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GEOLOGICAL SURVEY

STRATIGRAPHIC CORRELATION AND PETROGRAPHY OF THE BEDDED TUFFS, YUCCA MOUNTAIN, NYE COUNTY, NEVADA

By

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ABSTRACT

"Bedded tuffs" that occur between major pyroclastic-flow deposits from the base of the Tiva Canyon Member of the Paintbrush Tuff to the base of the Tram Member of the Crater Flat Tuff at Yucca Mountain, Nevada, represent a group of inhomogeneous volcanic deposits of various origins. Detailed field, petrologic, and scanning electron microscopic examination of the components and internal structures of the bedded tuffs reveal that many of these volcaniclastic deposits, previously described as "reworked", can be lithologically identified as pyroclastic-surge deposits, weathered zones, or possible soil horizons. Other deposits included within these "bedded tuffs" are porous pyroclastic-fall and nonwelded pyroclastic-flow deposits that have undergone in-situ diagenetic alteration.

The bedded-tuff units thicken toward the north end of Yucca Mountain, which indicates that the probable source area is the Timber Mountain-Oasis Caldera Complex. In the Paintbrush and Crater Flat Tuffs, pyroclastic-surge deposits, which are limited in their extent from their source, are also indicators that the source area of the volcanics was to the north. The exception to the above evidence is the bedded tuffs at the base of the tuffaceous beds of Calico Hills, whose source area appears to be to the east-northeast of Yucca Mountain.

Each bed type within the bedded tuffs has its own megascopic and microscopic characteristics that can be used to separate the lithologies. Those beds at depth, which have undergone a great deal of diagenetic alteration, retain physical characteristics of their original nature.

Within the bedded tuffs, the diagenetic sequence is: (1) Precipitation of a smectitic rind-forming clay, (2) dissolution of the volcanic glass, (3) precipitation of heulandite/clinoptilolite, (4) another phase of smectitic-clay precipitation, then (5) precipitation of potassium feldspar. In the bedded tuffs below the Paintbrush Tuff, mordenite and analcime occur as late-stage diagenetic products. Calcite occurs as a replacement mineral from the Paintbrush Tuff down through the tuffaceous beds of Calico Hills and Crater Flat Tuff.

A compilation of density and porosity values for pyroclastic-fall and nonwelded pyroclastic-flow deposits reveal that differences between these units, based on these physical properties, are negligible. However, permeability values in pyroclastic-fall units are several orders of magnitude higher than in pyroclastic-flow beds because there are more numerous connecting pore spaces.

INTRODUCTION

Location and Purpose

Bedded tuffs serve as stratigraphic markers between the major ash-flow tuffs at Yucca Mountain, Nye County, Nevada (fig. 1). The bedded tuffs can be divided on the basis of their mode of deposition into pyroclastic-fall, pyroclastic-surge, and nonwelded pyroclastic-flow deposits; each of these deposits may have weathered surfaces. The stratigraphy and mineralogy of the major ash-flow tuffs have been investigated at Yucca Mountain by Byers and others (1976), Christiansen and others (1977), Spengler and others (1981), Maldonado and Koether (1983), Byers and Warren (1983), Lobmeyer and others (1983), and Scott and Castellanos (1984). However, there has been minimal study of the origin and lateral continuity of the individual beds that comprise bedded-tuff units at Yucca Mountain. The major objective of this study is to subdivide sequences of bedded tuffs and to correlate these units between core holes (fig. 2).

Silicified, silty ash deposits of pyroclastic-fall and pyroclastic-surge origin represent identifiable stratigraphic marker beds for short distances between individual core holes. Silicic ashes are commonly excellent time lines for correlation because field exposures resist weathering (Wilcox, 1965).

Other types of pyroclastic-fall deposits, including graded pumice-fall deposits, are dispersed extensively to the south of the nested Timber Mountain-Oasis Valley Caldera Complex. Because these deposits contain distinctive types of crystals, lithic material, and pumice, they provide an excellent means of correlation. Oxidized soil horizons also represent distinctive marker beds for correlation.

Another objective of this study is to define macroscopic, petrographic, and scanning electron microscope (SEM) criteria that can be used to subdivide the bedded-tuff deposits with respect to their depositional origin. Previously described "reworked" units can now be identified as weathered zones or surge deposits based on petrographic and SEM analysis. Petrographic criteria presented in this paper concentrate on the microscopic rock fabrics and the variation in abundance of pumice, phenocryst, and matrix content of pyroclastic-fall versus weathered volcaniclastic deposits. These criteria can be useful in delineating stratigraphic marker units in future core holes at Yucca Mountain.

Knowledge of the characteristics of the bedded-tuff deposits is also an important component for the development of hydrologic-flow models for the unsaturated as well as saturated zones in Yucca Mountain. Porosity in the bedded-tuff units has been significantly affected by alteration histories. In many tuffs, extensive dissolution of glass shards and pumice fragments has significantly increased porosity and permeability. In contrast, hydrated iron oxides and clays in weathered zones act as pore-occluding cements, and have reduced porosity and permeability. Beneath the Paintbrush Tuff, diagenetic minerals in the nonwelded pyroclastic-flow and -fall deposits are so abundant that the two types of volcanic deposits have similar physical properties.

Stratigraphy of Bedded Tuffs at Yucca Mountain

Bedded-tuff deposits precede each major pyroclastic-flow deposit (fig. 3). The sequence of pyroclastic deposits exposed at Yucca Mountain is similar to the idealized cross section described by Best (1984). The basal part is

Figure 1.--Aerial view of Yucca Mountain, Nye County, Nevada. Geographic features and core holes are labeled.

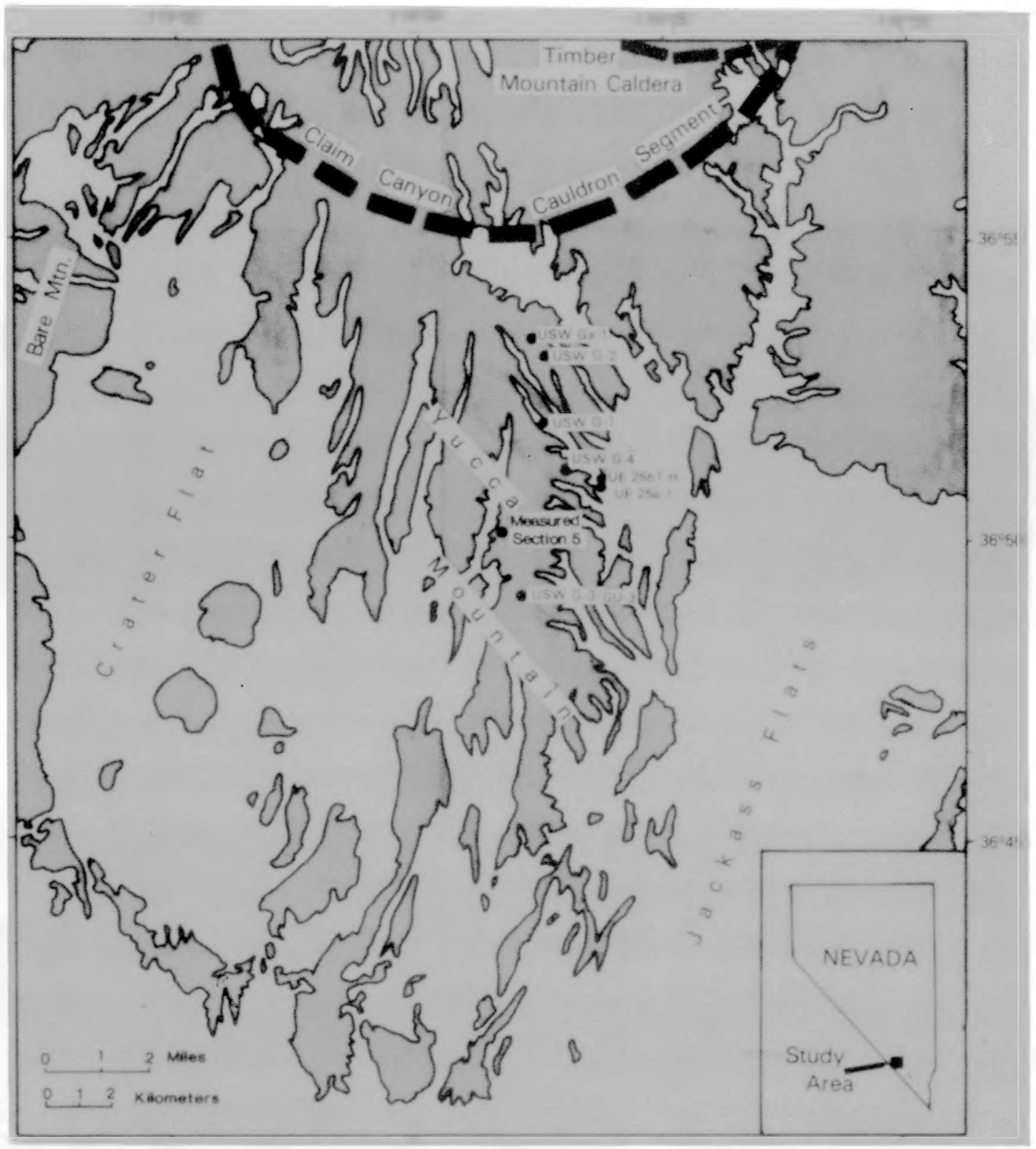


Figure 2.--Location map of core holes on Yucca Mountain, Nye County, Nevada.

generally a pyroclastic-fall deposit consisting of graded pumice and ash beds, followed stratigraphically upward by a pyroclastic-surge layer, and a nonwelded pyroclastic flow. In the bedded tuffs at Yucca Mountain, one or more reddish oxidized zones overlie the nonwelded pyroclastic-flow and pyroclastic-fall beds, indicating a hiatus in the eruption sequence, or a change in eruptive behavior. These zones are included in the generalized stratigraphic sequence in figure 4.

The bedded-tuff deposits investigated in this study are chiefly well-stratified, pyroclastic-fall deposits. Pauses between eruption events allowed sufficient time for fine ash particles to settle from the ash cloud and to be deposited on top of the coarse-grained pumice and lithic-fragment layers (Sparks and Walker, 1977). Reverse grading of the fall deposits suggests that the eruptions increased in intensity with time, whereas normal grading indicates that eruptive energy steadily decreased (Lirer and others, 1973).

Studies, such as those at Mt. Vesuvius, Italy (Lirer and others, 1973), show that pyroclastic-fall layers several meters thick can accumulate within a few hours. At the northern end of Yucca Mountain, near core hole USW G-2 (fig. 2), bedded-tuff deposits that are unsorted and massive, with little internal structure, indicate rapid accumulations near a vent area.

It is difficult to estimate the time spans between periods of eruptive activity; but the presence of oxidized, weathered zones in pyroclastic-fall and nonwelded pyroclastic-flow deposits suggest that there were extended periods of exposure of at least several hundred years. Detrital clay commonly infiltrated the weathered zones, which may extend several meters below the surface of the deposit.

In the bedded-tuff sequences at Yucca Mountain, there are no conglomeratic or fluvial sedimentary deposits between pyroclastic-fall and pyroclastic-flow units. Deposits once thought to be fluvial are now considered to be pyroclastic-surge deposits on the basis of their microscopic features.

METHODS OF STUDY

Cores of the bedded units that occur between the Tiva Canyon, Pah Canyon, Yucca Mountain, and Topopah Spring Members of the Paintbrush Tuff, rhyolite of the Calico Hills, and the Prow Pass, Bullfrog, and Tram Members of the Crater Flat Tuff, and the Lithic Ridge Tuff were examined and described in detail; these include core holes USW G-1, USW G-2, USW GU-3/G-3, USW G-4, UE25a #1 and UE25b #1 (fig. 2). Correlations, which were first based on megascopic characteristics, were later verified by petrographic analysis whenever possible.

Core recovery is commonly poor in the poorly consolidated bedded tuffs that separate members of the Paintbrush Tuff and this results in stratigraphic gaps. Therefore, core data were supplemented by measuring outcrop sections near the core holes. Detailed lithologic logs from both core and measured sections are given in Appendixes 1-6.

Thin sections from both outcrop and core samples were analyzed petrographically. Crystal content, lithic fragments, pumice, and matrix were counted in thin sections at 160X magnification, with 2,000-3,000 points per slide, depending on the size and geometry of the slide.

In altered tuffs, powder X-ray diffraction analysis of samples allowed for identification of the bulk mineralogy.

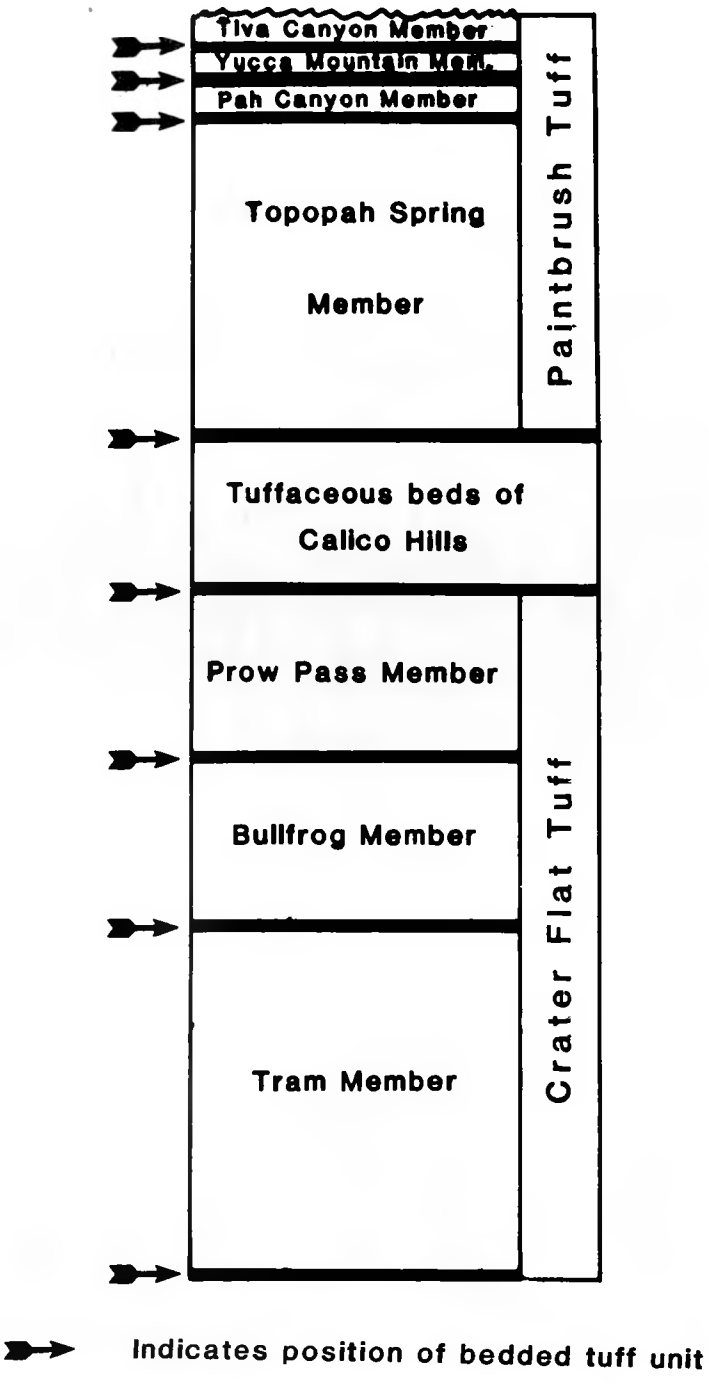


Figure 3.--Generalized stratigraphic section for Miocene units at Yucca Mountain. Bedded tuffs, which occur between the major pyroclastic flow members, are indicated by arrows.

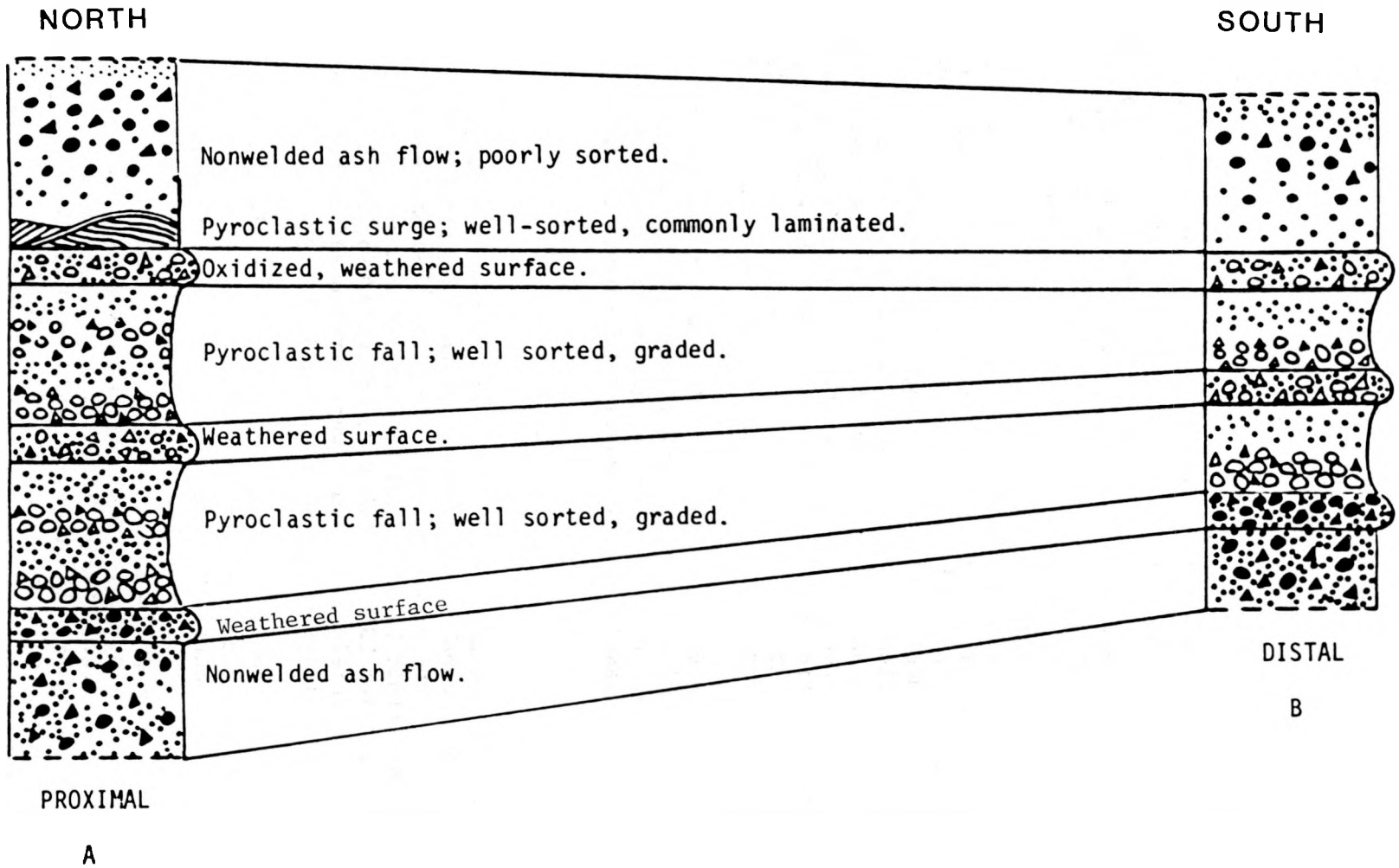


Figure 4.--Generalized bedded-tuff sequence between major pyroclastic flow members at Yucca Mountain proximal (A) and distal (B) to source area. Pyroclastic-surge deposits are near USW G-2 in the northern portion of Yucca Mountain, but disappear to the south.

A Cambridge 2250 Mark 2 scanning electron microscope (SEM) and attached energy-dispersive system (EDX) were used to determine the mineralogy of alteration material that could not be identified by the petrographic microscope, and to establish paragenetic relationships. Thin sections and rock chips were gold coated within a vacuum chamber, then placed in the electron column for examination and spectrographic analysis. All rock chips examined under the SEM were from core samples. Outcrop samples were not used to avoid contamination by clay related to recent weathering. The SEM was also used for studying shard- and pumice-grain morphology, which helped to determine the mode of deposition of the bedded-tuff units (Sheridan and Marshall, 1983).

PYROCLASTIC-FALL DEPOSITS

Field and Core Megascopic Characteristics of Pyroclastic-Fall Deposits

The following discussions in this section are based on megascopic observations of the pyroclastic-fall deposits within all the bedded-tuff units between pyroclastic-flow members.

Mantled bedding over paleotopography is recognized in outcrops by the consistency in thickness of the pyroclastic-fall layers and their conformity with the underlying topography (see fig. 17a). In core samples, mantled bedding is distinguished by the continuity in dip attitudes between the contacts of the graded pumice and ash layers.

Pyroclastic-fall deposits commonly occur in alternating co-sets of dense silty ash layers and granule- to pebble-sized pumice- and lithic-fragment layers; grading is commonly multiple reverse or normal, depending on increasing or decreasing eruptive intensity, respectively. The normally graded deposits illustrated in figure 5 were the product of closely spaced eruptions.

The well-sorted beds of coarse pumice lapilli and lithic fragments, and very fine-grained ash, are the result of density settling within ash clouds. The pumice and lithic fragments are randomly oriented in a pyroclastic fall in contrast to their alignment in a pyroclastic flow by flow direction or welding.

In outcrop, a change in slope profile (fig. 4) within a sequence of bedded tuffs usually indicates a change in depositional mode. The poorly indurated pyroclastic-fall deposits, especially pumice-fall deposits lacking in lithic material and ash matrix, tend to form weathered back slopes. In contrast, abundant matrix material or clay supports the pumice lapilli in the cliff-forming weathered zones (see fig. 17b in section under weathered zones).

Pyroclastic-fall deposits are commonly overlain by layers of fine-to-silty ash representing the last particles to settle from the ash cloud (fig. 6) (Sparks and Walker, 1977). These ash deposits, which commonly have graded contacts with the underlying pumice fall, may be confused with weathered zones, especially where the ash layer contains a few large, rounded, pumice grains. The fine ash layers, however, are generally unoxidized and better sorted.

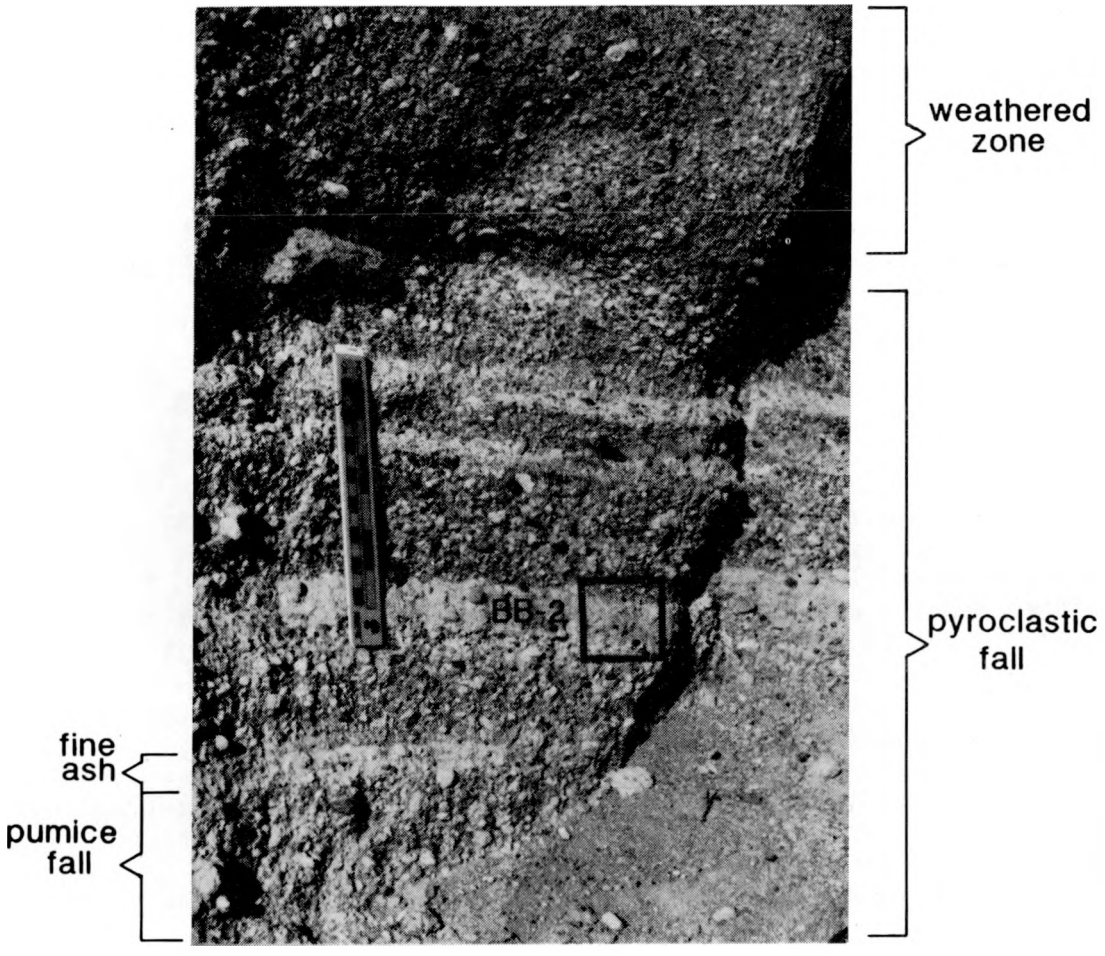


Figure 5.--The normally graded pyroclastic-fall deposits at the base of the Yucca Mountain Member were produced by successive eruptive pulses. Coarse pumice and lithic-fragment layers alternate with fine ash layers in a series of closely spaced eruptions. Photograph taken near USW G-2.

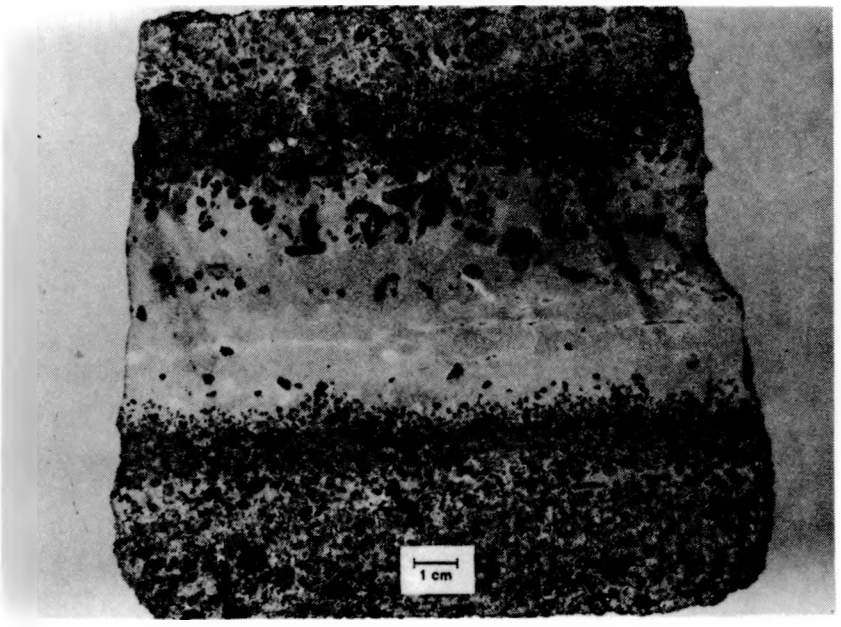


Figure 6.--Close-up of sample collected from pyroclastic-fall site in figure 5. Note graded contacts of the fine ash-fall layer with the overlying and underlying coarse-grained pumice- and lithic-fall layers.

Petrographic Characteristics of Pyroclastic-Fall Deposits

Pyroclastic-fall deposits commonly exhibit a bimodal size distribution, inasmuch as the settling velocities of particles are proportional to grain size and density. Small, dense, lithic fragments and crystals appear to have fallen through the air at the same velocity as larger, less dense pumice particles.

Crystals (or phenocrysts) in pyroclastic-fall deposits are commonly very fractured; yet all the crystal pieces remain together like a jigsaw puzzle between framework grains of pumice (fig. 7). This observation strongly suggests that the fracturing occurred post-depostionally; otherwise, the crystal fragments would be scattered.

In the Paintbrush pyroclastic-fall deposits, the pumice grains that surround the cracked crystals are generally not deformed; moreover, the vesicles are spherical. In pyroclastic-fall deposits with bimodal size texture, the dense smaller crystals and lithic fragments tend to fill pockets between the larger pumice grains (fig. 8). The brittle crystals are separated from one another, and there are no long or concavo-convex contacts between the crystals that would suggest compaction was the cause for cracking.

Below the bases of the Bullfrog and Tram Members of the Crater Flat Tuff, pumice grains in the bedded tuffs have deformed ductilely around crystals and lithic fragments, commonly forming a pseudomatrix between more competent framework grains (fig. 9). (Note that welded pumice-fall deposits also exhibit this feature.) Isolated cracked crystals, which suggest a pyroclastic-fall origin, are evident in these deeply buried deposits.

The cause of the cracking is still enigmatic. Possibly it results from differential thermal stresses between phenocrysts and glassy pumice after their deposition (table 1). The phenocrysts, which have an ordered atomic structure, could be expected to undergo a greater change in volume during cooling than the glassy pumice that has an amorphous structure. At 700 to 800 °C, glass is not crystallized yet, whereas the phenocrysts are solid (J.R. Smyth, oral commun., 1988). Therefore, the phenocrysts might tend to fracture brittlely, while the pumice remains ductile.

Table 1.--Coefficients of volume and linear thermal expansion[1] at 20 °C

Volume Expansion:	
Feldspar.....	14.0 to 18.0 x 10^{-6} °C
Quartz.....	34.0 x 10^{-6} °C
Linear Expansion:	
Silica (non-ordered)....	0.54 x 10^{-6} °C
Glasses (commercial)...	1.0 to 10.0 x 10^{-6} °C

[1]B.J. Skinner, in Clark, S.P., 1966 p. 92, 95.

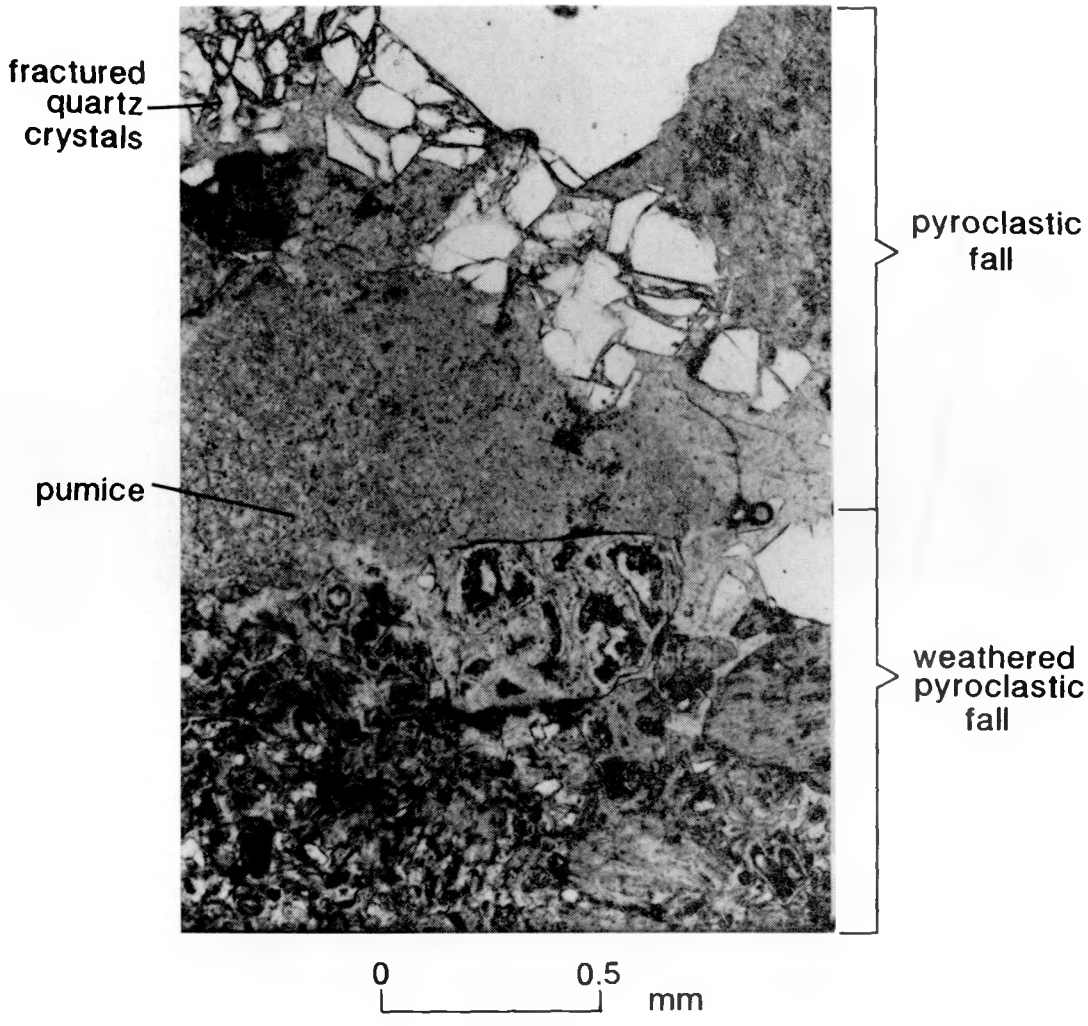


Figure 7.--Thin section G-1 1418.93. Photomicrograph of the contact between a weathered zone and overlying pyroclastic-fall deposit. Crystals in a pyroclastic fall undergo thermal contraction upon cooling and fracture in a brittle manner. These fractured crystals are common in pyroclastic-fall deposits, but not in weathered deposits, where the crystal fragments are scattered in the matrix.

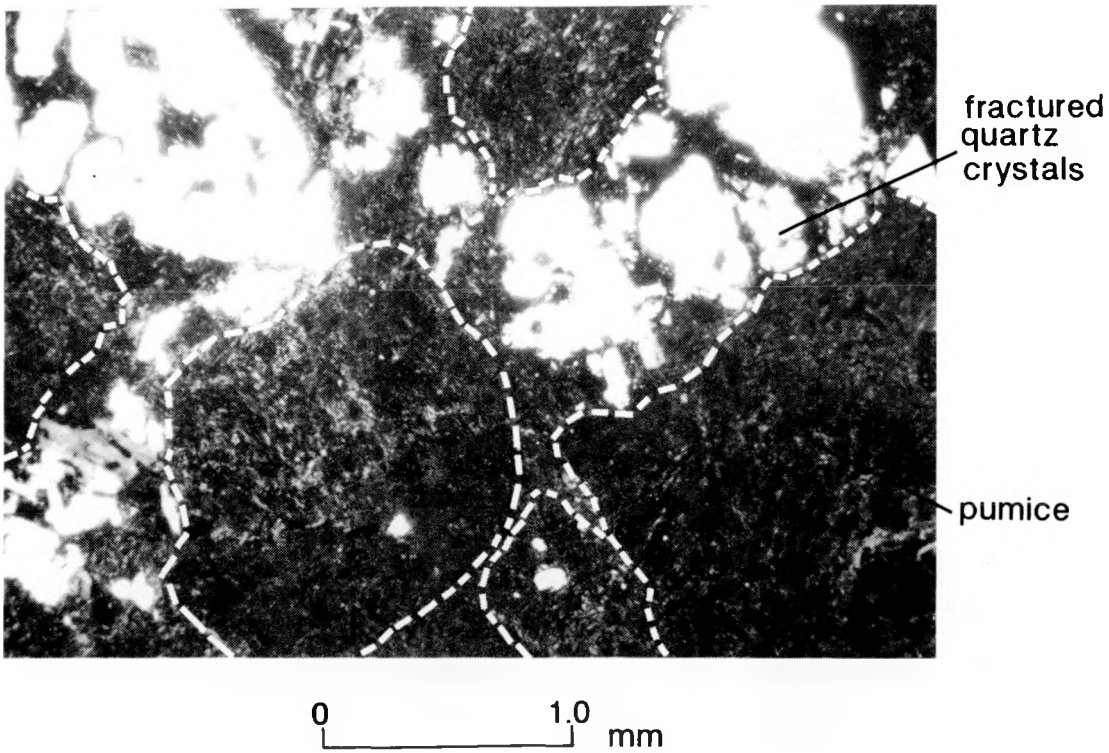


Figure 8.--Thin section G-1 1422.30. Typical bimodal size distribution of grains in a pyroclastic-fall deposit within the bedded tuffs of the Paintbrush Tuff. Fractured phenocrysts are held together by the lighter, larger pumice grains.

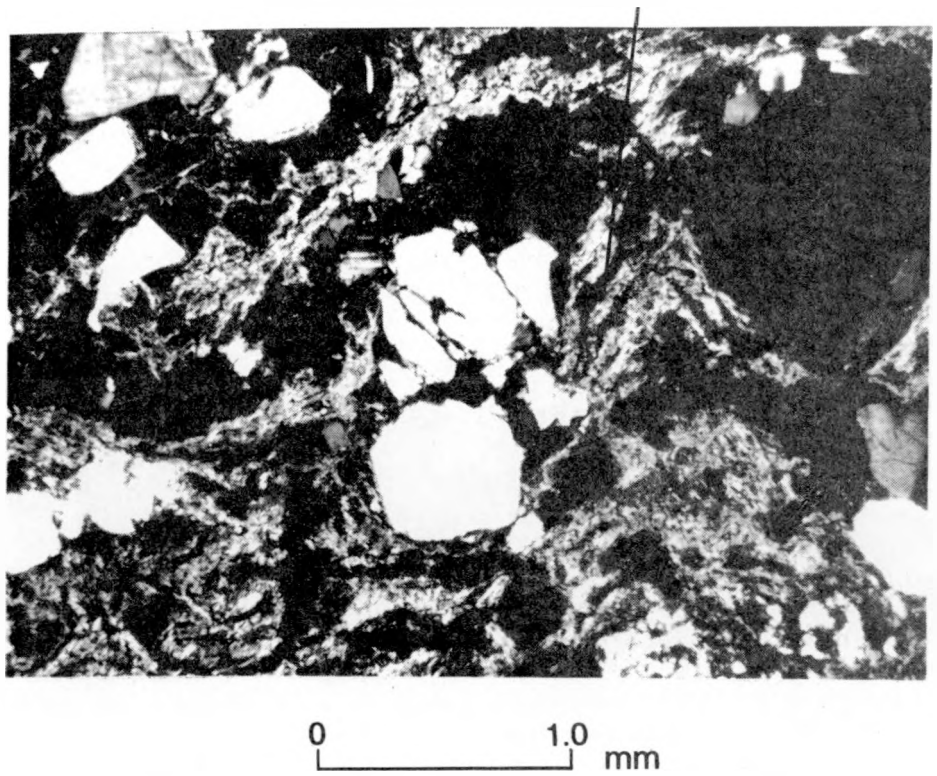


Figure 9.--Thin section G-2 3574.35. A pyroclastic-fall deposit in bedded tuffs at the base of the Tram Member. Fractured phenocrysts of quartz are held together by pumice grains, but the pumice has been ductilely deformed around the crystals due to heat at deposition, or more likely, burial pressure.

Scanning Electron Microscope Characteristics of Pyroclastic-Fall Deposits

Heiken and Wohletz (1985) compiled an atlas on the different shard and vesicle morphologies produced by various types of known volcanic eruptions worldwide. The mode of deposition of fine-grained ash deposits within the bedded tuffs was determined from shard-particle morphology obtained by our SEM observations, and comparing these with the atlas.

Vesicles in pumice associated with pyroclastic-fall deposits are elongated and fluted and are commonly coalesced (fig. 10). Particles adhering to the shard surfaces are rare.

