	HD-352A	USW G-2	95.9	54C-1	-5.9	19.8	00016052
☒ Yes	HD-352A	USW G-2	95.9	54C-5	-5.9	19.7	00016052
☒ Yes	HD-352A	USW G-2	95.9	56C-3	-5.9	19.8	00016052
☒ Yes	HD-353A	USW G-2	196.9	54C-2	-8.2	19.5	00016053
☒ Yes	HD-353A	USW G-2	196.9	54C-6	-8.2	19.5	00016053
☒ Yes	HD-353B	USW G-2	196.9	54C-7	-8.4	18.9	00016053
☒ Yes	HD-354A	USW G-2	204.3	54C-8	-7.5	17.2	00016054
☒ Yes	HD-355B	USW G-2	236.7	54C-9	-7.7	17.9	00016055

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
⊠ Yes	HD-355B	USW G-2	236.7	55C-4	-7.7	17.9	00016055
⊠ Yes	HD-356B	USW G-2	240.7	54C-10	-7.9	19.0	00016056
⊠ Yes	HD-357A	USW G-2	248.0	55C-2	-8.7	19.0	00016057
⊠ Yes	HD-358B	USW G-2	257.8	55C-3	-7.5	17.4	00016058
⊠ Yes	HD-359A	USW G-2	178.4	55C-5	-7.7	18.3	00016060
⊠ Yes	HD-360A	USW G-2	258.2	55C-6	-8.0	19.3	00016059
⊠ Yes	HD-361A	USW G-2	280.2	55C-7	-8.4	19.1	0001[illegible]061
⊠ Yes	HD-362B	USW G-2	280.2	55C-8	-8.3	18.7	00016062
⊠ Yes	HD-366A	USW G-2	304.2	56C-1	-7.8	18.1	00016066
⊠ Yes	HD-366B	USW G-2	304.2	56C-2	-8.0	18.8	00016066
⊠ Yes	HD-366C	USW G-2	304.2	56C-5	-8.0	19.0	00016066
⊠ Yes	HD-367A	USW G-2	324.5	56C-7	-6.9	16.7	00016067
⊠ Yes	HD-367C	USW G-2	324.5	56C-6	-7.2	17.2	00016067
⊠ Yes	HD-368A	USW G-2	346.7	57C-9	-8.1	18.3	00016068
⊠ Yes	HD-368B	USW G-2	346.7	57C-10	-7.4	16.8	00016068
⊠ Yes	HD-370A	USW G-2	360.8	57C-2	-7.9	19.1	00016070
⊠ Yes	HD-370B	USW G-2	360.8	57C-3	-7.9	19.0	00016070
⊠ Yes	HD-577A	USW G-2	1254.7	57C-4	-7.6	15.8	00016081
⊠ Yes	HD-578A	USW G-2	1256.2	57C-5	0.4	4.0	00016082
⊠ Yes	HD-579A	USW G-2	1268.8	57C-7	-0.2	4.7	00016083
⊠ Yes	HD-579B	USW G-2	1268.8	57C-6	-0.1	6.3	00016083
⊠ Yes	HD-580A	US[illegible]	1272.3	57C-8	-0.2	8.8	00016084
⊠ Yes	HD-581B	US[illegible]	1493.6	57C-10	-0.7	6.6	00016085
⊠ Yes	HD-582A	USW G-2	1497.4	58C-1	-2.1	6.5	00016086
⊠ Yes	HD-582B	USW G-2	1497.4	58C-2	-0.6	6.9	00016086
⊠ Yes	HD-583A	USW G-2	1556.7	58C-5	1.1	2.0	00016087
⊠ Yes	HD-583A	USW G-2	1556.7	72C-3	1.1	2.0	00016087
⊠ Yes	HD-584A	USW G-2	1559.6	58C-6	1.8	4.9	00016088
⊠ Yes	HD-585A	USW G-2	1618.0	58C-7	1.2	8.5	00016089
⊠ Yes	HD-586A	USW G-2	1624.7	58C-8	0.9	9.9	00016090
⊠ Yes	HD-587B	USW G-2	1651.7	58C-10	1.3	8.9	00016091
⊠ Yes	HD-588A	USW G-2	1655.4	59C-1	1.2	8.2	00016092
⊠ Yes	HD-588A	USW G-2	1655.4	61C-6	1.2	8.4	00016092
⊠ Yes	HD-589A	USW G-2	1668.7	59C-2	0.6	9.2	00016093
⊠ Yes	HD-590A	USW G-2	1717.8	59C-3	-1.4	5.8	00016094
⊠ Yes	HD-590A	USW G-2	1717.8	59C-4	-1.5	5.8	00016094
⊠ Yes	HD-591A	USW G-2	1732.2	59C-5	-1.9	8.8	00016095
⊠ Yes	HD-591B	USW G-2	1732.2	59C-6	-1.4	9.0	00016095
⊠ Yes	HD-593A	USW G-2	1757.1	61C-8	0.0	8.1	00016097
⊠ Yes	HD-594A	USW G-2	1760.7	60C-4	-0.2	6.8	00016098
⊠ Yes	HD-595A	USW G-2	1763.4	60C-7	-0.8	7.5	00016099
⊠ Yes	HD-595A	USW G-2	1763.4	61C-5	-0.8	7.7	00016099
⊠ Yes	HD-595C	USW G-2	1763.4	60C-9	-0.3	8.4	00016099

