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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

STRATIGRAPHY, STRUCTURE, AND SOME PETROGRAPHIC FEATURES OF TERTIARY VOLCANIC ROCKS AT THE USW G-2 DRILL HOLE, YUCCA MOUNTAIN, NYE COUNTY, NEVADA

by

Florian Maldonado and S. L. Koether

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ABSTRACT

A continuously cored drill hole designated as USW G-2, located at Yucca Mountain in southwestern Nevada, penetrated 1830.6 m of Tertiary volcanic strata composed of abundant silicic ash-flow tuffs, minor lava and flow breccias, and subordinate volcaniclastic rocks.

The volcanic strata penetrated are comprised of the following in descending order: Paintbrush Tuff (Tiva Canyon Member, Yucca Mountain Member, bedded tuff, Pah Canyon Member, and Topopah Spring Member), tuffaceous beds of Calico Hills, Crater Flat Tuff (Prow Pass Member, Bullfrog Member, and Tram unit), lava and flow breccia (rhyodacitic), tuff of Lithic Ridge, bedded and ash-flow tuff, lava and flow breccia (rhyolitic, quartz latitic, and dacitic), bedded tuff, conglomerate and ash-flow tuff, and older tuffs of USW G-2. Comparison of unit thicknesses at USW G-2 to unit thicknesses at previously drilled holes at Yucca Mountain indicate the following: (1) thickening of the Paintbrush Tuff members and tuffaceous beds of Calico Hills toward the northern part of Yucca Mountain; (2) thickening of the Prow Pass Member but thinning of the Bullfrog Member and Tram unit; (3) thinning of the tuff of Lithic Ridge; (4) presence of approximately 280 m of lava and flow breccia not previously penetrated by any drill hole; and (5) presence of an ash-flow tuff unit at the bottom of the drill hole not previously intersected, apparently the oldest unit penetrated at Yucca Mountain to date.

Petrographic features of some of the units include: (1) decrease in quartz and K-feldspar and increases in biotite and plagioclase with depth in the tuffaceous beds of Calico Hills; (2) an increase in quartz phenocrysts from the top to the bottom members of the Crater Flat Tuff; (3) a low quartz content in the tuff of Lithic Ridge, suggesting tapping of the magma chamber at quartz-poor levels; (4) a change in zeolitic alteration from heulandite to clinoptilolite to mordenite with increasing depth; (5) lavas characterized by a rhyolitic top and dacitic base, suggesting reverse compositional zoning; and

(6) presence of hydrothermal mineralization in the lavas that could be related to an intrusive under Yucca Mountain or to volcanism associated with the Timber Mountain-Claim Canyon caldera complex.

A fracture analysis of the core resulted in tabulation of 7,848 fractures, predominately open and high angle. The fractures were filled or coated with material in various combinations and include the following in decreasing abundance: $CaCo_3$, iron oxides and hydroxides, SiO_2, manganese oxides and hydroxides, clays and zeolites. An increase in the intensity of fracturing can be correlated with the following: (1) densely welded zones, (2) lithophysal zones, (3) vitrophyre, (4) silicified zones, (5) fault zones, and (6) cooling joints.

Numerous fault zones were penetrated by the drill hole, predominately in the lithophysal zone of the Topopah Spring Member and below the tuffaceous beds of Calico Hills. The faults are predominately high angle with both a vertical and lateral component. Three major faults were penetrated, two of which intersect the ground surface, with displacements of at least 20 m and possibly as much as 52 m. The faults and some fractures are probably related to the regional doming of the area associated with the volcanism-tectonism of the Timber Mountain-Claim Canyon caldera complex, and to Basin and Range tectonism.

INTRODUCTION

Studies by the USGS (U.S. Geological Survey) since 1978, have contributed to the stratigraphic and structural knowledge of the Yucca Mountain area, Nevada. Several deep holes have been cored as part of a continuing effort by the USGS on behalf of the U.S. Department of Energy to characterize rock masses at Yucca Mountain in exploring for a potential nuclear waste repository. This study is part of the Nevada Nuclear Waste Storage Investigations Program.

The Tertiary volcanic strata of the area has been investigated in a continuously cored 1830.6-m drill hole, designated as USW G-2. Stratigraphy penetrated by the drill hole has been compared with information from holes previously drilled south of the USW G-2 site, and referred to as the southern drill holes (USW G-1, USW H-1, UE25b-1H, and UE25a-1) in this report.

Yucca Mountain is located along the southwestern edge of the Nevada Test Site, southwestern Nevada (fig. 1), approximately 135 km northwest of Las Vegas. Drill hole USW G-2 is located toward the northern end of Yucca Mountain north of the block of interest (fig. 2).

Drill-Hole History

USW G-2 was spudded March 25, 1981, with coring completed October 11, 1981 (table 1). The surface casing was set at 88.2 m with coring commencing at 88.3 m and continuing to a total depth of 1830.6 m. Core sizes were 9.75 cm from 88.3 to 1438.5 m and 7.3 cm from 1438.5 to 1830.6 m.

A suite of geophysical logs run by Birdwell Division of Seismograph Service Corp., included the following: caliper, density, electric, velocity, temperature, neutron, gamma ray, and televiewer. A trace injector test was run by Petroleum Data, Inc.

A directional survey, with stations every 7.6 m, was conducted for the entire drilled interval. The survey shows that the hole deviated 15.2 m south and 75.3 m west with a maximum drift angle of less than 5° (fig. 3). Previous drill holes (UE25a-1, UE25b-1H, USW G-1, and USW H-1) also drifted to the west. This predominate drift direction could be structurally controlled, and could be related to faults dipping predominately to the west with blocks downdropped to the west.

The orienting of core during drilling was attempted; however, the data obtained are questionable; therefore, no oriented core data will be discussed in this report.

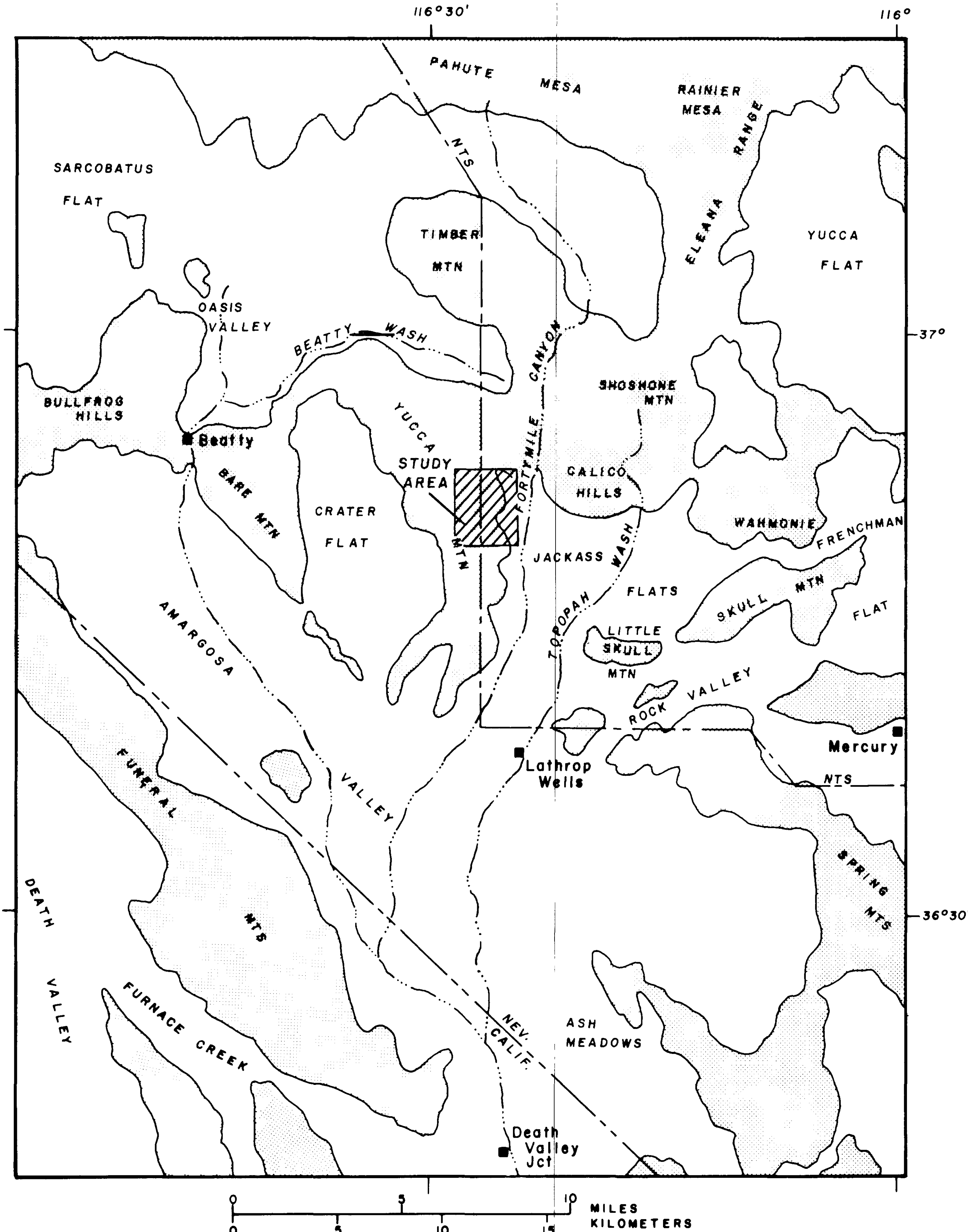


Figure 1.--Map showing Nevada Test Site and vicinity and location of study area.

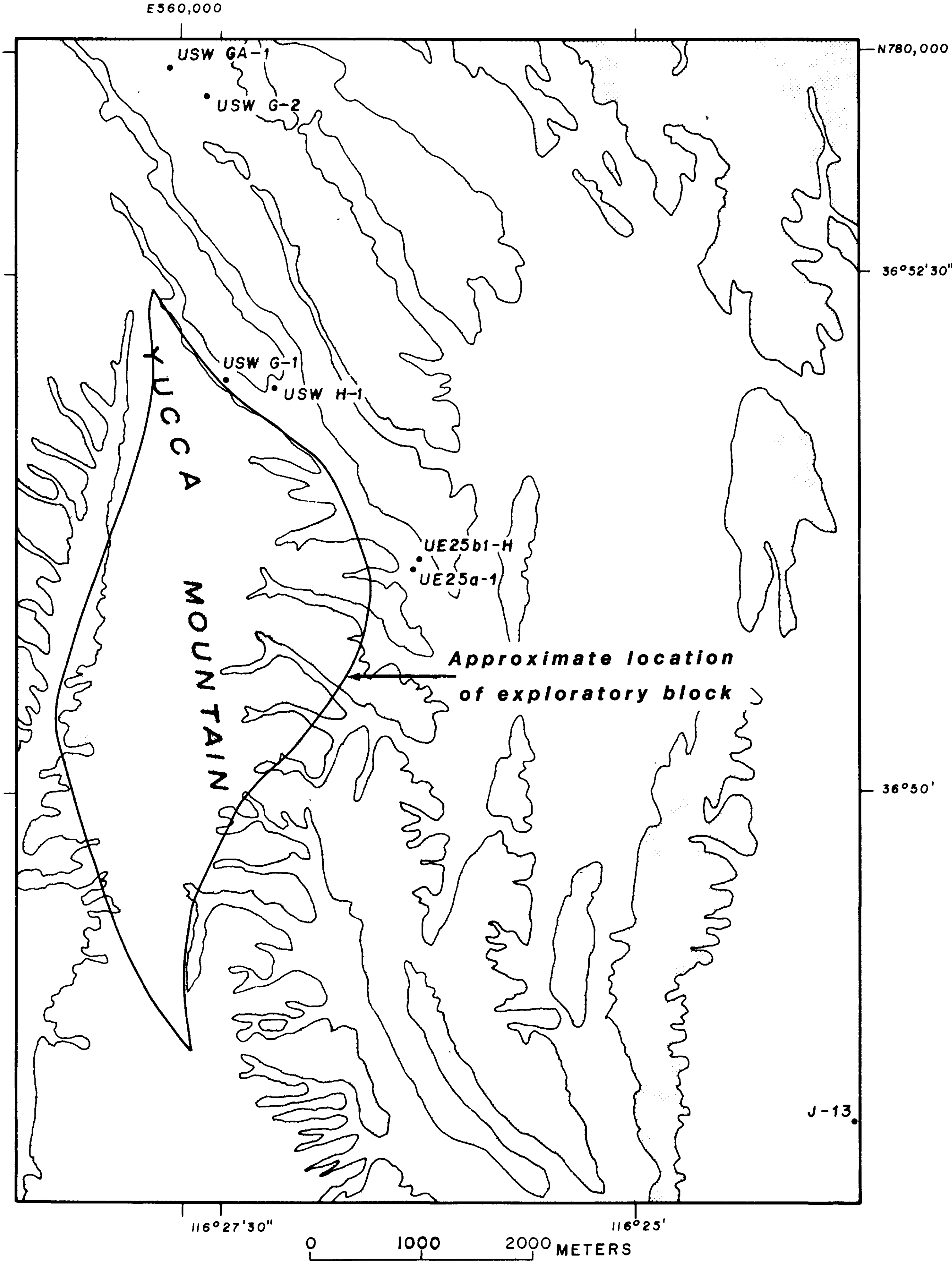


Figure 2.--Map showing location of USW G-2 drill hole and southern drill holes.

Table 1.--Abridged drill-hole history of USW G-2, Yucca Mountain, Nevada

Nevada State coordinates: N. 237,385 m
E. 170,841 m

Ground elevation: 1554 m

Drilling record: Spudded March 25, 1981
Completed coring October 11, 1981

Drill rigs: CP, Joy #1, Ideco #37

Circulating media: Air foam and polymer mud

Drill-hole sizes:

Size (cm)	Interval (meters)
43.75	0 - 85.9
30.63	85.9- 242.3
21.88	242.3- 813.8
15.63	813.8- 947.3
15.30	947.3-1438.5
7.45	1438.5-1830.6

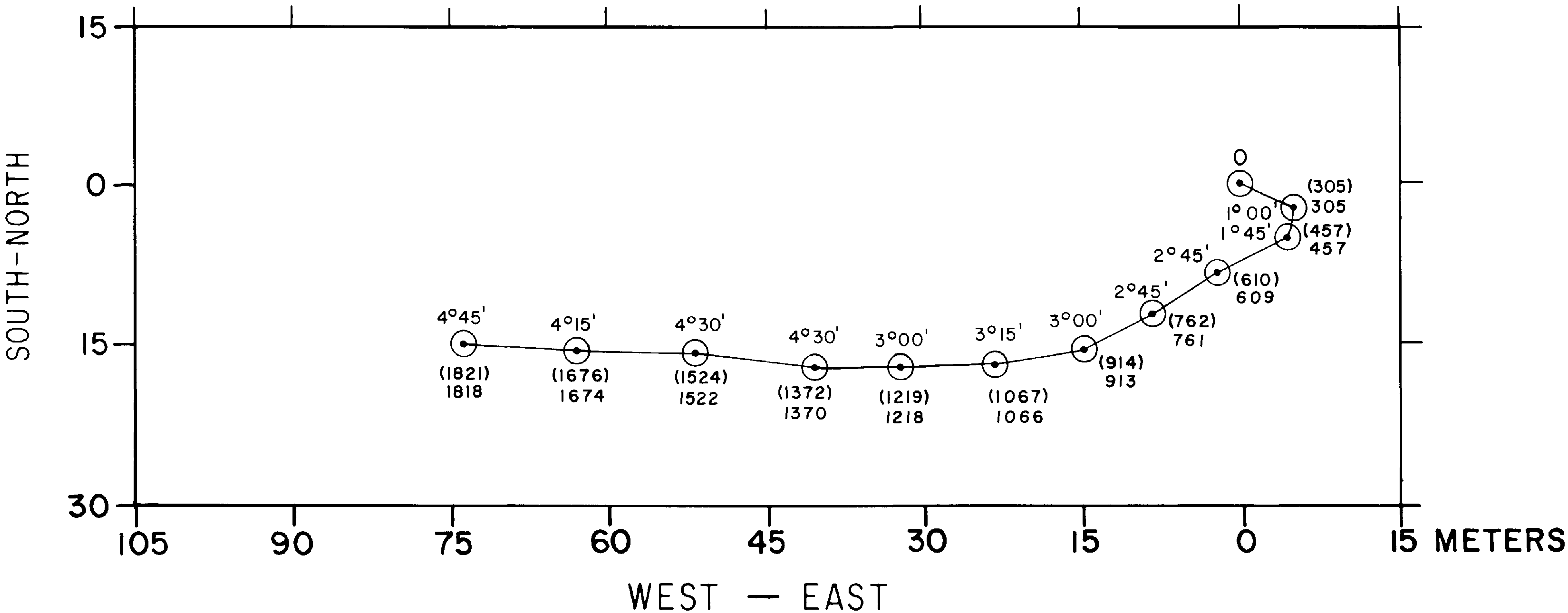


Figure 3.--Diagram showing deviation of drill hole.

Acknowledgments

Appreciation is expressed to the following Fenix & Scisson, Inc. geologists who monitored the drilling and sampling operations; D. O. Blout, M. P. Chornack, B. W. Cork, G. A. DePaolis, L. P. Escobar, C. R. Kneiblher, R. G. Lahoud, L. D. Parrish, S. J. Waddell, and J. B. Warner. Appreciation is also expressed to P. D. Blackmon for X-ray diffraction analysis, to R. B. Scott for fracture data, and to F. M. Byers, Jr. and S. F. Diehl for petrographic work, all of the USGS.

GENERAL GEOLOGIC SETTING

Yucca Mountain is located in the southwestern Nevada volcanic field, a faulted, dissected volcanic plateau, composed predominately of silicic ash-flow tuffs, with minor lava flows and volcaniclastic rocks of Miocene age. Several caldera complexes are found in the area and include the Timber Mountain-Oasis Valley complex, Silent Canyon, and Black Mountain calderas (fig. 4), all located north-northwest of Yucca Mountain. These calderas have been described by Byers and others (1976) and Christiansen and others (1977). A more recently recognized caldera complex, the Crater Flat caldera (Carr, 1982) is hypothesized to be west of Yucca Mountain in the Crater Flat area (fig. 4), and could extend east to include part of the Yucca Mountain area. The caldera complexes occur along the Walker Lane zone (Gianella and Callaghan, 1934; Carr, 1976) and in a zone characterized by the presence of northeast-trending left-lateral faults. The area is also characterized by a strong north- to northwest-trending Basin and Range high-angle normal fault system, predominately downdropped to the west. The general geology of the Yucca Mountain area is shown on figure 5, and the subsurface geology relative to several drill holes on figure 6.

The general stratigraphy (exposed and in the subsurface) of the Yucca Mountain area consists of Tertiary rocks and are the following in descending order: Timber Mountain Tuff, Paintbrush Tuff, tuffaceous beds of Calico Hills, Crater Flat Tuff, dacitic (rhyodacitic) lava and flow breccia, tuff of Lithic Ridge, rhyolitic, quartz latitic and dacitic lava and flow breccia, and older ash-flow and bedded tuffs. The general stratigraphy and age determination of the ash-flows and their respective source areas are indicated in table 2.

STRATIGRAPHY

The rock units penetrated by the drill hole are composed of essentially rhyolitic ash flows, with lesser rhyodacitic and dacitic lavas and flow-breccias, with minor tuffaceous sediments, and ash-fall tuffs occurring between the cooling units. The tuffaceous sediments and ash-fall tuff at the

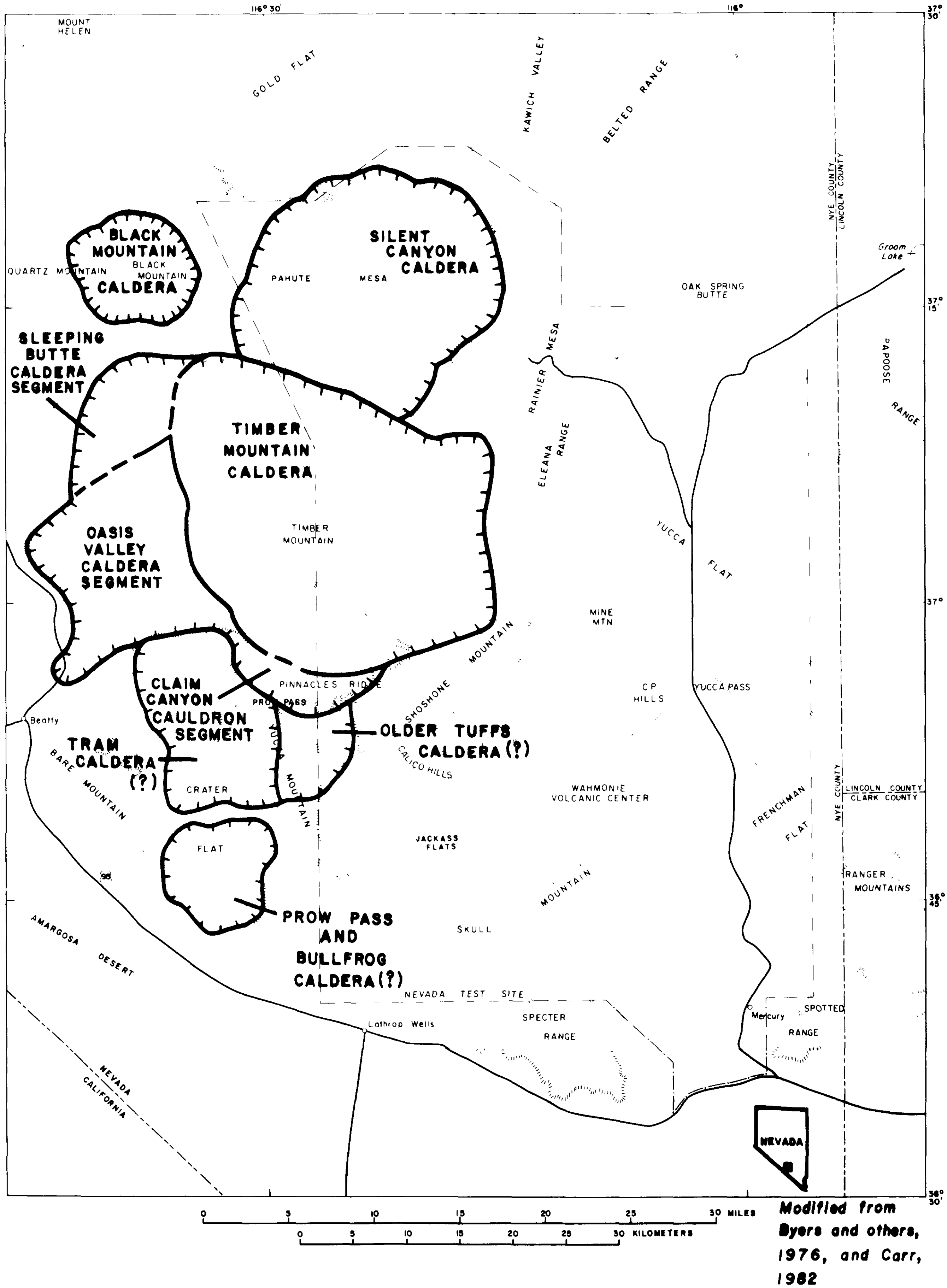


Figure 4.--Map showing location of caldera complexes relative to Yucca Mountain.

