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Yucca Mountain Site Characterization Project

Structures in Continuously Cored, Deep Drill Holes at Yucca Mountain, Nevada, with Notes on Calcite Occurrence

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STRUCTURES IN CONTINUOUSLY CORED, DEEP DRILL HOLES AT YUCCA MOUNTAIN, NEVADA, WITH NOTES ON CALCITE OCCURRENCE

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ABSTRACT

A study of more than 22,000 feet of core from five deep drill holes at Yucca Mountain, Nevada, provided data on the attitude and vertical distribution of faults and fractures, the sense of fault displacement, and the occurrence of calcite.

The study was done mainly to look for evidence of fault flattening at depth, but no consistent downward decrease in dip of faults was found, and no increase in strata rotation was evident with increasing depth. Master faults near drill holes USW G-3 and G-2, originally interpreted in reports on these holes as listric and planar, respectively, are probably geometrically more complex than originally assumed, and can be reinterpreted as planar and strike-slip faults.

Oblique-slip predominates on faults in core from Yucca Mountain, especially in drill hole USW G-2. No other particular pattern of slip is suggested by the observations, although faults with similar slip appear to cluster at various depths.

In the two drill holes located near prominent faults that dip toward the holes (USW G-3 and G-2), an apparent increase in the frequency of faults occurs below the tuffs and lavas of Calico Hills. Some of this increase occurs in brittle lavas and flow breccias in the lower part of the volcanic section. In the two holes presumed to be relatively removed from the influence of important faults at depth, the vertical distribution of faults is relatively uniform.

Calcite occurs mainly in two general zones, voids in welded portions of the Paintbrush Tuff, and in a deeper zone, mostly below 3,500 feet. Calcite is least abundant in USW G-4, which may reflect the fewer faults and fractures encountered in that drill hole.

This work was performed under WBS 1.2.3.2.8.4.2.

The data in this report was developed subject to Quality Assurance controls in QAGR S123284C, Revision 1, PCA 4.0; the data is not qualified and is not to be used for licensing.

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1.0 INTRODUCTION

A review of U.S. Geological Survey reports on five continuously cored drill holes at Yucca Mountain indicates that few data have been published on the distribution and dips of faults encountered in these holes. Such information could constitute evidence bearing upon the mechanism and timing of faults in the proposed repository site area. The variation in frequency of faults with depth also might be considered as evidence of the mechanism and chronology of structural development of Yucca Mountain. Information on the style and chronology of faulting is important in development of a tectonic model, which in turn may be used to predict future fault movements and the degree of long-term structural and hydrologic stability of the Yucca Mountain area.

The extensional structure at Yucca Mountain consists mainly of a series of nearly parallel normal faults that strike north to north-northeast. At the surface the large faults are spaced about 1/2 to 1 mile apart and dip steeply west at 65° to 80° (Scott and Bonk, 1984). The tuffs they displace dip eastward at 5° to 15°.

The subsurface configuration of the faulting has not been well-defined by existing drill holes. The faults may be listric, planar, or both. It has been suggested, principally by Scott (1990), that Yucca Mountain is underlain by westward-dipping, low-angle normal or detachment faults. In such a model, many faults of the upper plate of the detachment are listric or curviplanar and flatten toward low-angle faults at depth. If this is the case, fault inclination should show, on average, a gradual decline with increasing drill hole depth. According to Scott (1990), an accommodation structure, probably a low-angle normal fault, should occur between 1 and 4 kilometers (3,200 to 13,000 feet); several of the drill holes at Yucca Mountain reach depths of 6,000 feet. In addition, structural rotation of strata could increase at deeper levels if the faults flatten with depth. This could occur as a result of reverse drag flexing (Hamblin, 1965) and the tendency for strata to maintain a 90° relationship with faults displacing them (Anderson, 1971). Reverse drag does not appear to be common on many normal faults, however, suggesting that most faults are not concave surfaces, or that the curvature is slight or is restricted to deep portions of the faults (Zoback and others, 1981).

Planar or "domino-style" extensional faults require some means of accommodating the theoretical voids that would be created at the bottoms of tilted blocks. This can be accomplished by ductile flow (Miller and others, 1983), a detachment (Wernicke and Burchfiel, 1982), or by internal small-scale block deformation (Angelier and Colletta, 1983). Such deformation, if present, probably does not occur at depths penetrated by drill holes at Yucca Mountain.

2.0 STUDY METHOD

All available core, approximately 22,000 feet from five drill holes (Figure 2-1), was examined at the Yucca Mountain Project Sample Management Facility at various times between November 1989 and September 1990. Faults and prominent fractures were noted and, where obvious, dips and the general orientation of slickensides were recorded. A few faults overlooked in this examination, but recorded by previous workers in published reports (Scott and Castellanos, 1984; Maldonado and Koether, 1983; Spengler et al., 1979; Spengler and Chornack, 1984; Spengler et al., 1981), were added to the data. Distinct stratal inclinations also were noted; these were combined with dips published in the above reports.

Because of the general interest of project scientists in the distribution of carbonate in the subsurface, prominent calcite coatings or void fillings were recorded during the fault examination.

The distinction between the terms "fault," "fracture," or "shear fracture," as used by some authors (e.g., Spengler and Chornack, 1984), is commonly difficult and somewhat subjective. In general, in this study a natural break in the core was called a fault if it had one or more of the following characteristics: juxtaposition of obviously different lithologies, easily identifiable slickensides, breccia or gouge, and/or unusually broken and clayey or altered rock. Only prominent, generally planar, natural fractures whose dips could be determined were recorded (Appendix A), on the assumption that most of these are related to the fault pattern; some may have slight but undetected displacement.

Drill-hole deviation from vertical has a significant effect on the structural data in two of the five drill holes, USW G-3 and USW G-2. Both holes deviated in a west-southwest direction (Scott and Castellanos, 1984, Figure 23). USW G-3 slanted westward as much as 20° from the vertical (Scott and Castellanos, 1984, Figure 31). USW G-2 deviated westward almost 5° from the vertical (Maldonado and Koether, 1983, Figure 3) below about 4,200 feet. In this report, correction for drill-hole deviation was based on the assumption that all faults dip westward in the deviated portions of these two drill holes, in accordance with the general structural pattern at the surface at Yucca Mountain. Therefore, the fault dips reported in Appendix A were reduced from 5° to 20° in the deeper portions of USW G-3, and 5° in the lower part of USW G-2. Although antithetic or conjugate faults may be present locally, the mapping and cross sections by Scott and Bonk (1984) indicate faults of easterly dip are rare.

