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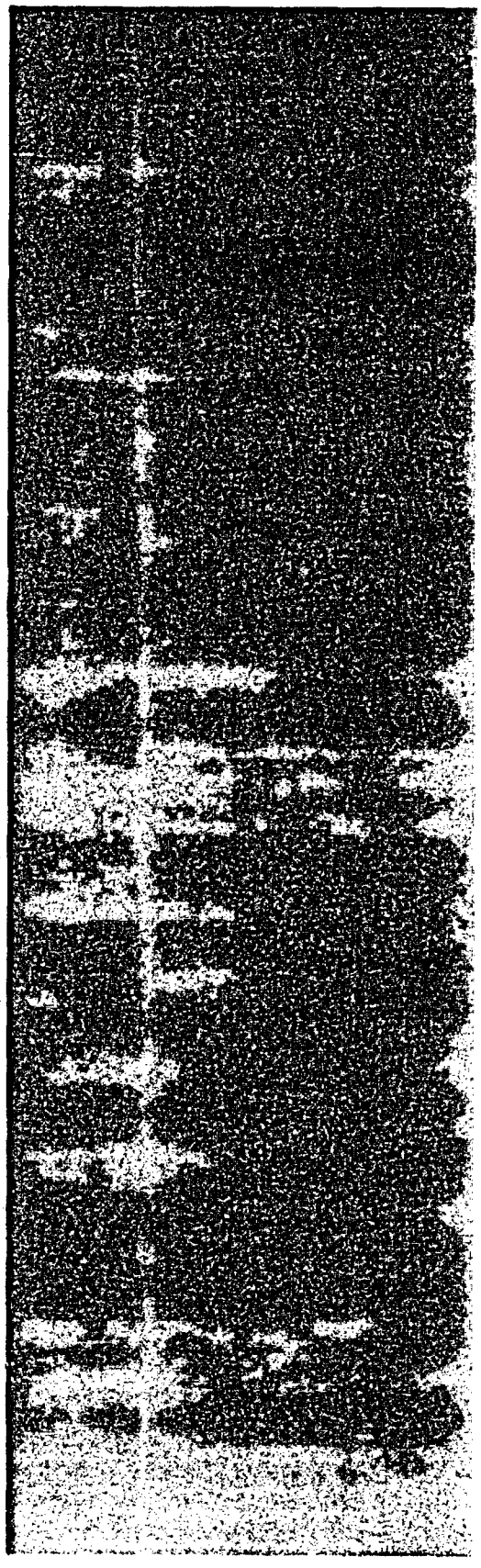

Revised Mineralogic Summary of Yucca Mountain, Nevada

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Revised Mineralogic Summary of Yucca Mountain, Nevada

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REVISED MINERALOGIC SUMMARY OF YUCCA MOUNTAIN, NEVADA

by

D. L. Bish and S. J. Chipera

ABSTRACT

We have evaluated the three-dimensional mineral distribution at Yucca Mountain, Nevada, using quantitative x-ray powder diffraction analysis. All data were obtained on core, cuttings, or sidewall samples obtained from drill holes at and around Yucca Mountain. Previously published data are included with corrections, together with new data for several drill holes. The data in this report therefore supersede previously published quantitative x-ray diffraction data for these samples. The new data presented in this report used the internal standard method of quantitative analysis, which yields results of high precision for the phases commonly found in Yucca Mountain tuffs, including opal-CT and glass. Mineralogical trends with depth previously noted are clearly shown by these new data. Glass occurrence is restricted almost without exception to above the present-day static water level (SWL), although glass has been identified below the SWL in partially zeolitized tuffs. Silica phases undergo well-defined transitions with depth, with tridymite and cristobalite occurring only above the SWL, opal-CT occurring with clinoptilolite-mordenite tuffs, and quartz most abundant below the SWL. Smectite occurs in small amounts in most samples but is enriched in two distinct zones. These zones are at the top of the vitric nonwelded base of the Tiva Canyon Member and at the top of the basal vitrophyre of the Topopah Spring Member. Our data support the presence of several zones of mordenite and clinoptilolite-heulandite as shown previously. New data on several deep clinoptilolite-heulandite samples coexisting with analcime show that they are heulandite. Phillipsite has not been found in any Yucca Mountain samples, but erionite and chabazite have each been found once in fractures. Laumontite has been positively identified in several samples from drill hole UE-25p#1 and may also occur near the bottom of USW G-1.

I. INTRODUCTION

The Yucca Mountain Project, formerly the Nevada Nuclear Waste Storage Investigations (NNWSI) Project, of the U.S. Department of Energy has been conducting an on-going study of Yucca Mountain and surroundings to assess the suitability of the area to host the nation's first high-level radioactive waste repository. Research on this Project has pursued numerous avenues. One of the broad studies of fundamental importance in assessing the ability of the site to perform adequately as a geologic repository

is that of the mineralogy and petrology of the rocks at Yucca Mountain. Complete, three-dimensional information is required on the rock types and properties and on the distribution of all minerals at Yucca Mountain. These data are required to permit optimal siting of a repository and accurate prediction of the possible interactions between heat and waste from the potential repository and the rocks and minerals. In addition, because the primary potential mechanism of radionuclide migration to the accessible environment is via groundwater transport, accurate data are required concerning the nature of the rocks and minerals along potential flow paths away from the repository. Los Alamos National Laboratory has given considerable effort to characterize and understand the mineralogy and petrology of the rocks at and surrounding Yucca Mountain (Heiken and Bevier 1979; Sykes et al. 1979; Bish 1981; Bish et al. 1981; Caporuscio et al. 1982; Vaniman et al. 1984; Bish and Vaniman 1985). This report summarizes our current knowledge of the three-dimensional mineralogy at Yucca Mountain. The report contains some data previously published (Bish and Vaniman 1985) and corrects printing errors that were contained therein. In addition, this report contains new data for drill holes USW G-1, J-13, UE-25a#1 (Bish and Chipera 1986) and UE-25p#1 (Chipera and Bish 1988). The data presented here therefore update previously published x-ray data, but the mineralogic cross sections presented in Appendix B of Bish and Vaniman (1985) have not been reconstructed and remain valid because of their schematic nature.

II. ANALYTICAL METHODS

The x-ray data presented in Appendix A were obtained primarily from core samples, with some data obtained from either drill-cutting or sidewall samples. The locations of the drill holes studied are shown in Fig. 1. Depths are known for both core and sidewall samples, but depths for drill cuttings are approximate within a range of about 10 ft (3.28 m). Older x-ray data were obtained on samples ground under acetone to pass through a 325-mesh (45-μm) sieve, but data for drill holes J-13, USW WT-1, USW WT-2, USW G-1, UE-25a#1, and UE-25p#1 were obtained on samples ground under acetone to less than 5 μm in an automatic Brinkmann Retsch mill with an agate mortar and pestle. The particle size distributions of these newer samples were verified using a Horiba CAPA-500 centrifugal particle size distribution analyzer calibrated with glass microsphere standards. This fine crystallite size is necessary to ensure adequate particle statistics and to minimize primary extinction (Klug and Alexander 1974, pp. 365-367). A portion of most of the newer samples was mixed with a 1.0-μm corundum (Al_2O_3) internal standard in the ratio 80% sample to 20% internal standard. Those samples analyzed with an internal standard are designated with an "I" in Appendix A in a column labeled "method." Those samples with no method designation in Appendix A were analyzed using the external standard method (see below). The powders resulting from the above preparation treatment were mounted in a 22- x 44-mm cavity in a glass slide; this sample area is sufficient for the sample to contain the x-ray beam as low as 8.0°2θ. Powder samples from USW G-4 were mounted in a sample spinner on the diffractometer; all other samples were examined stationary.

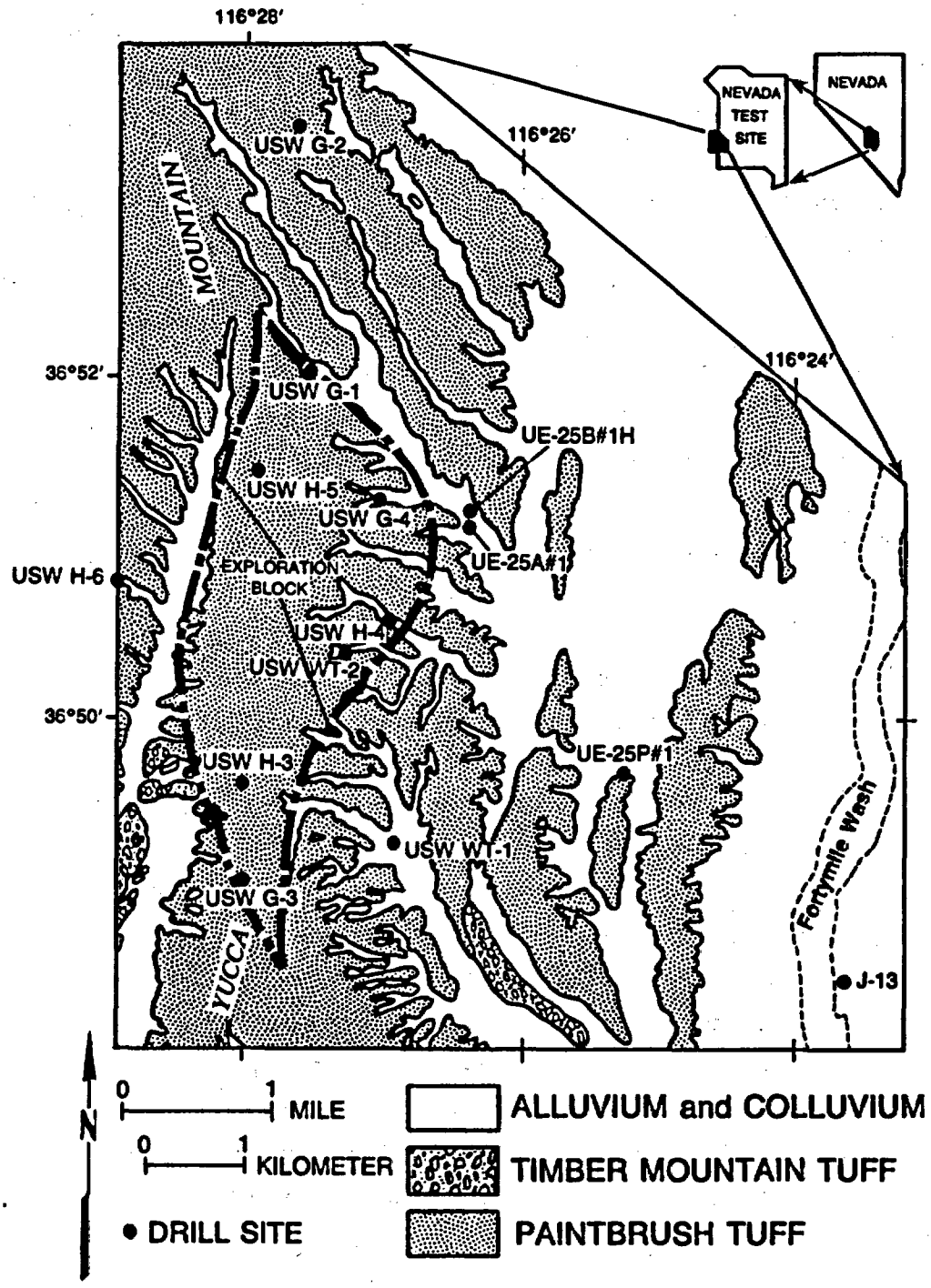

Fig. 1. Location map of Yucca Mountain, Nevada, showing the outline of the exploration block for the NNWSI Project and the locations of drill holes mentioned in the text. Drill hole J-12 is located outside of this figure to the southeast and can be found on the location map published in Bish et al. (1984).

All x-ray powder diffraction data were obtained on an automated Siemens D-500 diffractometer using Cu-Kα radiation, a graphite diffracted-beam monochromator, and pulse-height analysis. Data from USW G-2 and UE-25b#1H were collected manually, scanning from 2.0° to 36.0° 2θ at a rate of 1°/min. All other data were collected automatically in the step-scan mode, with a step size of 0.02°2θ and count times of at least 2.0 s per step. Data for samples with no internal standard were collected from 2.0° to 36.0°2θ, and data for samples with an added corundum internal standard were collected from 2.0° to 50.0°2θ. Several samples were examined using count times as long as 55 s per step to improve detection limits for trace phases.

Mineral identification was accomplished by comparison of observed diffraction patterns with standard patterns measured in this laboratory, by comparison with published standards from the Joint Committee on Powder Diffraction Standards (JCPDS), and by comparison with patterns calculated using the program POWD10 (Smith et al. 1982). Clay mineral standards were obtained from the Clay Minerals Society Source Clay Repository, and zeolite standards were obtained from the Minerals Research Corporation, Clarkson, New York. Differentiation between kaolinite and chlorite was accomplished by heating, but admixed smectite and low amounts of chlorite/kaolinite often gave ambiguous results. Hematite identification was based on major peaks at 33.2° and 35.7°2θ. However, overlap with zeolite peaks made the unambiguous determination of the presence of hematite impossible in zeolitized samples.

A. Quantitative Analyses

Qualitative identification of the crystalline phases present in tuffs can be accomplished quickly and accurately using x-ray powder diffraction. The factors making optical identification of minerals ambiguous, such as the very fine-grained and intergrown texture of the tuffs, do not affect x-ray powder diffraction analyses. However, quantitative multicomponent analysis of rock samples is not straightforward and is complicated by numerous factors (Bish and Chipera 1988). These factors include variations in degree of preferred orientation of crystallites, variations in crystallite size, variations in degree of crystallinity (crystal perfection), and variations in composition (solid-solution effects). In addition, the diffraction patterns from these complex mixtures of minerals often show peaks from at least six different phases. Thus the method of obtaining intensities from these complex patterns with numerous overlapping peaks can significantly affect quantitative results. Finally, because all of our quantitative analyses require the use of standards, the choice of standards plays a crucial role. It is important that standards be as similar to the minerals in the rocks as possible.

All of our older analyses and several recent analyses of samples for which amounts were insufficient for the internal standard method employed the external standard or adiabatic method of Chung (1974a,b). However, whenever sufficient sample was available, our recent analyses employed the internal standard or "matrix-flushing" method of Chung (1974a,b) with 1.0-μm corundum as the internal standard. Both methods require that reference intensity ratios (RIRs) be determined before quantitative analysis. We

have therefore experimentally determined RIRs, the ratio of the integrated intensity of a given reflection of the phase of interest to the integrated intensity of the 113 reflection of corundum in a 1:1 mixture by weight, for most phases found in Yucca Mountain tuffs. The 1:1 ratio of standard to sample was chosen for convenience. In practice any ratio can be used for standardization because the relative amounts of standard and sample are incorporated into the reduction of standard runs. RIR values used in our analyses are given in Table I, together with sources of materials. In the absence of sufficient pure material, RIRs for some phases were calculated using the program POWD10 (Smith et al. 1982).

All of the experimentally measured RIR values for standards in Table I represent the average of six repetitions of the standard-plus-corundum mixture. The values in Table I are strictly applicable only to data obtained on our Siemens diffractometer in its current configuration. Modifications of the instrument or of the sample preparation and mounting method will ideally require remeasurement of RIRs for all phases.

The RIR value for smectite was obtained from material separated from USW G-1 1415 (431.3 m), and this RIR was used for most analyses. However, samples below 3400 ft (1036 m) in USW G-1 showed evidence for some chloritic interlayers, and the RIR for these samples was obtained from the smectite from USW G-1 3490 (1063.8 m). Smectite analyses for UE-25p#1 used RIRs measured on smectites separated from samples at different depths within the UE-25p#1 drill hole. Older analyses employed an RIR for clinoptilolite measured for a clinoptilolite from the 1660-ft (506-m) depth in drill hole UE-4P at the Nevada Test Site. Recent RIRs for clinoptilolite were measured for five different samples to assess the effects of composition and preferred orientation on RIR (Table I). There is an approximately linear relationship between the RIR for the 9.8° (020) reflection and the intensity ratio of the 9.8° reflection to the sum of the reflections between 22.4° and 22.7°2θ (Fig. 2). Thus our recent analyses (USW G-1, UE-25a#1, J-13, and UE-25p#1) used the ratio of the 9.8° peak to the sum of the 22.4°-22.7°2θ peaks to determine the RIR of the 9.8°2θ 020 reflection and used a fixed RIR for the 22.4°-22.7°2θ cluster. When the intensity between 22.4° and 22.7°2θ was not measurable, we used a value of 0.97 for the 9.8°2θ 020 RIR. We compensate for the effects of preferred orientation and chemistry on the mordenite diffraction pattern by using a procedure similar to that used for clinoptilolite. We experimentally determine the ratio of the mordenite 9.8° and 19.6°2θ peaks and then use an appropriate RIR. However, mordenite usually coexists with clinoptilolite, making use of the 9.8°2θ mordenite peak impossible because of interference with the 9.8°2θ clinoptilolite 020 reflection. In these cases, we use an RIR for the 19.6°2θ peak of 0.20. The strong 25.6°2θ mordenite reflection cannot be easily used because of interference with both feldspar and corundum internal standard reflections. Analcime has little compositional variability, so we use an RIR measured on a single natural sample.

TABLE I
REFERENCE INTENSITY RATIOS (RIRs) FOR MINERALS ANALYSED

MINERAL	SOURCE	REFLECTION *hkl* (2θ range)	RIR
Analcime	Wikieup, AZ	211 (15.8)	1.27
		400 (26.0)	1.80
Calcite	Lab Reagent	104 (29.4)	2.96
		116 (48.5)	0.58
Chlorite	Flagstaff Hill, CA,	001 (6.1)	1.53
	Ripidolite	002 (12.4)	3.14
		004 (25.1)	1.74
Clinoptilolite	25525 Castle Creek, ID		
	27032 Castle Creek, ID	020 (9.8)	0.97
	27073 Sheaville, OR	(22.4-22.7)	1.06
	27083 Buckhorn, NM	(30.0)	0.49
	UE4P-1660 Yucca Flat, NV		
Cristobalite	Synthetic Cristobalite	101 (21.9)	4.91
		200 (36.1)	0.84
Dolomite	UE-25p#1-4313/4318,	104 (30.9)	2.69
	Yucca Mt, NV	113 (41.1)	0.48
Feldspar			
Albite	Amelia, VA	(13.4-14.0)	0.24
Albite	Amelia, VA	111 (23.6)	0.27
Sanidine	Eifel, Germany	(13.4-14.0)	0.13
Sanidine	Eifel, Germany	130 (23.6)	0.55
Fluorite	Lab Reagent	111 (28.3)	3.24
		220 (47.0)	3.70
Gypsum	Wyoming Selenite	020 (11.5)4	4.25
Hematite	Cleater Moor, England	104 (33.2)	2.38
		110 (35.7)	1.20
Hornblende	Yucca Mt, NV	110 (10.4)	2.34
Illite	Silver Hill, MT	001 (8.8)	0.57
Ilmenite	Koidu, Sierra Leone	104 (32.8)	1.91
		024 (49.0)	0.62

TABLE I (Cont)

MINERAL	SOURCE	REFLECTION *hkl* (2θ range)	RIR
Kaolinite	Average of Wards' Kaolin, Washington County, GA, and Mesa Alta, NM	001 (12.3)	1.37
Laumontite	Collected by D. Bish in Oregon, 1984	110 (9.3)	1.15
		200 (12.9)	0.47
		130 (21.3)	0.59
Magnetite	Ontario, Canada	220 (30.1)	0.78
		311 (35.4)	2.54
Mica	Avg of calculated and Bancroft, Ontario	001 (8.8)	3.8
Mordenite	Union Pass, AZ	200 (9.8)	0.44
	Lovelock, NV	330 (19.6)	0.20
	USW G1-2314, Yucca Mt, NV	202 (25.7)	0.36
Opal-CT	28501 Kliwikerthal, Czech. 92509 Owyhee County, ID	(21.0-22.1)	1.80
Quartz	Hot Springs, AR	100 (20.8)	0.86
		101 (26.6)	4.19
Smectite	Yucca Mt, NV	001	3.85
		001	1.73
Tridymite	Nevada Test Site, NV	(20.5)	1.18
		(21.6)	1.10

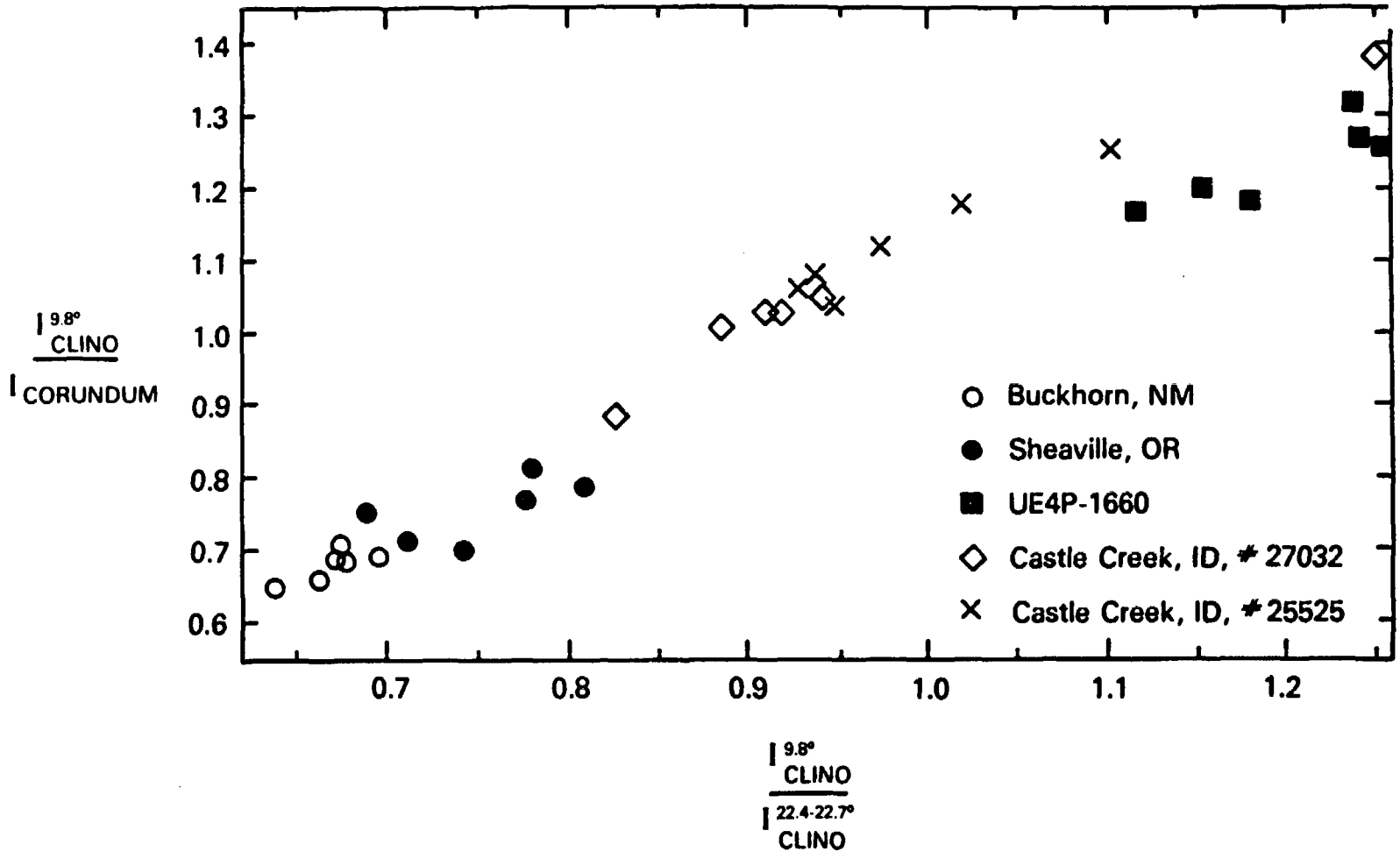

Fig. 2. Relationship between the RIR for the 9.8° clinoptilolite peak and the intensity ratio of the 9.8° reflection to the sum of the reflections between 22.4° and 22.7°2θ (CuKα).

Older analyses used a calculated RIR for tridymite, but recent analyses used an RIR measured on a tridymite-rich sample from Yucca Flat, Nevada Test Site, Nevada. An RIR for tridymite was chosen that yielded a matrix-flushing-analysis total of 100% for this sample, including the other crystalline phases present in the sample. The RIR for tridymite is thus of lower precision than RIRs for other samples that can be obtained in pure form. Older analyses included opal-CT with cristobalite, but recent analyses separated the two, using an RIR for opal-CT measured on two natural samples between 21.0° and 22.1°2θ. RIRs for alkali feldspar were obtained from natural albite and sanidine for peaks in the range 13.4° to 14.0°2θ and at about 23.6°2θ. These peaks are relatively free from interference from other phases, and if both peaks are used, the relative amounts of K-feldspar and albite can be determined.