PYROCLASTIC-SURGE DEPOSITS

Field and Core Megascopic Characteristics of Pyroclastic-Surge Deposits

The term "pyroclastic surge", recommended by Wohletz and Sheridan, (1979), is used in this report rather than ground and (or) base surge, which are terms that have been applied to similar deposits that are not volcanic in origin. Fisher and Schmincke (1984) have remarked how difficult it is to distinguish between fluvial, reworked pyroclastic material and pyroclastic surge deposits. This problem surfaced during logging of the core, where no large-scale diagnostic features such as cross beds could be seen to help make the distinction. Many of the surge deposits cored at Yucca Mountain have previously been described as tuffaceous sandstones or reworked units; but their lack of fluvial characteristics, and their stratigraphic position within a pyroclastic sequence, suggest that they have an eruptive volcanic origin.

The pyroclastic-surge deposits in the bedded tuffs of the Paintbrush Tuff are mainly planar near their source to the north at core hole USW G-2, and they thin rapidly to the southeast. The surge beds do not have the characteristically high antidune features reported for many localities (Fisher, 1979). Small-scale antidune structures (Fisher and Schmincke, 1984) with low-angle cross bedding (8.5° average dip of four antidunes) are visible in limited outcrops in the bedded tuffs at the base of the ashflow of the Yucca Mountain Member near core hole USW G-2 (see fig. 30). The explosions from the Timber Mountain-Oasis Valley Caldera Complex may have produced a different morphology of pyroclastic-surge bed forms, or else the large, near-vent antidune structures have been eroded away.

Identification of pyroclastic-surge deposits in the bedded tuffs of the Paintbrush Tuff is easier because of the greater availability of exposures to field check against limited features observable in the two-in.-diameter core. The bedded tuffs of the Paintbrush Tuff also have not undergone the extensive alteration of the more deeply buried tuffaceous beds of Calico Hills and the Crater Flat Tuff.

The most common feature of the surge deposits at Yucca Mountain is the occurrence of separate laminae of crystals and shards. Within the more complicated bedded-tuff sequences in USW G-4 at the base of the tuffaceous beds of Calico Hills, there are fine-to-silty ash beds, broken by dessication cracks, that alternate with more crystal-rich layers (see fig. 32). Large pumice is rare or absent. These beds are classified as surge deposits on the basis of their sorting characteristics and lack of common fluvial structures.

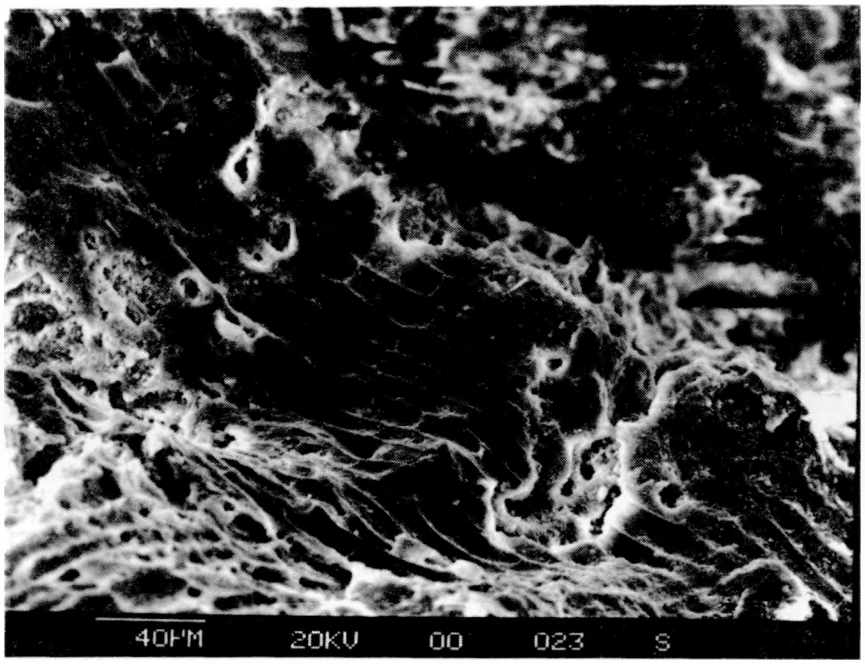


Figure 10.--The vesicles in pyroclastic-fall deposits are elongated in contrast to the more rounded and ovoid vesicles of surge and nonwelded pyroclastic-flow deposits. Compare with figures 13a and 16.

Fisher and Schmincke (1984) have described morphological differences between "cold, dry" and "hot, wet" surge deposits. The different features exhibited by the pyroclastic-surge layers of the Paintbrush and the Crater Flat Tuffs may reflect these different modes of deposition. The thin surge deposit (USW G-4 at 2,734 ft) at the top of the bedded-tuff sequence between the Tram and Bullfrog Members (see fig. 34), shows soft sediment deformation features that may develop in a wet surge; the bedding is convoluted with small-scale flame structures.

One of the most extensive dry surge beds is a thick, thinly-laminated deposit (fig. 11) that was previously described as a reworked tuff between the Bullfrog and Prow Pass Members (see fig. 33). The deposit is directly above pyroclastic-fall beds and below a pyroclastic flow, which is the characteristic stratigraphic position for the occurrence of surge deposits (Best, 1982). This surge deposit is exposed at the northern end of Yucca Mountain and is observed in core from USW G-2 to USW G-3 (see fig. 33). The unit is crossbedded, with foresets that dip from 5° to 14°; the thin laminations quickly converge at low angles. There are no observed channels cut into the lower pyroclastic-fall deposits that would suggest reworking or stream erosion, nor are there any conglomeratic facies.

Petrographic Characteristics of Pyroclastic-Surge Deposits

In the surge beds, biotite and other elongate minerals have been aligned by laminar flow, Crystals and shards are sorted into separate layers, which may also be a result of laminar flow. Both rounded and well-formed bipyramidal quartz crystals occur within the same crystal-rich lamina (figs. 12A and B). The rounding of the quartz is due to resorption, and not to the transporting process.

There is no petrographic evidence that the extensive, laminated deposit between the Bullfrog and Prow Pass Members is fluvial in origin. Geopetal structures could be expected in a sedimentary environment where there is abundant void space and fine-grained ash material, but these fluvial features are not present.

Scanning Electron Microscope Characteristics of Pyroclastic-Surge Deposits

SEM studies of shard morphologies have helped to establish these units as pyroclastic-surge deposits. The shard features compare well with worldwide surge examples illustrated by Heiken and Wohletz (1985). Shards are angular; vesicles are few and non-connecting (fig. 13A). Conchoidal, stepped-fracture surfaces on shards and drop-like particles are common features (fig. 13B).

NONWELDED PYROCLASTIC-FLOW DEPOSITS

Field and Core Megascopic Characteristics of Nonwelded Pyroclastic-Flow Deposits

Nonwelded pyroclastic-flow deposits are commonly interbedded with pyroclastic-fall and -surge deposits in the northern part of Yucca Mountain, close to the source area. The pyroclastic-flow units commonly have erosive bases with an underlying rubble layer of pumice and lithic fragments. The nonwelded pyroclastic-flow deposits tend to be massive, relatively

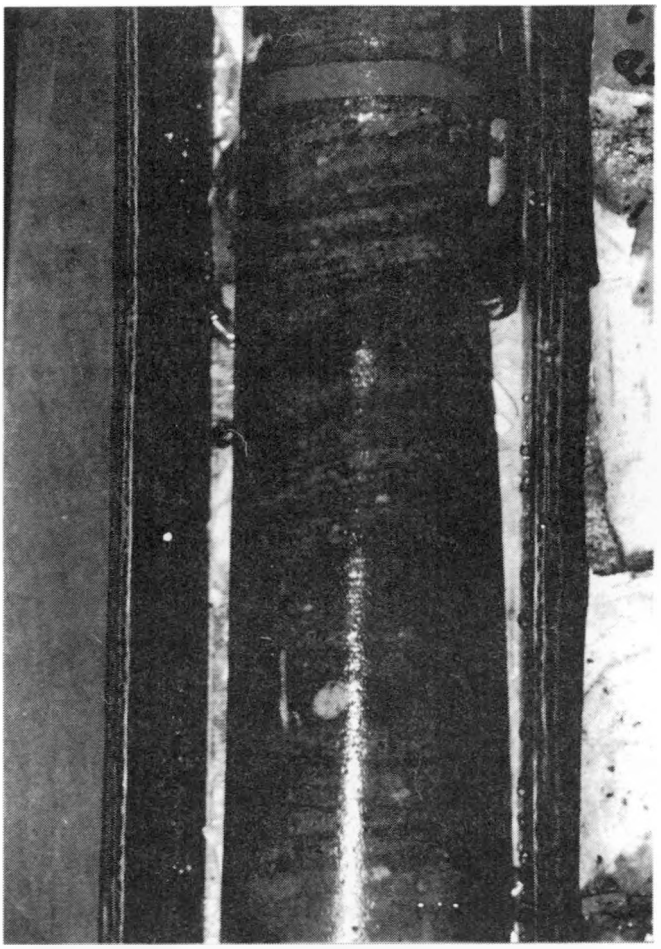
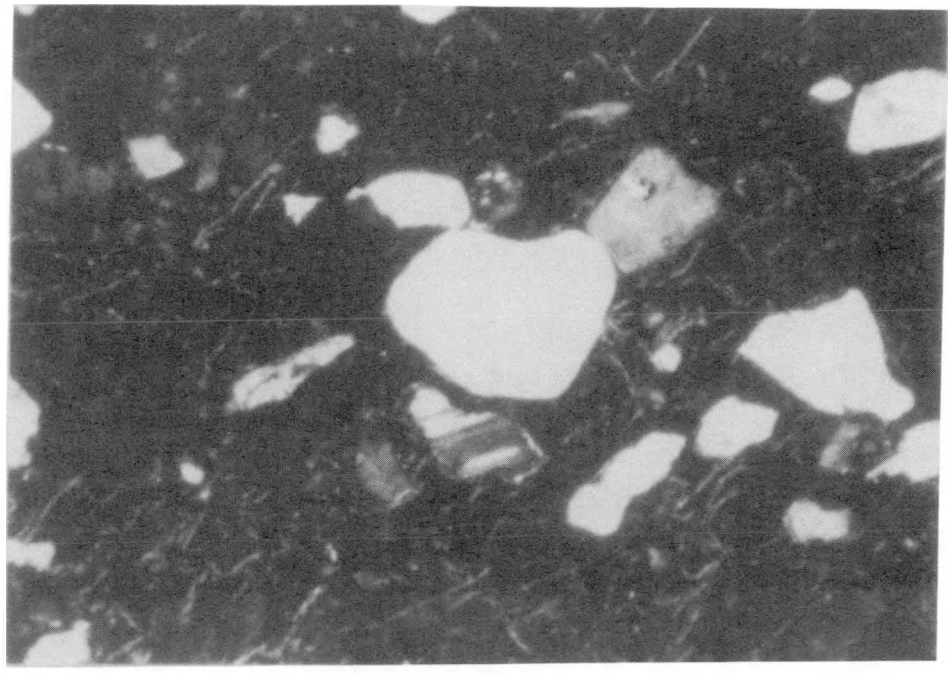
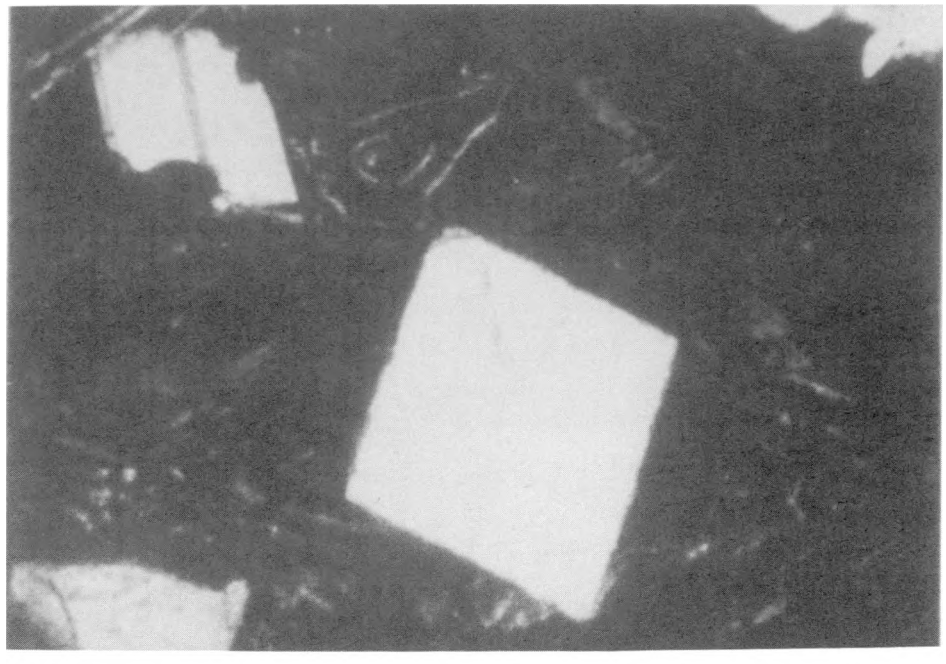


Figure 11.--Core sample of thinly laminated pyroclastic-surge deposit in bedded tuff between Bullfrog and Prow Pass Members of the Crater Flat Tuff in USW G-1 at 2,156 ft. The alternate light and dark bedding is due to the sorting of crystals and fine-grained ash, respectively, into separate layers with rounded pumice grains present.



A

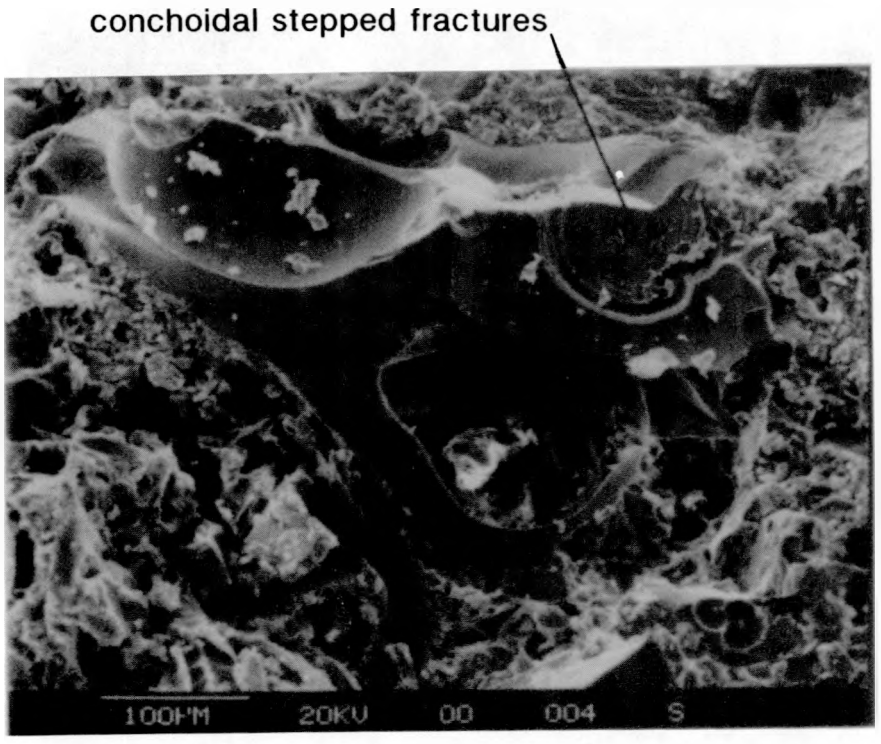
0 0.1 mm



B

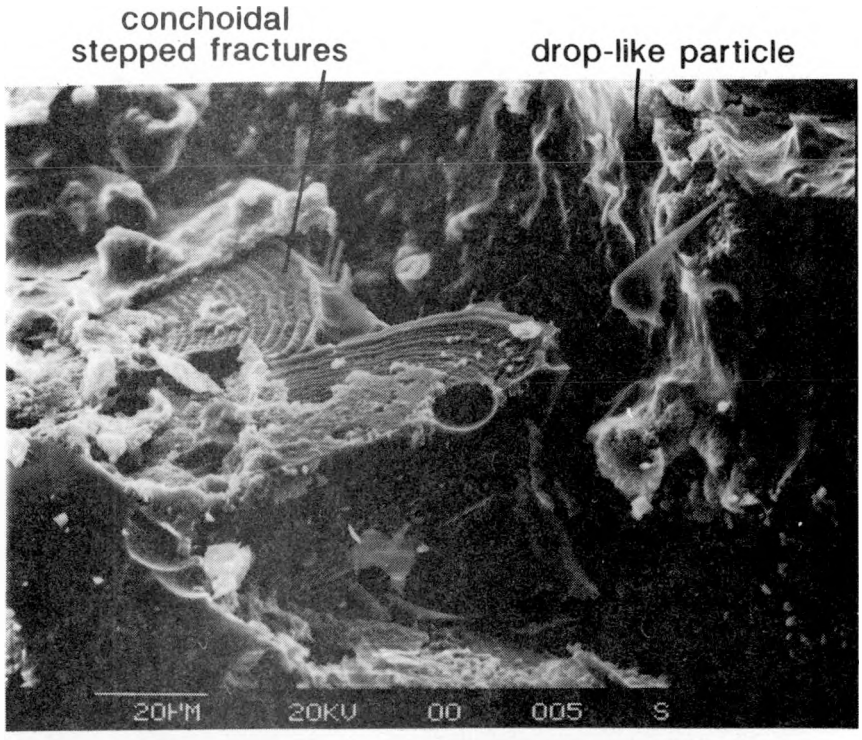
0 0.1 mm

Figure 12.--Photographs of thin section G-1 2157.20. A, Crystals are concentrated in laminae in pyroclastic-surge deposits. Rounding of center grain is due to resorption. B, Bipyramidal quartz crystals occur with rounded phenocrysts in pyroclastic-surge laminae, suggesting that these units are not fluvial in origin.



A

Figure 13A.--Scanning electron micrograph of shards in a pyroclastic-surge deposit: A, Thin section G-1 2157.00, in the bedded tuffs at the base of the Prow Pass Member. Vesicles are few and large with many adhering particles. Note the conchoidal, stepped-fracture surface in the upper-right corner of the photograph. B, Thin section G-4 2239.63. Conchoidal, stepped-fracture surfaces and drop-like particles are common.



B

Figure 13.--Continued

homogeneous, and poorly sorted; but there is commonly a faint gradation of coarse-grained to fine-grained, subrounded pumice upward in a deposit. Discontinuous trains of cobble-sized lithic fragments are helpful features to distinguish a nonwelded pyroclastic flow from a massive, near-vent pyroclastic-fall deposit (fig. 14).

Petrographic Characteristics of Nonwelded Pyroclastic-Flow Deposits

The matrix material in the nonwelded pyroclastic-flow deposits is composed of shards with comminuted crystal fragments and fine-grained ash material that cannot be resolved by the microscope. Nonwelded pyroclastic-flow units generally contain a greater percentage of large pumice fragments than the oxidized weathered zones. Shards in nonwelded pyroclastic-flow deposits typically show hydration rims (fig. 15). Vesicles are ovoid to round when viewed with both the petrographic microscope and the SEM.

Scanning Electron Microscope Characteristics of Nonwelded Pyroclastic-Flow Deposits

The interiors of shards are commonly highly vesiculated, with coalesced vesicles that are filled by fine ash or dusted with adherent particles (fig. 16).

WEATHERED ZONES

Field and Core Megascopic Characteristics of Weathered Tuffs

In extensively exposed bedded units to the north of Yucca Mountain at Pahute Mesa, oxidized, weathered zones cut across the underlying curved mantle bedding (fig. 17A). The weathered units form distinct, sharp contacts against the overlying layers, but the lower contacts are gradational into the underlying units. Identical weathered boundaries are recognized in the less well-exposed bedded tuff outcrops at Yucca Mountain (fig. 17B).

Weathered zones, as well as fine-grained, silicified ash deposits, tend to be resistant, forming cliff faces. Fine-grained matrix material altered to clay and (or) detrital clay acts as a cement between the framework pumice grains, providing greater strength than in the unconsolidated tuffs. Initially, pyroclastic fall-deposits are very porous. Subsequently, detrital clay may infiltrate (Walker and others, 1978) the surface of a bedded tuff during rain storms (which are commonly associated with volcanic eruptions), or clay minerals may form from the alteration of the original minerals and glass during exposure.

"Reworking" implies that transportation of the original material has occurred. In the past, this term has inappropriately been applied to the oxidized zones that represent the weathered surfaces of tuff units. Weathering has altered the mineralogic and textural character of the tuff units, but it is an "in-situ" alteration that has broken down the host-rock material.

Reddish, oxidized clayey horizons commonly overlie and grade into underlying pyroclastic-fall and (or) nonwelded pyroclastic-flow deposits. The origin can be determined only by thin section and (or) SEM examination. Clay may be the result of in situ alteration or it may be detrital, having been

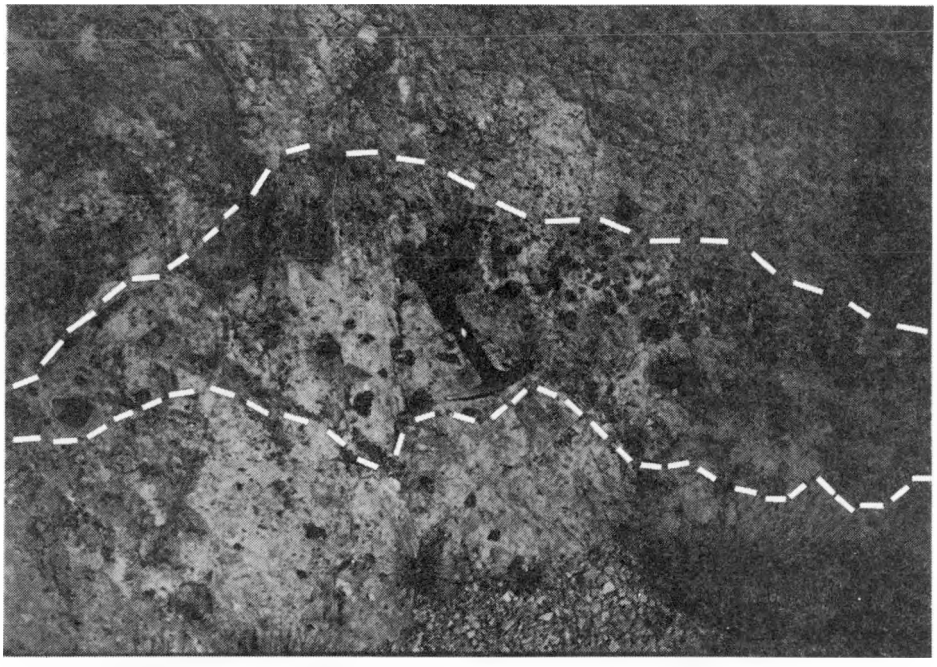


Figure 14.--A discontinuous train of lithic fragments in a nonwelded pyroclastic flow within the bedded tuffs at the base of the Yucca Mountain Member of the Paintbrush Tuff.

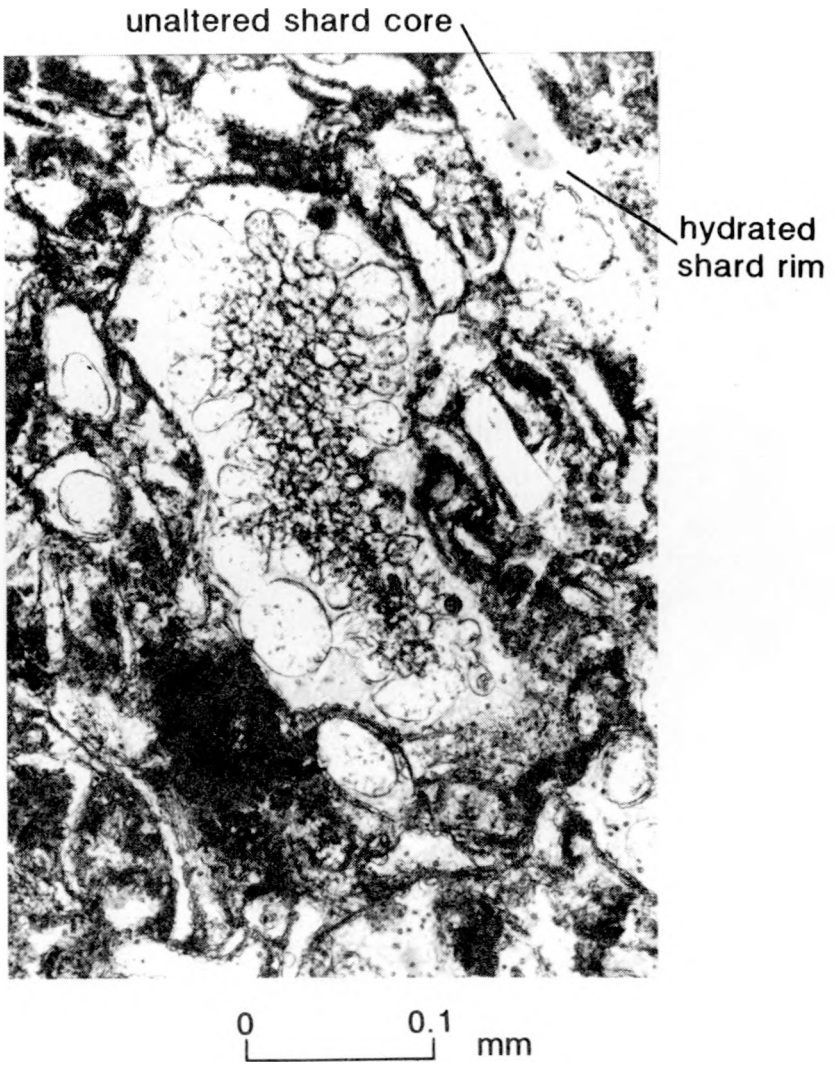


Figure 15.--Thin section 3-1-85. Vesiculated shards from a nonwelded pyroclastic flow of the basal Yucca Mountain Member. These tuffs are very porous because of the abundance of vesicles, but they have lower permeabilities than the pyroclastic-fall deposits. Note the shard in the upper right corner with the hydrated rim and unaltered center.

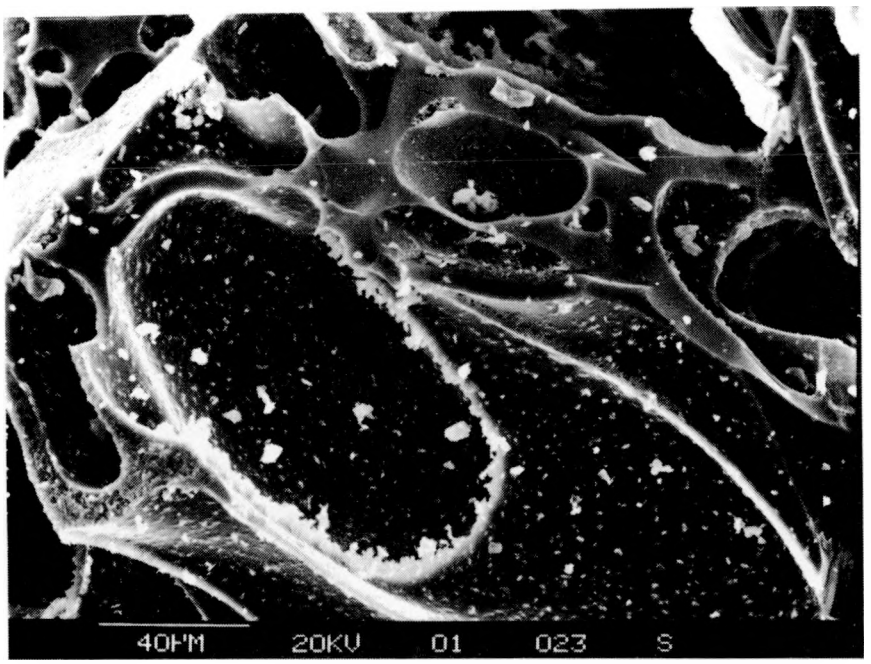


Figure 16.--Scanning electron micrograph of a typical shard in a nonwelded pyroclastic flow. Vesicles are fewer in shards in a nonwelded pyroclastic flow than in a pyroclastic fall. Vesicles are rounded to ovoid and are commonly filled with fine-ash material, or have adhering particles.

Figure 17A.--Photographs showing: A, Curved, mantled bedding is cut across by an erosional unconformity. Weathered pyroclastic-fall deposits overlie the mantle bedding. B, Coarse-grained pumice fall overlying a reddish, oxidized soil(?) horizon in the bedded tuffs between the Yucca Mountain and Pah Canyon Members. The weathered surface is an erosional unconformity between cycles of eruption.

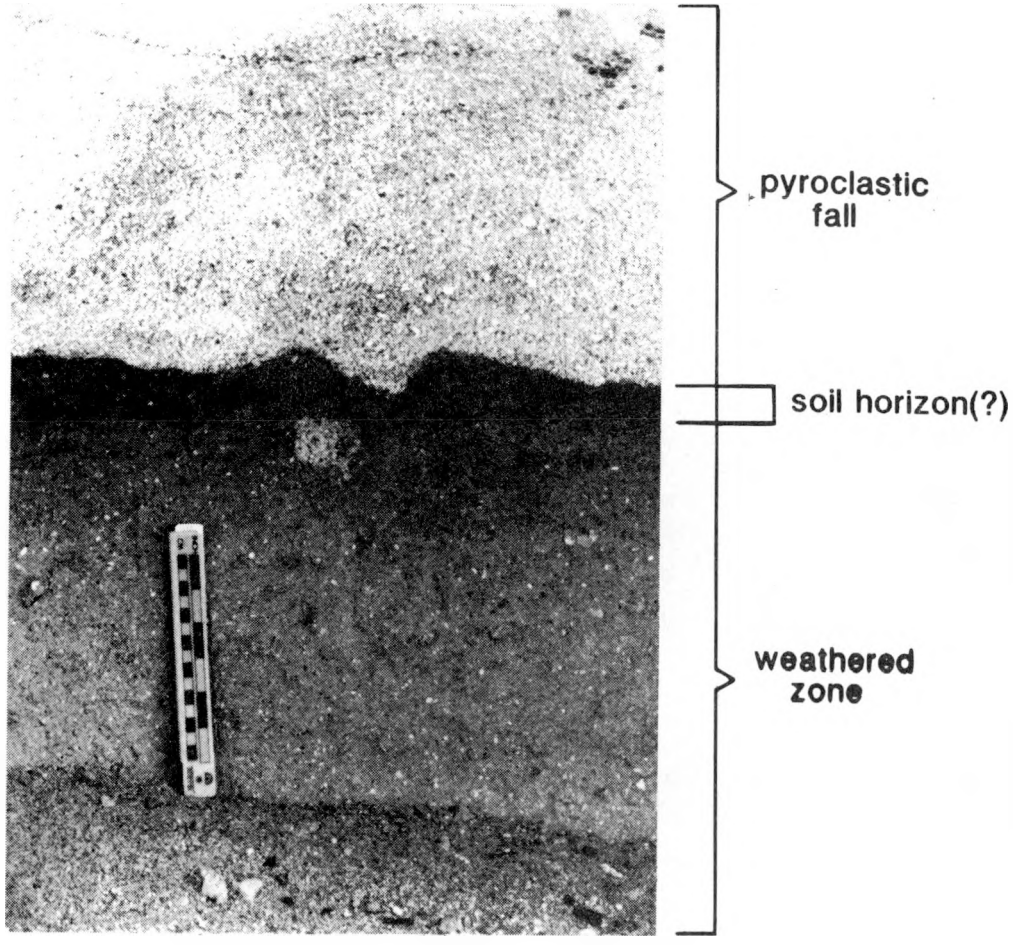


Figure 17.--Continued

carried into the porous volcanic material by downward percolating meteoric water. These oxidized zones may have formed by: (1) Exposures that were subjected to weathering, (2) "baking" from the heat of overlying pyroclastic deposits, or (3) alteration by oxidizing pore waters.

Petrographic Characteristics of Weathered Tuffs

Comminuted crystal material, fine ash, and shards comprise the matrix material between framework grains in the oxidized, weathered tuffs (fig. 18). The comminuted crystals in the weathered surfaces of pyroclastic-fall deposits are probably derived largely from the in situ disintegration and scattering of fractured crystals during weathering, although many fragments may have also represent crystals broken during eruption.

Glass is an unstable material that is highly reactive to pore water. In deposits that have undergone severe weathering, the glassy pumice is the first constituent to undergo dissolution, and therefore the framework grains will ultimately consist of the more stable crystal and lithic fragments. There are increasing grain-to-grain contacts between crystal fragments as the degree of weathering increases. The percentage of fractured crystals that are still held together in a unit may be an indication of the amount of weathering a pyroclastic fall has undergone. Many of the oxidized, weathered surfaces of pyroclastic-fall deposits contain both comminuted material and fractured, but intact, crystals.

Many bedded tuffs that have been altered by weathering are cemented by clay minerals, hematite, or hydrated iron oxides, which fill intergranular voids and coat grains (fig. 19). Hematite and clay cements can form early in the diagenetic history of a rock through the dissolution of glass and ferromagnesium minerals.

Weathered tuffs that contain abundant clay, and that appear to be buried soil horizons, commonly display dessication cracking in the clay matrix (fig. 20). The core sample was impregnated with epoxy before thin sections were made to preserve diagnostic textural features. Several soil horizons extend for considerable distances and are useful stratigraphic markers between the core holes (see fig. 32).

Point counts of matrix (or cement), pumice, and crystal/lithic fragments from bedded tuffs in the Paintbrush Tuff and tuffaceous beds of Calico Hills, revealed that a major textural distinction between a weathered unit and a pyroclastic fall is the higher percentage of matrix material (especially clay minerals) in a weathered unit (table 2). In the bedded tuffs below the Crater Flat members, diagenetic alteration of the volcanic material made it difficult to distinguish pumice and crystal boundaries from matrix material.

Table 2.--Summary of the petrology of pyroclastic-fall and weathered volcaniclastic deposits from the Paintbrush Tuff and tuffaceous beds of Calico Hills, Yucca Mountain, Nevada

	Average percent			Number of samples
	Pumice	Crystals/lithic fragments	Fine-grained matrix	
Weathered deposits..	42.9	15.6	41.5	10
Pyroclastic fall....	69.7	19.8	10.5	10

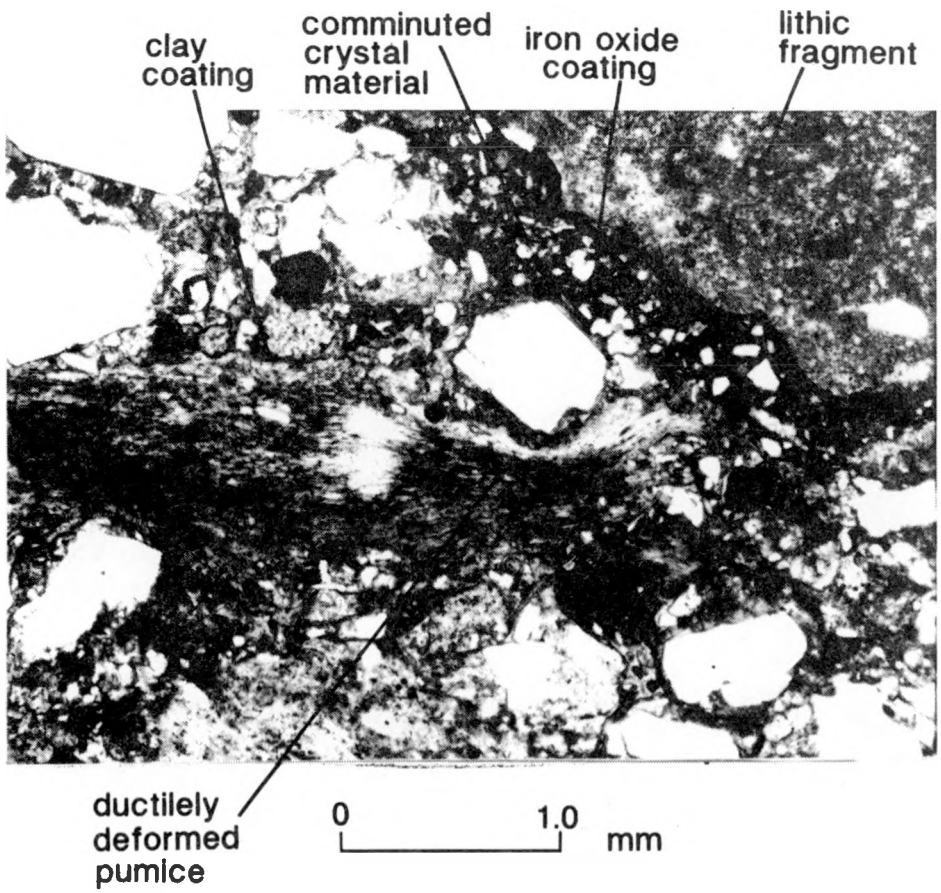


Figure 18.--Thin section G-4 1752.00. This photomicrograph illustrates: (1) a ductilely deformed pumice grain against a crystal, (2) an abundance of clay coating the grains, and (3) comminuted crystal material in the matrix of a weathered pyroclastic flow. The weathered tuffs are poorly sorted with a broad range in grain size and contain a greater percentage of matrix material than pyroclastic-fall deposits.

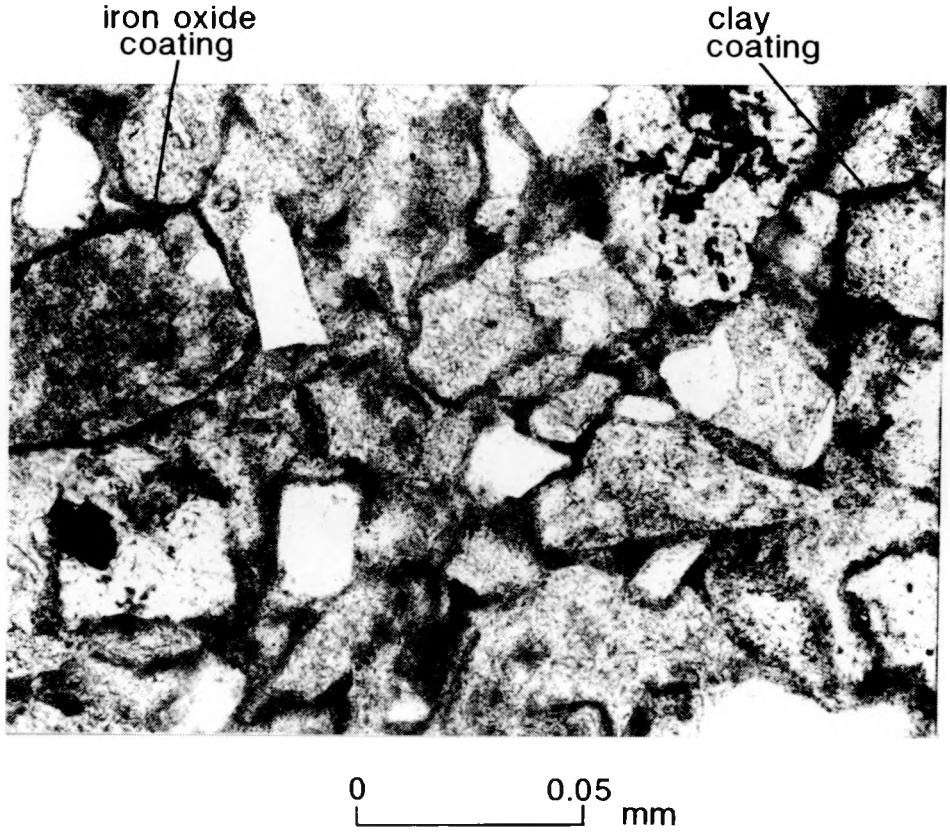


Figure 19.--Thin section G-1 1765.00. Clay and iron oxides form complete coatings around grains and are pore-filling cements in this weathered surface of a bedded-tuff unit.