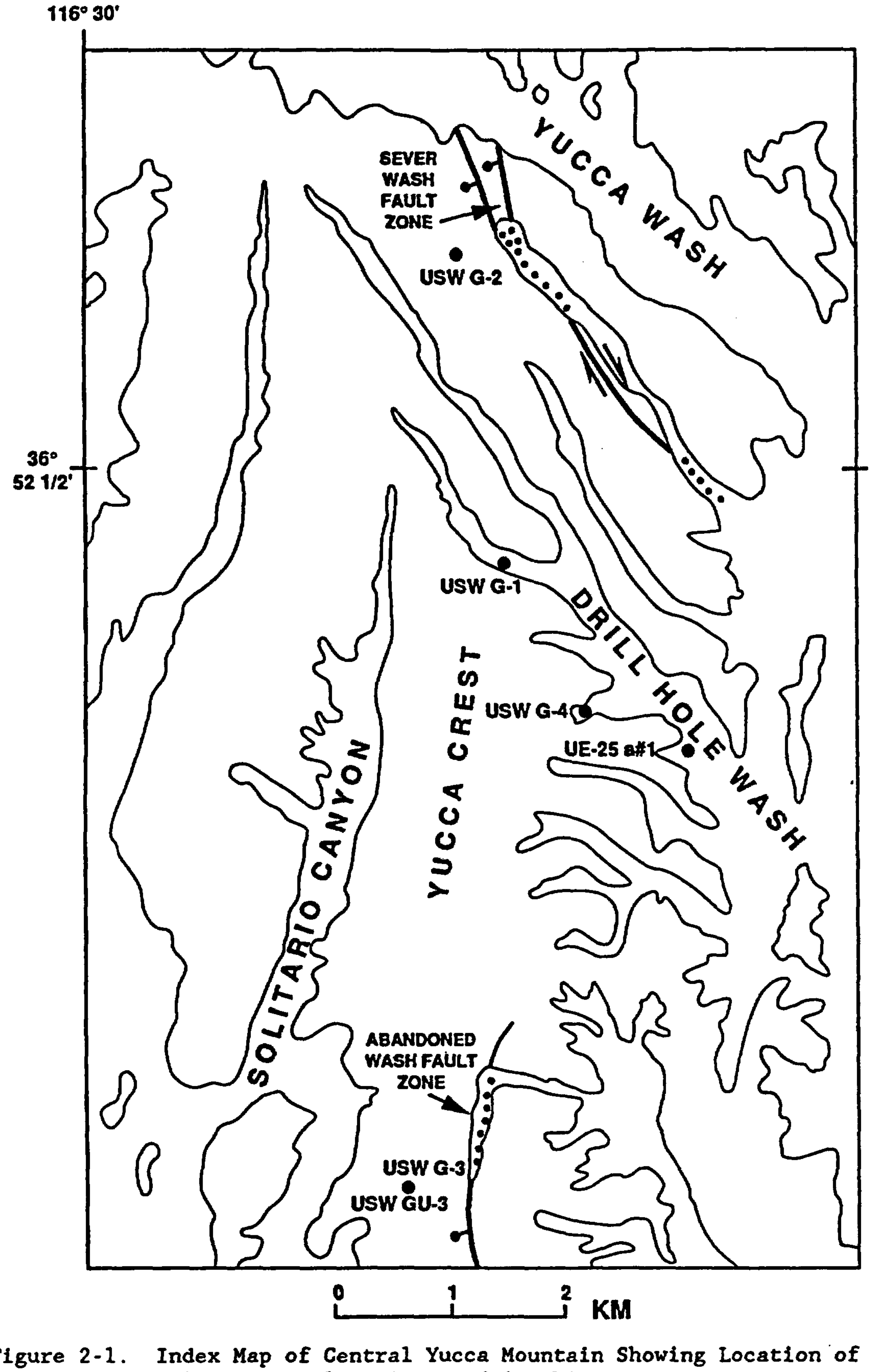


Figure 2-1. Index Map of Central Yucca Mountain Showing Location of Drill Holes and Faults Discussed in This Report

3.0 ATTITUDE OF STRUCTURAL FEATURES

No consistent downward decrease in dip of faults was found in this study (Figures 3-1 and 3-2), except possibly in drill hole USW G-3. If anything, there is a slight steepening of fault dips in holes USW G-1 and G-2 with increased depth (Figure 3-1). Not enough good data can be obtained from existing core to resolve structural questions at the USW G-3 drill hole, but there is no evidence that faults become lower angle with depth in the other four drill holes studied. Neither USW G-4 nor UE-25 a#1 are deep enough to provide conclusive data, however. Data from the remaining two holes, USW G-1 and G-2, suggest a planar system of faults (Table 3-1).

Table 3-1

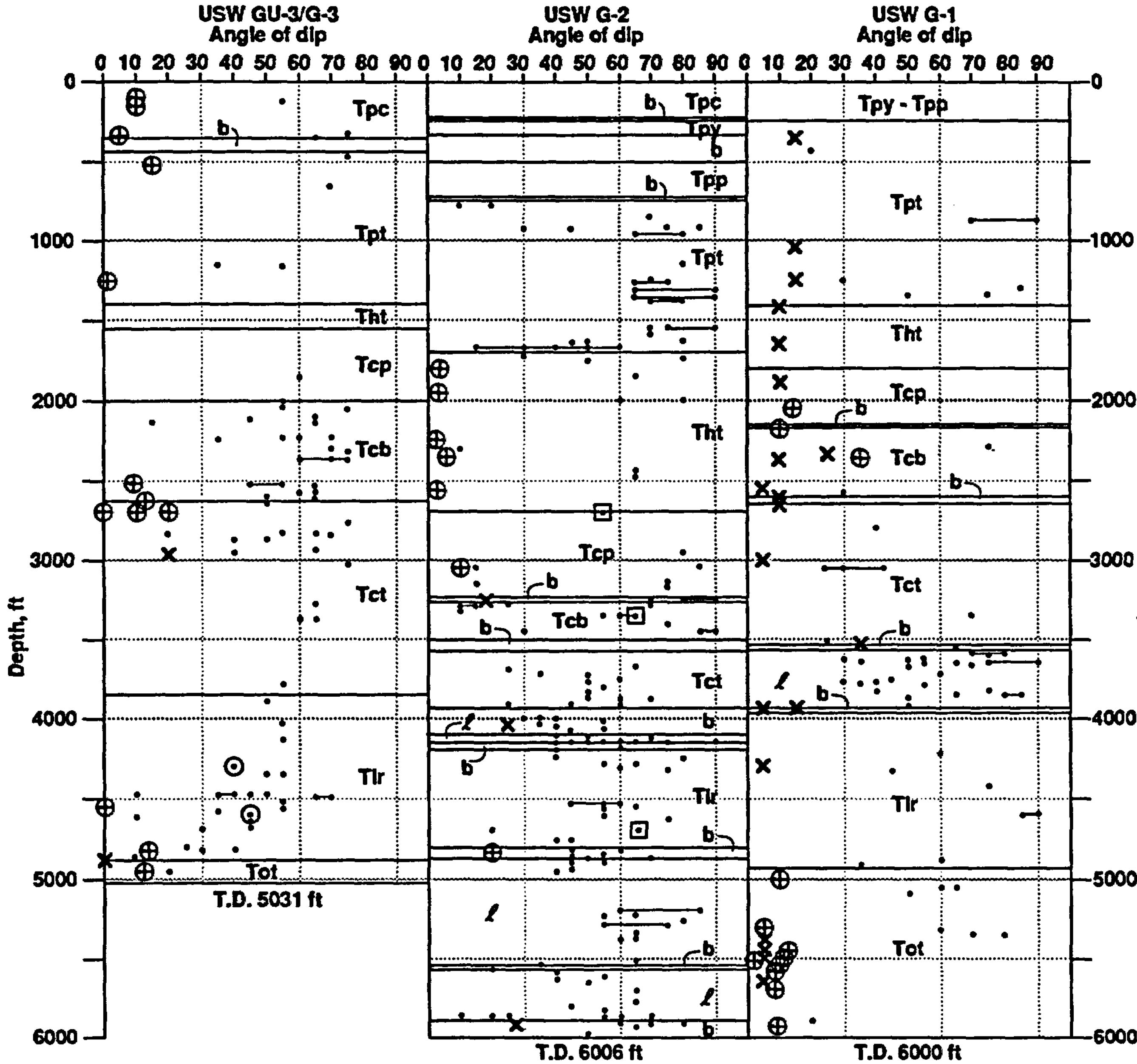
AVERAGE DIP OF FAULTS IN CORE FROM DRILL HOLES USW G-1, G-2, AND GU-3/G-3, 1,000 FOOT INTERVALS

	Number of observations and average dip per interval		
Depth, ft	USW G-1	USW G-2	USW GU-3/G-3
0-1,000	(2) 50°	(9) 52°	(5) 68°
1,000-2,000	(5) 54°	(19) 65°	(3) 50°
2,000-3,000	(3) 48°	(7) 59°	(30) 58°
3,000-4,000	(31) 54°	(32) 53°	(6) 62°
4,000-5,000	(6) 60°	(55) 52°	(23) 40°
5,000-6,000	(8) 58°	(32) 55°	No data

Structure at USW G-3

It has been proposed (Scott and Castellanos, 1984) that faults encountered at about 1,310 m (4,297.5 feet) and 1,402 m (4,600 feet) in USW G-3 are strands of the Abandoned Wash fault zone (Figures 2-1 and 3-3) that have flattened from 77° at the surface to about 50° (corrected for hole deviation) at depth. Although the available information permits this interpretation, several considerations suggest that the two previously mentioned faults are not the Abandoned Wash. If so, an essentially planar Abandoned Wash fault is a reasonable alternative interpretation.