All of our analyses, apart from data collected manually, used integrated intensities rather than peak heights. Analysis of manually collected data (USW G-2, UE-25b#1a) employed peak heights. The use of integrated intensities compensates for several sample-related problems, including variations in crystallinity and crystallite size. Most integrated intensities were obtained using the Siemens first-derivative peak-search routine (IDENT) that yields precise intensities for resolved peaks. However, this routine divides the intensity of overlapping peaks at the midpoint between the two, which is only an approximation for most peaks. Closely overlapping or very broad peaks were measured by planimetry, and completely overlapping peaks were not decomposed. Overlapping tridymite and cristobalite peaks in samples from USW WT-1 and USW WT-2 were decomposed using a Siemens profile-refinement routine with a Gaussian profile function. However, more recent analyses employed manual planimetry, which we found to be superior to the profile-refinement results. Future analyses will probably employ the more-sophisticated profile-refinement program, FIT, in the latest Siemens software package, DIFFRAC 500.

As noted above, we solved the internal standard equation of Chung (1974a) to analyze for amounts of individual phases when an internal standard was used:

$$X_i = \frac{X_c}{K_{i,n}} \frac{I_{i,n}}{I_c} , \qquad (1)$$

where X_i is the weight fraction of component i, $K_{i,n}$ is the RIR for line n of component i, X_c is the weight fraction of corundum in the sample (commonly 20%), $I_{i,n}$ is the integrated intensity of line n of component i, and I_c is the integrated intensity of the corundum 113 reflection. It is important to note that this method does not require that the sum of the phases be equal to 100%. Therefore, amounts of glass or other amorphous material such as opal-A can be determined by assuming that the difference between the total crystalline phases and 100% is due to amorphous components. There was petrographic evidence for glass in all samples in which we report glass.

For older analyses and the recent analyses in which amounts of sample were insufficient for an internal standard analysis, we solved the external standard equation derived by Chung (1974b):

$$X_i = \left(\frac{K_{i,n}}{I_{i,n}} \sum_{j=1}^{m} \frac{I_{j,n}}{K_{j,n}} \right)^{-1} , \qquad (2)$$

where X_i is the unknown weight fraction of phase i in the rock, $K_{i,n}$ is the RIR for line n of phase i, $I_{i,n}$ and $I_{j,n}$ are the integrated intensity of line n of phase i and j, respectively, and m is the number of phases in the mixture. This equation differs from Eq. (1) in that it is derived using the constraint that the sum of all phases equals 100%. Both Eqs. (1) and (2) "flush" out the mass absorption coefficients by ratioing the RIRs for each phase. We have coded both the internal and the external standard methods, with all of the appropriate RIRs and correction routines in our computer program QUANT. The correction routines in QUANT include (1) correction of mordenite for overlap with smectite, feldspar, and corundum; (2) correction of cristobalite for overlap with albite and tridymite; (3) correction of corundum for overlap with calcite; (4) correction of clinoptilolite for overlap with mordenite; and (5) correction of clinoptilolite and opal-CT for mutual overlap. In addition, we have incorporated a routine correcting for compositional effects on the clinoptilolite RIR. In practice, these corrections improve our accuracy and yield more realistic errors.

B. Precision of Analyses

Numerous factors affect the precision of our quantitative analyses. Some can be explicitly accommodated and others must be approximated. Factors attributable to the sample or to the sample preparation process include solid solution, other variations in composition, and preferred orientation. Errors resulting from these factors are primarily attributable to differences between samples and standards. Other potentially important errors are encountered in data analysis, such as peak overlap, peak integration, counting statistics, and peak-versus-background discrimination. Many of these errors are either cancelled or can be determined during experimental measurement of RIRs. For example, errors due to preferred orientation will be compensated for if the standards exhibit the same degree of preferred orientation as the samples to be analyzed. Errors due to peak integration and peak-versus-background discrimination are typically similar for samples and standards and thus tend to be implicitly corrected for. However, errors may be significantly increased in our samples because of the presence of numerous phases with overlapping peaks. In these cases, errors due to partial or complete peak overlap, leading to problems in peak integration, are not explicitly accounted for. Therefore, we have incorporated a section of code into QUANT that can consider the presence of any combination of phases in the tuff samples and allow for the resulting peak overlaps when calculating relative errors. We consider both the errors in RIRs

and the presence of overlapping pairs of phases when calculating errors. Included among the latter are the effect of the presence of (1) smectite on the relative errors for mordenite; (2) mordenite on clinoptilolite; (3) mordenite on feldspar; (4) feldspar on mordenite; (5) feldspar on cristobalite; (6) clinoptilolite on mordenite; (7) clinoptilolite on quartz; (8) clinoptilolite on feldspar; (9) tridymite on cristobalite; (10) tridymite on feldspar; and (11) opal-CT on clinoptilolite. The resulting relative errors are thus increased by every peak overlap for the sample, and we believe the reported errors for internal standard analyses are conservative. Errors for external standard analyses are typically larger than those inherent in internal standard analyses. The usual reason for employing only external standard analysis is insufficient sample, and in many cases amounts of sample available were too small to fill our standard sample holders.

III. MINERAL DISTRIBUTIONS AT YUCCA MOUNTAIN

The results of quantitative analyses are presented in tabular form in Appendix A and, as noted above, supersede the tabular data presented in Bish and Vaniman (1985). We have not redrawn the geologic cross sections presented in Bish and Vaniman (1985) but instead have prepared figures illustrating the mineralogy as a function of depth in each drill hole for which we have sufficient data (Appendix B). The figures in Appendix B reveal many mineralogical details at a glance and illustrate some of the trends with depth discussed below. The mineral distributions at Yucca Mountain differ from drill hole to drill hole, but certain systematics are apparent. Bish and Vaniman (1985) described the distributions of each significant phase at Yucca Mountain. In this report we provide an updated summary of the mineralogy as a function of depth.

Glass

Glass, or material amorphous to x rays, occurs above and below the potential repository host rock at Yucca Mountain (the welded, devitrified Topopah Spring Member, Tptw) but rarely occurs below the present-day static water level (SWL). The glasses can be divided into two categories: vitrophyric glass and vitric, nonwelded tuff. The vitrophyre is a zone of densely welded tuff at the base of the Topopah Spring Member that consists predominantly of glass with lesser amounts of smectite, feldspar, and silica minerals. Nonwelded vitric tuff occurs both above and below the Topopah Spring Member welded unit and is more abundant than vitrophyric glass across most of Yucca Mountain. The lower nonwelded vitric tuff thins and disappears to the east where the stratigraphic dip and structural displacements bring the basal glassy zone closer to the SWL. This vitric nonwelded material may have important paleohydrologic significance because the preservation of shards and pumice composed of nonwelded glass is rare below past SWLs. We have, however, identified glass below the water table in partially zeolitized material in USW G-3 1827.2 (556.9 m) below the water table. Preservation of glass in saturated rocks may be coupled to rock permeability or the "armoring" of glass by alteration phases.

Opal-CT

As noted above, previous analyses of Yucca Mountain tuffs did not distinguish opal-CT from cristobalite. Our most recent analyses include separate determinations of opal-CT, a disordered silica phase containing both cristobalite- and tridymite-like structural units (Jones and Segnit 1971). Almost without exception, opal-CT occurs in samples containing clinoptilolite and/or mordenite. Thus the presence of opal-CT may be linked genetically to the formation of these two zeolites. Most of the opal-CT samples exhibit evidence for cristobalite- and tridymite-like stacking, but some more closely resemble opal-C (predominantly cristobalite-like stacking).

Silica Polymorphs

The three crystalline silica polymorphs, quartz, cristobalite, and tridymite, are abundant in the rocks at Yucca Mountain. Tridymite is common only in relatively shallow rocks, often associated with devitrification features and always above the SWL. It is absent in the north end of Yucca Mountain, where mineralogical evidence suggests that a high heat flow existed in the past (Bish and Semarge 1982). There appears to be a correlation between the loss of tridymite and the first appearance of abundant groundmass quartz with increasing depth. This transition in part reflects the passage from zones of common high-temperature vapor-phase crystallization (tridymite) to zones of lower-temperature devitrification (quartz) within the Topopah Spring Member.

In samples in which cristobalite was distinguished from opal-CT (see page 9), cristobalite is very restricted in rocks below the SWL, whereas it is present in virtually every shallow sample examined above 400-m depth. Because of overlap of the major cristobalite peak with significant feldspar peaks in x-ray diffraction patterns, the precision of analysis of cristobalite when present in amounts below 10% is poor. Thus, the deeper samples identified as containing small amounts of cristobalite may in fact contain no cristobalite. The presence of cristobalite at shallow depths probably reflects the unsaturated nature of these rocks over much, if not all, of their history. Ernst and Calvert (1969) showed that an aqueous fluid is necessary for rapid recrystallization of cristobalite to quartz, and the recrystallization is accelerated in alkaline solutions. They concluded that conversion of the Monterey Formation porcelanite (cristobalite) to quartz in relatively pure water at 50°C would take between 4 and 5 m.y.

With depth, cristobalite gives way to opal-CT in zeolitized rocks in several drill holes. Quartz is present in most samples examined at Yucca Mountain, but it is typically less abundant at shallow depths and in glass-, clinoptilolite-, and mordenite-containing samples and generally increases in abundance below the depth where clinoptilolite and mordenite disappear, i.e., where cristobalite and opal-CT are no longer important silica phases.

Smectite

Smectite is present in small amounts in virtually all samples examined, but two zones of abundant smectite can be mapped across Yucca Mountain. These zones occur at the top of the vitric nonwelded base of the Tiva Canyon Member, which contains up to 35% smectite, and at the top of the basal

vitrophyre of the Topopah Spring Member, which contains up to 45% smectite. The zones are generally less than 3 ft (1 m) thick but are thicker in drill holes USW G-1, G-2, and UE-25a#1. In addition, smectite concentrations are higher at all depths at the northern end of Yucca Mountain (USW G-1, USW G-2, UE-25a#1, and UE-25b#1), probably because of the higher heat flow in the past (Bish and Semarge 1982).

Clinoptilolite/Heulandite and Mordenite

Several studies have emphasized the occurrence of at least four distinct zones of clinoptilolite-heulandite (C-H) plus mordenite beneath Yucca Mountain (Bish et al. 1984; Vaniman et al. 1984). These zones occur primarily where glassy material remained outside the zones of devitrification in the centers of ash flows. There is therefore a correlation between zeolitized material and the nonwelded tops, bottoms, and distal edges of ash flows. Exceptions to this correlation occur, including the zeolitized tuff in the devitrified Tram Member in USW G-3 and the zeolitized interval at the boundary between the devitrified zone and the vitrophyre of the Topopah Spring Member. In general, however, the thicker zeolitized horizons tend to correlate with those intervals that retained glass following early tuff devitrification.

Some chemical and crystallographic data suggest that the C-H zeolite above the basal vitrophyre in the Topopah Spring Member is heulandite, and similar data show that some deeper C-H zeolites coexisting with analcime are heulandite. We separated the C-H from UE-25p#1 at 3480-3490 ft (1060.7-1063.8 m) and performed heating experiments to discriminate between clinoptilolite and heulandite (Mumpton 1960). The material in this sample was clearly heulandite, as the diffraction pattern completely disappeared after heating to 450°C overnight.

Other Zeolites

As reported by Bish and Vaniman (1985), none of the previous reports of erionite or phillipsite in Yucca Mountain rocks have been verified. However, Bish and Vaniman reported that one sample of erionite has been conclusively identified in a fracture from UE-25a#1 at 1296 ft (395 m). Phillipsite has not yet been identified in any samples. We are currently surveying numerous Yucca Mountain samples for the presence of erionite using newly developed techniques that allow the detection of several hundred ppm erionite using x-ray powder diffraction (Bish and Chipera 1987). Chabazite was recently identified in a fracture sample in J-13 at 1345-ft (410-m) depth. Laumontite has been tentatively identified in trace amounts near the bottom of USW G-1 and conclusively identified in four samples in UE-25p#1. The occurrence of this Ca-rich zeolite may reflect the influence of Ca-rich groundwater on these rocks.

Analcime and Albite

Only a few drill holes have penetrated deep enough to intersect analcime-bearing zones and even fewer are deep enough to contain authigenic albite. In general, the shallowest occurrence of these two minerals is in the northern portion of Yucca Mountain, especially USW G-2, although analcime occurs in significant amounts in drill hole J-13 at 1995-ft (608-m) depth. Mineralogic trends with depth suggest that analcime formed through alteration of clinoptilolite and that authigenic albite formed from analcime (Bish et al. 1981).

Economically Important Minerals

Although studies specifically directed at identifying occurrences of economically important minerals have not been performed by us to date, the results of our analyses allow some generalizations to be made. The most abundant minerals of potential economic importance at Yucca Mountain are the zeolites clinoptilolite and mordenite. These zeolites occur at Yucca Mountain in thick sequences containing up to 90% total zeolite. However, these deposits generally occur at depths greater than 1000 ft (304 m) (the shallowest occurrence is in USW G-2 at depths >750 ft), making commercial utilization very difficult, expensive, and therefore highly unlikely. Deposits of zeolite-rich rocks occur south of Yucca Mountain in a small outcrop at the base of Busted Butte and north at Prow Pass in a larger deposit. Both outcrops are of the tuff of Calico Hills and contain in excess of 50% total zeolite. Considering the presence of large, high-purity, near-surface deposits in Nevada, California, and Oregon and the low price of the natural zeolites clinoptilolite and mordenite, it is unlikely that the outcrop deposits near Yucca Mountain will become economically important unless a demand for clinoptilolite/mordenite-rich rock develops at the potential repository itself.

Other potentially economically important minerals at Yucca Mountain include sulfides such as pyrite and cinnabar, fluorite, barite, gold, and silver. Of these phases, only pyrite, fluorite, and barite have been identified by us at Yucca Mountain. Fluorite occurs as a fracture or vein filling below 1000-ft depth in several drill holes and as a trace phase near the bottom of UE-25p#1. Pyrite and barite have both been identified optically near the bottoms of some drill holes; even where optically identified, they are both present at levels below 1%. Gold and siliver have not been identified by either optical or x-ray diffraction methods, and chemical methods will be used to assess their concentration in the rocks. Information to date provides no evidence for the presence of any economically important mineral deposit at Yucca Mountain. For the potentially important phases present, low concentration and/or deep burial preclude economic use.

IV. SUMMARY

Our quantitative analyses of Yucca Mountain rocks have improved significantly since the first analyses were conducted over nine years ago. We now routinely detect small amounts of glass, we are able to detect some phases below the percent level, and we can accommodate the variations in chemistry and preferred orientation common among many minerals in the Yucca Mountain rocks. In addition, we now routinely discriminate between opal-CT and cristobalite. Although many improvements in technique have been made, our present results are still qualitatively similar to those first obtained by Heiken and Bevier (1979), Sykes et al. (1979), and Bish et al. (1981). Our x-ray diffraction methods are well suited to analysis of volcanic tuffs, rocks that in many cases are difficult to characterize completely by conventional optical methods. Quantitative mineralogic data on numerous drill holes at and around Yucca Mountain have allowed us to understand the significant lateral and vertical mineralogic variations. A complete

knowledge of the mineralogy existing at and around Yucca Mountain is important for us to be able to predict the mineralogy along possible flow paths away from the potential repository. In addition, understanding of the distribution of potentially reactive phases such as zeolites, smectites, and glass will permit optimal siting of the potential repository and minimize possible deleterious interactions between the repository and the host rocks.

ACKNOWLEDGMENTS

We appreciate a thorough review by D. Vaniman and comments by S. Mattson. We are grateful to M. Jones for typing the tables in Appendix A.

APPENDIX A

X-RAY DIFFRACTION ANALYSES OF YUCCA MOUNTAIN TUFF FROM CORE, CUTTINGS, AND SIDEWALL SAMPLES

APPENDIX A

X-RAY DIFFRACTION ANALYSIS OF TUFF

Cuttings

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Hematite
J-12										
620-630	189.0-192.0	9±4	3±2	-	-	-	6±3	53±10	30±20	-
650-660	198.1-201.2	<1	2±1	2±1	13±4	2±1	10±3	70±10	-	<1
710-720	216.4-219.5	<1	1±1	-	<2	14±2	7±3	78±10	-	<1
770-780	234.7-237.7	1±1	-	-	-	14±2	4±2	81±10	-	<1
860-870	262.1-265.2	<1	-	-	-	10±2	4±2	86±10	-	1±1
905-915	275.8-278.9	3±2	<1	-	-	12±2	3±2	83±10	-	<1
983-992	299.6-302.4	<1	<1	-	-	24±3	8±3	68±10	-	-
1067-1077	325.2-328.3	<1	<1	-	-	34±4	3±2	63±10	-	<1
1093-1097	333.1-334.4	38±7	-	51±10	-	<1	11±3	-	-	-
1107-1110	337.4-338.3	-	-	4±2	-	1±1	6±3	9±4	80±20	-
1121-1126	341.7-343.2	-	-	-	-	2±1	4±2	14±5	80±20	-
1136-1139	346.3-347.2	33±7	-	54±10	-	2±1	10±3	-	-	-

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Calcite	Glass	Hematite	Other
J-13																
427	130	I	-	-	-	-	-	15±1	Tr.	14±1	-	70±13	-	-	Tr.	-
492	150	I	-	-	-	-	-	8±1	Tr.	22±1	-	67±10	-	-	-	-
591	180	I	5±1	-	-	-	-	-	1±1	-	-	-	-	94±1	-	-
607	185	E	73±18	-	-	-	-	-	Tr.	7±1	-	-	-	20±18	-	-
689	210	E	26±5	-	1±1	-	-	-	5±1	13±1	-	54±6	-	-	Tr.	-
801	244	I	2±1	-	-	-	-	6±1	1±1	23±1	-	66±10	-	-	Tr.	-
925	282	I	3±1	Tr.	-	-	-	2±1	29±1	3±1	-	62±8	-	-	-	-
1033	315	I	1±1	Tr.	-	-	-	2±1	30±1	-	-	69±9	-	-	Tr.	-
1102	336	I	Tr.	Tr.	-	-	-	2±1	20±1	-	-	78±10	-	-	Tr.	-
1194	364	E	-	Tr.	-	-	-	-	33±1	-	-	67±8	-	-	Tr.	-
1293	394	I	-	Tr.	-	-	-	-	33±1	-	-	63±7	-	-	Tr.	-
1296	395	E	-	-	-	-	-	-	36±1	-	-	64±8	-	-	Tr.	-
1345	410	I	-	-	-	-	-	-	Tr.	-	11±2	8±1	-	81±3	-	-
1421	433	E	3±1	Tr.	27±3	-	-	-	Tr.	-	25±5	13±2	-	30±15	-	Tr.[c]
1457	444	I	2±1	-	80±8	-	-	-	2±1	-	8±2	7±1	Tr.	-	-	-
1512	461	I	Tr.	-	47±12	-	-	-	5±1	-	39±8	6±1	-	-	-	-
1515	462	I	4±1	-	64±6	-	-	-	1±1	-	12±2	14±3	-	-	-	-
1519	463	I	5±1	-	56±8	Tr.	-	-	7±1	-	18±4	13±2	-	-	-	-
1575	480	I	20±4	-	-	-	-	-	2±1	-	-	13±2	-	65±5	-	-
1883	574	I	1±1	Tr.	-	-	-	-	34±1	-	-	67±8	Tr.	-	-	-
1995	608	I	2±1	-	-	-	43±2	-	33±1	-	-	24±3	-	-	-	-
2001	610	I	2±1	Tr.	-	-	42±2	-	28±1	-	-	29±3	-	-	-	-
2005	611	I	2±1	Tr.	-	-	35±1	-	27±1	-	-	31±4	-	-	-	-
2133	650	I	-	2±1	-	-	-	-	32±1	-	-	65±8	-	-	Tr.	-
2178	664	I	-	1±1	-	-	-	-	32±1	-	-	66±8	Tr.	-	Tr.	-
2382	726	I	8±2	3±1	-	-	25±1	-	34±1	-	-	33±4	-	-	-	-
2533	772	I	2±1	2±1	-	-	-	-	32±1	-	-	62±7	-	-	Tr.	-
2680	817	I	3±1	3±1	-	-	-	-	30±1	-	-	61±7	Tr.	-	Tr.	-
2982	909	I	2±1	2±1	-	-	-	-	39±1	-	-	56±7	Tr.	-	Tr.	-
2999	914	I	4±1	1±1	-	-	13±1	-	36±1	-	-	44±5	2±1	-	-	-
3251	991	I	33±7	Tr.	2±1	-	-	-	21±1	-	-	34±4	7±1	-	-	1±1[d]

[a]Sample designation, e.g., 427 refers to a sample from drill hole J-13 at 427-ft depth.

[b]I = Internal Standard Method, E = External Standard Method.

[c]Hornblende.

[d]Chlorite.

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Glass	Hematite	Other
UE-25a#1														
84	25.6	I	3±1	-	-	-	-	Tr.	25±1	-	69±9	-	Tr.	-
157	47.9	I	1±1	-	-	-	-	Tr.	24±1	-	74±9	-	-	-
187	57.0	I	-	-	-	-	-	Tr.	24±1	-	74±9	-	Tr.	-
226	68.9	I	42±8	2±1	-	-	-	-	Tr.	-	19±2	36±9	-	-
251	76.5	I	24±5	2±1	-	-	-	Tr.	Tr.	-	14±2	59±5	-	-
277	84.4	I	-	1±1	-	-	-	-	Tr.	-	16±2	80±2	2±1	-
335	102.1	I	Tr.	Tr.	-	-	8±1	-	5±2	-	77±13	-	1±1	Tr.[c]
450	137.2	I	5±1	Tr.	-	-	7±1	3±1	17±1	-	69±10	-	Tr.	-
469	143.0	I	-	Tr.	-	-	8±1	2±1	20±1	-	64±10	-	1±1	-
677	206.4	I	1±1	Tr.	-	-	-	21±1	12±1	-	66±8	-	-	-
733	223.4	I	3±1	Tr.	-	-	2±1	18±1	13±1	-	60±8	-	-	-
744	226.8	I	2±1	Tr.	Tr.	-	Tr.	13±1	16±1	-	67±8	-	-	-
836	254.8	I	1±1	Tr.	Tr.	-	-	31±1	Tr.	-	66±8	-	Tr.	-
848	258.5	I	2±1	Tr.	-	-	-	31±1	3±1	-	60±7	-	Tr.	-
879	267.9	I	Tr.	Tr.	-	-	-	26±1	8±3	-	63±7	-	Tr.	-
894	272.5	I	2±1	Tr.	-	-	4±1	21±1	10±1	-	61±8	-	Tr.	-
937	285.6	I	-	-	-	-	5±1	25±1	10±1	-	61±9	-	Tr.	-
1012	308.5	I	Tr.	-	-	-	5±1	19±1	7±3	-	67±9	-	Tr.	-
1061	323.4	I	-	-	3±1	-	2±1	32±1	1±1	-	60±8	-	1±1	-
1112	338.9	I	1±1	Tr.	-	-	-	28±1	7±2	-	63±7	-	-	-
1153	351.4	I	1±1	Tr.	-	-	-	27±1	9±3	-	64±8	-	Tr.	-
1195	364.2	I	1±1	Tr.	-	-	-	28±1	8±3	-	62±7	-	Tr.	-
1264	385.3	I	1±1	Tr.	5±1	-	-	24±1	8±3	-	61±8	-	-	-
1279	389.8	I	6±1	Tr.	-	-	-	-	2±1	-	6±1	85±2	-	-
1324	403.6	I	-	-	80±12	6±2	-	2±1	-	6±1	4±1	-	-	-
1358	413.9	I	-	-	69±17	10±2	-	Tr.	-	17±3	2±1	-	-	-
1382	421.2	I	-	Tr.	30±18	43±8	-	Tr.	-	21±4	7±3	-	-	-
1424	434.0	I	-	-	70±14	9±2	-	Tr.	-	17±3	3±1	-	-	-
1478	450.5	I	2±1	-	63±7	-	-	4±1	-	23±5	9±2	-	-	-
1528	465.7	I	1±1	-	35±11	21±5	-	2±1	-	21±4	20±5	-	-	-
1566	477.3	I	7±1	-	38±5	Tr.	-	4±1	-	29±6	24±4	-	-	-
1630	496.8	I	2±1	-	68±12	8±2	-	2±1	-	14±3	10±2	-	-	-
1680	512.1	I	-	-	66±14	11±3	-	3±1	-	17±3	5±1	-	-	-
1718	523.6	I	1±1	-	45±12	15±4	-	2±1	-	20±4	22±5	-	-	-
1824	556.0	I	6±1	2±1	18±1	-	-	18±1	-	-	52±7	-	-	-

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Glass	Hematite	Other
UE-25a#1														
1852	564.5	I	-	Tr.	-	-	-	41±1	-	-	51±6	-	1±1	2±1[d]
1904	580.3	I	7±1	Tr.	-	-	-	34±1	-	-	61±7	-	Tr.	-
1953	595.3	I	2±1	Tr.	-	-	-	33±1	-	-	61±7	-	-	-
2002	610.2	E	Tr.	Tr.	-	-	-	41±1	-	-	58±7	-	-	-
2051	625.1	I	5±1	-	-	-	-	28±1	-	-	65±8	-	-	-
2113	644.0	I	3±1	-	11±1	-	-	Tr.	-	-	17±2	69±3	-	-
2220	676.7	I	1±1	-	50±14	18±5	-	Tr.	-	15±3	14±4	-	-	-
2304	702.3	I	4±1	-	39±7	13±4	-	12±1	-	-	33±7	-	-	-
2361	719.6	I	3±1	1±1	-	-	-	46±2	-	-	50±6	-	1±1	-
2408	734.0	I	2±1	1±1	-	-	-	38±1	-	-	60±7	-	Tr.	1±1[d]
2449	746.5	I	2±1	Tr.	-	-	-	41±1	-	-	58±7	-	Tr.	1±1[d]
2492	759.6	I	4±1	1±1	-	-	-	36±1	-	-	57±7	-	Tr.	-

[a]Sample designation, e.g., 84 refers to a sample from drill hole UE-25a#1 at 84-ft depth.