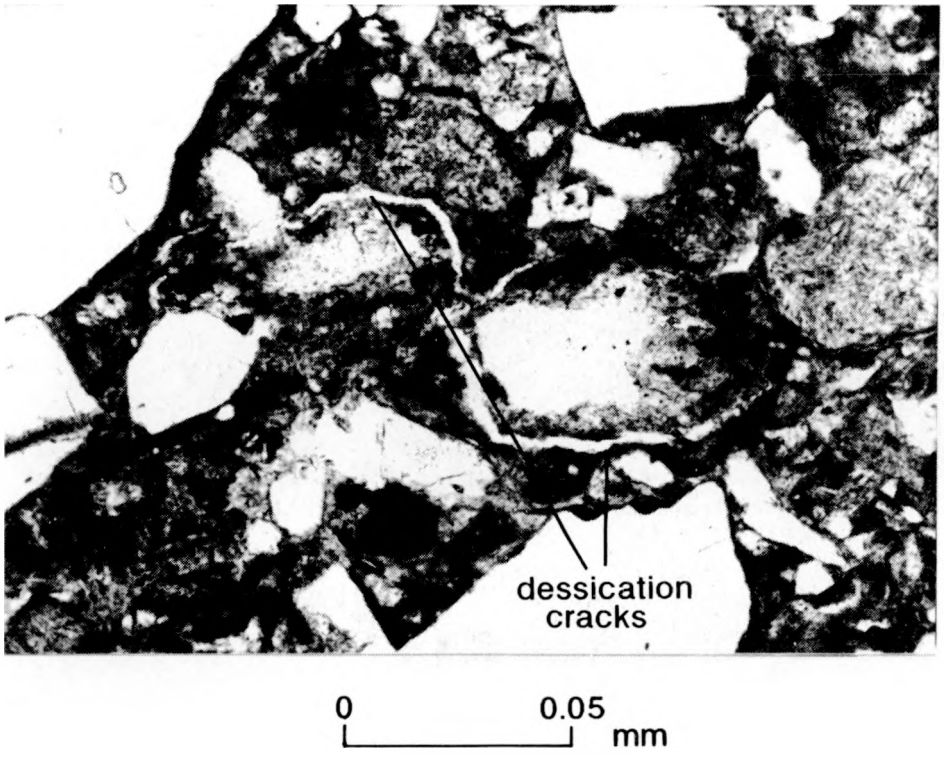


Figure 20.--Thin section G-4 1752.00. Shrinkage porosity in a weathered tuff. Extensive dessication cracking in clay, which has coated grains and occluded pore spaces, has opened the rock to circulating pore fluids.

Scanning Electron Microscope Characteristics of Weathered Tuffs

Paleoclimatic evidence indicates that the climate of the Miocene was more moist than today's arid environment (J.A. Wolf, oral commun., 1988). Atmospheric detrital clay may have filtered into the porous bedded tuffs by percolating rainwater. The particle aggregates shown in figure 21 (center) may be detrital clay that has melded together under burial pressure. These granule-like particles are only found in the weathered units, not with other diagenetic products in the unweathered tuffs.

Iron oxides may have a platy morphology and coat grains in oxidized, weathered zones like clays; but a clay rind can be recognized as such under the petrographic microscope because it has a birefringence, whereas the iron oxides are opaque.

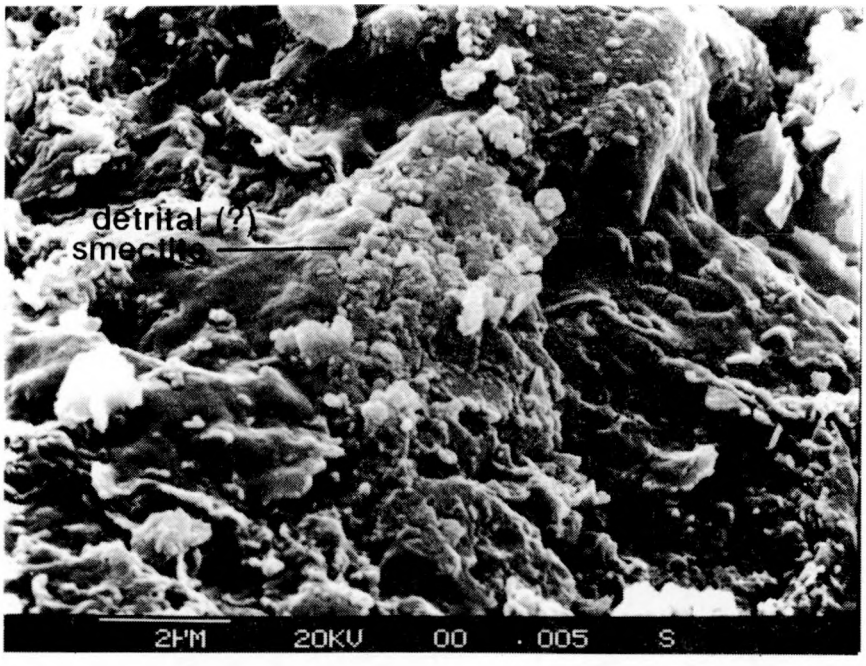
DIAGENESIS IN THE BEDDED TUFFS

Diagenetic Zones in the Yucca Mountain Stratigraphic Column

Diagenetic mineral assemblages define zones of alteration with depth, which vary in thickness and cross stratigraphic boundaries (Moncure and others, 1981; Caporuscio and others, 1985). With increasing depth, the following diagenetic zones are defined by authigenic minerals within the bedded tuffs: (1) The upper zone (Tiva Canyon, Yucca Mountain, Pah Canyon Members) is vitric with incipiently altered glass; clays and zeolites exist in small proportions, (2) the middle zone (Topopah Spring Member, tuffaceous beds of Calico Hills) contains abundant clinoptilolite with lesser amounts of smectite, cristobalite, and mordenite, (3) in the lower zone (Crater Flat Tuff), clinoptilolite and mordenite occur, but analcime also appears, replacing clinoptilolite and filling pore spaces. Smectite gives way to a mixed layer illite/smectite that decreases in expandability with depth. Other diagenetic minerals in alteration zones 2 and 3 include potassium feldspar and quartz.

Calcite is sporadically abundant throughout the three, broad diagenetic zones. In sample G-2 404.00, a nonwelded pyroclastic flow in alteration zone 1, calcite cement replaced the fine matrix material, essentially sealing the deposit, thereby preventing further diagenetic reactions. The glassy pumice grains and phenocrysts, however, were left intact. In contrast, calcite in alteration zone 3 has replaced the matrix, pumice, and plagioclase phenocrysts, obscuring the original nature of the volcanic deposit.

Devitrification products, such as cristobalite and opal, occur throughout the stratigraphic column, but other authigenic silicate minerals are vertically zoned. X-ray diffraction patterns from core samples show the progressive change in mineralogy with depth (fig. 22): (a) A pyroclastic fall at the base of the Yucca Mountain Member in the Paintbrush Tuff shows an abundance of unaltered glassy constituents cemented by clay, (b) in the tuffaceous beds of Calico Hills, zeolites (especially clinoptilolite) are a major component of the rock, and (c) at the base of the Tram Member in the Crater Flat Tuff, analcime appears as an alteration product.



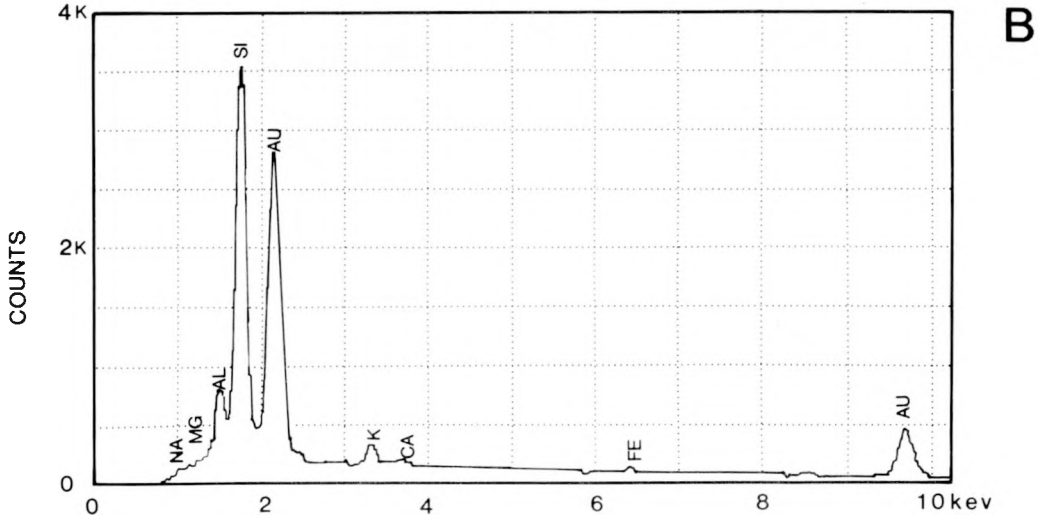


Figure 21.--A, Scanning electron micrograph of sample G-1 2162.80. Particle aggregates in the middle of the photograph may be detrital clay which has melded together. Compare this clay morphology with figure 24 which illustrates authigenic smectite that has a webbed structure and forms perpendicular to grain surfaces. B, EDX spectrograph of detrital clay.

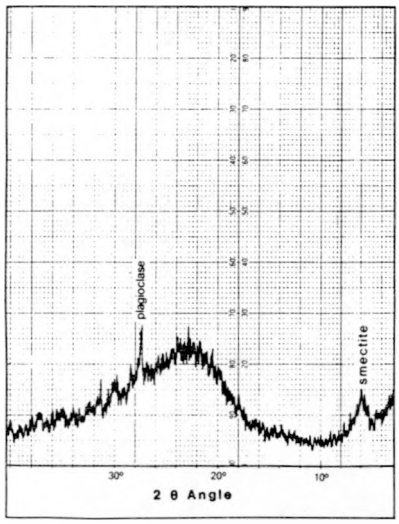
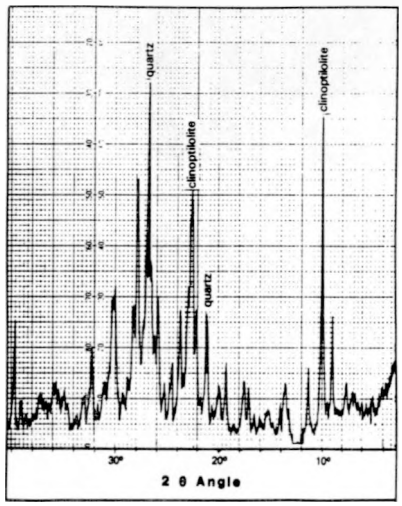


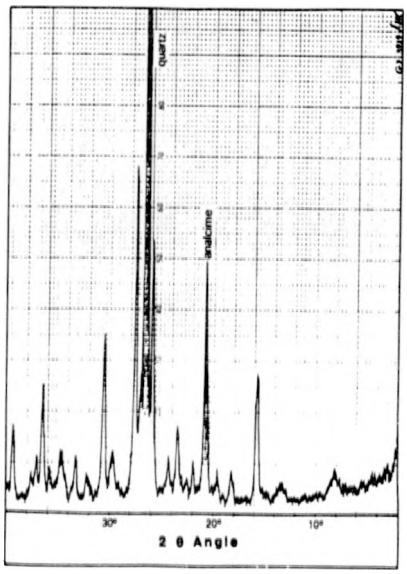
Figure 22.--In the shallow Paintbrush bedded tuffs, glass is the main constituent, and the powder X-ray diffraction pattern is an amorphous hump. The plagioclase peak is due to the presence of phenocrysts in the rock. Smectite is the only alteration product.

a. USW G-4
148.8 ft



b. UE25a #1
1,816.0 ft

The sample analyzed is from the base of the tuffaceous beds of Calico Hills. At this depth, clinoptilolite, is the major alteration product in the rock. Quartz is present as a phenocryst as well as a devitrification product of glass.



c. USW G-2
3,929.8 ft

Analcime occurs only in the deeply buried bedded tuffs at the base of the Tram Member. Alteration minerals obscure textures indicative of a deposit's origin.

Clay

Clay is generally the first authigenic mineral to precipitate in the tuffs, forming rinds around shards, pumice, crystals, and lithic fragments. There are two morphological types of clay in the bedded tuffs: (1) A webbed, authigenic clay that develops perpendicular to grain boundaries, and forms rinds around grains (figs. 23 and 24), and (2) platy clay coats that are formed from melded granules of detrital clay (see fig. 21) (Walker and others, 1978). Detrital clay is restricted to the weathered zones, but the webbed, authigenic clay is found in all bedded tuff units throughout the stratigraphic column. Based on petrographic observations, X-ray diffraction, and energy dispersive X-ray spectra, both detrital and authigenic clays are smectite.

Pumice in unconsolidated pyroclastic-fall and nonwelded pyroclastic-flow deposits is commonly outlined by authigenic clay and iron oxides (fig. 25). Clay alteration halos also occur along microfractures in these units and are indicators of flow paths of pore solutions.

Clay and (or) iron-oxide coats are commonly preserved, whereas the unstable glass and labile minerals, which they surround, have undergone dissolution (the next stage in diagenesis). Thin section G-4 1752.00 (fig. 26) depicts a hornblende with a clay coat that outlines the original boundary of the grain. The hornblende grain has partially dissolved, and the void space has been filled subsequently by a blocky clinoptilolite phase. The clay rim has not been distorted after dissolution, which indicates that compaction did not take place, and that the zeolites are a post-clay precipitate. Both shards and heavy minerals show the sequence of: (1) clay alteration, (2) dissolution of grains, and (3) zeolite precipitation.

Zeolites

Zeolites occur in all the bedded tuff deposits. X-ray diffraction results from Los Alamos Laboratories indicate that the zeolites are clinoptilolite and mordenite (Bish and Vaniman, 1985; Caporuscio and others, 1985). Zeolites commonly line voids left by shard dissolution. Viewed under crossed nicols, clinoptilolite is seen as rectangular, clear crystals with low birefringence, and mordenite as fibrous crystal sprays (see fig. 23). Analcime in thin sections from the Tram Member has sharp trapezohedron outlines.

Clinoptilolite (heulandite) forms rectangular crystals in voids left by dissolution of glass shards and pumice (fig. 27). Fibrous mordenite replaced the clinoptilolite at varying depths in the core holes (fig. 28). A mordenite zone has its greatest thickness toward the north, at USW G-2, and decreases in thickness to the south, toward USW G-3 (R.A. Sheppard, oral commun., 1987). Analcime was only detected in powder X-ray diffraction analysis of samples taken from the Tram Member.

Feldspar

Rhombic-shaped potassium feldspar crystals (adularia) have precipitated on many zeolite surfaces. However, the feldspar does not occur in conjunction with authigenic clay; therefore, the paragenetic relationship between the two minerals cannot be determined (fig. 29).

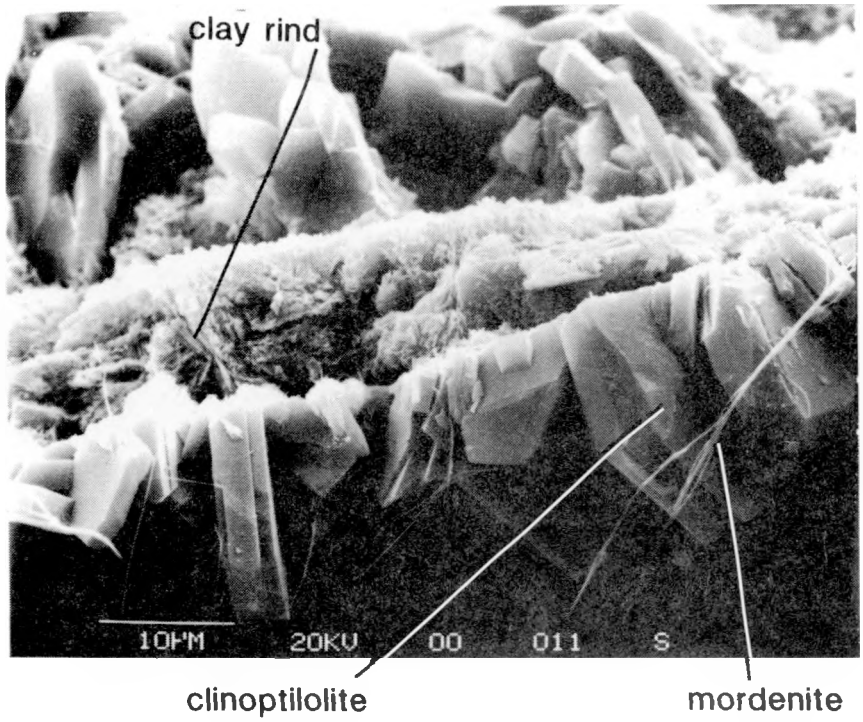


Figure 23.--Scanning electron micrograph of authigenic, smectitic clay that formed a clay rind around a framework grain that later underwent dissolution. Zeolites have grown into the dissolution void and intergranular pore space.

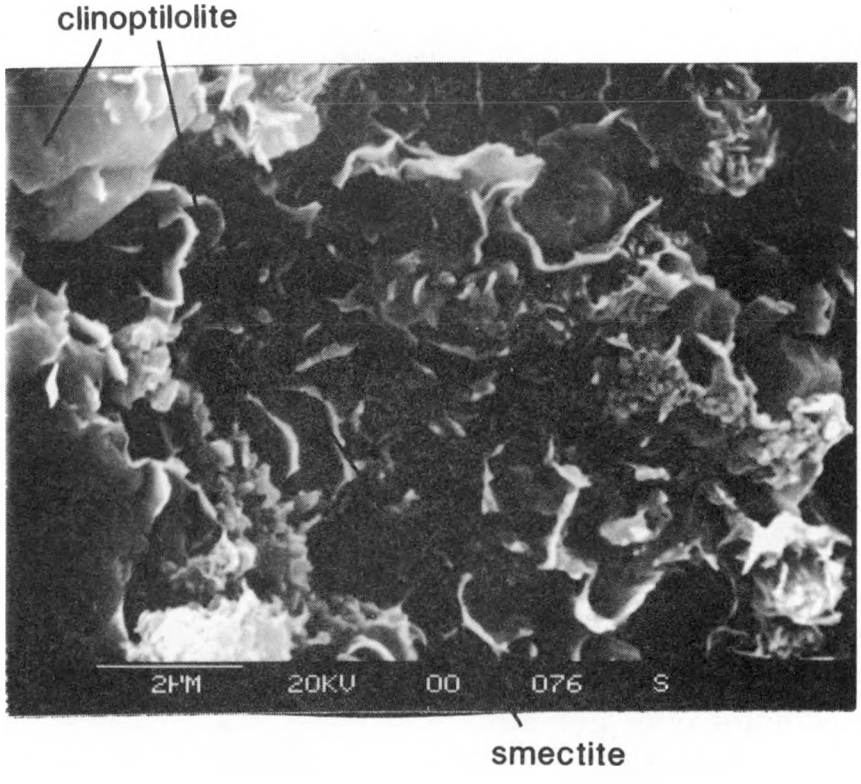


Figure 24.--Scanning electron micrograph cf sample G-4 1752.00. Authigenic smectite has a webbed morphology and has precipitated perpendicular to the grain and zeolite surfaces. Here, clay is coating authigenic clinoptilolite that has grown within a dissolved shard. Note that in figure 23 clay does not overgrow the zeolite crystals.

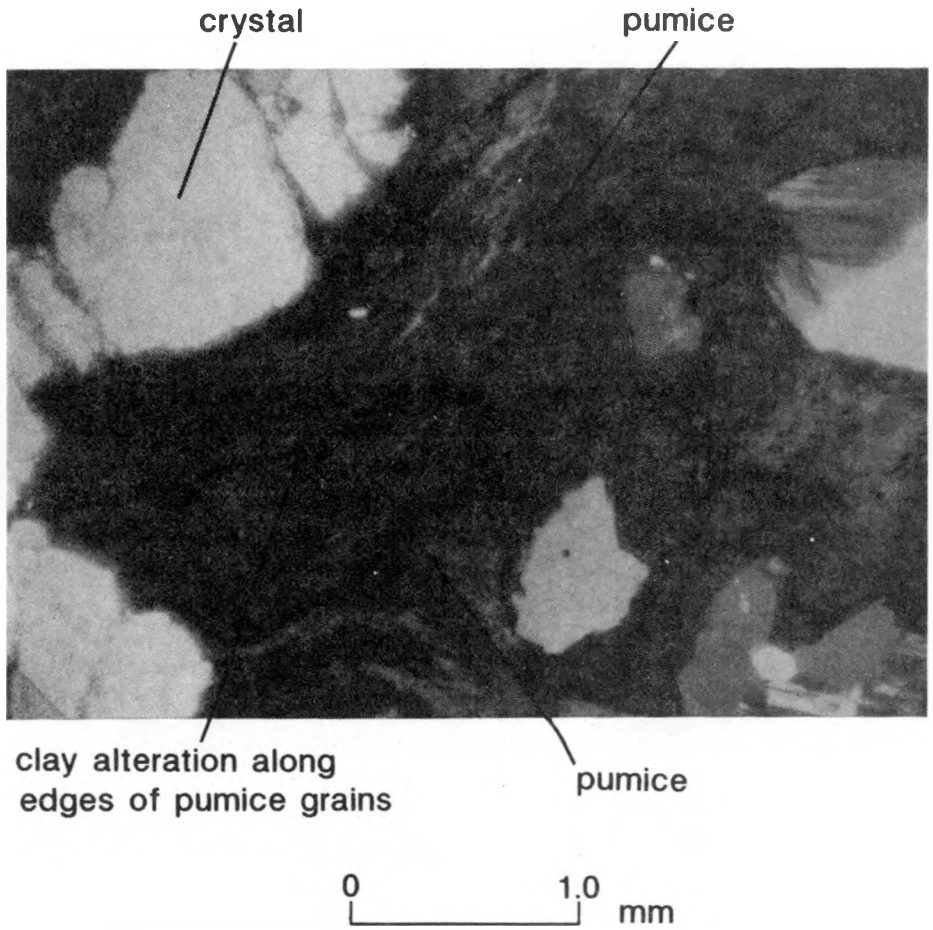


Figure 25.--Thin section G-2 1714.00. Alteration of glass to clay has occurred along the peripheries of flow paths for pore solutions. These alteration zones outline pumice grains and microfractures in the bedded tuffs.

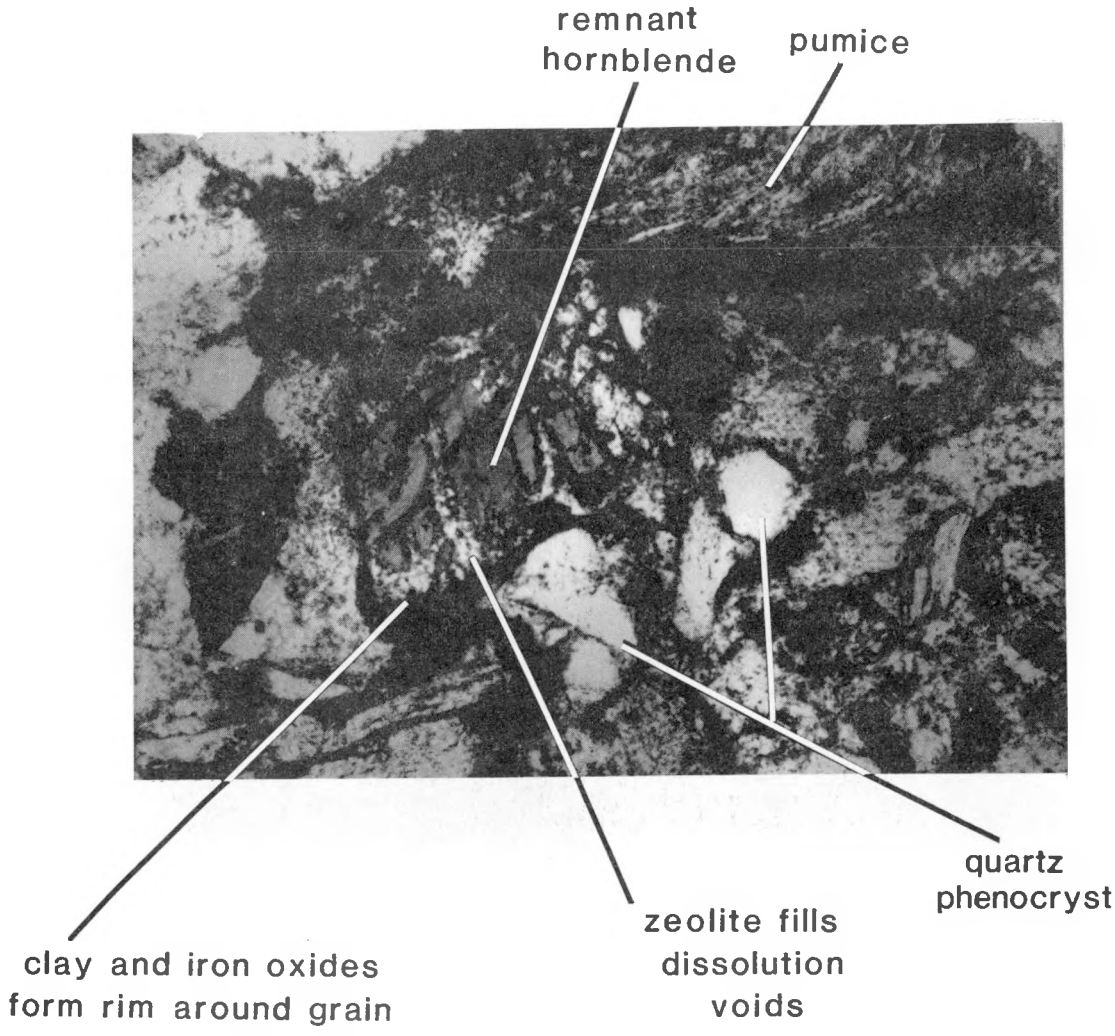


Figure 26.--Thin section G-4 1752.00. The photomicrograph shows the diagenetic sequence of mineral formation within a weathered zone: (1) a clay rind formed around a hornblende grain, (2) the hornblende grain underwent partial dissolution, and (3) clinoptilolite precipitated, filling the dissolution voids. Note that the clay rim has not been distorted after dissolution, indicating no compaction after deposition of the clay.

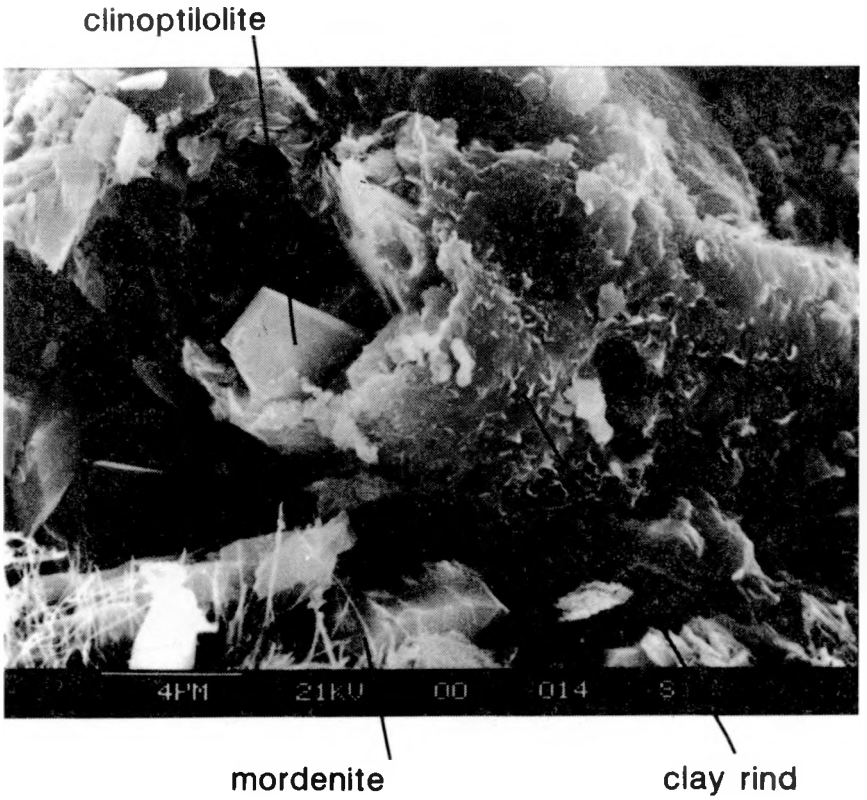


Figure 27.--Scanning electron micrograph of an authigenic clay rind formed by clay platelets parallel to the original grain surface in a weathered zone. The void has been filled by tabular clinoptilolite crystals. Note the fibrous mordenite crystals in the lower-left corner.

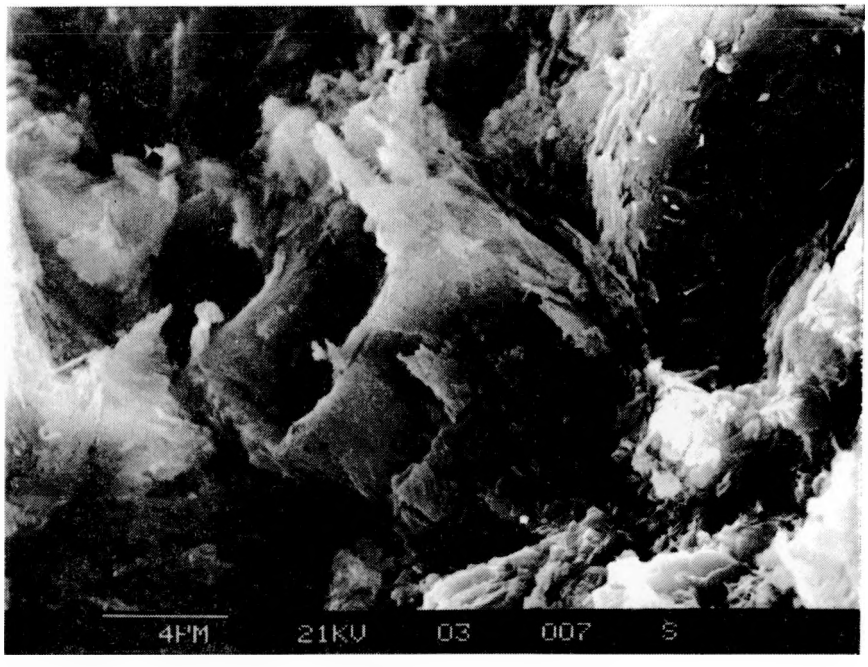
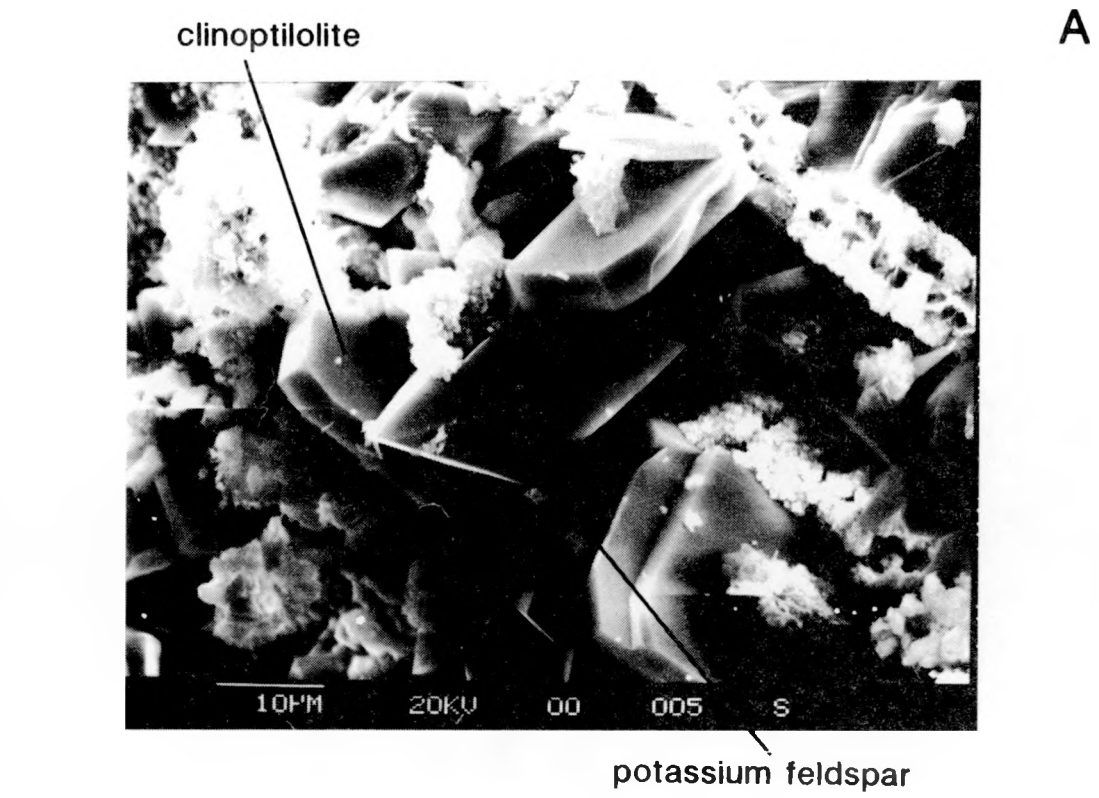


Figure 28.--Scanning electron micrograph of mordenite that has replaced clinoptilolite. The mordenite, normally found in a fibrous state, has assumed the rectangular shape of the clinoptilolite crystal.



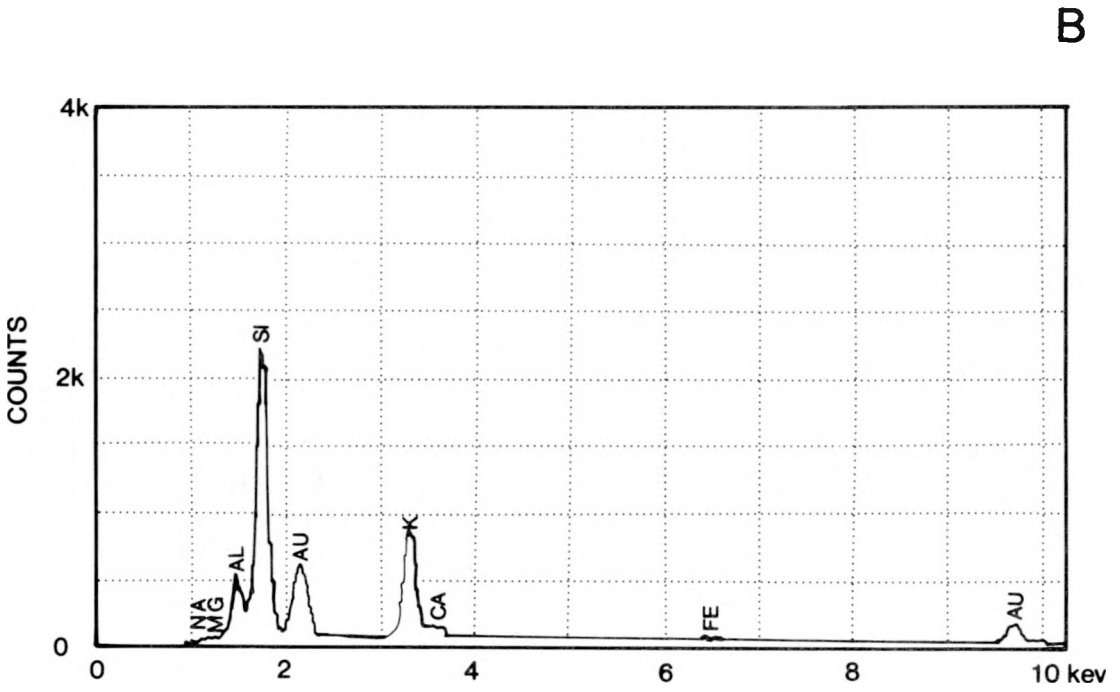


Figure 29.--A, Scanning electron micrograph of authigenic, rhombic-shaped, potassium feldspar (center of photograph). B, Precipitated over clinoptilolite.

Paragenesis of Diagenetic Minerals

The following table is a summary of the order of appearance of diagenetic minerals with increasing depth in the bedded tuffs:

Table 3.--Summary of the paragenesis of authigenic minerals in the bedded-tuff sequence

increasing depth	---------->
calcite	---------->
smectitic clay	---------->
glass/feromagnesium mineral dissolution	---------->
clinoptilolite/mordenite	---------->
illite/smectite	---------->
mordenite	---------->
potassium feldspar	---------->
analcime	---------->

PHYSICAL PROPERTIES OF THE BEDDED TUFFS AND ADJACENT NONWELDED PYROCLASTIC-FLOW DEPOSITS

Physical-property data on bulk density, grain density, and porosity of the bedded tuffs are scattered among several publications (Anderson, 1984; Lappin, 1982; Price, 1983). Porosity data also exist for bedded tuffs that have not been logged in detail; therefore, it is not known whether the sample tested was from a pumice fall, a surge unit, or a clay-rich weathered zone. Analysis of available data indicates that average values for porosity and permeability differ for each type of bedded-tuff layer, presumably because of their diverse modes of deposition and varying percentages of pumice, crystal, lithic fragments, and matrix components. Physical-property values vary with depth as alteration zones are encountered.

Pumice-rich pyroclastic-fall deposits would be expected to have low bulk-density values due to abundant open-vesicle and intergranular void space. Bulk density is controlled more by this factor than by mineral composition (Anderson, 1984). The voids through which solutions travel may be composed of primary porosity factors such as vesicle space and intergranular porosity, or of secondary porosity factors such as dissolution voids and microfracturing (figs. 20, 23).

A review of the literature shows that the range of grain-density values is smaller than the range of bulk-density values, which also indicates that bulk density is dependent on void space (table 4).

An abundance of clay minerals and iron oxides in the weathered tuff zones has lowered porosity values and increased bulk- and grain-density values by occluding vesicles in pumice and filling pore spaces. However, shrinkage porosity, resulting from dehydration cracking in clay, can increase porosity and decrease density values (fig. 20).

Nonwelded pyroclastic-flow deposits are expected to be as porous as pyroclastic-fall deposits because of available, undeformed vesicle space (fig. 15). Vesicles within nonwelded pyroclastic-flow deposits may be clogged with fine-ash material, but porosities may still remain high--within the range of porosities for pyroclastic-fall beds (table 4). Moreover, porosity values may

TABLE 4.--Summary of available density and porosity data of the bedded tuffs and the adjacent nonwelded ashflows
[Leaders (---) indicate no data]

Researcher/ core hole	Lithologic unit	Average bulk density values (g/cm3)	Range in bulk-density	Grain density	Range in grain-density values	Porosity (percent)	Number of samples
Lappin (1982)	Base of Topopah Spring:						
USW G-1	Nonwelded ashflow.....	1.70	1.59 to 1.81	2.42	2.37 to 2.47	30	2
	Base of Calico Hills:						
	Nonwelded ashflow.....	1.55	1.47 to 1.63	2.37	2.24 to 2.48	34	16
	Bedded tuff.....	2.00	---	2.62	---	24	1
	....do.....	2.10	---	2.56	---	30	1(?)
	Base of Prow Pass:						
	Partially welded ashflow.	1.73	1.64 to 1.74	2.39	2.35 to 2.41	30	4
	Bedded tuff (weathered zone).	1.80	1.78 to 1.82	2.47	2.46 to 2.47	28	2
	Base of Bullfrog:						
	Nonwelded ashflow.....	1.67	1.64 to 1.70	2.45	2.43 to 2.46	32	2
	Bedded tuff (weathered zone).	1.86	1.82 to 1.89	2.46	2.44 to 2.47	25	2
UE25a-1	Base of Calico Hills:						
	Bedded tuff.....	2.17	---	2.47	---	20	2
UE1-H	Base of Bullfrog:						
	Partially/nonwelded ashflow.	1.91	1.78 to 1.94	2.43	2.39 to 2.52	22	9
	Bedded tuff.....	2.00	1.99 to 2.01	2.62	2.61 to 2.62	23	2
	Partially/nonwelded ashflow.	1.89	1.85 to 1.93	2.49	2.37 to 2.61	27	11
Price (1983)	Base of Calico Hills:						
USW G-1	Bedded tuff.....	---	---	2.61	---	36	4
	Nonwelded ashflow.....	---	---	2.65	---	29	4
	Base of Prow Pass:						
	Bedded tuff (weathered zone).	---	---	2.48	---	38	3
	Base of Bullfrog:						
	Bedded tuff.....	---	---	2.48	2.47 to 2.49	26	7
Anderson (1984)	Base of Tiva Canyon:						
USW GU-3	Nonwelded ashflow.....	2.30	---	2.49	---	8	1
	Bedded tuff(?).....	1.41	---	2.31	---	39	1
	Base of Bullfrog:						
	Bedded tuff.....	1.92	---	2.45	---	22	1
	Base of Tram						
	Bedded tuff.....	2.08	---	2.52	---	17	1
Summary of data:							
Bedded tuff.....		1.93	---	2.73	---	27	27
Nonwelded ashflow.....		1.82	---	2.46	---	30	49

be higher in a nonwelded pyroclastic flow deposit that is adjacent to a pyroclastic-fall or weathered unit that contains detrital or authigenic clay that is occluding pore space (table 4).