The two main faults in the drill hole occur in the Lithic Ridge Tuff, which is about 920 feet thick in USW G-3 (Scott and Castellanos, 1984, Table 10). It is about 975 feet thick in USW G-1 (Spengler et al., 1981) about 3.5 miles to the north. The Abandoned Wash Fault has about 150 feet of displacement in the vicinity of USW G-3, but despite the presence of at least 23 faults in the Lithic Ridge in USW G-3, the unit does not appear to be significantly thinned as a result of the faults, assuming the thickness at USW G-1 is representative. The faults in the Lithic Ridge in USW G-3 at depths of 4,297.5 and 4,600 feet were described by Scott and Castellanso (1984) as "major" and containing "thick gouge zones." Examination of these structures for this report showed crushed zones 2 to 6 inches wide, but identical lithology on opposite sides of the faults.



EXPLANATION

- • Fault, plotted to nearest 5°. In a few places, faults (from Appendix A) of similar dip are too close together to plot separately.
- ⊡ "Important" fault of Maldonado and Koether (1983).
- ⊙ "Major" fault of Scott and Castellanos (1984).
- ✕ Stratal dip, corrected for deviation of drill holes USW G-2 and G-3.
- ⊕ Stratal dip previously published. (See appropriate drill hole report.)

Fault dips are corrected as follows: USW GU-3/G-3, 0-820 ft: 0°; 820-2460 ft: -5°; 2460-3280 ft: -10°; 3280-4100 ft: -15°; 4100-5031 ft: -20°. USW G-2, 0-4200 ft: 0°; 4200-6006 ft: -5°.

Stratigraphic units:

Tpc - Paintbrush Tuff, Tiva Canyon Member
Tpy - Paintbrush Tuff, Yucca Mountain Member
Tpp - Paintbrush Tuff, Pah Canyon Member
Tpt - Paintbrush Tuff, Topopah Spring Member
Tht - Tuffs of Calico Hills
Tcp - Crater Flat Tuff, Prow Pass Member
Tcb - Crater Flat Tuff, Bullfrog Member
Tct - Crater Flat Tuff, Tram Member
Tlr - Lithic Ridge Tuff
Tot - "Older" Tuffs
b - Bedded tuffs (Very thin units not shown)
ℓ - Lavas and flow breccia

Figure 3-1. Relation Between Depth and Dip of Faults and Strata for Drill Holes USW GU-3/G-3, G-2, and G-1

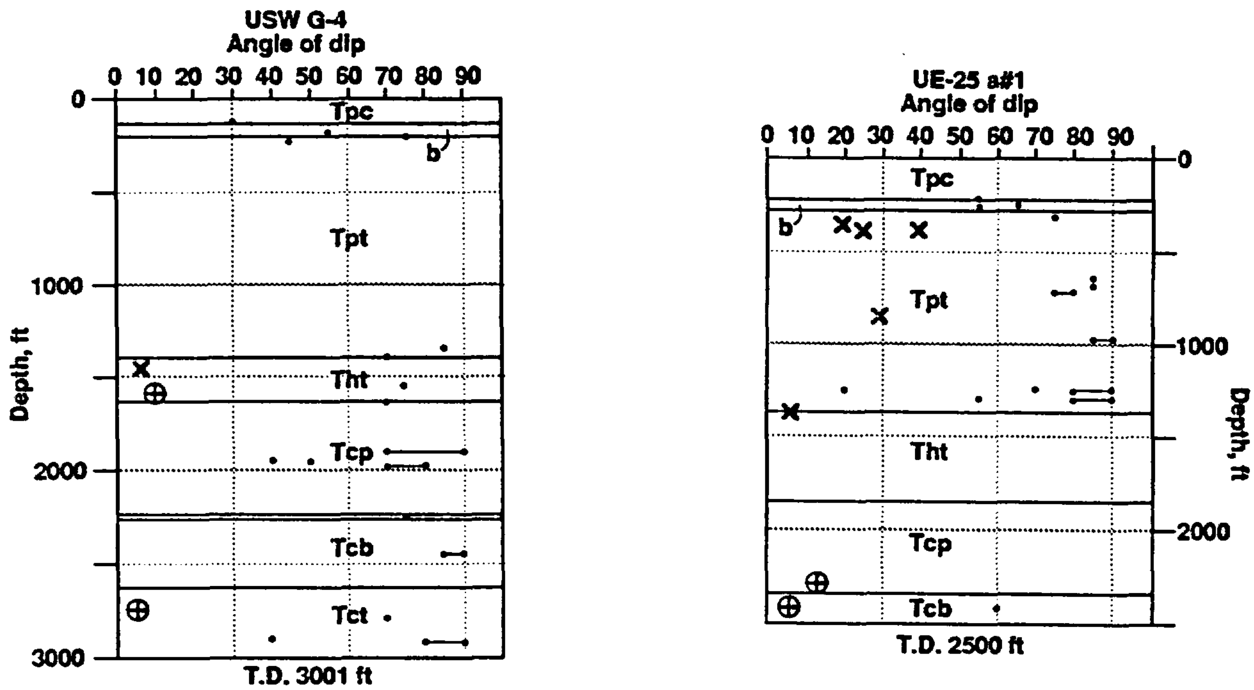


Figure 3-2. Relation Between Depth and Dip of Faults and Strata for Drill Holes USW G-4 and UE-25 a#1