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-596A	USW G-2	1786.9	60C-10	0.4	9.9	00016100
☒ Yes	HD-597A	USW G-2	1792.2	61C-2	-0.1	7.3	00016101
☒ Yes	HD-597B	USW G-2	1792.2	61C-3	1.1	10.8	00016101

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-926B	UE-25 A-5	85.2	63C-9	-6.3	17.8	00019106
☒ Yes	HD-926C	UE-25 A-5	85.2	63C-10	-6.4	17.7	00019106
☒ Yes	HD-927A	UE-25 A-5	85.9	64C-1	-2.8	14.7	00019107
☒ Yes	HD-927B	UE-25 A-5	85.9	64C-2	-6.7	17.8	00019107
☒ Yes	HD-927C	UE-25 A-5	85.9	64C-4	-6.4	17.7	00019107
☒ Yes	HD-928A	UE-25 A-5	86.9	64C-5	-7.5	18.6	00019108
☒ Yes	HD-928B	UE-25 A-5	86.9	64C-6	-6.5	18.3	00019108
☒ Yes	HD-929B	UE-25 A-5	92.2	64C-7	-5.8	17.9	00019109
☒ Yes	HD-931A	UE-25 A-5	104.8	64C-8	-6.8	17.8	00019111
☒ Yes	HD-932A	UE-25 A-5	108.5	64C-10	-5.2	15.9	00019112
☒ Yes	HD-933A	UE-25 A-5	110.9	65C-1	-6.2	17.6	00019113
☒ Yes	HD-935A	UE-25 A-5	140.2	65C-3	-5.9	17.3	00019115
☒ Yes	HD-936A	UE-25 A-5	143.2	66C-5	-6.2	17.5	00019116
☒ Yes	HD-937A	UE-25 A-5	145.8	66C-6	-6.0	15.2	00019117
☒ Yes	HD-937B	UE-25 A-5	145.8	65C-7	-6.0	16.2	00019117
☒ Yes	HD-938B	UE-25 A-5	147.7	65C-9	-6.1	16.8	00019118

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-904A	UE-25 RF-3	3.4	62C-2	-6.5	19.6	00019210
☒ Yes	HD-905A	UE-25 RF-3	4.3	62C-3	-6.3	19.3	00019211
☒ Yes	HD-906A	UE-25 RF-3	4.7	62C-4	-5.8	19.0	00019212
☒ Yes	HD-907A	UE-25 RF-3	5.7	62C-5	-6.0	18.6	00019213
☒ Yes	HD-908A	UE-25 RF-3	9.3	62C-6	-5.3	19.3	00019214
☒ Yes	HD-909A	UE-25 RF-3	11.6	62C-7	-5.5	19.6	00019215
☒ Yes	HD-910A	UE-25 RF-3	15.9	62C-8	-4.7	19.5	00019216
☒ Yes	HD-911A	UE-25 RF-3	19.9	62C-9	-6.0	18.9	00019217
☒ Yes	HD-912A	UE-25 RF-3	25.9	63C-8	-6.1	19.0	00019218
☒ Yes	HD-913A	UE-25 RF-3	30.8	63C-1	-5.6	21.4	00019219