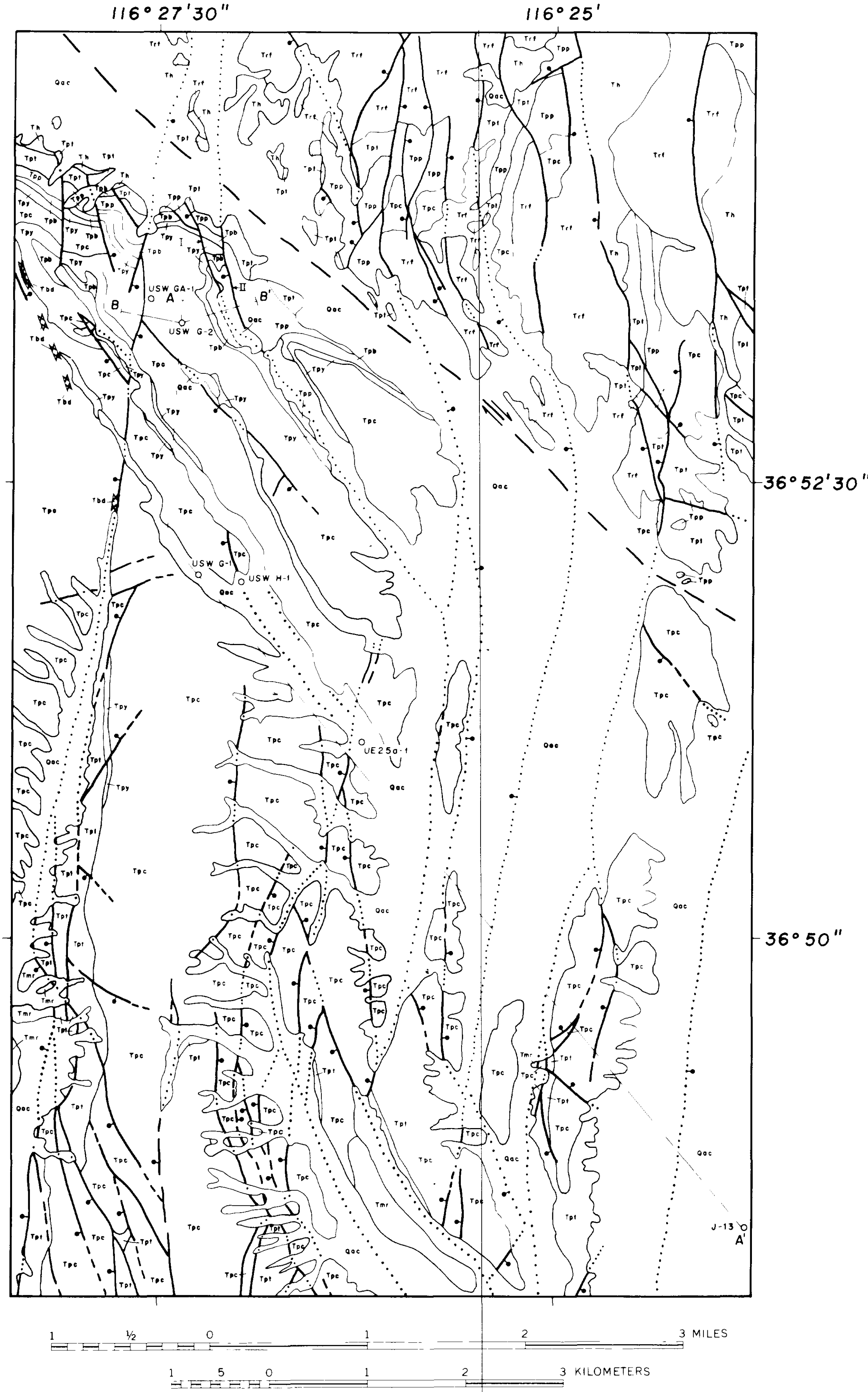
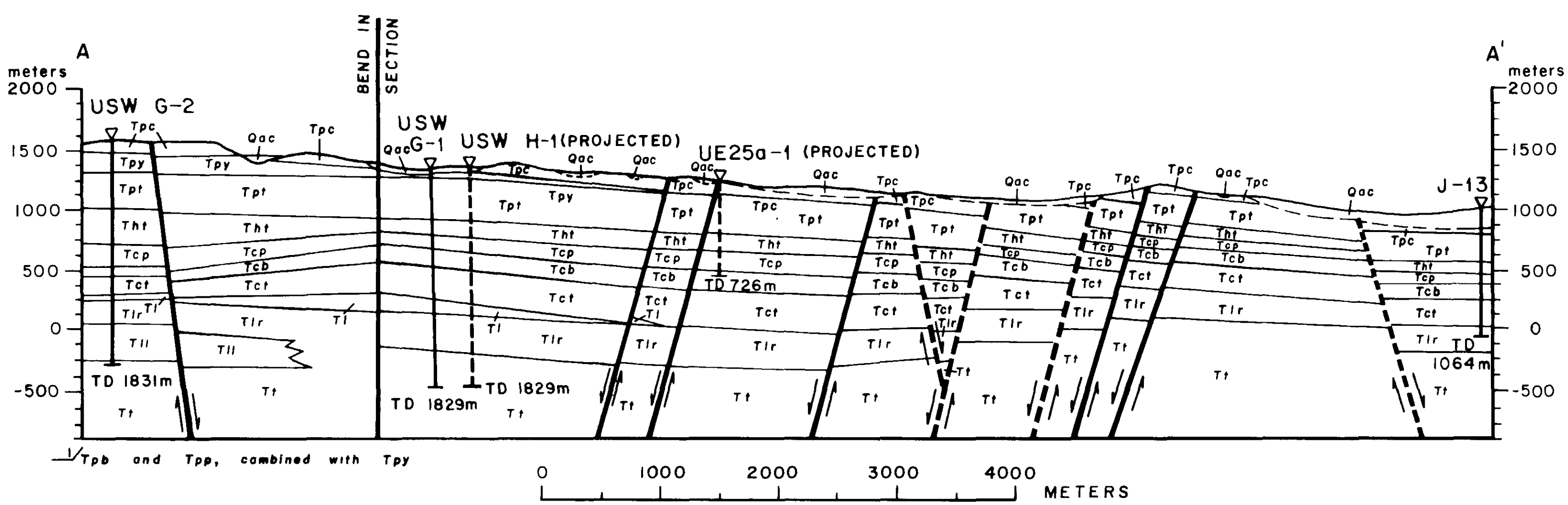


Figure 5.--Generalized geologic map (section line A-A' shown on figure 3 and B-B' on figure 22).

EXPLANATION OF SYMBOLS

Qac	Alluvium
Tpc	Tiva Canyon Member
Tpy	Yucca Mountain Member [1]
Tpt	Topopah Spring Member
Tht	Tuffaceous beds of Calico Hills
Tcp	Prow Pass Member
Tcb	Bullfrog Member
Tct	Tram Unit
Tl	Lava flow and flow breccia
Tlr	Tuff of Lithic Ridge
Tll	Lava flow and flow breccia
Tt	Older tuffs



[1] Tpb and Tpp, combined with Tpy

Figure 6.--Geologic cross section along line A-A' of figure 5.

EXPLANATION

Qac	Alluvium and Colluvium (Quaternary)
Tbd	Basalt Dikes of Yucca Mountain (Tertiary)
Trf	Rhyolites of Fortymile Canyon (Tertiary)
Tmr	Rainier Mesa Member of Timber Mountain Tuff (Tertiary)
	Paintbrush Tuff (Tertiary)
Tpc	Tiva Canyon Member
Tpy	Yucca Mountain Member
Tpb	Bedded Tuff
Tpp	Pah Canyon Member
Tpt	Topopah Spring Member
Th	Rhyolites of Calico Hills (undivided,Tertiary)
	Fault, dashed where approximately located, dotted where concealed , bar and ball on downthrown side
	Contact
USW G-2	Approximate location of drill holes
I, II	Indicates faults discussed in text

Figure 5.--Continued

Table 2.--General stratigraphy and source areas, Yucca Mountain area and vicinity, Nevada

[Leaders (---) indicate no age determination available]

	Age (m.y.)	Volcanic center	Formation	Unit
Miocene	11.3	Timber Mountain caldera	Timber Mountain Tuff	Rainier Mesa Member
	12 13	Claim Canyon caldera	Paintbrush Tuff	Tiva Canyon Member Yucca Mountain Member Bedded tuff Pah Canyon Member Topopah Spring Member
	13.4	Northwest part of the Calico Hills		Tuffaceous beds of Calico Hills
	13.5	Crater Flat caldera	Crater Flat Tuff	Prow Pass Member Bullfrog Member
		Tram caldera (?)		Tram unit
		Northern Yucca Mountain area		Dacitic lava and flow breccia
	---	Northeastern Crater Flat (?)		
	---	?		Tuff of Lithic Ridge
		Northern Yucca Mountain area		Rhyolitic, quartz latitic and dacitic lava and flow breccia
	---	Northeastern Crater Flat(?)		
	---	Northeastern Yucca Mountain (?)		Older ash-flow and bedded tuffs

base of each cooling unit are described with the overlying cooling unit for the sake of discussion with the exception of a bedded tuff containing predominately ash flows that occurs between the Yucca Mountain and Pah Canyon Members. The thickness of the respective units are indicated in table 3 in descending order and plotted graphically on plate 1. (See table 1a of the appendix for detailed description.)

Paintbrush Tuff

The Paintbrush Tuff comprises, in descending order, the following cooling units: Tiva Canyon, Yucca Mountain, Pah Canyon, and Topopah Spring Members. A fairly thick local nonwelded ash-flow tuff unit that was mapped as part of bedded tuff by Christiansen and others (1965) occurs between the Yucca Mountain and Pah Canyon Members.

Tiva Canyon Member

The Tiva Canyon Member is the lower part of a compound cooling ash-flow tuff unit that is compositionally zoned with upper quartz-latitic, middle rhyolitic, and lower high-silica rhyolitic units (Byers and others, 1976). The upper part of the compound cooling unit is represented by the tuff of Chocolate Mountain, largely an intracaldera unit exposed only in a few isolated localities at Yucca Mountain, but widely exposed within the Claim Canyon cauldron segment (fig. 5), north of Yucca Mountain; consequently, this upper part will not be discussed any further in this report.

The drill hole penetrated 68.6 m of the Tiva Canyon Member and 6 m of ash-fall and tuffaceous sediments at the base. Six major subunits were observed and are in descending order: vitric densely welded (quartz-latite caprock), devitrified densely welded (quartz-latite caprock), lithophysal zone, devitrified densely welded, devitrified moderately to partially welded vapor-phase zone, and a basal argillized nonwelded zone. These subunits vary in thickness and are described in more detail in table 1a of the appendix.

In general, the Tiva Canyon contains sanidine, plagioclase, biotite hornblende, and rare quartz phenocrysts. In the quartz-latite zone, the unit is phenocryst rich and contains as much as 15 percent phenocrysts and is characterized by the presence of bronze-colored biotite. The phenocryst content decreases drastically below the quartz-latite zone to approximately 2 percent phenocrysts near the base of the cooling unit.

Yucca Mountain Member

The Yucca Mountain Member is a simple ash-flow cooling unit with an upper and lower nonwelded to partially welded zone that envelopes a middle moderately to densely welded zone. The moderately to densely welded zone is characterized by the presence of manganese oxide speckles both disseminated throughout the matrix and along fractures. Petrographically, the unit is crystal poor, and contains approximately 1 percent sanidine, plagioclase, biotite, and quartz phenocrysts.

Table 3.--Comparison of unit thickness at several deep drill holes, Yucca Mountain, Nevada

[Dashed (----) lines indicate unit not penetrated by drill hole; thicknesses in meters (feet)]

Rock units	USW G-2 TD 1830.6 m (6,006 ft)	USW G-1[1] TD 1828.8 m (6,000 ft)	USW H-1[2] TD 1828.8 m (6,000 ft)	UE25b-1H[2] TD1219.9 m (4,002.3 ft)
Tiva Canyon Member-------	68.6 (225.0)	----	27.4 (90.0)	27.4 (90.0)
Bedded tuff--------------	6.0 (20.0	----	1.5 (5.0)	----
Yucca Mountain Member----	29.2 (96.0)	12.2 (40.0)	19.8 (65.0)	----
Bedded tuff--------------	0.8 (2.5)	10.7 (35.0)	9.1 (30.0)	----
Bedded tuff (ash flow)---	44.0 (144.5)	----	----	----
Bedded tuff--------------	3.1 (10.0)	----	----	----
Pah Canyon Member--------	70.9 (232.7)	30.5 (100.0)	90.0 (27.4)	6.1 (20.0)
Bedded tuff--------------	8.8 (28.7)	----	----	4.6 (15.0)
Topopah Spring Member----	287.0 (941.6)	356.3 (1168.9)	350.5 (1150.0)	338.3 (1110.0)
Bedded tuff--------------	17.0 (56.0)	6.6 (21.6)	4.6 (15.0)	10.7 (35.0)
Tuffaceous beds of of Calico Hills.	288.7 (947.0)	94.8 (310.9)	90.5 (297.0)	148.4 (487.0)
Bedded tuff--------------	----	19.8 (65.1)	11.1 (56.2)	----
Prow Pass Member---------	176.1 (577.9)	107.1 (351.5)	134.7 (441.8)	147.4 (483.6)
Bedded tuff--------------	10.2 (33.6)	6.4 (21.0)	6.1 (20.0)	1.7 (5.4)
Bullfrog Member----------	67.5 (221.5)	130.6 (428.6)	113.4 (372.0)	149.8 (491.6)
Bedded tuff--------------	21.6 (70.6)	11.5 (37.8)	11.4 (37.3)	9.1 (29.9)

Table 3.--Comparison of unit thickness at several deep drill holes, Yucca Mountain, Nevada--Continued

Rock units	USW G-2 TD 1830.6 m (6,006 ft)	USW G-1[1] TD 1828.8 m (6,000 ft)	USW H-1[2] TD 1828.8 m (6,000 ft)	UE25b-1H[2] TD1219.9 m (4,002.3 ft)
Tram unit----------------	103.6 (340.0)	269.0 (882.6)	271.5 (890.7)	310.4 (1018.5)
Bedded tuff--------------	50.3 (164.9)	11.0 (36.2)	12.2 (40.0)	18.0 (59.2)
Lava (dacite) flow and flow breccia.	[3]22.0 (71.1)	110.3 (361.8)	111.6 (366.0)	----
Bedded tuff--------------	13.8 (45.2)	7.9 (25.8)	7.9 (26.0)	----
Tuff of Lithic Ridge-----	185.3 (608.0)	297.2 (974.9)	265.2 (870.0)	42.1 (12.8)
Bedded tuff--------------	[4]7.3 (24.0)	5.9 (19.5)	8.5 (28.0)	----
Older ash flows and bedded tuff of USW G-1.	[5]8.8 (28.6)	323.0 (1059.8)	320.0 (1050.0)	----
Bedded tuff--------------	5.5 (18.2)	----	----	----
Lava (rhyolitic) and flow breccia.	101.0 (331.3)	----	----	----
Lava (quartz latitic) and flow breccia.	113.6 (432.0)	----	----	----
Bedded and ash-flow tuff--	10.1 (33.3)	----	----	----
Lava (dacitic) and flow breccia.	65.5 (214.8)	----	----	----
Bedded tuff, conglomerate, and ash-flow tuff.	17.4 (57.1)	----	----	----
Older tuffs of USW G-2-----	19.3 (63.5)	----	----	----

[1]Unit thickness from R. W. Spengler and others, 1982.

[2]Unit thickness from R. W. Spengler, written commun., 1982.

[3]Lava is rhyodacitic in USW G-2.

[4]Part of bedded and ash-flow tuff in lithologic log.

[5]Unit b (ash flow) present, units a and c missing.

The drill hole penetrated 29.2 m of the cooling unit and 0.8 m of bedded tuffaceous sediments at the base. The member thins to the south as indicated by the southern drill holes (fig. 6; table 3). The source of the Yucca Mountain Member is north of the drill hole; consequently, a thinning of the unit is expected southward.

Bedded Tuff

Bedded and nonwelded ash-flow tuffs occur locally between the Yucca Mountain Member and underlying Pah Canyon. The bedded sequence is 44 m thick at USW G-2, where it consists essentially of ash flow intercalated with some ash fall. North of the drill-hole site, this unit contains abundant ash fall and attains a thickness of approximately 90 m. The unit eventually pinches out south of USW G-2, as evidenced by the southern drill holes (table 3).

The ash flows were probably emplaced locally at a low temperature, as evidenced by lack of welding. The tuffs are mostly vitric and partly argillized and contain large pumice and abundant volcanic lithics. The tuffs are characterized by a very low phenocryst content of quartz, sanidine, and plagioclase.

Pah Canyon Member

The Pah Canyon Member is a simple ash-flow cooling unit with an upper and lower nonwelded to partially welded zone, and a middle moderately to densely welded zone. The sheet displays an upper and lower vitric zone that envelopes a middle zone that is partly zeolitized and argillized. The zeolitized zone could possibly represent a perched zone, since zeolites have not been previously identified in the Pah Canyon Member. The unit is fairly crystal poor, containing approximately 5 percent phenocrysts of biotite, sanidine, and plagioclase.

The drill hole penetrated 70.9 m of the Pah Canyon Member and 8.8 m of basal tuffaceous sediments intercalated with some ash-fall tuff. The Pah Canyon, like all of the Paintbrush members, thins toward the southern drill holes.

Topopah Spring Member

The Topopah Spring Member is a multiple ash-flow compound cooling unit (compositionally zoned) as indicated by Lipman and others (1966). The compositional zonation grades from crystal-poor rhyolite at the base to crystal-rich quartz latite toward the top; petrographically the unit contains sanidine, plagioclase, biotite and clinopyroxene phenocrysts (Lipman and others, 1966). The sheet has been described in detail by Lipman and others (1966) and the reader is referred to that report for a more detailed description.

The member is 287 m thick at USW G-2 compared to the southern drill holes where it is approximately 338 m (UE25b-1H), 350 m (USW H-1), and 356 m (USW G-1) thick. The missing strata could be the result of thinning of the sheet due to paleotopography, structural omission of strata as suggested by the presence of numerous fault zones, or a combination of both.

At USW G-2, the member consists of the following zones in descending order: nonwelded, moderately welded, vitrophyre, densely welded vapor phase, densely welded lithophysal, vitrophyre, moderately welded and nonwelded zones and is underlain by 17 m of bedded tuff. Only the lithophysal zone will be discussed here. (See appendix for further description.)

The lithophysal zone is the thickest zone, approximately 200 m thick in USW G-2 compared to 215 and 260 m in the UE25a-1 and USW G-1 drill holes, respectively. The lithophysal cavities are typically surrounded by groundmass that has been altered, resulting in a mottled appearance around the cavities. The cavities and surrounding altered zone are commonly spheroidal and occasionally flattened (fig. 7), open to partially filled, and predominantly coated or filled with calcite and some quartz and feldspar toward the top (276-287 m). Calcite is abundant in this interval decreasing with depth, and apparently is absent below 380 m. A sample of calcite, collected at 348 m, was age dated at 142,000+20,000 yrs. B.P. (J. N. Rosholt, written commun., 1982) using the uranium-series dating. Below 380 m the cavities are predominately coated with quartz and feldspar; however, other minerals are probably present, but in very minor amounts, At the UE25a-1 drill hole, the lithophysal cavities in the Topopah Spring Member are coated with traces of pseudobrookite, montmorillonite, illite, clinoptilolite, hematite, dolomite, and siderite (Spengler and others, 1979).

At the USW G-2 drill hole, the lithophysal zone varies in amount of lithophysae. In order to obtain a better understanding of the lithophysal zone, a point count of the lithophysae was attempted. The procedure included laying out a measuring tape over the core and counting a point every 3 cm in zones where lithophysae were very abundant and every 1.5 cm in zones where lithophysae were sparse. For the purpose of the point count, lithophysae included the cavity and (or) mottled zone surrounding the cavity. This procedure was done for the entire lithophysal zone, resulting in lithophysae in volume percent of the rock. The data are summarized on figure 8, where the entire lithophysal zone is expressed mostly in 3-m increments.

The lithophysal zone contains from trace amounts to as much as 90 percent lithophysae per volume of rock in some zones, and averages (per 3-m increment) from 3 to as much as 72 percent. The zone can be divided into at least four major subzones based on the percent of lithophysae. These subzones are indicated on figure 8, and include subzones IV (270-329 m), III (329-384 m), II (384-438 m), and I (438-489 m) in descending order. The boundaries of these subzones are marked by substantial decrease in lithophysae; this suggests that at least four major pulses of ash flow occur within the lithophysal zone.

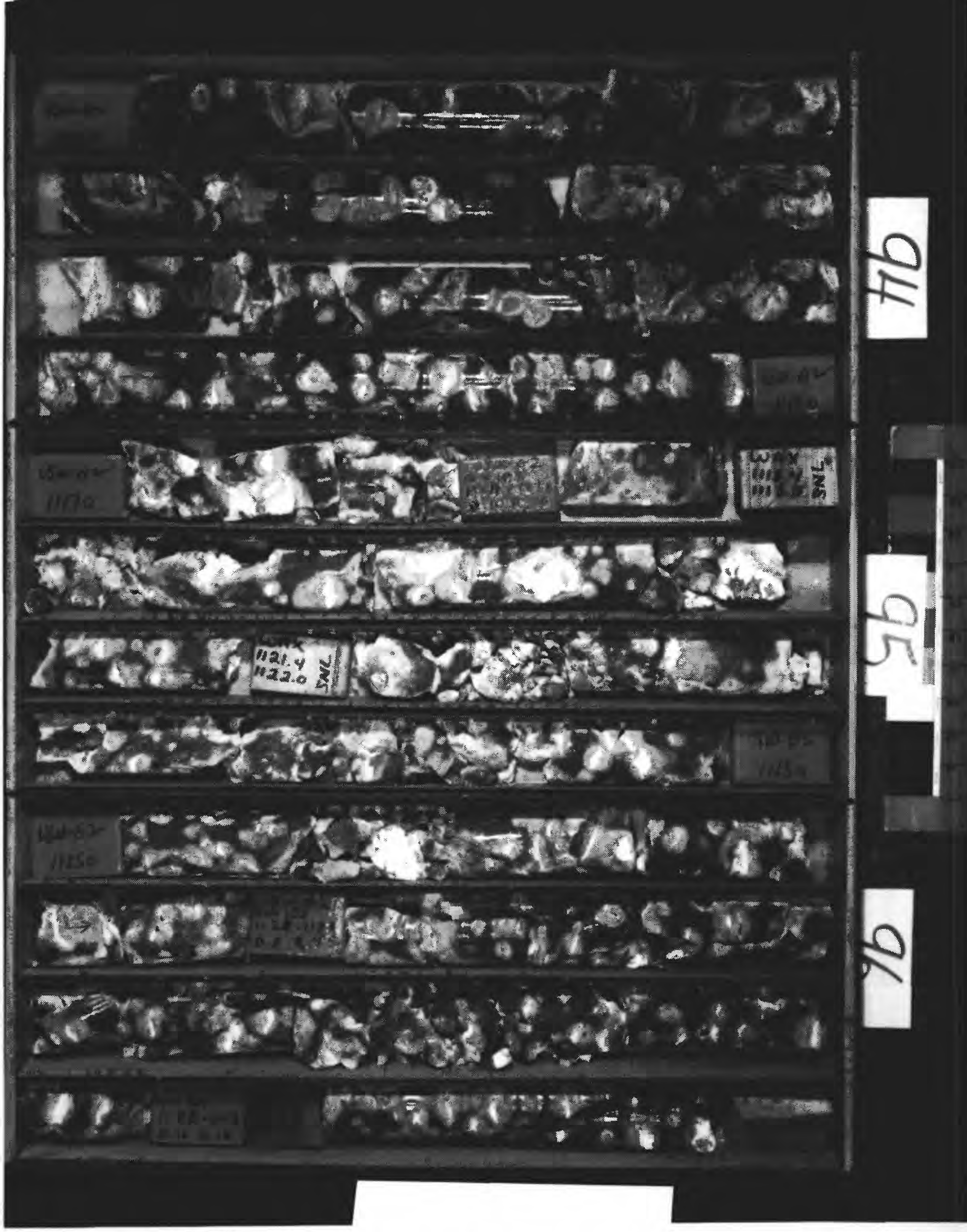


Figure 7.--Core from the lithophysal zone of the Topopah Spring Member, USW G-2 drill hole, Yuca Mountain, Nevada.