The effect of clay, iron oxides, and other alteration minerals on physical property values is more apparent at depth. For the bedded tuffs and adjacent nonwelded pyroclastic-flow deposits at the base of the Prow Pass and Bullfrog Members, porosity values are similar due to the effects of burial alteration.

A summary of the available data suggests that there are no real physical-property differences in density and porosity between the bedded tuffs and the adjacent nonwelded pyroclastic-flow deposits. A sampling bias may exist because the unconsolidated, friable pumice-fall deposits tended to disintegrate when tested.

Although the pyroclastic-fall and nonwelded pyroclastic-flow deposits may have similar physical properties, pore space is inferred to be more abundant and well-connected in pyroclastic-fall beds, which generates greater permeability (L.A. Anderson, oral commun., 1986). Anderson has discovered that the pyroclastic-fall deposits have two to three orders of magnitude greater hydraulic conductivity values than that in nonwelded pyroclastic-flow deposits (table 5). These data stress the importance of being able to identify specific lithologies encountered in the core holes.

Table 5.--USW GU-3 hydraulic conductivity in microdarcies
[L.A. Anderson, oral commun., 1986]

Type of deposit	Sample depth (meters)	Hydraulic conductivity	
		Vertical	Horizontal
Welded pyroclastic flow.....	305.7	0.9	4.3
"Bedded tuff" (that is, pyroclastic fall).	370.9	140,000.0	61,200.0
Nonwelded pyroclastic flow....	435.2	440.0	1,200.0

CORRELATIONS OF BEDDED TUFF COLUMNAR SECTIONS

Columnar sections were drawn for each bedded-tuff interval between ash-flow formations and members, and then were correlated between core holes. The columnar sections are presented as figures (figs. 30-35) that are individually

discussed below. Distinctive marker beds, described as stratigraphic horizons, which were important in correlating a bedded unit, are alphabetically labeled on the columnar sections. Separation of the bedded-tuff units was based on megascopic lithologic differences seen in the core and thin sections using pumice, crystal, and other textural petrologic criteria. Detailed lithologic descriptions of the bedded-tuff units in the core are presented in Appendixes 1-6.

Bedded Tuffs between the Tiva Canyon, Yucca Mountain, Pah Canyon, and Topopah Spring Members

The Yucca Mountain and Pah Canyon ash-flow members pinch out to the south. Therefore, the pyroclastic-fall deposits between the major ash-flow members (Tiva Canyon, Yucca Mountain, Pah Canyon, Topopah Spring) of the Paintbrush Tuff merge to the south, coming in direct contact with one another in core hole USW G-3. The inference is that major denudation episodes did not take place between the deposition of the Topopah Spring and Tiva Canyon ash flows, and that rapid and continuous volcanic activity occurred during the deposition of the bedded tuffs of the Paintbrush Tuff.

Among various authors, there is a discrepancy in published lithologic logs of the geologic core holes with respect to the boundaries of the bedded-tuff units between the Pah Canyon and Topopah Spring Members (fig. 30). One problem centers on a gray, pumice-rich deposit (base at Horizon A) that has been described as an "ashflow" in USW G-2 and UE25a #1, but as an "ashfall" in USW G-4 and USW G-3 (fig. 30). The abundance of pumice fragments ranges from 90 percent, where the unit is called an ash fall, to less than 40 percent, where it is termed an ash flow. This discrepancy in naming the unit has created problems in choosing a consistent upper boundary for the Topopah Spring Member between core holes because the appearance of a pyroclastic-fall deposit has been used to define stratigraphic boundaries. This correlation problem arises because of the lateral facies changes common in pyroclastic-flow and -fall deposits (Hildreth and Mahood, 1985).

Measured section 5 on figure 30 is a vertical section through the bedded tuffs between the Tiva Canyon and Topopah Spring Members. This measured section was needed to correlate beds between USW G-4 and USW G-3/GU-3 because the Yucca Mountain and Pah Canyon Members pinch out to the south.

Horizon B, the base of a silty ash bed, is a good correlation contact that provides the first good evidence for an pyroclastic-fall unit between the Pah Canyon and Topopah Spring Members. Due to poor core recovery, this unit is not seen in USW G-4.

Bedded Tuffs between Topopah Spring Member and Tuffaceous Beds of Calico Hills

The most striking feature on columnar section figure 31 is the anomalously thick bedded-tuff units to the north in USW G-2. Maldonado and Koether (1983) postulated that this core hole is at the site of a buried caldera or other topographic depression where infilling has occurred. The thickness of the bedded units may also be related to low-energy, near-source pyroclastic-flow and -fall activity.

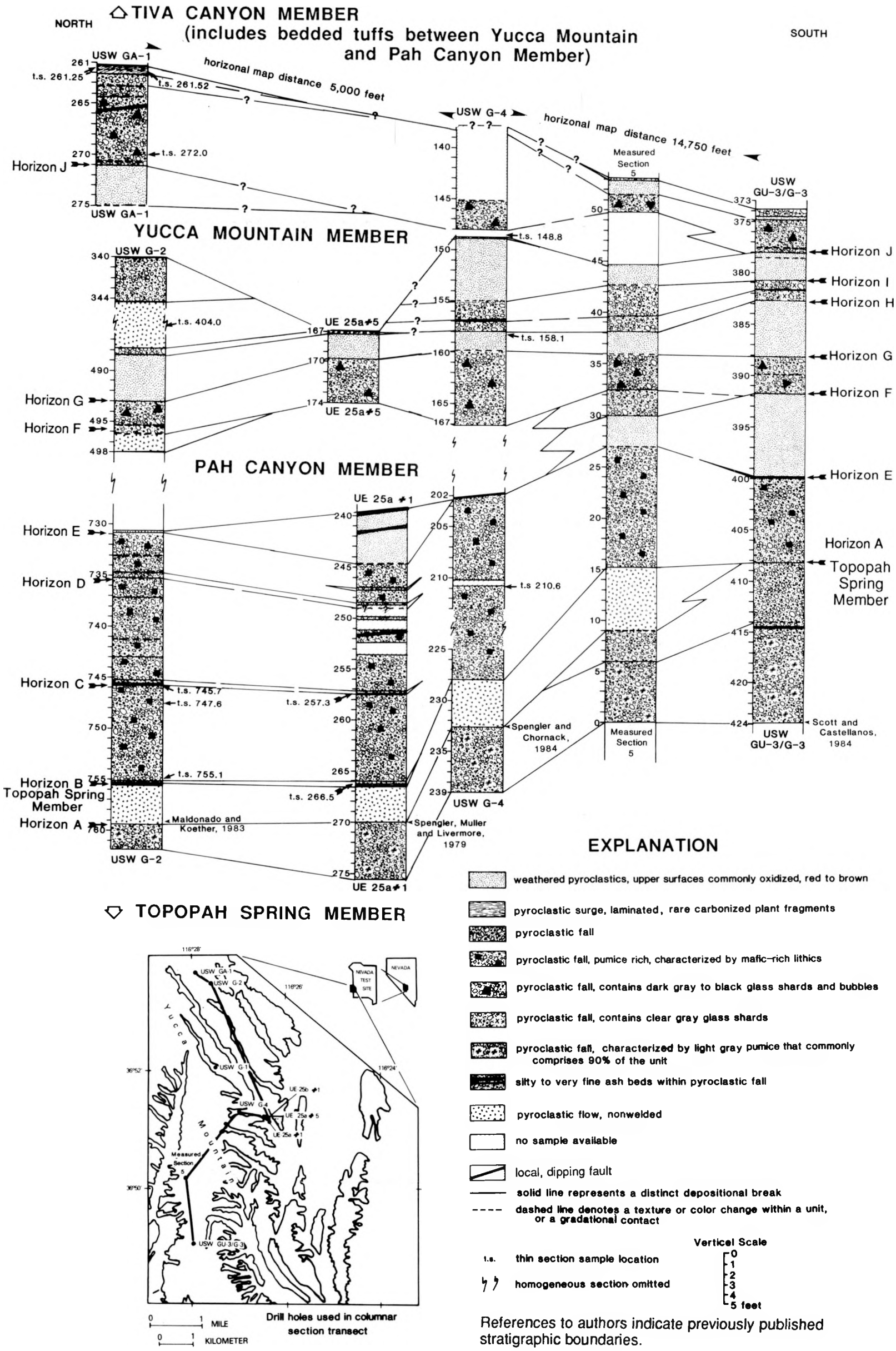


Figure 30.--Columnar sections of bedded tuffs between the Tiva Canyon and topopah Spring Members.

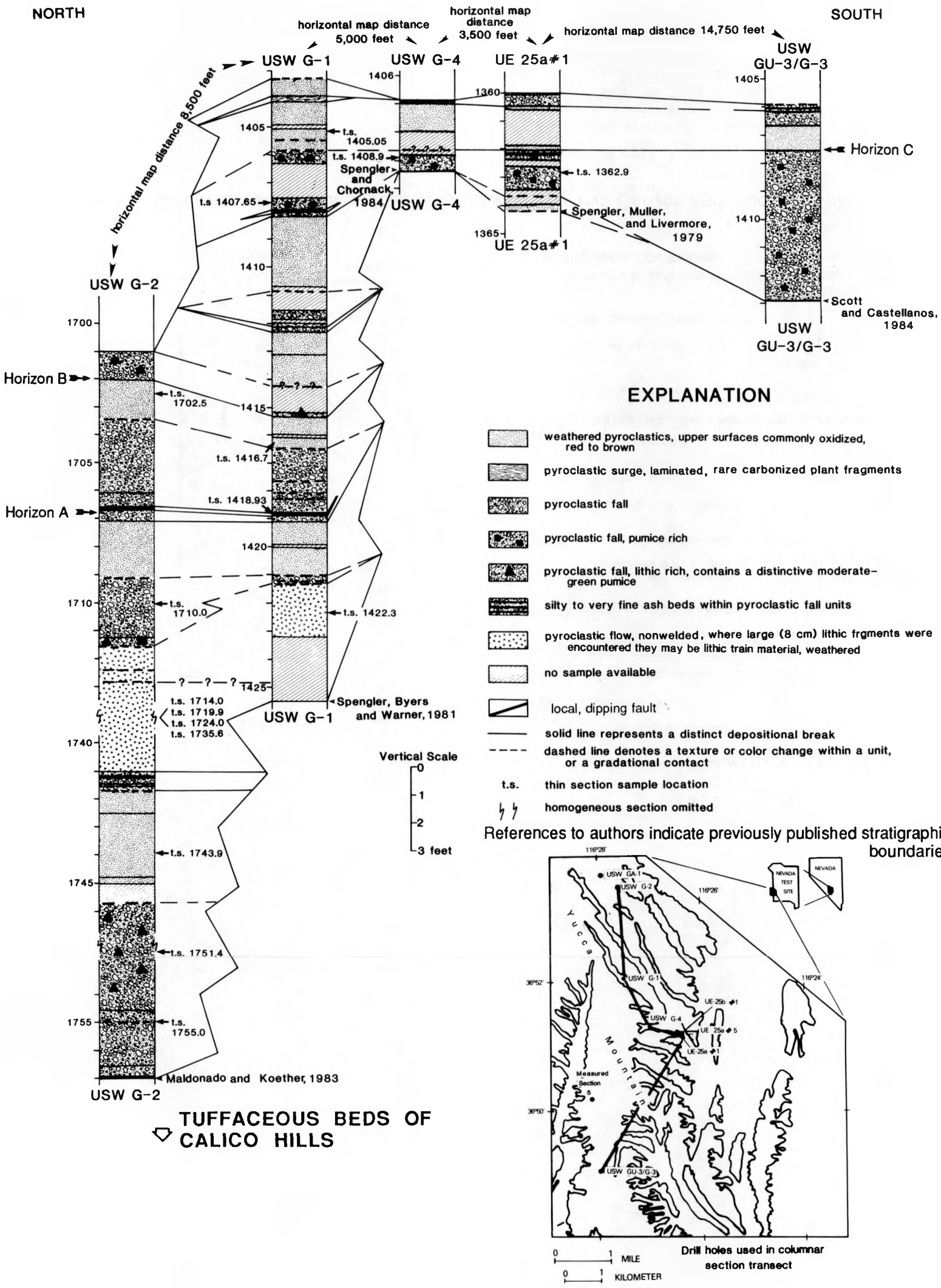


Figure 31.--Columnar sections of bedded tuffs between Topopah Spring Member and tuffaceous beds of Calico Hills.

Horizon A is a tie line within a pyroclastic fall between core holes USW G-2 and USW G-1. This horizon is at a series of thin, silicified, silty ash beds that overlie the coarse-grained lithic-rich base of a pyroclastic-fall deposit. Because of a thinning trend in the bedded tuffs to the south, this deposit is not seen in the other core holes.

Horizon B is also limited to core holes USW G-2 and USW G-1. Horizon B is a distinctive surface between an oxidized, weathered zone and an overlying coarse-grained lithic- and pumice-rich base of a pyroclastic fall.

Horizon C is the base of an extensive pyroclastic-fall deposit in core hole USW G-1 to the north, that continues through core holes USW G-4, UE25a #1, and USW GU-3 to the south.

The only disagreement with a prior boundary line is in core hole UE25a #1, where we added a weathered part of a pyroclastic flow to the bedded tuffs. Missing core may be responsible for the difference in depth measurements.

Bedded Tuffs between Tuffaceous Beds of Calico Hills and Crater Flat Tuff

There are several consistent marker beds between core holes USW G-1, USW G-4, and UE25a #1 (fig. 32). However, the bedded-tuff units in core holes USW G-3/GU-3 were difficult to correlate with any units in the closest core hole, UE25a #1. The USW G-3/GU-3 tuffs are more biotite-rich than the tuffs in UE25a #1, and they contain perlitic black glass. The USW G-3/GU-3 bedded tuffs contain zeolitic pumice, but the zeolitization is not as pervasive as in the other core holes. All of these differences raise the question as to whether the bedded tuffs in USW G-3/GU-3 are related to the tuffs and rhyolites of Calico Hills.

Another problem arose in correlating the very thick nonwelded pyroclastic-flow and thin pyroclastic-fall deposits in USW G-2 with the other core holes to the south. It is possible that a topographic low may have helped to preserve more volcanic units in the northern part of Yucca Mountain.

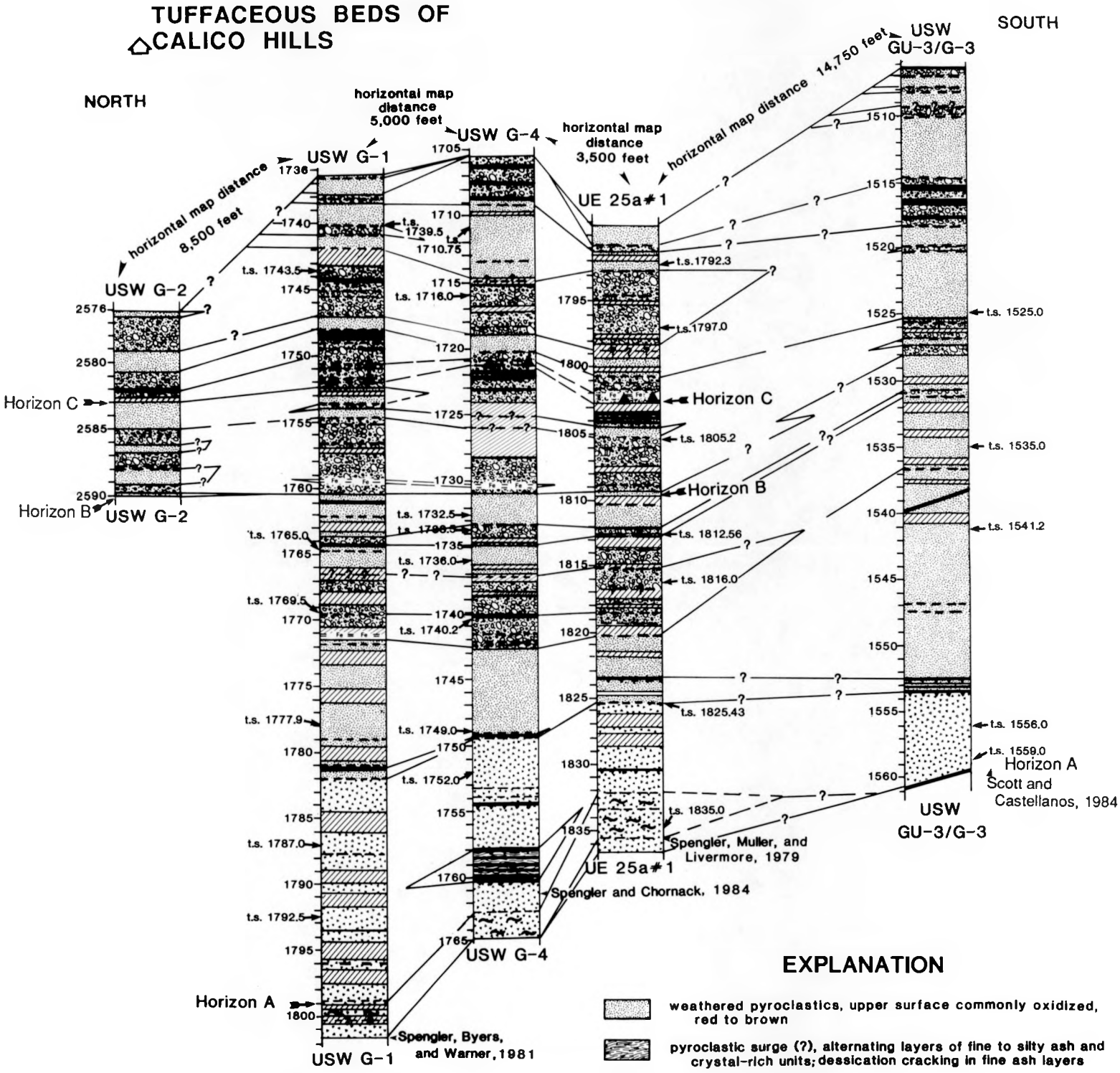
Horizon A, in core holes USW G-1, USW G-4, and UE25a #1, is a contact between a weathered pyroclastic flow and an underlying zeolitic pyroclastic flow with fiamme texture. This correlation is based on an alteration texture, which could cross a stratigraphic boundary. Various authors created discrepancies in the basal stratigraphic boundaries for the bedded-tuff units between the different core holes (fig. 32). The revised stratigraphic base for the bedded tuffs is determined by the depth of weathering in the pyroclastic flow.

Horizon B is a distinctive contact between the oxidized surface of a lithic-rich weathered zone and an overlying inversely-graded pyroclastic-fall deposit. The oxidized, weathered zone may be a paleosol; scanning electron micrographs show intergranular clays that appear to be detrital in origin.

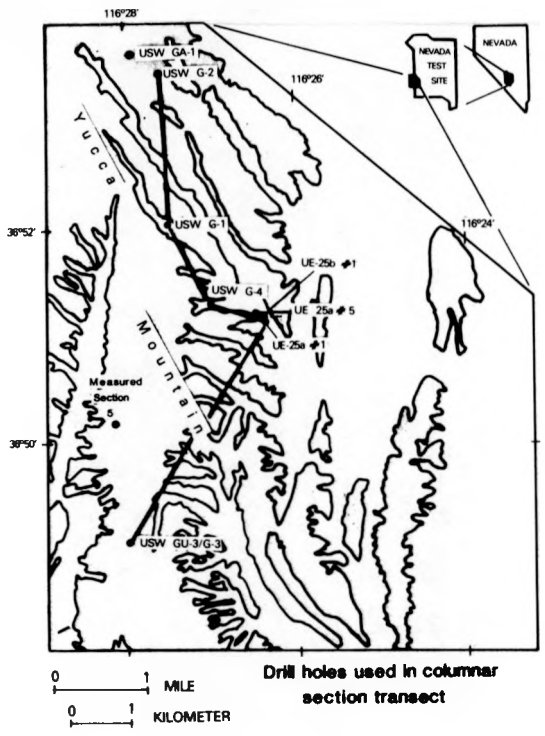
Horizon C is the base of a very coarse-grained, lithic-rich layer within a well-stratified pyroclastic-fall deposit. This fall deposit contains a yellowish-green, vuggy, zeolitic pumice lapilli, which is distinctive at this horizon between USW G-3/GU-3 and the other core holes.

Bedded Tuffs between Prow Pass and Bullfrog Members

Based on alkali feldspar compositions, Bish and others (1981) showed that a part of the bedded tuffs at the base of the Prow Pass Member in USW G-1 is



PROW PASS MEMBER



EXPLANATION

- weathered pyroclastics, upper surface commonly oxidized, red to brown
- pyroclastic surge (?), alternating layers of fine to silty ash and crystal-rich units; dessication cracking in fine ash layers
- pyroclastic fall
- pyroclastic fall, contains lithic-rich layers; correlation based on the appearance of vuggy, zeolitic, moderate-yellow green pumice
- pyroclastic flow, streaky appearance due to compressed argillic pumice
- weathered pyroclastic flow(?), the unit contains comminuted crystal materal in the matrix and platy clay coating grains
- silty to very fine ash beds within an unit
- no sample available
- local, dipping fault
- dessication cracks in fine to silty ash layers
- solid line represents a distinct depositional break
- dashed line denotes a texture or color change within a unit, or a gradational contact
- Fe iron oxide banding
- t.s. thin section sample location
- homogeneous section omitted

Vertical Scale
0
5 feet

References to authors indicate previously published stratigraphic boundaries.

Figure 32.--Columnar sections of bedded tuffs between tuffaceous beds of Calico Hills and the Prow Pass Member.

genetically related to the underlying Bullfrog Member. Pyroclastic-fall deposits are generally assumed to be related to a renewed burst of volcanic activity, and therefore, associated with overlying pyroclastic-flow deposits.

Horizon A in figure 33 is a stratigraphic contact at the base of a pyroclastic-fall deposit that has lateral continuity among all the core holes except USW G-3/GU-3.

The massive units, described as "reworked" in previously published lithologic logs (see fig. 33), appear to be weathered, nonwelded pyroclastic-flow and pyroclastic-surge deposits. Horizon B separates a thinly bedded pyroclastic-fall unit and an overlying pyroclastic-surge deposit. This contact is an excellent time-stratigraphic line for correlation. The surge deposit is an extensive unit present in all the geologic core holes and is easily recognized by its distinctive silty- to fine-grained laminae that converge at low angles.

Two stratigraphic contacts of the bedded tuffs with the underlying pyroclastic-flow deposits have been changed by this study. In core hole USW G-1, the contact at the base of a pyroclastic fall was moved downward to include a weathered surface of an ash flow. In core holes USW G-3/GU-3, the contact was moved downhole to a fracture zone.

Carr and others (1986) postulated the existence of a caldera on Crater Flat between Bare Mountain and Yucca Mountain that may have been the source for the Crater Flat Tuffs (fig. 2). However, the bedded tuffs between the Prow Pass and Bullfrog Members are thick in the northern part of Yucca Mountain, and they thin to the south. The pyroclastic-surge bed capping the bedded tuffs indicate a flow direction from north to south; therefore, the source for the Crater Flat Tuffs is inferred to be the Timber Mountain-Oasis Valley Caldera Complex.

Bedded Tuffs between Bullfrog and Tram Members

The bedded tuffs between the Bullfrog and Tram Members include pyroclastic-fall, weathered zones, nonwelded pyroclastic-flow, and probable pyroclastic-surge deposits (fig. 34).

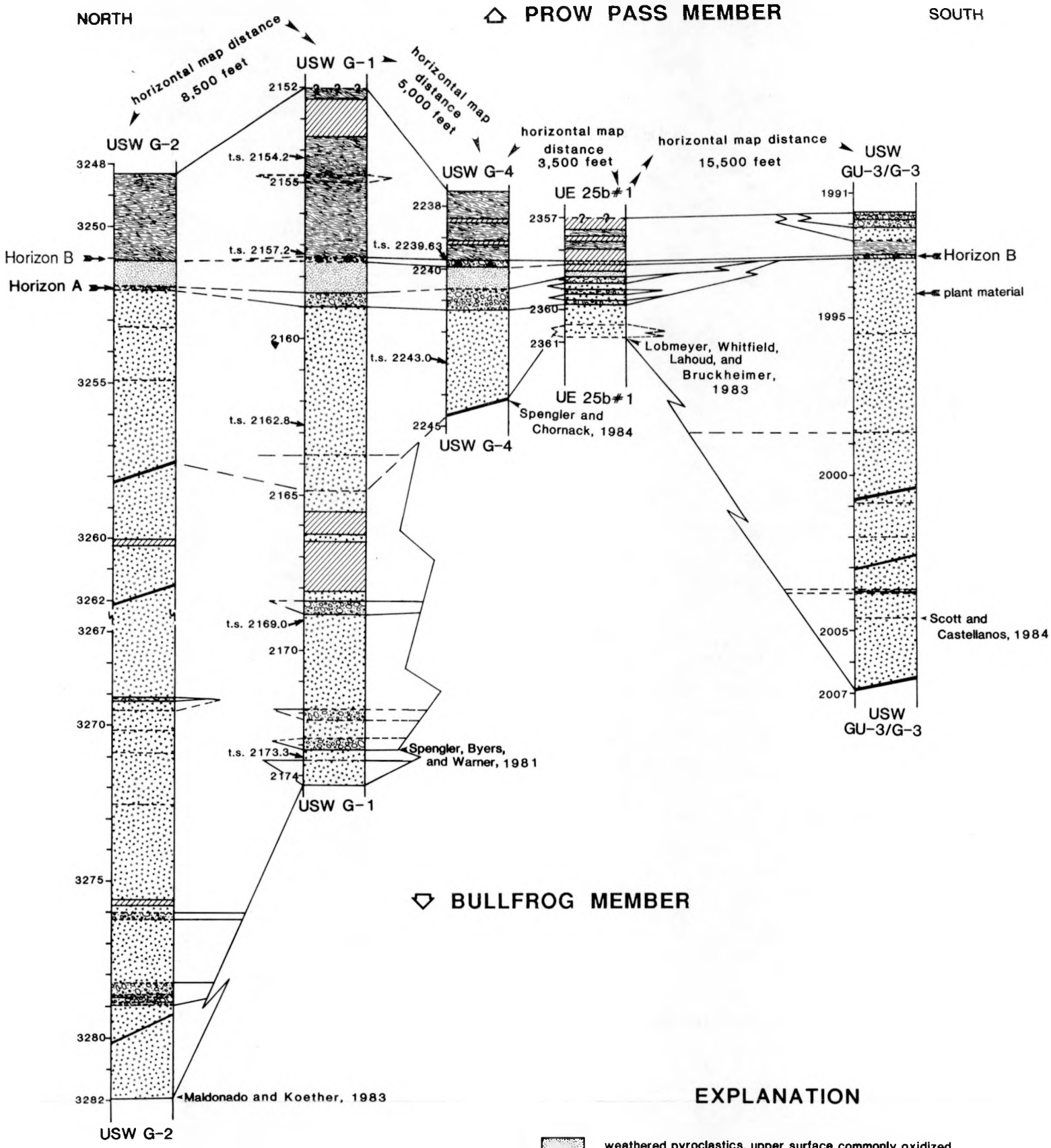
Horizon A, a time-stratigraphic line between core holes USW G-1, USW G-4, and UE25b #1, is a silty ash layer that lies within a clay-rich, nonwelded pyroclastic flow.

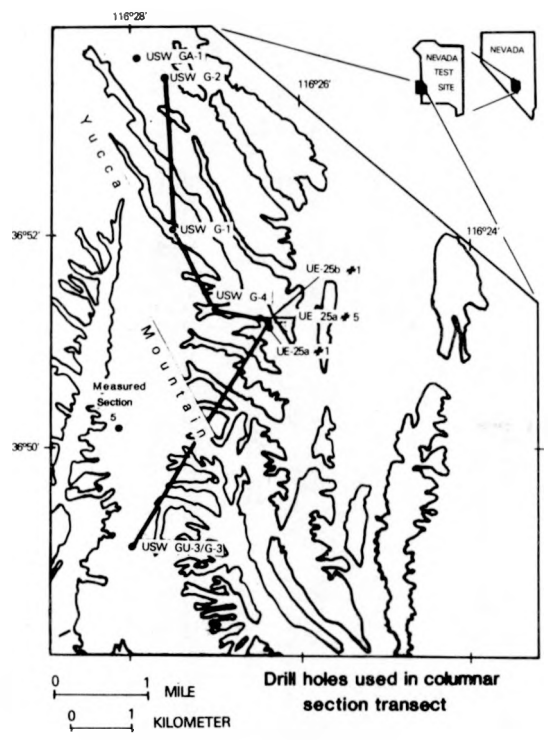
Horizon B is a consistent contact between a basal nonwelded ash-flow unit and an overlying inversely graded pyroclastic fall. Silty-ash layers within the pyroclastic-fall deposit are good marker units for correlation in all the core holes.

Horizon C is a stratigraphic contact between an inversely graded pyroclastic fall and an underlying nonwelded pyroclastic flow. A consistent silty ash layer occurs within a medium-grained pyroclastic-fall deposit that underlies a coarse-grained pumice and lithic layer of the pyroclastic-fall deposit.

Horizons D and E are stratigraphic contacts between pyroclastic-fall deposits and apparent weathered zones.

A major problem in correlating these bedded tuffs is the unusual thickness of units encountered in USW G-2. This northern area of Yucca Mountain is postulated by other authors (see fig. 34) to be in or near a caldera-fill, which may account for the greater accumulation of the bedded tuffs. The stratigraphic base of the bedded tuffs in USW G-2 was extended downward to include a newly identified pyroclastic fall.





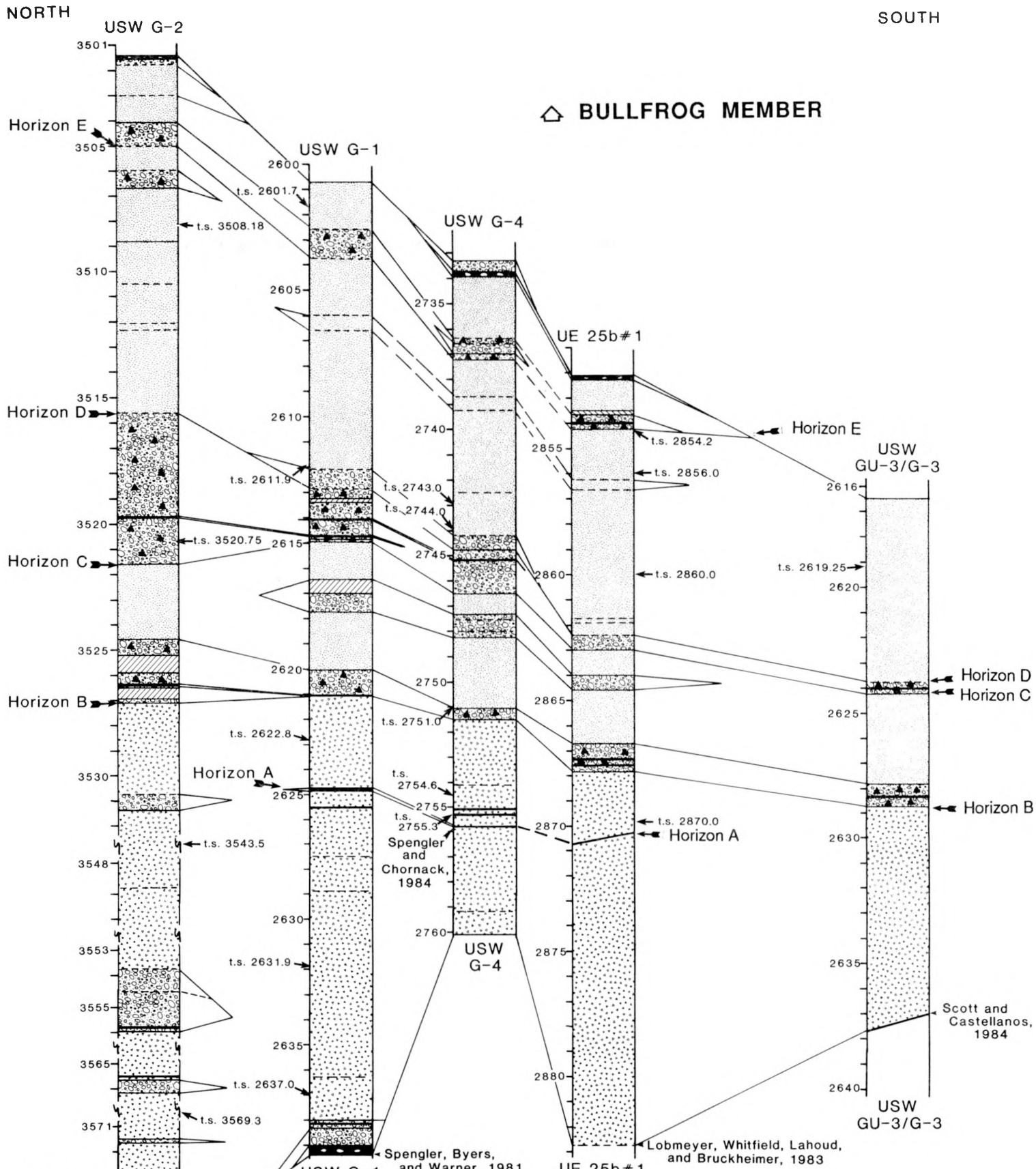
EXPLANATION

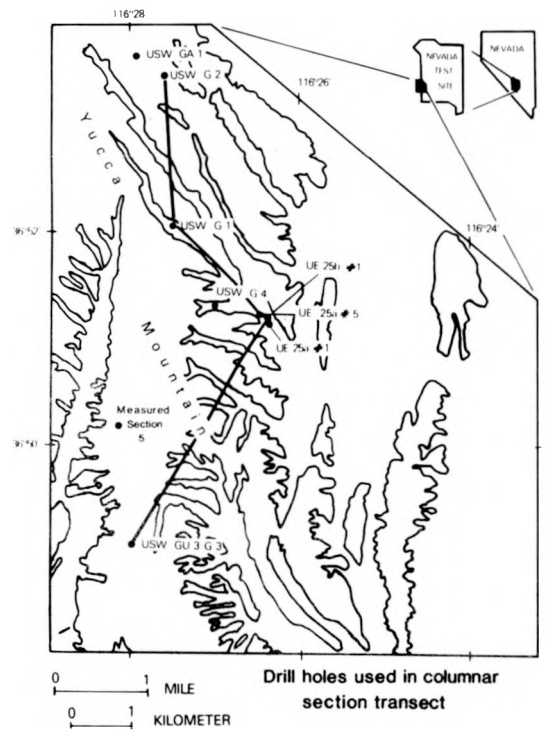
- weathered pyroclastics, upper surface commonly oxidized, red to brown
- pyroclastic surge; laminated, well-sorted , silty ash layers up to 1 cm thick; zeolitic
- pyroclastic fall
- pyroclastic fall, bedded, with silty to very fine ash beds
- pyroclastic fall, pumice-rich layers
- pyroclastic flow (?), nonwelded, upper surface may be weathered
- no sample available
- local, dipping fault
- ——— solid line represents a distinct depositional break
- - - - - dashed line denotes a texture or color change within a unit, or a gradational contact
- t.s. thin section sample location
- ϟ ϟ homogeneous section omitted

Vertical Scale
0
1
2
3 feet

References to authors indicate previously published stratigraphic boundaries.

Figure 33.--Columnar sections of bedded tuffs between Prow Pass Member and Bullfrog Member.





EXPLANATION

- weathered pyroclastics, upper surface commonly oxidized, red to brown
- pyroclastic fall
- pyroclastic fall, coarse-grained, pumice rich
- pyroclastic flow, weathered, unit contains platy clay rinds around grains, comminuted crystal material in matrix
- pyroclastic surge, convoluted bedding in silty ash layers
- silty to very fine ash beds within a unit
- no sample available
- local, dipping fault
- solid line represents a distinct depositional break
- dashed line denotes a texture or color change within a unit, or a gradational contact
- t.s. thin section sample location
- homogeneous section omitted

Vertical Scale
0
1
2 feet

References to authors indicate previously published stratigraphic boundaries.

Figure 34.--Columnar sections of bedded tuffs between the Bullfrog Member and the Tram Member

In core hole USW G-4, the base of the bedded tuffs was extended downward to 2,760.2 ft because the unit appeared to be the same above and below the thin, fine-ash layers that were previously considered to be the base.

Bedded Tuffs between the Tram Member and Lithic Ridge Tuff

Horizons A and B in the bedded tuffs at the base of the Tram Member are contacts between pyroclastic-fall deposits and weathered tuffs (fig. 35). These contacts are only observed in core holes USW G-2 and USW G-1. The correlations are based on coarse grained size and similar gray, rhyolitic lithic fragments.

Similarily, Horizons C and D are contacts between pyroclastic fall and weathered tuffs in core holes UE25b #1 and USW G-3/GU-3. Both fall units are similar in grain size and type of lithic fragments.

USW G-4 was not cored to the stratigraphic base of the Tram Member, and this creates a gap in information. Horizon E, the base of another pyroclastic-fall unit, is in holes USW G-2, USW G-1, and UE25b #1. Megascopic characteristics are similar; the unit is graded with well-defined ash layers. Within this fall deposit is a dense, gray, silty ash bed (Horizon F) that extends to core hole USW G-3/GU-3, tying the four core holes together on a time-stratigraphic line.

The bedded tuffs of the Tram Member contain highly altered, massive, poorly sorted pyroclastic material that is difficult to recognize megascopically as pyroclastic-fall deposits. The lithologic boundary for the bedded tuffs in USW G-2 was extended downward on the basis of petrographic observations that indicated a fall origin. The unusually thick section of the bedded tuffs in USW G-2 may indicate a near-vent source.