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-267A	USW G-3/GU-3)	313.0	351-C-10	-4.3	18.9	00004681
☒ Yes	HD-267B	USW G-3/GU-3)	313.0	352-C-1	-4.8	19.2	00004681
☒ Yes	HD-268A	USW G-3/GU-3)	1309.7	352-C-4	2.2	10.9	00004682
☒ Yes	HD-268B	USW G-3/GU-3)	1309.7	352-C-5	2.2	10.6	00004682
☒ Yes	HD-268C	USW G-3/GU-3)	1309.7	352-C-6	2.4	11.4	00004682
☒ Yes	HD-268D	USW G-3/GU-3)	1309.7	352-C-7	2.3	9.5	00004682
☒ Yes	HD-269A	USW G-3/GU-3)	1346.0	352-C-8	2.0	11.7	00004683
☒ Yes	HD-269B	USW G-3/GU-3)	1346.0	352-C-9	0.6	10.2	00004683
☒ Yes	HD-270A	USW G-3/GU-3)	1464.0	351-C-6	1.7	7.5	00004684
☒ Yes	HD-276A	USW G-3/GU-3)	294.7	351-C-8	-3.9	18.7	00004690
☒ Yes	HD-276B	USW G-3/GU-3)	294.7	351-C-9	-5.2	19.2	00004690
☒ Yes	HD-277A	USW G-3/GU-3)	296.3	351-C-7	-5.4	19.4	00004691
☒ Yes	HD-277A	USW G-3/GU-3)	296.3	67C-10	-5.4	19.2	00004691
☒ Yes	HD-278A	USW G-3/GU-3)	346.9	357-C-9	-6.4	19.1	00004692
☒ Yes	HD-278B	USW G-3/GU-3)	346.9	357-C-10	-5.7	18.9	00004692
☒ Yes	HD-278C	USW G-3/GU-3)	346.9	358-C-1	-6.2	19.0	00004692
☒ Yes	HD-279A	USW G-3/GU-3)	357.8	352-C-2	-5.9	18.9	00004693
☒ Yes	HD-279B	USW G-3/GU-3)	357.8	352-C-3	-5.7	19.4	00004693
☒ Yes	HD-382A	USW G-3/GU-3)	11.5	65C-10	-5.8	19.6	00016102
☒ Yes	HD-383B	USW G-3/GU-3)	14.6	66C-1	-5.6	20.9	00016103
☒ Yes	HD-383C	USW G-3/GU-3)	14.5	66C-2	-6.4	21.0	00016103
☒ Yes	HD-384A	US[illegible]3/GU-3)	31.5	66C-3	-6.4	20.7	00016104
☒ Yes	HD-385B	US[illegible]GU-3)	45.6	66C-6	-6.5	21.1	00016105
☒ Yes	HD-386A	USW G-3/GU-3)	50.3	66C-8	-6.4	20.7	00016106
☒ Yes	HD-387A	USW G-3/GU-3)	60.7	66C-9	-5.3	20.7	00016107
☒ Yes	HD-388B	USW G-3/GU-3)	62.5	66C-10	-6.4	20.1	00016108
☒ Yes	HD-388C	USW G-3/GU-3)	62.5	67C-2	-5.5	20.7	00016108
☒ Yes	HD-390A	USW G-3/GU-3)	73.5	67C-4	-6.6	20.3	00016110
☒ Yes	HD-390B	USW G-3/GU-3)	73.5	67C-5	-6.4	20.9	00016110
☒ Yes	HD-390C	USW G-3/GU-3)	73.5	67C-6	-6.8	20.5	00016110
☒ Yes	HD-390D	USW G-3/GU-3)	73.5	67C-7	-4.8	20.0	00016110
☒ Yes	HD-390E	USW G-3/GU-3)	73.5	67C-8	-6.7	20.4	00016110
☒ Yes	HD-391A	USW G-3/GU-3)	75.8	67C-9	-6.1	20.3	00016111
☒ Yes	HD-392A	USW G-3/GU-3)	82.8	68C-2	-6.5	20.2	00016112
☒ Yes	HD-392B	USW G-3/GU-3)	82.8	68C-3	-5.4	20.4	00016112
☒ Yes	HD-392B	USW G-3/GU-3)	82.8	69C-6	-5.5	20.4	00016112
☒ Yes	HD-395A	USW G-3/GU-3)	100.6	68C-6	-6.0	20.3	00016115
☒ Yes	HD-395B	USW G-3/GU-3)	100.6	68C-7	-5.6	19.9	00016115
☒ Yes	HD-397A	USW G-3/GU-3)	112.1	68C-10	-5.4	20.7	00016117
☒ Yes	HD-397B	USW G-3/GU-3)	112.1	69C-1	-6.6	19.6	00016117
☒ Yes	HD-398A	USW G-3/GU-3)	131.4	69C-2	-5.3	19.9	00016118
☒ Yes	HD-400B	USW G-3/GU-3)	146.2	69C-5	-5.4	20.0	00016120
☒ Yes	HD-401A	USW G-3/GU-3)	151.9	69C-7	-4.2	20.0	00016121