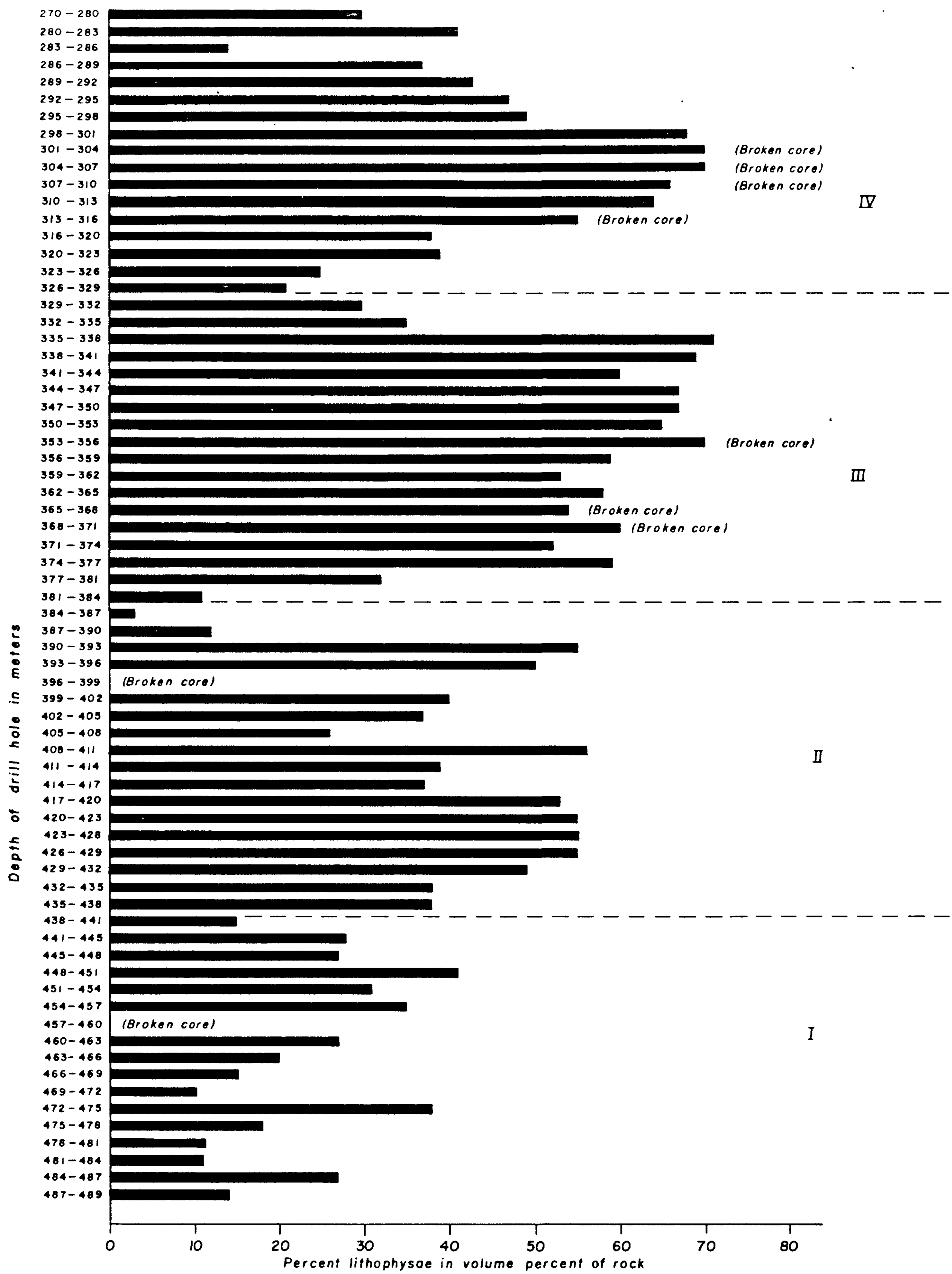


Figure 8.--Bar graph showing lithophysae variation in the lithophysal zone of the Topopah Spring Member.

Tuffaceous Beds of Calico Hills

The tuffaceous beds of Calico Hills is an informal name for tuffaceous rocks with possible source area located in the northwest part of the Calico Hills (fig. 1). As expected, the 288.7-m thickness of the unit at USW G-2 is thicker than at the southern drill holes. This may be due to proximity to the source area or the result of filling of a paleovalley. The unit is composed essentially of nonwelded ash-flow tuff with 15 thin tuffaceous sedimentary beds with minor ash-fall tuffs. The rocks are typically zeolitized and characterized by a decrease in quartz and sanidine and an increase in plagioclase and biotite phenocrysts with depth (fig. 9). An increase in phenocrysts and overall increase in lithics was also observed with depth. The tuffaceous beds of Calico Hills at USW G-2 can be divided into three (upper, middle, and lower) subunits on the basis of mineral content.

The upper subunit is 158.9 m thick, and occurs from 535.5 to 694.4 m. The subunit is characterized by a relatively higher quartz-sanidine phenocryst content and lower biotite-plagioclase content than the underlying subunits. The subunit is pervasively zeolitized and ranges from 50 to 70 percent in zeolites (clinoptilolite and mordenite) as indicated by X-ray analysis (table 4). Seven tuffaceous sedimentary beds with minor ash-fall tuffs occur throughout the unit.

The middle subunit is 32.6 m thick at interval 694.4-727.0 m. This subunit could possibly represent the mineralogic transition in phenocryst content from a high quartz-sanidine to a low quartz-sanidine. The interval is also characterized by alternating thin ash-flow tuffs with thin tuffaceous sediments with some ash-fall tuffs.

The lower subunit is 97.2 m thick, occurs at 727.0-824.2 m, and contains a relatively higher plagioclase-biotite phenocryst and lower quartz-sanidine phenocryst content than overlying subunits. Quartz phenocrysts are slightly resorbed. The zeolite (mordenite and clinoptilolite) content is estimated to range from 30-50 percent, a decrease from the overlying subunits.

The basal part (tuffaceous sediments and ash fall) of the tuffaceous beds of Calico Hills is absent. A major fault places a nonwelded ash-flow tuff of the Calico Hills against the densely to moderately welded zone of the underlying Prow Pass Member. This fault will be discussed in more detail under the section, "Structural Properties of the Core."

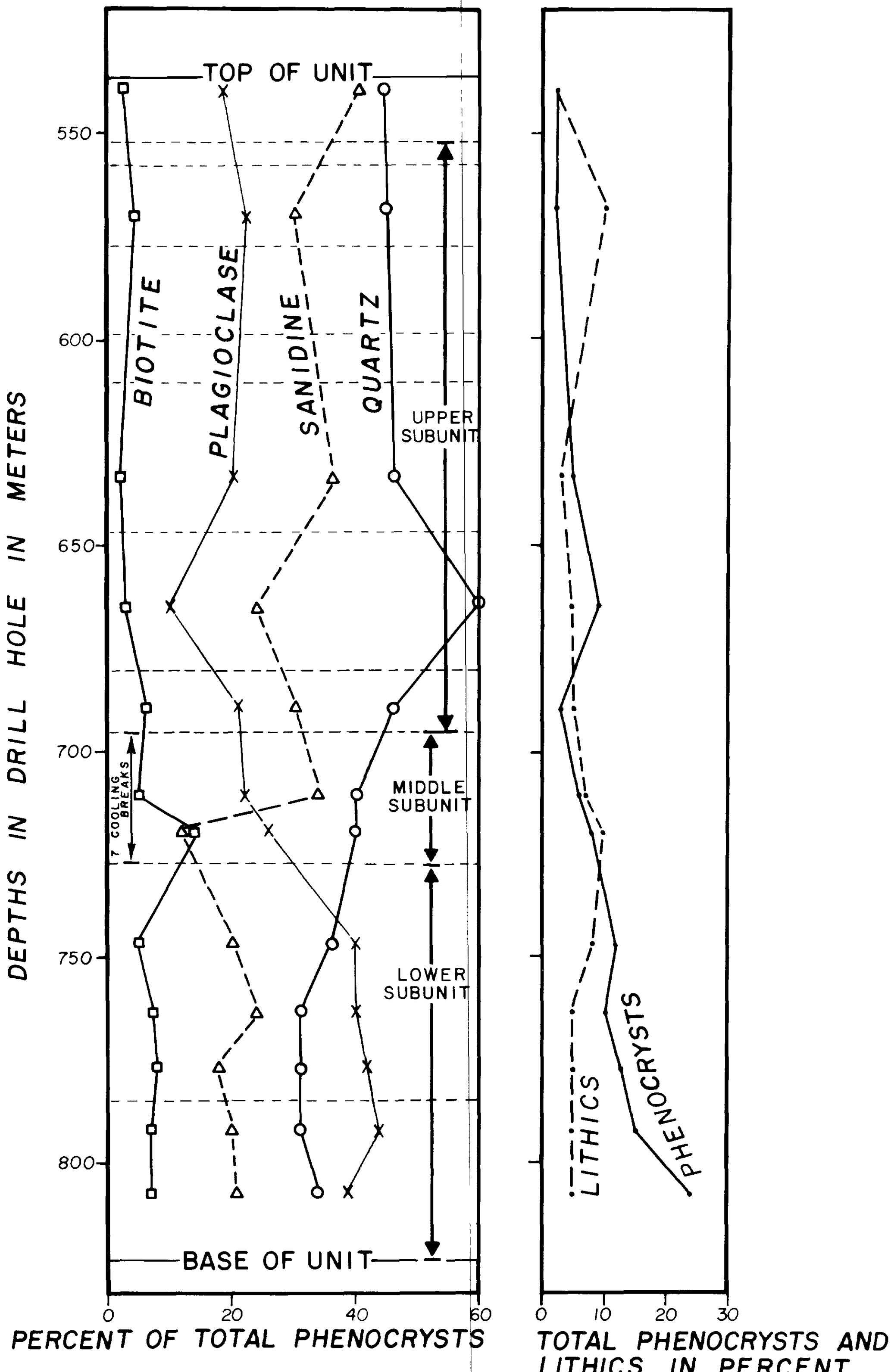


Figure 9.--Graph showing phenocrysts and lithic variations in the ash-flow tuffs of the tuffaceous beds of Calico Hills.

Table 4.--X-ray analyses of core samples from drill hole, USW G-2, Yucca Mountain, Nevada

[Estimated amounts of mineral present were determined by X-ray diffraction and are listed below as parts in 10; Tr, trace (<5 percent), <1=5-9 percent; leaders (---)indicate minerals not identified; NW, PW, MW, indicate nonwelded, partially, and moderately welded ash-flow tuff, respectively. Stratigraphic unit symbols shown on pl. 1. Analyst, Paul D. Blackmon, USGS]

Depth of samples (meters)	Strati-graphic unit	Welding zone	Mineral content: Montmorillonite	Illite-Mica	Illite	Quartz	Feldspar	Cristobalite-opaline silica	Amorphous (ash)	Carbonate (acid reaction)	Clinoptilolite	Heulandite/clinoptilolite	Clinoptilolite/heulandite	Clinoptilolite/mordenite	Mordenite/clinoptilolite	Mordenite	Analcime	Hematite	Chlorite
170.7	Tpp	NW-PW	[1]<1	TR	---	TR	3	4	<1	TR	1	---	---	---	---	---	---	---	---
171.5	Tpp	NW-PW	TR	TR	---	---	3	3	<1	TR	---	2	---	---	---	---	---	---	---
187.2	Tpp	PW-NW	<1	TR	---	TR	5	2	TR	TR	<1	---	---	---	---	---	---	---	---
205.7	Tpp	PW-NW	[2]3	TR	---	---	2	1	<1	TR	---	---	3	---	---	---	---	---	---
539.6	Tht	NW	TR	---	---	TR	1	<1	<1	TR	---	---	---	7	---	---	TR	---	---
569.9	Tht	NW	TR	TR	---	<1	1	<1	TR	TR	---	---	---	7	---	---	---	---	---
600.5	Tht	NW	TR	TR	---	TR	1	<1	<1	TR	---	---	---	7	---	---	---	---	---
630.9	Tht	NW	TR	TR	---	TR	2	<1	<1	TR	---	---	---	6	---	---	---	---	---
664.0	Tht	NW	TR	TR	---	TR	1	<1	<1	TR	---	---	---	---	7	---	---	TR	---
692.8	Tht	NW	TR	TR	---	---	3	<1	TR	TR	---	---	---	---	---	5	---	---	---
724.2	Tht	NW	TR	TR	---	<1	2	TR	<1	TR	---	---	---	---	5	---	---	TR	---
753.2	Tht	NW	TR	TR	---	1	3	TR	TR	TR	---	---	---	---	4	---	---	TR	---
783.4	Tht	NW	TR	TR	---	2	3	---	TR	TR	---	---	---	---	---	3	---	TR	---
813.9	Tht	NW	TR	<1	---	2	3	---	TR	TR	---	---	---	---	---	3	---	TR	---
878.2	Tcp	NW-PW	[2]TR	TR	---	4	5	---	TR	TR	---	---	---	---	---	---	---	TR	---
898.6	Tcp	NW-PW	[2]<1	TR	---	2	6	---	TR	TR	---	---	---	---	---	---	---	TR	---
923.0	Tcp	PW-NW	[1]2	TR	---	3	4	---	---	TR	---	---	---	---	---	TR	---	TR	---
934.5	Tcp	PW-NW	TR	TR	---	TR	2	1	2	TR	---	---	---	4	---	---	---	TR	---
945.5	Tcp	PW-NW	<1	---	TR	---	2	2	2	TR	---	---	---	---	---	3	---	---	---
956.5	Tcp	NW	TR	---	[3]TR	2	4	---	TR	TR	---	---	---	---	2	---	TR	[4]TR	---
983.7	Tcp	NW	[5]<1	---	<1	2	2	---	TR	TR	---	---	---	3	---	---	1	[6]TR	---
1,011.6	Tcb	PW-NW	[7]TR	TR	[8]TR	3	5	---	TR	TR	---	---	---	---	---	---	---	TR	---
1,018.0	Tcb	PW-NW	[7]TR	TR	---	3	6	---	TR	TR	---	---	---	---	---	---	---	TR	---
1,033.3	Tcb	MW	[7]TR	TR	---	4	5	---	TR	TR	---	---	---	---	---	---	---	TR	---
1,050.9	Tcb	PW-NW	[7]TR	TR	[9]TR	2	5	TR	TR	---	---	---	---	---	---	---	1	[6]TR	---
1,060.7	Tcb	NW	[2]<1	TR	---	2	4	---	<1	---	---	---	---	---	---	2	---	---	---
1,147.6	Tct	PW	---	<1	[10]4	3	1	---	<1	TR	---	---	---	---	---	---	---	TR	---
1,182.6	Tct	PW	---	<1	[11]3	3	1	---	<1	TR	---	---	---	---	---	---	---	TR	---
1,286.3	Tlr	PW	---	1	[9]2	2	3	---	<1	TR	---	---	---	---	---	---	TR	[4]TR	---
1,316.9	Tlr	PW	---	<1	[11]2	3	2	---	TR	TR	---	---	---	---	---	---	TR	[4]TR	TR
1,347.2	Tlr	PW	---	1	[11]2	2	3	---	<1	TR	---	---	---	---	---	---	---	[4]TR	---
1,377.7	Tlr	PW	---	<1	[11]2	3	3	---	<1	TR	---	---	---	---	---	---	---	[4]TR	---
1,439.9	Tlr	PW	---	2	[12]1	2	3	---	1	TR	---	---	---	---	---	---	---	TR	---
1,463.3	Tlr	PW	---	2	[12]<1	3	3	---	<1	TR	---	---	---	---	---	---	---	TR	---
1,820.3	Tt	PW	---	2	[13]TR	3	3	---	<1	TR	---	---	---	---	---	---	---	TR	TR
1,830.5	Tt	PW	---	2	[13]TR	2	4	---	TR	TR	---	---	---	---	---	---	---	---	TR

[1]20-30 percent illite mixed layers.
[2]15-25 percent illite mixed layers.
[3]10-20 percent expandable layers.
[4]Contains goethite instead of hematite.
[5]10-20 percent illite mixed layers.
[6]Contains magnetite instead of hematite.
[7]Aluminum or hydroxyl interlayers.
[8]20-25 percent expandable layers.
[9]20-30 percent expandable layers.
[10]25-30 percent expandable layers.
[11]15-25 percent expandable layers.
[12]15-20 percent expandable layers.
[13]<10 percent expandable layers.

Crater Flat Tuff

The Crater Flat Tuff consists, in descending order, of the following cooling units: Prow Pass and Bullfrog Members, and Tram unit.

Prow Pass Member

The Prow Pass Member is 176.1 m thick at USW G-2, thicker than at the southern drill holes (table 3), possibly indicating a thickening toward a source area, or presence of a paleotopographic low near the USW G-2 area, that was partially filled by the sheet. The cooling unit is composed of approximately 10-15 percent phenocrysts predominately quartz (highly resorbed, fig. 10), sanidine, plagioclase, and trace amounts of biotite and hornblende (fig. 11). The member is distinguished from the other member of the Crater Flat by the presence of orthopyroxene and an abundance of mudstone lithics possibly derived from the Eleana Formation of Mississippian-Devonian age, which crops out to the northeast of the Yucca Mountain area.

Megascopic examination of cores from drill holes USW G-1, USW G-2, UE25b-1H, and UE25a-1 at Yucca Mountain have lead to the identification of four subunits within the Prow Pass Member (table 5). The uppermost subunit is absent at USW G-2.

Table 5.--Occurrence and thickness of subunits of the Prow Pass Member at several deep drill holes, Yucca Mountain, Nevada

[Leaders (---) indicate subunit not penetrated by drill hole; interval in meters; (thickness in meters)]

Subunit	USW G-2	USW G-1	UE25b-1H	UE25a-1
4	--- (faulted out)	549.1-605.6 (56.5)	570.6-582.8 (12.2)	559.5-594.3 (34.8)
3	824.2-862.3 (38.1)	---	---	---
2	862.3-929.2 (66.9)	605.6-632.1 (26.5)	582.8-648.7 (65.9)	594.3-643.0 (48.7)
1	929.2-990.1 (60.9)	632.1-655.9 (23.8)	648.7-717.9 (69.2)	643.0-710.6 (67.6)

Subunit 4 has been described by Spengler and others (1982) as an "uppermost subunit" that is partially welded, vapor phase, moderate reddish orange toward the top grading to light gray toward the base (downhole). The maximum thickness of this subunit is 57 m in drill hole USW G-1.

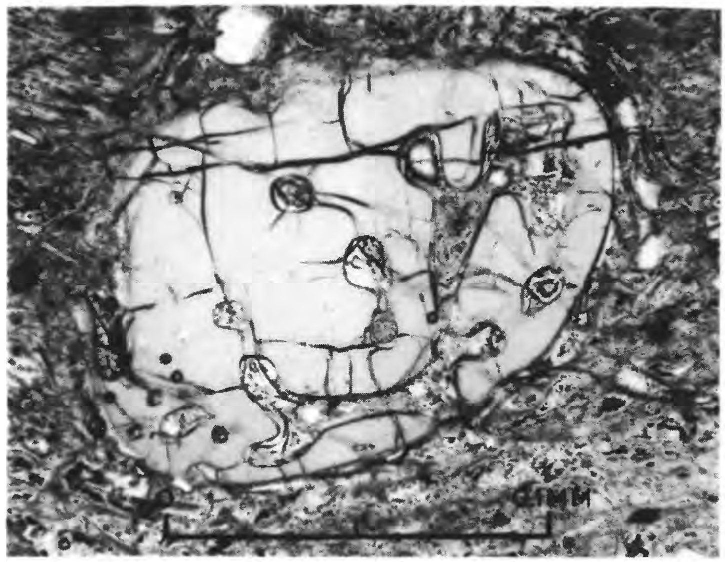


Figure 10.--Photomicrograph of tuff of the Prow Pass Member showing intensely resorbed quartz. Plane polarized light.

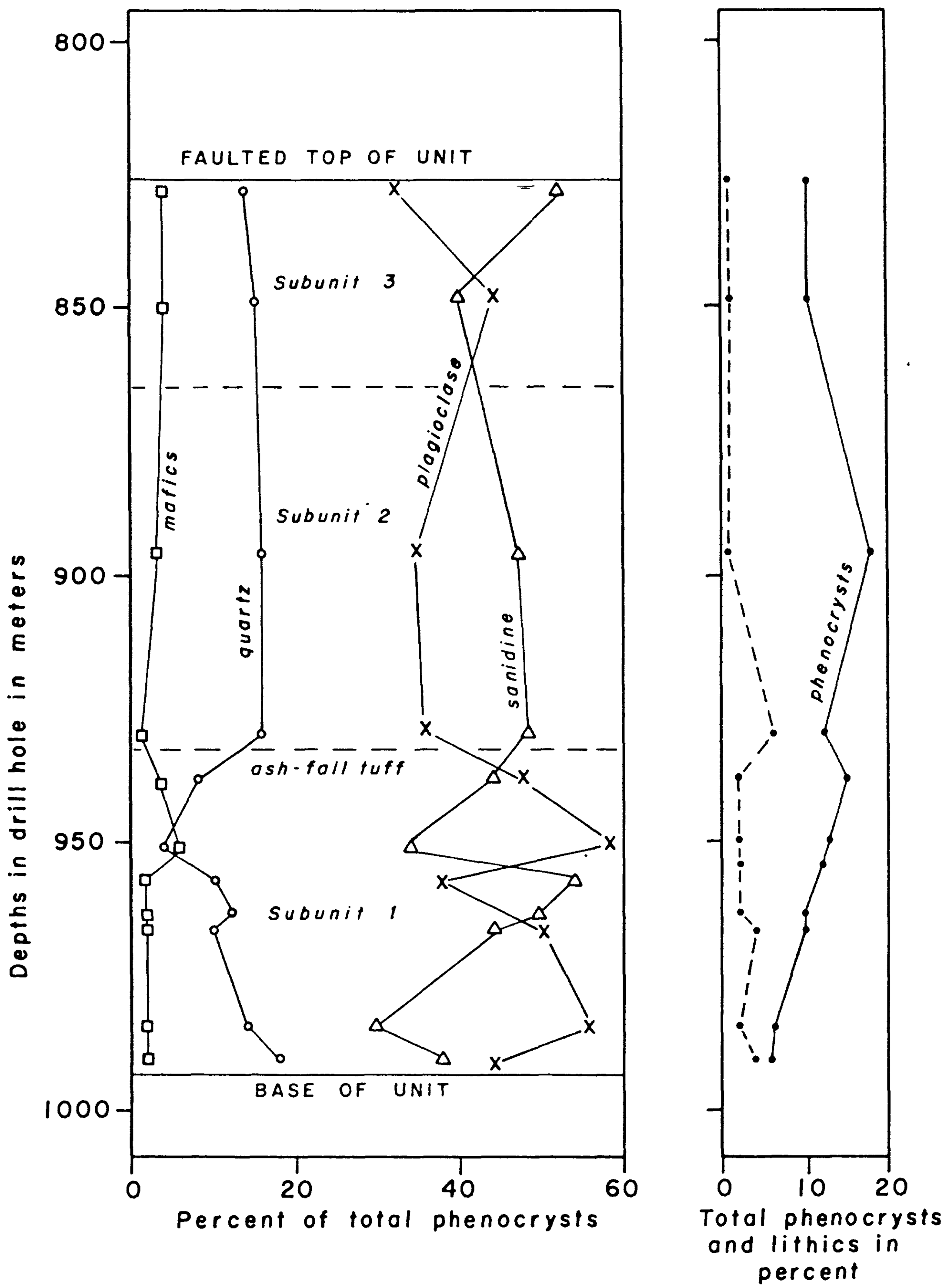


Figure 11.--Graph showing phenocryst and lithic variations in the Prow Pass Member of the Crater Flat Tuff.

At USW G-2 a fault occurs at the contact between the overlying Calico Hills tuffs and the Prow Pass Member displacing the complete section of subunit 4 and part of the upper section of subunit 3. Subunit 3 occurs between 824.2 and 862.3 m, is densely to moderately welded, and pale red to pale brown and contains less phenocrysts and lithics than the overlying subunit. The true thickness at the USW G-2 drill-hole site was not determined as the upper part has been displaced. The subunit was not penetrated by any of the southern drill holes, thus suggesting the possibility that the source area for the Prow Pass Member lies closer to the USW G-2 drill site than the area surrounding the southern drill holes.

Subunit 2 is present between 862.3 and 929.2 m, is moderately welded to nonwelded, brownish gray and grayish orange pink. This subunit is distinguished from the overlying and underlying subunits by the following criteria: (1) a decrease in degree of welding, (2) an increase in abundance of reddish-brown mudstone lithics, (3) an increase in phenocrysts and lithic content (fig. 11), (4) the presence of varying degrees of reddish iron oxide mottling, and (5) the presence of a thin ash-fall tuff at the base. This subunit is equivalent to the "middle subunit" penetrated by the USW G-1 drill hole and described by Spengler and others (1982). The UE25b-1H drill hole also penetrated this subunit at 582.8-648.7 m. The thin (approximately 5 cm) ash-fall tuff at the base of the subunit is present at drill hole USW G-1 and G-2, but absent in drill hole UE25b-1H.

The basal subunit 1 occurs at 929.2-990.1 m in USW G-2 and is partially welded to nonwelded, light olive gray, dark yellowish brown, and yellowish gray. The subunit is characterized by intense alteration, mostly zeolitization and silicification. This subunit could be equivalent to the "lowermost subunit" of Spengler and others (1982) at drill hole USW G-1, however in that area, the subunit has not been intensely altered. At UE25b-1H, a zone that occurs between 648.7 and 717.9 m has been zeolitized and silicified and appears to correlate with subunit 1. The subunit at USW G-2 overlies 10.2 m of tuffaceous sediments intercalated with some ash-fall tuff.

Bullfrog Member

The Bullfrog Member consists of approximately 10-15 percent phenocrysts of quartz (moderately to strongly resorbed sanidine, plagioclase, and biotite (fig. 12). Compared to the overlying member, the Bullfrog contains an increase in biotite, decrease in mudstone lithics, and no orthopyroxene phenocrysts. No hornblende was recognized in thin section, probably due to extreme alteration; however, hornblende has been reported from the Bullfrog from drill holes USW G-1 and UE25b-1H.

The member at USW G-2 is 67.5 m thick, thinner than at the southern drill holes where it is 130.6 m (USW G-1), 149.8 m (UE25b-1H) and 113.4 m (UE25b-1H) thick. The missing strata could be partly related to thinning of the sheet northward, or to structural omission, but probably a combination of both. At USW G-1, the member can be broken into three subunits based on the presence of thin ash-fall tuffs between the subunits. They include an upper subunit (662.3-673.5 m), a middle subunit (673.5-706.5 m), and a lower subunit (706.5-792.9 m).