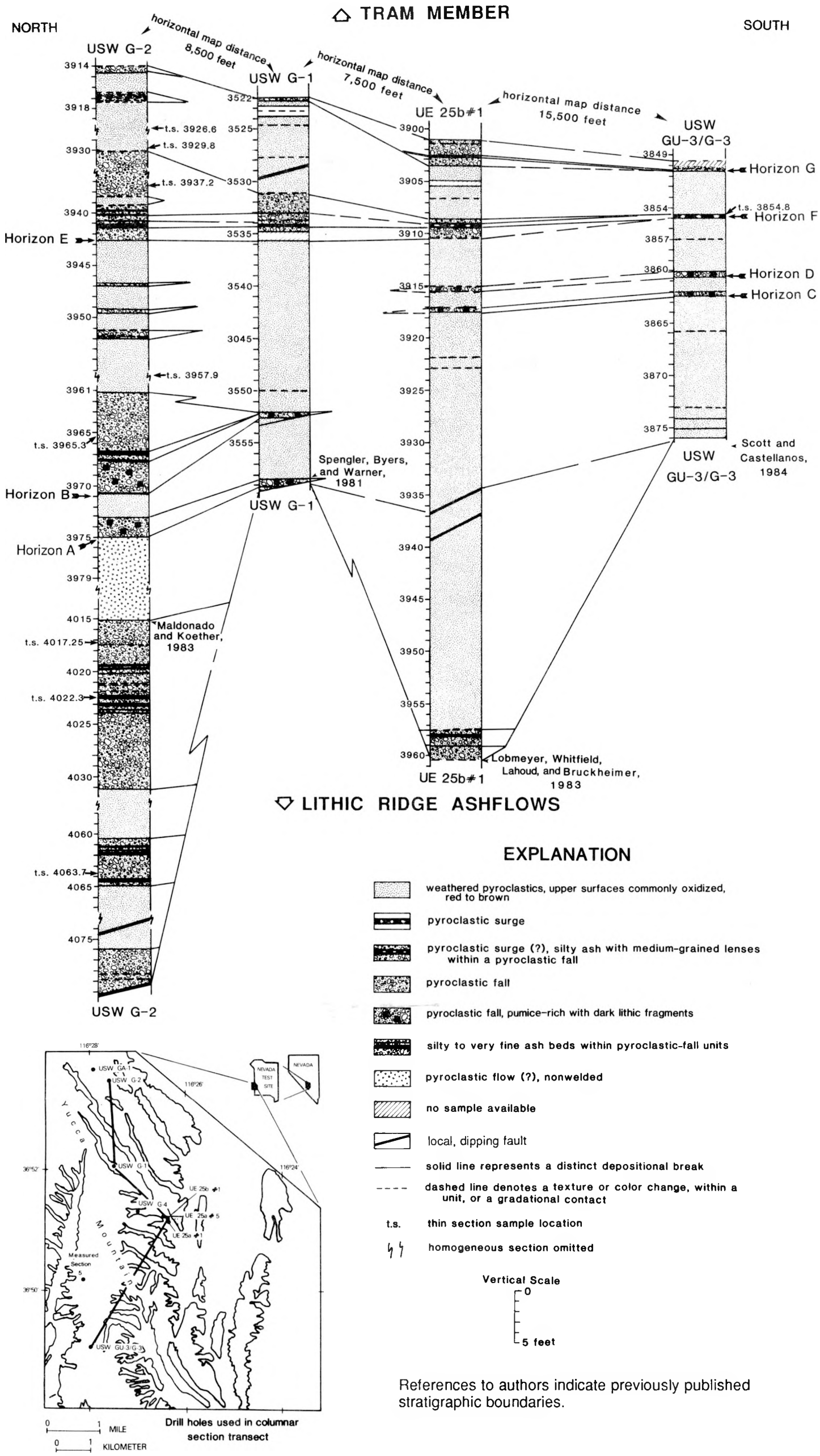
SUMMARY

Microscopic Criteria

A major objective of this study of bedded tuffs was to define depositional modes or environments of the various units, as well as microscopic criteria that would serve to separate them. Diagnostic characteristics are summarized in table 6. Previous lithologic descriptions seem to need revision. Certainly, the term "reworked" should be discontinued from usage. Most of the units previously described as reworked have been identified and described as weathered zones and pyroclastic-surge deposits.

Textural microscopic features are diagnostic of the mode of deposition of the bedded tuffs. Crystals that had fractured post-depositionally through volume changes associated with thermal expansion and contraction, are ubiquitous in pyroclastic-fall deposits. Even in the highly diagenetically altered bedded tuffs of the Crater Flat Tuff, there are fractured crystals that do not appear to have been broken under compaction.

Under the SEM, vesicle abundance and shard structures can be used to differentiate between pyroclastic-fall, -surge, and nonwelded pyroclastic-flow deposits. Pumice in pyroclastic-fall deposits is highly vesicular with many connecting pore spaces. Vesicle abundance tends to be less in the nonwelded pyroclastic-flow deposits, and is least abundant in the pyroclastic-surge units.



References to authors indicate previously published stratigraphic boundaries.

Figure 35.--Columnar sections of bedded tuffs between the Tram Member and the Lithic Ridge Tuff.

Table 6.--Features of pyroclastic deposits within the bedded tuffs at Yucca Mountain, Nevada

Type of deposit	Field and core characteristics	Petrographic characteristics	SEM characteristics
Pyroclastic fall	Bases are nonerosive; fall mantle underlying topography; thickness decreases with increasing distance from vent area.	Large, light pumice and small, dense crystals may occur together, creating a bimodal size distribution.	Vesicles in pumice are elongated or fluted with thin walls, vesicles are commonly coalesced.
	Units are normally or reversely graded.	Thermally fractured phenocrysts are held together by the surrounding pumice.	Authigenic clay platelets perpendicular to grain surfaces, forming clay rinds; authigenic zeolites, cristobalite, and potassium feldspar line voids in pumice and shards left by dissolution and in intergranular pore space.
	Well-sorted beds, internally stratified; randomly oriented pumice and tabular elements.	Pumice may act as pseudomatrix between crystals and (or) lithic fragments.	
	Forms weathered slopes.	Abundant pore space is common, but zeolites and clays may be present as cements.	
Pyroclastic surge	May mantle the topography or have an erosive base.	Laminations a few millimeters to a centimeter thick may be present.	Vesicles in shards are few and form large, curved surfaces; shards are angular.
	Rare carbonized plant fragments.		
	Small-scale antidunes common in Paintbrush surge deposits; pinch and swell structures are present.	Well-sorted crystal versus shard layers; tabular minerals and shards are aligned in flow direction.	Drop-like particles may be present.
	Planar beds with laminations and low-angle cross bedding common in Crater Flat surge deposits; convoluted bedding is present.	Fine-ash material acts as a cement; little or no pore space.	Conchoidal, stepped-fracture surfaces are common.
	Well-sorted beds of crystal and ash material in all surge deposits; pumice is rare or absent.		Adhering particles on shards.
Nonwelded pyroclastic flow	Erosive bases; commonly with an underlying rubble layer.	Poorly sorted with broken crystals; ash and commminuted material comprise matrix.	Ovoid vesicles are commonly clogged with fine-ash material; moderate amount of adherent particles; vesicles are commonly coalesced.
	Rare carbonized plant fragments.		
	Faintly graded or massive, relatively homogeneous; poorly sorted, wide range in grain size; pumice may be subrounded.	Round to ovoid vesicles in shards and pumice; many shards have highly vesiculated interiors.	Authigenic clay platelets perpendicular to grain surfaces; authigenic zeolites, cristobalite, and feldspar fill voids.
	May contain discontinuous trains of lithic material.	Hydration rims on shards.	
Weathered zones	Bases are erosional gradational into underlying units; upper contacts are sharp.	Comminuted crystal material is a part of the matrix; the scattering of the fractured crystals in fall deposits leads to poorer sorting and a greater range in grain size.	Vesicle and shard morphology are clues to the original nature of the weathered unit.
	Normal grading or massive.	Increasing grain-to-grain contacts between crystal material as degree of weathering increases; pumice grains have undergone disintegration, replacement by clays, or dissolution.	"Chunky" detrital clay particles may be present; clay platelets parallel to grain surfaces.
	Poorly sorted; pumice commonly subrounded.	Clays or iron oxides coat grains, occluding pore spaces.	Authigenic iron oxides and clay coat grains; authigenic zeolites and other minerals such as potassium feldspar and cristobalite fill voids.
	Clay matrix adds strength to unit; generally forms a cliff face.	Dessication cracks in clay matrix; forms secondary porosity.	

Cements of clay minerals and hydrated iron oxides that coate grains are indicative of oxidized, weathered zones or paleosol horizons. Two morphologies of authigenic smectitic clay were recognized: (1) A rind-forming clay with platelets parallel to the coated grain surface, and (2) a webbed clay with platelets perpendicular to the grain surface.

Zeolites in the bedded tuffs form diagenetic alteration zones with increasing depth (Moncure and others, 1981; Caporuscio and others, 1985). Heulandite and clinoptilolite are common zeolites in the shallow Paintbrush bedded tuffs. In the Calico Hills and upper Crater Flat bedded tuffs, mordenite occurs with clinoptilolite. Analcime occurs as an alteration mineral in the bedded tuffs at the base of the Tram Member. Smectite appears to be an early as well as late diagenetic product, commonly coating the intermediate-stage alteration minerals.

Lateral Continuity of the Bedded Tuffs

There are several bedded-tuff contacts that are excellent correlation horizons along the length of Yucca Mountain between core holes USW G-2 to the north and USW G-3/GU-3 to the south. These beds have sharp contacts that denote a change in mode of deposition, such as a well-bedded pyroclastic fall on a pyroclastic flow, or on an oxidized, weathered surface. Good examples are Horizon B (fig. 30), Horizon C (fig. 31), Horizon B (figs. 32, 33, 34), and Horizon A (fig. 35). These horizons are reliable time-stratigraphic marker beds over relatively long distances because of their lateral continuity.

For short distances between individual core holes, the megascopic physical features of the bedded-tuff deposits--types of lithic fragments, sorting, presence of silty ash beds, or percentages of the components--are good correlation tools.

Discrepancies in locating the contacts between the bedded-tuff units and the pyroclastic-flow deposits are common in the literature. These discrepancies, missing units, and gradual lateral changes were resolved in this study by laying out and comparing the core samples.

The source for the Crater Flat Tuff is uncertain. Proposed source areas are Crater Flat to the west of Yucca Mountain (Carr and others, 1986), and the Timber Mountain-Oasis Valley Caldera Complex to the north of Yucca Mountain (Byers and others, 1976). There is a simple relationship in all the Crater Flat Tuff members; the bedded units consistently are thickest at the north end of Yucca Mountain in core hole USW G-2 and generally thinner to the south. However, at core holes USW G-3/GU-3, the bedded tuffs slightly increase in thickness, perhaps reflecting a topographic low at the time of eruption and deposition (table 7). In the USW G-2 core in the northern part of Yucca Mountain, massive, poorly sorted pyroclastic-fall beds indicate near-source deposits.

Furthermore, the well-laminated pyroclastic-surge deposit below the base of the Prow Pass Member has its greatest thickness to the north of Yucca Mountain; the laminae dip and converge to the south. Surge deposits are near-source units; therefore, the Prow Pass Member probably did not erupt from Crater Flat, but came from the Timber Mountain-Oasis Valley Caldera Complex. The laterally thinning bedded-tuff units also indicate that the Bullfrog and Tram Members have a source area from the northern calderas.

Table 7.--Thickness of bedded units between members of the Crater Flat Tuff
[Leaders (---), indicate no data]

Bedded units at base of:	USW G-2	USW G-1	USW G-4	UE25b #1/UE25a #1	USW GU-3/G-3
Prow Pass.....	33.60	22.40	5.00	4.70	15.20
Bullfrog.....	74.43	38.75	27.20	30.58	22.00
Tram.....	165.40	36.30	---	59.20	25.60

ACKNOWLEDGMENTS

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APPENDIX 1

Lithologic description of bedded tuff core between Tiva Canyon, Yucca Mountain, Pah Canyon, and Topopah Spring Members

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-Color Chart, Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW GU-3

Bedded tuffs at base of Tiva Canyon Member

Stratigraphic and lithologic description (starting depth 373.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), or weathered tuff(?), moderate-yellowish-brown, poorly sorted, moderately indurated; pumice, pale-red, grayish-orange, grayish-orange-pink, 20-25%, angular to subangular; lithic fragments, abundant gray- to -black glass shards, grayish-red volcanic lithic fragments, 15%. (Core is missing from 374.10 to 374.45 ft)	0.80	374.50
Pyroclastic fall, pinkish-gray with pale-yellowish-brown silty zones, weathered at top, moderately to well-sorted, well-indurated, medium-grained; pumice, pinkish-gray, grayish-orange-pink, >50%; lithic fragments, gray- to -black glass, grayish-red, medium-light-gray volcanic lithic fragments, 3%. Particle size averages 2 mm. Components are angular to subangular. (Core is missing from 377.30 to 378.45 ft)	3.50(?)	378.00(?)
HORIZON J		
Weathered tuff, moderate-yellowish-brown, poorly sorted, well-indurated; pumice, pinkish-gray, grayish-orange, 10-12%; lithic fragments, gray- to -black glass shards, grayish-red, olive-black, medium-dark-gray volcanic lithic fragments. Components are angular to subangular. Gradational contact with underlying fall deposit. (Note: 3 ft of core lost in 10-ft core run to 388.80 ft)	2.80	380.80
HORIZON I		
Pyroclastic fall, pinkish-gray, moderate- to well-sorted, moderately indurated, coarse-grained; pumice, pinkish-gray, 70%, up to 1 cm; lithic fragments, clear- to -gray glass shards, light-brown, medium-gray, very-dusky-red volcanic lithic fragments, 10-15%. Components are angular to subangular	1.60(?)	381.60(?)

Lithologic log of USW GU-3--Continued

Bedded tuffs at base of Tiva Canyon Member

Stratigraphic and lithologic description (starting depth 373.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall or weathered fall, grayish-orange, moderately sorted, well-indurated; pumice, very-pale-orange, grayish-orange, some light-gray, up to 2 cm, most pumice 2-3 mm, 40%; lithic fragments, grayish-red volcanic lithic fragments, 1-2%	1.10(?)	382.70(?)
HORIZON H		
Weathered tuff, light-brown, poorly sorted, moderately indurated; pumice, grayish-orange-pink, light-gray, moderate-orange-pink, 10%, increases downhole, pumice up to 1 cm diameter; lithic fragments, glass shards, grayish-red volcanic fragments, <1%	5.50(?)	388.20(?)
HORIZON G		
Pyroclastic fall, silicified at top, fine-ash component is pale-yellowish-brown with white pumice, moderate to poorly sorted, well-indurated; pumice, yellowish-gray, white, light-gray, 15-20%, up to 2 cm; lithic fragments, black, very-dusky-red, 1-2%. Components are subangular to subrounded. At 389.90 ft, fall becomes coarse-grained, yellowish-gray, lacks the pale-yellowish-brown matrix; pumice, yellowish-gray, 70%; lithic fragments, gray- to -black glass shards, medium-gray, grayish-red volcanic fragments, 7-10%. Components are angular to subangular	3.50	391.70
HORIZON F		
Weathered tuff, light-brown, moderate-yellowish-brown, poorly sorted, moderate to well-indurated; pumice, very-pale-orange, moderate-orange-pink, 10-15%, increases downhole to 20%, subangular to subrounded; lithic fragments, black glass, grayish-red, medium-gray, moderate-reddish-orange, volcanic lithic fragments, 3%, angular. Color becomes pale-yellowish-brown towards base. Fault at 399.80 ft. (Note: 3.4 ft of core lost in 10-ft core run.)	8.10	399.80

Lithologic log of USW GU-3--Continued

Bedded tuffs at base of Tiva Canyon Member

Stratigraphic and lithologic description (starting depth 373.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), yellowish-gray silty ash bed, dips 65°; cut by fault, .05 in. offset	0.20	400.00
HORIZON E		
Pyroclastic fall, pale-yellowish-orange, color grades into mottled moderate-reddish-brown and grayish-orange at 401.00 ft, alteration colors, argillic, poorly sorted, poorly to moderately indurated; pumice, very-pale-orange, grayish-orange, stained red by iron oxide, 20-25%(?), subangular to subrounded; lithic fragments, black glass, black Topopah Spring caprock, mafic-rich dacitic(?) lithic fragments, medium-gray volcanic fragments. Unit is highly altered to clay. Moderate-brown at base	8.30	408.30
Pyroclastic fall(?), altered to moderate, reddish-brown at top, grades downhole to medium-gray, poorly sorted, poorly to moderately indurated; pumice, light-gray, moderate-orange-pink, pumice is compressed, fused, up to 40%; lithic fragments, light-gray volcanic lithic fragments, 1%. White, silty ash bed from 414.50 to 414.60 ft, well-indurated. Fused, light- to medium-gray pyroclastic fall continues to base	15.60	423.90

Measured section 5 (outcrop locality) of bedded tuffs at base of Yucca Mountain Member, West Yucca Mountain

Stratigraphic and lithologic description	Thickness of interval (ft)
Pyroclastic fall(?), white, light-gray, moderately sorted; pumice, white, coarse-grained	.4
Weathered tuff, oxidized, moderate-yellowish-brown, poorly to moderately sorted; pumice, very-pale-orange, grayish-orange, 10-15%; lithic fragments, light-gray glass, medium-gray volcanic fragments, 5%	1.50
Pyroclastic fall, white, light-gray, well-sorted, poorly indurated. Mostly covered by talus	1.00(?)
Weathered tuff, light-brown, poorly sorted well-indurated; pumice, pinkish-gray, grayish-orange-pink; lithic fragments, gray- to -black glass shards, grayish-red volcanic lithic fragments	2.00
Pyroclastic fall, very-light-gray, moderately sorted, moderately indurated, coarse-grained; pumice, very-light-gray, pinkish-gray, up to 1 cm; lithic fragments, clear- to -gray glass shards, medium-gray, grayish-red volcanic fragments	3.0
Pyroclastic fall or weathered fall, grayish-orange-pink, moderately sorted, well-indurated; pumice, very-pale-orange, grayish-orange; lithic fragments, grayish-red	1.50
Weathered tuff, light-brown, poorly sorted, well-indurated; pumice, light-gray, grayish-orange-pink, 10%; lithic fragments, clear- to -gray glass shards, grayish-red volcanic fragments	2.3
Pyroclastic fall, white- to pinkish-gray, zones of light-brown fine ash, moderately sorted, moderately indurated; pumice, very-light-gray, pinkish-gray; lithic fragments, gray glass shards, medium-light-gray, grayish-red volcanic fragments	3.5
Pyroclastic fall, pinkish-gray, yellowish-gray, very coarse-grained, poorly sorted; pumice, pinkish-gray, yellowish-gray; lithic fragments, medium-gray, grayish-red volcanic fragments	2.5

Measured section 5 (outcrop locality) of bedded tuffs at base of Yucca Mountain Member, West Yucca Mountain--Continued

Stratigraphic and lithologic description	Thickness of interval (ft)
Weathered tuff, light-brown, poorly sorted, well-indurated; pumice, moderate-orange-pink, very-light-gray, pale-pink; lithic fragments, medium-gray, grayish-red volcanic fragments	3.0
Pyroclastic fall, very-pale-orange, pale-yellowish-orange, grades into mottled moderate-reddish-brown and grayish-orange, moderately sorted, poorly indurated; pumice, very-pale-orange, grayish-orange; lithic fragments, black glass, black Topopah Spring caprock, dacitic(?) lithic fragments, medium-gray, grayish-red volcanic fragments	11.8
Pyroclastic flow, moderate-reddish-brown, nonwelded, poorly to moderately indurated; pumice, moderate-reddish-brown, pinkish-gray, yellowish-gray; lithic fragments, grayish-red, medium-gray	6.2
Pyroclastic fall(?), moderate-reddish-brown, moderately indurated; pumice, moderate-reddish-brown, grayish-pink, pale-red; lithic fragments, medium-gray volcanic fragments	3.0
Pyroclastic fall, medium-light-gray, moderately indurated; pumice, medium-light-gray, light-gray, 90% of rock	9.0

Lithologic log of USW G-4

Bedded tuffs at base of Yucca Mountain Member

Stratigraphic and lithologic description (starting depth 148.8 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
(Note: In a 10-ft drill run, only 3.60 ft were recovered)		
Pyroclastic fall, inversely graded, well-sorted, moderately indurated, pale-red silty ash bed at base with a moderate-reddish-brown oxidation layer; grades upward into a coarse pumice and lithic-fragment zone; pumice, pale-red, grayish-orange, 25%, up to 1.5 cm diameter; lithic fragments, grayish-red, moderate-brown, black glass, 15-20%, up to 4 mm diameter	0.15(?)	148.90(?)
Weathered tuff, pale-yellowish-brown, moderately sorted, well-indurated; pumice, pinkish-gray, 15%; lithic fragments, black glass shards, grayish-red and medium-gray volcanic fragments, 10%	3.10(?)	152.00(?)
Pyroclastic fall, inversely graded, pale-yellowish brown, pinkish-gray, well-sorted beds, poorly to moderately indurated; basal unit is a silty, pale-yellowish-brown ash layer; middle unit is medium-grained, composed of pinkish-gray pumice (>50%), and grayish-red, light-brown, lithic fragments (10%); top unit is a coarse-grained pinkish-gray pumice and grayish-red lithic-fragment zone.	6.00(?)	158.00(?)
(Note: In a 10-ft drill run, only 3.5 ft of core were recovered)		
Pyroclastic fall, grayish-orange, moderately sorted; pumice, very-pale-orange, 35%; lithic fragments, black, medium-gray, pale-reddish-brown, 1-2%; average particle size is 1 mm	0.90(?)	158.90(?)
Weathered tuff(?), moderate-reddish-brown, poorly sorted, poorly to moderately indurated; pumice, grayish-orange-pink, moderate-orange-pink, 7-10%, up to 5 mm diameter; lithic fragments, medium-light-gray, grayish-red, 5%, up to 3 mm diameter	2.70(?)	160.70(?)

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Yucca Mountain Member

Stratigraphic and lithologic description (starting depth 148.8 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, light-gray, moderate- to well-sorted, poorly indurated, bronze biotite present; pumice, light-gray, yellowish-gray, >50%; lithic fragments, grayish-red, light-gray glassy shards, 7%	7.50(?)	168.20(?)

Lithologic log of USW G-4

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 188.00 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff(?), moderate-yellowish-brown, poorly sorted, poorly to moderately indurated; (Note: only 2 ft of core were recovered from a 10-ft core run); pumice, grayish-orange, very-pale-orange towards base, 7-10%; lithic fragments, grayish-red, medium-gray, 3-5%. Sanidine and biotite present. Fault contact at base	10.50(?)	198.50(?)
Weathered tuff, yellowish-gray, poorly sorted, poorly to moderately indurated; pumice, white, very-pale-orange, 5-7%; lithic fragments, grayish-red, 1%	0.30	198.80
Pyroclastic fall, weathered at top, nonwelded, moderate-yellowish-brown, grades into yellowish-gray with streaky moderate-reddish-orange alteration, conspicuous biotite, coarse-grained, poorly to moderately sorted, poorly to moderately indurated; pumice, very-pale-orange, yellowish-gray, light-gray, 20%; lithic fragments, grayish-red, black, up to 4 cm, 5%. Near vertical fault at 202.20 ft, moderate-reddish-orange staining. Grades into yellowish-gray, poorly indurated at 210.00 ft. [Note: 3 ft of core lost in recovery]. At 218.00 ft, fall is coarse-grained, very-pale-orange, poorly sorted, poorly to moderately indurated, conspicuous biotite; pumice, moderate-yellowish-brown, very-pale-orange, yellowish-gray, 40%; lithic fragments, black Topopah Spring caprock, pale-red-brown, 7%. Occasional dark-gray, unconsolidated, mafic-rich dacitic(?) lithic fragments. Sanidine and biotite present	29.20	228.00
HORIZON B		
Pyroclastic flow or weathered flow(?), moderate-yellowish-brown, poorly sorted, poorly to moderately indurated; large pumice fragments, light-gray, white 5-7%, up to 4 cm; lithic fragments, grayish-red, 3-5%. Gradational contact with underlying flow	4.60	232.60

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 188.00 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON A		
(Note: Only cuttings were available from USW G-1 drill hole.)		

Lithologic log of UE25a #1

Bedded tuffs at base of Tiva Canyon Member

Stratigraphic and lithologic description (starting depth 217.10 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, fault contact at top, light-brown, moderate-yellowish-brown, poorly sorted, poorly indurated; pumice, light-brownish-gray, pale-red-purple, minor very-pale-orange, 10%, argillic; lithic fragments, black Topopah Spring caprock, gray glass, 1%	0.70	217.80
Pyroclastic fall light-brownish-gray, moderately sorted, poorly indurated; pumice, light-brownish-gray, pale-red-purple, >50%; lithic fragments, grayish-red, black. Concentration of manganese oxide(?) at base	0.90	218.70

Lithologic log of UE25a #5

Bedded tuffs at base of Yucca Mountain Member

Stratigraphic and lithologic description (starting depth 167.00 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, grayish-pink with a moderate-reddish-orange oxidation layer at the base, coarse-grained, poorly to moderately sorted, poorly indurated (not well represented in core); pumice, grayish-pink, up to 40%; lithic fragments, grayish-red, 10-15%	0.10(?)	167.10(?)
Weathered tuff, pale-reddish-brown, poorly sorted, well-indurated; pumice, grayish-pink, pinkish-gray, 15%, up to 5 mm; lithic fragments, light-gray glass, medium-gray volcanic fragments, 3-5%. Core is missing from 168.80 to 169.50 ft	2.60	169.70
Pyroclastic fall, pinkish-gray, moderately to well-sorted, moderately to well-indurated; pumice, pinkish-gray, grayish-pink, >50%, partially argillic; lithic fragments, gray glass, moderate-reddish-brown, grayish-red volcanic fragments, 10-15%. Core is missing from 170.40 to 171.10 ft and from 174.00 to 174.80 ft. At 174.00 ft, there are white, pinkish-gray, coarse pumice fragments which may have come from the above fall unit	4.30(?)	174.00(?)
Weathered tuff(?), pinkish-gray, pale-reddish-brown, poorly sorted, poorly to moderately indurated; pumice, grayish-pink, white, 15%, partially argillic; lithic fragments, dark-reddish-brown, grayish-red, 7%. Core is missing from 175.10 to 175.70 ft	1.50(?)	175.50(?)
Weathered pyroclastic flow(?), moderate-reddish-orange, poorly sorted, moderate- to well-indurated; pumice, grayish-pink, pinkish-gray, 7-10%; lithic fragments, gray glass, 1%. Core is missing from 177.40 to 178.00 ft and from 178.50 to 185.30 ft.	9.80(?)	185.30(?)

(Note: The Pah Canyon Member ash flows are not exposed as far south as USW GU-3/G-3.)

Lithologic log of UE25a #1

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 239.50 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff(?), moderate-yellowish-brown, grayish-orange, poorly sorted, moderately indurated, grades into unaltered nonwelded flow; pumice, very-pale-orange, 5-7%, size increases with depth to 2 cm; lithic fragments, grayish-red, 2%. Biotite present. Fault at 239.50 and 242.20 ft	5.2	244.70
Pyroclastic fall, color change at 244.70 ft from above unit to yellowish-gray, pale-yellowish-brown. [Core missing from 245.70 to 246.10 ft]. Interval from 246.10 to 247.00 ft is pale-reddish-brown, poorly sorted; pumice, light-gray, 10-15%; lithic fragments, black, medium-gray, grayish-red, 5%	2.30	247.00
Pyroclastic fall, pale-reddish-brown, light-brown, moderately sorted, poorly to moderately indurated; pumice, light-gray, grayish-orange, 25%; lithic fragments, grayish-red, moderate-reddish-brown, black, 10%	0.25	247.25
Pyroclastic fall, pale-reddish-brown, light-brown, poorly sorted, poorly to moderately indurated; pumice, yellowish-gray, light-gray, 10%, increases downhole to 15%; lithic fragments, black, grayish-red, 5-7%. Gradational contact with underlying unit	1.25	248.50
Pyroclastic fall, pale-reddish-brown with moderate-reddish-orange streaky alteration, poorly to moderately sorted beds, poorly to moderately indurated; pumice, light-gray, grayish-orange-pink, grayish-orange, up to 40%; lithic fragments, black, grayish-red, lithic fragment-rich interval at 248.60 ft, up to 4 mm. (Core missing from 248.70 to 249.90 ft). Contact is missing	0.50(?)	249.00(?)

Lithologic log of UE25a #1--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 239.50 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON D		
Pyroclastic fall, light-gray, yellowish-gray, poorly sorted, moderately indurated, hornblende and biotite present; pumice, very-pale-orange, yellowish-gray, 20%; lithic fragments, black Topopah Spring caprock, grayish-red, light-brown. Occasional dark-gray, unconsolidated mafic-rich, dacitic(?) lithic fragments, which are used for correlation. (Core is missing from 250.20 to 251.20 ft and 252.40 to 253.60 ft). Fault at 251.60 ft	8.20	257.20
Pyroclastic fall, bedded zone from 257.30 to 257.40 ft, coarse lithic fragment-rich layer overlies a grayish-orange silty ash bed	0.20	257.40
HORIZON C		
Pyroclastic fall, light-gray, yellowish-gray, poorly sorted, moderately indurated; pumice, very-pale-orange, yellowish-gray, 15-20%; lithic fragments, black, grayish-red, moderate-reddish-brown, 7%	8.60	266.0
Pyroclastic fall, moderate-yellowish-brown, poorly sorted, poorly indurated; pumice, grayish-orange, very-light-gray, 7-10%; lithic fragments, medium-light-gray, moderate-red, 5%. Grades into underlying pyroclastic fall	0.40	266.40
Pyroclastic fall, moderate-yellowish-brown, moderate- to well-sorted beds, poorly to moderately indurated; pumice, very-pale-orange, grayish-orange, light-gray, 35%; lithic fragments, medium-gray, grayish-red, 15%. Medium-grained pumice and lithic-fragment layer overlies a grayish-orange-pink silty ash bed	0.10	266.50

Lithologic log of UE25a #1--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 239.50 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON B		
Weathered pyroclastic flow, light-brown, moderate-yellowish-brown, poorly sorted, poorly to moderately indurated; pumice, grayish-orange-pink, light-gray, 7% near top of unit, grades downhole to 3%; lithic fragments, grayish-red, 5% near top. Gradational contact into underlying pyroclastic fall	3.50(?)	270.00(?)
HORIZON A		

Lithologic log of USW G-2

Bedded tuffs at base of Yucca Mountain Member

Stratigraphic and lithologic description (starting depth 340.0 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
(Note: In a 10-ft drill run, only 2.7 ft of core were recovered)		
Pyroclastic fall, possibly weathered at top (brown, oxidized); pumice, white, light-gray, pinkish-gray, locally up to 40%, angular; lithic fragments, medium-gray glassy shards, moderate-reddish-orange, up to 40% in interval from 343.30 to 343.85 ft.	4.40(?)	344.40(?)
(Note: In a 6.5-ft drill run, only 4.6 ft of core were recovered.)		
Pyroclastic flow, nonwelded, white, pinkish-gray, poorly indurated at top, grades down to well-indurated, poorly sorted; pumice, pinkish-gray, white, light-gray at top, 15-20%, up to 5 cm, subrounded; lithic fragments, gray- to -black-glass shards, dark-reddish-brown, moderate-brown volcanic fragments, 5%, up to 2 cm, angular to subangular. Thin pyroclastic fall at 375.15 ft. Texture change in flow, pinkish-gray, poorly sorted, well-indurated; pumice, white, 7-10%, up to 2.5 cm; lithic fragments, black glass, moderate-reddish-orange, dark-reddish-brown, medium-gray volcanic fragments, 7-10%, up to 2.5 cm, angular. Coarser-sized lithic fragments apparent. Unit is poorly indurated from 398.00 ft to the base.	143.50(?)	487.90(?)
(Note: In a 10-ft drill run, only 6.60 ft of core were recovered.)		
Pyroclastic fall, oxidation layer at top of unit, white, appears to be normally graded, well-sorted, poorly indurated; pumice, white, >50%; lithic fragments, light-gray glass, very-dusky-red volcanic fragments, 15%	0.55(?)	488.45(?)
Weathered tuff, dark-yellowish-brown, pale-yellowish-brown, poorly sorted, moderately indurated at top, poorly indurated downhole; pumice, white, grayish-orange, light-gray, very-pale-orange, 7-10%, angular to subangular; lithic fragments, gray- to -black glass, medium-gray, grayish-red volcanic fragments, 5%, angular	5.00(?)	493.00(?)

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Yucca Mountain Member

Stratigraphic and lithologic description (starting depth 340.0 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), rubble encountered resembling fall material at 493.00 ft, white, light-gray, poorly to moderately sorted, poorly indurated; pumice, very-pale-orange, very-light-gray, white, >50%; lithic fragments, gray glass, grayish-red, very-dusky-red volcanic fragments, 10%	3.00(?)	496.00(?)
Weathered pyroclastic flow(?), nonwelded, pale-yellowish-brown, grayish-orange, poorly sorted, poorly indurated; pumice, very-pale-orange, grayish-orange, white, 10-15%, up to 5 cm; lithic fragments, grayish-red up to 5 mm	2.00(?)	498.00(?)

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 730.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, moderate-yellowish-brown, silicified, poorly sorted, well-indurated; pumice, very-pale-orange, 5%, rounded; lithic fragments, dark-reddish-brown, medium-light-gray, 2%, angular. Unit is mainly silty ash	0.15	730.85
Pyroclastic fall, moderate-reddish-brown oxidized top, slightly weathered; grades to moderate-yellowish-brown, poorly sorted, well-indurated; pumice, light-gray, yellowish-gray, 10%, coarse, up to 2 cm, subangular, contains biotite; lithic fragments, medium-light-gray, dark-gray, moderate-brown, blackish-red, 5-7%, angular, up to 0.8 cm. At 733.00 ft, pumice is predominantly moderate-orange-pink, increases to 15%. (Core is missing from 734.50 to 734.70 ft). Contact missing	3.85	734.70
Pyroclastic fall, moderate-reddish-orange, poorly sorted; coarse pumice and lithic fragments, up to 3 cm from 734.70 to 735.10 ft; medium-grained, average diameter of components 3 mm, lithic-rich base at 735.20 ft. Pumice, moderate-orange-pink, yellowish-gray, up to 25% in basal unit; lithic fragments, black, grayish-red, 15%	0.50	735.20

HORIZON D

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 730.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, oxidized at top, grayish-orange, yellowish-gray, conspicuous biotite, poorly sorted, well-indurated to 737.20 ft; pumice, grayish-orange-pink, very-pale-orange, 7%, subangular to subrounded, up to 2 cm; lithic fragments, blackish-red, grayish-red, 2%, up to 3 cm. Unit is poorly indurated from 737.20 to 739.60 ft. Character of tuff changes at 739.60 ft, well-indurated, very-pale-orange, yellowish-gray, poorly sorted; pumice, yellowish-gray, pinkish-gray, 25%; lithic fragments, dark-reddish-brown, grayish-red, light-brown, 7-10%. Poorly indurated from 741.30 to 734.00 ft. (Due to the poor induration of the core, it is difficult to assign footages at depositional changes.) Moderately indurated at 743.00 ft, color change to grayish-orange, poorly sorted, moderately indurated; pumice, very-pale-orange, grayish-orange, 15-20%; lithic fragments, grayish-red, dark-reddish-brown, 3%. Occasional dark-gray, unconsolidated mafic-rich, dacitic lithic fragments are a good stratigraphic correlation tool	10.05	745.30
Pyroclastic fall, normally graded, light-brown, moderately sorted, poorly to moderately indurated, coarse pumice and lithic fragments, silty ash layer with white pumice at base; pumice, very-pale-orange, >50% in top of unit; lithic fragments, dark-reddish-brown, 7%	Thin section at 745.70 0.40(?)	745.70(?)
HORIZON C		

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 730.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, grayish-orange, poorly sorted, poorly to moderately indurated; pumice, very-light-gray, very-pale-orange, 10%, angular to subrounded; lithic fragments, medium-gray, dark-reddish-brown, 5%, angular. (Core is missing from 751.00 to 753.00 ft). The interval from 753.00 to 754.20 ft contains very coarse pumice and lithic fragments; pumice, pinkish-gray, grayish-orange, very-light-gray, up to 3 cm; lithic fragments, moderate-red, grayish-brown, up to 3 cm. Unit grades to moderate-yellowish-brown, moderate-brown at 754.20 ft, poorly sorted; pumice, grayish-orange, very-light-gray, moderate-orange-pink, 10-15%; lithic fragments, very-dusky-red, grayish-red, medium-gray, 3-5%	Thin section at 755.10 9.40	755.10
Pyroclastic fall, moderate-reddish-brown, well-sorted, well-indurated, silicified, interbedded silty ash to coarse-grained pumice layers; pumice, grayish-orange, grayish-orange-pink, very-pale-orange, grayish-green, up to 35%; lithic fragments, dark-reddish-brown, dark-gray, up to 15%. Moderate-reddish-brown silty ash layers show mantle and sag structures	3.35	755.35
HORIZON B		

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Pah Canyon Member

Stratigraphic and lithologic description (starting depth 730.70 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic flow, nonwelded, moderate-yellowish-brown, light-brown, conspicuous biotite, poorly sorted, well-indurated; pumice, grayish-orange, light-gray (derived from underlying flow(?)), 10-15%; lithic fragments, grayish-red, dark-reddish-brown, 3%	4.05	759.40

HORIZON A

APPENDIX 2

Lithologic description of bedded tuff core
between Topopah Spring Member and tuffaceous beds of Calico Hills

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 ft or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-color Chart,
Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW GU-3

Bedded Tuffs at Base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,406.4 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, well-sorted beds, grayish-brown at top, silty ash with very-pale-orange pumice to 1,406.5 ft, moderately indurated; basal pumice and lithic layer; pumice, grayish-orange-pink, 20%; lithic fragments, moderate-brown, medium-gray, grayish-black, 10-15%. Contact is irregular with underlying weathered unit	0.20	1,406.60
Weathered tuff, moderate-brown, oxidized top of fall, poorly to moderately indurated; pumice, light-brown, grayish-orange-pink, subrounded, 20%; lithic fragments, moderate-brown, medium-gray, grayish-black, 10-15%	0.90	1,407.50
HORIZON C		
Pyroclastic fall, light-brownish-gray, light-gray, moderate- to well-sorted, poorly indurated, vitric; pumice, pinkish-gray, argillic, >50%; lithic fragments, moderate-brown, medium-gray, yellowish-gray, up to .7 cm, but generally <.1 cm	5.40	1,412.90

Lithologic log of UE25a #1

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,360.0 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, grayish-red-purple fine-grained ash layer at top of unit; pumice and lithic-fragment-rich zone beneath, pinkish-gray, yellowish-gray, poorly to moderately sorted, well-indurated; pumice, pinkish-gray, grayish-yellow, pale-red, moderate-orange-pink, 10-12%, light-gray, dark- gray, 20-25%, angular to subangular, up to 2 cm. Pumice and lithic fragments decrease in size at 1360.50 ft. Gradational contact with underlying unit	0.50	1,360.50
Weathered tuff, pumice- and lithic fragment-rich zone at top, grayish-pink, very-pale-orange, moderate-orange-pink, moderate- to well-sorted, well-indurated, decreases in size towards base; pumice, grayish-pink, moderate-orange-pink, 25-30%, subangular to subrounded; lithic fragments, dark-reddish-brown, moderate-brown, 15%, subrounded. (Core missing from 1,360.6 to 1,361.8 ft)	1.50	1,362.00
HORIZON C		
Pyroclastic fall, black clay(?) layer at 1,362.05 ft), pale-red to grayish-red-purple, moderate- to well-sorted, well-indurated; pumice, grayish-red-purple, pale-red-purple, pale-pink, 50%, subangular, some flattening of pumice; lithic fragments, moderate-brown, dark-reddish-brown, 15-20%, angular to subangular. (Core missing from 1,362.30 to 1,362.6 ft and 1,363.4 to 1,363.9 ft). Contact missing	1.70	1,363.70

Lithologic log of UE25a #1--Continued

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,360.0 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, moderate-reddish-brown, concentration of coarser pumice- and lithic-fragments at top of unit, poorly to moderately sorted, well-indurated; pumice, moderate-orange-pink, pale-red, 15%, subangular; lithic fragments, medium-dark-gray, dark-gray, grayish-brown, 10%, angular to subangular. Pyrolusite at 1364.00 ft. Gradational contact with underlying Calico Hills pyroclastic flow	0.46	1,364.16

Lithologic log of USW G-4

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,406.9 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), moderate-orange-pink, silty to medium-grained ash layer, moderately sorted, well-indurated, zeolitic(?)	0.10	1,407.00
Weathered tuff, moderate-reddish-brown, poorly sorted, well-indurated, zeolitic(?); pumice, grayish-red-purple, pale-pink, pale-red-purple, light-olive, 15-20%, subrounded; lithic fragments, black, moderate-brown, 1-2%, subangular. Some pyrolusite staining, biotite and hornblende present. Coarser grained towards base. Contact is missing; core is missing from 1,408.0 to 1,408.8 ft	1.50(?)	1,408.50(?)
HORIZON C		
Pyroclastic fall, pale-grayish-red-purple, light-brownish-gray, moderately to well-sorted, well-indurated; pumice, light-brownish-gray, moderate-orange-pink, grayish-red-purple, 35%, subangular to subrounded; lithic fragments, dusky-red, light-brown, 10%	0.90(?)	1,409.40(?)