[b]I = Internal Standard Method, E = External Standard Method.

[c]Calcite.

[d]Kaolinite.

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Quartz	Alkali Feldspar	Calcite	Kaolinite	Other
UE-25b#1H											
2402	732.1	15±5	6±4	-	-	-	40±10	40±10	-	-	-
2450	746.8	10±5	7±3	-	-	-	40±10	40±10	6±4	-	-
2525	769.6	10±5	10±5	-	-	-	40±10	40±10	-	-	-
2596	791.3	10±5	6±4	-	-	-	40±10	40±10	6±4	-	-
2651	808.0	10±5	6±4	-	-	-	40±10	40±10	-	-	-
2737	834.2	3±2	6±4	-	-	-	30±10	50±10	-	-	-
2832	863.2	15±5	6±4	3±2	18±7	-	23±7	30±10	3±2	-	-
2847	867.7	7±3	2±1	<2	18±9	-	29±4	44±10	-	-	-
2855	870.2	18±7	3±2	3±2	18±7	-	23±7	30±10	6±4	-	-
2867	873.9	18±7	6±4	-	3±2	-	30±10	50±10	-	-	-
2879	877.5	23±7	15±5	10±5	10±5	-	30±10	30±10	6±4	-	-
2919	889.7	-	10±5	-	30±10	-	23±7	30±10	-	-	-
2946	897.9	6±4	6±4	-	-	-	40±10	40±10	6±4	-	-
2953	900.1	6±4	6±4	-	-	-	40±10	40±10	6±4	-	-
2988	910.7	10±5	10±5	Tr.	-	-	40±10	40±10	3±2	-	-
3050	929.6	10±5	10±5	3±2	-	-	30±10	50±10	6±4	-	-
3092	942.4	6±4	7±3	Tr.	-	-	50±10	40±10	3±2	-	-
	Fracture	-	6±4	-	-	-	40±10	30±10	23±7	-	-
3095	943.4	3±2	10±5	-	-	-	40±10	50±10	-	-	-
3098	944.3	10±5	10±5	-	-	-	30±10	50±10	3±2	-	-
3128	953.4	10±5	10±5	-	-	-	30±10	50±10	3±2	-	-
	Fracture	3±2	3±2	-	-	-	30±10	30±10	23±7	-	-
3163	964.1	3±2	10±5	-	-	-	30±10	50±10	3±2	-	-
	Fracture	-	3±2	-	-	-	20±10	20±10	60±10	-	-
3185	970.8	18±7	15±5	-	-	-	30±10	40±10	-	-	-
	Fracture	3±2	3±2	-	-	-	10±5	-	70±10	-	6±4[a],20±10[b]
3196	974.1	6±4	10±5	-	-	-	30±10	50±10	-	-	-
3222	982.1	3±2	10±5	-	-	-	30±10	60±10	-	-	-
3225	983.0	10±5	10±5	-	-	-	30±10	50±10	-	-	-
3257	992.7	40±10	10±5	-	-	-	20±10	30±10	-	-	-
3267	995.8	23±7	6±4	-	-	-	40±10	30±10	-	-	-
3298	1005.2	10±5	6±4	-	-	Tr.	30±10	50±10	-	-	-
3326	1013.8	10±5	10±5	-	-	3±2	30±10	50±10	-	-	-
3362	1024.7	18±7	10±5	-	-	3±2	30±10	40±10	-	Tr.	-
3374	1028.4	10±5	10±5	-	-	20±10	30±10	30±10	-	<2	-
3393	1034.2	10±5	7±3	-	-	20±10	30±10	30±10	10±5	3±2	-

APPENDIX A (continued)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Quartz	Alkali Feldspar	Calcite	Kaolinite	Other
UE-25b#1H											
3401	1036.6	3±2	6±4	-	-	20±10	30±10	30±10	3±2	3±2	-
3459	1054.3	10±5	10±5	-	-	20±10	30±10	23±7	6±4	6±4	-
3469	1057.4	10±5	10±5	-	-	20±10	30±10	30±10	6±4	6±4	-
3506	1068.6	18±7	10±5	-	-	20±10	30±10	30±10	6±4	6±4	-
3530	1075.9	15±5	7±3	-	-	23±7	30±10	40±10	3±2	<2	-
	Fracture	15±5	-	-	-	10±5	30±10	30±10	-	7±3	-
3548	1081.4	10±5	10±5	-	-	3±2	30±10	40±10	6±4	3±2	-
	Inclusion	15±5	10±5	-	-	-	23±7	40±10	15±5	<2	-
3571	1088.4	7±3	6±4	-	-	3±2	40±10	23±7	30±10	3±2	-
3572	1088.7	6±4	6±4	-	-	<2	30±10	40±10	23±7	<2	-
	Inclusion	18±7	10±5	-	-	-	30±10	30±10	10±5	<2	-
3602	1097.9	10±5	6±4	-	-	20±10	30±10	30±10	10±5	<2	-
	Fracture	3±2	-	-	-	10±5	6±4	-	40±10	-	40±10[a]
3660	1115.6	10±5	6±4			23±7	30±10	30±10	6±4	3±2	-
	Fracture	-	-	-	-	23±7	15±5	6±4	60±10	-	-
3708	1130.2	10±5	6±4	-	-	23±7	30±10	40±10	-	3±2	-
3767	1148.2	10±5	10±5	-	-	23±7	35±10	23±7	10±5	6±4	-
3792	1155.8	15±5	7±3	-	-	10±5	30±10	40±10	6±4	3±2	-
3835	1168.9	15±5	7±3	-	-	23±7	30±10	30±10	6±4	3±2	-
3880	1182.6	15±5	7±3	-	-	15±5	30±10	30±10	10±5	3±2	-
3901	1189.0	40±10	6±4	-	-	Tr.	30±10	23±7	-	Tr.	-
3902	1189.3	40±10	3±2	-	6±4	-	23±7	23±7	23±7	-	-
3904	1189.9	30±10	-	-	-	23±7	30±10	23±7	3±2	-	-
3910	1191.8	10±5	-	-	-	6±4	40±10	40±10	-	-	-
3926	1196.6	15±5	10±5	-	-	-	30±10	30±10	15±5	6±4	-
3956	1205.8	23±7	10±5	-	-	3±2	23±7	40±10	6±4	3±2	-
3963	1207.9	30±10	10±5	-	-	18±7	30±10	30±10	6±4	Tr.	-
3988	1215.5	18±7	18±7	-	-	-	30±10	40±10	-	-	-
	Fracture	3±2	3±2	-	-	-	10±5	15±5	80±10	-	-

[a] Fluorite.
[b] Todorokite.

APPENDIX A (cont)

Cuttings, Sidewall, and Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Hema-tite	Cal-cite	Dolo-mite	Other
UE-25p#1																
200-210	61.8-64.0	I	-	1±1	-	-	-	14±1	-	6±3	-	76±14	2±2	-	-	-
260-270	79.2-82.3	E	2±1	Tr.	-	-	-	Tr.	3±1	24±4	-	71±14	-	-	-	-
280-290	85.3-88.4	E	2±1	Tr.	-	-	-	Tr.	5±1	25±4	-	68±14	-	-	-	-
410-420	125.0-128.0	I	3±1	Tr.	-	-	-	4±1	9±1	24±2	-	59±8	1±1	-	-	-
570-580	173.7-176.8	I	2±1	Tr.	-	-	-	Tr.	30±2	3±1	-	67±8	Tr.	-	-	-
810-820	246.9-249.9	I	2±1	Tr.	-	-	-	-	27±2	5±2	-	59±7	Tr.	-	-	-
900-910	274.3-277.4	I	1±1	Tr.	-	-	-	-	36±2	1±1	-	61±7	Tr.	-	-	-
1040-1050	317.0-320.0	I	-	Tr.	-	-	-	-	27±2	5±2	-	67±8	Tr.	-	-	-
1240-1250	378.0-381.0	E	1±1	-	54±8	-	-	-	Tr.	-	20±8	24±6	-	-	-	-
1260-1270	384.0-387.1	E	1±1	-	62±10	-	-	-	Tr.	-	23±8	14±4	-	-	-	-
1290SW	393.2	I	2±1	-	37±3	-	-	-	3±1	-	22±9	39±6	-	-	-	-
1340-1350	408.4-411.5	I	Tr.	-	56±4	-	-	-	2±1	-	20±6	21±4	-	-	-	-
1400SW	426.7	I	10±3	1±1	34±2	-	-	-	17±1	-	-	29±4	-	-	-	9±6[c]
1420SW	432.8	I	12±4	1±1	-	-	-	-	24±2	-	-	40±5	1±1	-	-	22±7[c]
1470SW	448.1	I	5±2	-	-	34±11	-	-	25±2	-	-	40±12	-	-	-	2±1[d]
1590-1598	484.6-487.1	I	-	-	3±1	-	-	-	39±2	-	-	60±7	1±1	-	-	-
1640-1650	499.9-502.9	I	5±2	-	-	-	-	-	37±2	-	-	58±7	1±1	-	-	-
1690-1700	515.1-518.2	I	7±2	-	40±3	-	-	-	11±1	-	17±6	25±4	-	-	-	-
1730-1740	527.3-530.4	I	3±1	-	60±4	-	-	-	4±1	-	14±4	17±3	-	-	-	-
1790-1800	545.6-548.6	I	1±1	-	45±8	23±7	-	-	12±1	-	-	18±5	-	-	-	-
1830-1840	557.8-560.8	I	Tr.	2±1	-	-	-	-	45±2	-	-	39±5	1±1	-	-	12±3[d]
1870-1880	570.0-573.0	I	3±1	-	9±1	-	-	-	27±2	-	-	55±7	Tr.	-	-	-
1920-1930	585.2-588.3	I	5±2	2±1	-	-	-	-	28±2	-	-	64±8	2±1	-	-	-
1970-1980	600.5-603.5	I	Tr.	1±1	-	-	-	-	35±2	-	-	61±7	1±1	-	-	-
1990-2000	606.6-609.6	I	1±1	1±1	-	-	-	-	39±2	-	-	60±7	Tr.	-	-	-
2030-2040	618.7-621.8	I	2±1	Tr.	-	-	-	-	31±2	-	-	59±7	1±1	-	-	7±7[c]
2070-2080	630.9-634.0	I	Tr.	Tr.	-	-	-	-	39±2	-	-	59±7	1±1	-	-	-
2120-2130	646.2-649.2	I	Tr.	Tr.	-	-	-	-	36±2	-	-	65±8	1±1	-	-	-
2150-2160	655.3-658.4	I	3±1	Tr.	Tr.	-	-	-	29±2	-	-	61±7	1±1	1±1	-	-
2210-2220	673.6-676.7	I	3±1	-	-	28±8	14±1	-	28±2	-	-	33±9	-	Tr.	-	-
2240-2250	682.8-685.8	I	7±2	1±1	-	3±1	8±1	-	29±2	-	-	52±7	-	-	-	-
2280-2290	694.9-698.0	I	6±2	3±1	31±2	-	4±1	-	22±2	-	-	32±5	-	Tr.	-	-
2330-2340	710.2-713.2	I	11±3	1±1	2±1	-	4±1	-	32±2	-	-	45±5	-	Tr.	-	-
2370-2380	722.4-725.4	I	7±2	2±1	-	-	-	-	40±2	-	-	49±6	1±1	-	-	-
2410-2420	734.6-737.6	I	Tr.	1±1	-	-	-	-	43±2	-	-	51±6	1±1	-	-	Tr.[d]

APPENDIX A (cont)

Cuttings, Sidewall, and Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Hema-tite	Cal-cite	Dolo-mite	Other
UE-25p#1																
2460-2470	749.8-752.9	I	2±1	1±1	-	-	-	-	32±2	-	-	61±7	1±1	-	-	1±1[d]
2510-2520	765.0-768.1	I	-	2±1	-	-	-	-	24±2	-	-	77±9	1±1	-	-	-
2570-2580	783.3-786.4	I	2±1	2±1	-	-	-	-	30±2	-	-	71±8	1±1	-	-	-
2630-2640	801.6-804.7	I	7±2	1±1	-	-	-	-	34±2	-	-	57±7	1±1	-	-	-
2650-2660	807.7-810.8	I	15±5	1±1	-	-	-	-	31±2	-	-	51±6	2±1	1±1	-	-
2690-2700	819.9-823.0	I	4±1	1±1	-	-	-	-	34±2	-	-	56±7	1±1	Tr.	-	-
2750-2760	838.2-841.2	I	13±4	1±1	13±1	-	-	-	32±2	-	-	35±5	1±1	Tr.	-	-
2790-2800	850.4-853.4	I	21±6	1±1	4±1	-	-	-	29±2	-	-	39±5	2±1	Tr.	-	-
2840-2850	865.6-868.7	I	25±8	Tr.	-	-	Tr.	-	42±2	-	-	34±4	2±1	-	-	-
2890-2900	880.9-883.9	I	15±5	Tr.	-	-	-	-	34±2	-	-	47±6	1±1	2±1	-	-
2940-2950	896.1-899.2	I	4±1	1±1	-	-	2±1	-	36±2	-	-	55±6	Tr.	-	-	-
2980-2990	908.3-911.4	I	6±2	1±1	-	-	6±1	-	29±2	-	-	55±6	1±1	-	-	-
3030-3040	923.5-926.6	I	11±3	Tr.	1±1	-	Tr.	-	30±2	-	-	53±6	1±1	1±1	-	-
3080-3090	938.8-941.8	I	15±5	Tr.	-	-	-	-	44±2	-	-	34±4	Tr.	Tr.	-	3±1[e]
3130-3140	954.0-957.1	I	6±2	Tr.	2±1	-	5±1	-	34±2	-	-	50±6	-	1±1	-	Tr.[e], Tr.[f]
3160-3170	963.2-966.2	I	13±4	Tr.	3±1	-	11±1	-	37±2	-	-	39±5	-	-	-	-
3230-3240	984.5-987.6	I	5±2	-	Tr.	-	19±1	-	38±2	-	-	37±4	-	-	-	Tr.[g]
3270-3280	996.7-999.7	I	5±2	-	2±1	-	13±1	-	36±2	-	-	43±5	-	-	-	-
3320-3330	1011.9-1015.0	E	25±10	-	4±1	-	-	-	38±5	-	-	25±5	Tr.	1±1	-	7±3[g]
3370-3380	1027.2-1030.2	I	22±7	-	2±1	-	-	-	35±2	-	-	35±4	1±1	Tr.	-	4±1[g]
3410-3420	1039.4-1042.4	I	7±2	-	3±1	-	6±1	-	35±2	-	-	44±5	Tr.	-	-	Tr.[e], 1±1[g]
3453C	1052.5	I	6±2	-	2±1	-	13±1	-	38±2	-	-	39±5	-	Tr.	-	-
3480-3490	1060.7-1063.8	I	7±2	-	7±1	-	4±1	-	40±2	-	-	42±5	-	1±1	-	-
3510-3520	1069.8-1072.9	I	11±3	-	-	-	-	-	37±2	-	-	49±6	-	1±1	-	3±1[g]
3550-3560	1082.0-1085.1	I	4±1	2±1	-	-	-	-	43±2	-	-	45±5	1±1	1±1	-	-
3560-3570	1085.1-1088.1	E	7±2	1±1	-	-	-	-	42±5	-	-	49±9	Tr.	1±1	-	-
3590-3600	1094.2-1097.3	I	9±3	-	-	-	-	-	42±2	-	-	48±6	Tr.	-	-	-
3630-3640	1106.4-1109.5	I	19±6	-	-	-	-	-	32±2	-	-	41±5	2±1	1±1	-	6±2[g], 1±1[h]
3650-3660	1112.5-1115.6	I	19±6	-	-	-	-	-	29±2	-	-	42±5	2±1	2±1	-	4±1[g], 1±1[h]
3660-3670	1115.6-1118.6	I	16±5	1±1	-	-	-	-	30±2	-	-	51±6	2±1	5±1	-	1±1[h], Tr.[f]
3690-3700	1124.7-1127.8	I	15±5	-	-	-	3±1	-	36±2	-	-	38±4	1±1	1±1	-	4±1[g], 1±1[h]
3720-3730	1133.9-1136.9	E	20±8	-	-	-	2±1	-	27±4	-	-	41±8	1±1	4±1	-	3±1[g], 1±1[h]
3750-3760	1143.0-1146.0	I	15±5	-	Tr.	-	-	-	33±2	-	-	36±4	1±1	1±1	8±1	Tr.[e], 4±1[g]
3790-3800	1155.2-1158.2	I	14±4	-	-	-	-	-	35±2	-	-	23±3	-	4±1	21±2	1±1[h]
3820-3830	1164.3-1167.4	I	9±3	-	Tr.	-	-	-	44±2	-	-	19±2	-	2±1	22±2	-

APPENDIX A (cont)

Cuttings, Sidewall, and Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Hema-tite	Cal-cite	Dolo-mite	Other
UE-25p#1																
3860-3870	1176.5-1179.6	I	10±3	-	-	-	-	-	52±3	-	-	33±4	-	1±1	-	-
3913C	1192.7	I	37±11	-	-	-	-	-	53±3	-	-	-	-	8±1	-	-
3916C	1193.6	I	45±14	-	-	-	-	-	49±2	-	-	-	-	3±1	-	Tr.[h]
3928C	1197.3	I	40±12	-	-	-	-	-	18±1	-	-	-	-	47±2	-	1±1[i]
3940-3950	1200.9-1204.0	I	9±3	-	-	-	Tr.	-	39±2	-	-	44±5	1±1	-	-	3±1[g]
3980-3990	1213.1-1216.2	I	13±4	-	2±1	-	2±1	-	32±3	-	-	48±6	1±1	-	-	5±2[g]
4040-4050	1231.4-1234.4	I	16±5	-	2±1	-	Tr.	-	29±2	-	-	29±3	-	1±1	23±2	6±2[g]
4070-4080	1240.5-1243.6	I	29±9	1±1	1±1	-	Tr.	-	30±2	-	-	38±5	-	Tr.	8±1	-
4080-4090	1243.6-1249.1	I	2±1	-	-	-	-	-	5±1	-	-	-	-	3±1	85±6	Tr.[i]
4170-4180	1271.0-1274.1	I	9±3	-	-	-	-	-	8±1	-	-	-	-	4±1	80±6	-
4313-4318	1314.6-1316.1	I	1±1	-	-	-	-	-	4±1	-	-	-	-	4±1	93±7	-

[a]Samples followed by SW are sidewall samples; those followed by C are drill core samples. The remaining samples are all drill cuttings.

[b]I = Run using the Internal Standard Method; E = Run using the External Standard Method.

[c]Glass.

[d]Kaolinite.

[e]Laumontite.

[f]Hornblende.

[g]Illite.

[h]Chlorite.

[i]Fluorite.

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Calcite	Glass	Hematite	Other
USW G-1																
292	89.0	I	-	1±1	-	-	-	4±1	1±1	15±1	-	72±10	-	-	Tr.	-
352	107.3	I	-	Tr.	3±1	-	-	9±1	-	8±4	-	73±12	-	-	1±1	-
399	121.6	I	-	Tr.	-	-	-	12±1	-	5±2	-	78±13	-	-	1±1	Tr.[c]
450	137.2	I	3±1	Tr.	-	-	-	24±3	2±1	6±3	-	67±15	-	-	1±1	-
553	168.6	I	2±1	-	-	-	-	7±1	4±1	27±2	-	61±9	-	-	1±1	-
619	188.7	I	2±1	Tr.	-	-	-	20±2	2±1	11±1	-	65±14	Tr.	-	1±1	-
673	205.1	I	1±1	Tr.	-	-	-	6±1	4±1	24±1	-	64±10	-	-	1±1	-
722	220.1	I	2±1	Tr.	-	-	-	Tr.	3±1	22±1	-	72±9	-	-	-	-
757	230.7	I	1±1	Tr.	-	-	-	6±1	4±1	27±1	-	67±9	-	-	1±1	-
819	249.6	I	2±1	Tr.	-	-	-	4±1	4±1	26±1	-	65±9	-	-	Tr.	-
874	266.4	I	2±1	-	-	-	-	7±1	19±1	5±2	-	66±10	-	-	Tr.	-
936	285.3	I	-	-	-	-	-	-	28±1	-	-	40±5	35±1	-	-	Tr.[c]
995	303.3	I	3±1	-	-	-	-	5±1	4±1	23±1	-	64±9	-	-	Tr.	-
1063	324.0	I	2±1	Tr.	-	-	-	7±1	11±1	16±1	-	64±10	-	-	1±1	-
1104	336.5	I	2±1	-	-	-	-	4±1	11±1	20±1	-	59±8	-	-	1±1	-
1123	342.3	I	2±1	Tr.	-	-	-	6±1	7±1	18±1	-	64±10	-	-	Tr.	-
1179	359.4	I	3±1	-	-	-	-	3±1	15±1	19±1	-	56±7	-	-	1±1	-
1191	363.0	I	4±1	-	-	-	-	6±1	11±1	16±1	-	63±9	-	-	1±1	-
1240	378.0	I	2±1	Tr.	-	-	-	2±1	15±1	17±1	-	64±8	-	-	Tr.	-
1274	388.3	I	2±1	Tr.	Tr.	-	-	2±1	16±1	18±1	-	62±8	-	-	Tr.	-
1281	390.4	I	2±1	Tr.	-	-	-	2±1	18±1	14±1	-	66±8	-	-	Tr.	-
1286	392.0	I	33±7	-	10±1	-	-	-	3±1	16±1	-	38±5	-	-	-	-
1319	402.0	I	-	-	-	-	-	-	Tr.	-	3±1	5±1	-	92±2	-	-
1341	408.7	I	-	-	2±1	-	-	-	Tr.	-	4±1	6±1	-	87±2	-	-
1357	413.6	I	1±1	-	-	-	-	-	Tr.	-	3±1	7±1	-	88±2	-	-
1392	424.3	I	Tr.	-	6±1	-	-	-	Tr.	-	2±1	3±1	-	88±2	-	-
1400	426.7	I	Tr.	-	83±10	-	-	-	2±1	-	12±2	2±1	-	-	-	-
1492	454.8	I	Tr.	-	63±17	11±3	-	-	3±1	-	19±4	5±1	-	-	-	-
1539	469.1	I	1±1	Tr.	46±7	Tr.	-	-	11±1	-	19±4	17±3	-	-	-	-
1561	475.8	I	Tr.	-	62±18	17±4	-	-	2±1	-	11±2	6±2	-	-	-	-
1639	499.6	I	Tr.	-	60±14	12±3	-	-	3±1	-	12±2	10±2	-	-	-	-
1693	516.0	I	-	-	50±15	16±4	-	-	3±1	-	15±3	13±3	-	-	-	-
1748	532.8	I	-	-	55±17	11±2	-	-	3±1	-	26±5	4±1	-	-	-	-
1774	540.7	I	Tr.	1±1	49±8	11±2	-	-	13±1	4±1	-	19±4	-	-	-	-
1784	543.8	I	4±1	Tr.	25±5	13±4	-	Tr.	9±1	7±2	-	41±9	1±1	-	-	-