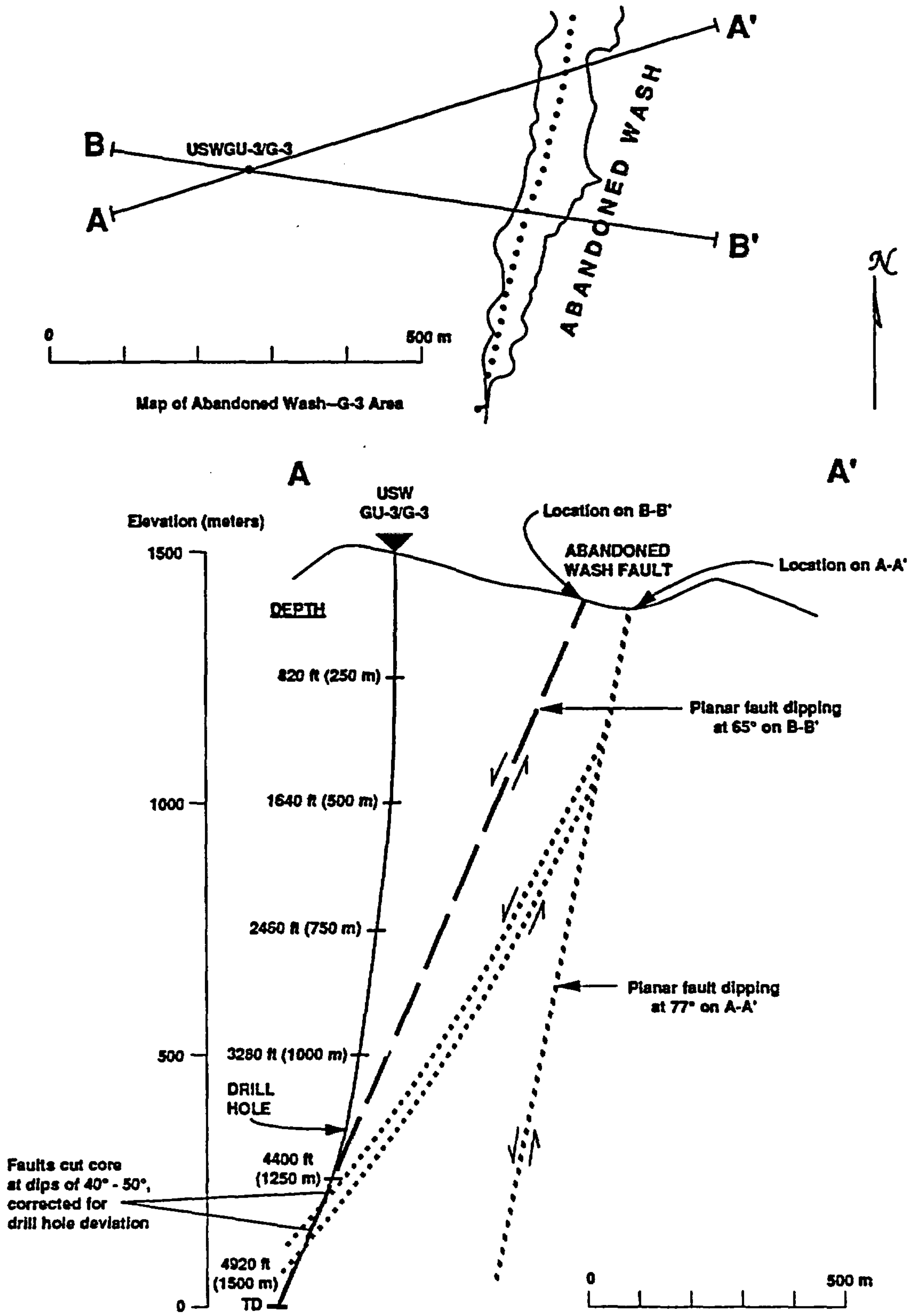


Figure 3-3. Map and Cross Section Through Drill Hole USW G-3/GU-3 Adapted From Scott and Castellanos (1984, Figures 30 and 31). Short dashed lines are fault projections from Scott and Castellanos (1984), on their cross section line A-A'. Long-dashed line is a planar abandoned wash fault dipping 65° and located on a line of section (b-b') at right angles to the fault.

Another indication that the Abandoned Wash faults do not flatten toward USW G-3 is the lack of significant strata rotation. If the faults are listric one would expect the beds to be dipping at relatively high angles in the lower part of the drill hole, owing to the tendency for stratal dips to maintain a general 90° relationship with faults that displace them (Anderson, 1971). No stratal dips in USW GU-3 and G-3 exceed 20°; the average of 16 measurements is about 8°. The average dip of 24 faults in the lower part of the hole is about 41°, an amount seemingly incompatible with the low stratal dip. There is no evidence of the presence near USW G-3 of the highly rotated blocks of Tiva Canyon Member mapped by Scott and Bonk (1984) to the north on the west side of Abandoned Wash. Three dips in the lower part of the drill hole are 0° (4,560 feet), and 13° (4,890 feet) and 12° (4,964 feet); the latter two dips are west-northwest (Scott and Castellanos, 1984, Table 9), as opposed to the generally eastward dips of the area. As these dips were measured on oriented core it is assumed that they are true dips, corrected for drill-hole deviation. A dip of 20° was measured in this study at a depth of 4,874 feet, but it is in bedded tuff described by Scott and Castellanos (1984, p. 121) as cross bedded and reworked. If the actual dip direction is westerly, as indicated by Scott and Castellanos, then this dip is actually nearly horizontal, as plotted in Figure 3-1.

The low westerly stratal dips in the drill hole at 4,560 and 4,890 feet could be explained as drag associated with the hanging wall of the Abandoned Wash Fault, and some of the faults with low dips in the lower part of the hole could be antithetic to the Abandoned Wash Fault. If this is correct, the dip of these faults would be easterly and should be increased about 15° to 20°, rather than decreased as in Figure 3-1, essentially removing the apparent trend of fault flattening in the lower part of USW G-3.

It should be noted that the cross section of Scott and Castellanos (1984, Figure 31) through the drill hole (A-A', Figure 3-3) is not drawn at right angles to the Abandoned Wash Fault, and therefore gives a somewhat distorted view of the relationships. Any planar fault with a dip greater than 65° will not intersect the westward deviating drill hole, but if the fault is listric and dips 77° at the surface, as shown by Scott and Castellanos (1984, Figure 31), a more abrupt flattening is required than shown.

In summary, existing information suggests that drill hole USW G-3 did not encounter the Abandoned Wash Fault, which allows the interpretation that the fault could be essentially planar.

Structure at USW G-2

The structue at USW G-2 is unique among the five drill holes studied. Together with USW G-3 it contains several faults with important displacement, but of more significance is the fact that it lies near a northwest-striking right-lateral fault zone (Scott and Bonk, 1984), the Sever Wash Fault (Figure 2-1). This is mapped (Scott and Bonk, 1984) as two main subparallel faults that dip toward the drill hole. According to Maldonado and Koether (1983, Figure 22), two strands of the fault were penetrated at depths of 2,704 and 4,672 feet in USW G-2; dips of about 55° and 65°, repsectively, were measured in this study, in agreeent with those reported by Maldonado and Koether (1983). They projected these dips to the surface as planar faults that appear to coincide with the location of the two Sever Wash fault strands, but surface dips measured (Scott and Bonk, 1984) on the westernmost of the two faults are significantly higher than the subsurface drill hole dip of 55°. Six surface dips of the western fault range form 74° to 87°, and average 80°. Thus, an unrealistically abrupt flattening from 80° at the surface to 55° at 2,704 feet would be required if the faults connect.

Unlike the other deep drill holes, USW G-2 shows a distinct and persistently greater number of faults at depth, below the tuffs of Calico Hills (Figure 3-1; Table 3-1). Between the top of the Crater Flat Tuff (the fault at 2,704 feet) and the bottom of the hole at 6,006 feet, more than 166 faults were noted. Most of these faults show oblique or horizontal slip (Table 4-1). No such swarm of faults is evident at the surface; therefore, it is likely that many of these faults predate the Paintbrush Tuff and Calico Hills. The abundance of faults at depth may represent breakage from pre-Calico Hills strike-slip activity on the Sever Wash Fault zone, or other structures concealed beneath the Paintbrush Tuff.

Several additional drill holes would be necessary to determine the three-dimensional geometry of the faults at depth, as well as the lateral extent of the abundant pre-Calico Hills faults in the northeastern Yucca Mountain area. Such drill hole data could contribute to an understanding of the higher water table (Gemmell, 1990) in this area by better defining the fault and fracture permeability at depth.

4.0 SENSE OF FAULT DISPLACEMENT

The study also provided some information on the type of displacement on faults, as revealed by slickensides on the fault surfaces (Table 4-1). Of 117 faults with slickensides noted, only 29 percent were dip-slip, 52 percent were oblique slip, and 19 percent were horizontal slip. Oblique slip predominates at all locations except UE-25 a#1, which probably has too few observations to be meaningful. USW G-2 stands out as having not only the most faults with slickensides observed, but also by far the most oblique displacements. No particular change in sense of slip with depth is obvious in the data (Appendix A), although faults appear to cluster in groups with similar slip vectors.