Lithologic log of USW G-1

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,403.3 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic fall, grayish-yellow, yellowish-gray, moderately sorted, well-indurated, faint bedding; pumice, grayish-red, moderate-brown, 10-15% in layers, subrounded; lithic fragments, grayish-brown, 2%, angular, up to 0.3 cm diameter; pyrolusite staining	0.70	1,404.00
Pyroclastic surge(?) or fall(?), light-brownish-gray, yellowish-gray, distorted silty ash beds at top and bottom of unit, silicified; pumice, light-brown, 5%; lithic fragments, dark-reddish-brown, medium-dark-gray, 1%. Soft-sediment deformation	0.10	1,404.10
Weathered tuff, light-brown, pale-brown, mottled, poorly to moderately sorted, well-indurated; pumice, grayish-red, grayish-red-purple, 15%, subrounded to rounded; lithic fragments, moderate-brown, dusky-brown, 10%, subangular. Gradational contact with underlying unit	Thin section at 1,405.0 1.80	1,405.90
HORIZON C		
Pyroclastic fall, pale-red-purple at top to pinkish-gray at base, moderately to well-sorted, well-indurated; pumice, grayish-red-purple, pale-red, moderate-orange-pink, 40% (locally >50%); lithic fragments, moderate-brown, dusky-brown, 5%, increasing downhole to 10%. (Core is missing from 1,406.3 to 1,407.5 ft). At 1,406.3 ft, oxidized zone. Silty ash layer at 1,408.05 ft, thinly bedded from 1,408.05 to 1,408.10 ft	Thin section at 1,407.65 2.35	1,408.25
Weathered tuff, moderate-reddish-brown, poorly sorted, well-indurated, oxidized at top; pimice pale-pink, grayish-red-purple, 10-15%, subrounded to rounded; lithic fragments, dusky-brown, 5%, subangular. Unit is grayish-orange-pink, moderately sorted towards base. (Core missing from 1,410.55 to 1,411.50 ft). Contact missing	2.75	1,411.50

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,403.3 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, bedded, possible weathering, reddish-brown, pale-red-purple, moderately sorted, moderately indurated; pumice, grayish-red-purple, yellowish-gray, minor moderate-greenish-yellow, pale-red-purple, up to 35-40% in layers, angular; lithic fragments, grayish-brown, grayish-red, dusky-brown, up to 25% in layers (especially at base)	1.30	1,412.30
Weathered tuff, moderate-reddish-brown, oxidized, poorly sorted, well-indurated; pumice, pale-pink, grayish-red-purple, 10%, subangualar to subrounded, minor (1%) moderate-greenish-yellow pumice/lithic fragments; lithic fragments; grayish-brown, moderate-brown, 5%. (Core is missing from 1,413.10 to 1,415.20 ft). Contact missing	1.70	1,414.00
Pyroclastic fall, only basal section represented in core, coarse-pumice and lithic-fragment zone, well-sorted, well-indurated; pumice, grayish-orange-pink, grayish-red-purple, moderate-orange-pink, minor moderate-greenish-yellow, 35%; lithic fragments, blackish-red, dark-reddish-brown, 7-10%	1.30	1,415.30
HORIZON B		
Weathered tuff, moderate-reddish-brown at top, grades downhole to moderate-reddish-orange, poorly sorted, well-indurated; pumice, pale-red-purple, pale-pink, minor moderate-greenish-yellow pumice/lithic fragments, 15%, subangular to subrounded; lithic fragments, blackish-red, dark-reddish-brown, 10%, angular. Gradational contact with underlying pyroclastic fall	1.20	1,416.50
Pyroclastic fall, well-sorted beds, light-brownish-gray, grayish-red-purple, well-indurated, silicified; pumice, light-brownish-gray, pale-red-purple, pale-red, minor moderate-greenish-yellow, >50%, angular to subangular; lithic fragments, dark-reddish-brown, blackish-red, 15%, angular. Silty, silicified ash layers at 1,418.10 ft, and 1,418.80 to 1,418.90 ft	Thin section at 1,416.00 and 1,419.10 2.60	1,419.10

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,403.3 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON A		
Weathered tuff, oxidized at top, moderate-reddish-orange, poorly sorted, well-indurated; pumice, grayish-red-purple, pale-red-purple, yellowish-gray, moderate-greenish-yellow, 15%, angular; lithic gragments, dark-reddish-brown, moderate-brown, 2-3%. Gradational contact with underlying unit	1.85	1,420.95
Weathered pyroclastic fall(?), moderately sorted beds, moderate-reddish-orange, light-brownish-gray, well-indurated; pumice, grayish-red-purple, moderate-greenish-yellow, yellowish-gray at top of unit, up to 35%; lithic fragments, medium-dark-gray	0.35	1,421.30
Pyroclastic flow(?), pale-moderate-reddish-orange, poorly sorted, well-indurated; pumice, pale-red-purple, grayish-red-purple, 10%, local pumice-rich zones up to 20%, iron-oxidation rims on pumice; lithic fragments, moderate-reddish-orange, dark-reddish-brown, blackish-red, 5%. (Core missing from 1,423.30 to 1,425.50 ft). Contact missing	4.30(?)	1,425.50(?)

Lithologic log of USW G-2

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,701.00 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, inversely graded, well-sorted beds, pale-pink, moderate-orange-pink, well-indurated; pumice, moderate-orange-pink, pale-red-purple, (moderate-greenish-yellow pumice/lithic fragments), 40-45%, up to 2.5-cm-diameter in top layer; lithic fragments, very-dusky-red, dark-reddish-brown, up to 3-cm-diameter in top layer	1.00	1,702.00
HORIZON B		
Weathered tuff, moderate-orange-pink, poorly sorted, well-indurated; pumice, moderate-orange-pink, grayish-orange-pink, pale-greenish-yellow, 15-20%, angular to subangular; lithic fragments, very-dusky-red, dark-gray, 5%, increase to 10% downhole. Gradational contact with underlying unit	Thin section at 1,702.50 1.45	1,703.45
Pyroclastic fall, pale-red, well-sorted beds, inversely graded, moderate- to well-indurated; pumice, pale-red, grayish-orange-pink, moderate-orange-pink, minor moderate-greenish-yellow, >50%; lithic fragments, very-dusky-red, 10%. Silicified, silty ash beds at 1,706.00 ft (moderate-orange-pink) and 1,706.80 to 1,706.90 ft (light-red to pale-red)	3.65	1,707.10
HORIZON A		
Weathered tuff, pale-reddish-brown, poorly sorted, well-indurated; pumice, moderate-orange-pink, pale-red, minor pale-greenish-yellow, 7%, subrounded, coarse pumice at top, up to 1.5 cm; lithic fragments, grayish-red, 2-3%, subrounded; pyrolusite staining. Gradational contact with underlying unit	2.05	1,709.15
Pyroclastic fall, bedded, inversely graded, pale-pink, grayish-orange-pink, well-sorted, well-indurated, silicified; pumice, grayish-orange-pink, moderate-orange-pink, pale-red, minor pale-greenish-yellow, >50% lithic fragments, blackish-red, dark-reddish-brown, 5%, up to 20% in basal lithic fragment-rich layer. Silty ash bed from 1,711.25 to 1,711.50 ft, pale-reddish-brown	Thin section at 1,710.00 2.50	1,711.65

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,403.3 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, faintly bedded, pale-reddish-brown, moderately sorted, well-indurated; pumice, moderate-orange-pink, moderate-greenish-yellow, 7-10%; lithic fragments, very-dusky-red, olive-gray, dark-reddish-brown, grayish-red-purple, 5%. Color change from 1,712.40 to 1,712.80 ft, grayish-orange-pink, moderately sorted, well-indurated. Gradational contact with underlying unit	1.15	1,712.80
Pyroclastic flow, pale-reddish-brown, weathered at top, (1,712.80 to 1,713.40 ft), nonwelded, poorly sorted, well-indurated, moderate-orange-pink; pumice, moderate-orange-pink with pale-red rims, very-pale-orange, pale-red, moderate-pink, pale-greenish-yellow, 10%, occasional pumice up to 3 cm; lithic fragments, moderate-reddish-brown, blackish-red, 5-7%, up to 0.6 cm. From 1,728.60 to 1,734.40 ft, large pumice/lithic fragment-rich zone; pumice up to 8.0 cm and lithic fragments up to 2.0 cm. At 1,738.55 and 1,738.90 ft, moderate-greenish-yellow alteration layers, pumice increase downhole to 15%	28.20	1,741.00
Pyroclastic fall(?), bedded, light-red, moderate-orange-pink, poorly to moderately sorted, silicified from 1,741.00 to 1,741.20 ft, silty light-red ash with pale-pink pumice (10%, up to 1 cm) and very-dusky-red lithic fragments (2%, up to 1 cm). Moderate-red, thin, silty ash at 1,741.20 ft. From 1,741.20 to 1,741.55 ft, moderate-orange-pink; pumice, moderate-orange-pink, grayish-yellow, 5%; lithic fragments, very-dusky-red, 5%. Thin, pale-red silty ash layers at 1,741.40 and 1,741.45 ft. Faint lithic fragment layer at base. Gradational contact with underlying unit	0.70	1,741.70
Weathered tuff, moderate-pink, poorly sorted, well-indurated; pumice, moderate-orange-pink, moderate-greenish-yellow, 10%; lithic fragments, moderate-brown, dark-gray, 5%	0.80	1,742.50

Thin section at 1,714.00, 1,719.90, 1,724.00 and 1,735.60

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Topopah Spring Member

Stratigraphic and lithologic description (starting depth 1,403.3 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff(?), moderate-orange-pink, poorly sorted, well-indurated, very coarse-grained pumice and lithic fragments, up to 2 cm; pumice, grayish-orange-pink, minor moderate-greenish-yellow, light-brown, argillic; lithic fragments, dark-gray, moderate-reddish-brown	Thin section at 1,743.90 2.30	1,744.80
Weathered pyroclastic fall(?), moderate-orange-pink, faintly bedded, poorly to moderately sorted, well-indurated; pumice, grayish-orange-pink, moderate-orange-pink, pale-greenish-yellow, argillic, 25%; lithic fragments, very-dusky-red, dark-gray, 7%. Dark-yellowish-brown fine ash layer from 1,737.50 to 1,737.62 ft. (Core missing from 1,745.00 to 1,745.70 ft; lower contact is missing)	0.90(?)	1,745.70(?)
Pyroclastic fall(?), moderate-orange-pink, poorly to moderately sorted, well-indurated, very coarse-grained pumice and lithic fragment unit separted by thin lithic fragment-free zones at 1,746.35 and 1,746.65 ft; pumice, moderate-orange-pink, moderate-reddish-orange, moderate-greenish-yellow, 35-40%; lithic fragments, moderate-brown, grayish-purple,dark-gray, 20%. From 1,749.85 to 1,749.90 ft, pale-reddish-brown silty ash with moderate-orange-pink pumice. At 1,751.6 ft, pumice(?) blocks as much as 24 cm in diameter with a moderate-reddish-brown matrix. Base of lithic fragment-rich pyroclastic fall at 1,753.55 ft. Pumice is fractured; tectonic disturbance(?)	Thin section at 1,751.40 8.85	1,754.55
Pyroclastic fall(?), moderate-reddish-brown matrix with grayish-orange-pink pumice(?) blocks, poorly sorted, well-indurated. Pink pumice(?) is argillic, fractured with infilling of reddish matrix. At 1,755.0 ft, there is a depositional break, possible distorted ash layers at base	1.80	1,756.55
Pyroclastic fall(?), bedded, moderate-orange-pink, moderate-to well-sorted, well-indurated; pale-olive staining, pale-reddish-brown silty ash at base	0.45	1,757.00

APPENDIX 3

Lithologic description of bedded tuff core between tuffaceous beds of Calico Hills and Prow Pass Member

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 ft or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-color Chart, Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW G-3

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,506.5 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, well-sorted silty ash to coarse-grained pumice and lithic beds, yellowish-gray, moderately indurated; pumice, yellowish-gray, white, >50% at base of unit, zeolitic; lithic fragments, moderate-reddish-orange, dark-reddish-brown, black glass, up to 40% in layers	0.50	1,507.00
Weathered tuff, pale-yellowish-brown, poorly sorted, moderately indurated, grades into bedded fall; pumice, very-pale-orange, white, 10-15%, zeolitic, subrounded; lithic fragments, black glass, moderate-brown, medium-light-gray, 10-15%, angular to subrounded	0.50	1,507.80
Pyroclastic fall, yellowish-gray, moderately sorted beds, poorly to moderately indurated; pumice, very-pale-orange, white, >50% in layers, zeolitic, subrounded; lithic fragments, black glass, moderate-brown, angular, up to 20% in layers	0.45	1,508.25
Weathered tuff, yellowish-gray, poorly to moderately indurated; pumice, white, very-light-gray, very-pale-orange, 10-15%, zeolitic, subangular to subrounded; lithic fragments, black glass, medium-gray volcanic fragments, 7-10%, angular	1.06	1,509.31(?)
Pyroclastic fall(?), white, pale-yellowish-gray, well sorted beds with weathered(?) interval from 1,509.55 to 1,509.85 ft; pumice, very-pale-orange, very-light-gray, >50% in many layers, zeolitic, subangular to subrounded; lithic fragments, black glass, moderate-brown, medium-light-gray, up to 40% in layers, lithic fragment-rich at base	0.72	1,510.03
Weathered tuff, pale-yellowish-brown, poorly sorted, poorly indurated; pumice, very-light-gray, very-pale-orange, 10%, zeolitic; lithic fragments, moderate-brown, black glass, 5-7%. Moderate-brown, lithic-fragment-rich pyroclastic fall(?) from 1,512.00 to 1,512.15 ft. Coarse-grained pumice and lithic fragment-rich pyroclastic fall(?) from 1,513.75 to 1,514.00 ft	4.62	1,514.65

Lithologic log of USW G-3--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,506.5 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), yellowish-gray, very-pale-orange, pale-yellowish-brown, bedded, silty ash layers (up to .35 ft thick) with coarse pumice and lithic beds, light-brown iron-oxide layers, poorly to moderately indurated; pumice, moderate-orange-pink, yellowish-gray, very-light-gray, up to 30% in layers, zeolitic; lithic fragments, dark-reddish-brown, moderate-brown, black glass, up to 20% in layers	3.71	1,518.36
Weathered tuff, very-pale-yellowish brown, poorly sorted, moderately indurated; pumice, yellowish-gray, very-pale-orange, 20-25%, zeolitic, subangular, up to 1.5 cm; lithic fragments, medium-gray, black glass, 5%, angular, up to .8 cm. Unit grades into a pumice-rich zone downhole	1.44	1,519.80
Pyroclastic fall(?), unit is pumice-rich, gradational contact above and below, pale-yellowish-brown, moderate-orange-pink, moderately sorted and indurated; pumice, very-pale-orange, moderate-orange-pink, 25%, zeolitic, subangular; lithic fragments, black glass, medium-light-gray, 5%, angular	0.38	1,520.18
Weathered tuff, pale-yellowish-brown, poorly sorted, moderately indurated; pumice, very-light-gray, very-pale-orange, yellowish-gray, 20%, zeolitic; lithic fragments, medium-light-gray, dark-reddish-brown, 5%, black glass, moderate-greenish-yellow fragments towards base of unit	Thin section at 1,525.00 5.14	1,525.32
Pyroclastic fall, bedded, pale-yellowish-brown, yellowish-gray, well sorted beds, thin, silty to very-fine ash layers at the top, moderately indurated; pumice, yellowish-gray, very-pale-orange, moderate-orange-pink, zeolitic; lithic fragments, dark-reddish-brown, medium-gray, black glass, some moderate-greenish-yellow fragments	1.48	1,526.80

Lithologic log of USW G-3--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,506.5 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, pale-yellowish-brown, poorly sorted, moderately indurated, conspicuous biotite; pumice, very-pale-orange, very-light-gray, 7-10%, zeolitic, subrounded; lithic fragments, dark-reddish-brown, moderate-brown, 7%, subangular	0.54	1,527.34
Pyroclastic fall, very-pale-orange, moderately well-sorted beds, poor to moderately indurated; pumice, very-pale-orange, moderate-orange-pink, 40%, zeolitic, subangular to subrounded; lithic fragments, dark-reddish-brown, grayish-red, minor pale-greenish-yellow fragments, 10%, angular	0.71	1,528.05
Weathered tuff, pale-yellowish-brown, poorly sorted, moderately indurated, conspicuous biotite; pumice, very-pale-orange, moderate-orange-pink, 10-15%, subangular; lithic fragments, dark-reddish-brown, grayish-red, 7%, angular to subangular	2.63	1,530.68
Pyroclastic fall(?), moderately sorted bedding, very-pale-orange, moderately indurated; pumice, very-pale-orange, moderate-orange-pink, 35%; lithic fragments, moderate-brown, grayish-red, 15-20%	0.47	1,531.15
Weathered tuff, pale-yellowish-brown, poorly sorted, moderately to well indurated, biotite conspicuous; pumice, white, very-pale-orange, moderate-orange-pink, 7-10%, subangular; lithic fragments, dark-reddish-brown, medium-gray, 7%, angular. Closed, mineral-filled fracture at 1,535.2 ft. Lithic fragment and pumice grain size increase downhole to 1,537.7 ft. Medium-grained, weathered zone between 1,537.7 and 1,537.90 ft	Thin section at 1,535.00 6.75	1,537.90

Lithologic log of USW G-3--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,506.5 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, pale-yellowish-brown, poorly to moderately sorted, moderately to well indurated, conspicuous biotite steeply-dipping fracture zone between 1,539.0 and 1,540.0 ft; pumice, very-pale-orange, white, 5-7%; lithic fragments, dusky-brown, moderate-brown, medium-light-gray. Pumice and lithic fragment grain size increase downhole. Color change occurs from 1,546.60 to 1,547.37 ft, dark-yellowish-brown, well indurated. Occasional large floating pumice (up to 1.5 cm) and lithic fragments (up to 1.5 cm). Pale-yellowish-brown, weathered tuff continues, possibly a flow; poorly sorted, moderately to well indurated; conspicuous biotite; pumice, very-pale-orange, average 10%, local, very-rich-pumice zones from 1,549.40 to 1,550.80 ft, 25%; lithic fragments, grayish-red, medium-light-gray, 5-7%	14.57	1,552.47
Pyroclastic surge(?), pale-brown, silty ash beds with dessication cracks at top, middle and bottom of unit, conspicuous biotite, well-sorted, well-indurated; pumice, very-pale-orange, 1-2%, zeolitic; rare lithic fragments	1.09	1,553.56
Pyroclastic flow (weathered?), pale-yellowish-brown, poorly sorted, well-indurated; pumice, very-pale-orange, pale-pink, moderate-orange-pink, 5-7%, zeolitic; lithic fragments, medium-gray, grayish-brown, moderate-brown, 1%. Contact was placed at a fracture at 1,560.30 ft by Scott and Castellanos (1984). Unit is poorly indurated below fracture	6.74	1,560.30

Thin section at 1,541.20

Lithologic log of UE25a #1

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,789.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff(?), pale-reddish-brown to pale-brown, well-indurated, zeolitic; pumice, very-pale-orange, pale-yellowish-orange, minor pale-red-purple; lithic fragments, dark-gray, grayish-red, blackish-red; fragments increase in grain size downhole, tuff is pale-yellowish-brown	1.50	1,790.80
Pyroclastic fall(?), pumice-rich zone, yellowish-gray to pale-olive; pumice, yellowish-gray, pale-olive, flattened; lithic fragments, dark-reddish-brown, grayish-red-purple, medium-gray	.52	1,791.32
Weathered tuff, dark-reddish-brown at top, grades downhole to yellowish-gray, grain size coarsens in bedded fall deposits towards base	Thin section at 1,792.3 1.43	1,792.75
Pyroclastic fall, yellowish-gray to grayish-yellow, interbedded fine- to coarse-grained layers, well-indurated, zeolitic; pumice, yellowish-gray, pale-greenish-yellow; lithic fragments, dark-reddish-brown, very-dusky-red. At 1,794.40 ft, tuff grades into a fine- to medium-grained tuffaceous sandstone or pyroclastic fall, grayish-orange-pink, yellowish-gray; pumice, yellowish-gray, very-pale-orange; lithics, dark-reddish-brown, very-dusky-red	Thin section at 1,792.00 5.75	1,798.50(?)
(Note: Core is missing from 1,798.20 to 1,799.30 ft.		
Weathered tuff, grayish-orange-pink at top, pale-brown to pale-yellowish-brown at base	2.20	1,800.70
Pyroclastic fall, graded bedding, fine ash layers from 1,800.70 to 1,801.15 ft; medium- to coarse-grained from 1,801.15 to 1,801.58 ft, pale-olive; oxidized layer at 1,801.85 ft.		
(Note: Core missing from 1,802.70 to 1,803.50 ft.)		

Lithologic log of UE25a #1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,789.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, well indurated, zeolitic; fine-ash beds from 1,803.50 to 1,803.64 ft, 1,803.90 to 1,803.98 ft and 1,804.11 to 1,804.21 ft,		
HORIZON C		
greenish-gray; interbedded coarse-grained pumice layers are yellowish-gray, pale-pink; lithic fragments, dark-reddish-brown, very-dusky-red, medium-gray	3.80	1,804.50
Weathered tuff, pale-brown, well-indurated, zeolitic; pumice, yellowish-gray; lithic fragments, moderate-brown, dark-reddish-brown	Thin section at 1,805.2 0.76	1,805.26
Pyroclastic fall, grayish-pink, grayish-orange-pink, well-indurated, zeolitic; pumice, grayish-orange-pink. At 1,806.06 ft, the fall is coarser grained; pumice, yellowish-gray, pale-grayish-orange-pink; lithic fragments, dark-reddish-brown. Core missing from 1,807.4 to 1,807.9 ft. From 1,808.80 to 1,809.32 ft, grain size decreases	4.06	1,809.32
HORIZON B		
Weathered tuff, pale-yellowish-brown at top. Core missing from 1,809.7 to 1,810.30 ft. Weathered tuff below missing core moderate-red; pumice, pale-yellowish-orange, pale-greenish-yellow, yellowish-gray; lithic fragments, dark-yellowish-brown, moderate-brown	2.87	1,812.19
Pyroclastic fall(?), .01 inch thick silty ash layer at top, pumice-rich zone	0.42	1,812.61
Weathered tuff, moderate-red at top. Core missing from 1,812.80 to 1,813.70 ft. At 1,813.79 ft, tuff is pale-yellowish-brown, yellowish-gray; pumice, moderate-greenish-yellow (at top), grayish-yellow, pale-greenish-yellow, very-pale-orange; lithic fragments, moderate-brown. Core missing from 1,814.80 to 1,815.20 ft	2.59	1,815.20(?)

Lithologic log of UE25a #1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,789.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, grayish-pink at top; pumice, grayish-pink, yellowish-gray; lithic fragments, moderate-brown, very-dusky-red. Pyroclastic fall is yellowish-gray, coarser-grained than above. From 1,818.62 to 1,819.33 ft, unit is bedded, light-brownish-gray, grayish-orange-pink, fine- to medium-grained. At 1819.33 tuff is coarse-grained. Core missing from 1,819.40 to 1,820.32 ft	Thin section at 1,816.00 5.12(?)	1,820.32(?)
Weathered pyroclastic flow(?), moderate-red, well-indurated; pumice, moderate-orange-pink, white. At 1,823.60 ft, dessication cracks in a silty ash layer. Weathered unit continues, very-fine-ash layers to medium-grained, dark-reddish-brown	5.08	1,825.40
Weathered pyroclastic flow(?), moderate-reddish-brown; pumice, white, very-pale-orange, 7-10%; lithic fragments, black, medium-dark-gray, 3-5%. Core missing from 1,827.70 to 1,828.75 ft. At 1,830.60 ft, there is a yellowish-gray, silty ash, discontinuous bedding due to dessication cracking(?). From 1,829.70 to 1,830.00 ft, the unit is yellowish-gray, pale-reddish-brown, has a streaked appearance, pyrolusite at base, silicified. Poorly indurated at 1,831.3 ft. Moderate-reddish-brown tuff continues to base	Thin section at 1,825.43 6.80	1,832.20
HORIZON A		
Pyroclastic flow, moderate-reddish-orange at top, moderate-red, fiamme, streaked appearance, moderately indurated, zeolitic; pumice, yellowish-gray; lithic fragments, dark-reddish-brown, black. Iron-oxide stained, closed, irregular fractures at 1,835.70 ft	Thin section at 1,835.00 3.50	1,835.70
Weathered pyroclastic flow, yellowish-gray; pumice, yellowish-gray, very-pale-orange, 5-7%; lithic fragments, black, moderate-brown, 2%	1.00	1,836.70

Lithologic log of USW G-4

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,705.45 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, moderately sorted beds, silty to pebble-size layers, moderate-orange-pink, moderate-reddish-orange, light-olive-brown, zeolitic, silicified; pumice, pale-greenish-yellow, grayish-orange-pink, flattened towards base; lithic fragments, blackish-red, dusky-red, minor reddish-orange. At 1,708 ft, pumice has altered to swelling clays along fractures	3.63	1,709.08
Weathered tuff, moderate-yellowish-brown, pale-reddish-brown, at 1,712.0 ft, tuff grades into a pale-yellowish-brown, then to a pinkish-gray, poorly sorted, components are very angular; pumice, yellowish-gray, very-pale-yellow, pale-greensih-yellow, minor moderate-orange-pink; lithic fragments, dark-reddish brown, medium-dark-brown, lithic fragments, dark-reddish-brown, medium-dark-gray, dark-gray, minor moderate-reddish-brown. At 1,713.0 ft, there are large lithic (up to 1 cm) and pumice (up to 2 cm) fragments. Pumice here is moderate-orange-pink, pale-greenish-yellow, yellowish-gray, 1 grayish-red-purple. From 1,713.4 to 1,714.6 ft, the unit is pale-yellowish-brown, moderately sorted. Core missing between 1,714.6 and 1,715.1 ft	Thin section at 1,710.75 6.02(?)	1,715.10(?)
Pyroclastic fall(?), interbedded fine- to coarse-grained layers, pinkish-gray, well-indurated, well-sorted. From 1,717.10 to 1,718.31 ft, fall is very-pale-orange, coarse-grained; pumice, very-pale-orange; lithic fragments, very-dark-red. From 1,718.31 to 1,719.08 ft, very fine-to medium-grained, dusky-yellow ash beds	Thin section at 1,716.00 3.98	1,719.08
Weathered tuff(?), pale-yellowish-brown; pumice, very-pale-orange, pale-greenish-yellow; lithic fragments, very-dusky-red	1.17	1,720.25

HORIZON C

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,705.45 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, bedded units, pale-olive-gray from 1,720.25 to 1,720.90 ft, very fine- to -medium and coarse-grained layers; pumice, pale-greenish-yellow; lithic fragments are minor constituents, dusky-red, very-dusky-red. From 1,720.90 to 1,722.28 ft, interbedded coarse-grained fall material with finer layers, yellowish-gray, well-sorted; pumice, yellowish-gray, very-pale-orange, pale-greenish-yellow; lithic fragments finer-grained than the pumice, dark-reddish-brown, dark-gray, blackish-red. From 1,722.28 to 1,722.34 ft, tuff is dark-yellowish-brown silty ash layer with a pale-yellowish-gray pumice layer through the middle. From 1,722.34 to 1,722.72 ft, tuff is yellowish-gray, composed of coarse pumice. From 1,722.72 to 1,723.05 ft, tuff is lithic-rich, layer steeply dipping at top, undulated, yellowish-gray; pumice, yellowish-gray, moderate-greenish-yellow; lithic fragments, pale-reddish-brown, very-dusky-red, dark-gray, grayish-black with phenocrysts. Between 1,723.05 and 1,724.00 ft, pyroclastic fall, yellowish-gray, fine- to medium-grained, minor coarse-grained pumice, moderately well-sorted; pumice, pale-greenish-yellow, very-pale-orange, yellowish-gray. Core is missing from 1,724.00 and 1,728.20 ft	5.85(?)	1,726.00(?)
(Note: Large section of core missing from 1,724.0 to 1,728.2 ft.) Pyroclastic fall, yellowish-gray, well-sorted, coarse at top, fining downhole; pumice, moderate-pink at top, yellowish-gray, very-pale-orange, pale-greenish-yellow; lithic fragments, dark-reddish-brown. Local iron-oxide staining. From 1,730.23 to 1,731.07 ft, fall is medium-grained, grayish-orange, yellowish-gray; pumice, very-pale-orange, pale-grayish-orange, yellowish-gray	5.07(?)	1,731.07(?)
HORIZON B		
Weathered tuff, dark-yellowish-brown, well-indurated, poorly sorted; pumice, white, very-pale-orange, angular; lithic fragments, dark-reddish-brown, angular	Thin section at 1,732.50 2.22	1,733.29

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,705.45 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), gradational contact, yellowish-gray, color change at 1,733.29 ft, thin, dipping, pale-reddish-brown layer at this depth; pumice, yellowish-gray, very-pale-orange; lithic fragments, dark-reddish-brown	Thin section at 1,733.50 1.51	1,734.80
Weathered tuff, pale-yellowish-brown; pumice, very-pale-orange, yellowish-gray, subangular; lithic fragments, dark-reddish-brown	Thin section at 1,736.00 2.20(?)	1,737.30(?)
(Note: Core missing from 1,737.0 to 1,737.6 ft.)		
Pyroclastic fall, grayish-pink, grayish-orange-pink, moderately well-sorted; pumice, grayish-pink, grayish-orange-pink, white; lithic fragments, moderate-brown, very-dusky-red. Towards base of tuff, pumice is pale-pink, very-pale-orange, and pale-greenish-yellow; lithic-fragment size and abundance increases	Thin section at 1,740.13 to 1,740.23/across contact 2.88(?)	1,740.18(?)
Pyroclastic fall, fine- to coarse-grained interbedded layers, moderately well-sorted, yellowish-gray at top; pumice, yellowish-gray, very-pale-orange; lithic fragments, dusky-brown. Tuff grades downhole to a pale-yellowish-brown from 1,741.22 to 1,741.55 ft, fine-grained thin layers, well-sorted, lithic-poor. From 1,741.55 to 1,742.21 ft, tuff is yellowish-gray, coarse-grained, lithic-rich; pumice, pale-greenish-yellow, pale-grayish-orange; lithic fragments, dusky- brown. Grayish-red, thin laminations at 1,742.21 and 1,742.38 ft. At base, tuff is pale-grayish-orange-pink, well-sorted, medium- to coarse-grained; pumice, moderate-orange-pink, yellowish-gray; lithic fragments, moderate-brown	2.49	1,742.67
Weathered tuff, pale-yellowish-brown, pale-brown, moderately sorted, mostly fine- to medium-grained, some coarse material; pumice, very-pale-orange, white, pale-pink at 1,747.0 ft, altered to swelling clays; lithic fragments, dark-reddish-brown, 4 cm long lithic fragment at 1,744.0 ft. Tuff grades downhole to pale-yellowish-brown, less sorted. Fine ash layer from 1,750.05 to 1,750.18 ft, pale-yellowish-brown	Thin section at 1,749.00 7.67	1,750.34

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,705.45 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow(?), moderate-red; pumice, white, pale-yellowish-orange, biotite-rich, argillic, vapor-phase crystallization; lithic fragments, dark-reddish-brown. Pumice-rich zone from 1,753.32 to 1,753.90 ft. From 1,754.25 to 1,754.61 ft, tuff is mottled, fine-grained; filled fractuee at 1,754.52 ft, medium-bluish-gray; dessication cracking. Tuff grades downhole to pale-red, grayish-red, then pale-yellowish-brown at 1,756.0 ft. From 1,757.00 to 1,758.93 ft, unit is pale-yellowish-brown, light-olive-gray; pumice, very-pale-orange, pale-yellowish-orange; lithic fragments, moderate-brown, dark-reddish-brown. Grades downhole into pyroclastic fall	8.59	1,758.93
Pyroclastic surge(?), interbedded, silty- to medium-grained layers, grayish-red at top, grades downhole to pale-brown with grayish-red intervals. Dessication cracking in top and bottom silty ash layers	2.42	1,761.35
Weathered pyroclastic flow(?), moderate-yellowish-brown at top, well-indurated, poorly sorted, contains pyrolusite; pumice, white, grayish-orange-pink, minor very-pale-orange, 10%, local pumice-rich zones; lithic fragments, dark-gray, brownish-gray, 1%	1.45	1,762.80
HORIZON A		
Pyroclastic flow(?), moderate-reddish-orange, zeolitic, argillic, contains biotite; pumice, grayish-orange, altered to clays, compressed into fiamme, numerous partings in the core; rare lithic fragments	1.90	1,764.70

Thin section at 1,752.00

Lithologic log of USW G-1

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,736.40 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, olive gray, pale yellowish brown, poorly sorted, well-indurated; pumice, grayish-orange-pink, pale-greenish-yellow, 10%; lithic fragments, very-dark-red, medium-light-gray, 5-7%; pumice and lithic fragments are subangular-to-subrounded. Gradational contact to pumice-rich zone below	1.40	1737.80
Pyroclastic fall(?), inversely graded, pale-greenish-yellow, well-sorted, well-indurated, zeolitic; pumice, pale-greenish-yellow, up to 3.5 cm at top of unit, >50%, flattened at base; lithic fragments, very-dusky-red, grayish-red, 10%	0.70	1,738.50
Weathered tuff, pale-yellowish-brown, poorly sorted. well-indurated, zeolitic; pumice, pale-greenish-yellow, white, minor pale-pink(1%), 10%; lithic fragments, dusky-red, dark-gray, 7-10%, subangular-to -subrounded	Thin section at 1,739.50 1.70	1,740.20
Pyroclastic fall, well-sorted beds, yellowish-gray, zeolitic; pumice, grayish-yellow-green, pale-greenish-yellow, dark-greenish-yellow, moderate-orange-pink, up to 25-30%, subangular; lithic fragments, dark-reddish-brown, minor medium-gray, up to 10% in beds	0.60	1,740.80
Weathered tuff, yellowish-gray, moderately well-sorted, well-indurated, zeolitic; pumice, yellowish-gray, light-greenish-gray, 7-10%; lithic fragments, dusky-red, very-dusky-red, moderate-brown, 5%, subangular-to -subrounded. Core missing from 1,741.80 to 1,743.20 ft. Contact missing	1.70	1,742.50
Pyroclastic fall, well-sorted beds, yellowish-gray to grayish-yellow-green, well-indurated,zeolitic; pumice, yellowish-gray, pale-greenish-yellow, grayish-yellow-green, pale-pink up to 25-30% in beds, subangular- to -subrounded; lithic fragments, dark-reddish-brown, 15%, angular. Fracture zone at 1,746.50 ft	Thin section at 1,743.50 4.50	1,747.00
Weathered tuff, yellowish-gray, well-indurated, poorly sorted, zeolitic; pumice, white, minor pale-yellowish-green, 10-15%; lithic fragments, dark-reddish-brown, very-dusky-red, 1-2%	0.95	1,747.95

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,736.40 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, well-sorted beds, pale-olive, yellowish-gray, pale-yellowish-brown, silicified silty ash beds, zeolitic; pumice, pale-greenish-yellow, white, grayish-orange-pink, >50% in beds;		
HORIZON C		
lithic fragments, dark-reddish-brown, grayish-red-purple, moderate-reddish-orange, lithic-rich zones up to 25% at 1,751.0 and 1,752 ft	4.45	1752.40
Weathered tuff, yellowish-gray, poorly sorted, well-indurated, zeolitic; pumice, pale-greenish-yellow, 7%, subangular; lithic fragments, dark-reddish-brown, very-dusky-red, 5%, angular to subangular. Gradational contact with underlying tuff	1.15	1,753.55
Pyroclastic fall, yellowish-gray, normally graded, well-sorted, well-indurated, zeolitic; pumice, yellowish-gray, pale-greenish-yellow, 70%; lithic fragments, dark-reddish-brown, moderate-reddish-brown, grayish-red, 15%	0.45	1,754.00
Weathered tuff, pale-reddish-brown at top, oxidized, pale-yellowish-brown, poorly sorted, well-indurated, zeolitic, pyrolusite; pumice, pale-greenish-yellow, 12%; lithic fragments, dark-reddish-brown, grayish-red, with iron-oxide rims, 5%	0.70	1,754.70
Pyroclastic fall, pale-greenish-yellow, grayish-orange-pink, well-sorted beds, well-indurated, zeolitic, fracture zone from 1,756.00 to 1,757.00 ft, no displacement; pumice, pale-greenish-yellow, grayish-orange-pink, >50%; lithic fragments, dark-reddish-brown, very-dusky-red, 15%. Iron-oxide layers at 1,759.38 and 1,759.50 ft	5.65	1,760.35
HORIZON B		

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,736.40 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, moderate-reddish-brown, oxidized, possibly a soil horizon, color change at 1,762.10 ft, yellowish-gray, poorly sorted, well-indurated, zeolitic; pumice, white, very-pale-orange, pale-greenish-yellow, 7% at top, grades downhole to 12%; lithic fragments, dark-reddish-brown, very-dusky-red, 5-7%. Core missing from 1,762.50 to 1,763.30 ft. Contact missing	2.65	1,763.00
Pyroclastic fall(?), yellowish-gray, silty ash beds are yellowish-brown, moderately sorted layers, well-indurated, zeolitic; pumice, yellowish-gray, pale-greenish-yellow, 40%; lithic fragments, very-dusky-red, moderate-reddish-brown, 5%. Possibly weathered from 1,763.80 to 1,764.25 ft	1.40	1,764.40
Weathered tuff, pale-reddish-brown, moderate-reddish-brown, oxidized, poorly sorted, well-indurated, zeolitic; pumice, white, very-pale-orange, pale-pink, 7-10%; lithic fragments, grayish-red, very-dusky-red, 3%. Pumice and lithic fragments have iron-oxide rims. Core missing from 1,766.00 to 1,767.00 ft. Contact missing	Thin section at 1,765.00 2.10	1,766.50
Pyroclastic fall, inversely graded, moderately sorted beds, yellowish-gray, pale-yellowish-brown, pale-greenish-yellow, well-indurated, zeolitic, conspicuous biotite; pumice, pale-greenish-yellow, very-pale-orange, 45% in many beds; lithic fragments, very-dusky-red, 7-10%. Iron-oxide layers at 1,771.05 and 1,771.15 ft. Thin, pyrolusite layer at contact with underlying unit	Thin section at 1,769.52 4.90	1,771.40