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Calcite	Glass	Hematite	Other
USW G-1																
1799	548.3	I	3±1	-	51±12	-	-	-	1±1	-	35±7	12±2	-	-	-	-
1819	554.4	I	1±1	-	43±12	11±3	-	-	2±1	-	20±4	26±6	-	-	-	-
1942	591.9	I	2±1	-	-	-	-	-	28±1	5±2	-	67±8	-	-	-	-
2136	651.1	I	-	-	17±9	34±8	-	-	Tr.	-	23±5	22±7	-	-	-	-
2173	662.3	I	-	Tr.	33±5	9±2	-	-	2±1	8±2	-	41±8	-	-	-	-
2190	667.5	I	4±1	Tr.	51±9	-	-	-	4±1	-	23±5	19±3	-	-	-	-
2198	670.0	I	1±1	Tr.	48±9	2±1	-	-	4±1	-	20±4	20±4	-	-	-	-
2256	687.6	I	-	-	Tr.	44±7	-	-	3±1	-	22±4	26±9	-	-	-	-
2279	694.6	I	Tr.	Tr.	29±14	38±8	-	-	3±1	-	8±2	21±7	-	-	-	-
2290	698.0	E	2±1	Tr.	31±15	43±10	-	-	3±1	2±1	-	18±7	-	-	-	-
2316	705.9	I	-	Tr.	30±9	23±5	-	-	19±1	-	-	27±7	-	-	-	-
2401	731.8	I	3±1	Tr.	-	-	-	-	35±1	Tr.	-	62±7	-	-	1±1	-
2456	748.6	I	1±1	Tr.	-	-	-	-	32±1	-	-	67±8	-	-	Tr.	-
2486	757.7	I	1±1	1±1	-	-	-	-	33±1	-	-	67±8	-	-	Tr.	-
2499	761.7	I	Tr.	Tr.	-	-	-	-	32±1	Tr.	-	66±8	-	-	Tr.	-
2506	763.8	I	Tr.	Tr.	-	-	-	-	32±1	Tr.	-	63±7	-	-	Tr.	-
2544	775.4	I	Tr.	Tr.	-	-	-	-	36±1	Tr.	-	64±8	-	-	Tr.	-
2564	781.5	I	Tr.	Tr.	40±15	27±6	-	-	3±1	-	10±2	20±6	-	-	-	-
2600	792.5	I	-	-	48±22	39±9	-	-	Tr.	-	2±1	12±4	-	-	-	-
2606	794.3	I	Tr.	-	42±13	26±6	-	-	12±1	-	1±1	17±5	-	-	-	-
2607	794.6	I	-	-	26±7	21±4	-	-	20±1	1±1	-	29±7	-	-	-	-
2622	799.2	I	Tr.	Tr.	30±6	14±3	-	-	21±1	1±1	-	30±7	-	-	-	-
2641	805.0	I	2±1	2±1	30±4	6±2	-	-	4±1	7±2	-	44±8	-	-	-	-
2663	811.7	I	Tr.	2±1	40±8	15±4	-	-	5±1	4±1	-	33±8	-	-	-	-
2734	833.3	I	Tr.	2±1	31±3	4±1	-	-	16±1	8±2	-	40±7	-	-	-	-
2765	842.8	I	4±1	1±1	15±1	Tr.	-	-	18±1	8±2	-	52±7	-	-	-	-
2804	854.7	I	1±1	1±1	-	-	-	-	31±1	1±1	-	62±7	-	-	Tr.	-
2805	855.0	I	3±1	Tr.	-	-	-	-	33±1	1±1	-	62±7	-	-	Tr.	-
2820	859.5	I	1±1	1±1	-	-	-	-	36±1	Tr.	-	65±8	-	-	Tr.	-
2838	865.0	I	2±1	Tr.	-	-	-	-	31±1	-	-	64±8	-	-	-	-
2868	874.2	I	1±1	Tr.	-	-	-	-	36±1	Tr.	-	63±7	-	-	-	-
2884	879.0	I	2±1	1±1	-	-	-	-	34±1	-	-	64±8	-	-	-	-
2915	888.5	I	2±1	1±1	-	-	-	-	36±1	-	-	61±7	-	-	-	-
2932	893.7	I	1±1	1±1	-	-	-	-	36±1	-	-	64±8	-	-	-	-
2937	895.2	I	2±1	2±1	-	-	-	-	35±1	-	-	63±7	-	-	-	-

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Calcite	Glass	Hematite	Other
USW G-1																
2948	898.6	I	2±1	1±1	2±1	-	-	-	30±1	-	-	67±8	1±1	-	-	-
2966	904.0	I	1±1	2±1	-	-	-	-	36±1	-	-	61±7	-	-	-	-
2981	908.6	I	3±1	1±1	-	-	-	-	37±1	-	-	58±7	-	-	-	-
3018	919.9	I	18±4	1±1	7±1	-	4±1	-	33±1	-	-	34±4	Tr.	-	-	-
3079	938.5	I	11±2	1±1	13±1	-	5±1	-	36±1	-	-	34±5	-	-	-	-
3167	965.3	I	10±2	1±1	19±1	-	5±1	-	31±1	-	-	31±4	-	-	-	-
3288	1002.2	I	17±3	Tr.	40±2	-	1±1	-	18±1	-	-	20±3	-	-	-	-
3401	1036.6	I	4±1	Tr.	10±1	-	2±1	-	38±1	-	-	43±6	Tr.	-	-	-
3523	1073.8	I	7±1	Tr.	13±1	-	1±1	-	32±1	-	-	46±6	2±1	-	-	2±1[d]
3621	1103.7	I	24±5	-	-	-	-	-	3±1	6±2	-	59±7	2±1	-	2±1	-
3810	1161.3	I	65±13	-	-	-	-	-	-	-	-	37±4	2±1	-	-	-
3940	1200.9	I	48±10	Tr.	2±1	-	2±1	-	19±1	-	-	23±3	Tr.	-	-	2±1[d]
4246	1294.2	I	17±3	Tr.	-	-	6±1	-	38±1	-	-	38±5	-	-	-	-
4400	1341.1	I	7±1	1±1	-	-	13±1	-	39±1	-	-	42±5	Tr.	-	-	-
4503	1372.5	I	4±1	1±1	-	-	19±1	-	39±1	-	-	37±4	2±1	-	-	-
4555	1388.4	I	21±4	Tr.	-	-	2±1	-	22±1	-	-	47±6	Tr.	-	Tr.	-
4612	1405.7	I	13±3	2±1	-	-	7±1	-	34±1	-	-	41±5	-	-	Tr.	-
4626	1410.0	I	4±1	-	-	-	-	-	42±1	-	-	52±6	4±1	-	-	-
4652	1417.9	I	7±1	Tr.	-	-	11±1	-	40±1	-	-	38±5	-	-	-	-
4700	1432.6	I	6±1	Tr.	-	-	7±1	-	46±1	-	-	40±5	-	-	-	-
4750	1447.8	I	8±2	1±1	-	-	10±1	-	37±1	-	-	44±5	-	-	-	-
4805	1464.6	I	8±2	Tr.	-	-	9±1	-	38±1	-	-	43±5	2±1	-	-	-
4848	1477.7	I	6±1	Tr.	-	-	11±1	-	41±1	-	-	38±5	-	-	-	-
4876	1486.2	I	4±1	Tr.	-	-	4±1	-	45±1	-	-	45±5	2±1	-	-	-
4912	1497.2	I	7±1	Tr.	-	-	8±1	-	43±1	-	-	37±4	-	-	-	-
4941	1506.0	I	27±5	Tr.	-	-	7±1	-	27±1	-	-	25±3	6±1	-	-	-
4958	1511.2	I	8±2	-	-	-	17±1	-	46±1	-	-	30±4	-	-	-	-
4998	1523.4	I	30±6	Tr.	-	-	3±1	-	39±1	-	-	27±3	Tr.	-	-	Tr.[c]
5026	1531.9	I	5±1	Tr.	-	-	2±1	-	45±1	-	-	51±6	-	-	-	-
5049	1538.9	I	52±10	2±1	-	-	-	-	5±1	-	-	28±3	Tr.	-	Tr.	-
5093	1552.3	I	5±1	Tr.	3±1	-	2±1	-	39±1	-	-	47±6	2±1	-	Tr.	Tr.[d]
5126	1562.4	I	2±1	Tr.	-	-	15±1	-	50±1	-	-	33±4	Tr.	-	-	Tr.[d]
5167	1574.9	I	2±1	Tr.	-	-	14±1	-	46±1	-	-	40±5	Tr.	-	-	Tr.[d]
5212	1588.6	I	1±1	Tr.	-	-	16±1	-	48±1	-	-	38±5	-	-	-	Tr.[d]
5253	1601.1	I	1±1	Tr.	-	-	27±1	-	36±1	-	-	35±4	Tr.	-	-	-

APPENDIX A (cont)

Core

Sample[a]	Depth (m)	Method[b]	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Opal-CT	Alkali Feldspar	Calcite	Glass	Hematite	Other
USW G-1																
5296	1614.2	I	2±1	-	-	-	19±1	-	37±1	-	-	39±5	-	-	-	Tr.[d]
5310	1618.5	I	29±6	Tr.	-	-	-	-	23±1	-	-	52±6	-	-	-	-
5311	1618.8	I	6±1	-	1±1	-	-	-	46±1	-	-	45±5	1±1	-	-	-
5329	1624.3	I	11±2	-	-	-	12±1	-	40±1	-	-	40±5	-	-	-	Tr.[d]
5338	1627.0	I	41±8	Tr.	1±1	-	-	-	28±1	-	-	26±3	Tr.	-	-	-
5348	1630.1	I	9±2	Tr.	Tr.	-	-	-	35±1	-	-	44±5	9±1	-	-	-
5378	1639.2	I	46±9	Tr.	15±1	-	-	-	17±1	-	-	24±3	-	-	-	-
5412	1649.6	I	5±1	1±1	-	-	12±1	-	40±1	-	-	40±5	-	-	-	Tr.[d]
5433	1656.0	I	35±7	2±1	20±1	-	-	-	9±1	-	-	27±4	2±1	-	-	Tr.[d]
5458	1663.6	I	26±5	Tr.	25±2	-	-	-	18±1	-	-	28±4	Tr.	-	-	-
5477	1669.4	I	5±1	-	-	-	12±1	-	44±1	-	-	36±4	-	-	-	-
5498	1675.8	I	5±1	Tr.	-	-	17±1	-	38±1	-	-	41±5	Tr.	-	-	-
5534	1686.8	I	38±8	1±1	20±1	-	4±1	-	8±1	-	-	24±3	1±1	-	-	2±1[c]
5560	1694.7	I	5±1	1±1	16±1	23±7	-	-	21±1	-	-	33±8	Tr.	-	-	Tr.[d]
5596	1705.7	I	2±1	2±1	1±1	-	7±1	-	34±1	-	-	50±6	2±1	-	-	Tr.[d]
5637	1718.2	I	3±1	1±1	-	-	16±1	-	38±1	-	-	42±5	Tr.	-	-	1±1[d]
5679	1731.0	I	20±4	Tr.	-	-	13±1	-	24±1	-	-	36±4	Tr.	-	-	Tr.[d]
5699	1737.1	I	5±1	Tr.	-	-	9±1	-	33±1	-	-	50±6	Tr.	-	-	Tr.[d]
5746	1751.4	I	12±2	Tr.	-	-	10±1	-	32±1	-	-	46±5	Tr.	-	-	1±1[d]
5803	1768.8	I	10±2	Tr.	-	-	-	-	29±1	-	-	54±6	1±1	-	-	1±1[d]
5847	1782.2	I	13±3	Tr.	-	-	-	-	29±1	-	-	54±6	1±1	-	-	1±1[d],1±1[e]
5898	1797.7	I	7±1	Tr.	-	-	12±1	-	42±1	-	-	34±4	Tr.	-	-	-
5947	1812.6	I	12±2	-	2±1	-	15±1	-	28±1	-	-	34±4	1±1	-	-	1±1[d]
5980	1822.7	I	14±3	Tr.	4±1	-	-	-	29±1	-	-	40±5	Tr.	-	-	2±1[d]

[a]Sample designation, e.g., 292 refers to a sample from drill hole USW G-1 at 292-ft depth.

[b]I = Internal Standard Method, E = External Standard Method.

[c]Hornblende.

[d]Chlorite.

[e]Laumontite(?).

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW G-2													
10	3.0	-	7±3	-	-	-	15±5	-	40±10	40±10	-	-	-
100	30.5	-	3±2	-	-	-	18±7	-	40±10	40±10	-	-	-
200	61.0	-	-	-	-	-	10±5	-	40±10	40±10	-	-	-
230	70.1	-	-	-	-	-	10±5	-	40±10	40±10	-	-	-
270	82.3	6±4	-	-	-	-	-	-	40±10	40±10	23±7	-	-
304	92.7	-	-	-	-	-	15±5	7±3	40±10	40±10	-	-	-
331	100.9	40±10	-	-	-	-	-	-	40±10	15±5	-	-	-
338	103.0	50±10	-	-	-	-	-	-	-	7±3	-	40±10	-
358	109.1	23±7	-	-	-	-	-	Tr.	7±3	30±10	-	30±10	-
395	120.4	10±5	<2	-	-	-	-	3±2	15±5	23±7	-	40±10	-
501	152.7	12±8	<3	-	-	-	-	-	7±3	15±5	-	50±10	-
547	166.7	10±5	3±2	-	-	-	-	-	10±5	15±5	-	50±10	-
548	167.0	-	3±2	7±3	-	-	-	-	30±10	40±10	-	-	-
561	171.0	15±5	<3	15±5	-	-	-	-	30±10	32±8	-	-	-
627	191.1	10±5	3±2	15±5	-	-	-	-	30±10	40±10	-	-	-
675	205.7	40±10	3±2	23±7	-	-	-	Tr.	7±3	23±7	-	-	-
723	220.4	10±5	3±2	-	-	-	-	-	3±2	7±3	40±10	23±7	-
743	226.5	35±10	3±2	3±2	-	-	-	10±5	10±5	15±5	10±5	20±7	-
762	232.3	3±2	-	75±8	-	-	15±5	-	10±5	3±2	-	-	-
770	234.7	<2	7±3	-	-	-	-	-	23±7	70±10	-	-	-
822	250.5	7±3	3±2	-	-	-	15±5	-	30±10	40±10	-	-	-
855	260.6	3±2	3±2	-	-	-	10±5	-	30±10	40±10	-	-	-
898	273.7	<2	3±2	3±2	-	-	7±3	-	30±10	50±10	-	-	-
921	280.7	15±5	-	-	-	-	-	30±10	23±7	30±10	7±3	-	-
951	289.9	<2	-	-	-	-	-	23±7	30±10	30±10	-	-	-
984	299.9	6±4	-	-	-	-	-	23±7	15±5	23±7	23±7	-	-
1032	314.6	6±4	<2	-	-	-	-	23±7	30±10	30±10	-	-	-
1072	326.7	6±4	<2	-	-	-	-	30±10	10±5	40±10	-	-	-
1133	345.3	10±5	<2	-	-	-	-	23±7	30±10	50±10	-	-	-
1178	359.1	3±2	<2	-	-	-	-	18±7	30±10	40±10	-	-	-
1234	376.1	6±4	-	-	-	-	-	18±7	30±10	40±10	-	-	-
1281	390.4	10±5	-	-	-	-	-	23±7	23±7	40±10	-	-	-
1331	405.7	10±5	-	-	-	-	-	23±7	30±10	40±10	-	-	-
1382	421.2	10±5	<2	-	-	-	-	23±7	23±7	50±10	-	-	-
1420	432.8	10±5	-	-	-	-	-	23±7	30±10	40±10	-	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW G-2													
1461	445.3	10±5	-	-	-	-	-	15±5	40±10	40±10	-	-	-
1536	468.2	15±5	-	3±2	-	-	-	15±5	40±10	40±10	-	-	-
1585	483.1	10±5	-	3±2	-	-	-	18±7	30±10	40±10	-	-	-
1634	498.0	40±10	<2	40±10	-	-	-	-	23±7	-	-	-	-
1664	507.2	<2	-	<2	-	-	-	7±3	7±3	15±5	-	60±10	-
1691	515.4	10±5	-	50±10	7±3	-	-	-	20±5	10±5	-	-	-
1745	531.9	15±5	-	40±10	7±3	-	-	7±3	23±7	15±5	-	-	-
1752	534.0	10±5	-	60±10	7±3	-	-	3±2	10±5	7±3	-	-	-
1798	548.0	<2	-	50±10	23±7	-	-	10±5	15±5	23±7	-	-	-
1848	563.3	-	-	50±10	23±7	-	-	Tr.	23±7	15±5	-	-	-
1899	578.8	<2	<2	50±10	23±7	-	-	7±3	15±5	15±5	-	-	-
1952	595.0	-	3±2	7±3	50±10	-	-	15±5	15±5	15±5	-	-	-
2001	609.9	-	<2	7±3	50±10	-	-	15±5	15±5	23±7	-	-	-
2078	633.4	3±2	3±2	30±10	30±10	-	-	7±3	15±5	15±5	-	-	-
2158	657.8	3±2	3±2	30±10	23±7	Tr.	-	7±3	23±7	15±5	-	-	-
2248	685.2	3±2	<2	30±10	30±10	-	-	10±5	23±7	23±7	-	-	-
2353	717.2	<2	6±4	10±5	30±10	-	-	23±7	23±7	15±5	-	-	-
2430	740.7	3±2	10±5	30±10	10±5	-	-	30±10	5±5	30±10	-	-	-
2528	770.5	3±2	10±5	3±2	23±7	-	-	30±10	3±2	30±10	-	-	-
2667	812.9	3±2	7±3	-	30±10	-	-	23±7	3±2	40±10	-	-	-
2744	836.4	3±2	<2	-	-	-	-	40±10	7±3	50±10	-	-	-
2820	859.5	<2	<2	-	-	-	-	30±10	6±4	60±10	-	-	-
2869	874.5	<2	3±2	-	-	-	-	30±10	3±2	60±10	-	-	-
2887	880.0	3±2	<2	-	-	-	-	30±10	3±2	60±10	-	-	-
2950	899.2	6±4	<3	-	-	-	-	30±10	6±4	50±10	-	-	-
2970	905.3	10±5	<3	-	-	-	-	40±10	5±5	50±10	-	-	-
3037	925.7	40±10	<2	-	3±2	-	-	30±10	3±2	23±7	-	-	-
3067	934.8	-	<2	7±3	30±10	-	-	-	30±10	30±10	-	-	-
3192	972.9	7±3	-	30±10	10±5	Tr.	-	30±10	3±2	30±10	-	-	-
3228	983.9	6±3	-	1±1	-	30±10	-	34±10	-	29±10	-	-	-
3250	990.6	23±7	<2	10±5	10±5	30±10	-	23±7	3±2	23±7	-	-	-
3308	1008.3	3±2	15±5	-	-	-	-	23±7	5±5	50±10	-	-	-
3330	1015.0	-	6±4	-	-	-	-	30±10	5±5	60±10	-	-	-
	Fracture	10±5	6±4	-	-	-	-	15±5	-	23±7	-	-	50±10[a]
3349	1020.8	<2	6±4	-	-	-	-	23±7	5±5	60±10	-	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW G-2													
3366	1026.0	<2	6±4	-	-	-	-	30±10	5±5	60±10	-	-	-
3416	1041.2	<2	6±4	-	-	-	-	30±10	-	60±10	-	-	-
3454	1052.8	28±7	3±2	-	23±7	Tr.	-	25±10	-	25±10	-	-	-
3492	1064.4	18±7	3±2	-	23±7	7±3	-	30±10	-	23±7	-	-	-
3512	1070.5	15±5	7±3	-	6±4	15±5	-	30±10	-	40±10	-	-	3±2[b]
3541	1079.3	10±5	7±3	-	-	30±10	-	30±10	-	23±7	-	-	3±2[b]
3578	1090.6	23±7	10±5	-	23±7	-	-	30±10	-	23±7	-	-	-
3627	1105.5	15±5	10±5	-	-	3±2	-	30±10	-	40±10	-	-	-
3671	1118.9	10±5	7±3	-	-	7±3	-	30±10	-	40±10	7±3	-	<2[b]
3720	1133.9	10±5	7±3	-	-	Tr.	-	30±10	-	40±10	-	-	-
3724	1135.1	25±5	3±2	-	-	-	-	40±10	-	30±10	-	-	3±2[b]
3750	1143.0	25±5	10±5	-	-	-	-	30±10	-	40±10	-	-	-
3772	1149.7	23±7	7±3	-	-	-	-	30±10	-	40±10	-	-	-
3795	1156.7	32±8	-	-	-	<2	-	40±10	-	30±10	-	-	3±2[b]
3833	1168.3	30±10	6±4	-	-	-	-	30±10	-	30±10	-	-	-
3875	1181.1	25±5	7±3	-	-	3±2	-	40±10	-	23±7	-	-	-
3908	1191.2	18±7	-	-	-	-	-	30±10	-	40±10	6±4	-	-
3933	1198.8	15±5	-	-	-	30±10	-	30±10	-	30±10	7±3	-	-
3968	1209.4	18±7	6±4	-	-	Tr.	-	40±10	-	40±10	-	-	Tr.[b]
4005	1220.7	15±5	10±5	-	-	3±2	-	23±7	-	40±10	7±3	-	-
4090	1246.6	23±7	18±7	-	-	6±4	-	23±7	-	30±10	10±5	-	-
4167	1270.1	15±5	15±5	-	-	<2	-	23±7	-	40±10	10±5	-	3±2[b]
4199	1279.9	15±5	10±5	-	-	Tr.	-	18±7	-	40±10	18±7	-	<2[b]
4209	1282.9	10±5	7±3	-	-	6±4	-	18±7	-	50±10	3±2	-	-
4267	1300.6	15±5	7±3	-	-	3±2	-	30±10	-	40±10	3±2	-	-
4329	1319.5	10±5	6±4	-	-	3±2	-	30±10	-	40±10	10±5	-	-
4467	1361.5	10±5	6±4	-	-	3±2	-	23±7	-	40±10	10±5	-	-
	Pumice	23±7	-	-	-	-	-	23±7	-	40±10	10±5	-	-
4570	1392.9	10±5	7±3	-	-	3±2	-	30±10	-	40±10	18±7	-	-
4788	1459.4	15±5	3±2	-	-	Tr.	-	30±10	-	40±10	10±5	-	-
4805	1464.6	20±10	-	-	-	Tr.	-	40±10	-	40±10	-	-	-
4816	1467.9	23±7	-	-	-	Tr.	-	40±10	-	30±10	6±4	-	-
4838	1474.6	23±7	-	-	-	3±2	-	30±10	-	40±10	6±4	-	-
4873	1485.3	30±10	-	-	-	<2	-	30±10	-	30±10	-	-	-
4885	1488.9	30±10	-	-	-	-	-	30±10	-	30±10	3±2	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW G-2													
4893	1491.4	23±7	7±3	-	-	<2	-	30±10	-	30±10	-	-	-
4924	1500.8	18±7	10±5	-	-	3±2	-	30±10	-	30±10	7±3	-	-
4949	1508.5	40±10	10±5	-	-	-	-	23±7	-	23±7	-	-	-
5017	1529.2	20±10	-	-	-	-	-	30±10	-	40±10	-	-	3±2[b]
	Spherulite	6±4	-	-	-	-	-	40±10	-	40±10	6±4	-	3±2[b]
5029	1532.8	20±10	20±10	-	-	-	-	30±10	-	30±10	-	-	-
5144	1567.9	6±4	20±10	-	-	-	-	30±10	-	40±10	6±4	-	-
5171	1576.1	18±7	30±10	-	-	-	-	23±7	-	23±7	6±4	-	-
5206	1586.8	15±5	18±7	-	-	Tr.	-	23±7	-	40±10	-	-	6±4[b]
5213	1588.9	10±5	10±5	-	-	-	-	30±10	-	30±10	6±4	-	10±5[b]
5305	1617.0	10±5	10±5	-	-	-	-	23±7	-	40±10	10±5	-	<2[b]
5369	1636.5	10±5	15±5	-	-	-	-	30±10	-	40±10	10±5	-	-
5379	1639.5	6±4	15±5	-	-	-	-	30±10	-	40±10	10±5	-	-
5434	1656.3	6±4	23±7	-	-	<2	-	23±7	-	40±10	-	-	-
5493	1674.3	3±2	23±7	-	-	-	-	30±10	-	40±10	15±5	-	-
5505	1677.9	10±5	15±5	-	-	-	-	23±7	-	40±10	7±3	-	6±4[c]
5538	1688.0	25±10	-	-	-	-	-	23±7	-	30±10	18±7	-	10±5[c]
5596	1705.7	15±5	-	-	-	-	-	23±7	-	40±10	6±4	-	7±3[c]
5638	1718.5	18±7	-	-	-	Tr.	-	18±7	-	40±10	18±7	-	6±4[c]
5657	1724.3	30±10	-	-	-	-	-	23±7	-	30±10	6±4	-	6±4[c]
5696	1736.1	15±5	-	-	-	<2	-	23±7	-	40±10	18±7	-	10±5[c]
5762	1756.3	10±5	-	-	-	-	-	23±7	-	40±10	23±7	-	10±5[c]
5820	1773.9	-	-	-	-	-	-	23±7	-	40±10	6±4	-	18±7[c]
5885	1793.7	18±7	-	-	-	-	-	23±7	-	18±7	30±10	-	6±4[c]
5895	1796.8	18±7	-	-	-	-	-	30±10	-	30±10	23±7	-	6±4[c]
5918	1803.8	10±5	-	-	-	-	-	40±10	-	40±10	-	-	6±4[b], 3±2[c]
5926	1806.2	15±5	-	-	-	Tr.	-	40±10	-	40±10	-	-	-
5931	1807.8	23±7	-	-	-	-	-	23±7	-	40±10	6±4	-	10±5[b]
5951	1813.9	23±7	-	-	-	<2	-	30±10	-	40±10	6±4	-	3±2[b]
5971	1820.0	18±7	-	-	-	3±2	-	30±10	-	40±10	-	-	-
5992	1826.4	18±7	-	-	-	3±2	-	40±10	-	40±10	6±4	-	3±2[b]

[a] Hematite.
[b] Kaolinite.
[c] Chlorite.