TABLE 4-1

SENSE OF DISPLACEMENT FROM SLICKENSIDES ON FAULTS IN DEEP DRILL HOLES AT YUCCA MOUNTAIN (Rake angles: horizontal-slip 0-30°; oblique-slip 30°-60°; dip-slip 60°-90°)

	Number of Observations						
Drill hole	Dip-slip	(%)	Oblique-slip	(%)	Horizontal-slip	(%)	Total
UE-25 a#1	3	(50)	2	(33)	1	(17)	6
USW G-1	7	(35)	8	(40)	5	(25)	20
USW G-2	14	(23)	37	(62)	9	(15)	60
USW GU-3/G-3	8	(36)	10[1]	(45)	4[1]	(18)	22
USW G-4	2	(22)	4	(44)	3	(33)	9
Total	34	(29)	61	(52)	22	(19)	117

[1] Two sets, oblique and horizontal slickensides, are present on one fault.

5.0 VERTICAL DISTRIBUTION OF FAULTS

Except in drill hole UE-25 a#1, there is an apparent increase in the number of faults below the Paintbrush Tuff or tuffs and lavas of Calico Hills (Figures 3-1 and 3-2). There are many intervals hundreds of feet thick, however, showing little or no evidence of faults (e.g., 1,200 to 1,800 feet and 3,370 to 3,750 feet in USW G-3; 300 to 700 feet in USW G-2; 500 to 800 feet, 1,400 to 2,200 feet, and 5,400 to 5,900 feet in USW G-1; 300 to 1,400 feet and 2,500 to 2,800 feet in USW G-4; 1,400 to 2,400 feet in UE-25 a#1). Fractures are also rare to absent in many thick intervals.

Probably only two of the drill holes yield significant data with respect to the chronologic development of faults. USW G-1 and G-4 are located well away from significant surface faults and, in contrast to the other three holes, probably do not approach major fault zones at depth. In USW G-1, fault distribution appears to be fairly uniform throughout the hole, if the lava and flow breccia interval (Figure 3-1) is excluded. The brittle character of the lavas, together with their location within a thick section of less competent, poorly welded and nonwelded tuffs, may have concentrated stress in the lavas. The tuffs at those depths may have yielded more by plastic deformation than by faulting. USW G-4 penetrates to only about the middle of the Tram Member (Figure 3-2), but to that depth the fault distribution is fairly uniform. USW G-2 exhibits more faults at depth, below the tuffs of Calico Hills, but it is not clear whether this is a result of the proximity of the lower part of the hole to the Sever Wash Fault or to a set of older faults covered by the younger tuffs.

Thus, although it is difficult to draw a firm conclusion from the available drillhole data, it appears that there is no consistent increase in the number of faults with depth. Although older faulting, unexposed at the surface, may occur in some areas. The end of significant faulting at the site area on Yucca Montain is constrained by the surface geology, which shows relatively large and generally equal displacement of the Tiva Canyon and underlying members of the Paintbrush Tuff, but only minor displacement of the Rainier Mesa Member of the Timber Mountain Tuff (Carr, 1984; Scott and Bonk, 1984).

6.0 CALCITE OCCURRENCE

Although calcite is proportionately a small constituent of the tuffs at Yucca Mountain, its occurrence, chiefly in voids and fractures in welded tuff in the unsaturated zone, is more common than many of the drill holes indicate. The importance of calcite at Yucca Mountain is twofold: (1) as a datable isotopic indicator of the timing and mechanism of water movement through the rock, and (2) as a factor in the possible generation of gaseous $^{14}CO_2$ from the repository to the surface.

During logging of structures in the core, obvious occurrences of calcite were noted and are summarized in Appendix B. This was done partly because the recording of calcite in existing drill-hole logs is inconsistent. Identification of calcite was made entirely megascopically, as rules of the core storage facility prohibited destructive testing, including the use of hydrochloric acid. Many light-colored, fine-grained, very thin mineral coatings were observed that may be calcium carbonate in part, but most of these are not included in the summary in this report.

In general, calcite decreases in abundance with depth; it is most common in the welded portions of the Paintbrush Tuff in fractures, faults and lithophysae. In drill hole UE-25 a#1, calcite is very rare below 1,200 feet (see also Spengler et al., 1979). One possible occurrence of fluorite was noted at 901 ft in UE-25 a#1. Other fluorite occurrences are mentioned by Scott and Castellanos (1984, Table 11) in USW GU-3 and G-3. Opal, quartz, and chalcedony also occur locally with the calcite; these minerals were not recorded unless unusually abundant.

Although calcite is more abundant near the surface and there are many thick intervals lacking in calcite at depth, deeper zones of calcite occur, especially in holes USW G-1 and G-2 between approximately 3,500 and 6,000 feet. In USW GU-3 and G-3, little void-filling calcite occurs between approximately 650 and 1,700 feet, and between 3,300 and 4,300 feet. Very little secondary calcite occurs in hole USW G-4, even in the Paintbrush Tuff, and in that hole calcite is the least abundant of all types of fracture coatings (Spengler and Chornack, 1984; Carlos, 1987).

The interpretation favored in this report is that most of the calcite observed in the Paintbrush Tuff in the subsurface was derived from Quaternary surficial deposits of aeolian calcium carbonate-rich sand, remnants of which remain on the surface as sand ramps (Hoover, 1989). Leaching of the carbonate available for downward transport could have been enhanced during periods of higher Pleistocene precipitation, which supported more vegetation, stabilized the dunes, and created slightly acidic soil conditions favorable to solution of calcium carbonate at the surface.

7.0 CONCLUSIONS

Of the five drill holes examined, only USW G-1 perhaps is deep enough and sufficiently removed from complex fault zones to be a valid sample of the third dimensional aspects of extensional faults at Yucca Mountain. Taken as a whole, however, the available data on both the attitude of faults and dip of strata suggest that there is no tendency for faults to flatten substantially or for stratal dips to increase with depth. As there is no indication of significant ductile or small-scale deformation in the existing drill-hole core, it is likely that if a detachment exists at Yucca Mountain it probably lies at a depth well below present exploration.

Although the question of whether a significant episode of faulting preceded the Paintbrush Tuff or tuffs of Calico Hills at Yucca Mountain is generally unresolved, data from drill hole USW G-2 suggests the possibility of significant older faulting in some areas. Clearly, faults are more numerous in lavas and flow breccia beneath the Tram Member, but this may be a function, in part at least, of the mechanical properties of the lavas.

Calcite is most common in openings in the welded Paintbrush Tuff, although it also occurs sporadically below approximately 3,500 feet. Calcite is least common in USW G-4, which could be the result of its location in an area of minimal faults and fractures.

Finally, in order to resolve the fundamental and tectonically important questions of fault geometry at Yucca Mountain, several three-point groups of holes should be drilled to recover oriented core in locations that will intersect and define faults or fault zones typical of the prominent structural grain.

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APPENDIX A

SUMMARY OF FAULTS AND SELECTED FRACTURES IN DEEP CORED DRILL HOLES AT YUCCA MOUNTAIN

Depths measured to nearest 1.0 feet, dips to nearest 5°. I-Dip indeterminant.

Fractures noted are prominent natural breaks without breccia or obvious displacement. Fractures whose dips were not determined are not listed.

Faults characterized as "small" or "very small" have identical lithology on either side, the zone of slippage is relatively narrow (<3/8 in.), and the walls are not obviously brecciated or altered. "Small" faults have displacements of an inch or so; faults with "very small" displacement show evidence of slight movement (slickensides), but no measureable offset of textures or stratification.