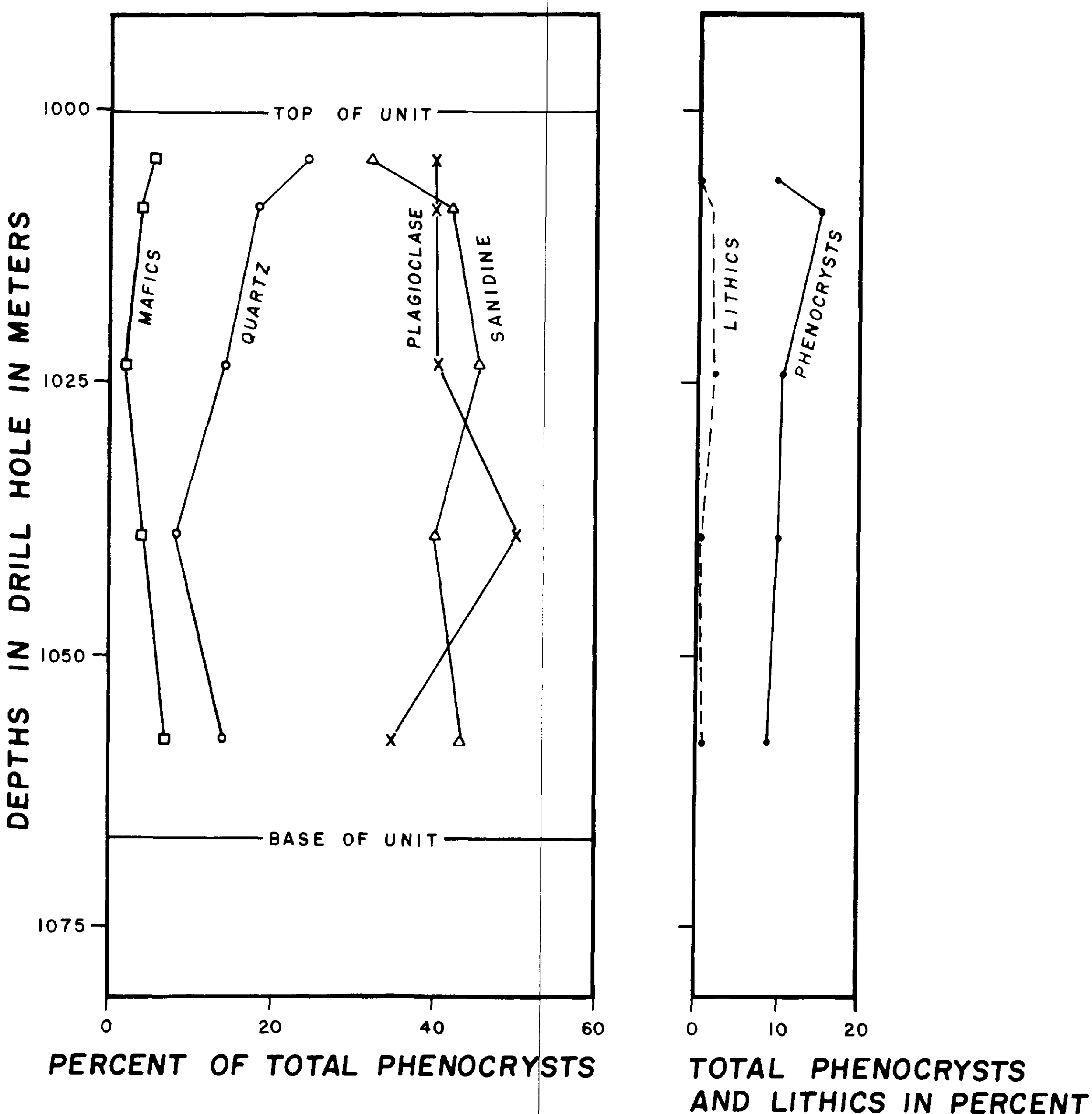


Figure 12.--Graph showing phenocrysts and lithic variations in the Bullfrog Member of the Crater Flat Tuff.

At USW G-2, no ash-fall tuff was recognized as marker beds to correlate with the USW G-1 drill hole. However, a thin (approximately 21 m) light-gray, partially welded vapor-phase zone is present toward the top of the Bullfrog (1000.3-1021.4 m) that could possibly correlate with a light-gray, partially welded vapor-phase zone present in the upper part of hte lower subunit at USW G-1. Modal analysis data from the two zones of each respective hole appear to correlate. If the two zones do indeed correlate, then the upper, middle, and part of the lower subunits identified at USW G-1, are missing in USW G-2, with only part of the lower subunit present. At this time, it is very difficult to determine if the upper and middle subunits were ever deposited in the USW G-2 area or if they were structurally displaced. Faults present in the core suggest the possibility that portions of the light-gray, partially welded, vapor-phase zone of the lower subunit are structurally displaced. This zone is approximately 60 m and 40 m thick at UE25b-1H and USW G-1, respectively, but only approximately 21 m at USW G-2; suggesting that the zone is either thinning northward or structurally displaced. The displaced strata could possibly be offset on a fault penetrated at 1015 m.

Tram Unit

The Tram unit at USW G-2 is 103.6 m thick, substantially thinner than at the southern drill holes where it is 271.5 m (USW H-1), 269.0 m (USW G-1), and 310.4 m (UE25b-1H) thick. The Tram unit at Yucca Mountain consists of an upper lithic-poor subunit and a lower lithic-rich subunit. The lithic-poor subunit contains approximately 5 percent lithics and is approximately 131, 135, and 110 m thick at drill holes USW H-1, USW G-1, and UE25b-1H, respectively, but is missing at USW G-2. The subunit is also characterized by the presence of thin (as much as 0.8 m) laminated tuffaceous sediments intercalated with the subunit at UE25b-1H and USW H-1, but missing at USW G-1.

The lithic-rich subunit in the southern drill holes of Yucca Mountain generally contains from 10 to as much as 50 percent lithics and is approximately 140, 134, and 200 m thick at drill holes USW H-1, USW G-1, and UE25b-1H, respectively. At USW G-2, the subunit is approximately 104 m thick and can be subdivided further into two sections, an upper and a lower. The upper section is approximately 45 m thick and contains from 50 to as much as 95 percent lithics consisting of rhyolite, quartz latite, and dacite lavas, and tuff xenoliths. In some zones, the ash flow is so saturated with lithics that it has nearly lost its glass-shard matrix and resembles an epiclastic deposit. The upper section has not been identified at the southern drill holes. The lower section is approximately 60 m thick and contains less than 50 percent lithics. This lower section can possibly be correlated with the most "lithic-rich" subunit of the Tram penetrated by the southern drill holes.

Petrographically the Tram unit at USW G-2 contains 5-10 percent phenocrysts comprised of quartz (slightly resorbed), plagioclase, sanidine, biotite, and trace amounts of hornblende (fig. 13). The Tram is distinguished from the overlying Bullfrog Member by more quartz phenocrysts, which are not as strongly resorbed as those in the Bullfrog. The Tram contains more quartz, little or no sphene, and fewer rhyolite spherulite xenoliths than the underlying tuff of Lithic Ridge (F. M. Byers, written commun., 1982). Finely disseminated pyrite is present in the matrix and lithics towards the base of the lithic-rich subunit of the Tram, in the southern drill holes; however, no pyrite was identified in cores from the USW G-2 drill hole.

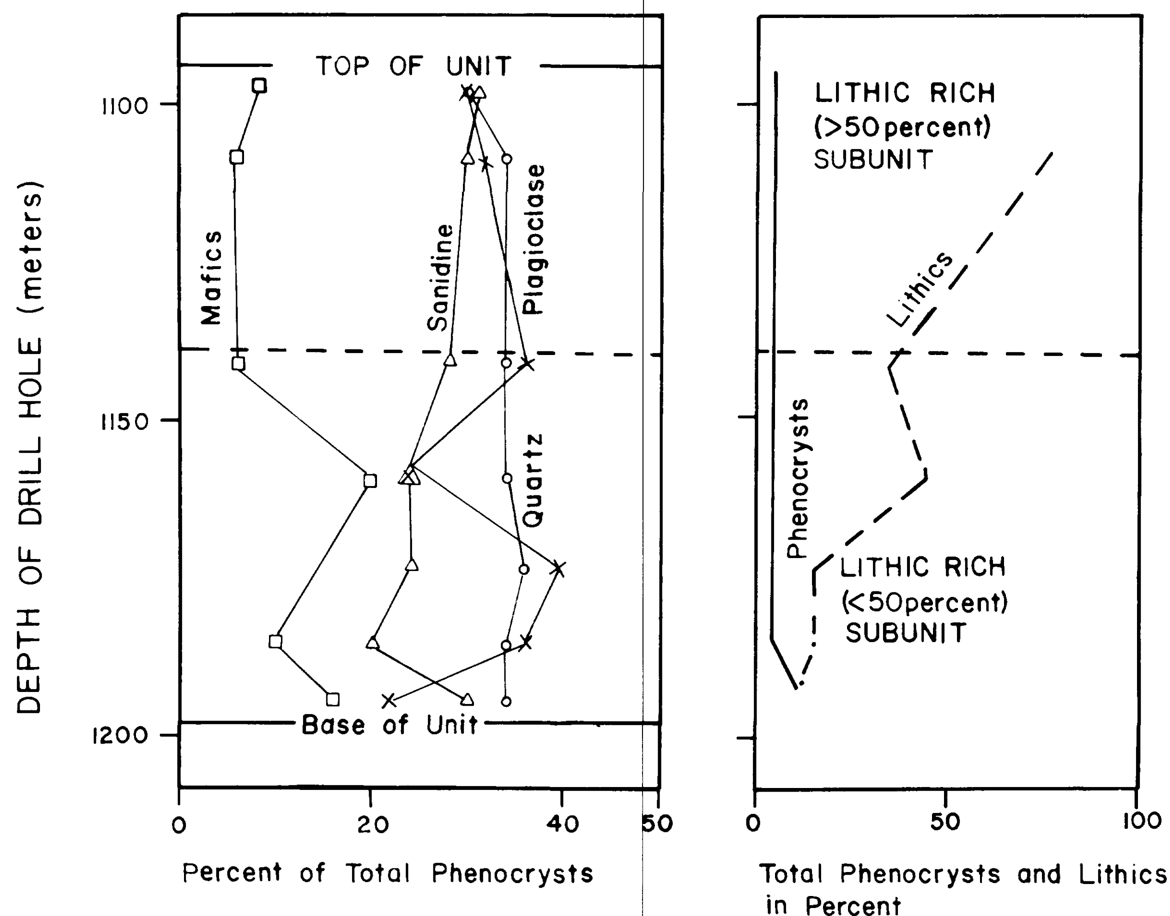


Figure 13.--Graph showing phenocrysts and lithic variations in the Tram unit.

Lava and Flow Breccia between Tram Unit and Tuff of Lithic Ridge

Approximately 22 m of lava and flow breccia of rhyodacitic composition were penetrated at USW G-2, where the flow breccia (autoclastic) occurs toward the top of the lava. The unit is considerably thin compared to an equivalent unit penetrated at USW G-1 (110 m) and USW H-1 (112 m), and appears to be pinching northward.

Petrographically, the unit is porphyritic and comprised of plagioclase, hornblende, and biotite phenocrysts, as much as 40 percent phenocrysts in contrast to the equivalent unit penetrated in USW G-1 and H-1, that contained approximately 15 percent phenocrysts. The unit at USW G-2 contains abundant hornblende, zircon and traces of clinopyroxene pseudomorphs while the equivalent unit at USW G-1 contained some hornblende, trace of zircon, and conspicuous clinopyroxene. The petrography of the unit at USW G-1 has dacite affinities while the unit at USW G-2 has those of rhyodacite, suggested by the presence of zircon and a trace of clinopyroxene. Chemical-analysis data of a sample taken at 1260 m also indicates a rhyodacite affinity (D. Vaniman, written commun., 1982).

The lava and flow breccia overlie approximately 14 m of reworked and bedded tuff that is characterized by abundant intermediate lava clasts, 1 mm to 3 cm, and occasionally blocks as large as 0.5 m.

Tuff of Lithic Ridge

The tuff of Lithic Ridge is an informal unit previously referred to as the "lithic-rich tuff" by Spengler and others (1982). The tuff of Lithic Ridge appears to be a cooling unit that varies in thickness between drill holes USW G-2, USW H-1 and USW G-1 (table 3). The sheet consists of a thin (2.5-m) medium-gray, phenocryst-rich and lithic-poor, moderately to densely welded zone that overlies a thick (183 m) fairly homogeneous light-bluish-gray to grayish-olive-green lithic-rich partially welded zone. The upper moderately to densely welded zone was not penetrated by the southern drill holes at Yucca Mountain. The lack of thickness at USW G-2 could possibly be due to thinning of the sheet over a paleotopographic high that was formed by an underlying thick sequence of lava and flow breccia. Parts of the sheet could also have been structurally displaced by a fault penetrated at 1424 m. This fault will be discussed in more detail under the section, "Structural Properties of the Core."

Petrographically, the upper moderately to densely welded zone contains as much as 25 percent phenocrysts (fig. 14), predominately of plagioclase, with some biotite, and trace amounts of quartz and alkaline feldspar(?). In contrast, the underlying partially welded zone contains 10-20 percent phenocrysts, containing substantially more alkaline feldspar, and more quartz and less plagioclase (fig. 15) than the overlying zone. The lithic content also differs in the two zones. The moderately to densely welded zone is characterized by a low content (approximately 5 percent) compared to the underlying partially welded zone that contains from 10 to 15 percent lithics. The lithics include rhyolite, quartz latite, and dacite lava and sparse ash-flow tuff.

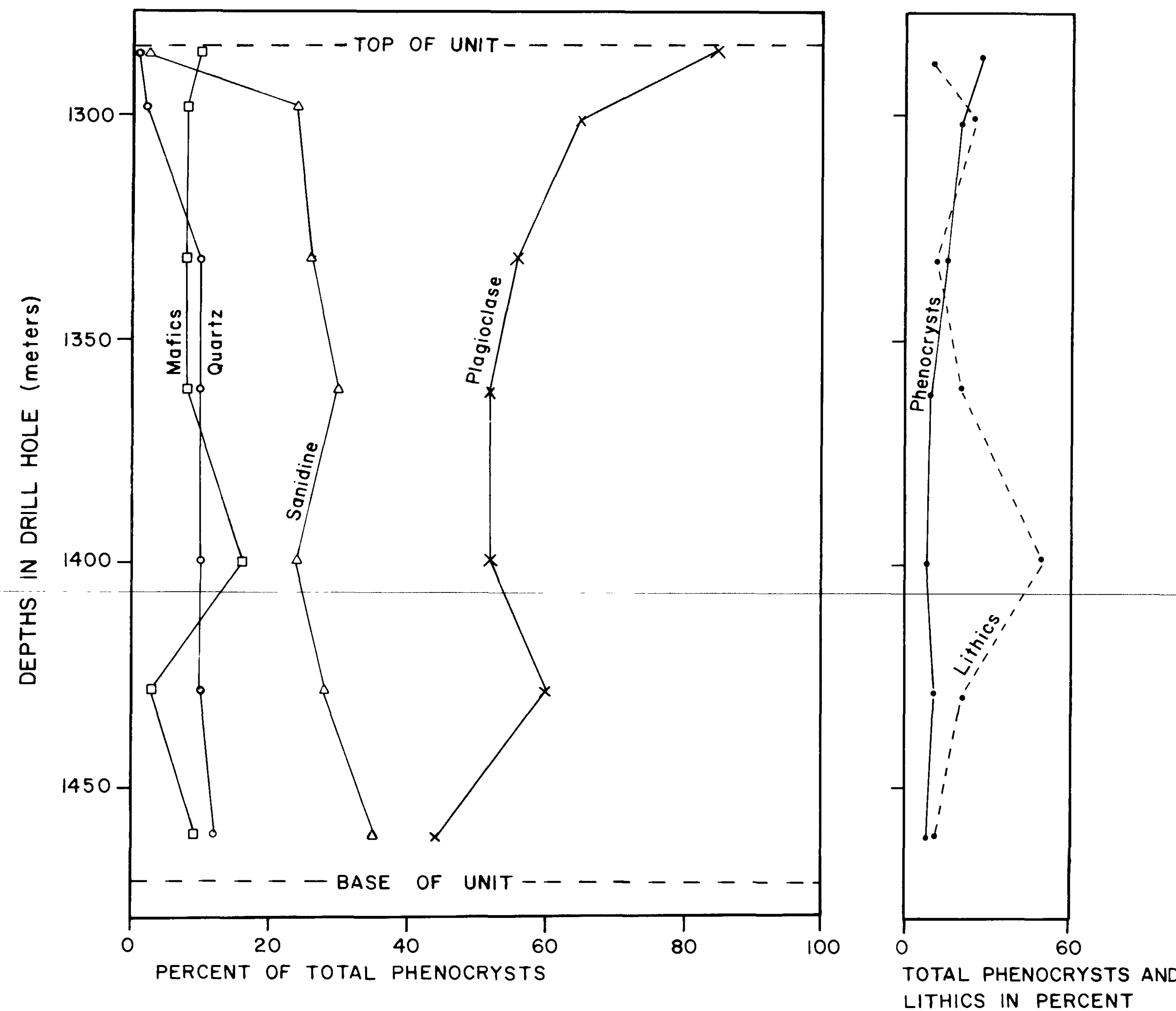


Figure 14.--Graph showing phenocrysts and lithic variations in the tuff of Lithic Ridge.

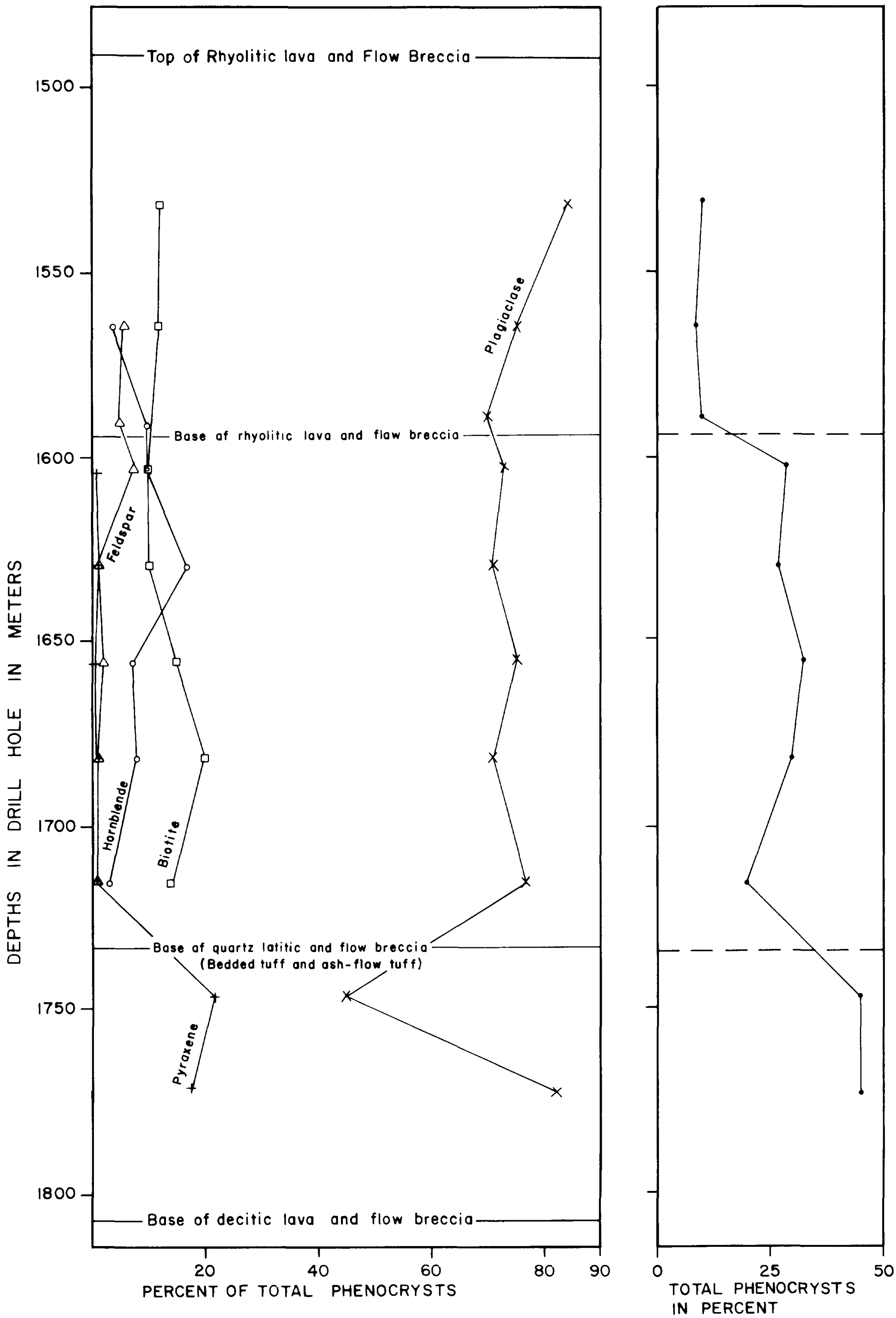


Figure 15.--Graph showing phenocrysts and lithic variation in the rhyolitic, quartz latitic, and dacitic lava and flow breccia.

Bedded and Ash-Flow Tuff

The tuff of Lithic Ridge is underlain by approximately 13 m of tuffaceous sediments, with a thin (approximately 9 m) ash-flow tuff intercalated with the tuffaceous sediments. This thin ash-flow tuff is very light gray to light greenish gray, partially welded, and contains 15-20 percent phenocrysts. The phenocrysts consist of plagioclase, biotite, and sparse sanidine and quartz. The ash flow apparently has the same phenocryst composition (table 6) and probably correlates with a thin ash-flow tuff that is present in USW G-1 at 1656-1661 m (F. M. Byers, Jr., oral commun., 1982). This thin ash flow in USW G-1 is the uppermost ash flow of unit C, which is the lowest unit of the "older ash-flow and bedded tuffs" of USW G-1 (Spengler and others, 1982). Unit C is approximately 173 m thick in USW G-1, and thins drastically north of the USW G-1 drill site. No other units of the "older ash-flow and bedded tuffs" of USW G-1 were identified in USW G-2.

Table 6.--Comparison of modal analysis data of samples from a thin ash-flow tuff in USW G-1 and USW G-2 drill holes, Yucca Mountain, Nevada

Phenocrysts and lithics	Drill holes and sample depths		
	USW G-1 (1657.6 m)	USW G-2 (1474.6 m)	USW G-2 (1475.6 m)
Plagioclase---------	84.7	87.4	84.3
Alkaline feldspar---	2.8	2.7	5.1
Quartz--------------	1.1	.7	1.0
Biotite-------------	8.2	6.3	9.1
Opaques-------------	3.2	3.0	.5
Lithics-------------	1.0	1.5	2.0

Lava and Flow Breccia

General Features

The USW G-2 drill hole penetrated a sequence of altered lavas and flow breccias approximately 298 m thick. The sequence has phenocrysts with rhyolitic affinities toward the top, quartz latitic in the middle and dacitic towards the base. A cooling break occurs between the quartz latitic lava and dacitic lava at 1718.3-1728.4 m where the quartz latitic unit overlies a thin reworked bedded tuff that in turn overlies a thin (5 m) ash-flow tuff. The bedded tuff appears to be fused where the quartz latitic lava overlies the tuff. The ash-flow tuff is partially welded, and contains approximately 15-25 percent phenocrysts of plagioclase and biotite with trace amounts of quartz, sanidine(?), hornblende, and pyroxene and could possibly be genetically related to the underlying dacitic lava flow.

Rhyolitic, Quartz Latitic, and Dacitic Lava and Flow Breccia

The rhyolitic lava and flow breccia are 101 m thick, porphyritic, and contain approximately 5-15 percent phenocrysts of plagioclase, biotite, hornblende, and K-feldspar, with zircon and apatite abundant in the groundmass. The lava is enclosed by a flow breccia at the top and toward the base of the unit, and is typically flow banded and spherulitic, with spherulites occuring between the flow brecciated top and base. The spherulites are so common in some areas that the flow-banded texture has been masked. The rhyolite overlies the quartz latitic lava and flow breccia at 1586.6 m, in a zone where brecciation and slickensides are present, suggesting a fault contact between the two units.

The quartz latitic lava and flow breccia is approximately 132 m thick, porphyritic, and contains approximately 15-25 percent phenocrysts of plagioclase, biotite, and hornblende (pseudomorphs), with trace amounts of K-feldspar, and pyroxene (pseudomorphs). Zircon and apatite are abundant in the groundmass. This unit is distinguished from the overlying rhyolitic unit by an increase in phenocrysts, a decrease in plagioclase and K-feldspar and an increase in biotite and pyroxene (fig. 15). The unit is intensely altered, with hornblende replaced mainly by feldspars, calcite, and opaques, biotite by hematite, magnetite, sphene, and calcite, and plagioclase by calcite and sericite. Fluorite filling vesicles and voids in plagioclase phenocrysts were observed in a thin section sample taken from 1595 m (fig. 16).