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW GU-3												
31.0	9.5	3±1	2±1	-	-	-	-	10±5	75±5	12±3	-	-
45.0	13.7	-	-	-	-	6±2	-	17±3	75±5	-	-	-
79.0	24.1	-	-	-	-	25±5	2±1	6±2	70±5	-	-	-
103.1	31.4	-	-	-	-	7±3	2±1	20±5	70±5	2±1	-	-
	Fracture	-	-	-	-	2±1	-	2±1	9±3	90±5	-	-
196.3	59.8	-	-	-	-	-	-	25±5	75±5	-	-	-
	Vein	3±1	-	-	-	-	-	3±2	10±5	85±5	-	-
245.7	74.9	2±1	-	-	-	3±1	2±1	25±5	70±5	-	-	-
303.6	92.5	<1	-	-	-	-	-	25±5	75±5	-	-	-
316.8	96.6	-	-	-	-	-	-	22±3	75±5	-	-	-
341.5	104.1	3±2	-	-	-	-	-	30±5	70±5	-	-	-
356.5	108.7	7±3	-	-	-	-	-	15±5	40±5	-	40±10	-
376.1	114.6	4±2	-	-	-	-	3±1	5±3	50±5	-	40±10	-
410.0	125.0	20±4	~1	-	-	-	2±1	25±5	50±5	-	-	-
414.3	126.3	3±2	~1	-	-	-	3±2	20±5	75±5	-	-	-
417.5	127.3	12±3	~1	-	-	-	6±2	17±3	65±5	-	-	-
424.4	129.4	-	~1	-	-	6±2	2±1	17±3	75±5	-	-	-
429.0	130.8	-	2±1	-	-	4±2	4±2	20±5	70±5	-	-	-
	Vein	-	-	-	-	-	-	2±1	6±2	92±3	-	-
430.5	131.2	-	3±1	-	-	4±2	-	12±3	80±5	-	-	-
465.5	141.9	-	~1	-	-	10±5	-	9±3	80±5	-	-	-
482.0	146.9	-	~1	-	-	20±5	-	7±3	70±5	3±1	-	-
520.3	158.6	-	-	-	-	20±5	-	5±3	70±5	3±1	-	-
	Cavity	-	-	-	-	15±5	-	-	12±3	77±3	-	-
525.3	160.1	~1	-	-	-	20±5	~1	6±2	70±5	-	-	-
	Cavity	-	-	-	-	35±10	-	2±1	53±5	10±5	-	-
579.0	176.5	~1	-	-	-	12±3	-	22±3	65±5	-	-	-
633.4	193.1	~1	~1	-	-	7±3	2±1	22±3	70±5	-	-	-
674.7	205.7	~1	~1	-	-	5±3	2±1	22±3	70±5	-	-	-
	Fracture	-	-	-	-	70±10	12±3	-	17±3	-	-	-
702.5	214.1	~1	~1	-	-	-	6±2	17±3	70±5	-	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW GU-3												
769.1	234.4	~1	~1	-	-	6±4	~1	22±3	65±5	-	-	-
849.4	258.9	~1	~1	-	-	-	4±2	17±3	75±5	-	-	-
	Fracture	-	-	-	-	5±3	77±3	~1	15±5	-	-	-
910.5	277.5	~1	-	-	-	-	4±2	27±3	65±5	-	-	-
	Fracture	~1	-	-	-	40±10	17±3	2±1	40±5	-	-	-
924.3	281.7	~1	-	-	-	10±5	12±3	12±3	65±5	-	-	-
	Fracture	-	-	-	-	12±3	80±5	~1	7±3	-	-	-
951.1	289.9	~1	-	-	-	5±3	8±2	17±3	70±5	-	-	-
	Fracture	-	-	-	-	25±5	50±5	2±1	24±5	-	-	-
954.8	291.0	~1	~1	-	-	-	17±3	12±3	70±5	-	-	-
1027.0	313.0	-	-	-	-	-	6±4	17±3	75±5	-	-	-
	Fracture	2±1	-	-	-	-	7±2	~1	6±2	40±5	-	40±5[a]
1061.0	323.4	-	-	-	-	-	20±2	7±3	70±5	-	-	-
1130.3	344.5	-	~1	-	-	-	17±3	10±2	70±5	-	-	-
1175.0	358.1	~1	~1	-	-	-	35±5	3±1	60±5	-	-	-
1195.7	364.5	5±1	-	-	-	-	3±1	27±3	35±5	-	30±10	-
	Vein	-	Tr.	~1	-	-	8±2	22±3	70±5	-	-	-
1227.0	374.0	2±1	-	-	-	-	8±2	17±3	35±5	-	40±10	-
1302.4	397.0	2±1	-	-	-	-	4±2	12±3	40±5	-	45±15	-
1322.0	403.0	-	-	-	-	-	4±2	7±3	30±5	-	65±15	-
1344.8	409.9	-	-	-	-	-	7±3	7±3	30±5	-	55±15	-
1369.6	417.5	-	-	-	-	-	4±2	6±4	25±5	-	65±15	-
1394.5	425.0	-	-	-	-	-	4±2	6±4	30±5	-	65±15	-
1394.6	425.1	-	-	-	-	-	4±2	6±4	30±5	-	65±15	-
1415.5	431.4	-	-	-	-	-	5±3	6±4	35±5	-	55±15	-
1439.2	438.7	Tr.	Tr.	-	-	-	20±5	6±4	20±5	-	55±15	-
1439.5	438.8	~1	2±1	-	-	-	5±3	6±4	35±5	-	55±15	-
1468.5	447.6	-	2±1	-	-	-	5±3	6±4	35±5	-	55±15	-
1493.7	455.3	~1	-	2±1	-	-	5±3	6±4	25±5	-	65±15	-
1498.3	456.7	-	-	3±1	-	-	7±3	6±4	25±5	-	65±15	-
1510.7	460.5	3±1	~1	-	-	-	5±3	6±4	25±5	-	65±15	-
1537.5	468.6	3±1	3±1	2±1	-	-	17±3	4±2	50±5	3±1	20±10	2±1[b]
1571.6	479.0	2±1	2±1	-	-	-	4±2	5±3	45±5	-	45±15	-
1598.5	487.2	4±2	~1	-	-	-	5±3	2±1	45±5	-	45±15	-
1603.0	488.6	-	~1	-	-	-	2±1	30±5	65±5	-	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW GU-3												
1624.2	495.1	-	~1	-	-	7±3	20±5	2±1	70±5	-	-	-
1653.2	504.0	~1	~1	-	-	15±5	15±5	3±2	70±5	-	-	-
1709.0	521.0	~1	-	-	-	-	12±3	12±3	70±5	2±1	-	-
1744.0	531.6	-	-	-	-	-	6±2	25±5	70±5	-	-	-
1827.2[c]	557.0	2±1	-	30±2	-	-	4±1	7±2	19±3	-	38±4	-
1874.0	571.2	-	-	50±5	-	-	7±3	5±3	40±5	-	-	-
1935.8	590.0	3±2	-	60±5	-	-	4±2	4±2	30±5	-	-	-
1986.0	605.3	-	-	70±5	-	-	4±2	6±2	20±5	-	-	-
1993.1	607.5	-	-	60±5	-	-	4±2	10±2	25±5	-	-	-
2013.2	613.6	2±1	2±1	50±5	-	-	3±1	4±2	40±5	-	-	-
	Fracture	30±5	3±1	15±5	-	-	10±5	-	40±5	-	-	-
2070.2	631.0	2±1	-	-	-	7±3	20±5	3±1	70±5	-	-	-
2138.2	651.7	2±1	2±1	-	-	-	17±3	12±3	70±5	-	-	Tr[b]
2177.3	663.6	2±1	2±1	-	-	-	20±4	10±4	65±5	-	-	Tr[b]
2189.3	667.3	2±1	2±1	-	-	-	12±3	15±3	70±5	-	-	Tr[b]
2198.0	670.0	2±1	2±1	-	-	-	12±3	17±3	70±5	-	-	-
	Fracture	7±2	1±1	2±1	-	-	11±3	10±2	69±5	-	-	-
2226.0	678.5											
	Fracture	99±1	-	-	-	-	-	-	-	-	-	1±1[d]
2360.0	719.3	-	2±1	-	-	-	20±3	12±3	70±5	-	-	1±1[b]
	Fracture	2±1	2±1	-	-	-	37±3	-	40±5	-	-	17±8[e]
2369.4	722.2	2±1	2±1	-	-	-	17±3	12±3	70±5	-	-	1±1[b]
2467.4	752.1	-	2±1	-	-	-	20±2	10±2	70±5	-	-	1±1[b]
2548.4	776.8	30±5	2±1	12±3	-	-	8±2	-	50±5	-	-	-
2577.4	785.6	3±1	6±2	50±5	-	-	2±1	5±3	35±5	-	-	1±1[b]
2615.3	797.1	2±1	4±2	40±5	-	-	5±2	7±3	45±5	-	-	-
2623.4	799.6	3±1	2±1	30±5	-	-	5±2	2±2	60±5	-	-	-
2656.6	809.7	4±2	5±2	30±5	-	-	5±2	8±2	50±5	-	-	-
2695.7	821.7	~1	3±1	30±5	-	-	7±3	10±5	40±5	-	-	10±5[e]
	Fracture	-	~1	10±5	-	-	80±5	10±5	-	-	-	10±5[e]
2727.4	831.3	1±1	3±1	-	-	-	17±3	15±5	65±5	-	-	-
	Vein	1±1	2±1	-	-	-	23±5	11±2	63±5	-	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW GU-3												
2914.5	888.3	-	3±1	-	-	-	21±3	7±3	65±5	-	-	-
2971.0	905.6	1±1	3±2	-	-	-	15±3	12±3	70±5	-	-	-
	Fracture	-	1±1	Tr.	-	-	56±5	5±3	38±5	-	-	-
3004.5	915.8	-	3±2	-	-	-	30±5	4±2	65±5	-	-	-
	Fracture	-	4±2	-	-	-	17±3	2±1	75±5	-	-	-
3045.3	928.2	1±1	3±1	-	-	-	21±3	7±3	65±5	-	-	-
3113.1	948.9	1±1	4±2	-	-	-	12±3	17±3	65±5	-	-	-
3164.1	964.4	2±1	4±2	10±5	-	-	9±3	15±5	60±5	-	-	-
3207.4	977.6	2±1	3±1	10±5	-	-	9±3	17±3	60±5	-	-	-
	Fracture	4±1	6±1	15±5	-	-	16±2	15±5	45±5	-	-	-
3226.0	983.3	5±1	3±1	6±4	-	-	12±3	15±5	60±5	-	-	-
3239.0	987.3	-	2±1	-	-	-	16±2	15±5	65±5	-	-	-
	Fracture #1	-	2±1	-	-	-	32±3	11±4	55±5	-	-	6±4[f]
	Fracture #2	-	-	-	-	-	41±5	-	38±5	-	-	20±10[e]
3311.0	1009.2	3±1	3±1	15±5	-	-	14±2	10±5	55±5	-	-	-
3475.3	1059.3	3±1	4±1	20±5	-	-	14±2	10±5	50±5	-	-	-
3589.4	1094.1	7±3	3±2	35±5	-	-	12±3	7±3	35±5	-	-	-
3672.0	1119.2	6±2	3±2	15±5	-	-	16±2	8±4	45±5	-	-	7±3[e]
3759.1	1145.8	9±3	4±2	15±5	-	-	27±3	-	45±5	-	-	-
3854.8	1174.9	7±3	2±1	35±5	-	-	25±5	-	30±5	-	-	-
3859.3	1176.3	3±1	2±1	25±5	-	-	27±3	-	40±5	5±1	-	-
3936.3	1199.8	1±1	5±1	10±5	5±3	-	30±2	~1	50±5	-	-	-
4008.3	1221.7	3±1	6±2	-	15±5	-	32±3	-	45±5	-	-	-
4117.0	1254.9	4±2	~1	-	9±3	-	35±3	-	50±5	-	-	-
4240.6	1292.5	12±3	3±1	-	-	-	27±3	-	50±5	7±3	-	-
4263.8	1299.6	4±2	2±1	-	25±5	-	32±3	-	35±5	1±1	-	-
4297.1	1309.8											
	Fracture	4±2	1±1	-	7±3	-	37±3	-	7±3	40±5	-	-
4416.0	1346.0	4±2	1±1	-	7±3	-	37±3	-	9±3	40±5	-	-
4423.0	1348.1	9±3	2±1	12±3	7±3	-	32±3	-	35±5	2±1	-	-
4503.7	1372.7	20±5	2±1	4±2	4±2	-	37±3	-	35±5	-	-	-
	Fracture	7±3	1±1	3±1	-	-	62±3	-	30±5	-	-	-
4568.4	1392.5	17±3	3±1	2±1	12±3	-	27±3	-	35±5	1±1	-	-
4600.3	1402.2	6±2	2±1	2±1	-	-	51±3	-	40±5	-	-	-
4708.5	1435.2	9±3	2±1	-	17±3	-	34±2	-	35±5	2±1	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Other
USW GU-3												
4756.5	1449.8	6±2	2±1	-	12±3	-	37±3	-	40±5	-	-	-
4786.4	1458.9	7±3	2±1	-	17±3	-	32±3	-	40±5	-	-	-
4803.2	1464.0	1±1	2±1	-	17±3	-	35±3	-	40±5	-	-	-
	Vein	-	-	-	Tr.	-	1±1	-	-	83±10	-	16±5[a]
4869.4	1484.2	3±1	1±1	-	37±3	-	34±2	-	25±5	-	-	-
4906.5	1495.5	2±1	2±1	-	35±5	-	34±2	-	27±3	-	-	-
5014.0	1528.3	4±2	2±1	-	15±5	-	37±3	-	40±5	-	-	-

[a] Fluorite.
[b] Hornblende.
[c] Analyzed using the Internal Standard Method.
[d] Hematite.
[e] Mordenite.
[f] Cryptomelane.

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW G-4											
47	14.3	2±1	-	-	-	-	2±1	28±5	70±10	-	-
72	21.9	~1	-	-	-	-	2±1	28±5	70±10	-	-
107	32.6	-	-	-	-	-	2±1	32±5	67±10	-	-
123	37.5	25±10	-	-	-	-	-	15±5	40±10	20±10	-
148	45.1	35±15	-	-	-	-	-	15±10	-	50±20	-
170	51.8	28±10	5±2	-	-	-	8±2	5±2	40±20	20±10	-
220	67.1	10±5	3±2	-	-	-	4±2	5±2	60±20	20±10	-
231	70.4	8±4	10±5	-	-	-	-	3±2	60±20	20±10	-
236	71.9	-	-	-	-	-	10±5	10±5	20±10	60±20	-
268	81.7	-	~1	-	-	20±10	-	6±2	73±10	-	-
280	85.3	-	~1	-	-	10±5	-	5±2	80±20	-	-
332	101.2	-	2±1	-	-	7±5	-	15±5	76±20	-	-
383	116.7	3±2	~1	-	-	15±10	-	11±5	70±10	-	-
410	125.0	3±2	~1	-	-	17±10	~1	12±5	66±10	-	-
416	126.8	3±2	~1	-	-	9±5	~1	14±5	73±10	-	-
447	136.2	2±1	~1	-	-	6±4	3±1	20±5	68±10	-	-
514	156.7	2±1	-	-	-	6±4	2±1	22±5	69±10	-	-
556	169.5	2±1	-	-	-	19±10	8±2	9±5	58±10	-	4±2[a]
625	190.5	2±1	-	-	-	11±5	17±4	6±2	63±10	-	-
676	206.0	3±1	-	-	-	4±2	4±1	23±5	66±10	-	-
694	211.5	3±2	-	-	-	17±8	4±1	13±2	62±10	-	-
746	227.4	~1	-	-	-	-	3±1	28±5	68±10	-	-
817	249.0	2±1	-	-	-	-	25±3	7±3	65±10	-	-
934	284.7	~1	-	-	-	8±4	16±2	11±4	63±10	-	-
1026	312.7	~1	-	-	-	5±2	9±2	20±5	66±10	-	-
1089	331.9	~1	-	-	-	16±8	12±2	10±4	61±10	-	-
	Fracture	-	-	-	-	-	66±5	~1	32±10	-	-
1117	340.5	~1	-	-	-	-	16±2	14±4	69±10	-	-
1163	354.5	-	Tr.	-	-	-	16±2	15±4	69±10	-	-
	Inclusion	~1	-	-	-	-	35±5	3±2	61±10	-	-
1190	362.7	~1	Tr.	-	-	-	25±3	13±4	60±10	-	-
1244	379.2	~1	~1	-	-	-	17±3	15±4	67±10	-	-
1282	390.8	~1	~1	-	-	-	16±3	18±4	65±10	-	-
1283-1293E	391.1-394.1	~1	~1	-	-	-	6±2	23±4	69±10	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW G-4											
1299	395.9	2±1	Tr.	5±2	-	-	8±2	23±4	62±10	-	-
1301	396.5	-1	-1	5±2	-	-	9±2	20±4	65±10	-	-
1310	399.3	-1	-1	3±2	-	-	5±2	24±5	65±10	-	-
1314	400.5	45±10	-	28±5	-	-	2±1	14±4	11±5	-	-
1330	405.4	-	-	-	-	-	10±5	-	20±10	70±20	-
1341	408.7	-	-	-	-	-	10±5	-	30±10	60±20	-
1372	418.2	6±2	2±1	1±1	-	-	5±2	12±5	36±10	40±20	-
1381	420.9	7±3	-	56±10	-	-	5±2	4±2	28±10	-	-
	Inclusion	-	4±2	10±5	-	-	10±5	-	-	75±20	-
1392	424.3	2±1	-	70±15	-	-	2±1	4±2	21±10	-	-
	Inclusion	-	2±1	-	-	-	5±3	-	-	95±20	-
1419	432.5	-	2±1	30±10	-	-	7±2	8±3	53±10	-	-
1432	436.5	3±2	4±2	75±15	-	-	11±4	7±4	-	-	-
1438	438.3	3±2	-1	75±15	-	-	4±2	4±2	13±5	-	-
1470	448.1	3±2	-	77±10	-	-	6±2	14±4	-	-	-
1544	470.6	3±2	-	50±10	20±10	-	6±2	12±4	-	-	-
1602	488.3	-	-1	40±10	12±5	-	5±2	8±4	30±10	-	-
1685	513.6	-1	-	50±10	15±10	-	4±2	7±3	19±10	-	-
1707	520.3	-1	-1	32±10	12±5	-	3±2	14±4	38±10	-	-
1734	528.5	-	4±2	30±10	10±5	-	12±2	15±4	29±10	-	-
1763	537.4	7±3	-	50±10	-	-	-	32±5	13±5	-	-
1779	542.2	2±1	-	45±10	-	-	-	10±4	44±10	-	-
1788	545.0	3±1	-	28±10	-	-	4±2	5±2	61±10	-	-
	Fracture	-	-	-	93±10	-	7±2	-	-	-	-
1794	546.8	-	-1	-	-	-	3±1	29±5	67±10	-	-
1841	561.1	2±1	-1	-	-	-	27±5	3±2	67±10	-	-
1871	570.3	-1	-1	-	-	-	23±5	5±2	69±10	-	-
1938	590.7	-1	-	-	-	-	5±2	29±4	65±10	-	-
1952	595.0	-1	Tr.	-	-	-	5±2	18±4	76±10	-	-
1958[b]	596.8	8±2	-	35±3	5±2	-	5±1	4±1	46±8	-	-
1968	599.8	3±2	-	15±5	20±10	-	8±2	10±4	45±10	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW G-4											
1989	606.2	-	~1	44±10	-	-	7±3	15±4	33±10	-	-
2039	621.5	-	-	30±10	15±10	-	5±2	8±3	42±10	-	-
2069	630.6	-	-	35±10	20±10	-	3±1	4±2	35±10	-	-
2090	637.0	-	-	10±5	35±10	-	5±2	10±4	40±10	-	-
2100	640.1	2±1	-	30±10	30±10	-	2±1	-	35±10	-	-
	Fracture	-	-	5±3	35±10	-	20±4	-	40±10	-	-
2131	649.5	-	~1	30±10	20±10	-	2±1	-	46±10	-	-
2202	671.2	-	-	40±10	10±5	-	4±2	7±3	37±10	-	-
2226	678.5	~1	-	35±10	15±10	-	6±2	2±1	38±10	-	-
2238	682.1	~1	-	50±10	25±10	-	6±2	-	18±10	-	-
2248[b]	685.2	Tr.	3±1	47±3	-	-	5±1	-	50±8	-	-
2263	689.8	-	5±3	-	-	-	19±5	~1	75±10	-	-
2285	696.5	~1	5±3	-	-	-	32±5	2±1	60±10	-	-
2343	714.1	~1	3±2	-	-	-	31±5	-	65±10	-	-
	Fracture 1	9±5	3±2	-	-	-	49±5	-	39±10	-	-
	Fracture 2	6±3	2±1	-	-	-	38±5	-	54±10	-	-
2355	717.8	-	3±1	-	-	-	31±5	-	66±10	-	-
2381	725.7	~1	2±1	-	-	-	30±5	-	67±10	-	-
2423	738.5	~1	2±1	-	-	-	26±5	-	70±10	-	-
2516	766.9	-	3±1	-	-	-	29±5	-	68±10	-	-
2533	772.1	~1	2±1	-	-	-	31±5	-	66±10	-	-
2551	777.5	-	2±1	-	-	-	25±5	-	73±10	-	-
2566	782.1	-	2±1	-	-	-	31±5	-	68±10	-	-
2598	791.9	~1	2±1	-	-	-	25±5	-	71±10	-	-
2681	817.2	22±5	2±1	-	-	-	9±4	-	67±10	-	-
2716	827.8	-	-	-	80±10	-	20±5	-	-	-	-
2731	832.4	-	-	13±5	60±10	-	27±5	-	-	-	-
2754	839.4	12±5	2±1	3±2	23±10	-	29±5	-	33±10	-	-
2758	840.6	-	5±2	3±2	15±5	-	24±5	-	53±10	-	-
2762	841.9	~1	6±2	3±2	15±5	-	23±5	-	52±10	-	-
2792	851.0	-	2±1	2±1	71±14	-	5±1	-	19±9	-	-

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW G-4											
2823	860.5	2±1	6±2	16±10	8±5	-	28±5	-	39±10	-	-
	Fracture	7±5	2±1	5±3	60±20	-	27±5	-	-	-	-
2838[b]	865.0	-	1±1	-	-	-	39±1	-	64±8	-	Tr.[c]
2840	865.6	-	6±2	-	-	-	39±5	-	54±10	-	-
2875	876.3	-	4±2	-	-	-	35±5	-	61±10	-	-
2931[b]	893.3	Tr.	1±1	-	-	-	38±1	-	61±7	-	Tr.[c]
2947	898.2	-	3±2	-	-	-	31±5	-	66±10	-	-
	Fracture	-	-	-	-	-	10±5	-	-	-	80±20[d]
3000	914.4	-	4±2	-	-	-	42±5	-	54±10	-	-

[a] Calcite.
[b] Analyzed using the Internal Standard Method.
[c] Hematite.
[d] Cryptomelane.