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,736.40 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, moderate-reddish-brown at top, color change at 1,771.80 ft, dark-yellowish-brown, pale-yellowish-brown, poorly sorted, well-indurated, conspicuous biotite, zeolitic; pumice, white, very-light-gray, minor-yellowish-green, 7-10%; lithic fragments, moderate-brown, grayish-red, 7%. Lithic fragments increase in size downhole up to 1 cm. Texture change at 1,779.30 ft. From 1,779.30 to 1.780.90 ft, weathered tuff, pale-red, pale-yellowish-brown; pumice, pale-greenish-yellow, white, contains biotite, 15%, altered-to -swelling clays; lithic fragments, medium-light-gray, moderate-reddish-brown, up to 2 mm	Thin section at 1,771.90 9.50	1,780.90
Weathered pyroclastic fall(?), at 1,780.90 ft, thin layer of fine-grained ash, pale-greenish-yellow; pumice, pale-yellowish-brown; at 1,780.95 ft, thin ash/pumice layer, argillic, grayish-orange-pink, grayish-green; iron-oxide layer, light-red, at 1,781.05 ft. Material between layers is pale-olive; pumice, grayish-yellow-green, white, 5%; rare lithic fragments	0.25	1,781.15
Weathered tuff, light-olive-gray from 1,781.05 to 1,781.45 ft; at 1,781.45 ft, apparent dark-reddish-brown fractures; color change in unit to grayish-red, poorly sorted, well-indurated, zeolitic, argillic, conspicuous biotite; pumice, white, very-light-gray, 7%; lithic fragments, grayish-olive, 1%	0.75	1,781.90

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 1,736.40 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow(?), grayish-red, pale-reddish-brown, well-indurated, poorly to moderately sorted, conspicuous biotite; pumice, yellowish-gray, very-light-gray, white, very-pale-orange, occasionally lenticular, altered- to -swelling clays, ranges from 1 to 5%, pumice-rich zone at 1,783.00 ft; lithic fragments, dark-gray, dark-reddish brown, dusky-yellow-green. Color change at 1,788.00 ft, pale-brown, pale-yellowish-brown, well-indurated, poorly sorted; at 1,792.00 ft, pumice, pale-greenish-yellow, moderate-orange-pink, very-light-gray, altered- to -swelling clays, 5-7%, pumice-rich zone at 1,793.40 ft; lithic fragments, grayish-red, dark-reddish-brown, grayish-olive, 2%. Tuff changes color to moderate-yellowish-brown, pale-yellowish-brown downhole. Iron-oxide bands at 1,795.85 and 1,795.90 ft	Thin section at 1,787.00 and 1,792.50 16.60	1,798.50
HORIZON A		
Pyroclastic flow, mottled, grayish- orange-pink, pale-olive, nonwelded, zeolitic, argillic, moderately to well-indurated; pumice, yellowish-gray, pale-greenish-yellow, white, 7-10%; lithic fragments, blackish-red, 1%. Base of unit is at a fine, moderate-orange-pink ash bed	3.00	1,801.50

Lithologic log of USW G-2

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 2,576.20 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, pale-olive, poorly sorted, well-indurated, zeolitic; pumice, grayish-yellow-green, 7%; lithic fragments, grayish-red, dark-reddish-brown, 5%. Gradational contact with underlying unit	0.55	2,576.75
Pyroclastic fall, well-sorted beds, well-indurated, zeolitic, yellowish-gray, pale-greenish-yellow, pale-red-purple; pumice, commonly flattened, grayish-red-purple, yellowish-gray, light-greenish-gray, >50%; lithic fragments, dark-reddish-brown, blackish-red, 15% in some beds. Coarse-grained pumice and lithic fragment layer from 2,576.75 to 2,577.35 ft	2.45	2,579.20
Weathered pyroclastic flow, pale-red, grayish-red, poorly sorted, well-indurated; pumice, very-pale-orange, pale-red, 7-10%; lithic fragments, medium-gray, grayish-red, 5-7%. Gradational contact with underlying unit	1.50	2,580.70
Pyroclastic fall, pale-greenish-yellow, yellowish-gray, well-sorted beds, well-indurated; pumice, pale-greenish-yellow, >50%; lithic fragments, dark- reddish-brown, grayish-red, 15%. Core missing from 2,581.00 to 2,581.70 ft. Silty ash bed at 2,581.70 ft. Pale-reddish-brown, fine-grained ash layer at 2,582.10 to 2,581.15 ft. From 2,581.15 to 2,581.25 ft, coarse pumice and lithic fragments; pumice, pale-greenish-yellow, moderate-greenish-yellow, vuggy. Sag structures in underlying		
HORIZON C		
fine-ash layer. Pink-reddish-brown, silty ash layer at 2,582.72. Core missing from 2,582.80 to 2,583.20 ft. Contact missing	2.30	2,583.00
Weathered tuff, moderate-red, poorly sorted, well-indurated, zeolitic; pumice, grayish-orange-pink, subrounded, 3% at top, increase in size and amount to base, 15-20%; lithic fragments, dark-reddish-brown, 1-2%. Color change at 2,583.80 ft, pale-reddish-brown; pumice, very-pale-orange. Conspicuous biotite	2.00	2,585.00

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Calico Hills

Stratigraphic and lithologic description (starting depth 2,576.20 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall/weathered, mottled, very-pale-orange, moderate-orange-pink, moderately sorted, well-indurated, zeolitic; pumice, very-pale-orange, 30-35%; lithic fragments, dark-reddish-brown, grayish-red, 5-7%. Gradational contact with underlying unit	1.20	2,586.20
Pyroclastic fall, moderate-orange-pink at top, very-light-gray, moderately sorted, well-indurated, zeolitic, conspicuous biotite; pumice, very-light-gray, 40%; lithic fragments, dark-reddish-brown, 10%. Iron oxides at contact	0.60	2,586.80
Weathered pyroclastic flow(?), pinkish-gray, pale-yellowish-brown, moderately sorted, well-indurated, zeolitic; pumice, very-light-gray, very-pale-orange, 10%, argillic, up to 2 cm, lenticular; lithic fragments, moderate-brown, dark-yellowish-brown, 3-5%. Color change at 2,588.10 ft, moderate-reddish-orange at top, light-brown, grayish-orange, poorly sorted, moderately indurated; pumice, very-light-gray, argillic, lenticular, 5-7%; lithic fragments, dark-reddish-brown, moderate-reddish-brown, 2%	2.30	2,589.10
Pyroclastic fall, very-light-gray, white, moderately sorted, moderate- to well-indurated, moderate-reddish-orange layer at top; pumice, white, 35-40%; lithic fragments, grayish-red, dark-reddish-brown, 15%	0.70	2,589.80
HORIZON B		
Weathered top of pyroclastic flow, pale-reddish-brown	0.20	2,590.00

APPENDIX 4

Lithologic description of bedded tuff core between Prow Pass and Bullfrog Members

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 ft or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-color Chart, Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW GU-3

Bedded tuff at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 1,991.60 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, moderately sorted beds, moderately indurated, moderate-reddish-orange, silty ash bed at top, overlies pale-red silty ash bed with coarse pumice. At 1,991.65 ft, tuff is pumice-rich, grayish-yellow, pale-greenish-yellow, moderately sorted, moderately indurated, zeolitic; pumice, pale-greenish-yellow, 10%, subangular to subrounded; lithic fragments, dark-reddish-brown mudstone, up to 1 cm, 1-2%; pyrolusite staining. At 1,991.80 ft, fine ash bed, grayish-yellow, well-sorted, well-indurated, pyrolusite; rare dark-reddish-brown mudstone lithic fragments at base of unit	0.45	1,992.05
Weathered tuff, grayish-yellow, moderately sorted, well-indurated, pyrolusite staining, zeolitic; pumice, pale-greenish-yellow, 5%, up to 1 cm, subangular to subrounded; lithic fragments, dark-reddish-brown mudstone, <1%. Gradational contact with underlying unit	0.45	1,992.50
Pyroclastic surge, well-sorted, laminated beds, light-brown, grayish-orange, moderate-reddish brown, well-indurated, zeolitic, some pyrolusite staining (dendrites); pumice, very-pale-orange, pale-greenish-yellow, up to 5%, subrounded; lithic fragments, grayish-red, <1%	0.40	1,992.90
HORIZON B		
Pyroclastic fall, pumice-rich layer above moderate-reddish-brown silty ash bed at 1,992.90 ft, Pumice-rich zone at base of unit, grayish-yellow, pale-greenish-yellow, >50%. Core missing from 1,992.30 to 1,992.70 ft	0.15	1,993.05
Pyroclastic flow, partially weathered (?), moderate-reddish-brown yellowish-gray, mottled, poorly sorted, well-indurated, zeolitic; pumice, grayish-yellow, 10%, up to 0.5 cm, subangular to subrounded; lithic fragments, grayish-red, 2-3%. Manganese-oxide staining. Hornblende present. At 1,993.95 ft, possible silicified organic material. Textural change at 1,995.50 ft, decrease in pumice to 3-5%. At 1,998.00 ft, change in pumice color, moderate-orange-pink, minor pale-greenish-yellow.		

Lithologic log of USW GU-3--Continued

Bedded tuff at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 1,991.60 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Concentration of pumice at 1,998.60 ft, white- to very-pale-orange. Fault at 2,000.70 ft, manganese oxide with slickensides. Color change at 2,000.70 ft to pale-red; pumice altered- to -swelling clays at 2,000.90 ft. Tuff grades to light-brownish-gray at 2,001.40 ft. Color change at 2,002.00 ft, pinkish-gray to yellowish-gray, moderately sorted, well-indurated, argillic at top, <1% pumice; unit between two faults/fractures. Fault at 2,002.50 ft, color and texture change, weathered, yellowish-gray, light-brownish-gray, mottled; tuff is vuggy. Color change at 2,003.00 ft, pale-greenish-yellow, moderately sorted, well-indurated, vuggy; pumice, dark-yellowish-orange, 1-2%, subrounded; lithic fragments, grayish-red, 1%, subangular to subrounded	10.65	2,003.70
Pyroclastic fall, moderately sorted, moderate- to well-indurated, pumice layer over fine-grained ash bed; pumice, greenish-yellow, pale-greenish-yellow, >50%; lithic fragments, dark-reddish-brown, moderate-yellowish-brown, 3%. Fine ash layer, pale-yellowish-brown, well sorted, well indurated	0.10	2,003.80
Pyroclastic flow, partially weathered (?) grayish-orange-pink, light-brownish-gray, mottled, well sorted, well indurated, conspicuous biotite; pumice, light-brownish-gray, altered- to -swelling clays, 3-5%; lithic fragments, grayish-red, <1%. Color and texture change at 2,004.30 ft, grayish-yellow, moderate- to well-sorted, well-indurated; pumice, yellowish-gray, altered- to -swelling clay, 5%; lithic fragments, medium-light-gray, grayish-orange, 1%. Grayish-black zone at 2,004.60 ft, possible carbonaceous material. Color and texture change at 2,004.70 ft, light-brown, well sorted, well indurated, conspicuous biotite; pumice, very-pale-orange, medium-light-gray, 3%; lithic fragments, dark-reddish-brown, medium-gray, 1%. Fault contact at 2,006.80 ft, silicified zone, clay coating on fault surface. Color change across fault contact	3.00	2,006.80

Lithologic log of UE25b #1--Continued

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 2,356.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge, yellowish-gray, grayish-yellow, pale-red, moderate-red-silty layer at top, well sorted, well indurated, zeolitic, patches (up to 0.5 cm) of moderate-olive-brown discoloration (2%); pumice, pale-greenish-yellow, grayish-yellow, 3%, subrounded; lithic fragments, dark-gray, 3-5%, subangular, up to 0.1 cm. Pale-red coloration occurs in thin (0.5 cm) bands. At 2,357.50 ft, thin, moderate-reddish-brown and moderate-olive-brown layer. Thin, dark-reddish-brown layer near base of unit	2.10	2,358.45
HORIZON B		
Pyroclastic fall(?), zeolitic; concentration of pumice and lithic fragments, moderately sorted, well indurated; pumice, grayish-yellow, pale-greenish-yellow, 50%; lithic fragments, grayish-red-purple, medium-bluish-gray, medium-gray, 10-15%. Gradational contact with underlying unit	0.05	2,358.50
Weathered tuff, moderate-red, dark-reddish-brown, moderately sorted, well indurated; pumice, grayish-yellow, pale-greenish-yellow, 3-5%, up to 0.5 cm, subangular to subrounded; lithic fragments, dark-gray, grayish-black, grayish-olive mudstone(?), 1%. Gradational color change at contact, very-pale-orange and moderate-red, mottled. Gradational contact with underlying unit	0.40	2,358.90
Pyroclastic fall, grayish-yellow, pale-greenish-yellow, zeolitic, moderately sorted, well indurated; pumice, grayish-yellow, pale-greenish-yellow, 50% subangular, pumice may have moderate-red rims; lithic fragments, medium-light-gray, grayish-black, 2%	0.15	2,359.05
Weathered tuff, moderate-red, pale-reddish-brown, poorly to moderately sorted, well indurated; pumice, very-pale-orange, up to 5% at base of unit, up to 1 cm, subangular to subrounded; lithic fragments, grayish-black, dusky-brown, 2%, subangular. Gradational contact with underlying unit	0.15	2,359.20

Lithologic log of UE25b #1--Continued

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 2,356.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, pale-greenish-yellow, well sorted, well indurated, zeolitic; pumice, pale-greenish-yellow, grayish-pink, >50%, subangular, pumice has moderate-pink alteration rims; lithic fragments, dark-gray, dusky-brown, 5-7%, angular to subangular	0.20	2,359.40
Weathered tuff, grayish-yellow, moderately sorted, well indurated; pumice, pale-greenish-yellow, 3-5%, subrounded; lithic fragments, grayish-black, grayish-olive-green, 7%, subangular to subrounded. Gradational contact with underlying unit	0.20	2,359.60
Pyroclastic fall, pale-greenish-yellow; pumice, pale-greenish-yellow, moderate-pink, many with light-red alteration rims, >50%, subangular to subrounded; lithic fragments, moderate-reddish-brown mudstone(?), black, carbonaceous		
HORIZON A		
Weathered pyroclastic flow(?), light-brown, pale-yellowish-brown grades to moderate-red, moderate-reddish-brown, well sorted at top grades to moderately sorted, well indurated; pumice, moderate-orange-pink, grayish-orange, up to 5%, subrounded; lithic fragments, medium-bluish-gray, grayish-black, grayish-olive mudstone(?), 3%, subangular to subrounded. Thin, black bands at contact	1.40	2,361.05

Lithologic log of USW G-4

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 2,238.0 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge, laminated, grayish-orange-pink, yellowish-gray, well sorted, silty ash beds, zeolitic; rare pumice, yellowish-gray; rare lithic fragments, grayish-red, <1 mm in diameter	1.60	2,239.6
HORIZON B		
Pyroclastic fall(?), bedded, pale-red, pale-pink; appears pale-greenish-yellow; pumice at top of unit in a pale-red silty ash layer that goes to 2,239.7 ft. Unit is underlain by a pale-red, grayish-orange-pink, flattened pumice bed; lithic fragments, medium-light-gray, <1% in silty ash bed, dark-reddish-brown, medium-gray, 1% in pumice bed, dark-reddish-brown alteration halos around lithic fragments. Gradational contact with underlying unit	Thin section at 2,239.63 0.15	2,239.75
Weathered pyroclastic flow(?), mottled, yellowish-gray, moderate-red, gradational contact with underlying pyroclastic fall, zeolitic, poorly sorted, well indurated; pumice, very-pale-orange, pale-greenish-yellow, 10-15%; lithic fragments, grayish-red, 2%, patchy grayish-olive alteration halos around lithic fragments	0.90	2,240.65
Pyroclastic fall(?), yellowish-gray, pale-greenish-yellow, moderately sorted, well indurated; pumice, yellowish-gray, pale-greenish-yellow, 45%; lithic fragments, grayish-red, dusky-brown, 10%. Thin, pale-red, silty ash layer at base	0.60	2,241.25
HORIZON A		
Weathered pyroclastic flow, moderate-red, poorly sorted, well indurated, zeolitic; pumice, moderate-orange-pink, moderate-reddish-orange, 10%; lithic fragments, light-gray, black, 2-3%. Fault contact at base of unit	Thin section at 2,243.00 2.95	2,243.00

Lithologic log of USW G-1--Continued

Bedded tuff at the base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 2,152.0 ft, upper contact is missing)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge, grayish-yellow, grayish-orange-yellowish-gray, laminated, silty- to -fine ash (.2 to 1.2 cm, massive at top), cross bedding with dips as much as 20°, well sorted, well indurated, zeolitic, patchy and layered pyrolusite; pumice, yellowish-gray, 2%, rare pumice up to 1 cm, mostly medium-grained; lithic fragments, grayish-red, <1%	Thin section at 2,154.2 and 2,157.2 5.45(?)	2,157.45(?)
HORIZON B		
Pyroclastic fall, bedded, pale-red, pale-greenish-yellow, well sorted, moderately indurated, zeolitic; pumice, pale-greenish-yellow, pale-red, up to 35%; lithic fragments, grayish-red, 2%	0.10	2,157.55
Weathered tuff, moderate-red, poorly sorted, well indurated, zeolitic, concentration of pyrolusite at top; pumice, pale-red, pale-greenish-yellow, very-pale-orange, 10-15%; lithic fragments, black black mudstone(?), grayish-red, 2-3%. Gradational contact with underlying unit	0.95	2,158.50
Weathered pyroclastic fall(?), moderate-reddish-brown, yellowish-gray, poorly to moderately sorted, well indurated, zeolitic; pumice, yellowish-gray, minor greenish-yellow, 40%; lithic fragments, moderate-brown, black, dark-reddish-brown, 5%. Gradational contact with underlying unit	0.50	2,159.00
HORIZON A		
Pyroclastic flow(?), nonwelded, moderate-red, oxidized, weathered at top, pale-red, poorly sorted, well indurated; pumice, very-pale-orange, pale-greenish -yellow, minor light-olive, 10-15%; lithic fragments, medium-gray, brownish- black, 2-3%; components angular to subrounded, grain size coarsens downhole. From 2,159.00 to 2,162.00 ft, the rock is fractured. Pyrolusite(?) layer at 2,163.70 ft; color change to yellowish-gray, pale-reddish-brown, poorly to moderately sorted; pumice, moderate-yellow-green, yellowish-gray, 10%, subangular, subrounded; lithic fragments, blackish-brown (mudstone?), dark-reddish-brown, moderate-brown, angular, 5%. From 2,164.40 to 2,166.30 ft, coarse-grained,		

Lithologic log of USW G-1--Continued

Bedded tuff at the base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 2,152.0 ft, upper contact is missing)	Thickness of interval (ft)	Depth to bottom of interval (ft)
moderate-yellowish-green pumice up to 40%; lithic fragments, brownish-black, 5-7%. From 2,168.50 to 2,168.80 ft, pumice-rich zone, yellowish-gray, 30%, conspicuous aligned biotite. From 2,168.80 to 2,171.80 ft, tuff is poorly sorted, pale-reddish-brown, moderate-red, well indurated, zeolitic; pumice, yellowish-gray, 25%; lithic fragments, grayish-brown, dusky-brown, 2-3%; components are subangular to subrounded	12.80	2,171.80
Pyroclastic fall(?), disturbed(?), moderate-red, yellowish-gray, moderately sorted, moderately indurated, zeolitic; pumice, yellowish-gray, 30%; lithic fragments, grayish-red, dark-reddish-brown, 3%; concentration of aligned biotite. All contacts are gradational	0.40	2,172.20
Weathered tuff(?), moderate-red, poorly sorted, well indurated, zeolitic; pumice, grayish-orange-pink, very-pale-orange, 15%, angular; lithic fragments, grayish-brown, <1%	0.60	2,172.80
Pyroclastic fall(?), moderate-red, poorly to moderately sorted, well indurated, zeolitic; pumice, pale-red-purple, very-pale-orange, 40%; lithic fragments, dark-reddish-brown, dusky-brown, 1%, angular	0.35	2,173.15
Weathered pyroclastic flow(?), moderate-reddish-brown, pyrolusite concentrated at 2,173.35 ft, also concentration of pumice up to 25%, poorly to moderately sorted, well indurated, zeolitic; pumice, very-pale-orange, grayish-orange-pink, 3-5%, subangular, subrounded; lithic fragments, grayish-black, 1%, angular	1.10	2,174.40

Lithologic log of USW G-2

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 3,248.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge, light-olive-gray, dark-gray, medium-light-gray, thinly laminated, well sorted, well indurated, zeolitic, cross bedded; pumice, moderate-yellow-green, argillic, <1%; lithic fragments, moderate-brown, black, up to 2% in layers	2.75	3,251.05
HORIZON B		
Weathered tuff(?), dark-gray, medium-dark-gray, poorly sorted, well indurated, zeolitic; pumice, yellowish-gray, 10-15%; lithic fragments, grayish-brown, black, 5%; components are angular to subangular	0.85	3,251.90
Pyroclastic fall(?), medium-light-gray, moderately sorted, poorly indurated, zeolitic; pumice, light-greenish-gray, light-gray, 25-30%; lithic fragments, black, 5%	0.10	3,252.00
HORIZON A		
Weathered pyroclastic flow(?), dark-gray, poorly sorted, well indurated, zeolitic; pumice, very-pale-orange, yellowish-gray, 10-15%; lithic fragments, medium-dark-gray, black, 3%. Concentration of pumice at 3,252.2 ft, gradational texture and color change, olive-gray, pumice content decreases to 5-7%, pale-greenish-yellow, very-pale-orange; lithic fragments, brownish-black, moderate-reddish-orange, 5%, up to 1.5 cm diameter. Thin, dark-gray ash layer at 3,253.10 ft. Stringers of dark-gray ash material at base. Gradational contact	1.90	3,253.90
Weathered pyroclastic flow(?), pinkish-gray, yellowish-gray, poorly sorted, well indurated, zeolitic; pumice, very-pale-orange, 7%; lithic fragments, grayish-red, dark-reddish-brown, 3-5%; components are angular. Large, 11 cm, pale-reddish-brown, lithic fragment at 3,255.4 ft. Core broken at 3,255.7 ft. Coarse-grained (up to 2 cm) lithic fragment interval from 3,255.70 to 3,256.70 ft. Weathered tuff unit continues to 3,258.00 ft--steeply dipping, silica-coated fracture encountered	4.10	3,258.00

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 3,248.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow(?), pale-red-purple, moderately sorted, well indurated, zeolitic, very fractured interval; pumice, very-pale-orange, pale-pink, 3-5%; lithic fragments, dark-reddish-brown, moderate-brown, 3-5%. Components are subangular. Near 3,262.0 ft, colors are mottled due to steeply dipping fracture/faulting, grayish-red-purple in silicified fault zones, pale-red-purple matrix; pumice, pale-pink, light-gray, 5-7%, subangular; lithic fragments, dark-reddish-brown, dusky-brown, 5%; pyrolusite staining, iron oxides. At 3,267.60 ft, moderate-orange-pink tuff; pumice, very-pale-orange, pale-greenish-yellow, light-brown, 7%; lithic fragments, moderate-brown, grayish-red, medium-gray, 7-10%, angular to subangular	11.10	3,269.10
Pyroclastic fall, bedded, pale-brown, grayish-orange-pink, well sorted, well indurated, zeolitic, silty ash beds at top; very-pale-orange pumice and grayish-red lithic fragment zone at base	0.10	3,269.20
Pyroclastic flow, nonwelded, moderate-reddish-orange, oxidized to 3,269.50 ft, weathered, components subrounded. Very-pale-yellowish-brown, yellowish-gray, poorly sorted, well indurated, zeolitic; pumice, pale-yellowish-orange, very-pale-orange, subangular to subrounded, 5-7%, pumice-rich zones at 3,270.20 and 3,270.80 ft; lithic fragments, grayish-red, moderate-reddish-brown, dark-gray, subangular, 5%. At 3,272.60 ft, pumice-rich zone, argillic, moderate-red, possible fracture. Rhyolitic, medium-gray, dark-gray, lithic fragment-rich interval from 3,273.00 to 3,273.80 ft, subangular. Minor grayish-yellow-green pumice near base. Weathered(?) interval from 3,275.00 to 3,275.90 ft. Pumice-rich interval from 3,275.90 to 3,276.20 ft, moderately sorted; thin, gray ash layer at top; pumice, grayish-yellow, yellowish-gray, 15-20%, argillic, subangular; lithic fragments, dark-gray, concentrated below thin ash layer, 7%	7.00	3,276.20

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Prow Pass Member

Stratigraphic and lithologic description (starting depth 3,248.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow(?), yellowish-gray, grayish-yellow-green, poorly sorted, well indurated, zeolitic; pumice, grayish-yellow, yellowish-gray, argillic, 10-12%; lithic fragments, dark-gray, dark-reddish-brown, 7%. Components are subangular to subrounded. Concentration of lithic fragments at 3,277.90 ft	1.70	3,277.90
Weathered pyroclastic fall(?), light-olive-gray, grayish-yellow-green, faintly bedded, moderately sorted, well indurated, zeolitic; pumice, concentrated near top, grayish-yellow, yellowish-gray, argillic, 15-20% in interval from 3,277.90 to 3,278.20 ft; lithic fragments, dark-gray, medium-dark-gray, up to 10% in layers	1.10	3,279.00
Weathered tuff, grayish-yellow-green, poorly to moderately sorted, well indurated, zeolitic; pumice, grayish-yellow-green, yellowish-gray, 5%, argillic; lithic fragments, dark-gray, medium-dark-gray, dark-reddish-brown, 7%. Steeply dipping fault from 3,279.40 to 3,280.60 ft, moderate-red, light-gray gouge material. Lithic-rich zone to base, brownish-gray, medium-light-gray, grayish-red, light-red lithic fragments up to .7 cm. Mafic-rich at base	2.90	3,281.90

Appendix 5

Lithologic description of bedded tuff core
between Bullfrog and Tram Members

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 ft or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-color Chart,
Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW GU-3

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,616.5(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, moderate-red with mottled light-gray-zones, poorly sorted, manganese-oxide staining; pumice, grayish-pink, pale-red, white, 7-10%, up to 0.5 cm near base; lithic fragments, grayish-red to grayish-brown, 2%, up to 0.7 cm, angular to subangular. At 2,623.00 ft, pumice increases to 30%. Gradational contact with underlying unit	7.40	2,623.90
HORIZON D		
Pyroclastic fall, bedded, grayish-orange-pink to white, moderately to well sorted; pumice, white, grayish-pink, minor pale-greenish-yellow, >50%, somewhat flattened; lithic fragments, dark-reddish-brown, grayish-brown, 3%. Silty, moderate reddish-brown ash bed at 2,624.15 ft	0.27	2,624.23
HORIZON C		
Weathered tuff, moderate-red, poorly sorted; pumice, pale-red, moderate-orange-pink, 25-35%, up to 0.5 cm, minor very-pale-orange; lithic fragments, moderate-brown to dusky-brown, 5-7%, up to 0.4 cm, angular to subangular. Gradational contact with underlying unit	3.57	2,627.80
Pyroclastic fall, bedded, grayish-pink, moderately to well sorted, coarser at base; pumice, grayish-orange-pink, 40%, up to 1.3 cm, minor pale-greenish-yellow; lithic fragments, grayish-brown, 5-7%, up to 1.2 cm. Silty, moderate-reddish-brown ash bed at 2,628.35 ft	0.80	2,628.60
HORIZON B		
Weathered pyroclastic flow(?), moderate-red; pumice, moderate-orange-pink, 5-7%; lithic fragments, medium-gray, moderate-brown, 3-5%, angular to subrounded. Clay or zeolite-coated fractures at 2,630.00 ft (coatings do not react to HCl). Fault(?)/fractures at 2,635.50 ft. Gradational contact with underlying unit. Fractures at base of unit	9.90	2,638.50

Lithologic log of UE25b #1

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,852.11 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge/fluvial(?), light-brownish-gray, 1-mm pumice in fine-ash matrix; pumice, yellowish-gray, pale-greenish-yellow, 15%, subrounded; lithic fragments, dark-reddish-brown, 2-3%, subangular, moderately sorted	0.02	2,852.13
Pyroclastic surge/fluvial(?), grayish-red, 1 to 2-mm pumice in fine-ash matrix; pumice, pale-greenish-yellow to white, 3-5%, subrounded; lithic fragments, grayish-brown, well sorted. Very-fine ash at base. Gradational contact with underlying unit	0.08	2,852.21
Weathered tuff, grayish-red; pumice, light-gray, white, pale-red, 15%; lithic fragments, dark-reddish-brown, grayish-brown, 2%, subangular to subrounded, poorly sorted. Color change at 2,853.70, yellowish-gray	1.69	2,853.90
(Note: Core missing from 2,853.80 to 2,854.00 ft)		
Pyroclastic fall, bedded, well sorted, yellowish-gray pumice, yellowish-gray to moderate-greenish-yellow, 50%; lithic fragments, moderate-reddish-brown, grayish-red-purple, light-gray, 15-20%, subangular. Discontinuous, pale-olive, silty ash layer at 2,854.25 ft	Thin section at 2,854.20 0.35	2,854.25
HORIZON E		
Weathered tuff, yellowish-gray; pumice, yellowish-gray, minor grayish-yellow, 10%, subangular to subrounded; lithic fragments, moderate-reddish-brown, 2%, subangular, poorly sorted. Dark-yellowish-green alteration zone at 2,855.30 ft. Gradational contact with underlying unit	1.35	2,855.60
Weathered tuff, grayish-red; pumice, yellowish-gray, 7-10%, subangular to subrounded; lithic fragments, dark-reddish-brown, 2%, subangular, poorly sorted. Gradational contact with underlying unit	Thin section at 2,856.00 0.25	2,856.25
Weathered tuff, grayish-red alteration zone; pumice, pale-olive with dark-reddish-brown irregular aureoles, vuggy, 7-10%, subangular to subrounded; lithic fragments, dark-reddish-brown, 2%, subangular, poorly sorted. Gradational contact with underlying unit	0.35	2,856.60

Lithologic log of UE25b #1--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,852.11 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, grayish-red; pumice, grayish-pink, 10%; lithic fragments, moderate-brown, olive-black, dusky-yellowish-green, 2%, subangular to subrounded. Unit grades down to pale-red, pale-olive; pumice, pale-olive; lithic fragments, moderate-brown, subangular to subrounded. At 2,861.90 to 2,861.95 ft, two closely spaced iron-oxide layers dip 27°. Material between iron-oxide layers is same weathered tuff with one large (3.3 cm), white pumice containing mafic minerals; could be a fracture zone	Thin section at 2,860.00 5.82	2,862.42
HORIZON D		
Pyroclastic fall, bedded, moderate- to well-sorted, grayish-yellow-green; pumice, pale-pink, moderate-yellowish-green, light-greenish-gray (mottled, green colors in alteration zones), 50%, minor flattening of pumice; lithic fragments, dark-reddish-brown, moderate-brown, 7-10%, angular	0.68	2,863.10
HORIZON C		
Weathered tuff, pale-olive, medium-grained, well sorted; pumice, pale-greenish-yellow, 25%, subangular, biotite in pumice; lithic fragments, light-brown, <1%	0.90	2,864.00
Pyroclastic fall, bedded, pale-greenish-yellow, pale-olive, moderate-yellowish-green at base, medium- to coarse-grained at top, medium-grained towards base; pumice, moderate-reddish-orange at top, moderate-greenish-yellow, 50%; lithic fragments, light-brown, moderate-brown, 7-10% (10% at top), angular, well sorted; aligned biotite; manganese-oxide staining	0.60	2,864.60
Weathered tuff, pale-red, grayish-orange-pink, moderate-orange-pink; pumice, very-pale-orange, pale-greenish-yellow, 10%, subangular to subrounded poorly sorted; lithic fragments, dark-reddish-brown, dark-gray, 3%. From 2,865.60 to 2,865.90 ft, color change is greenish-gray, moderate- to well-sorted, poorly indurated; pumice, light-greenish-gray, subrounded; lithic fragments, dark-reddish-brown. At 2,865.90 ft, unit coarser and poorly sorted	2.05	2,866.65

Lithologic log of UE25b #1--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,852.11 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
(Note: Core missing from 2,866.50 to 2,867.10 ft)		
Pyroclastic fall, bedded, grayish-yellow-green to light-greenish-gray; pumice, light-greenish-gray, pale-pink, very-pale-orange, >40%, angular; lithic fragments, moderate-reddish-brown, dark-reddish-brown, up to 5% in some beds. Pyrolusite at base of tuff, occurs in bands. Pale-yellowish-brown, fine ash layers with dark-yellowish-green staining at 2,867.30 and 2,867.60 ft	1.20	2,867.80
HORIZON B		
Weathered pyroclastic flow(?), grayish-red, poorly to moderately sorted; pumice, pale-red, pale-pink, 7-10%, subangular to subrounded; lithic fragments, blackish-red, 1-2%, very angular to angular. At 2,870.70 ft, fracture zone with clay or fault gouge and slickensides. At 2,871.70 ft, gradational color change to pale-red; pumice, pale-pink, 5%, subangular to subrounded; lithic fragments, moderate-reddish-brown, dark-reddish-brown, 2%. At 2,875.25 ft, color change to yellowish-gray to pale-brown, moderately sorted; pumice, yellowish-gray, 5%, subangular to subrounded; lithic fragments, dark-reddish-brown, 3%, angular. Occasional large pumice at 2,876.30 ft. Tuff is light-olive-gray, very poorly sorted at 2,880.90 ft, with coarse pumice and lithic fragments; pumice, up to 1.2 cm, angular to subrounded; lithic fragments, very angular. Weathered tuff grades down into pale-red flow with grayish-orange, pale-pink and very-light-gray pumice; lithic fragments, moderate-yellowish-brown, olive-gray and dark-reddish-brown	Thin section at 2,870.00. 14.89	2,882.69

Lithologic log of USW G-4

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,733.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow, thin, moderate-red zone between weathered and overlying flow, grayish-orange-pink, yellowish-gray, good alignment of hornblende, moderately sorted, well indurated; pumice, very-pale-orange, subangular, 5% near top, at 2,733.60 ft, pumice up to 15%, 1 cm in diameter; lithic fragments, dark-reddish-brown, <1%, subangular	0.45	2,733.75
Pyroclastic surge/fluvial(?), silty, dark-reddish-brown, moderate-red, well sorted, well indurated; pumice, white, very-pale-orange, concentrated near top of surge, 3%; rare, dark-reddish-brown lithic fragments	0.18	2,733.93
Weathered tuff, pale-red, moderately sorted at top, grades into poorly sorted, well indurated; pumice, grayish-orange-pink, grayish-pink, minor pale-purple, 10% at top, 15% at base, angular to subangular; lithic fragments, blackish-red, medium-dark-gray, moderate-brown, 3%, angular to subangular	2.47	2,736.40
Pyroclastic fall(?), yellowish-gray, moderately sorted, well indurated, grayish-red silty lens at base; pumice, yellowish-gray, very-pale-orange, 25%, angular; lithic fragments, moderate-brown, light-brown, 10-15%. Weathered, pale-red, poorly sorted interval from 2,736.60 to 2,737.00 ft. Moderately sorted, yellowish-gray pyroclastic fall continues to 2,737.45 ft	1.05	2,737.45
HORIZON E		
Weathered tuff, pale-red, moderately to poorly sorted, well indurated; pumice, grayish-orange pink, 10-15%, subangular; lithic fragments, moderate-brown, dark-reddish-brown, 3-5%, subangular. Pumice and lithic-fragment grain size increase downhole. At 2,738.58 ft, color change (yellowish-gray pumice) and texture change (moderately sorted). At 2,739.25 ft, pale-green pumice (up to 2.5 cm) present with iron-oxide rims; tuff poorly sorted. Increasing size of pumice and lithic fragments at	Thin sections at 2743.00 and 2744.00.	

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,733.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
2,741.50 ft; very poorly sorted, well indurated; pumice, grayish-orange-pink, very-pale-orange, 20%; lithic fragments, moderate-brown, medium-dark-gray, 7%. At 2,743.25 ft, color change, yellowish-gray, very poorly sorted, grayish-yellow-green; pumice, pale-greenish-yellow, pinkish-gray; lithic fragments, dusky-yellowish-brown, dark-gray, moderate-brown	6.55	2,744.00
HORIZON D		
Pyroclastic fall, "disturbed" from 2,744.0 to 2,744.75 ft, well sorted beds, yellowish-gray, grayish-orange-pink, very-pale-orange, well indurated; pumice, pale-greenish-yellow at top of unit, grayish-orange-pink, pinkish-gray, yellowish-gray, >50%; lithic fragments, dusky-brown, dark-reddish-brown, 10%	2.45	2,746.45
HORIZON C		
Weathered tuff, pale-yellowish-brown, pale-red, poorly sorted, well indurated; pumice, grayish-yellow, 10%; lithic fragments, moderate-brown, 1%, up to 3 cm with yellow-green alteration rims	0.80	2,747.25
Pyroclastic fall, yellowish-gray, well sorted beds, well indurated, inversely graded; pumice, yellowish-gray, >50%; lithic fragments, moderate-brown, locally up to 10%	0.95	2,748.20
Weathered tuff(?), pale-reddish-brown, pale-yellowish-brown, poorly sorted, well indurated; pumice, yellowish-gray, very-pale-orange, minor pale-olive, 7-10% increasing to 20% at base of unit, lenticular pumice may indicate a weathered flow; lithic fragments, brownish-black, 3-5%. Undulating contact with underlying pyroclastic fall	2.80	2,751.00
Pyroclastic fall, yellowish-gray, consists mainly of coarse-grained pumice and lithic fragments, well indurated; pumice, yellowish-gray, >50%; lithic fragments, dark-reddish-brown, very-dusky-red, 10-15%. Undulating contact	0.46	2,751.46

Lithologic log of USW G-4--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,733.30 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON B		
Weathered pyroclastic flow(?), grayish-red, poorly sorted, well indurated; pumice, grayish-pink, very-pale-orange, 10%; lithic fragments, grayish-red-purple, medium-dark-gray 5-7%. At 2,754.10 ft, decrease in pumice to 7%. At 2,755.00, 2,755.20 and 2,755.30 ft, distorted, silty ash layers. Flow grades into lithic-rich zone between 2,759.20 and 2,759.70 ft. Iron-oxide zone at contact	Thin sections at 2,754.60 and 2,755.30 8.74	2,760.20

Lithologic log of USW G-1

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,600.75 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, grayish-red, poorly to modererately sorted; pumice, grayish-orange-pink, yellowish-gray, minor moderate-pink; lithic fragments, dark-reddish-brown to blackish-red, 3-5%. Tuff grades downhole into pale-red. Gradational contact with underlying unit	Thin section at 2601.70 1.95	2,602.70
Pyroclastic fall, pinkish-gray, moderately to well sorted, coarse-grained. Grades into yellowish-gray, medium-grained at base. Gradational contact with underlying unit	1.00	2,603.70
Weathered tuff, grayish-red; pumice, pale-red, minor very-pale-orange, 25-30%; lithic fragments dark-reddish-brown, blackish-red, 3%. At 2,606.00 ft, color change to light-olive-gray; pumice, pale-olive (large pumice), moderate-orange-pink and pale-greenish-yellow (small pumice), 7-10%; lithic fragments, moderate-reddish-brown, grayish-black, 3%. Gradational contact at 2606.60 ft; pale-brown to brownish-gray; pumice, yellowish-gray, pale-greenish-yellow, 15%; lithic fragments, dark-reddish-brown, black, 3-5%. At 2,607.21 ft, grayish-orange pumice. Missing core intervals: 2,606.10 to 2,606.20 ft, 2,607.70 to 2,608.7.0 ft, 2,609.10 to 2,610.50 ft, and 2,611.00 to 2,611.40 ft. At 2,610.50 ft, weathered flow, pale-brown to brownish-gray, poorly sorted; pumice, moderate-orange-pink, very-pale-orange, 15%, coarse-grained; lithic fragments, blackish-red, <1%, coarse-grained. Minor lenticular pumice at base of tuff. At 2,612.15 ft, gradational contact with underlying tuff. Pyroclastic fall/weathered pyroclastic fall, grayish-yellow-green; pumice, light-greenish-gray, grayish-yellow-green, coarse-grained; lithic fragments, dark-reddish-brown, coarse-grained, occur at top of unit; medium- to coarse-grained at base. Gradational contact with underlying unit	Thin section at 2,611.90 9.12	2,612.82
HORIZON D		
Pyroclastic fall, graded, yellowish-gray, moderately sorted, medium-grained; pumice, light-greenish-gray, pinkish-gray; lithic fragments, reddish-brown.		