Although the quartz latitic unit has a flow breccia at the base of the lava flow, a corresponding flow breccia is apparently absent at the top of the flow, where a fault has been proposed, possibly displacing the upper flow brecciated zone. The lower flow breccia overlies the thin reworked bedded tuff and thin ash flow discussed earlier under general features. The thin ash flow overlies the dacitic lava and flow breccia.

The dacitic lava and flow breccia are approximately 66 m thick, and characterized by a flow brecciated top and bottom enveloping the lava flow. The unit is porphyritic and consists of approximately 30-45 percent phenocrysts of plagioclase and pyroxene, with abundant apatite but no zircon in the groundmass. The dacitic lava differs from the overlying rhyolitic and quartz-latitic lavas in containing very sparse to absent biotite and hornblende and a substantial increase in pyroxene and an overall increase in total phenocrysts (fig. 15). The unit is intensely altered with pyroxene replaced by chlorite, calcite, quartz, feldspar, and magnetite; plagioclase is replaced by calcite and sericite. A reddish-brown iron oxide is common in the groundmass and along fractures toward the base (1761.0-1785.9 m) of the unit. Barite was also identified in a vein at 1736 m (F. M. Byers, Jr., oral commun., 1982), occurring with calcite and quartz.

The following can be stated in characterizing the entire sequence of lavas: (1) an increase in phenocryst content occurs with depth, (2) K-feldspar is present in the rhyolitic unit, decreases in the quartz-latitic unit, and is absent in the dacitic unit, (3) hornblende and biotite are common in the rhyolitic and quartz latitic units, but, rare and almost absent in the dacitic unit, (4) pyroxene is absent in the rhyolitic unit, low in the quartz latitic unit, and common in the dacitic unit, (5) zircon is present in the rhyolitic and quartz latitic units but very rare to absent in the dacitic

Figure 16.--Photomicrograph of fluorite in vesicles and plagioclase phenocrysts in the quartz latitic lava flows. Crossed nicols.

unit, and (6) the pile of lavas has an inverse of the common sequence of dacite at the top and rhyolite at the base.

Bedded Tuff, Conglomerate, and Ash-Flow Tuff

This informal unit is approximately 17 m thick, and consists of conglomerates, reworked and bedded tuff, some ash-fall tuff, and a thin intercalated ash-flow tuff. A thin conglomerate is present at the base of the dacitic flow-breccia at 1793.9-1794.9 m that contains subrounded rhyolitic, intermediate and andesitic lava clasts and trace amounts of tuff clasts. The clasts in the conglomerate decrease toward the base where it overlies a reworked tuff that becomes thin bedded toward the base. This thin-bedded interval overlies another thin conglomerate at 1803.1-1804.8 m that contains angular to subrounded tuff, intermediate lava, and pumice clasts. The conglomerate overlies a thin tuffaceous sandstone at the base, that in turn overlies a thin ash flow at 1804.8-1807.4 m. The ash flow is partially welded and contains approximatley 10-15 percent phenocrysts comprised of quartz, plagioclase, sanidine, and biotite. This unit appears to have the same phenocryst content as the underlying ash-flow units ("older tuffs" of USW G-2) and probably represents the last phase in the eruption cycle of that unit. A thin reworked and bedded tuff approximately 4 m thick occurs between the thin ash-flow tuff and the underlying tuffs, suggesting a period of quiescence between the main eruption and the last thin eruption of ash flow.

Older Tuffs of USW G-2

The USW G-2 drill hole penetrated approximately the upper 19 m of this unit. This informal unit has not been correlated with any other unit as it has not been previously penetrated by drill holes nor recognized in outcrop. It probably underlies the older ash-flow and bedded tuffs of USW G-1. The portion of this unit penetrated by the drill hole is partially to moderately welded, devitrified, and contains approximately 20 percent phenocrysts of quartz, sanidine, plagioclase, and biotite. The unit has undergone intense alteration with plagioclase altering to sericite, calcite, and epidote, sanidine to sericite and calcite, and biotite to chlorite, sericite, and sphene(?).

STRUCTURAL PROPERTIES OF THE CORE

Foliation and Bedding

The deviation of the hole has not been considered in the bedding and pumice-foliation measurements. However, because the maximum drift angle is so small (less than 5°, fig. 3), and because that occurs toward the bottom of the hole, no substantial change would result with a drift-angle correction.

Development of foliation in the ash-flow tuffs varies from poor to good within the numerous units, with eutaxitic structure well developed only in the Topopah Spring Member. Foliation measurements include only the dip of the plane of flattening of the pumice and not the strike, and were taken only in those units with well-developed foliation; consequently, only the following three units were considered for foliation measurements: Yucca Mountain, Topopah Spring, and Prow Pass Members. The dips of the pumice for all the measured units range from 2° to 11°, increasing in dip with depth as follows; 2° for the Yucca Mountain Member, 2° to 11° for the Topopah Spring Member, and 7° to 11° for the Prow Pass Member.

Numerous tuffaceous sediments and ash-fall tuffs occur between the cooling units that represent periods of quiescence. Some of the tuffaceous sediments and ash-fall tuff have been reworked by wind and (or) water resulting in rounding of fragments and formation of bedding planes, and some have been deposited directly in layers. The dips of bedded material were measured throughout the entire cored interval with the first measured bed occurring at 104 m, and the last measured bed at 1809 m (pl. 1). The dips of the beds range from 3° to 36°, with the shallower dips occurring above 1090 m, where they range from 3° to 10°. Below the 1090 m level, a substantial increase in the dip occurs where the dips range from 13° to 36°, but predominantly greater than 20°. The substantial increase in dip occurs below the Bullfrog Member, in a zone where numerous faults are present. The increase in dip could be related to tectonics, or could be primary dip, but is probably a combination of both.

Fracture Analysis

Fracture-analysis data were collected by visual inspection of core laid out in core boxes. In this analysis, breaks caused by drilling and (or) handling were not tabulated. These mechanical breaks are distinguished from natural breaks by the presence of an irregular breakage surface, lack of a smooth polish surface, and usually the absence of fracture filling or coating material. Open fractures are defined as natural breaks with an aperture between the walls as they appear in the core box, and can be clean, but are usually coated with some material. Closed fractures are breaks that are sealed or healed together by fracture-filling material. Sealed fractures indicate breaks usually filled by a soft material such as clay or calcite; thus, breakage can occur along that plane during drilling. Healed fractures are usually filled by harder material such as silica so that breakage does not necessarily occur along the "fossil" fracture plane. Some of the breaks that appear to be open fractures, on visual inspection could possibly be closed fractures or predominantly sealed fractures reopened during drilling and (or) handling. Consequently, they are tabulated as open and coated fractures.

Two types of fractures are defined, joints and shear fractures (faults). Joints are fracture planes along which there has been little or no apparent displacement of the walls, whereas shear fractures are planes along which there has been displacement of the walls as evidenced by the presence of slickensides along the fracture planes, displaced pumice, or offset of bedding planes. Most of the tabulated joints are probably cooling joints; however, some are joints related to cracking within fault zones. Similarly, some of the shear fractures have occurred along preexisting cooling joint planes.

Fractures (Joints and Shear Fractures)

A number of fractures was tabulated for the core and categorized based on the following parameters: (1) fracture frequency per stratigraphic unit, (2) fracture frequency per zones within each stratigraphic unit, (3) dips of fracture per 10°-dip increment whether open or closed per stratigraphic unit, and (4) open and closed fractures per 10°-dip increment per stratigraphic unit. Fracture data for parameters 3 and 4 represent a sampling of the total fractures based on 1,580 fractures. A more complete compilation that is part of the fracture analysis study at Yucca Mountain is continuing.

A total of 7,848 fractures was tabulated from the core. Fractures are distributed throughout the various stratigraphic units (fig. 17) with the Topopah Spring Member the most intensely fractured with 3,650 fractures, followed by the Prow Pass Member with 1,279. The rhyolitic lava and flow breccia follows with 672 fractures. The high number of fractures in the Topopah Spring Member reflects its thick densely welded lithophysal zone and numerous fault zones. The intensely fractured Prow Pass Member also reflects its densely welded to moderately welded zones, silicified zones, and numerous faults.

The total number of fractures per 3 m is graphically shown on plate 1, where the intensity of fracturing can be correlated with the following: (1) densely welded zones, (2) lithophysal zones, (3) vitrophyre, (4) silicified zones, (5) fault zones, (6) cooling joints in devitrified lavas and flow breccia, and (7) bedded tuffs with depth, possibly due to the thick overburden.

Dips (angle from the horizontal assuming a vertical drill hole) of fractures per 10° increment, whether open or closed were tabulated for each stratigraphic unit and are shown on figure 18. Approximately 60 percent of the 1,580 fractures range from 40° to 90°. Some of the more fractured units contain the highest proportion in this range; the Topopah Spring Member with 58 percent, the Prow Pass Member with 67 percent, and the dacitic lava and flow breccia with 72 percent.

Open and closed fractures per 10° increment were also tabulated for each stratigraphic unit and are shown on figure 19. The predominant type of fracture apparently is open and high angle (>45°). As mentioned earlier, some of the tabulated open fractures could possibly have been open during drilling; therefore, the closed fractures tabulated should be considered a very conservative estimate.

Fracture Fillings and Coatings

The fracture-filling or coating material was tabulated and is shown for all stratigraphic units on figure 20. The data represents a sampling (1,580 fractures) of the total fractures. A more complete compilation that is part of the fracture analysis study at Yucca Mountain is continuing. Six major filling or coating materials were documented occuring in various combinations and are as follows in decreasing abundance: $CaCo_3$, Fe, SiO_2, Mn, clay, and zeolites. The Fe and Mn also contain oxides and hydroxides. At the USW G-1 drill hole, Spengler and others (1982) indicate the principal fracture filling or coating material in decreasing abundance: SiO_2, MnO_2, Fe_2O_3, $CaCO_3$, and clay.

The following are some observations based on the fracture filling or coating material data: (1) iron oxides and hydroxides are abundant in most units with highest concentration in the Crater Flat Tuff (Prow Pass and Bullfrog Members and Tram unit), (2) clay is ubiquitous throughout the units increasing with depth from the Tram unit, (3) $CaCO_3$ is abundant in all units except the tuffaceous beds of Calico Hills and the Crater Flat Tuff members, (4) Sio_2 is common in the upper part of the drill hole, but rare below the Topopah Spring Member, (5) zeolites(?) are present only in the Topopah Spring Member, tuffaceous beds of Calico Hills, and the Prow Pass Member, and (6) manganese oxides and hydroxides are abundant in the Yucca Mountain Member but

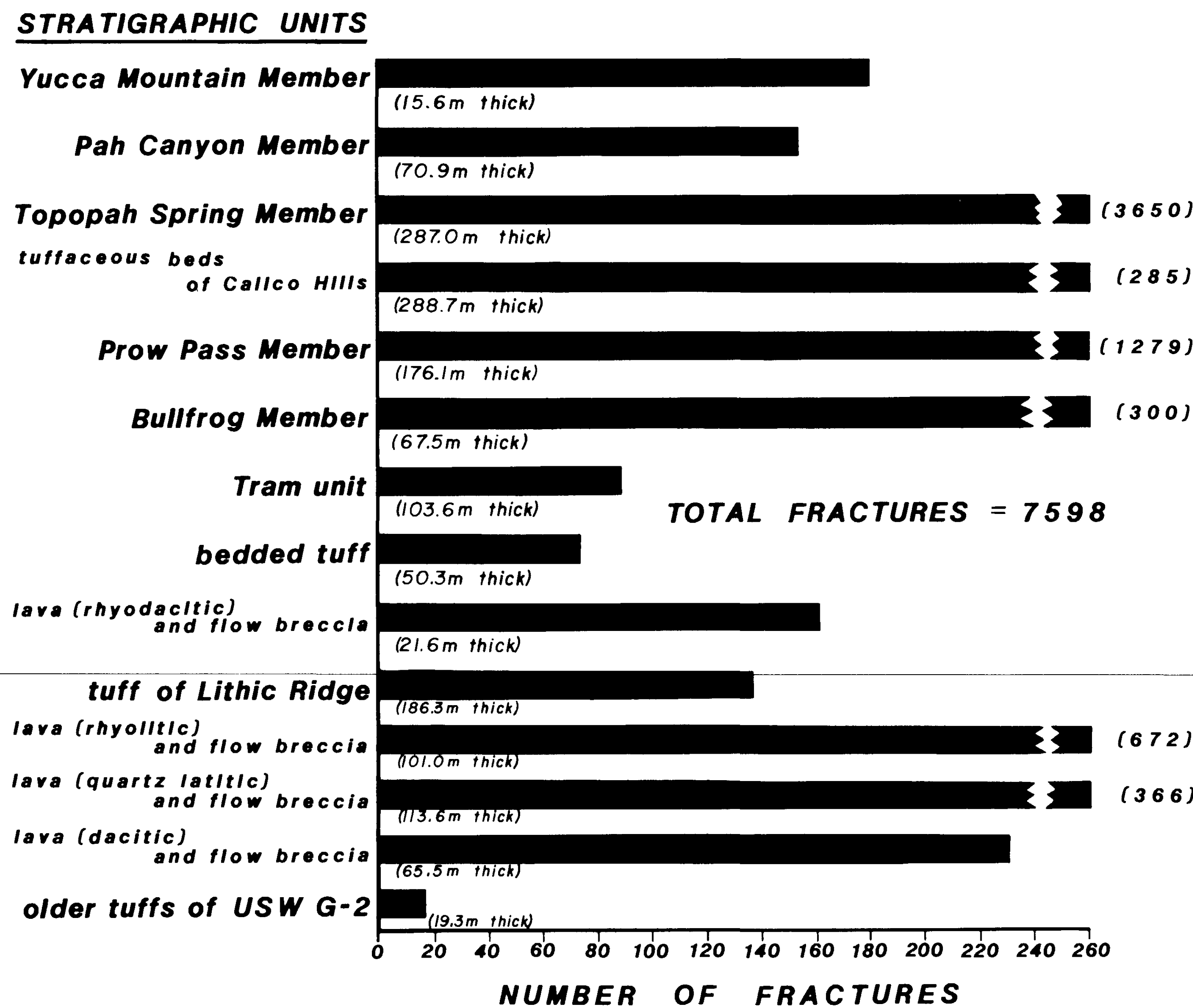


Figure 17.--Histogram showing fracture frequency per stratigraphic unit.

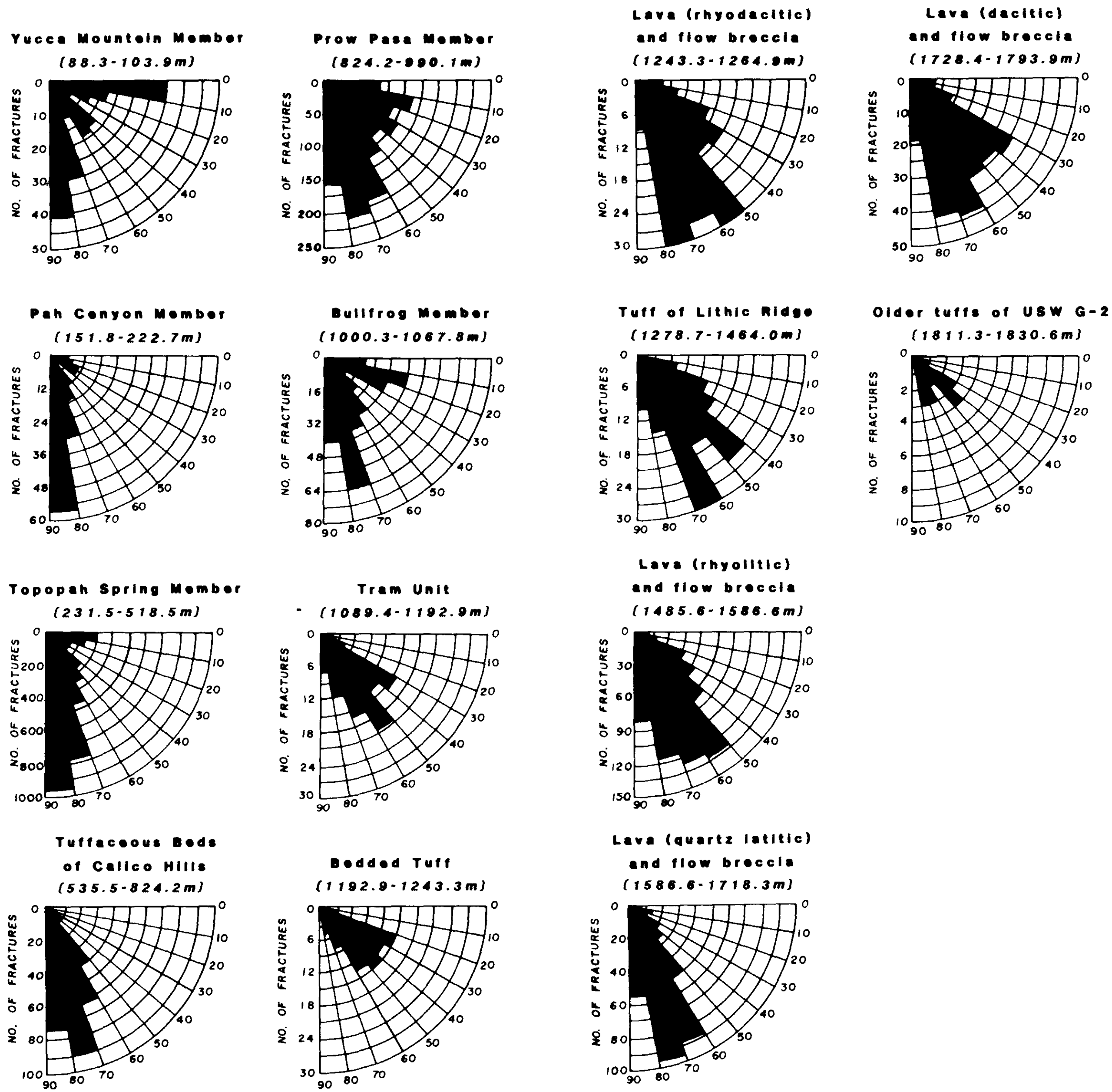


Figure 18.--Rose diagrams showing fractures per 10^{0} for individual stratigraphic units.

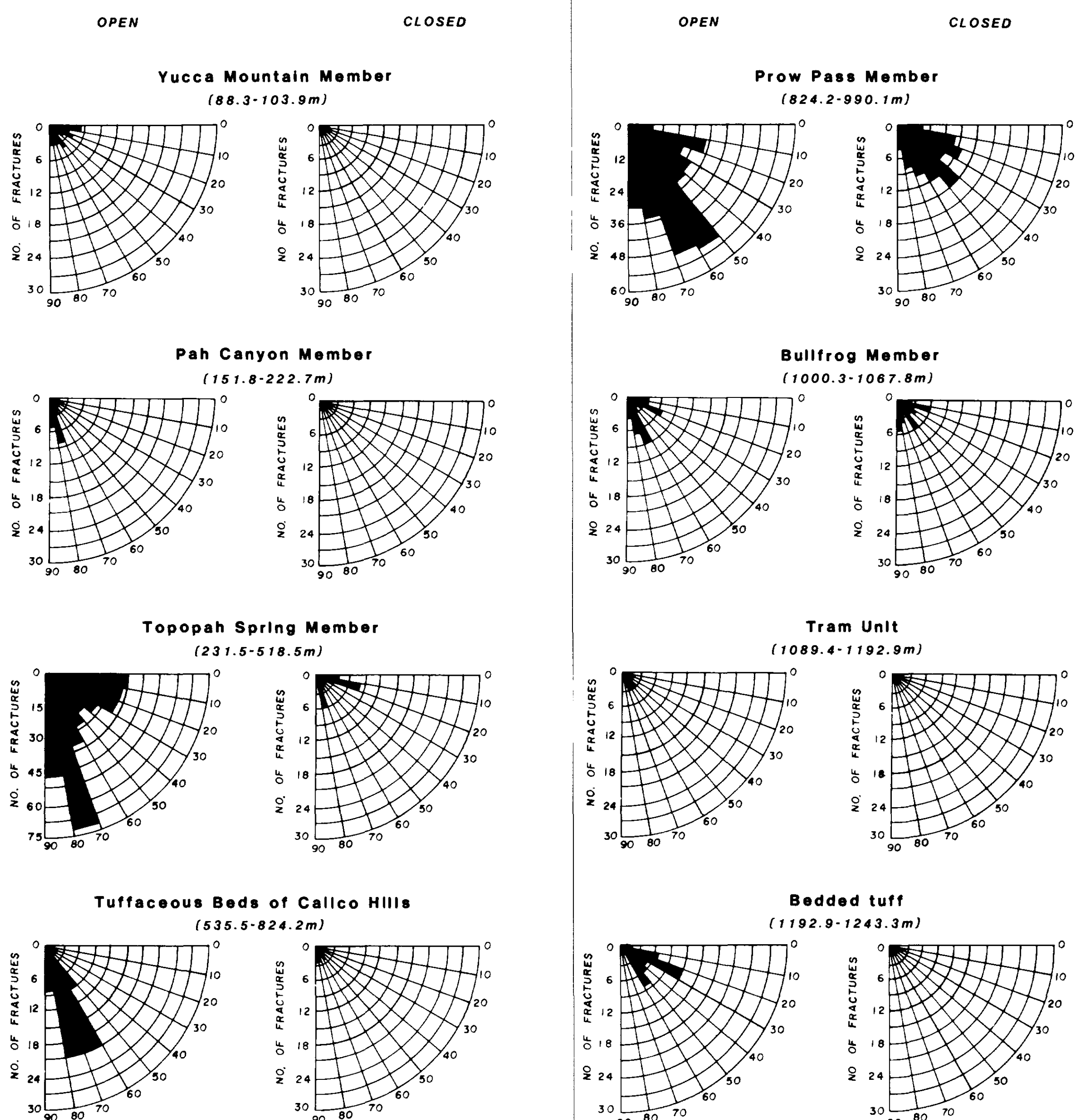


Figure 19.--Rose diagrams showing open and closed fractures per 10° increment for individual stratigraphic unit.