APPENDIX A (cont)

Sidewall and Cuttings

Sample[a]	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW H-3											
470-480	143.3-146.3	-	2±1	-	-	13±6	-	8±3	77±10	-	1±1[b]
520-530	158.5-161.5	-	-	-	-	Tr.	-	24±5	76±10	-	-
540-550	164.6-167.6	-	Tr.	-	-	21±4	-	5±3	73±10	-	1±1[b]
610-620	185.9-189.0	-	-	-	-	Tr.	-	29±5	71±10	-	1±1[b]
740-750	225.6-228.6	~1	~1	-	-	-	4±2	26±5	68±10	-	-
800-810	243.8-246.9	2±1	~1	-	-	Tr.	2±1	27±5	69±10	-	-
870-880	265.2-268.2	~1	Tr.	-	-	-	29±4	3±2	66±10	-	-
930-940	283.5-286.5	~1	~1	-	-	-	14±3	16±4	69±10	-	1±1[b]
990-1000	301.8-304.8	~1	-	-	-	4±2	Tr.	23±5	72±10	-	-
1030-1040	313.9-317.0	~1	-	-	-	Tr.	3±1	24±5	72±10	-	1±1[b]
1100-1110	335.3-338.3	~1	-	-	-	Tr.	2±1	23±5	74±10	-	1±1[b]
1160-1170	353.6-356.6	~1	~1	-	-	-	2±1	29±5	67±10	-	-
1270-1280	387.1-390.1	-	2±1	-	-	-	2±1	7±4	19±10	70±20	-
1320-1330	402.3-405.4	-	-	-	-	-	2±1	5±3	23±10	70±20	-
1550(SW)	472.4	Tr.	1±1	2±3	-	7±3	10±5	7±3	70±10	-	-
1655(SW)	504.5	Tr.	1±1	2±3	-	7±3	7±3	7±3	75±10	-	-
1700(SW)	518.2	Tr.	1±1	2±3	-	-	10±5	15±5	60±10	15±5	-
1800(SW)	548.6	2±3	1±1	60±10	-	-	7±3	-	30±10	-	-
1900(SW)	579.1	7±3	1±1	75±5	-	2±3	2±3	2±3	15±5	-	-
2400(SW)	731.5	-	1±1	75±5	-	-	2±3	2±3	15±5	-	1±1[c]
2440(SW)	743.7	-	1±1	35±5	30±10	-	2±3	2±3	30±10	-	-
2490(SW)	759.0	2±3	1±1	45±5	25±5	-	2±3	-	20±10	-	-

[a] Sample numbers represent depth of sample in feet. SW = sidewall core sample from Levy (1984).
[b] Hematite.
[c] Hornblende.

APPENDIX A (cont)

Sidewall and Cuttings

Sample[a]	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW H-4											
310-320	94.5-97.5	-	-1	-	-	11±4	-	10±4	75±10	-	1±1[b]
390-400	118.9-121.9	2±2	-1	-	-	14±4	2±1	13±4	68±10	-	-
440-450	134.1-137.2	2±2	-	-	-	19±5	2±1	13±4	64±10	-	1±1[b]
490-500	149.4-152.4	2±2	-	-	-	11±4	-1	18±5	67±10	-	1±1[b]
640-650	195.1-198.1	2±2	-	-	-	-	4±2	26±5	68±10	-	-
830-840	253.0-256.0	3±2	-1	-	-	12±4	-1	14±4	68±10	-	-
910-920	277.4-280.4	-1	-	-	-	-	11±2	20±5	67±10	-	-
940-950	286.5-289.6	-1	-	-	-	-	7±2	21±5	71±10	-	-
1040-1050	317.0-320.0	-1	-	-	-	-	6±2	23±5	70±10	-	-
1150-1160	350.5-353.6	2±2	-1	-	-	-	15±2	18±5	64±10	-	-
1190-1200	362.7-365.8	-	-	5±5	-	-	-	15±10	15±10	70±20	-
1230-1240	374.9-378.0	20±10	2±1	-	-	-	4±2	20±5	25±10	30±20	-
1312(SW)	399.9	2±3	1±1	5±5	-	-	10±5	7±3	30±10	60±10	-
1320-1330	402.3-405.4	-	-1	-	-	-	31±4	9±4	59±10	-	-
1350-1360	411.5-414.5	-	-	78±10	-	-	3±2	9±4	10±5	-	-
1410-1420	429.8-432.8	-	-	52±10	5±3	-	7±2	9±4	31±10	-	-
1420(SW)	432.8	2±3	1±1	70±10	-	-	2±3	2±3	25±5	-	-
1455(SW)	443.5	-	1±1	45±5	25±5	-	2±3	2±3	20±10	-	-
1540-1550	469.4-472.4	3±2	-	29±10	16±5	-	11±3	10±4	31±10	-	-
1550(SW)	472.4	2±3	-	75±10	-	-	1±1	2±3	15±5	-	-
1600-1610	487.7-490.7	-	9±3	31±10	-	-	17±4	9±4	35±10	-	-
1640-1650	499.9-502.9	-	-	10±5	-	-	6±2	24±5	60±10	-	-
1656(SW)	504.8	-	-	-	-	-	2±3	35±15	65±15	-	-
1710-1720	521.2-524.3	-1	-1	-	-	-	33±5	3±2	61±10	-	1±1[b]
1790-1800	545.6-548.6	3±2	-	-	-	-	15±4	17±5	64±10	-	-
1900-1910	579.1-582.2	-	-1	22±7	-	-	5±2	16±10	56±10	-	2±2[c]
1980-1990	603.5-606.6	-	3±2	11±5	23±6	-	2±1	6±3	55±10	-	2±2[c]

[a] Sample numbers represent depth of sample in feet. SW = sidewall core sample from Levy (1984).
[b] Hematite.
[c] Hornblende.

APPENDIX A (cont)

Sidewall, Core, and Cuttings

Sample[a]	Depth (m)	Smectite	Mica	Clino-ptilolite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW H-5										
50(DC)	15.2	-	-	-	17±8	-	2±3	80±10	-	-
190(DC)	57.9	-	-	-	2±3	-	25±5	80±10	-	-
420(DC)	128.0	15±5	-	-	-	1±1	12±3	35±5	45±5	1±1[b]
450(DC)	137.2	-	-	-	-	1±1	-	2±3	96±2	-
700(DC)	213.4	Tr.	1±1	-	20±5	-	15±5	65±10	-	-
720-730	219.5-222.5	3±2	Tr.	-	23±10	-	9±5	65±10	-	1±1[c]
800-810	243.8-246.9	3±2	-	-	Tr.	2±1	24±5	72±10	-	1±1[c]
830-840	253.0-256.0	-	-	-	Tr.	-	24±5	76±10	-	1±1[c]
920-930	280.4-283.5	2±2	~1	-	Tr.	3±1	24±5	71±10	-	-
970-980	295.7-298.7	2±2	-	-	Tr.	2±1	26±5	71±10	-	1±1[c]
1050(DC)	320.0	Tr.	1±1	-	-	2±3	40±10	55±10	-	-
1150-1160	350.5-353.6	2±2	Tr.	-	-	26±5	10±5	62±10	-	1±1[c]
1230-1240	374.9-378.0	2±2	Tr.	-	-	7±2	23±5	69±10	-	-
1290-1300	393.2-396.2	2±2	~1	-	-	10±2	18±5	71±10	-	1±1[c]
1380-1390	420.6-423.7	2±2	~1	-	-	15±4	20±5	65±10	-	1±1[c]
1450-1460	442.0-445.0	Tr.	~1	-	-	20±5	8±5	71±10	-	-
1490-1500	454.2-457.2	2±2	~1	-	-	9±2	21±5	68±10	-	1±1[c]
1590-1600	484.6-487.7	35±10	-	10±5	-	-	17±5	40±10	-	-
1610(DC)	490.7	-	-	-	-	1±1	2±3	7±3	90±5	-
1666(SW)	507.8	50±10	-	10±5	-	1±1	12±3	25±5	-	-
1710-1720	521.2-524.3	3±2	-	-	-	5±3	5±3	20±10	70±20	-
1750(DC)	533.4	-	-	Tr?	-	2±3	5±5	5±5	85±5	-
1762(SW)	537.1	-	-	-	-	1±1	1±1	5±5	95±5	-
1800(SW)	548.6	-	1±1	-	-	2±3	2±3	10±5	85±5	-
1852(SW)	564.5	-	1±1	-	-	2±3	-	7±3	95±5	-
1875(SW)	571.5	-	-	Tr?	-	2±3	Tr?	5±5	92±3	-
1917(SW)	584.3	-	1±1	25±5	-	30±5	15±5	35±10	-	-
1930(DC)	588.3	2±3	1±1	50±10	-	15±5	-	30±5	-	-
1966(SW)	599.2	5±5	-	-	-	2±3	-	15±5	75±10	-
2200(DC)	670.6	Tr.	-	60±10	-	2±3	2±3	35±5	-	-

[a] Sample numbers represent depth of sample in feet. SW = sidewall core sample; DC = drill (bit) cutting sample from Levy (1984).
[b] Hornblende.
[c] Hematite.

APPENDIX A (cont)

Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Anal-cime	Quartz	Cristo-balite	Alkali Feldspar	Glass	Other
USW H-6										
1092.4	333.0	Tr.	Tr.	-	-	20±5	9±5	70±10	-	-
1128.8	344.1	Tr.	~1	-	-	21±5	12±5	66±10	-	-
1149.2	350.3	Tr.	Tr.	-	-	16±5	15±5	69±10	-	-
1166.3	355.5	3±2	~1	-	-	21±5	13±5	62±10	-	-
1368.4	417.1	3±2	Tr.	-	-	8±3	3±2	25±5	60±25	-
1376.2	419.5	Tr.	~1	-	-	2±1	4±2	32±5	60±25	-
1380.8	420.9	10±5	-	-	-	7±5	10±5	20±10	60±25	-
1426.6	434.8	-	~1	6±3	-	7±5	10±5	25±10	60±25	-
1511.7	460.8	10±5	2±1	36±5	-	7±5	-	49±10	10±5	-
1671.4	509.4	Tr.	Tr.	-	-	5±3	23±5	72±10	-	-
1679.2	511.8	-	Tr.	-	-	4±2	25±5	72±10	-	-
1829.5	557.6	-	2±1	-	-	21±5	6±5	71±10	-	-
2051.0	625.1	Tr.	4±2	-	-	20±5	8±5	68±10	-	Tr.[a]
2354.6	717.7	-	2±1	-	-	17±5	13±5	67±10	-	-
2865.0	873.3	Tr.	3±2	18±5	-	29±5	-	50±10	-	-
3003.2	915.4	-	15±5	26±5	-	-	5±3	51±10	-	3±2[a]
3188.4	971.8	3±2	12±5	-	-	5±3	19±5	63±10	-	2±1[a]
3605.2	1098.9	Tr.	10±5	3±2	-	5±3	7±5	58±10	15±10	2±1[a]
3806.0	1160.1	3±2	8±5	9±5	12±5	22±5	2±1	46±10	-	-

[a] Hornblende.

APPENDIX A (cont)

Cuttings

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Hematite
USW WT-1												
440-450	134.1-137.2	5±3	-	-	-	8±4	-	4±2	12±4	-	70±20	-
500-510	152.4-155.4	-	4±2	-	-	11±5	-	12±4	72±10	2±1	-	1±1
550-560	167.6-170.7	-	1±1	-	-	19±4	-	10±3	71±10	-	-	1±1
640-650	195.1-198.1	1±1	-	-	-	11±4	9±2	16±3	62±10	-	-	1±1
690-700	210.3-213.4	1±1	-	-	-	-	19±2	19±3	61±10	-	-	1±1
780-790	237.7-240.8	1±1	1±1	-	-	3±2	25±3	9±2	61±10	1±1	-	-
840-850	256.0-259.1	1±1	1±1	-	-	6±3	20±2	16±3	56±10	-	-	<1
930-940	283.5-286.5	3±2	1±1	-	-	5±2	26±3	7±2	57±10	Tr.	-	<1
1000-1010	304.8-307.8	1±1	Tr.	-	-	-	22±2	16±3	60±10	1±1	-	<1
1090-1100	332.2-335.3	1±1	Tr.	-	-	-	24±3	15±3	58±10	-	-	<1
1160-1170	353.6-356.6	1±1	1±1	1±1	-	11±4	10±2	18±3	58±10	1±1	-	<1
1220-1230	371.9-374.9	-	1±1	-	-	5±3	27±3	8±2	59±10	-	-	<1
1300-1310	396.2-399.3	1±1	1±1	2±1	-	-	35±4	4±2	59±10	-	-	<1
1320-1330	402.3-405.4	2±1	1±1	14±4	-	-	20±2	13±4	50±10	-	-	-
1340-1350	408.4-411.5	1±1	1±1	29±8	-	-	10±2	9±3	51±10	-	-	-
1380-1390	420.6-423.7	-	1±1	40±10	12±4	-	8±2	7±3	31±6	-	-	-
1410-1420	429.8-432.8	-	Tr.	40±10	8±3	-	3±2	8±3	40±8	-	-	-
1470-1480	448.1-451.1	-	1±1	25±8	18±5	-	10±3	7±3	39±8	-	-	-
1510-1520	460.2-463.3	-	1±1	43±10	10±4	-	8±3	5±2	33±7	-	-	-
1550-1560	472.4-475.5	-	1±1	40±10	12±4	-	14±3	7±3	26±5	-	-	-
1570-1580	478.5-481.6	-	1±1	5±3	3±2	-	26±3	9±3	57±10	-	-	<1

APPENDIX A (cont)

Cuttings and Core

Sample	Depth (m)	Smectite	Mica	Clino-ptilolite	Morden-ite	Tridy-mite	Quartz	Cristo-balite	Alkali Feldspar	Calcite	Glass	Hematite
USW WT-2												
250-260	76.2-79.2	4±2	-	-	-	-	2±1	11±4	34±10	-	50±20	-
260-270	79.2-82.3	7±3	3±2	-	-	-	1±1	7±3	51±10	-	30±20	<1
290-300	88.4-91.4	1±1	2±1	-	-	10±4	-	9±3	78±10	-	-	1±1
370-380	112.8-115.8	<1	<1	-	-	19±6	1±1	5±3	72±10	-	-	1±1
420-450	128.0-131.0	1±1	<1	-	-	12±4	2±1	11±3	73±10	2±1	-	1±1
510-520	155.4-158.5	1±1	1±1	-	-	13±4	3±1	21±3	62±10	1±1	-	<1
570-580	173.7-176.8	3±2	<1	-	-	13±4	5±2	21±3	59±10	-	-	<1
650-660	198.1-201.1	2±1	<1	-	-	10±4	6±2	22±3	58±10	-	-	1±1
720-730	219.5-222.5	1±1	<1	-	-	10±4	8±2	19±3	61±10	-	-	-
780-790	237.7-240.8	1±1	<1	-	-	6±3	21±3	10±3	59±10	3±1	-	<1
850-860	259.1-262.1	1±1	<1	-	-	13±4	14±3	16±3	56±10	-	-	<1
930-940	283.5-286.5	1±1	<1	-	-	13±4	11±2	17±3	57±10	-	-	<1
990-1000	301.8-304.8	2±1	<1	-	-	-	14±2	21±3	62±10	1±1	-	<1
1060-1070	323.1-326.1	3±1	<1	-	-	-	16±2	19±3	61±10	-	-	<1
1130-1140	344.4-347.5	<1	<1	-	-	-	13±2	15±3	70±10	<1	-	<1
1190-1200	362.7-365.8	2±1	<1	1±1	-	-	4±3	9±3	56±10	-	30±20	-
1200-1210	365.8-368.8	1±1	-	1±1	-	-	7±4	15±4	26±10	-	50±20	-
1250-1260	381.0-384.0	2±1	1±1	-	-	-	9±4	12±4	36±10	-	40±20	-
1300-1310	396.2-399.3	<1	<1	1±1	-	-	10±4	12±4	36±10	-	40±20	-
1360-1370	414.5-417.6	<1	<1	<1	-	-	11±4	8±4	40±10	-	40±20	-
1420-1430	432.8-435.9	<1	<1	4±2	-	-	11±4	4±2	50±10	-	30±20	-
1450-1460	442.0-445.0	1±1	<1	<1	-	-	14±3	8±4	44±10	<1	30±20	-
1470-1480	448.1-451.1	<1	<1	5±3	-	-	8±3	8±4	49±10	-	30±20	-
1520-1530	463.3-466.3	3±2	1±1	24±5	-	-	11±3	12±4	48±10	-	-	-
1570-1580	478.5-481.6	-	2±1	19±4	-	-	18±2	7±3	53±10	-	-	-
1640-1650	499.9-502.9	1±1	<1	2±1	-	-	22±3	7±3	67±10	-	-	<1
1710-1720	521.2-524.3	1±1	<1	<1	-	-	22±3	7±3	69±10	-	-	<1
1750-1760	533.4-536.4	1±1	1±1	1±1	-	-	14±2	17±3	66±10	-	-	<1
1820-1830	554.7-557.8	4±2	-	19±4	-	-	5±2	14±3	59±10	-	-	-
1910-1920	582.2-585.2	-	1±1	42±10	-	-	5±2	6±3	47±10	-	-	-
2000-2010	609.6-612.6	-	-	30±8	10±4	-	3±2	3±2	55±10	-	-	-
2050.25 core	624.9	1±1	3±1	-	-	-	18±2	9±2	69±10	-	-	<1
2053.7 core	626.0	1±1	3±1	-	-	-	19±2	10±2	67±10	-	-	<1
2059.3 core	627.7	<1	3±1	-	-	-	21±2	9±2	66±10	-	-	<1

APPENDIX B

GRAPHICAL REPRESENTATION OF THE DATA IN APPENDIX A SHOWING THE RELATIVE ABUNDANCES OF MINERALS AND GLASS IN DRILL HOLES AT YUCCA MOUNTAIN, NEVADA. THE SCALES ON INDIVIDUAL FIGURES CAN BE USED TO ESTIMATE RELATIVE WEIGHT PERCENTAGES.

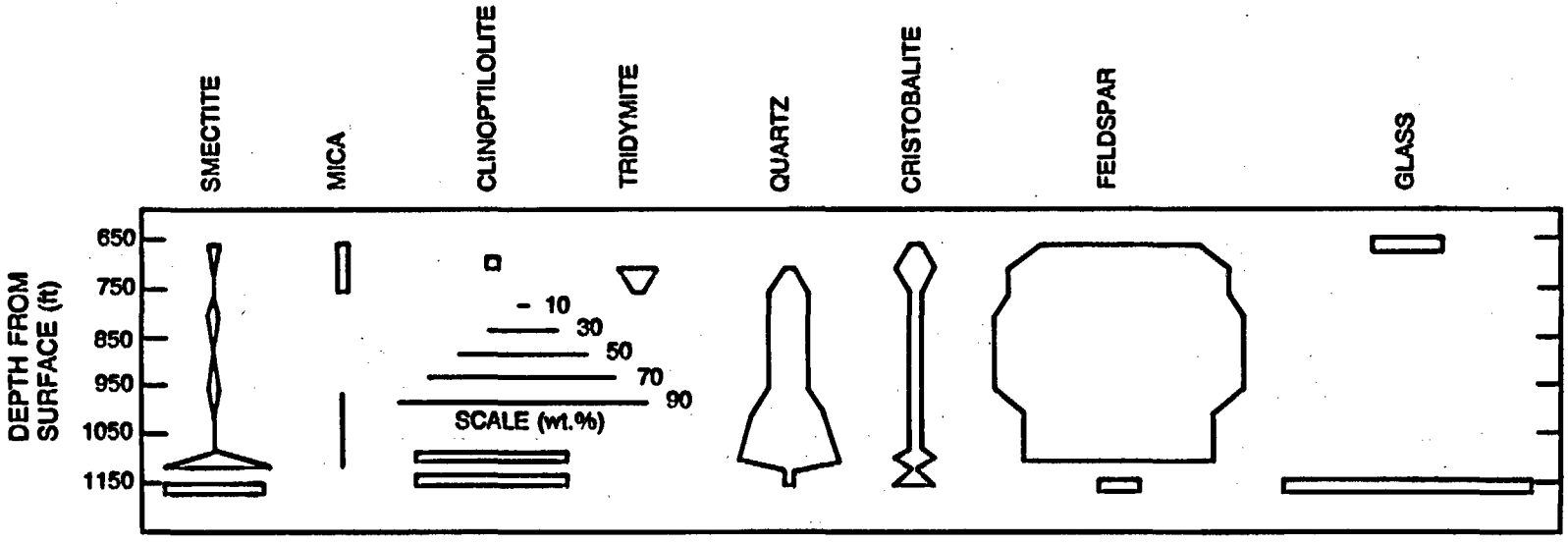

Fig. B-1. Drill hole J-12.

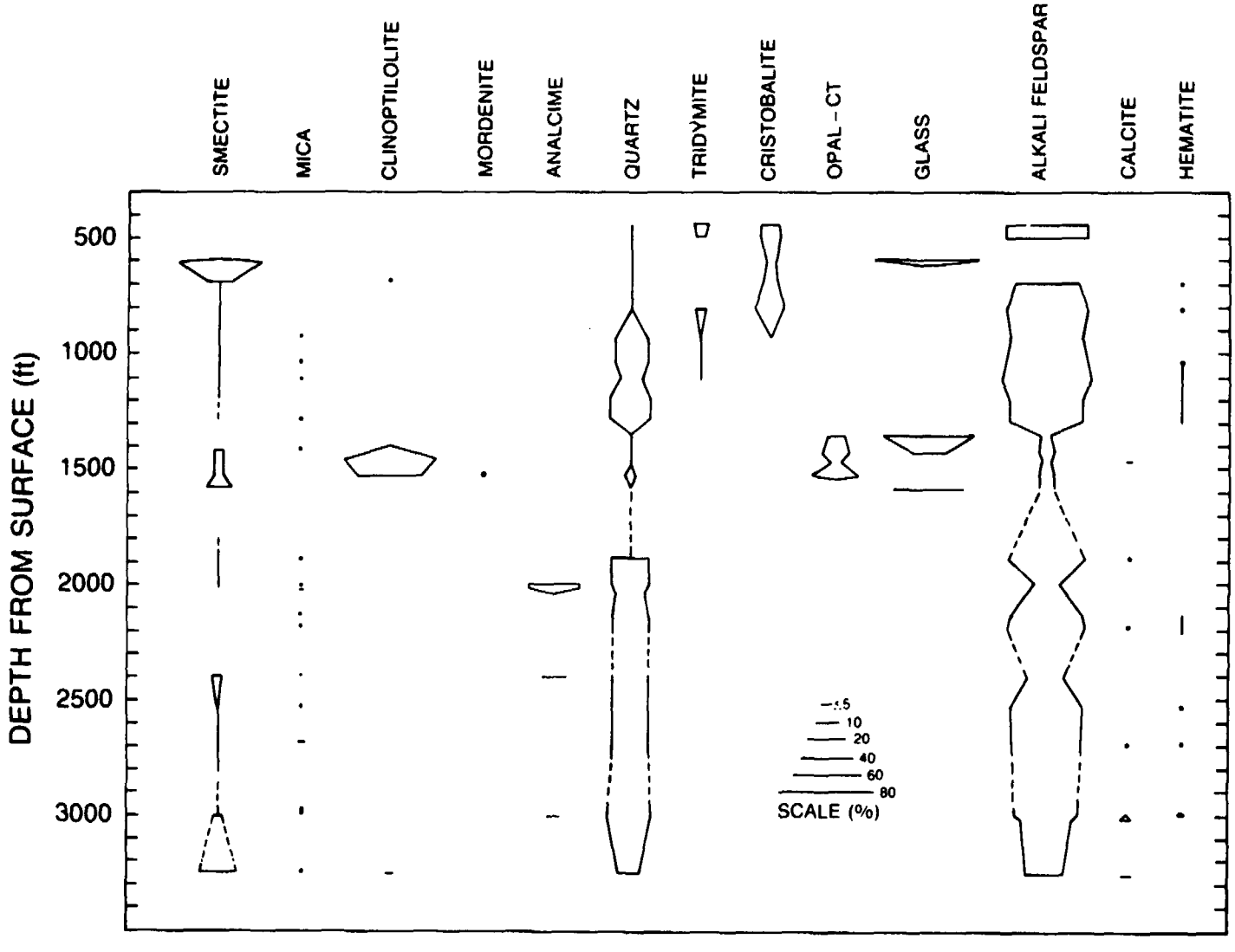

Fig. B-2. Drill hole J-13.