The terms dip-slip, oblique, and horizontal displacement refer to the general attitude of slickensides observed on fault plane.

UE-25 a#1
(No core 0 to 54 ft)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Faults	188-190	I		Clay, broken
Faults	193.5-195	I		Clay, broken
Fault	225	55°	Small	
Fault	249	65°	Small, dip-slip	
Fault	251.5	55°	Small, oblique	
Faults	264-267	I		Clay, broken
Faults	270-271	I		Clay, broken
Faults	302-314	I		Clay, broken
Fault	314.5	75°	Small, dip-slip	
Fracture	361	60°		
Faults	429-440	I		Clay, breccia
Faults	520-530	I		Clay, breccia
Fault	645	85°		Clay
Fracture	648	70°		Planar
Faults	666.5-673	I		Broken, breccia, clay
Fractures	675-676	80°		
Fracture	683	80°		Planar
Faults	688-689	I	Small	
Faults	690-692	85°	Very small, oblique	Planar
Fracture	692	30°		Planar
Fracture	695	35°		Planar
Faults	709-714	I		Broken
Faults	718-719	75°-80°		Breccia
Fractures	720-723	75°-85°		Planar
Fracture	729	40°		Planar
Fracture	731.5	50°		Planar
Faults	796-797.5	I		Stratigraphic mismatch
Fault	806	I	Small	
				Broken

UE-25 a#1
(Concluded)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Fault	810	I	Small	Broken
Fault	902-904			Broken, clay, breccia
Faults	936-940	I		Broken
Fault	967.5-970	85°-90°	Horizontal	
Fault	981-990	I		Broken, breccia
Fault	1072.5-1076	I		Broken
Fault	1118-1123	I		Broken, clay, breccia
Fault	1125.5-1126.5	I		
Fault	1155	I		Minor breccia
Faults	1155-1155.5	I		Broken
Faults	1164-1168	I		Broken
Fault	1209	70°	Small	
Faults	1209-1227	I		Clay, breccia
Faults	1238-1239	I		Breccia
Fault	1259	20°		Planar
Fault	1260.5	20°		Planar
Fault	1269	I		Broken
Fault	1273-1275	I		Broken
Fault	1280.5-1286	80°-90°	Very small	
Fracture	1293	85°		
Fault	1295-1298	80°		Tight, gouge
Fault	1299	55°		
Fault	1299-1301	I		Breccia, healed
Fault	1301-1304	80°-90°	Small	Tight
Fault	1434-1446	I		Broken, clay
Fault	1495-1503	I		Broken, clay
Fracture	1960-1961	75°		
Fracture	2000-2001.5	65°-80°		
Fracture	2002-2007	60°-90°		
Fracture	2036-2037	75°		Irregular
Fracture	2094	65°		Planar
Fracture	2106	65°		Planar
Fracture	2114.5	50°		Planar
Fracture	2115	50°		Planar
Fracture	2115.5	70°		Planar
Fracture	2142.5-2143	45°		Planar, tight
Fracture	2155	35°		Planar
Fracture	2176	40°		Planar
Fracture	2182-2182.5	75°		Clay-filled
Fracture	2188.5	45°		Planar
Fracture	2211	60°		Planar
Fracture	2211.5-2213	85°		Planar
Fracture	2237.5	85°		Planar
Fracture	2414	65°		Planar
Fault	2427	60°	Small	Dip-slip
Fracture	2437	75°		Irregular
T.D.	2501			

USW G-1
(No core 0 to 292 ft)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Fracture	297	40°		Planar
Fracture	308	65°		Planar
Fractures	324-325	85°		Open
Fractures	362-367	85°		
Fracture	388	70°		Planar
Fault	428	20°		Crushing, clay
Fracture	524	60°		Planar
Fracture	568	85°		Planar
Fractures	590-592	80°		Planar
Fracture	716	75°		Planar
Fractures	723-724	85°		Planar
Fractures	725.5-727	80°-90°		Planar
Fractures	727-727.5	65°		Planar
Fracture	729.5	70°		Planar
Fracture	730	20°		Planar
Fracture	736	70°		Planar
Fractures	743-744	75°-80°		Planar
Fractures	751-756	70°-90°		
Fracture	789.5	85°		
Fractures	803-805.5	75°		Planar
Faults	866-875	70°-90°	Oblique	Broken
Fracture	947	80°		Planar
Faults	1117-1124	I	Small	Clay, broken
Faults	1130-1142	I		Breccia, broken
Faults	1157-1161	I		Broken
Fracture	1228	20°		Planar
Fault	1264.5	30°	Small, dip-slip	
Fault	1266.5	30°	Small, dip-slip	Broken
Fracture	1293	50°		Irregular
Fractures	1293.5-1298	85°		Planar
Fracture	1299	40°		Planar
Faults	1305-1311	85°	Very small, horizontal	
Fault	1318.5	low-angle		Breccia
Fault	1329	50°	Small	
Faults	1333-1335	75°	Dip-slip	
Fractures	1337-1339	85°		Planar
Fractures	1352-1354	85°		Planar
Fractures	1448-1449	80°		Planar
Faults	1583-1585	I	Small	
Fractures	1827	10°-45°		Tight
Fault	2282	75°	Small, oblique	
Faults	2346.5-2347	I	Small	Broken
Fracture	2450	80°		Tight
Fracture	2468	70°		Tight
Fracture	2498	75°		Tight
Fractures	2503-2506	85°		Tight
Fractures	2530-2532	80°		Tight

USW G-1
(Continued)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Fractures	2538-2542	85°		Tight
Fractures	2556-2558	80°		Tight
Fault	2578.5	30°	Very small, dip-slip	Clay
Fracture	2673	10°-20°		Tight
Fault	2778	40°		Gouge
Fractures	2786-2788	50°-85°		Minor openings
Fractures	2789-2791	75°		Planar
Fractures	2796.5-2800	85°		Planar
Fracture	2800	5°-30°		Tight
Fractures	2849-2850.5	75°		Tight, planar
Fractures	2905-2906	70°		Planar
Fractures	2937-2938	90°		Irregular
Fracture	2970	55°		Tight, planar
Fracture	3037	70°-80°		Irregular
Fractures	3045-3048	20°-40°		Tight
Fault	3053	30°		
Fault	3057	25°-40°		Tight
Fault	3063.5	30°	2 cm	Tight
Fault	3127	I		Clay, broken
Fault	3357.5	70°		Clay, broken
Fault	3394	I		Clay, broken
Fault	3522	25°		Gouge 2 cm wide
Fault	3553	65°		Tight
Fracture	3570	60°		
Faults	3586-3587	70°		Tight
Faults	3588-3590	70°-80°		Tight
Faults	3601-3602	75°	Small	
Faults	3604-3607	I	Small, oblique	Irregular
Fault	3619	55°	Small	Clay
Fault	3620	50°	Small	Tight
Faults	3621-3622	I		Cemented
Faults	3624-3625	I		Gouge
Fault	3635	30°	Small	Clay
Faults	3638-3640	75°-90°	Very small, oblique	Irregular
Fault	3648.5	75°	Small	Clay
Fault	3650.5	35°	Small, dip-slip	
Fault	3652	55°	Small	Clay
Fault	3653	65°	Small	Planar
Fault	3663	70°		Irregular
Fracture	3670	30°		Planar
Fault	3676	50°		Tight, clay
Faults	3730	60°		
Fault	3750	45°		
Fault	3764	40°	Small	
Fault	3773.5	30°		
Fault	3787	55°		
Fault	3794	35°		
Faults	3807-3807.5	75°	Horizontal	Irregular
Fault	3811	40°	Small, oblique	