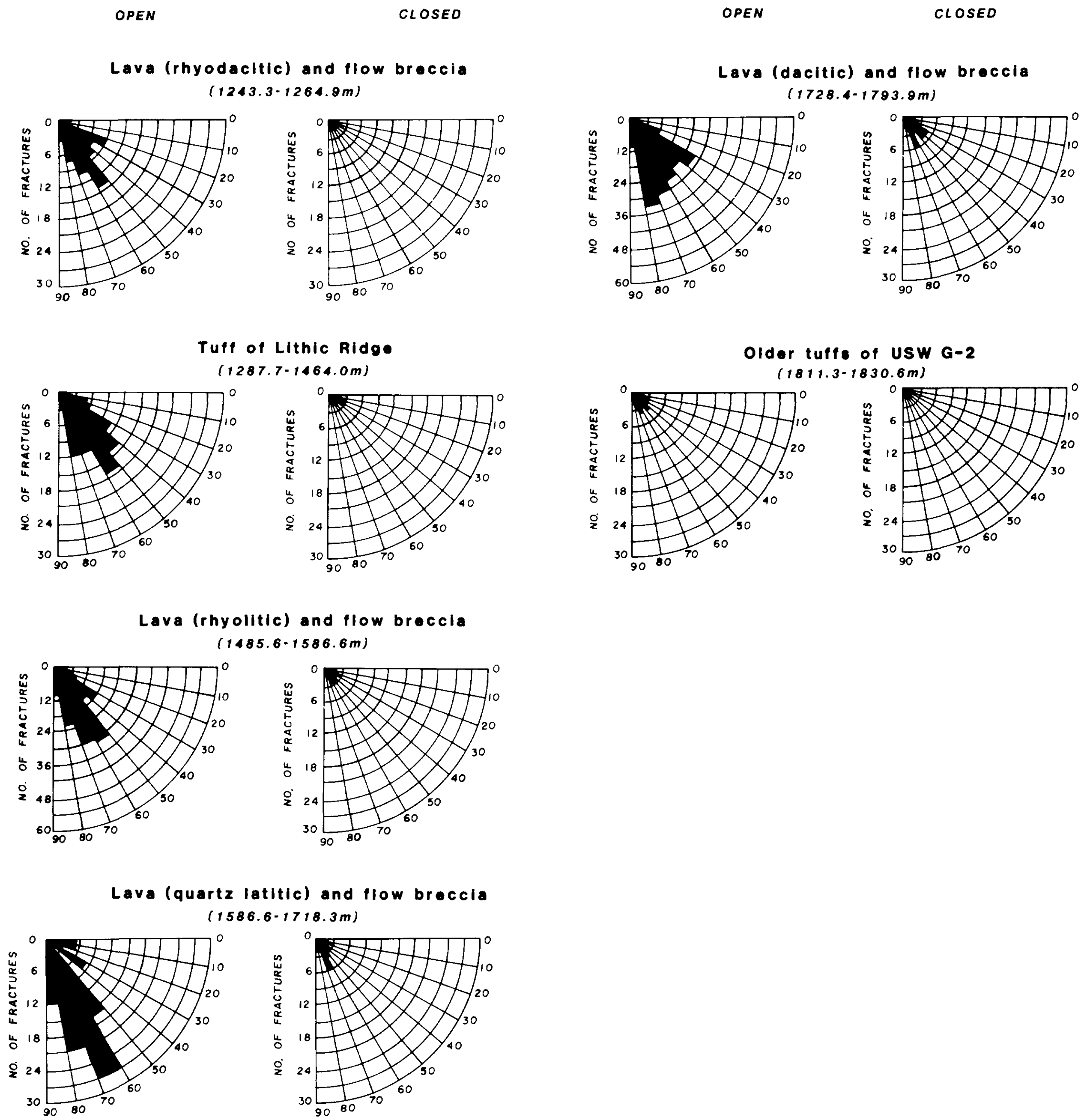


Figure 19.--Continued

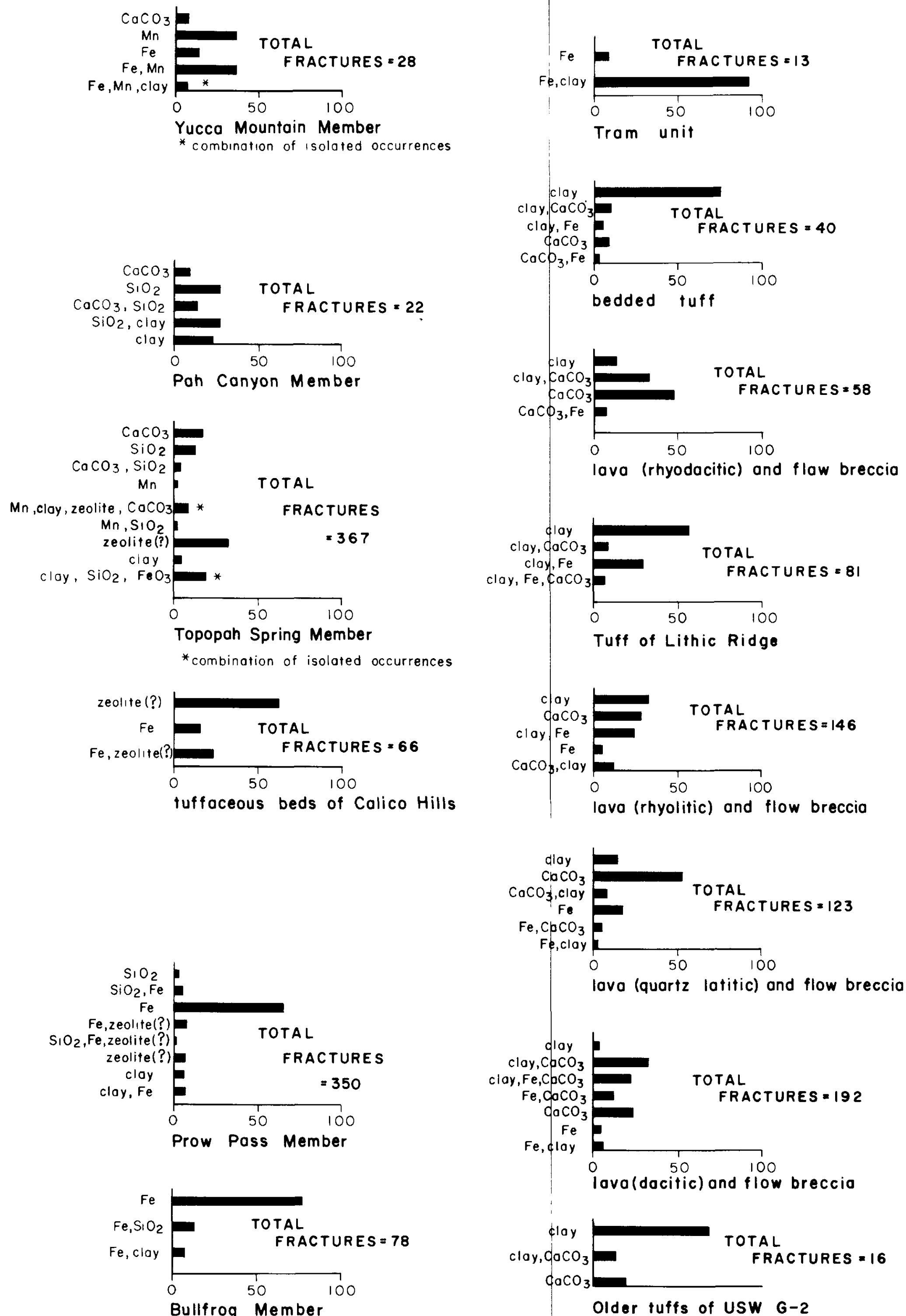


Figure 20.--Histograms showing types of fracture filling and coating material per stratigraphic unit.

rare in the Topopah Spring Member and essentially absent in the remaining stratigraphic units.

Shear Fractures and Fault Zones

Approximately 300 shear fractures were penetrated by drill hole USW G-2, based on a sampling of 1,580 fractures. The dips of the shear fractures and dips of the striation (rake) where attainable were tabulated and are plotted on figure 21. The data indicates that the shear fractures are predominantly high angle (>40°) agreeing with the general regional structural fabric of the area (Carr, 1976). The dips of the striations along the fractured planes can generally be distinguished as high angle or low angle (fig. 21). The high-angle group suggests a vertical component of movement and the low-angle group suggests a lateral component; thus, it appears that the rocks have been exposed to vertical as well as lateral movement. The lateral component could possibly be related to an ancient (pre-18 m.y.) northwest-trending right-lateral fault zone (Carr, 1982) that may be present in Yucca Wash (fig. 5) approximately 1 km north of the drill site.

The distribution of the shear fractures are plotted on plate 1, per 3-m interval for the entire cored interval. The distribution indicates a substantial increase below the tuffaceous beds of Calico Hills (824 m) where numerous fault zones have been penetrated.

The fault zones penetrated are characterized by the presence of: (1) slickensides, (2) fault breccia, (3) clay gouge, (4) broken core, and (5) missing strata. Shear fractures, although indicative of displacement, are not considered as fault zones if the above features are lacking, but are probably minor faults with minor displacements. The fault zones have been arbitrarily divided into two types, those thicker than 1.5 m, and those less than 1.5 m. Fault zones greater than 1.5 m thick are plotted on plate 1 and occur in the following units: (1) the lithophysal zone of the Topopah Spring Member where the major feature is the presence of breccia, (2) the Prow Pass and Bullfrog Members throughout the various welding zones, (3) the rhyodacitic lava and flow breccia, and (4) at the base of the rhyolitic lava and flow breccia. Fault zones less than 1.5 m thick are present in most of the units penetrated, and listed in table 7.

The presence of fault zones in certain units is partly related to the character of the rocks, for example, numerous fault zones are present in the brittle densely welded lithophysal zone in the Topopah Spring Member, and very rare in the thick nonwelded to partially welded zones of the tuffaceous beds of Calico Hills. This is not the case in the underlying units where the Crater Flat Tuff members and underlying tuff of Lithic Ridge are characterized by the presence of fault zones in the various welded zones. This is probably related to the occurrence of these units between two major faults that were penetrated by the drill hole.

Two major faults whose traces are located approximately 457 and 518 m east of the drill site (fig. 5) and are labled I and II, respectively, for the sake of discussion appear to have been penetrated by the drill hole. On the surface, fault I strikes northwest and dips approximately 55° to the southwest, and fault II strikes northwest and dips approximately 65° to the southwest. Fault I was penetrated by the drill hole at 824.2 m (fig. 22) where it

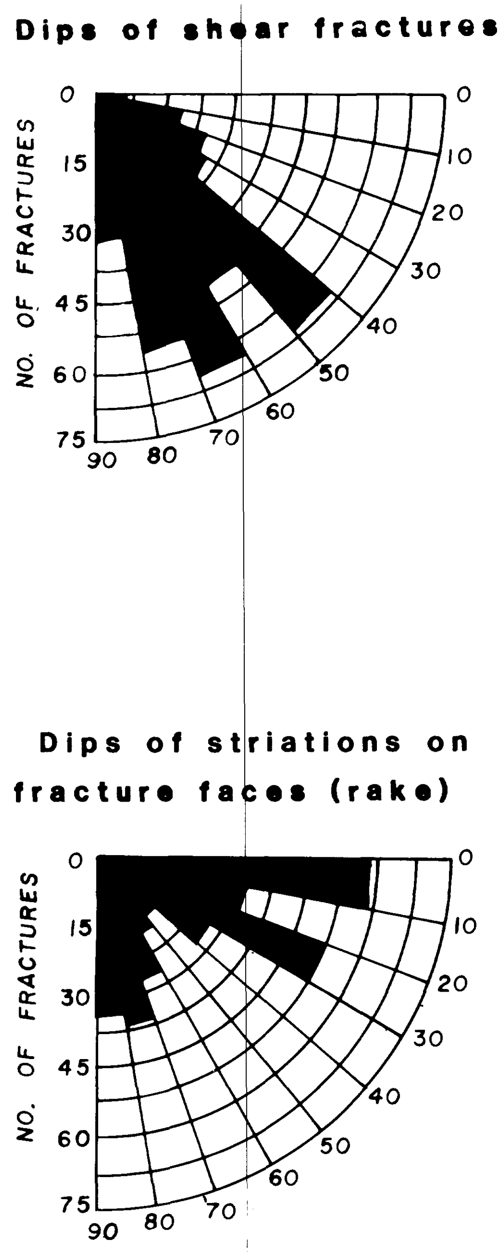


Figure 21.--Rose diagrams showing dips of shear fractures and striations on fracture face.

Table 7.--Fault zones less than 1.5 m thick, USW G-2 drill hole, Yucca Mountain, Nevada

Approximate depth (meters)	Evidence	Unit
101.6	Fault breccia-----------	Yucca Mountain Member.
377.8	----do------------------	Topopah Spring Member.
611.3- 612.3	Fault breccia and slickensides.	Tuffaceous beds of Calico Hills.
858.9- 859.2	Fault breccia-----------	Prow Pass Member.
965.6	Slickensides------------	Do.
999.6- 999.9	Fault(?) breccia--------	Bedded tuff.
1002.3-1003.5	Slickensides------------	Bullfrog Member.
1187.1	----do------------------	Tram unit.
1327.7-1328.6	Slickensides and broken-up core.	Tuff of Lithic Ridge.
1402.7	----do------------------	Do.
1407.6	----do------------------	Do.
1424.0	Slickensides------------	Do.
1489.9-1491.1	Slickensides and breccia	Rhyolitic lava and flow breccia.
1498.7	----do------------------	Do.
1541.9	Fault breccia-----------	Do.
1604.2-1604.7	Slickensides------------	Quartz latitic lava and flow breccia.
1763.6	Fault(?) breccia--------	Dacitic lava and flow breccia.

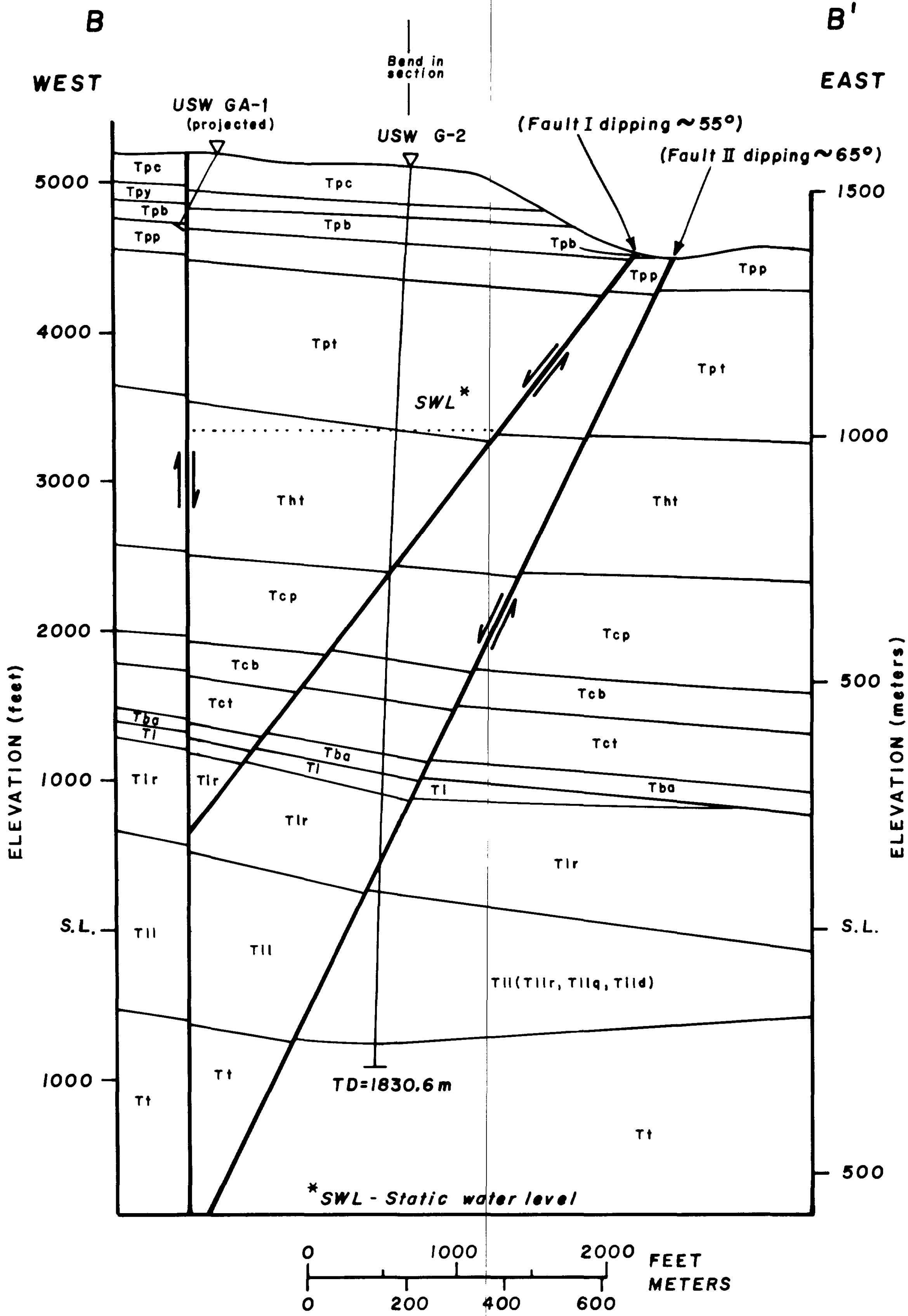


Figure 22.--Geologic cross section through USW G-2 drill hole.

EXPLANATION OF SYMBOLS

Tpc	Tiva Canyon Member
Tpy	Yucca Mountain Member
Tpb	Bedded tuff (ash flows)
Tpp	Pah Canyon Member
Tpt	Topopah Spring Member
Tht	Tuffaceous beds of Calico Hills
Tcp	Prow Pass Member
Tcb	Bullfrog Member
Tct	Tram unit
Tba	Bedded tuff
Tl	Lava flow and flow breccia
Tlr	Tuff of Lithic Ridge
Tll	Lava flow and flow breccia
Tt	Older tuffs

Figure 22.--Continued

is characterized by the presence of slickensides, fault breccia, and missing strata. The fault places a nonwelded to partially welded unit of the tuffaceous beds of Calico Hills against a densely welded to moderately welded unit of the Prow Pass Member. The nonwelded and partially welded light-gray vapor-phase zone of the Prow Pass Member has been structually displaced, allowing for at least 20 m of displacement along this fault.

Fault II appears to have been penetrated at approximately 1424 m (fig. 22) in the tuff of Lithic Ridge, where a shear fracture dipping approximately 70° is present. The zone is not characterized by any fault breccia such as fault I, but rather with shear fractures that occur at 1402.7, 1407.6, 1424.0, 1433.8, and 1441.1 m. No amount of displacement could be determined as the tuff of Lithic Ridge is so homogeneous; however, as the unit is substantially thinner at USW G-2 than at the southern drill holes, the thinning can partly be explained by structurally displacing some of the strata.

Numerous faults occur between the two major faults (I and II) with one displacing some units in the Bullfrog Member at 1015 m. The member is thinner at USW G-2 than at the southern drill holes at USW G-2, the two upper subunits and part of the lower are missing, so that the fault at 1015 m could account for as much as 50 m of the missing strata.

Core Index

A core index (CI) was calculated for all the cores. A core index is a measure of relative rock competency (J. R. Ege and M. J. Cunningham, written commun., 1975) and is calculated by the following formula:

$$CI = \frac{\text{Core broken (m)+core loss (m)+1/10 number of fractures}}{\text{Drilled interval (m)}} \times 100$$

Broken core is defined as pieces less than 10 cm in length whether broken by natural or mechanically induced fractures, which is a slight modification of Ege's definition, core loss as core not recovered from cored interval, and fractures as natural breaks, excluding fractures in the broken core interval. A CI of 50 indicates relatively incompetent rock.

The CI for all the cores has been plotted on plate 1, where the data indicate that the relatively incompetent rock can be correlated with the following: (1) bedded intervals, (2) densely welded lithophysal zone of the Topopah Spring Member, (3) moderately to densely welded zones, (4) silicified zones, and (5) fault zones, especially where brecciation has occurred.

SUMMARY

Stratigraphic Features

Drill hole USW G-2 penetrated 1830.6 m of Tertiary volcanic strata composed of silicic ash-flow tuffs, minor lava flows, and subordinate volcaniclastic rocks that comprise the following stratigraphic units in descending order: Paintbrush Tuff (Tiva Canyon Member, Yucca Canyon Member, bedded tuff, Pah Canyon Member, and Topopah Spring Member), tuffaceous beds of Calico Hills, Crater Flat Tuff (Prow Pass Member, Bullfrog Member, and Tram unit), lava and flow breccia (rhyodacitic), tuff of Lithic Ridge, bedded and ash-flow tuff, lava and flow breccia (rhyolitic, quartz latitic, and dacitic), bedded tuff, conglomerate and ash-flow tuff, and older tuffs of USW G-2.

Comparison of thickness of units at previously drilled holes at Yucca Mountain (USW G-1, USW H-1, UE25b-1H, and UE25a-1) with unit thicknesses at the USW G-2 drill hole indicates the following: (1) thickening of the Paintbrush Tuff members, and tuffaceous beds of Calico Hills toward the northern part of Yucca Mountain; (2) thickening of Prow Pass Member but thinning of the Bullfrog Member and the Tram unit; (3) thinning of the tuff of Lithic Ridge; (4) presence of approximately 280 m of lava and flow breccia not previously penetrated by any drill hole at Yucca Mountain; (5) almost complete thinning of the older tuffs of USW G-1, except for a very thin unit (approximately 9 m) that could possibly correlate with the older tuffs of USW G-1, and (6) presence of an ash-flow tuff unit at the bottom of the hole that is designated here as older tuffs of USW G-2, not previously been penetrated by any drill hole. This unit apparently underlies the older tuffs of USW G-1 and appears to be the oldest unit penetrated to date at Yucca Mountain.

The thickening of the Paintbrush Tuff, and the tuffaceous beds of Calico Hills was anticipated based on source areas for these two units located north and northeast, respectively, of Yucca Mountain; however, paleotopography and structure may be affecting the thickness of the units. The thickening of the Prow Pass Member northward could indicate a source area northwest of the Yucca Mountain area, while the thinning of the Bullfrog Member, Tram unit, and tuff of Lithic Ridge suggest source areas other than the northern part of Yucca Mountain. Possible source-area candidates are areas northwest, and southwest of Yucca Mountain in the Crater Flat area (Carr, 1982).

Petrographic Features

Salient petrographic features of some of the units are as follows: (1) a decrease in quartz and K-feldspar, and an increase in biotite and plagioclase occurs with depth in the tuffaceous beds of Calico Hills, (2) an increase in quartz downhole occurs in the Crater Flat Tuff members with depth, (3) a drastic decrease in quartz content occurs in the tuff of Lithic Ridge in comparison with the overlying Crater Flat Tuff members, and (4) the thick sequence of lavas is characterized by a rhyolitic upper flow and dacitic lower flow, expressing an inverse of the normal zoning of lavas. The reverse zoning could be produced by initially tapping a compositionally zoned magma chamber at a deep level via a deep fracture, with subsequent draining of progressively higher levels in the chamber.

A petrographic feature of interest is the occurrence of resorbed quartz in the lower portion of the tuffaceous beds of Calico Hills, and the Prow Pass and Bullfrog Members of the Crater Flat Tuff. It has been suggested that the presence of resorbed phenocrysts indicates the magma was unsaturated with respect to water (Steiner and others, 1925; Lipman and others, 1966; Robertson and Wyllie, 1971), and that ash-flow tuffs containing strongly resorbed phenocrysts may have been derived from high pressure zones within the magma (Noble, 1970).

Other petrographic features include various mineral assemblages resulting from alteration. One important type of alteration is zeolitization that primarily affects the tuffs forming zones that in general vary from heulandite to clinoptilolite to mordenite with depth. Another important alteration effect is characterized by the occurrence of barite, fluorite, calcite, and chlorite, and traces of pyrite in the lavas toward the bottom of the hole. This assemblage of minerals suggests that these lavas have been exposed to hydrothermal solutions that could be associated with an intrusive under Yucca Mountain. Another possible source of the hydrothermal solutions could be related to the volcanism associated with the formation of the Timber Mountain caldera complex.

Structural Features

Dips of pumice were only obtainable from the Yucca Mountain, Topopah Spring, and Prow Pass Members where they range from 2° to 11°, increasing with depth, possibly reflecting the paleotopography of the area. The increase in dip apparently is related to the numerous fault zones, but could also reflect the paleotopography.

Dips of tuffaceous sediments and bedded ash-fall tuff range from 3° to 36°. The shallower dips occur above 1090 m where they range from 3° to 10°. Below the 1090-m level, a substantial increase in the dip occurs and ranges from 13° to 36°, but predominantly greater than 20°.

The fracture analysis of the core resulted in tabulation of 7,848 fractures, predominantly open and high angle. Some of the tabulated fractures include cooling joints that are normally characterized as high angle, short in length, and rarely intersect each other. These cooling joints are difficult to distinguish from tectonic fractures in the cores if no evidence for displacement is present. The tectonic fractures are probably related to the regional doming of the area associated with the volcanism-tectonism of the Timber Mountain-Claim Canyon caldera complex. Some of the tectonic fractures are also related to the formation of the north-northwest-trending Basin and Range faults that are present at the Yucca Mountain area.

The intensity of fracturing varies throughout the units but generally an increase in fractures can be correlated with the more brittle rocks (densely welded, lithophysal, vitrophyre, and silicified zones). An increase in fractures was also observed near and within fault zones.

Some of the fractures were filled or coated with material in various combinations that include the following in decreasing abundance; $CaCO_3$, iron oxide and hydroxides, SiO_2, manganese oxide and hydroxides, clay, and zeolites. A sample of calcite from the upper half of the Topopah Spring Member indicates a date of 142,000±20,000 years. Some open fractures were observed to intersect the calcite-filled fractures, suggesting a possible younger age of formation for the open fractures; possibly even younger than the calcite that fills some of the fractures.

Numerous fault zones were penetrated by the drill hole, occurring particularly within the lithophysal zone of the Topopah Spring Member, and below the tuffaceous beds of Calico Hills. Measurements obtained along shear fractures indicate that most of the faults are high angle with both vertical and lateral component. These faults, like some of the fractures, are related to the regional doming of the area, resulting from the volcanism at Timber Mountain and to Basin and Range tectonism. Two major faults that intersect the ground surface east of the USW G-2 drill site were penetrated by the drill hole. One was penetrated at 824.2 m where it places a nonwelded to partially welded unit of the tuffaceous beds of Calico Hills against a densely welded to moderately welded unit of the Prow Pass Member, with at least 20 m of displacement. The second fault was intersected at 1,424 m where it displaces the tuff of Lithic Ridge. No amount of displacement could be determined due to the homogeneity of the unit, however, the unit's thinness is anomalous. Another important fault was intersected at 1015 m, where it offsets some units in the Bullfrog Member, that could amount to as much as 50 m. This fault does not appear to intersect the ground surface, but does occur between the two major faults, suggesting a possible relationship to these two faults.