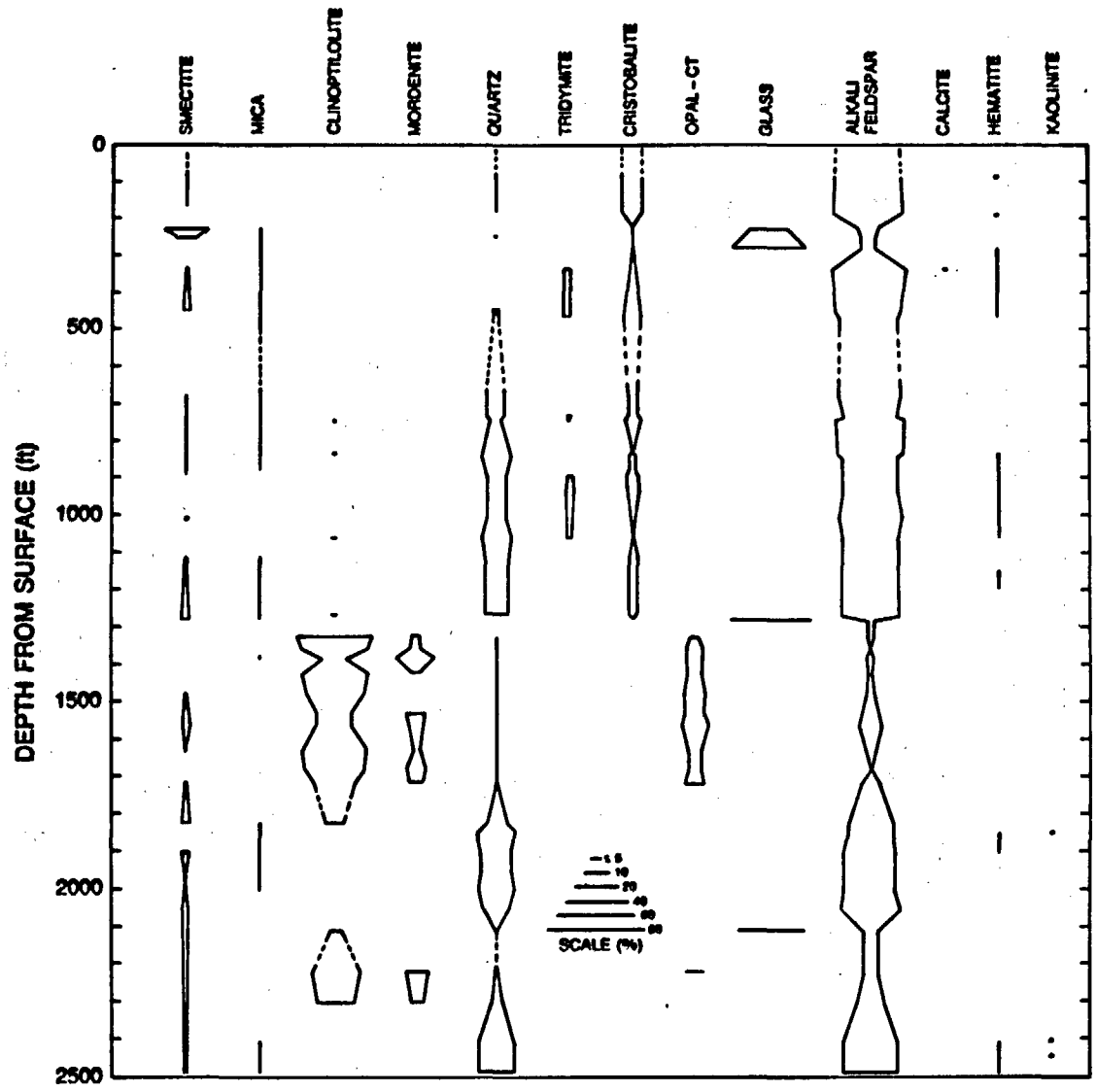

Fig. B-3. Drill hole UE-25a#1.

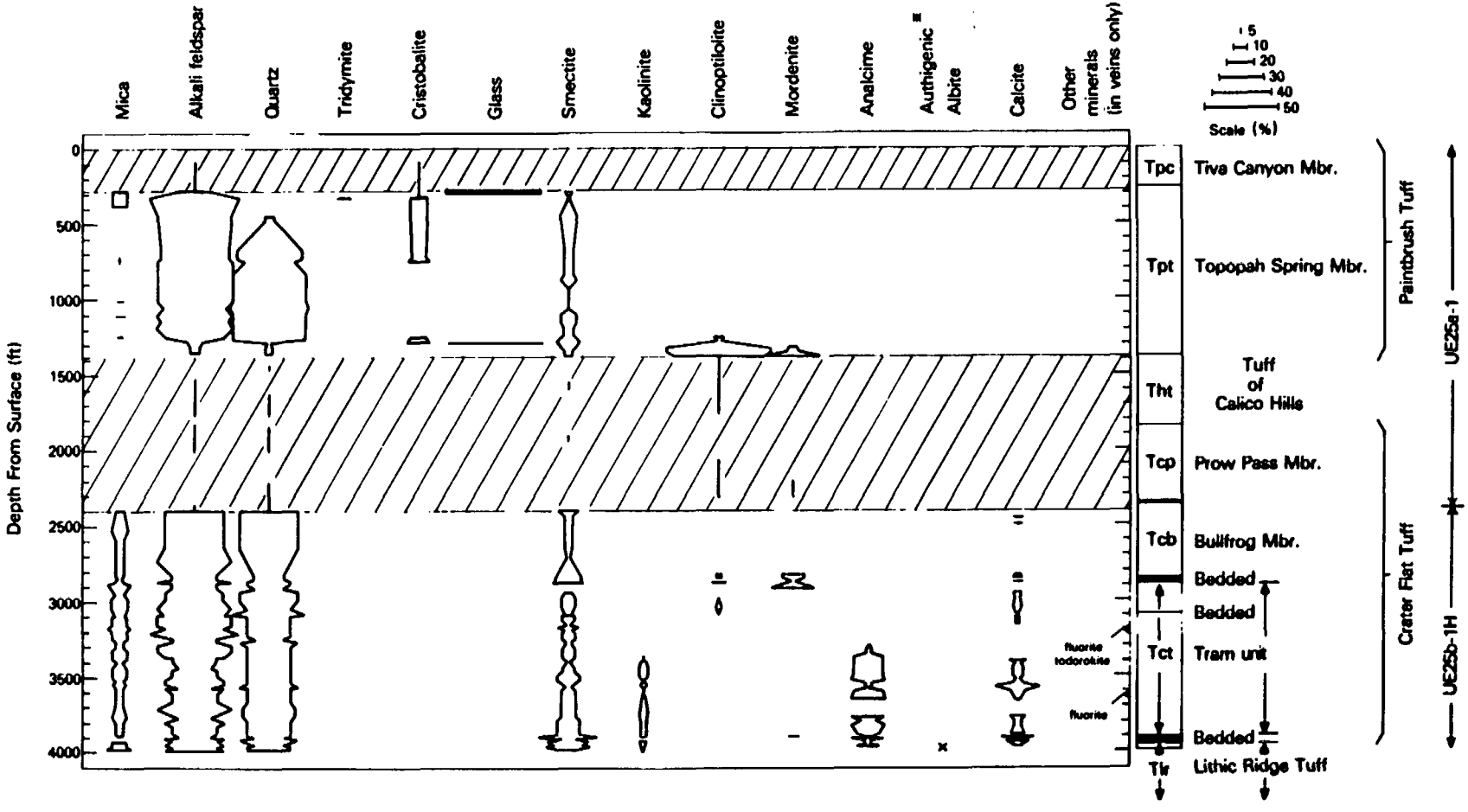

Fig. B-4. Drill holes UE-25a#1 and UE-25b#1H.

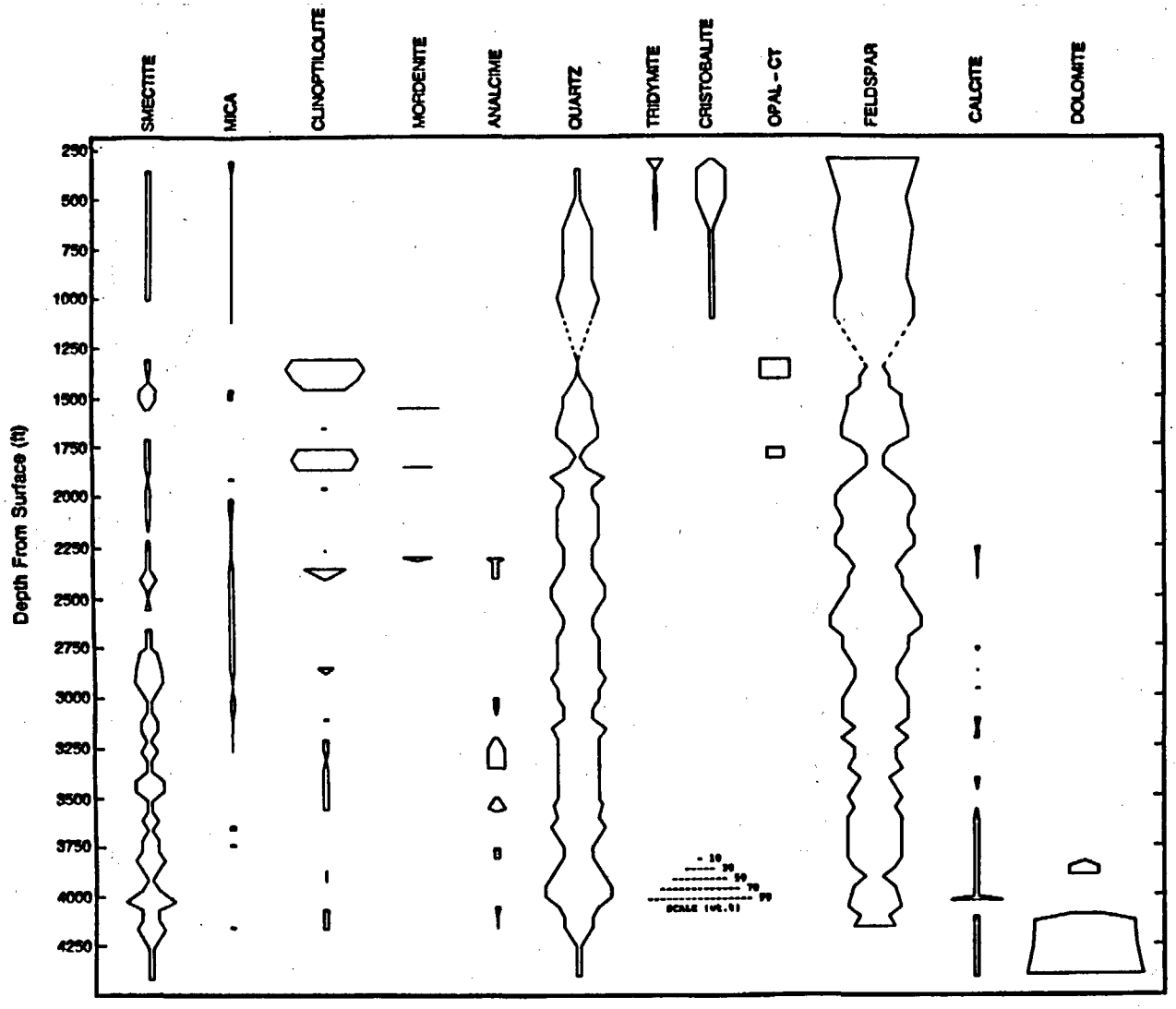

Fig. B-5. Drill hole UE-25p#1.

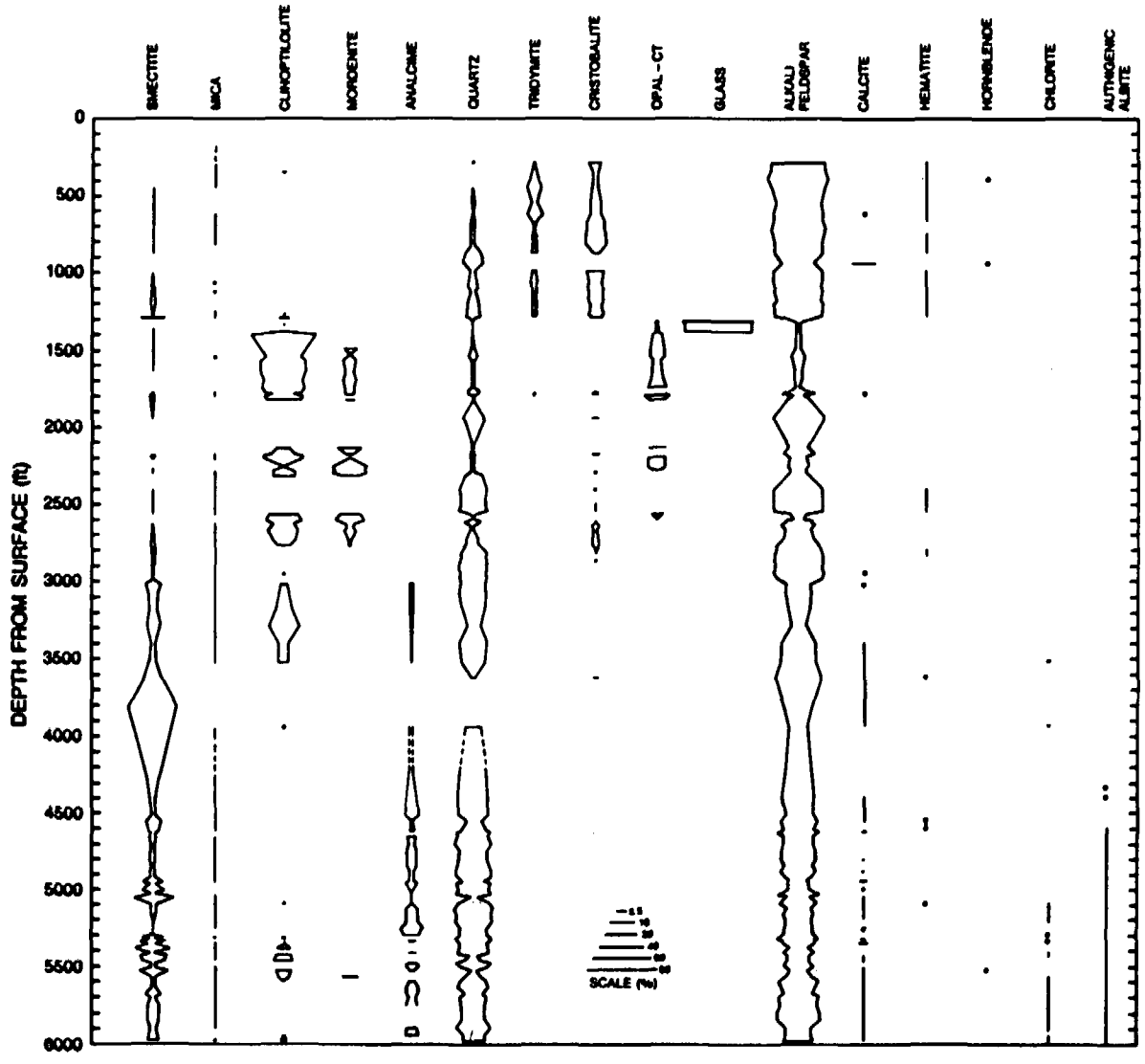

Fig. B-6. Drill hole USW G-1.

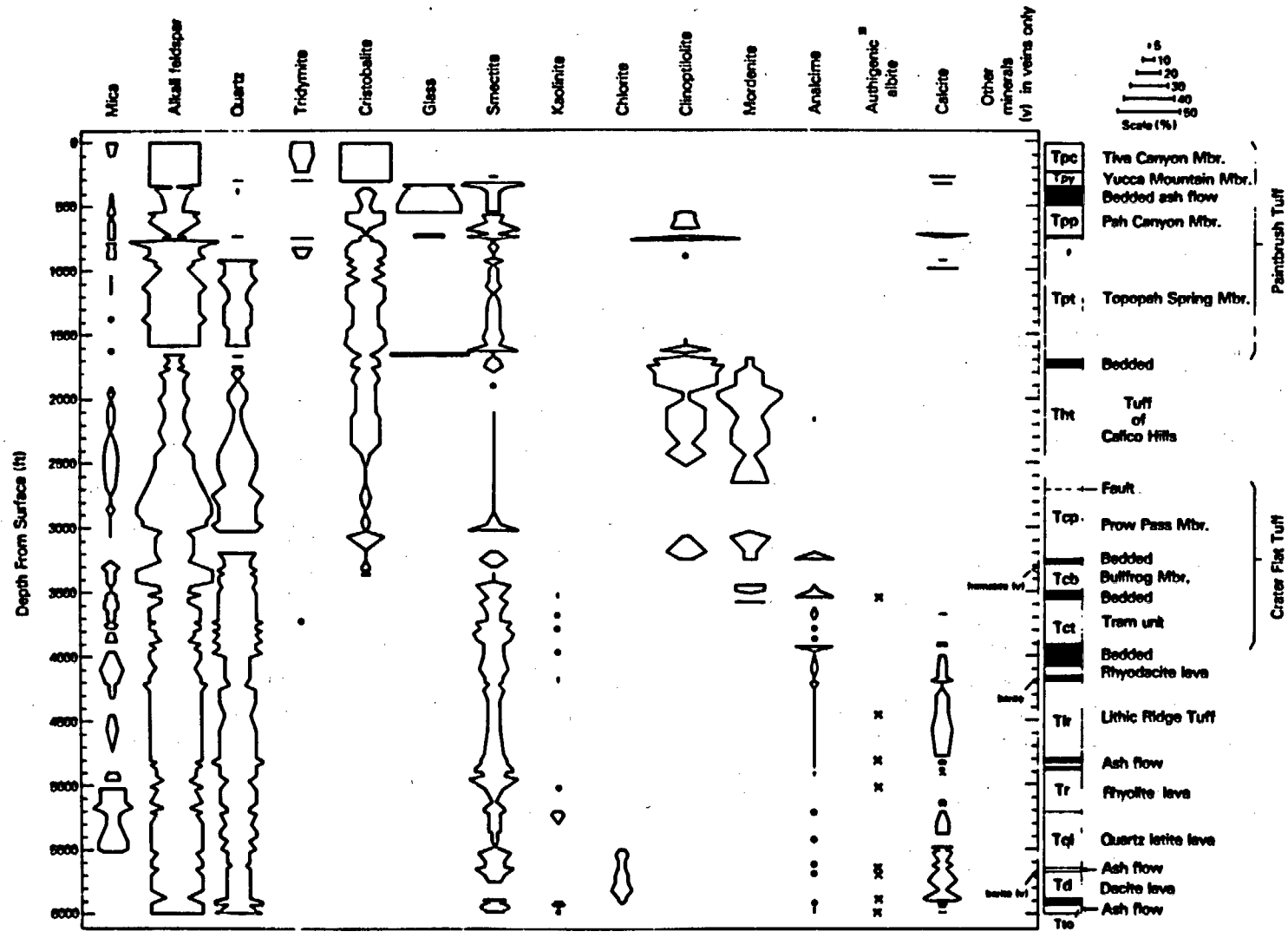

Fig. B-7. Drill hole USW G-2.

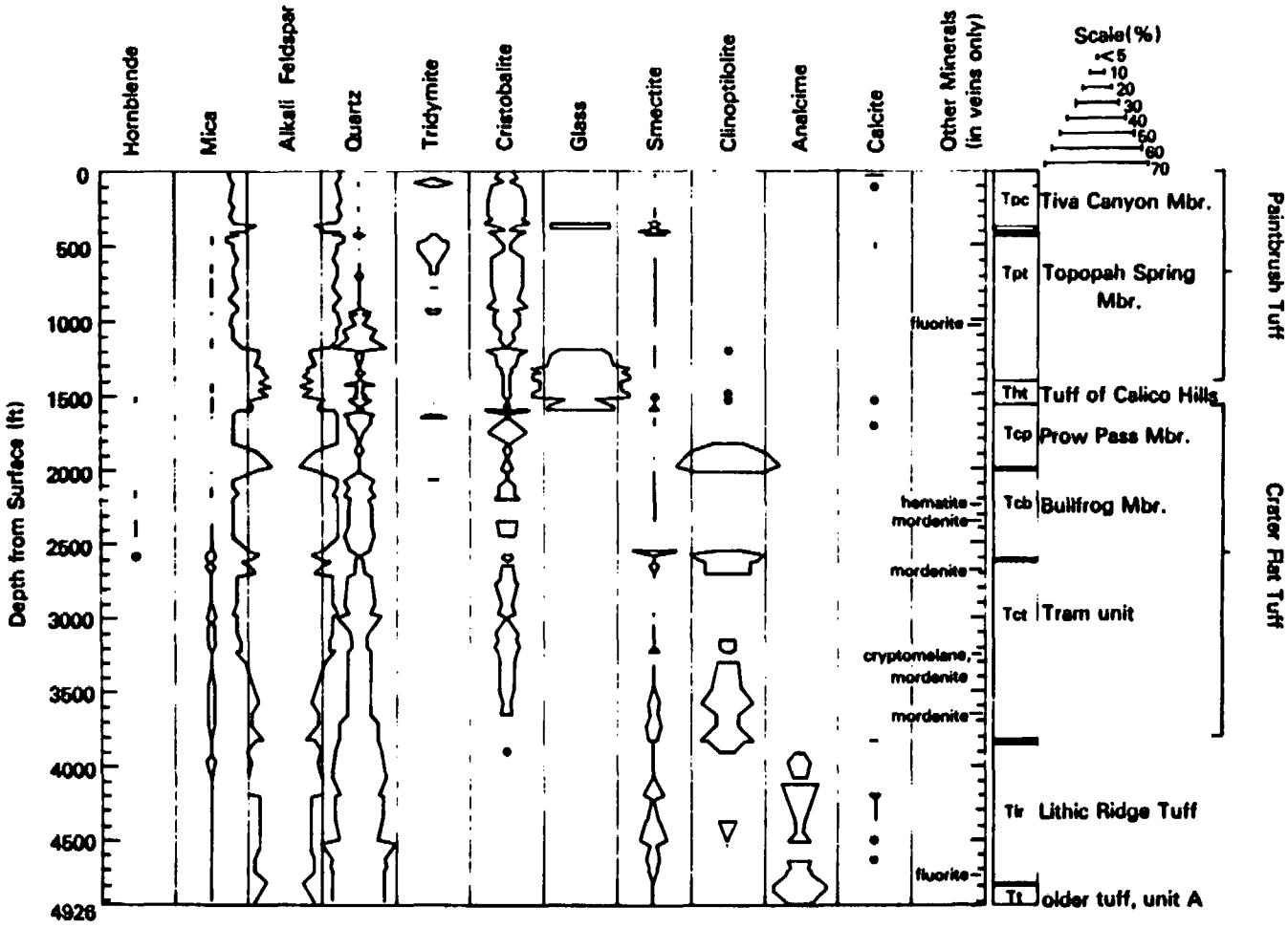

Fig. B-8. Drill holes GU-3 and G-3.

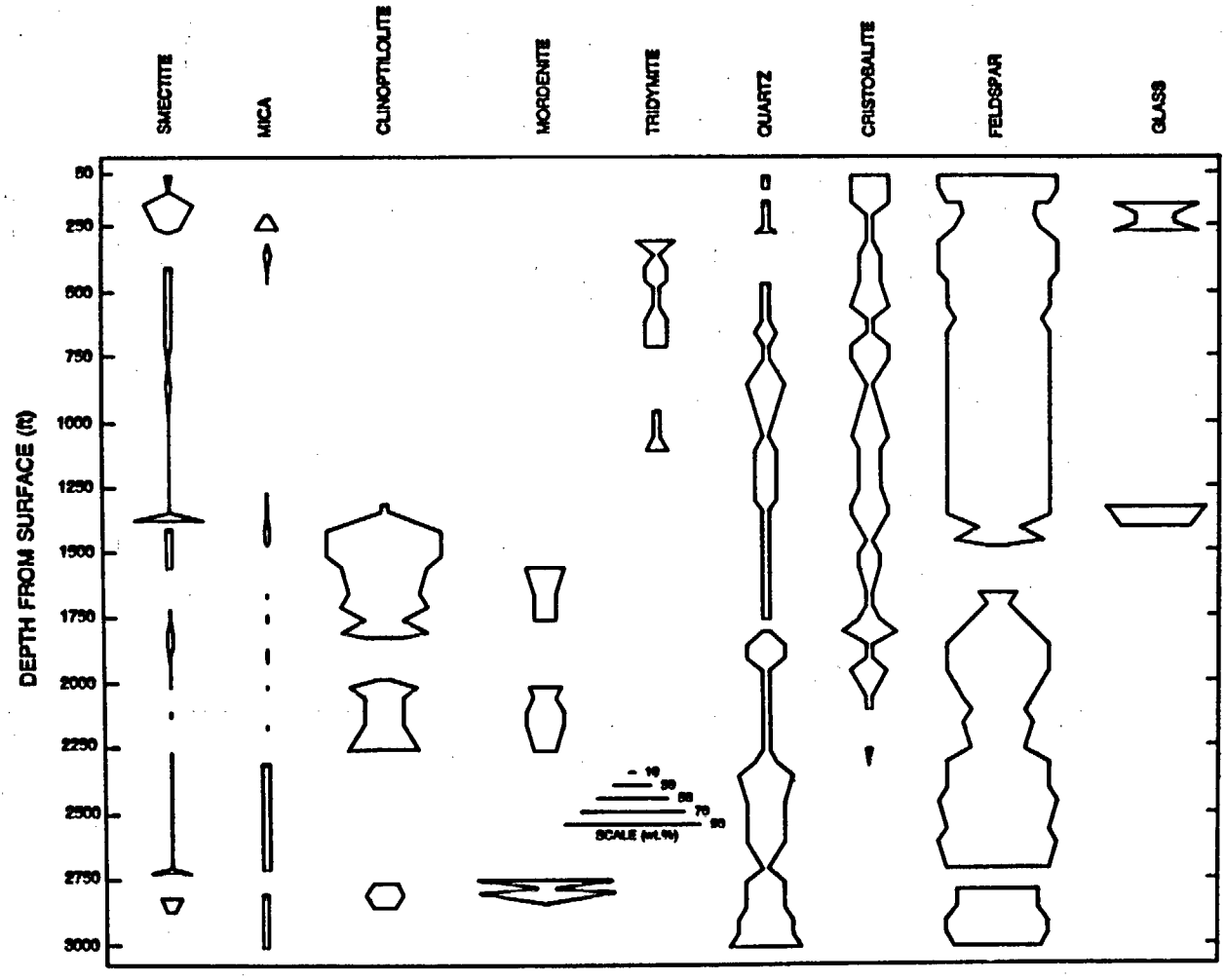

Fig. B-9. Drill hole USW G-4.