USW G-1
(Concluded)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Faults	3847-3848.5	80°-85°	Horizontal	Irregular
Fractures	3874	30°-70°		Tight
Fault	3877.5	50°	Small, dip-slip	Tight
Fault	3884	65°	Small	
Fracture	3890	25°		Tight
Faults	3908-3910	50°	Small	
Fault	4245	60°	Small	Healed
Fault	4340	45°		Irregular, healed
Faults	4431-4432	75°	Small, oblique	Clay
Faults	4680.5-4686	85°-90°	Horizontal	Tight
Fractures	4867-4876	85°		Minor openings
Fault	4883	60°	Small	Tight
Fault	4927	35°	Small	Tight
Fracture	5002	50°		
Fault	5057	60°	Small, oblique	Clay
Fault	5059	65°	Small	Clay
Fault	5067	60°	Small, horizontal	
Fault	5084	50°	Small, oblique	
Fracture	5086.5	50°		
Fracture	5312.5	75°		
Fault	5313	60°	Small	Tight
Faults	5338-5340	70°	Dip-slip	Irregular, clay, broken
Fracture	5344	30°		
Fault	5348.5	80°		
Fracture	5349.5	50°		
Fracture	5368	85°		
Fracture	5429	75°		
Fracture	5466.5	70°		Tight
Fracture	5481	85°		Tight
Fault	5899	20°	Small	
T.D.	6000			

USW G-2
(No core 0 to 290 ft)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fracture	300	10°		
Fracture	305	50°		Planar
Fracture	306	40°		Planar
Fracture	312	85°		Planar
Fracture	314.5	80°		Planar
Fracture	319	75°		Planar
Fracture	324	65°		Planar

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.

USW G-2
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fracture	336-337	80°		Planar
Fracture	560	50°-60°		
Fracture	581	70°		
Fracture	586	80°		
Fracture	619-620	70°-85°		
Fracture	645-647	80°		Open
Fracture	653	70°-80°		
Fracture	658	70°-80°		
Fracture	661	70°-80°		
Fracture	670	90°		
Fracture	672	80°		
Fracture	770	50°		
Fault	789	20°	Very small, oblique	
Fault	790	10°	Very small, oblique	
Fracture	813-818	60°		
Faults	856.5-858	70°		Breccia
Faults	867-870	I	Small	Broken
Faults	913-920.5	85°	0.5 cm	Broken
Fault	920.5	30°	Small	Tight
Faults	923.5-931	75°		Breccia
Faults	939-942	45°	Small	Broken
Faults	977-983	65°-80°		Breccia
Fault	985.5	65°	Small	
Faults	1157-1180	80°		Broken, breccia
Faults	1183-1185	I		Breccia
Faults	1249-1252	70°	Small	Broken
Faults	1264-1265	70°	Oblique	Broken, breccia
Faults	1277-1280	65°-75°	Small	Minor breccia
Faults	1300-1310	65°-90°	Horizontal	Breccia
Faults	1358-1366	65°-90°		Breccia
Faults	1376-1387	70°-80°		Breccia, openings
Fault	1409	I		Breccia
Faults	1419-1422	I		Breccia
Faults	1441-1452	I		Minor breccia
Faults	1461-1468	I		Minor breccia
Faults	1470-1487	I		Minor breccia
Fault	1494	I		Breccia
Faults	1538-1539	70°		Breccia
Faults	1552-1555	75°-90°		Breccia
Fault	1576	70°		Breccia
Faults	1604-1608.5	I		Breccia
Fault	1642	50°		
Fault	1643	45°		
Fault	1645	80°		
Faults	1655-1657	I		Breccia
Faults	1669-1671	30°-60°		Breccia

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.

USW G-2
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	1674	15°-40°	Small, oblique	
Fault	1678.5	50°	Small, oblique	
Fault	1752	80°		Tight
Faults	1752-1768	30°-60°	Small	Tight
Fault	1866	65°	Small, oblique	
Fracture	1870.5	60°		Tight
Fracture	1992.5	70°		Tight
Fractures	2002	55°		
Faults	2004-2007	60°		Clay, breccia
Fault	2009-2010	80°	Small	Tight
Fracture	2016	60°		
Fracture	2065.5	80°		
Fracture	2066.5	80°		
Fracture	2077.5	75°		Tight
Fracture	2084-2085	80°		Tight
Fracture	2089	80°		Tight
Fault	2182	I	Small	
Fracture	2214	70°		
Fault	2271.5	10°	Small	Tight
Fault	2440	65°	Small	Tight
Fault	2496.5	65°	Small	
Fault	2704	55°	Offset of at least 65 ft.[2]	Broken, rubbly
Fracture	2724	60°		Planar, tight
(No core 2787-2795)				
Fracture	2861-2864	85°		Open
Fracture	2873.5-2876	70°		Open
Fracture	2911	60°		Open
Fault	2979-2982.5	80°		Minor gouge
Fracture	3017-3018	60°		Tight
Fault	3045-3048	85°	Small, oblique	
Fault	3049	15°		Tight
Fractures	3050-3062	60°-80°		
Fault	3155-3156	75°	Small	
Fault	3157	15°	Small	Tight
Fault	3168.5	75°	Small	Irregular
Fracture	3249	80°		Tight
Fault	3257.5-3261	80°-90°	Small	
Fault	3263-3269	80°-90°	Small	
Fault	3279-3280.5	70°		Tight
Faults	3286	25°		

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.
[2]From Maldonado and Koether (1983).

USW G-2
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	3288	I		Tight irregular
Fault	3289	70°		Openings
Fault	3290	<50°		Broken
Fault	3293	10°-15°		Tight, minor gouge
Fault	3319	10°		Clay
Fault	3330	65°[2]		Missing strata
Faults	3337.5-3338.5	I		
Fault	3339	60°-65°	Small, oblique	Clay
Fault	3350.5	55°		Tight, clay
Fractures	3387-3392	85°		Tight
Faults	3396-3398	I	Small, oblique	Clay
Faults	3407-3408.5	75°	Small	
Faults and fractures	3440-3444	85°-90°		Tight
Fault	3459	30°	Small, dip-slip	Tight
Fault	3679	65°	Small	Irregular
Faults	3684-3686	I		Broken
Fault	3697	25°	Small	
Fault	3700	I	Oblique	Irregular, broken
Fault	3720	50°	Small	Clay
Fault	3720.5	35°	Small	Clay
Fault	3728	I		Broken
Fault	3735	I		Broken
Fault	3753	I		Broken, clay
Fault	3755.5	50°	Small	Clay
Fault	3762	60°	Small	Clay
Fault	3804	55°	Small, oblique	Clay
Faults	3811.5	50°	Small	Clay
Faults	3815.5	I	Small	Clay
Fault	3851	I		Broken
Fault	3865.5	50°	Small	Clay
Fault	3885	70°	Small	
Fault	3887	60°	Small	Clay
Fault	3896	I		Broken, clay
Fault	3901	25°	Small, dip-slip	
Fault	3902	60°	Small, oblique	
Fault	3905	45°	Small	Clay
Fault	3916	45°	Small	Clay
Fault	3971	I	Small	Clay

(About 9.5 ft of core missing at ± 3980 ft)

Fault	3989	I	Small	Clay
Fault	4000	40°	Small	Tight
Fault	4001	30°	Small, dip-slip	Tight
Fault	4004	35°	Small	Tight
Fault	4007.5	55°	Small, dip-slip	Clay

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.