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APPENDIX

Lithologic Description of Exploratory Drill Hole USW G-2

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada

[Cuttings at 0-88.3 m (0-289.7 ft); core at 88.3 m (289.7 ft) to TD; color designations from Rock-Color Chart (Goddard and others, 1948)]

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff		
Tiva Canyon Member		
Tuff, ash-flow, pale-brown glassy, densely welded, welded, vitric; pumice, black, vitric; contains approximately 10-15 percent sanidine and plagioclase phenocrysts (quartz latitic caprock)	13.7 (45.0)	13.7 (45.0)
Tuff, ash-flow, pale-red, densely welded, devitrified; pumice, very light gray, devitrified; contains approximately 10-15 percent feldspar sanidine, plagioclase, and bronze biotite (quartz latitic caprock)	18.3 (60.0)	32.0 (105.0)
Tuff, ash-flow, pale-red, and light-brownish-gray, densely welded, devitrified; pumice, medium-dark-gray, devitrified; approximately 2 percent sanidine and plagioclase biotite phenocrysts; lithophysae common	7.6 (25.0)	39.6 (130.0)
Tuff, ash-flow, pale-red and light-brownish-gray, densely welded, devitrified; pumice, medium-dark-gray, devitrified; as large as 1 cm; approximately 2 percent sanidine and plagioclase biotite phenocrysts; lithophysal zone, approximately 10-15 percent lithophysae	3.1 (10.0)	42.7 (140.0)
Tuff, ash-flow, pale-red and light-brownish-gray, densely welded, devitrified; pumice, medium-dark-gray, devitrified, as large as 4 cm; contains approximately 2 percent sanidine, plagioclase, and biotite phenocrysts	18.2 (60.0)	60.9 (200.0)
Tuff, ash-flow, grayish-pink, and grayish-orange-pink, moderately to partially welded, devitrified, partly argillic; pumice, medium-light-gray, vapor phase, as large as 3 cm, approximately 1 percent sanidine and plagioclase phenocrysts	6.2 (20.0)	67.1 (220.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff--Continued		
Tiva Canyon Member--Continued		
Tuff, ash-flow, grayish-pink, and moderate-orange-pink, nonwelded, partly argillized; pumice, medium-gray and grayish-orange-pink, argillized, as large as 2 cm	1.5 (5.0)	68.6 (225.0)
Bedded tuff		
Tuff, ash-fall, bedded, reworked, partly argillized, white, light-gray, grayish-pink, moderate-pink, and grayish-orange-pink, laminated to massive beds; contains pumice and volcanic lithics, subangular to rounded	6.1 (20.0)	74.7 (245.0)
Paintbrush Tuff--Continued		
Yucca Mountain Member		
Tuff, ash-flow, pinkish-gray and light-brownish-gray, nonwelded vitric; pumice, white, vitric, as large as 3 cm; sparse sanidine, plagioclase, and biotite phenocrysts	1.5 (5.0)	76.2 (250.0)
Tuff, ash-flow, light-gray, partially welded, partly devitrified and partly vitric; pumice, light-gray, vapor phase, as large as 3 cm; sparse sanidine and plagioclase phenocrysts	3.1 (10.0)	79.3 (260.0)
Tuff, ash-flow, light-gray to light-brownish-gray, moderately to densely welded, devitrified; pumice, light-gray, devitrified, as large as 3 cm; sparse sanidine and plagioclase phenocrysts; manganese oxide speckles common, as large as 3 mm, disseminated, and along fractures	9.0 (29.7)	88.3 (289.7)
Tuff, ash-flow, light-brownish-gray, moderately to densely welded, devitrified; pumice, gray, devitrified, as large as 4 cm; sparse sanidine and plagioclase phenocrysts; manganese speckles, oxide speckles, as large as 3 mm; disseminated and along fractures; occasional fractures coated with calcite	11.3 (37.0)	99.6 (326.7)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff--Continued		
Yucca Mountain Member--Continued		
Tuff, ash-flow, grayish-orange to pale-yellowish-orange, moderately welded grading to partially welded toward base, devitrified; pumice in upper part is devitrified, argillic in lower part; manganese oxide speckles common, disseminated and, along fractures, black mottled interval toward bottom 0.6 m; possible fault at about 101.6 m	2.9 (9.7)	102.5 (336.4)
Tuff, ash-flow, light-gray to very light gray, nonwelded, vitric; less than 1 percent sanidine and plagioclase phenocrysts; pumice, pink to pinkish-gray, argillic, abundant glass shards	1.4 (4.6)	103.9 (341.0)
Bedded tuff		
Tuff, reworked, bedded, very light gray to light-gray, individual beds range from 3 to 25 cm in thickness; composed predominantly of subangular to rounded pumice, argillized	0.8 (2.5)	104.7 (343.5)
Bedded tuff		
Tuff, ash-flow, with some ash-fall, grayish-pink to grayish-orange-pink, nonwelded, vitric and partly argillized; pumice, white to grayish-pink, vitric and partly argillized, as large as 4 cm; approximately 1 percent quartz, sanidine, and plagioclase phenocrysts; volcanic lithics common, as large as 6 cm increasing toward base, occasional black,vitric pumice toward base	44.0 (144.5)	148.7 (488.0)
Bedded tuff		
Tuff, reworked, pinkish-gray and very pale orange; contains pumice, argillic, 2-7 cm, subangular to rounded, and moderate-brown to pale-yellowish-brown volcanic lithics, as large as 3 cm, subrounded to rounded	3.1 (10.0)	151.8 (498.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff--Continued		
Pah Canyon Member		
Tuff, ash-flow, grayish-orange-pink and light-brown, nonwelded, vitric; pumice, grayish-orange-pink, vitric, as large as 8 cm; biotite phenocrysts common	12.1 (39.8)	163.9 (537.8)
Tuff, ash-flow, light- to very light gray, nonwelded to partially welded vitric; partly zeolitized and argillized; pumice, grayish-orange-pink, vitric, as large as 8 cm; biotite phenocrysts common in matrix and pumice; occasional pale-brown volcanic lithics	8.4 (27.6)	172.3 (565.4)
Tuff, ash-flow, grayish-orange-pink, partially to moderately welded, partly zeolitized; pumice, pale-brown to grayish-orange-pink, zeolitized(?), as large as 7 cm (vapor phase at 171.2-178.5 and 202.6-203.1 m); contains approximately 5 percent biotite, sanidine and plagioclase phenocrysts; moderate-brown and medium-light-gray volcanic lithics common, as large as 3 cm	30.8 (101.0)	203.1 (666.4)
Tuff, ash-flow, moderate-orange-pink, and grayish-orange-pink, partially welded to nonwelded, partly zeolitized and argillized; pumice, light-brown, zeolitized(?), as large as 3 cm; contains approximately 5 percent biotite, sanidine, and plagioclase phenocrysts; occasional moderate-brown volcanic lithics, as large as 3 cm	3.7 (12.1)	206.8 (678.5)
Tuff, ash-flow, white to grayish-orange-pink, nonwelded, vitric; pumice, grayish-orange-pink, vitric, as large as 5 cm; contains approximately 5 percent biotite, plagioclase and sanidine phenocrysts; moderate-brown volcanic lithics common	15.9 (52.2)	222.7 (730.7)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Bedded tuff		
Tuff, reworked, bedded, and some ash-fall, grayish-orange-pink, very light pink, and light-brown; individual beds range from 1 cm to massive; contains abundant pumice and volcanic lithics; 3-cm-thick silicified zone at 222.7 m; 3-cm-thick silicified ash-fall bed, moderate-reddish-brown at 230.1 m	8.8 (28.7)	231.5 (759.4)
Paintbrush Tuff--Continued		
Topopah Spring Member		
Tuff, ash-flow, light-gray to medium-light-gray, nonwelded, vitric; pumice blocks as large as 8 cm, light-gray to medium-light-gray, vitric	.7 (2.4)	232.2 (761.8)
Tuff, ash-flow, moderate-brown, moderately welded, devitrified; pumice, grayish-orange-pink, argillic, as large as 3 cm	1.6 (5.2)	233.8 (767.0)
Tuff, ash-flow (vitrophyre), grayish-red to black, densely welded, glassy; as much as 20 percent phenocrysts of biotite, sanidine, and plagioclase; black vitrophyre appears to be in fault contact with grayish-red vitrophyre at 234.7 m	1.1 (3.9)	234.9 (770.9)
Tuff, ash-flow, grayish-red, densely welded, devitrified; pumice, light-brownish-gray, mostly vapor phase, as large as 7 cm; contains approximately 15 percent bronze biotite, sanidine, and plagioclase phenocrysts; fractures commonly contain quartz and calcite; cavities in pumice occasionally contain quartz, along with vapor-phase crystallization material	41.4 (135.5)	276.3 (906.4)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
paintbrush Tuff--Continued		
Topopah Spring Member--Continued		
Tuff, ash-flow, light-gray to brownish-gray (partly mottled), densely welded, devitrified; pumice, devitrified, light-gray and moderate-brown, devitrified, as large as 10 cm; approximately 2 percent phenocrysts of sanidine and plagioclase, sparse light-gray volcanic lithics, lithics in upper part as large as 10 cm; lithophysae as much as 60 percent, and average approximately 30 percent, cavities commonly filled or coated predominantly with calcite, with some quartz; breccia (fault) at 282.1 m	10.5 (34.6)	286.8 (941.0)
Tuff, ash-flow, light-brown (mottled in places), densely welded, devitrified; pumice, light-gray, devitrified, as large as 6 cm; 1-2 percent sanidine and plagioclase phenocrysts; occasional light-gray volcanic lithics; lithophysae as much as about 90 percent, and average approximately 50 percent, as large as 10 cm, commonly spheroidal, cavities coated with quartz and feldspar, and less calcite than above subunit	37.8 (124.0)	324.6 (1,065.0)
Tuff, ash-flow, pale-yellowish-brown, densely welded, devitrified; pumice, light-gray, devitrified, as large as 3 cm; approximately 3 percent sanidine and plagioclase phenocrysts; lithophysae as much as 50 percent and average approximately 30 percent	10.2 (33.4)	334.8 (1,098.4)
Tuff, ash-flow, light-brown and light-brownish-gray (mottled), densely welded, devitrified; pumice, light-gray, devitrified; as large as 2 cm; approximately 2 percent sanidine and plagioclase; phenocrysts occasional light-gray volcanic lithics; lithophysae as much as 80 percent and average approximately 60 percent, as large as 7 cm, cavities commonly coated with quartz, and feldspar, and occasionally calcite, commonly spheroidal but occasionally flattened; brecciated zones at 353.3, 364.5, and 377.8 m; brecciated zone (fault) healed with calcite at 380.4 m	46.0 (151.0)	380.8 (1,249.4)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff--Continued		
Topapah Spring Member--Continued		
Tuff, ash-flow, pale-red, densely welded, devitrified; pumice, light-gray, devitrified, as large as 1 cm; approximately 2 percent sanidine and plagioclase phenocrysts; lithophysae as much as 13 percent and average approximately 5 percent, as large as 2 cm	6.8 (22.1)	387.6 (1,271.5)
Tuff, ash-flow, light-brown, pale-red, and medium-light-gray (mottled), densely welded, devitrified; pumice, light-gray, as large as 4 cm; light-gray volcanic lithics are common; approximately 2 percent sanidine and plagioclase phenocrysts; lithophysae as much as 82 percent and average approximately 40 percent, commonly spheroidal, with cavities coated with quartz and feldspar; slickensides a 389.5 and 396.2-398.4 m; brecciated zones at 398.4-398.9 m	12.6 (43.5)	400.2 (1,315.0)
Tuff, ash-flow, light-brown, pale-red, and medium-light-gray (mottled), densely welded, devitrified; pumice, light-gray, devitrified, as large as 6 cm, occasional light-gray volcanic lithics as large as 7 cm; approximately 2 percent sanidine and plagioclase phenocrysts; lithophysae as much as 75 percent, and average approximately 40 percent, the lithophysae (mottled areas) are spheroidal, usually coated with quartz and feldspar, and occasionally with calcite; brecciated zones at 447.1 and 448.9 m	54.9 (178.0)	455.1 (1,493.0)
Tuff, ash-flow, pale-red, and light-brown, densely welded, devitrified; pumice, light-brown to moderate-brown, devitrified, as large as 2 cm; approximately 2 percent sanidine sanidine and plagioclase phenocrysts; lithophysae as much as 56 percent and average approximately 20 percent, commonly flattened, and coated with quartz and feldspar; light-gray volcanic lithics common; brecciated zone at 473.2 m	33.8 (111.0)	488.9 (1,604.0)