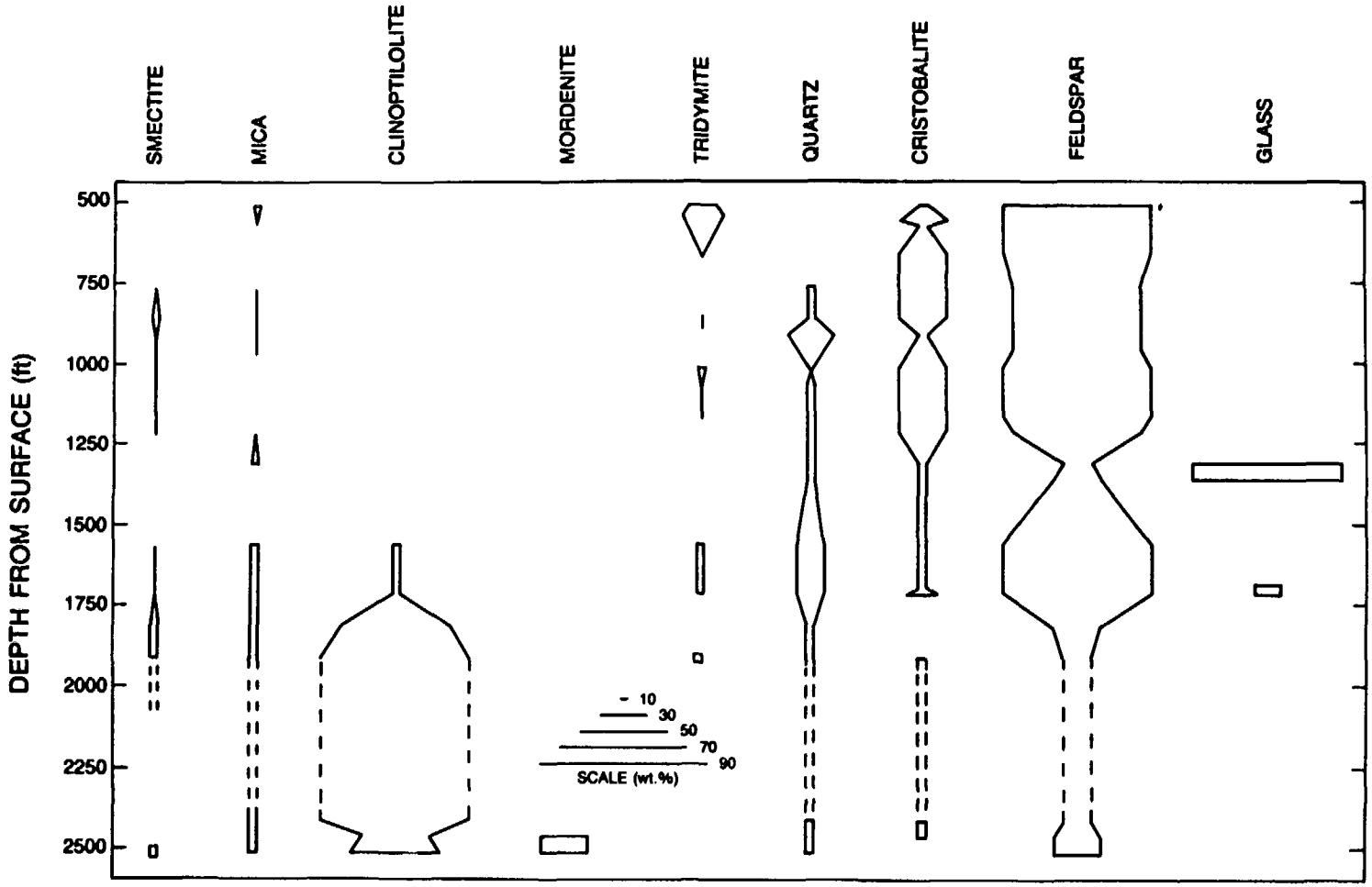

Fig. B-10. Drill hole USW H-3.

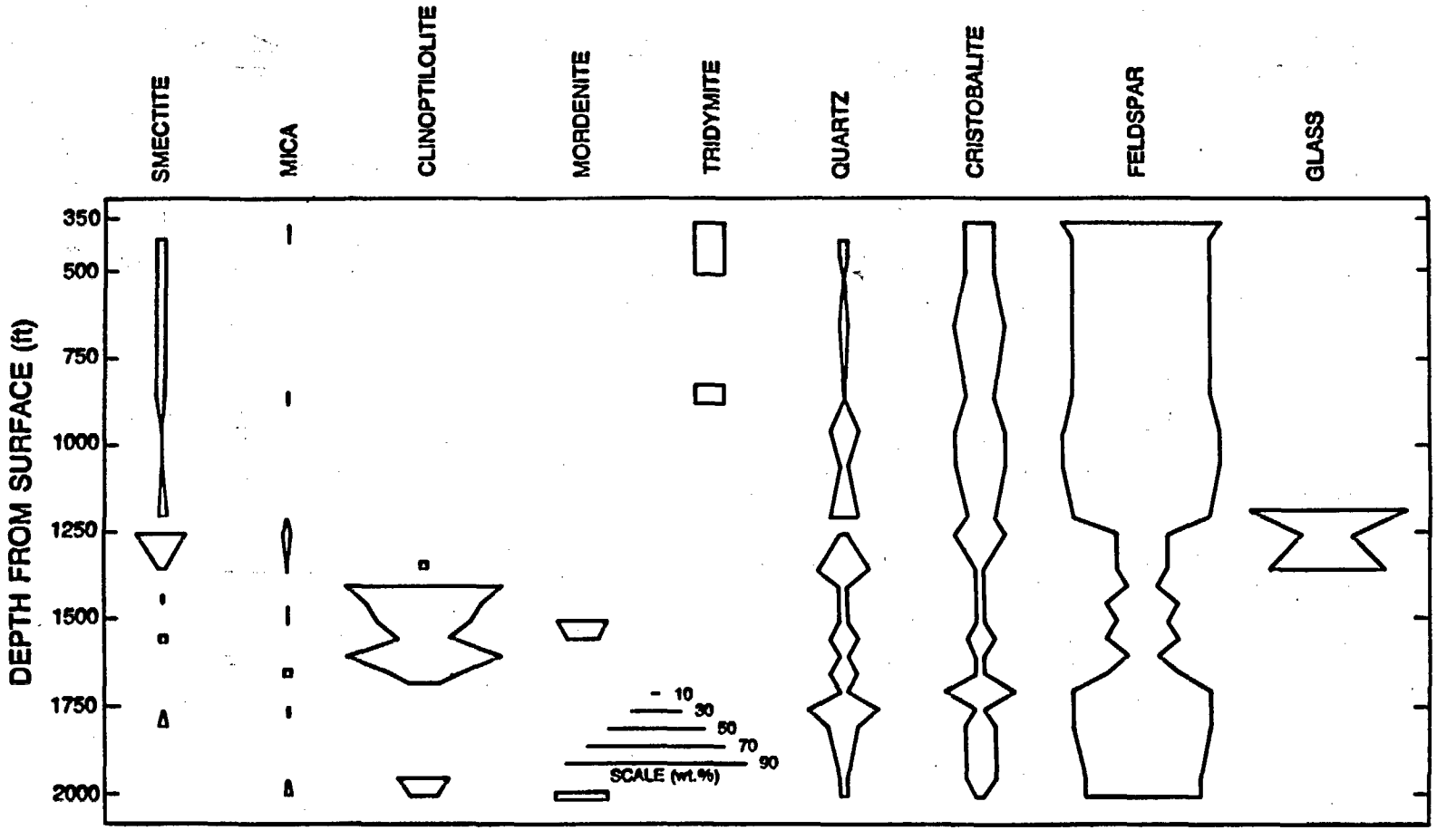

Fig. B-11. Drill hole USW H-4.

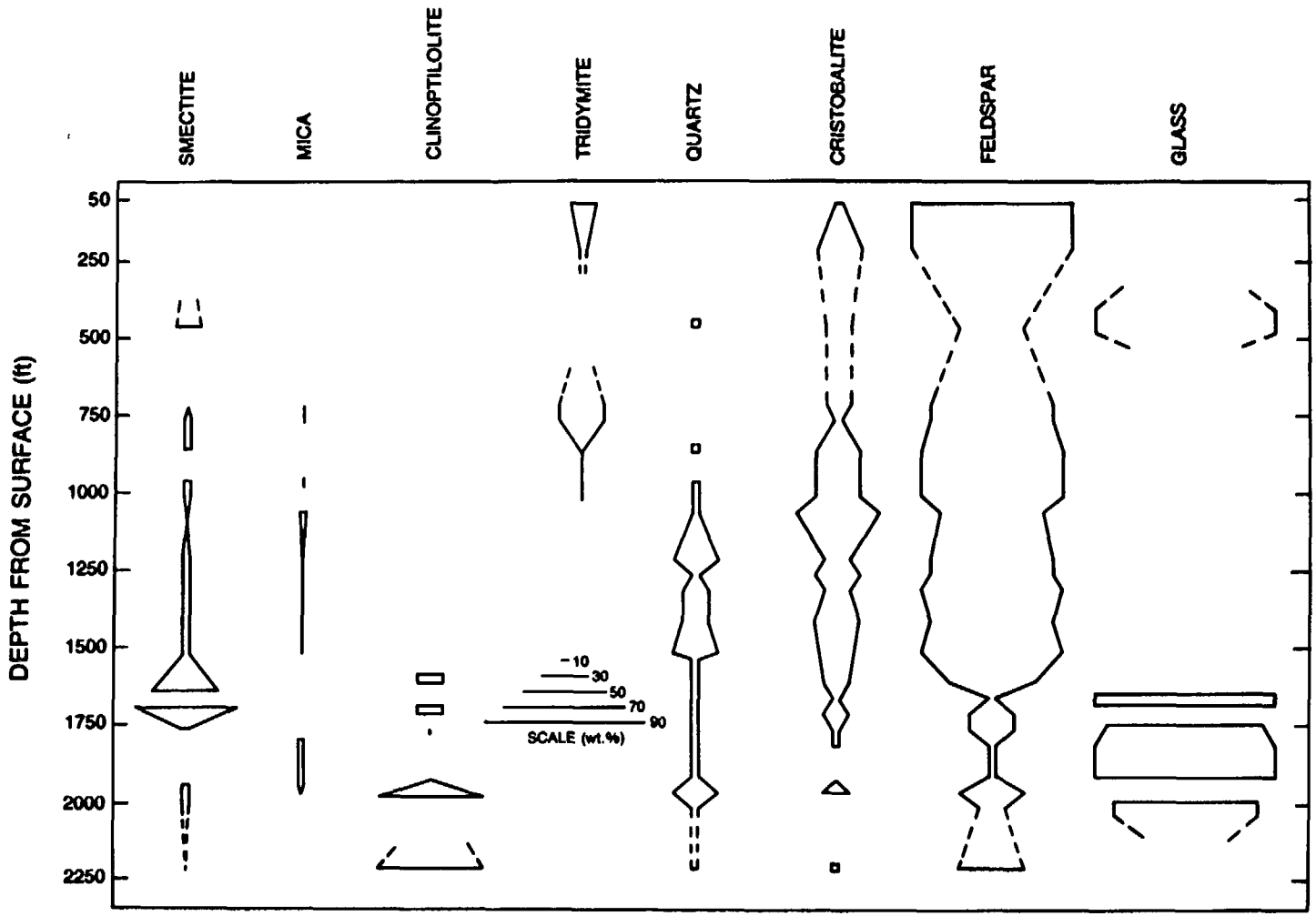

Fig. B-12. Drill hole USW H-5.

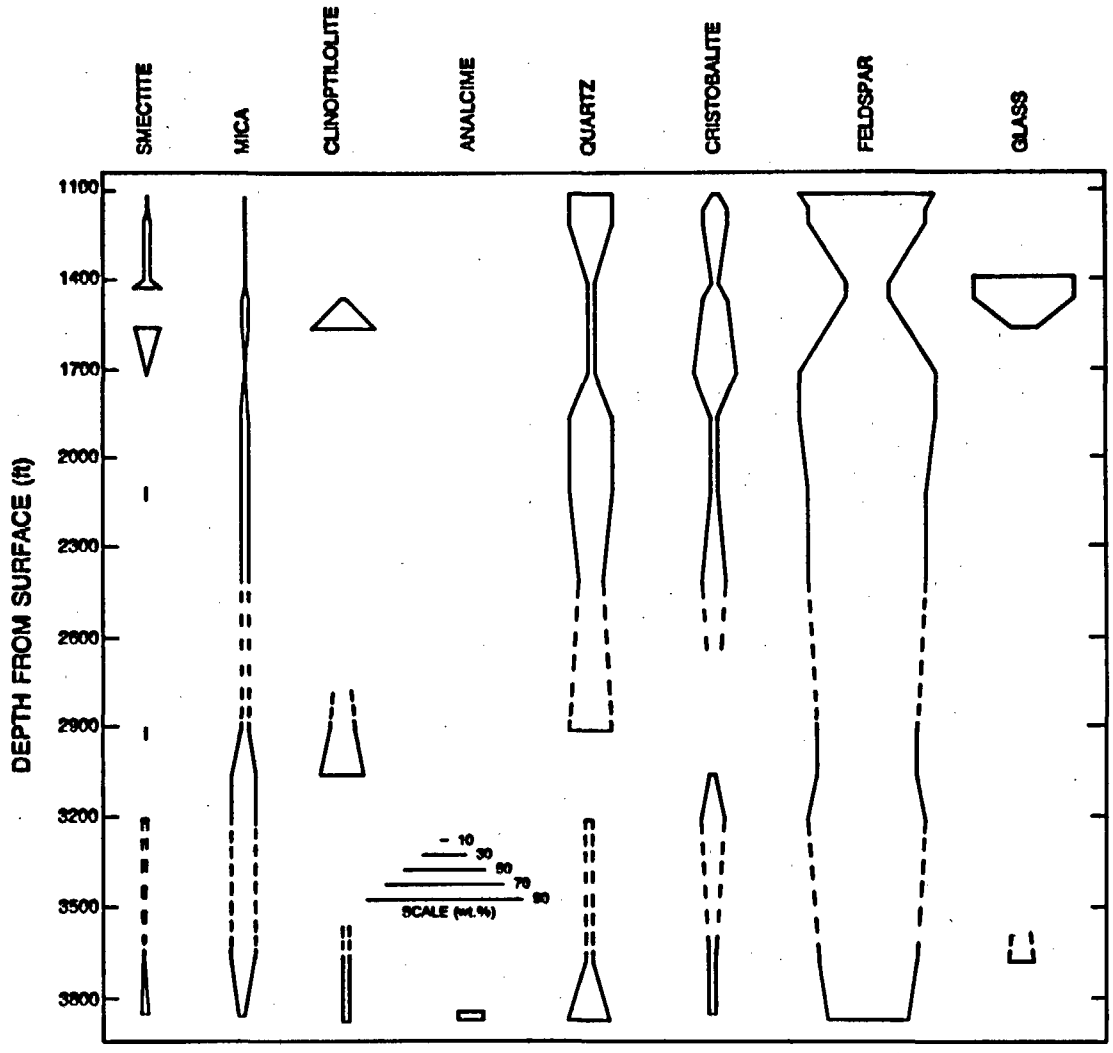

Fig. B-13. Drill hole USW H-6.

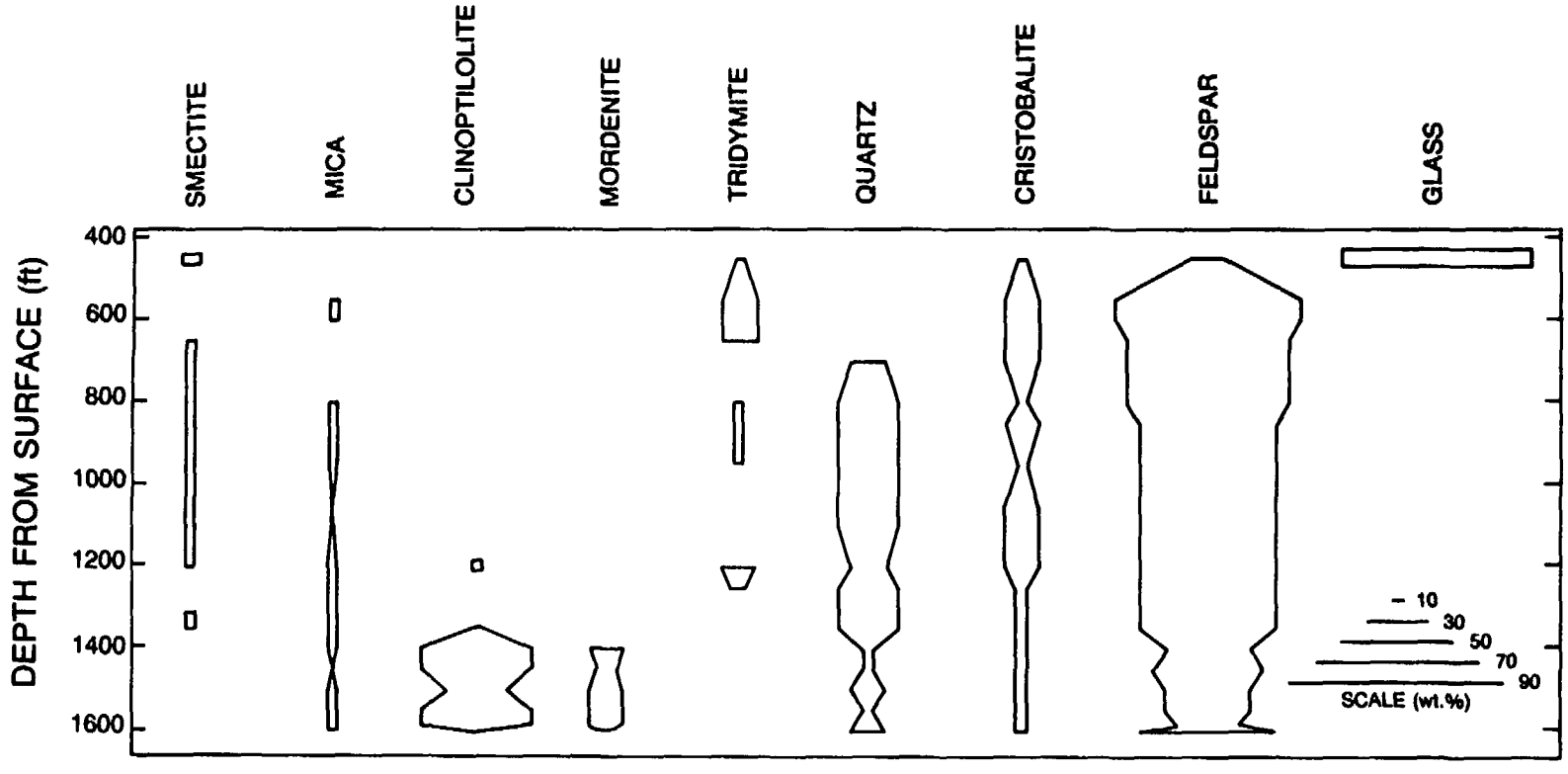

Fig. B-14. Drill hole WT-1.

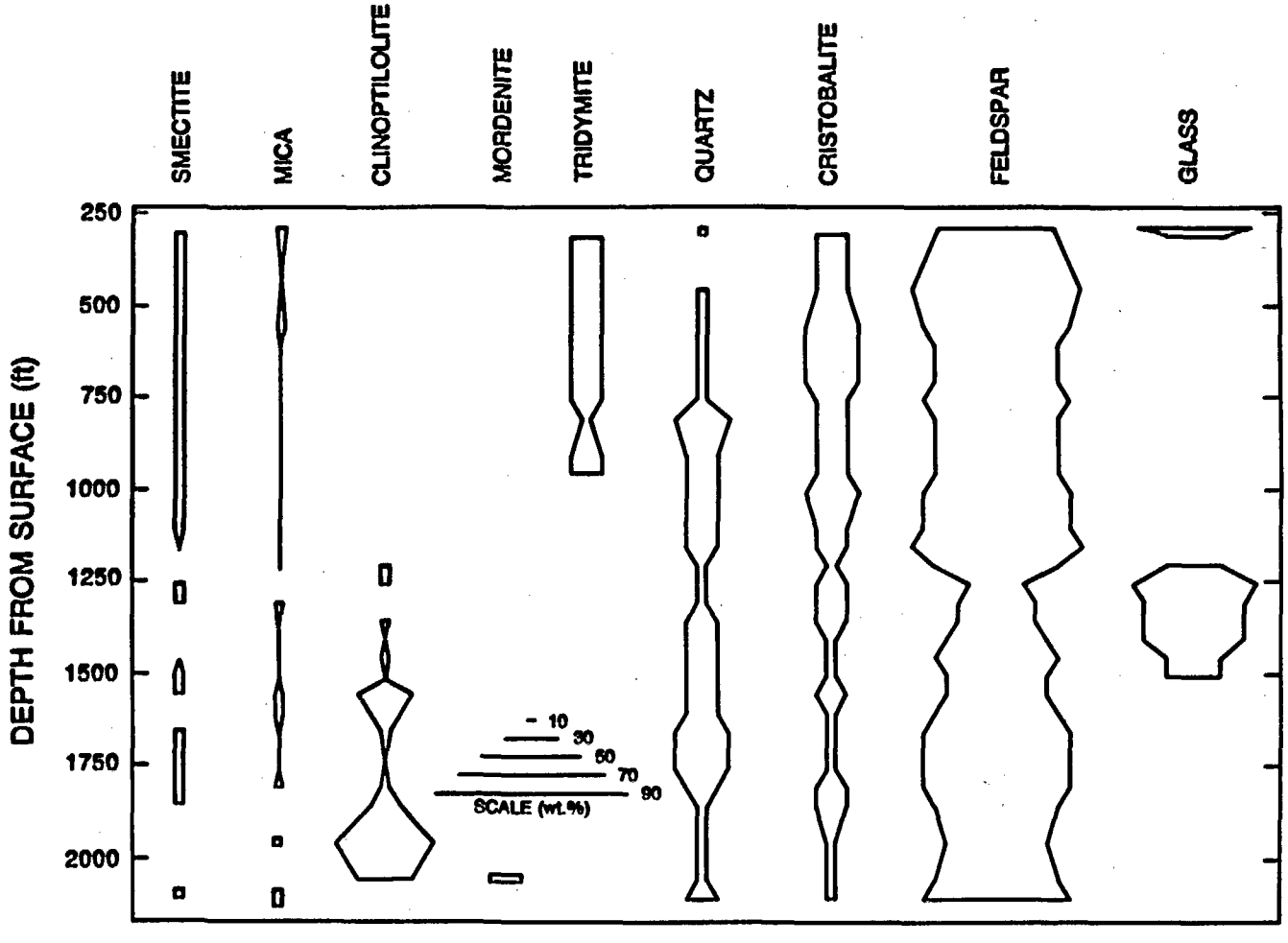

Fig. B-15. Drill hole WT-2.

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