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
⊠ Yes	HD-403A	USW G-3/GU-3)	168.6	69C-8	-4.1	19.3	00016123
⊠ Yes	HD-406A	USW G-3/GU-3)	192.0	69C-9	-5.8	20.0	00016126
⊠ Yes	HD-421A	USW G-3/GU-3)	341.7	70C-1	-5.3	18.4	00016141
⊠ Yes	HD-422A	USW G-3/GU-3)	349.8	71C-2	-6.0	18.1	000[illegible]6142
⊠ Yes	HD-422A	USW G-3/GU-3)	349.6	70C-2	-6.0	18.2	00016142
⊠ Yes	HD-424A	USW G-3/GU-3)	521.4	70C-3	-5.7	15.8	00016144
⊠ Yes	HD-598A	USW G-3/GU-3)	893.6	71C-5	2.1	9.6	00016157
⊠ Yes	HD-599A	USW G-3/GU-3)	897.9	72C-1	2.4	9.1	00016158
⊠ Yes	HD-599B	USW G-3/GU-3)	897.9	72C-4	3.2	8.9	00016158
⊠ Yes	HD-600A	USW G-3/GU-3)	900.3	72C-6	3.3	9.0	00016159
⊠ Yes	HD-601A	USW G-3/GU-3)	903.6	72C-7	2.2	9.2	00016160
⊠ Yes	HD-602B	USW G-3/GU-3)	908.5	72C-9	2.7	9.2	00016161
⊠ Yes	HD-606A	USW G-3/GU-3)	938.5	73C-1	3.7	9.4	00016165
⊠ Yes	HD-606B	USW G-3/GU-3)	938.5	73C-2	2.0	9.5	00016165
⊠ Yes	HD-608A	USW G-3/GU-3)	946.9	73C-4	3.2	9.0	00016167
⊠ Yes	HD-610A	USW G-3/GU-3)	1315.6	73C-5	2.3	7.1	00016169
⊠ Yes	HD-610B	USW G-3/GU-3)	1315.6	73C-6	2.3	11.0	00016169
⊠ Yes	HD-610C	USW G-3/GU-3)	1315.6	73C-7	2.6	7.7	00016169
⊠ Yes	HD-611A	USW G-3/GU-3)	1324.8	73C-8	1.6	10.0	00016170
⊠ Yes	HD-612A	USW G-3/GU-3)	1330.5	73C-9	1.0	8.3	00016171
⊠ Yes	HD-613A	USW G-3/GU-3)	1343.0	73C-10	1.4	11.0	00016172
⊠ Yes	HD-614A	USW G-3/GU-3)	1349.5	74C-2	2.1	11.0	00016173
⊠ Yes	HD-614B	US[illegible]GU-3)	1349.5	74C-3	1.9	11.2	00016173
⊠ Yes	HD-615A	USW G-3/GU-3)	1407.9	74C-4	1.6	7.8	00016174
⊠ Yes	HD-617A	USW G-3/GU-3)	1456.2	74C-6	0.9	12.0	00016176
⊠ Yes	HD-619A	USW G-3/GU-3)	1521.0	74C-8	2.3	10.6	00016178
⊠ Yes	HD-620A	USW G-3/GU-3)	1530.0	74C-10	0.9	8.9	00016179
⊠ Yes	HD-722A	USW G-3/GU-3)	13.3	70C-4	-6.6	20.6	00005520
⊠ Yes	HD-723A	USW G-3/GU-3)	14.4	70C-7	-6.6	20.7	0000551[illegible]
⊠ Yes	HD-723B	USW G-3/GU-3)	14.4	70C-8	-6.1	20.9	00005519
⊠ Yes	HD-724A	USW G-3/GU-3)	17.3	70C-9	-6.6	20.9	00005518
⊠ Yes	HD-725A	USW G-3/GU-3)	22.1	70C-10	-6.4	20.2	00005517
⊠ Yes	HD-726A	USW G-3/GU-3)	27.4	71C-1	-6.3	20.4	00005516

Request number 34, 10 pages.

CALCITE/SILICA - CARBONATE STABLE ISOTOPES

Accept?	HD #	Locality	Depth : m	Extn Log #	d13C pdb	d18O smow	SPC #
☒ Yes	HD-871-A	UE-25 A-6	35.8	25C-2	-7.6	18.8	00019121
☒ Yes	HD-872-A	UE-25 A-6	40.6	25C-3	-6.8	18.4	00019122
☒ Yes	HD-872A	UE-25 A-6	40.6	45C-10	-6.8	18.7	00019122
☒ Yes	HD-875-A	UE-25 A-6	114.4	25C-5	-5.5	16.7	00019125
☒ Yes	HD-876-A	UE-25 A-6	119.2	25C-6	-6.2	16.2	00019126
☒ Yes	HD-877-A	UE-25 A-6	121.6	25C-7	-7.0	17.9	00019127
☒ Yes	HD-877A	UE-25 A-6	121.6	46C-4	-[illegible].0	17.9	00019127
☒ Yes	HD-878-A	UE-25 A-6	125.5	26C-2	-7.2	17.9	00019128
☒ Yes	HD-879-A	UE-25 A-6	132.6	26C-3	-6.6	17.8	00019129

Request number 42.

See the following request for the remaining data.
#17 for site 106, #26 for Wahmonie,
#22 for Nevares Spring, #27 for Grapevine Spring,
#31 for UE 25 RF-9, #28 for Yucca Crest.