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Paintbrush Tuff--Continued		
Topopah Spring Member--Continued		
Tuff, ash-flow, pale-red and pale-yellowish-brown, densely welded, devitrified; pumice, moderate-brown, as large as 3 cm, devitrified; approximately 3 percent sanidine and plagioclase phenocrysts; occasional light-gray volcanic lithics; sparse lithophysae	9.1 (30.0)	498.0 (1,634.0)
Tuff, ash-flow, grayish-black to black (vitrophyre), light-brown in upper meter, densely welded, glassy; pumice, grayish-black, vitric, as large as 5 cm; sparse sanidine and plagioclase phenocrysts; pale-brown and medium-gray volcanic lithics common toward base, as large as 4 cm	9.3 (30.3)	507.3 (1,664.3)
Tuff, ash-flow, grayish-black (vitrophyre), moderately to densely welded, vitric; pumice, light-brown, partly vitric and partly devitrified, as large as 5 cm; sparse sanidine and plagioclase phenocrysts; light-gray volcanic lithics common, as large as 4 cm	1.4 (4.7)	508.7 (1,669.0)
Tuff, ash-flow, light-brown, with irregular zones of black, moderately welded, vitric to devitrified; pumice, moderate-brown, devitrified, as large as 4 cm; sparse sanidine and plagioclase phenocrysts; light-gray and grayish-brown volcanic lithics common, as large as 4 cm	3.7 (12.0)	512.4 (1,681.0)
Tuff, ash-flow, light-brown, and grayish-orange-pink, partially to nonwelded, devitrified; pumice, pale-brown and grayish-orange-pink, devitrified, as large as 3 cm; 1-2 percent sanidine and plagioclase phenocrysts; light-gray and grayish-brown volcanic lithics common, as large as 4 cm; some silicification and zeolitization of matrix and pumice toward base	6.1 (20.0)	518.5 (1,701.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Bedded Tuff		
Tuff, bedded, reworked, pale-pink to grayish-orange-pink, zeolitized thin-bedded to massive; pumice, pale-pink to pale-greenish-yellow, subrounded to rounded; medium-light-gray and grayish-brown, subrounded to rounded volcanic lithics, increase toward base; large blocks of at base, as large as 24 cm	17.0 (56.0)	535.5 (1,757.0)
Rhyolite lavas and tuffs of Calico Hills		
Tuffaceous beds of Calico Hills		
Tuff, ash-flow, grayish-orange-pink, nonwelded, devitrified, zeolitized; pumice, very pale orange, partly vitric and partly argillized and zeolitized, as large as 5 cm; 1 percent quartz sanidine and plagioclase phenocrysts; abundant brown volcanic lithics, as large as 1 cm	15.7 (51.3)	551.2 (1,808.3)
Tuff, bedded, reworked, moderate-yellowish-brown, thin grayish-orange-pink, air-fall intercalated with the bedded tuff; pumice fragments, pale-greenish-yellow, and zeolitized, rounded, as large as 2 cm; grayish-brown volcanic lithics, as large as 2 mm; beds dip approximately 4°	.2 (.7)	551.4 (1,809.0)
Tuff, ash-flow, grayish-orange-pink, nonwelded, devitrified, zeolitized; pumice, pale-yellowish-orange, zeolitized, partly argillized, as large as 5 cm; approximately 5 percent phenocrysts (quartz, sanidine, and plagioclase); grayish-brown volcanic lithics common, as large as 1 cm	4.8 (15.7)	556.2 (1,824.7)
Tuff, bedded, reworked, and ash-fall, grayish-orange-pink; pumice lithics, pale-greenish-yellow, zeolitized, as large as 1 mm, rounded and grayish-brown volcanic lithics, as large as 1 mm, rounded, beds dip approximately 1°	.1 (.5)	556.3 (1,825.2)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Rhyolite lavas and tuffs of Calico Hills--Continued		
Tuffaceous beds of Calico Hills--Continued		
Tuff, ash-flow, grayish-orange-pink, nonwelded, devitrified, zeolitized; pumice, very pale orange, zeolitized and argillized, as large as 2 cm; approximately 1 percent quartz, sanidine and plagioclase phenocrysts; grayish-brown volcanic lithics common, as large as 2 cm	19.9 (65.3)	576.2 (1,890.5)
Tuff, ash-fall, grayish-orange pink, very fine grained, argillized, contains approximately 1 percent quartz, and feldspar phenocrysts	.1 (.2)	576.3 (1,890.7)
Tuff, ash-flow, grayish-orange-pink to moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, grayish-pink and very pale orange, zeolitized, as large as 5 cm; approximately 2 percent quartz, sanidine, and plagioclase phenocrysts; grayish-brown volcanic lithics common, as much as 2 cm	21.1 (69.3)	597.4 (1,960.0)
Tuff, bedded, reworked, with a 1 cm ash-fall at base, moderate-orange-pink; pumice lithics, moderate-reddish-orange, zeolitized, as large as 2 cm, rounded flattened; grayish-brown volcanic lithics common, as large as 1 cm, rounded; beds dip approximately 2°	.2 (.5)	597.6 (1,960.5)
Tuff, ash-flow, moderate-orange-pink, nonwelded, zeolitized; pumice, grayish-pink, zeolitized, as large as 5 cm; 2 percent quartz sanidine and plagioclase phenocrysts; grayish-brown volcanic lithics common, as large as 2 cm	11.7 (38.5)	609.3 (1,999.0)
Tuff, bedded, reworked with some ash-fall, pinkish-gray, and pale-yellowish-brown; ash-fall occurs in upper 0.5 m; concentration of grayish-brown and light-gray volcanic lithics and zeolitized pumice fragments occur toward base of unit; slickensides at 611.3 and 612.3 m	3.6 (11.7)	612.9 (2,010.7)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Rhyolite lavas and tuffs of Calico Hills--Continued		
Tuffaceous beds of Calico Hills--Continued		
Tuff, ash-flow, grayish-pink and very pale orange, nonwelded, zeolitized; pumice, white and very pale orange, zeolitized, as large as 3 cm; 5 percent quartz, sanidine, plagioclase, and biotite phenocrysts; grayish-brown and light-gray volcanic lithics common, as large as 5 cm	33.8 (110.9)	646.7 (2,121.6)
Tuff, ash-fall, grayish-orange-pink, argillized, and partly zeolitized; conspicuous biotite phenocrysts and occasional quartz, sanidine, and plagioclase phenocrysts; banding present, dipping approximately 60°	.4 (1.4)	647.1 (2,123.0)
Tuff, ash-flow, grayish-pink to grayish-orange-pink, and yellowish-gray, nonwelded, zeolitized; pumice, white and pale-greenish-yellow, zeolitized and argillized, as large as 3 cm; approximately 5 percent phenocrysts, consisting of quartz (some resorbed), sanidine, plagioclase, and biotite; conspicuous reddish-brown and light-gray lithics as large as 7 cm, tuff lithics, approximately 12 cm toward top of unit	33.2 (109.0)	680.3 (2,232.0)
Tuff, bedded, reworked, and ash-fall, pale-greenish-yellow, grayish-orange-pink and very light gray; individual beds range from about 1 cm to 2 m and consist of rounded reddish-brown and light-gray volcanic lithics and pale-greenish-yellow pumice, zeolitized; thin (1 cm) ash-fall toward base; beds dip approximately 1°	3.1 (10.0)	683.4 (2,242.0)
Tuff, ash-flow, pale-yellowish-orange, nonwelded, argillized and zeolitized; pumice, white, argillized, as large as 3 cm; approximately 5 percent phenocrysts consisting of quartz (some resorbed), sanidine, plagioclase, and biotite; reddish-brown volcanic lithics common, as large as 2 cm	11.0 (36.3)	694.4 (2,278.3)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Rhyolite lavas and tuffs of Calico Hills--Continued		
Tuffaceous beds of Calico Hills--Continued		
Tuff, bedded, reworked, pale purple and grayish-orange-pink, zeolitized, and argillized; conspicuous biotite phenocrysts; reddish-brown volcanic lithics, as large as 10 cm	1.4 (4.4)	695.8 (2,282.7)
Tuff, ash-flow, very pale orange, nonwelded, devitrified, zeolitized; pumice, argillized, as large as 2 cm; approximately 5 percent phenocrysts consisting of quartz (some resorbed), sanidine, plagioclase and biotite; reddish-brown volcanic lithics common, and tuff lithics as large as 10 cm toward top of subunit	6.6 (21.9)	702.4 (2,304.6)
Tuff, bedded, reworked, very pale orange; blocks of tuff and pale purple ash-fall tuff common; banding (lamination) present at 702.7-702.9 m	.8 (2.4)	703.2 (2,307.0)
Tuff, ash-flow, very pale orange, nonwelded, devitrified, zeolitized; pumice, white, argillized, as large as 2 cm; approximately 5 percent phenocrysts consisting of quartz (some resorbed), sanidine, plagioclase, and biotite; reddish-brown volcanic lithics common, as large as 3 cm	9.4 (30.8)	712.6 (2,337.8)
Tuff, bedded, reworked, very pale orange and pale-yellowish-brown; individual beds range from 1 cm to 10 cm, and consist of reddish-brown and light-gray volcanic lithics, rounded, as as large as 2 cm, and pumice lithics, pale-greenish-yellow, zeolitized, as large as 1 cm; beds dip approximately 7°	1.1 (3.8)	713.7 (2,341.6)
Tuff, ash-flow, moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, white, argillized, as large as 7 cm, biotite in pumice more common; 5-10 percent quartz phenocrysts of quartz (some resorbed), sanidine, plagioclase, and biotite (more biotite than above subunit); reddish-brown volcanic lithics common, as large as 2 cm	6.7 (21.8)	720.4 (2,363.4)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Rhyolite lavas and tuffs of Calico Hills--Continued		
Tuffaceous beds of Calico Hills--Continued		
Tuff, reworked, massive, yellowish-gray; contains pumice, pale-greenish-yellow, zeolitized, as large as 1 cm, subrounded to rounded, and subrounded to rounded reddish-brown volcanic lithics, as large as 1 cm	.6 (2.2)	721.0 (2,365.6)
Tuff, ash-flow, moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, white, argillized, as large as 4 cm; 5-10 percent phenocrysts of quartz (some resorbed), sanidine, plagioclase, and biotite; reddish-brown volcanic lithics common, as large as 2 cm	2.6 (8.4)	723.6 (2,374.0)
Tuff, reworked, contains subrounded to rounded pumice, pale-greenish-yellow, zeolitized, as large as 5 mm, reddish-brown volcanic lithics, as large as 5 mm	.1 (.3)	723.7 (2,374.3)
Tuff, ash-flow, moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, white, argillized, as large as 4 cm; 5-10 percent phenocrysts of quartz (some resorbed), sanidine, plagioclase, and biotite; reddish-brown volcanic lithics common, as large as 2 cm	1.5 (5.1)	725.2 (2,379.4)
Tuff, reworked, massive, yellowish-gray; contains pumice lithics, zeolitized, pale-greenish-yellow, as large as 5 mm, and subrounded to rounded reddish-brown volcanic lithics as large as 5 mm	.2 (.6)	725.4 (2,380.0)
Tuff, ash-flow, moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, white, argillized, as large as 5 cm; 5-10 percent phenocrysts of quartz (some resorbed), sanidine, plagioclase and biotite; reddish-brown volcanic lithics common, as large as 1 cm	1.2 (4.0)	726.6 (2,384.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Rhyolite lavas and tuffs of Calico Hills--Continued		
Tuffaceous beds of Calico Hills--Continued		
Tuff, reworked, massive, very pale orange, contains pumice lithics, pale-greenish-yellow, zeolitized, as large as 1 cm, and reddish-brown volcanic lithics, as large as 1 cm, subrounded to rounded	.4 (1.2)	727.0 (2,385.2)
Tuff, ash-flow, grayish-orange-pink to moderate-orange-pink, nonwelded, devitrified, zeolitized; pumice, grayish-pink to grayish-orange-pink, argillized and zeolitized, as large as 5 cm; contains 5-10 percent phenocrysts of quartz (some resorbed), sanidine, plagioclase, and biotite; reddish-brown volcanic lithics common, as large as 2 cm	58.3 (191.3)	785.3 (2,576.5)
Tuff, bedded, reworked, light-brown, grayish-pink, and very light gray; individual beds range from 1 cm to 1.5 m and contains pumice, pale-greenish-yellow, zeolitized, as large as 2 cm, and reddish-brown and light-gray volcanic lithics as large as 1 cm, beds dip approximately 2°	3.5 (11.4)	788.8 (2,587.9)
Tuff, ash-flow, pale-red, and grayish-orange-pink, nonwelded to partially welded, devitrified, zeolitzed; pumice, white, grayish-pink, argillized and zeolitized, biotite in pumice very common, as large as 3 cm; approximately 15-25 percent phenocrysts of quartz (some resorbed), sanidine, plagioclase and biotite; reddish-brown volcanic lithics, as large as 5 cm; healed fracture toward base, dipping approximately 55°, slickensides at approximately 824.1 m	35.4 (116.1)	824.2 (2,704.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff		
Prow Pass Member		
Tuff, ash-flow, densely to moderately welded, pale-red to pale-brown, devitrified; pumice, grayish-pink, devitrified, as large as 2 cm; contains 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, biotite, and occasional pseudomorphs of orthopyroxene and hornblende; sparse brownish-gray mudstone and volcanic lithics; fault zone (breccia) at 824.1-824.7 m, fault plane at 824.2 m, dipping approximately 55°; upper nonwelded and partially welded light-gray vapor-phase zone of Prow Pass Member faulted out, as much as 20 m missing (gradational basal contact)	16.7 (55.0)	840.9 (2,759.0)
Tuff, ash-flow, pale-red to pale-brown, moderately welded, devitrified; pumice, grayish-pink, and pale-yellowish-brown; 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, biotite, and trace amounts of pseudomorphs of orthopyroxene and hornblende; occasional brownish-gray mudstone and volcanic lithics; brecciated zone (fault) at 858.9-859.2 m, dipping approximately 45° (gradational basal contact)	21.4 (70.0)	862.3 (2,829.0)
Tuff, ash-flow, pale-yellowish-brown, and medium-light-gray, moderately to partially welded, devitrified; pumice, grayish-pink, devitrified, as large as 4 cm; 10-20 percent phenocrysts of quartz (resorbed) sanidine, plagioclase, biotite, and occasional orthopyroxene and hornblende pseudomorphs, sparse volcanic lithics and increase in brownish-gray mudstone; occasional iron oxide staining and manganese along fractures toward base (gradational basal contact)	15.5 (51.0)	877.8 (2,880.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Prow Pass Member--Continued		
Tuff, ash-flow, pale-red, grayish-orange-pink and light-, brownish-gray, moderately to partially welded, devitrified, reddish iron oxide staining (mottled) more common throughout interval than overlying unit; pumice, grayish-pink, and grayish-orange-pink, devitrified, partly argillized, as large as 4 cm; 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, biotite and occasional orthopyroxene and hornblende pseudomorphs; 1-5 percent brownish-gray mudstone lithics, increasing towards base; fractures common, filled or coated with red material (iron oxide) and occasionally with black clay; intensely fractured, brecciated, and altered (mottled) zone at 877.8-881.2 m, fractures coated with red clay with alteration envelopes near fracture, interval could possibly indicate a fault zone; brecciated zone at 905.9-906.2 m; possible fault plane (slickenside) at 908.4-909.1 m	31.7 (104.0	909.5 (2,984.0)
Tuff, ash-flow, pale-pink to grayish-pink, and light-brownish-brownish-gray, partially welded to nonwelded, devitrified; pumice, white, very light gray and moderate-orange-pink, as large as 5 cm, argillized and zeolitized; contains 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, occasional biotite, and orthopyroxene and hornblende pseudomorphs; 2-8 percent grayish-brown mudstone lithics, as large as 1 cm, increasing towards base of unit, occasional volcanic lithics; iron oxide staining common, brecciated zone (fault) at 912.3-912.8 and 913.2-913.6 m	19.7 (64.4)	929.2 (3,048.4)
Tuff, ash-fall, pale-red, contains white pumice, approximately 1 mm, sparse moderate-reddish-brown volcanic lithics, approximately 1 mm and sparse feldspar phenocrysts; bed dips approximately 10°	.1 (.2)	929.3 (3,048.6)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Prow Pass Member--Continued		
Tuff, ash-flow, white to pinkish-gray, partially welded to nonwelded, devitrified, argillized and zeolitized; pumice, white to very light gray and grayish-orange-pink, devitrified, partly argillic, as large as 3 cm; contains approximately 10 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, and occasional biotite, and pseudomorphs of orthopyroxene and hornblende; 1-4 percent grayish-brown mudstone lithics, as large as 1 cm, and sparse volcanic lithics	3.8 (12.6)	933.1 (3,061.2)
Tuff, ash-flow (intensely altered zone), light-olive-gray, dark-yellowish-brown, partially welded to nonwelded, zeolitized, and partly silicified; pumice, yellowish-gray to light-greenish-gray, and greenish-gray, zeolitized, as large as 3 cm; 10-15 percent quartz (resorbed) sanidine, and plagioclase phenocrysts, occasional orthopyroxene and hornblende pseudomorphs with some biotite, chloritic mineral common; grayish-brown mudstone lithics common, as large as 1 cm; horiozntal fractures common, fracturing along foliation planes resulting in "hockey pucks" (933.1-944.7 m), altered zone could indicate a healed fault zone	11.7 (51.8)	944.8 (3,113.0)
Tuff, ash-flow (altered zone), dark-yellowish-brown, yellowish-gray, and grayish-red-purple, partially welded to nonwelded, devitrified, zeolitized and partly silicified to a lesser degree than the overlying unit; pumice, greenish-gray to light-greenish-gray, zeolitized, as large as 6 cm; approximately 10 percent quartz (resorbed), sanidine, plagioclase, and occasional biotite phenocrysts; occasional grayish-brown mudstone lithics and black volcanic lithics very common, as large as 1 cm; greenish mineral (epidote, chlorite?) common along fractures toward top of interval	12.9 (29.0)	957.7 (3,142.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Prow Pass Member--Continued		
Tuff, ash-flow, pinkish-gray, yellowish-gray, very light gray to medium-light-gray, nonwelded, devitrified, zeolitized and argillized; pumice, grayish-yellow-green to dusky-yellow-green, argillized; contains approximately 5 percent quartz (resorbed), sanidine, plagioclase and occasional biotite; volcanic lithics, as large as 1 cm common, approximately 2-5 percent black mudstone lithics, as large as 1 cm, increasing toward base; slickensides with reddish-brown clay (fault) at 965.6 m dipping approximately 70°	32.4 (106.3)	990.1 (3,248.3)
Bedded tuff		
Tuff, bedded, reworked, some ash-fall, light-gray to very light gray, light-brownish-gray, moderate-reddish-orange, pale-greenish-yellow, laminated at top to approximately 1 m thick, with both gradational and sharp contacts present, pumice is typically zeolitized; volcanic lithics range in size from 1 mm to large blocks toward base, as large as 15 cm; vertical fault at 992.9-996.1 m; brecciated zones within interval, and fault(?) at 999.6 m, dipping approximately 70°; possible fault(?) at 999.9 m	10.2 (33.6)	1000.3 (3,281.9)
Crater Flat Tuff--Continued		
Bullfrog Member		
Tuff, ash-flow, light-brown to pale-red, nonwelded, devitrified; pumice, grayish-orange-pink, argillized, as large as 3 cm, contains approximately 10-20 percent quartz (resorbed), sanidine, plagioclase, and biotite phenocrysts; tuff and lava lithics very common, as large as 12 cm; possible fault at 1002.3 m	2.5 (8.3)	1002.9 (3,290.2)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Bullfrog Member--Continued		
Tuff, ash-flow, white, grayish-orange-pink, and very light gray partially to moderately welded, devitrified, argillized; pumice, white, and grayish-red, partly vapor phase, argillized, as large as 3 cm; contains approximately 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, and biotite; sparse volcanic lithics throughout interval, however, upper 0.3 m rich in lithics; possible fault at 1003.5 m (gradational basal contact)	9.0 (29.8)	1011.9 (3,320.0)
Tuff, ash-flow (mottled zone) grayish-orange-pink and pale-pink, partially to moderately welded, devitrified; pumice, white to grayish-red vapor phase, devitrified, as large as 20 cm; contains approximately 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, and biotite phenocrysts; grayish-red volcanic lithics common; interval has been stained with grayish-red color; slickensides, with approximate dip of 65° (fault) at 1015.0 m and interval at 1017.7-1017.9 m, possible fault zone at 1021.1-1021.4 m coated with grayish-red clay	9.5 (31.0)	1021.4 (3,351.0)
Tuff, ash-flow, pale-red and grayish-orange-pink, moderately welded, devitrified, as large as 5 cm; contains approximately 10-15 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, and biotite; 2-3 percent grayish-brown volcanic lithics as large as 2 cm	29.2 (95.7)	1050.6 (3,446.7)
Tuff, ash-flow (altered), very light gray, grayish-green, light-greenish-gray, yellowish-gray, and grayish-yellow, partially to nonwelded, partly argillized; pumice, moderate-yellow-green, pale-greenish-yellow, partly argillized, as large as 4 cm; approximately 10-15 percent phenocrysts of quartz (resorbed) sanidine, plagioclase, and biotite; approximate horizontal fractures commonly coated/filled with grayish-red clay at 1051.6-1051.9 m	3.1 (10.3)	1053.7 (3,457.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Bullfrog Member--Continued		
Tuff, ash-flow, light-greenish-gray, light-brownish-gray, nonwelded, devitrified, partly zeolitized; pumice, dusky-yellow- green, and moderate-greenish-yellow, partly argillized, as large as 6 cm; contains approximately 10 percent phenocrysts of quartz (resorbed), sanidine, plagioclase, and biotite; 2-3 percent volcanic lithics	14.1 (46.4)	1067.8 (3,503.4)
Bedded tuff		
Tuff, bedded, reworked, with some ash-fall, light-gray, yellowish-gray, and very pale orange; individual beds range from 1 cm to massive (about 9 m), laminated toward top; pumice, grayish-yellow, and dusky-yellow-green, zeolitized(?); contains black, reddish-brown, medium-dark-gray, and grayish-yellow rhyolitic to intermediate lava lithics, angular to subrounded, as large as 3 cm; quartz, feldspar, and biotite crystal grains common	21.6 (70.6)	1089.4 (3,574.0)
Crater Flat Tuff--Continued		
Tram unit		
Tuff, ash-flow (lithic-rich >50 percent), contains approximately 50-95 percent grayish-red, light-greenish-gray, medium-light-gray, light-gray, and grayish-orange-pink lithics of tuff, rhyolitic, intermediate, and mafic lavas, angular to subrounded, as large as 15 cm, but normally range from 2-7 cm and average about 3 cm, lithics are set in a light-olive-gray to light-brownish-gray, argillized tuffaceous matrix that contains quartz, sanidine, plagioclase, and biotite phenocrysts; pyroclastic texture has been destroyed in some intervals due to the great number of lithics (gradational basal contact)	45.7 (150.0)	1135.1 (3,724.0)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Crater Flat Tuff--Continued		
Tram unit--Continued		
Tuff, ash-flow (lithic-rich <50 percent) grayish-red, pale-red, and light-gray toward base, partially welded, argillized; pumice, partly argillized, pale-greenish-yellow, as large as 2 cm; 5-10 percent phenocrysts of quartz (35 percent), sanidine, plagioclase, biotite, and trace amounts of hornblende; contains approximately 10-30 percent pale-brown, pale-greenish-yellow, grayish-pink, pale-yellowish-orange, and light-gray, lithics of tuff, rhyolite, intermediate, and mafic lavas, angular to subrounded, range from 1 mm to 5 cm and average about 1 cm, lithic size and density decreasing toward base; mottled interval at 1150.3-1164.0 m; fault(?) plane at 1187.1 m, dipping approximately 70°	57.8 (190.0)	1192.9 (3,914.0)
Bedded tuff		
Tuff, bedded, reworked, very light gray, pale-greenish-yellow, laminated to thick-bedded (about 3 m); contains pumice, pale-greenish-yellow, zeolitized and partly argillized, 1 mm to 1 cm, angular to subrounded and grayish-brown and medium-dark-gray rhyolitic and intermediate lava fragments, 1 mm to 1 cm, angular to subrounded,	20.8 (68.0)	1213.7 (3,982.0)
Tuff, ash-fall(?), grayish-red, massive bed; contains predominantly yellowish-gray to very light gray pumice, as large as 2 cm, zeolitized and partly argillized, subangular to rounded, occasional light-brown intermediate lava fragments, as large as 1 cm, conspicuous biotite with some feldspar, hornblende and quartz grains	10.1 (33.2)	1223.8 (4,015.2)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Bedded Tuff--Continued		
Tuff, bedded, reworked, and ash-fall, pale-olive, light-gray, and grayish-red, individual beds range 1 cm to approximately 8 m with intercalated ash fall; contains pumice, very light gray, zeolitized and partly argillized, as large as 2 cm, subangular to rounded, occasional light-brown intermediate lava lithics and light-greenish-gray tuff lithics as large as 3 cm; dacite lava block(?) at 1242.0-1242.8 m overlying a fine-grained ash-fall tuff that occurs at 1242.8-1243.3 m; ash-fall tuff contains pumice and intermediate lava fragments, subrounded, as large as 1 mm (possible faults(?) at 1240.5, 1242.0, and 1242.8 m)	19.5 (63.7)	1243.3 (4,078.9)
Lava and flow breccia		
Lava, flow breccia (autoclastic), rhyodacitic, pale-greenish-yellow, yellowish-gray; contains approximately 30-40 percent plagioclase, hornblende, and biotite phenocrysts; biotite, and hornblende slightly altered to chlorite; groundmass devitrified, partly argillic; brecciated zone (autoclastic zone) common toward top of unit, with blocks as large as 15 m; fault (slickensides) at 1253.8, 1256.2, 1264.6 and 1264.9 m	21.6 (71.1)	1264.9 (4,150.0)
Bedded tuff		
Tuff, reworked bedded, greenish-gray, and medium-bluish-gray, massive beds, with beds at 1277-1277.3 and 1278.5-1278.6 m, massive beds contain brownish-gray and light-brown intermediate lava lithics, 1 mm to 3 cm, subangular to subrounded and grayish-green tuff lithics, as large as 5 cm, biotite and hornblende rich, angular blocks of (about 0.5 m), medium-dark-gray intermediate lava, rich in biotite and hornblende at 1273.8 and 1277.9 m; slickensides occur at 1265.7, 1265.9, 1266.1, 1266.3 1266.8, 1269.3, 1271.3, 1273.4, 1274.2, 1274.3, 1274.4, 1274.7, 1275.0, 1275.1, 1276.6, 1278.2, 1278.5, and 1278.7 m	13.8 (45.2)	1278.7 (4,195.2)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Tuff of Lithic Ridge		
Tuff, ash-flow, medium-gray to medium-dark-gray, moderately to densely welded, devitrified, argillized; pumice, medium-dark-gray to dark-gray, argillized, as large as 4 cm; contains approximately 25 percent phenocrysts of quartz biotite, sanidine and plagioclase; slickensides at 1279.0, 1279.1, 1279.5, 1279.6, 1279.8, 1280.0, and 1280.9 m	2.5 (8.2)	1281.2 (4,203.4)
Tuff, ash-flow, light-bluish-gray, light-gray, and grayish-yellow-green, partially welded, argillized; pumice, grayish-olive-green, grayish-yellow, moderate-yellow-green, pale-greenish-yellow, argillized, as large as 5 cm; contains approximately 10-20 percent phenocrysts of quartz, sanidine, plagioclase, biotite, and occasional sphene; 10-50 percent dusky-brown, pale-red, greenish-gray, grayish-black, and brownish-black lithics of rhyolite and intermediate lavas, rounded, slickensides present at 1299.7-1299.8, 1301.8-1302.1, 1315.7, 1327.7-1328.6, 1370.3, 1380.1, 1380.9, 1381.9, 1402.7, 1407.6, 1424.0 (fault, dipping approximately 70°), 1433.3, 1441.1, and 1441.6 m	182.8 (599.8)	1464.0 (4,803.2)
Bedded and ash-flow tuff		
Tuff, bedded, reworked, yellowish-gray, and light-yellowish-gray, zeolitized(?), individual beds range from 1 cm to 1.5 m thick, composed of pumice, pale-greenish-yellow and very light gray, zeolitized, 1-2 cm, and grayish-brown and medium-gray intermediate lava lithics, angular to subrounded, 1 mm-5 cm, upper contact dipping approximately 20°	7.3 (24.0)	1471.3 (4,827.2)
Tuff, ash-flow, very light gray and light-greenish-gray, partially welded, zeolitized(?); pumice, light-greenish-gray, zeolitized, contains 15-20 percent plagioclase, biotite, and sanidine(?) phenocrysts and trace amounts of quartz(?)	8.8 (28.6)	1480.1 (4,855.8)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Bedded and ash-flow tuff		
Tuff, bedded, reworked, light-greenish-yellow, light-greenish-gray, and light-brownish-gray, zeolitized(?); individual beds range from 1 cm to 1 m thick; matrix composed of altered lava material derived from underlying unit, rich in biotite, blocks of altered lava as large as about 0.5 m common toward base (1484.9-1485.6 m); grayish-red, and medium-gray, intermediate lava lithics common, as large as 2 cm angular to subrounded, pumice common toward top of unit, (lower part of unit probably represents eroded blocks from the underlying lava flow); slickensides at 1484.1 m	5.5 (18.2)	1485.6 (4874.0)
Lava and flow breccia		
Flow breccia, rhyolitic, bleached, light-gray, medium-light-gray, light-brownish-gray, devitrified, composed of about 5-10 percent plagioclase, biotite, and hornblende phenocrysts; plagioclase, biotite, and hornblende are altered; matrix in some areas argillized; spherulitic zone at 1504.6-1504.7 m; possible fault zones at 1489.9-1491.1 and 1498.7 m	22.6 (74.0)	1508.2 (4948.0)
Flow breccia, rhyolitic, grayish-orange-pink, and light-brown, argillized; composed of 5-10 percent plagioclase, biotite, and hornblende (pseudomorphs) phenocrysts; flow-banding common	1.7 (6.0)	1509.9 (4,954.0)
Lava, rhyolitic, flow-banded and spherulitic; light-greenish gray, yellowish-gray, light-brownish-gray, and medium-light-gray, devitrified, partly zeolitized(?) and argillized, contains approximately 5-10 percent plagioclase, biotite, and hornblende (pseudomorphs) phenocrysts; plagioclase, biotite and hornblende are altered; spherulites, grayish-brown, as large as 2 cm, common throughout interval; matrix appears to have been zeolitized(?); calcite and quartz present at 1529.6-1529.8 and 1545.9 m along fractures; argillized zone at 1532.8-1533.1 m, could indicate a fault(?); brecciated zone at 1535.9 and 1541.9 m, healed with calcite, possible fault(?)	45.2 (148.0)	1555.1 (5,102.0)

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Lava and flow breccia--Continued		
Lava, rhyolitic, flow-banded, light-brownish-gray, gray, devitrified, contains approximately 5-15 percent plagioclase, biotite, feldspar, and hornblende (pseudomorphs) phenocrysts; plagioclase, biotite, and hornblende altered; trace of spherulites as much as about 3 mm; occasional calcite in fractures; autoclastic zone (healed) at 1564.9-1577.0 m; fault zone at 1577.0-1584.1 m, partly argillized, slickensides common; brecciated zone at 1584.1-1586.6 m	31.5 (103.3)	1586.6 (5,205.3)
Lava, quartz latitic, light-greenish-gray, devitrified, contains approximately 15-25 percent plagioclase, biotite, hornblende (pseudomorphs), and pyroxene phenocrysts; plagioclase, biotite, hornblende, and groundmass are all altered; calcite common in fractures; fault plane (about 80°) at 1604.2-1604.7 m coated with calcite	18.1 (59.4)	1604.7 (5,264.7)
Lava, quartz latitic, light-brownish-gray, and medium-light-gray, devitrified; contains approximately 15-25 percent plagioclase, biotite, hornblende (pseudomorphs), and pyroxene phenocrysts; plagioclase, biotite, and hornblende are altered; matrix partly altered (mottled) to moderate-reddish-orange material (iron oxide), increasing with depth, biotite-rich xenoliths common throughout interval	60.1 (197.3)	1664.8 (5,462.0)
Lava, quartz latitic, brownish-gray, devitrified; contains approximately 15-25 percent plagioclase, biotite, hornblende (pseudomorphs) phenocrysts and pyroxene; plagioclase, biotite, and hornblende altered; matrix altered to brownish-gray material; biotite plagioclase-rich xenoliths common throughout interval	11.4 (37.4)	1676.2 (5,499.4)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Lava and flow breccia--Continued		
Flow-breccia, quartz latitic, greenish-gray, and light-greenish-gray, devitrified; contains approximately 25 percent plagioclase, biotite, and hornblende (pseudomorphs) phenocrysts, plagioclase, biotite, and hornblende altered; autoclastic blocks as large as 0.5 m	42.1 (137.9)	1718.3 (5,637.3)
Bedded and ash-flow tuff		
Tuff, fused, brownish-gray, contains abundant intermediate lava and some tuff lithics, as large as 5 cm, decreasing toward base; abundant feldspar in very fine matrix toward base	3.7 (12.3)	1722.0 (5,649.6)
Tuff, reworked and bedded, greenish-gray, massive beds contain pumice, grayish-green, partly argillized and zeolitized(?) and angular to subrounded intermediate lava lithics as large as 3 cm	1.0 (3.3)	1723.0 (5,652.9)
Tuff, ash-flow, light-gray to medium-light-gray, partially welded, devitrified; pumice, medium-gray, devitrified, contains approximately 15-25 percent plagioclase and biotite phenocrysts and trace amounts of quartz, sanidine(?), hornblende, and pyroxene phenocrysts; 5-15 percent intermediate lava lithics	5.4 (17.7)	1728.4 (5,670.6)
Lava and flow breccia		
Lava and flow breccia, dacitic, medium-bluish-gray, devitrified, contains approximately 30-40 percent phenocrysts comprised of plagioclase and pyroxene (pseudomorphs); autoclastic toward top of lava (1728.4-1735.4 m), healed with calcite at 1751.9 m	32.6 (107.0)	1761.0 (5,777.6)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Lava and flow breccia--Continued		
Lava, dacitic, dusky-brown, devitrified, contains 30-45 percent plagioclase and pyroxene (pseudomorphs) phenocrysts; reddish-brown iron-oxide staining common with coating along fractures; fault breccia healed with calcite at 1763.6 m (gradational lower contact)	24.9 (81.9)	1785.9 (5,859.5)
Lava and flow breccia, dacitic (as 1728.4-1761.0 m), medium-bluish-gray, devitrified, contains approximately 30-45 percent plagioclase and pyroxene (pseudomorphs) phenocrysts; autoclastic toward base of lava, 1787.9-1793.9 m	8.0 (25.9)	1793.9 (5,885.4)
Bedded tuff, conglomerate and ash-flow tuff		
Conglomerate, medium-gray, consists of bluish-gray, brownish-gray, and greenish-black intermediate lava clasts, with some tuff clasts toward base, predominantly subrounded, as large as 2 cm; clasts decrease toward base; gradational basal contact	1.0 (3.3)	1794.9 (5,888.7)
Tuff, reworked, bedded, medium-gray to light-greenish-gray, partly argillized, consists of intermediate lava, pumice and tuff lithics in a fine tuffaceous matrix; pumice more common toward base; massive bed towards top, thin bedded toward base	8.2 (27.1)	1803.1 (5,915.8)
Conglomerate, composed of angular to subrounded clasts (about 90 percent) of tuff; intermediate lava and pumice, as large as 3 cm, set in a light-greenish-gray tuffaceous matrix; fault at 1804.3 m; thin-bedded tuffaceous sandstone at base (1804.5-1804.8 m)	1.7 (5.5)	1804.8 (5,921.3)
Tuff, ash-flow, light-greenish-gray to light-brownish-gray, partially welded; pumice, pale-green, zeolitized(?) and partly argillized; contains approximately 10-15 percent quartz, plagioclase, sanidine and biotite; interval at 1804.8-1805.6 m could be reworked ash-fall(?) with compacted pumice	2.6 (8.5)	1807.4 (5,929.8)

Table 1a.--Lithologic description of exploratory drill hole USW G-2, Yucca Mountain, Nevada--Continued

Stratigraphic and lithologic description	Thickness of interval meters (feet)	Depth to bottom of interval meters (feet)
Bedded tuff, conglomerate and ash-flow tuff--Continued		
Tuff, reworked, bedded, pink-gray, greenish-gray to light-brownish-gray, partly argillized, massive to thin-bedded, contains angular to subrounded rhyolitic(?), intermediate lava and pumice lithics; thin bedded toward base	3.9 (12.7)	1811.3 (5,942.5)
Older tuffs of USW G-2		
Tuff, ash-flow, light-gray, partially to moderately welded (compacted pumice), devitrified; pumice, greenish-gray and dark-greenish-gray, argillized; contains approximately 10-20 percent quartz, sanidine, plagioclase, and biotite phenocrysts	19.3 (63.5)	1830.6 (6,006.0)
Total depth		1830.6 (6,006.0)