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,600.75 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Alignment and increase in biotite downhole. Missing core interval: 2,613.30 to 2,613.40 ft. At 2,613.40 ft, color change, pinkish-gray to yellowish-gray, coarse at base; pumice, grayish-orange-pink; lithic fragments, grayish-brown, dark-reddish-brown. Minor fine ash at 2,614.20 ft. Medium- to coarse-grained from 2,614.20 ft to base of tuff. Moderate-brown, glassy lithic fragments altered to grayish-olive clay in fine-ash layers at 2,614.69 and 2,614.72 ft. Gradational contact with underlying unit	2.08	2,614.90
HORIZON C		
Weathered tuff, pale-red; pumice, light-greenish-gray, rounded; lithic fragments, dark-reddish-brown, 2%. At 2,615.65 ft, local concentration of light-greenish-gray pumice and dark-reddish-brown lithic fragments. At 2,615.85 ft, color change, grayish-green, greenish-gray, light-brownish-gray; pumice, light-greenish-gray, lenticular pumice altered to dusky-yellowish-green; lithic fragments, dark-reddish-brown, 1%. Contact missing	1.50	2,616.40
(Note: Core missing from 2,616.40 to 2,617.00 ft.)		
Pyroclastic fall, bedded, color alternates pinkish-gray, light-greenish-gray, moderate- to well-sorted. Reddish-brown lithic fragments and coarse-grained pumice are concentrated in 0.1-ft beds. Biotite is aligned. Dark-yellowish-green at contact	1.30	2,617.70
Weathered tuff, grayish-red; pumice, pale-pink, light-brownish-gray to pinkish-gray; lithic fragments, dark-reddish-brown with green rims, 1%. At 2,618.25 ft, color change, grayish-orange pink; pumice, light-olive-gray to pale-yellowish brown, coarse (up to 2 cm), increase in abundance of pumice. At 2,619.13, color change, grayish-red to blackish-red; pumice, pale-red-purple, pale-pink, minor pale-greenish-yellow; lithic fragments, dark-reddish-brown. Abundant phenocrysts. Gradational contact with underlying unit	2.40	2,620.1

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,600.75 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, light-gray to pale-red with a conspicuous dark-reddish-brown zone; pumice, pale-greenish-yellow, grayish-orange-pink, 50%, (dark-reddish-brown zone, 10-12%), subangular to subrounded, some flattening and alignment of pumice, increased size and abuncance of pumice towards base of tuff; lithic fragments, dusky-red, very-dusky-red, moderate-brown, medium-gray, 7-10%, subangular to subrounded; alignment of biotite at base of tuff. At 2,621.05 ft, grayish-red, undulating fracture. Grayish-olive pumice, alteration zone below 2,621.05 ft	0.95	2,621.05
HORIZON B		
(Note: Core is too broken to accurately draw a contact.)		
Pyroclastic flow, weathered (?), grayish-red to grayish-brown; pumice, pale-pink, moderate-orange-pink, grayish-orange-pink, some altered- to -swelling clay, local concentration of dark-yellowish-green alteration products; lithic fragments, medium-light-gray, 1%. At 2,624.00 ft, minor coarse-grained, moderate-orange pumice, up to 2.2 cm. At 2,624.60 ft, grades into brownish-gray and grayish-brown; pumice, moderate-orange-pink, coarse-grained, up to 3 cm, lenticular. Distorted ash beds or clay-filled fractures from 2,624.80 to 2,624.90, and at 2,625.50 ft, grayish-brown to moderate-brown. Tuff grades down to pale-yellowish-brown; pumice, very-pale-orange,	Thin section at 2,622.80	
HORIZON A		
grayish-orange-pink. At 2,627.72, color change, moderate-orange-pink to light-brown. At 2,628.90, color change yellowish-gray, poorly to moderately sorted, number of large pumice clasts decreases; conspicuous alignment of biotite. Poorly sorted near 2,630 ft; large pumice and lithic fragments (up to 1 cm); pumice, moderate-orange-pink, very-pale-orange, some lenticular pumice, 10%, increases downhole to 15%; lithic fragments, blackish-red, grayish-red, dusky-brown, dark-yellowish-brown, 7%. Color of unit grades downhole to pinkish-gray, pale-grayish-orange-pink	Thin section at 2,631.90 16.40	2,636.50

Lithologic log of USW G-1--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 2,600.75 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic flow(?), pale-olive, moderately to well-sorted at base, zeolitic, biotite is aligned; pumice, dusky-yellowish-green with dusky-yellow rims, altered to clays; lithic fragments, dark-reddish-brown, light-brown	Thin section at 2,637.00 1.5	2,638.00
Pyroclastic fall(?), bedded units, pinkish-gray, pale-yellowish-brown, fine-grained, thin ash layers at 2,638.15 and 2,638.28 ft, coarse pumice and lithic fragments at top (up to 1.5 cm); pumice, very-pale-orange, pale-yellowish-orange, grayish-orange-pink; lithic fragments, dark-reddish-brown, black, dark-gray	1.0	2,639.00
Pyroclastic surge or fluvial(?), thinly laminated, silty- to medium-grained layers, faintly crossbedded, moderate-red, pale-brown, pale-red, dark-yellowish-brown. The basal .10 unit is weathered flow, aligned mafic minerals	0.50	2,639.50

Lithologic log of USW G-2

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 3,501.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic surge or fluvial(?), silty- to very fine-grained, grayish-black layer to 3,501.45 ft, dark-gray, black, well sorted, well indurated; pumice, grayish-yellow-green, medium-light-gray, poorly sorted; lithic fragments, black	0.10	3,501.45
Weathered tuff (?), fFrom 3,501.45 to 3,501.70 ft, medium-dark-gray; pumice, greenish-gray, 7-10%; lithic fragments, black, 5%. At 3,501.70 ft, color change, olive-gray, weathered, poorly sorted; pumice, light-olive-gray, grayish-yellow-green, 20%, altered to clays; lithic fragments, dark-reddish-brown, olive-black, 2%. At 3,503.00 ft, gradual color change, grayish-yellow-green, poorly to moderately sorted. Gradational contact with underlying unit	2.65	3,504.10
(Note: Two ft of extra core were picked up in this run. Measurements were made from base of run uphole.)		
Pyroclastic fall, bedded, well sorted, well indurated; pumice, grayish-yellow-green, >50%, some alteration to clays; lithic fragments, grayish-black, olive-black, 5%	1.00	3,505.10
HORIZON E		
Weathered tuff, grayish-yellow-green, moderately well sorted, well indurated; pumice, grayish-yellow-green, 7%; lithic fragments, medium-dark-gray, 3%	0.90	3,506.00
Pyroclastic fall, light-greenish-gray, well sorted beds, moderately indurated; pumice, light-greenish-gray, grayish-yellow-green, >50%; lithic fragments, dark-greenish-gray, brownish-gray, locally up to 7%	0.60	3,506.60
Weathered tuff, pale-olive, grayish-yellow-green, moderately sorted, upper ft of unit grades downhole into poorly sorted, well indurated; pumice, grayish-yellow-green, pale-greenish-yellow, 7%, altered to swelling clays; lithic fragments, grayish-black, olive-black, 10-12%, increasing in size downhole, up to 1.2 cm. At		

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 3,501.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
3,506.20 ft, possible plant fragments. At 3,508.25 ft, increase in amount of lithic fragments, medium-dark-gray, dark-gray, 15%, up to 0.5 cm. Gradual texture change at 3,510.55 ft, fewer (5%), larger (up to 1.0 cm) lithic fragments. At 3,511.00 to 3,512.40 ft, zone of scattered, coarse, lithic fragments (up to 1.0 cm); pumice, light-greenish-gray, 5%, up to 1.1 cm. Tuff poorly to moderately sorted. Contact with underlying unit missing	8.90	3,515.50
Note: Core missing from 3,514.80 to 3,516.50 ft.		
HORIZON D		
Pyroclastic fall, bedded, light-greenish-gray, grayish-yellow-green, pale-olive, well-sorted beds, coarse- to medium-grained, coarse-grained pumice and lithic-fragment zone at top of unit; pumice, light-greenish-gray, pale-greenish-yellow, very-light-gray, 25% at top, grading to 10-12% downhole, subangular to subrounded, up to 1.5 cm; lithic fragments, dark-gray, grayish-black, olive-gray, 15% at top, grading to 7-10%, subangular, up to 1.5 cm. Conspicuous biotite in finer-grained parts of tuff. At 3,518.20 ft, zone of black carbonaceous material. Coarse-grained pumice and lithic fragments at 3,518.80 ft. Core missing from 3,518.80 to 3,519.50 ft. Texture and color change at 3,518.80 to 3,519.50 ft, yellowish-gray, grayish-yellow-green, well sorted, medium- and fine-grained beds; pumice, white, light-greenish-gray, 20-25%, subrounded, up to 0.1 cm; lithic fragments, <1%; fine-grained beds at 3,519.50 and 3,519.75 ft, light-greenish-gray to greenish-gray with light-greenish-gray pumice. At 3,520.70, size of pumice and lithic fragments increase in well-sorted beds. Iron-oxide layers at 3,520.91, 3,521.32, and 3,521.42 ft. Tuff is very-dusky-red-purple at base	6.10	3,521.60

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 3,501.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON C		
Weathered tuff/tuffaceous sandstone(?), greenish-gray to dusky-yellow-green, well sorted; pumice, grayish-yellow-green, pale-olive; rare lithic fragments; biotite not aligned. Gradational change at 3,523.05 ft, weathered tuff, greenish-gray, poorly sorted; pumice, light-greenish-gray; lithic fragments, dark-greenish-gray, olive-black. Tuff has grayish-red-purple discoloration zones. Iron-oxide stained zone at 3,523.32 ft. Gradational contact with underlying unit. Grayish-red-purple at contact	3.03	3,524.63
Pyroclastic fall, bedded, grayish-yellow-green; pumice, moderate-yellow-green, light-yellowish-gray; lithic fragments, medium-gray, minor dark-gray. Core missing from 3,525.20 to 3,525.90 ft and 3,526.50 to 3,527.00 ft. At 3,526.32 ft, fine ash layer, grayish-red-purple. Tuff is grayish-red-purple at base, medium- to coarse-grained	2.40	3,527.03
HORIZON B		
Pyroclastic flow, weathered (?), grayish-green, moderately to poorly sorted; pumice, yellowish-gray, <1%; lithic fragments, medium-gray, dark-reddish-gray. Random, coarse-grained, lithic fragments from 3,529.00 ft to base of tuff; tuff becomes more poorly sorted. Gradational contact with underlying unit	3.72	3,530.75
Pyroclastic fall, normally graded bedding, greenish-gray, well sorted, fine- to medium-grained, becomes yellowish-gray to light-greenish-gray, coarse-grained near base; pumice, yellowish-gray, light-greenish-gray; lithic fragments, medium-gray	0.65	3,531.40
Pyroclastic flow,weathered(?), grayish-green, poorly sorted; pumice, grayish-green, 3-5%, scattered; lithic fragments, moderate-brown, medium-gray, 5-7%. At 3,532.85 ft, mudstone lithic fragments, olive-gray, 3.0 cm. Texture and color change at 3,538.80 ft, grayish-green; pumice becomes flattened, dark-greenish-gray to greenish-black, minor yellowish-green; lithic fragments, rhyolitic lava, dark-reddish-brown mudstone and devitrified tuff, up to 2.3 cm.		

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 3,501.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Core missing from 3,541.70 to 3,542.10 ft. At 3,542.40 ft, scattered, coarse-grained lithic fragments, 7-10%; pumice, 5-7%. Concentration of coarse lithic fragments (up to 5 cm) at 3,543.70 ft. Gradual color change at 3,544.20 ft, greenish-gray to grayish-red-purple; pumice, greenish-gray, 5-7%; lithic fragments, moderate-reddish-brown, medium-gray, grayish-black with dark-reddish-brown mudstone lithic fragments, 10-12%. At 3,545.00 ft, open vugs due to alteration of pumice. Color change at 3,548.18 ft, greenish-gray to light-olive-gray; pumice, light-greenish-gray, 15%, no open vugs; lithic fragments, moderate-brown, dark-reddish-brown, olive-black. Tuff has flattened, thin pumice. Tuff is pale-greenish-gray near base. Gradational contact with underlying unit	22.35	3,553.75
Weathered tuff, grayish-yellow-green, yellowish-gray; pumice, yellowish-gray, 30%, up to 1 cm; lithic fragments, dusky-red, medium-gray, 20%, up to 2.5 cm. Tuff has minor flattened pumice. Gradational contact with underlying unit	0.85	3,554.60
Pyroclastic fall, bedded, grayish-yellow-green, grayish-green, yellowish-gray; lithic fragments, light-brown, grayish-black. Coarse-grained layer at 3,555.15 ft, and fine-grained, grayish-purple ash layer at 3,555.60 ft	1.40	3,556.00
Pyroclastic flow, weathered (?), light-brownish-gray to grayish-green, poorly sorted; pumice, light-greenish-gray; lithic fragments, moderate-reddish-brown, medium-gray, grayish-black. Tuff has zones of flattened (fiamme), dusky-yellow-green pumice, moderately to poorly sorted at top, moderately sorted at base. At 3,560.70 ft, color change yellowish-gray to light-greenish-gray, poorly sorted. Concentration of coarse-grained lithic fragments at 3,561.40 to 3,561.70 ft, poorly sorted. At 3,561.70 ft, color change light-greenish-gray, moderately sorted with lenticular (fiamme) pumice. Tuff is grayish-green at base. At 3,565.50 ft, discontinuous fine ash layer, dusky-yellow-green	9.60	3,565.60
Weathered tuff, grayish-yellow-green, coarse-grained at top, medium-grained at base, moderately well sorted	0.60	3,566.20

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Bullfrog Member

Stratigraphic and lithologic description (starting depth 3,501.35 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic flow, weathered (?), gray to grayish-yellow-green, moderately to poorly sorted at top, poorly sorted toward middle and base, swelling clays present. At 3,567.50 ft, color change grayish-yellow-green to grayish-green; pumice, yellowish-gray, light-greenish-yellow, pale-greenish-yellow; lithic fragments, dark-reddish-brown, medium-dark-gray, grayish-black. Swelling clays are greenish-gray. (Core missing from 3,568.80 to 3,569.30 ft). At 3,569.50 ft, faint bedding in flow. Tuff is grayish-yellow-green; pumice, pale-greenish-yellow to grayish-yellow-green, altered to swelling clays, poorly sorted; lithic fragments, grayish-green, grayish-red, medium-gray, brownish-black; flattened pumice and moderately aligned biotite	5.25	3,571.45
Pyroclastic fall, bedded. Medium-grained, pale-greenish-yellow layer between thin, dusky-yellowish-brown ash layers at top and base	0.15	3,571.60
Pyroclastic flow/weathered flow, moderate-greenish-yellow to grayish-yellow-green; pumice altered to swelling clays; lithic fragments, grayish-olive-green, up to 4 cm	1.40	3,573.00
Pyroclastic flow/weathered flow, grayish-yellow-green with thin, dusky-yellow-green layers (fiamme). Possibly argillic/zeolitic. Gradational contact with underlying unit	0.90	3,573.90
Pyroclastic fall, bedded, grayish-yellow-green, light-olive-gray; abundant mafics. At 3,574.82 and 3,574.85 ft, coarse-grained, lithic-fragment layers, dark-reddish-brown and dusky-yellow-green. Irregular contact with underlying unit. Possible fiamme	1.40	3,575.30
Pyroclastic flow/weathered flow, medium-light-gray, very-fine-grained. Possible fracture zone at base	0.48	3,575.78

APPENDIX 6

Lithologic description of bedded tuff core
between Tram Member and Lithic Ridge Tuff

Note: Measurements to nearest 0.01 ft are given in actual measured value, although accuracy of measurement may be only to 0.1 ft or to nearest foot in a few cases. Conversion value to convert feet to meters is: feet X 0.3048).

Colors are based on Rock-color Chart,
Geological Society of America (Boulder, Colorado, 1975)

Lithologic log of USW GU-3

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,850.4 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered pyroclastic fall(?), yellowish-gray, poorly indurated, zeolitic, argillic, clay has slickensides, charcoal fragments mixed with clay; .9 ft lost, but depths recorded on core are used here	0.90(?)	3,850.50(?)
HORIZON G		
Weathered tuff, olive-gray, moderately sorted, well indurated; pumice, grayish-yellow at top, light-olive, moderate-green towards base, 7-10%, altered to swelling clays; lithic fragments, olive-black, 2%	4.10	3,854.60
Pyroclastic surge(?) or fluvial(?), light-olive-gray, grayish-yellow-green, silty ash bed with fine- to medium-grained ash lenses. Compressed black organic(?) or manganese-oxide material. Minor moderate-green alteration	0.30	3,854.90
HORIZON F		
Weathered tuff, dusky-yellow-green, poorly to moderately sorted, well indurated, zeolitic; pumice, grayish-yellow-green, moderate-green, locally 10-15%, argillic, grades downhole to grayish-green; lithic fragments, olive-black, rare dark-reddish-brown, 5%. At 3,857.05 ft, medium-gray zone with yellowish-gray pumice. Olive-black lithic fragments increase in size to 0.5 cm; pumice compressed, moderate-green, minor yellowish-gray, argillic	5.20	3,860.10
Pyroclastic fall(?), yellowish-gray, pale-olive, moderately sorted, moderate- to -well indurated, argillic; pumice, yellowish-gray, 50%; lithic fragments, dark-gray, 10%	0.50	3,860.60
HORIZON D		
Weathered tuff(?), grayish-green, poorly to moderately sorted, well indurated; pumice, grayish-yellow-green, moderate-blue-green, 5%; lithic fragments, greenish-black, 3-5%, not greater than 2 mm in diameter	1.20	3,861.80

Lithologic log of USW GU-3--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,850.4 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, yellowish-gray, pale-olive, moderately sorted, moderately indurated, argillic; pumice, yellowish-gray, pale-olive, 50%; lithic fragments, dark-gray, 5-7%. (Note: loss of .9 ft at base of drill run)	0.50	3,862.30
HORIZON C		
Weathered tuff(?), massive fall(?), dark-greenish-gray, moderate- to well-sorted, well indurated, zeolitic; pumice, grayish-yellow-green, light-gray, subrounded, 5%; lithic fragments, medium-dark-gray, olive-black, 5%, subangular. Clayey pale-olive pumice partings at 3,864.4 and 3,865.9 ft. Lithic fragments and pumice increase in grain size downhole, pumice up to 1.5 cm, lithic fragments up to 1 cm. Color change at 3,873.0 ft to olive-gray; pumice, pale-yellowish-green, yellowish-gray, grayish-yellow-green, 3-5%, up to 3 cm in diameter, argillic, flattened; lithic fragments, olive-black, light-gray, up to 3.5 cm in diameter. Brownish-gray silty ash bed with dessication cracks and clasts at 3,874.05 to 3,875.15 ft. Pumice moderate-yellowish-green at base	14.30	3,876.0

Lithologic log of USW UE25b #1

Bedded tuffs at the base of Tram Member

Stratigraphic and lithologic description (starting depth 3,901.10 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), olive-gray, bedded, gradational contact with overlying flow unit, well sorted, well indurated, zeolitic; pumice at top, white, pale-greenish-yellow, argillic, 3%; lithic fragments at top, black, 3-5%. Dark-greenish-gray, olive-black towards base with rare pumice or lithic fragments	1.60	3,902.70
Pyroclastic fall, grayish-black matrix, moderately sorted, moderately indurated, zeolitic; pumice, very-light-gray, light-greenish-gray, 35%, argillic, angular to subangular, zone of large (up to 4 cm) pumice at 3,903.1 ft; lithic fragments, black, up to 1 cm, 1%	0.80	3,903.50
HORIZON G		
Weathered tuff(?), dark-greenish-gray, greenish-black, poorly sorted, well indurated; pumice, yellowish-gray, black compressed glass(?) with white mineral-filled fractures from 3,903.50 to 3,903.85 ft. Texture change at 3,903.85 ft; pumice, very-light-gray, yellowish-gray, 10-15%, subangular, up to 1 cm, altered to swelling clays; rare black lithic fragments, <2 mm. Color change at 3,906.70 ft, olive-gray; pumice, very-light-gray, light-greenish-gray, average diameter 3 mm, 7-10%, subrounded; lithic fragments, black, <1%. Fault/fracture at 3,908.6 ft	5.10	3,908.60
Pyroclastic fall(?), well sorted beds, well indurated, zeolitic; thin, light-olive-gray silty ash at top. From 3,908.60 to 3,908.95 ft pumice-rich bed; pumice, greenish-gray, very-light-gray, 35%, argillic; lithic fragments, medium-dark-gray, 3-5%. From 3,908.95 to 3,909.50 ft, silty, light-gray to light-greenish-gray with fine- to medium-grained		
HORIZON F		
crystal and ash lenses, possible surge or fluvial, with black organic material. From 3,909.50 to 3,910.30 ft, faintly bedded, moderately sorted, greenish-gray, very-light-gray; pumice, greenish-gray, very-light-gray, 30%; lithic fragments, medium-light-gray, 7%	1.70	3,910.30

Lithologic log of USW UE25b #1--Continued

Bedded tuffs at the base of Tram Member

Stratigraphic and lithologic description (starting depth 3,901.10 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
HORIZON E		
Weathered tuff, greenish-gray, poorly sorted, well indurated, zeolitic; pumice, greenish-gray, light-greenish-gray, 3-5%, argillic, subangular to subrounded, up to 0.5 cm; lithic fragments,very-dusky-red, medium-dark-gray, 5%, subangular to subrounded, up to 1.0 cm. Texture change at 3,912.50 ft, increase in pumice, 5-7%, and lithic fragments, 5-7%. Discontinuous, dark-gray silty ash layer at 3,913.25 ft. From 3,914.50 to 3,915.00 ft, disturbed top of pyroclastic fall, greenish-gray matrix, poorly sorted, well indurated, zeolitic; pumice, light-greenish-gray, 40%, up to 1 cm, angular to subangular, argillic; lithic fragments, dark-gray, medium-gray, grayish-brown, 10%, subangular to subrounded	4.70	3,915.00
Pyroclastic fall, light-greenish-gray, moderately sorted, moderate- to -well indurated, zeolitic; pumice, light-greenish-gray, 25-30%, argillic; lithic fragments, black, medium-gray, 7-10%, angular	0.50	3,915.50
HORIZON D		
Weathered tuff, grayish-green, poorly sorted, well indurated, zeolitic; pumice, very-light-gray to light-greenish-gray, 7-10%, angular, lenticular; lithic fragments, black, medium-gray, 10%, angular. Gradational contact with underlying unit	1.60	3,917.10
Pyroclastic fall, grayish-yellow-green, moderately sorted, moderately indurated, zeolitic; pumice, grayish-yellow-green, light-greenish-gray, light-gray, 25%, argillic, angular to subangular; lithic fragments, olive-black, brownish-black, dark-greenish-gray, 10-15%, angular	0.50	3,917.60
HORIZON C		

Lithologic log of USW UE25b #1--Continued

Bedded tuffs at the base of Tram Member

Stratigraphic and lithologic description (starting depth 3,901.10 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff(?), massive pyroclastic fall(?), grayish-green, faintly bedded at top of unit, 3% pumice. At 3,919.50 ft, flattened, dusky-yellow-green pumice, 7%. At 3,921.90 ft, color change, dusky-yellow-green; pumice, moderate-greenish-yellow. Pumice-rich zone at 3,922.90 ft, pale-olive, very argillic. Pumice and lithic-fragment size increase downhole; rare moderate-reddish-brown lithic fragments. At 3,929.60 ft, occasional, large, lithic fragments up to 3.0 cm. Calcite-filled fracture zone from 3,936.00 to 3,939.00 ft, average dip 50°. At 3,939.25 ft, calcite-lined fault with slickensides, no dip. Gradational texture change at 3,956.00 ft, coarse-grained, light-olive pumice. Gradational contact with underlying unit	39.90	3,957.50
Pyroclastic fall, weathered at top, grayish-yellow-green, grayish-green, moderate- to well-sorted beds, moderate- to -well indurated, zeolitic; pumice, grayish-green, grayish-yellow-green, >50%; lithic fragments, medium-gray, dark-greenish-gray, 15%. From 3,957.95 to 3,958.15 ft, fine-grained ash layer, greenish-gray; from 3,958.60 to 3,959.00 ft, medium-dark-gray, silty- to fine-grained ash layer. Gradational contact with underlying unit	1.50	3,959.00
Weathered pyroclastic flow, olive-gray, poorly sorted, well indurated; pumice, grayish-yellow-green, yellowish-gray, 5%; lithic fragments, grayish-brown, medium-dark-gray, 3%	1.30	3,960.30

Lithologic log of drill hole USW G-1

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,521.90 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), yellowish-gray, pale-olive, moderately to well sorted, moderately indurated; pumice, yellowish-gray, argillic, 45%; lithic fragments, black, medium-gray, 10-15%. Thin, silicified, dark-gray, silty ash layer at top; beds dip	0.15	3,922.05
HORIZON G		
Weathered tuff, olive-gray, poorly sorted, well indurated, zeolitic; pumice, pale-greenish-yellow, pale-olive, 15%, altered- to -swelling clays; lithic fragments, black, 1%. Core missing from 3,522.70 to 3,523.70 ft, color change in this interval. Tuff, light-olive-gray, poorly sorted, moderate- to -well indurated; pumice, grayish-yellow, yellowish-gray, 15%, but >40% in pumice-rich zone from 3,524.00 to 3,524.10 ft, argillic; lithic fragments, medium-light-gray, light-brown, 1%. At 3524.70 ft, texture and color change pale-olive, moderately sorted, well indurated, zeolitic; pumice, moderate-greenish-yellow, pale-olive, 5%, partially argillic; lithic fragments, medium-light-gray, 1%. Vertical, calcite-coated fracture from 3,528.00 to 3,529.00 ft. Patchy pyrolusite(?) staining or carbonaceous material(?). Grades downhole into well-sorted, faintly bedded appearance	9.35	3,531.40
Pyroclastic fall, grayish-yellow-green, grayish-green, grayish-yellow, well sorted, dipping beds, well indurated, zeolitic; pumice, grayish-yellow, light-olive, dusky-green, 45%, argillic; lithic fragments, medium-gray, medium-dark-gray, locally moderate-reddish-orange, up to 10% in beds. Conspicuous biotite. Silty ash layer from 3,534.15 to		
HORIZON F		
3,534.20 ft, yellowish-gray and grayish-green with dark-gray lenses. Core missing from 3,534.90 to 3,535.60 ft. Contact missing	4.00	3,535.40
HORIZON E		

Lithologic log of drill hole USW G-1--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,521.90 ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, grayish-yellow-green, pale-olive, moderately to well sorted, well indurated, zeolitic; pumice, grayish-yellow-green, grayish-yellow, 5%; lithic fragments, medium-light-gray, olive-black, 5-7%. At 3,542.00 ft, argillic, grayish-yellow pumice. Pumice increases to 7-10%, up to 1 cm; lithic-fragment size increases up to 0.5 cm. Pumice and lithic fragments, angular to subangular. At 3,548.00 ft, lithic fragments up to 2.0 cm. Pumice increases to 25%, very argillic from 3,549.40 to 3,550.00 ft. At 3,550.00 ft, tuff grades into moderately well-sorted, tuffaceous sandstone, grayish-yellow-green, well indurated; pumice, and lithic fragments decrease to 0.3 cm. Closed fracture at 3,551.00 ft	16.65	3,552.05
Pyroclastic fall, grayish-yellow, well sorted, moderately indurated, zeolitic; pumice, grayish-yellow, dusky-yellow, >50%, argillic; lithic fragments, dark-gray, medium-light-gray, rare, moderate-reddish-orange, 15%. Basal contact at fault, 65° dip	0.65	3,552.70
HORIZON B		
Weathered tuff, grayish-olive at top grades downhole to pale-olive, poorly to moderately sorted, well indurated, zeolitic; pumice, grayish-yellow, yellowish-gray, 10%, argillic; lithic fragments, black, medium-light-gray, moderate-reddish-brown, 10%. At 3,554.80 and 3,555.00 ft, calcite-filled fault/fracture, slickensides present. Fractures at 3,556.00, 3,556.40 and 3,557.40 ft, possible silicification	4.70	3,557.40
Pyroclastic fall, grayish-yellow to grayish-yellow-green, well sorted, poorly indurated, zeolitic, argillic, fault contact at top and base of unit, slickensides present; pumice, grayish-yellow, pale-greenish-yellow, 70%, argillic; lithic fragments, black, medium-light-gray, 7-10%. Fault contact at base of unit	0.80	3,558.20
HORIZON A		

Lithologic log of USW G-2

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,913.50(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall(?), upper contact missing, pale-olive, grayish-yellow-green, moderately sorted, well indurated; pumice, light-greenish-gray, greenish-gray, 25%, argillic; lithic fragments, brownish-black, medium-gray, dusky-yellowish-brown, 7%. Core missing from 3,913.00 to 3,914.00 ft	1.00	3,914.50
Weathered tuff, greenish-gray, poorly sorted, well indurated, zeolitic; pumice, light-greenish-gray, greenish-gray, 7-10%, argillic; lithic fragments, brownish-black, medium-gray, dusky-yellowish-brown, 7%	2.00	3,916.50
Pyroclastic fall(?), poorly to moderately sorted dipping beds with weathered intervals, grayish-yellow-green, light-brownish-gray, moderately to well indurated; pumice, grayish-yellow-green, light-greenish-gray, argillic, 45% in pumice beds, 7% in weathered intervals; lithic fragments, brownish-gray, dusky-yellowish-green, grayish-brown, medium-gray, 10-15%	0.90	3,917.40
Weathered tuff, mottled-yellowish-gray and light-brownish-gray to 3,918.00 ft, light-brownish-gray to 3,920.60 ft, poorly sorted, well indurated, zeolitic; pumice, light-greenish-gray, pinkish-gray, 7%, argillic, up to 1.2 cm, subangular to subrounded; lithic fragments, grayish-red, pale-red, dusky-yellowish-green, some with dark-reddish-brown cores, medium-light-gray, 5-7%, up to 3 cm, subangular to subrounded. At 3,920.60 ft, color change to pinkish-gray. At 3,923.00 ft, color and texture change, mottled, greenish-gray, grayish-red, poorly sorted, well indurated; pumice, light-greenish-gray, pale-yellowish-green, 5% at top to 10-15% downhole, argillic, up to 0.6 cm; lithic fragments, medium-dark-gray, dark-reddish-brown, 3-5%, up to 0.5 cm. Near 3,927.00 ft, texture and color change, light-greenish-gray, pale-yellowish-green, poorly to moderately sorted, well indurated, conspicuous biotite; pumice; grayish-green, pale-yellowish-green, 5%; lithic fragments, medium-light-gray, grayish-red, 5-7%. Gradational contact with underlying unit	12.70	3,930.10

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,913.50(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, light-greenish-gray, pale-yellowish-green, moderately to well sorted, dipping beds, well indurated, possibly some weathered zones, zeolitic, conspicuous biotite; pumice, light-greenish-gray, greenish-gray, up to 30% in beds, argillic; lithic fragments, medium-dark-gray, dark-reddish-brown, medium-light-gray, up to 15%. Fracture/fault at 3,938.00 and 3,939.30 ft, possible slickensides. Silty, pale-olive ash beds from 3,939.85 to 3,939.90 ft and 3,940.10 to 3,940.20 ft. Silty, light-gray, pale-olive ash bed from 3,941.20		
HORIZON F		
to 3,941.35 ft. Middle zone, mottled, dark-yellowish-green alteration. Silty- to fine-grained, medium-gray ash bed, 0.03 ft thick, at base of unit	12.50	3,942.60
HORIZON E		
Weathered tuff, mottled, greenish-gray, grayish-red, poorly sorted, well indurated; pumice, grayish-yellow-green, pale-greenish-yellow, 5%, subrounded; lithic fragments, dark-gray, medium-dark-gray, dark-reddish-brown, 5-7%, subangular to subrounded	4.15	3,946.75
Pyroclastic fall(?), dipping beds, pale-yellowish-green, grayish-red, moderate-yellowish-green, discontinuous, fine ash layer at 3,947.00 ft, moderately sorted beds, well indurated; pumice, grayish-green, 40% in top layer, argillic; lithic fragments, light-greenish-gray, medium-dark-gray, dark-reddish-brown, up to 5%	0.30	3,947.05
Weathered tuff(?), mottled, grayish-red-purple, grayish-yellow-green, poorly sorted, well indurated; pumice, grayish-yellow-green, 10-15%, argillic; lithic fragments, medium-dark-gray, 5-7%	2.15	3,949.20
Pyroclastic fall, grayish-yellow-green, moderately sorted, well indurated, zeolitic; pumice, grayish-yellow-green 45%, argillic; lithic fragments, dark-gray, medium-gray, 10-15%	0.30	3,949.50

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,913.50(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Weathered tuff, pale-yellowish-green top, grades downhole to moderate-olive-brown, poorly sorted, well indurated, zeolitic; pumice, grayish-yellow, grayish-yellow-green, 5-7%, argillic; lithic fragments, blackish-red, medium-dark-gray, grayish-red, 5%. Fault/fracture from 3,949.50 to 3,950.00 ft. Fault contact at base, 1 cm offset	1.75	3,951.25
Pyroclastic fall, weathered(?), grayish-red-purple matrix, grayish-yellow-green pumice zones, faintly bedded, moderately sorted, well indurated, zeolitic; pumice, grayish-yellow-green, grayish-yellow, 15%, but 30% at base, argillic; lithic fragments, grayish-black, medium-dark-gray, 7%, but 10% in top and bottom layers	0.70	3,951.95
Weathered tuff or massive fall, grayish-yellow-green, poorly sorted, well indurated, zeolitic; pumice, grayish-yellow-green, moderate-yellow-green, 5-7%, argillic; lithic fragments, medium-dark-gray, dusky-yellowish-brown, 5-7%. At 3,958.80 and 3,958.90 ft, grayish-red-purple discolored zones with bleached aureoles. Gradational contact with underlying unit	9.15	3,961.10
Pyroclastic fall, light-greenish-gray, pale-yellowish-green, moderately to well sorted beds, normally graded, well indurated, zeolitic; pumice, light-greenish-gray, grayish-yellow-green, >50% in coarse-grained basal portion, argillic; lithic fragments, dark-gray, medium-light-gray, dusky-brown, olive-gray, up to 15% in basal, coarse-grained layer. Silty- to -fine ash beds from 3,966.80 to 3,966.85 ft, 3,966.95 to 3,967.00 ft, and 3,967.65 to 3,967.70 ft. Coarse-grained tuff from 3,969.70 to 3,970.75 ft. Silty, yellowish-gray to medium-gray ash layer at base	9.65	3,970.75
HORIZON B		
Weathered tuff, medium-gray, poorly to moderately sorted, well indurated, zeolitic; pumice, white, light-greenish-gray, 15%, argillic; lithic fragments, grayish-black, medium-gray, dusky-brown, moderate-brown, 15%. Gradational contact with underlying tuff	2.55	3,973.30

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,913.50(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
Pyroclastic fall, light-greenish-gray, yellowish-gray, pale-yellowish-green alteration, moderately sorted, well indurated, zeolitic; pumice, light-greenish-gray, yellowish-gray, 30%, partially argillic; lithic fragments, black, dusky-brown, medium-dark-gray, medium-light-gray, 15%. Fine- to medium-grained, medium-light-gray layer from 3,975.05 to 3,975.10 ft	1.80	3,975.10
HORIZON A		
Pyroclastic flow, weathered at top, dusky-yellowish-brown, poorly to moderately sorted, well indurated, zeolitic(?); pumice, light-greenish-gray, white, 7%, partially argillic; lithic fragments, very-light-gray, moderate-brown, dusky-green, 3-5%. Grades into nonwelded flow at 3,989.60 ft. Pyroclastic flow, blackish-red, nonwelded, poorly sorted, well indurated, zeolitic; pumice, light-greenish-gray, light-gray, light-olive, with conspicuous biotite, 10-15%, up to 2.5 cm, partially argillic; lithic fragments, pale-reddish-brown, dark-gray, pale-brown, 3-5%, up to 2.0 cm. Dusky-brown, silty ash layers at 3,997.90 and 3,998.65 ft. Faults with slickensides at 4,000.00, 4,001.00, 4,003.65, 4,006.40, and 4,007.35 ft. Dusky-brown, silty ash bed at 4,002.90 ft, with concentration of coarse-grained, light-greenish-gray pumice at base. Gradational contact with underlying tuff	40.05	4,015.15
Pyroclastic fall, dusky-brown, silty ash bed at top, minor weathering, mottled, grayish-olive, white, dusky-yellowish-brown, moderately to well sorted beds, well indurated. From 4,015.20 to 4,019.20 ft, massive unit, faintly bedded towards base; pumice, white, dusky-yellow-green, 35%; lithic fragments, dark-gray, medium-dark-gray, dark-reddish-brown, light-brown, grayish-green, 25%. Coarse, lithic-fragment-rich base. From 4,019.20 to 4,023.80 ft, alternating very-dusky-red, silty ash layers with light-greenish-gray pumice and lithic-fragment layers. Sag and mantle		

Lithologic log of USW G-2--Continued

Bedded tuffs at base of Tram Member

Stratigraphic and lithologic description (starting depth 3,913.50(?) ft)	Thickness of interval (ft)	Depth to bottom of interval (ft)
structures present. Conspicuous biotite. Possible weathered interval from 4,020.35 to 4,021.25 ft. Massive, poorly sorted interval from 4,023.80 ft to base of unit; could be weathered top of pyroclastic fall. Core missing from 4,030.00 to 4,031.20 ft. Contact missing	16.05	4,031.20
Pyroclastic flow(?), nonwelded, light-brownish-gray matrix grades downhole to light-gray, poorly sorted, well indurated, zeolitic, conspicuous biotite; pumice, white, pale-green, contains biotite, up to 8 cm, argillic; lithic fragments, dusky-green, dark-reddish-brown, medium-dark-gray, very-dusky-red-purple, up to 3 cm. Pumice/lithic fragments, black, >12 cm from 4,036.20 to 4,036.65 ft. Closed fractures/faults from 4,050.50 to 4,051.50 ft. Gradational contact with underlying unit	29.25	4,060.45
Pyroclastic fall, interbedded, dusky-brown, silty- to coarse-grained, light-greenish-gray, poorly to well sorted beds, well indurated, zeolitic, conspicuous biotite; pumice, very-light-gray, light-greenish-gray, pale-yellowish-green, average 10%, up to 30% in coarse-grained, pumice beds; lithic fragments, moderate-brown, dark-gray, grayish-orange-pink, up to 20% in coarse-grained beds	4.35	4,064.80
Weathered tuff(?), blackish-red, moderately to well sorted, well indurated; occasional pale-yellowish-green, biotite-rich, argillic pumice/ lithic fragments up to 11 cm. Tuff grades downhole to brownish-gray; pumice, very-light-gray, pale-yellowish-green, 5%; lithic fragments, moderate-brown, dark-gray, grayish-orange-pink, 3-5%. Texture change at 4,070.40 ft, poorly sorted, fault/fracture zone from 4,073.40 to 4074.90 ft	10.10	4,074.90
Pyroclastic fall(?), from 4,074.90 to 4,077.40 ft, coarse-grained, dacitic(?), medium-light-gray, contains biotite and hornblende; pumice, moderate-yellow-green, 5%, argillic. Fault contact with fine- to medium-grained, medium-light-gray fall deposit, from 4,077.40 to 4,078.90 ft. Fault contact at base	4.00	4,078.90

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