USW G-2
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	4044	35°	Small	Tight
Fault	4047	40°	Small, horizontal	Tight
Fault	4051.5	55°	Small	Tight
Fault	4061.5	40°	Small	
Fault	4077	45°	Dip-slip	Clay
Fault	4084	45°	Small	
Faults	4086-4091.5	I	Small	
Fault	4103.5	40°	Small	
Fault	4105	40°	Small, dip-slip	
Faults	4107-4115	50°		
Fracture	4117	70°		Tight
Fault	4122	50°-90°	Small, oblique	
Faults	4146-4146.5	50°-60°	Small, oblique	
Faults	4147	40°; 60°	Small, dip-slip	
Fault	4148	55°	Small, dip-slip	
Fault	4149	65°	Small, oblique	
Fault	4152	50°	Small, oblique	
Fault	4153	45°	Small, dip-slip	
Fault	4154	50°	Small, dip-slip	
Fault	4162.5-4163.5	75°	Small	Tight
Fault	4171	60°	Small, dip-slip	
Fault	4183	60°	Small, oblique	Clay
Fault	4196	I	Small	Irregular
Fault	4199	I	Small	Irregular
Fault	4199.5	I		Broken
Fault	4203	40°	Small, oblique	
Fracture	4263.5	65°		Tight
Fault	4264.5	40°	Small	
Fault	4270-4272	80°	Small, horizontal	Tight
Fault	4283	55°	Small	
Fault	4285	65°	Small, oblique	
Fault	4316	60°	Small	
Faults	4317-4320	I	Small	Irregular
Fault	4351	I	Small	
Faults	4354-4356	I		Broken
Fault	4356-4359	75°	Small, horizontal	Clay
Fault	4522.5	I	Small	
Fault	4523.5	55°	Small, horizontal	Clay
Faults	4527-4529	45°-60°	Small	
Fault	4531	55°	Small, oblique	
Fault	4534	65°	Small, oblique	Clay
Fault	4551	55°	Small, oblique	
Fault	4557	I		Irregular
Fracture	4602	55°		Planar
Fault	4618-4619	75°	Small, dip-slip	

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.

USW G-2
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	4672	65°		Clay, gouge
Fault	4703	20°	Small, oblique	
Faults	4709.5-4720	I	(No core, probable fault zone)	
Fault	4729	40°	Small	
Fault	4745	45°		Shears
Fault	4770	I	Small	Irregular
Fracture	4806	55°		Tight, planar
Fault	4811	45°	Small	Tight
Fault	4813	60°	Small	Tight
Faults	4816-4818	45°		Breccia
Fault	4820	45°	Small	
Fault	4831.5	55°	Small	Irregular
Fault	4833	45°	Small	Irregular
Faults	4848-4850	I	Small	Broken
Fault	4851.5	55°	Small	
Fault	4868	50°	Small	
Fault	4869-4870	70°	Small, oblique	
Faults	4873-4874	I		
Faults	4876-4877	I		
Fault	4879	45°	Small, oblique	
Faults	4882-4893	I		Broken
Fault	4895	I		Irregular
Fault	4896.5	55°	Oblique	Breccia, clay
Fault	4907.5	45°	Small, dip-slip	Tight
Fault	4909	I		Broken
Faults	4910-4921	I		Irregular
Faults	4926-4927	I		Broken
Faults	4929-4932	I		Broken
Faults	4938-4944	I		Broken
Faults	4947-4950	I		Broken
Fault	4955	40°		Tight
Fault	5019	I		Clay, low angle
Faults	5029-5030	I		Breccia, clay, broken
Faults	5064-5068	I		Broken
Faults	5082-5084	I		Broken
Faults	5094-5096	I		Broken
Faults	5100-5102	I		Broken
Fracture	5116	70°		Tight
Fault	5170	I	Small	Irregular
Faults	5174-5206	I	Major	Breccia, broken
Fault	5208-5809	60°-85°	Small, horizontal	Irregular
Faults	5223-5224	65°		Breccia
Fault	5263-5264.5	80°	Small, horizontal	Tight
Fault	5269	55°	Small, oblique	Tight
Fault	5295	55°-75°	Small	Tight
Fault	5319	65°	Small	Tight

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.

USW G-2
(Concluded)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	5367.5	65°	Small, horizontal	Tight
Fault	5372.5	60°	Small, oblique	Tight
Fractures	5418	65°		
Fault	5514.5	65°	Small	Tight
Fault	5563.5	35°	Small	Tight
Faults	5597	20°; 40°	Small	Tight
Fault	5624	55°	Small	Tight
Fault	5637	40°		
Fault	5672	50°	Small	Tight
Fault	5698	65°	Small, oblique	Tight
Fractures	5757	65°		
Fractures	5765-5780	30°-75°		Tight
Fault	5780	65°	Small, oblique	Tight
Fault	5809	45°		
Fault	5833	70°		
Fault	5841	70°	Oblique	
Fault	5845	55°	Horizontal	
Fault	5846.5	25°	Oblique	
Fault	5849.5	55°	Oblique	
Fault	5853.5	20°	Oblique	
Fault	5854	10°	Dip-slip	
Fault	5855	60°	Oblique	
Fault	5870	70°		
Fault	5898	70°		
Fault	5906.5	60°	Oblique	
Faults	5912.5-5914	I		Broken
Faults	5919-5920.5	I		Broken
Fault	5923.5	80°	Small	
Fault	5930.5	I	Small	Broken
Fault	5936	65°		
Fault	5985.5	50°	Oblique	
T.D.	6006			

[1]Dips corrected -5° below 4,200 ft to compensate for drill-hole deviation.
[2]From Maldonado and Koether (1983).

USW GU-3 and G-3
(No core 0 to 31 ft)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	139	55°	Small	Breccia
Fracture	149	75°		Filled

[1]Dips are corrected as follows for westerly drill-hole deviation (Scott and Castellanos, 1984), assuming all structures also dip westward: 0 to 820 ft: 0°; 820 to 2460 ft: -5°; 2460 to 3280 ft: -10°; 3280 to 4100 ft: -15°; 4100 to 5031 ft: -20°.

USW GU-3 and G-3
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fracture	153-155	80°		Smooth, tight
Fractures	207	70°-80°		Planar
Fault	344	75°	Very small	
Fault	370	65°	Very small, dip-slip	
Fault	481.5	75°		Breccia, filled
Fault	637	70°		Breccia
Fracture	689	80°		Planar
Fracture	695-697	80°		Planar
Fracture	775-779	85°		Planar
Fracture	1107	20°		Planar
Fracture	1138	45°		Planar
Fracture	1154	30°		Planar
Fault	1173.5	55°		Breccia, filled
Fault	1180	35°		Broken, clayey
Fractures	1685-1690	70°		Open
Fracture	1742	65°		Clay-coated
Fault	1835	60°	Very small	Tight, silicified
Fault	2007	55°	Small	Clay-coated
Fault	2013	55°	Small	Clay-coated
Fault	2067.5	75°		Broken
Fault	2078-2086	I		Broken
Fault	2100.5	65°	Very small	Tight, clay-coated
Fault	2111	45°	Very small, oblique	
Fault	2138.5	15°	Very small, horizontal	Tight, clay-coated
Fault	2145	65°	Very small, oblique	Tight, clay coated
Fracture	2211	75°		
Fault	2217	70°	Small	Tight
Fault	2222-2224	I		Broken, clayey
Fault	2225.5	High-angle	Horizontal	Irregular, clay
Fault	2239-2240	55°		Broken
Fault	2243	35°	Very small, oblique	
Fault	2246.5	60°	Very small, oblique	
Fracture	2255	45°		
Fracture	2283.5-2285	55°-70°		
Fault	2293	70°	Very small, oblique and horizontal	
Fault	2319	75°	Very small, oblique	
Fault	2333	I		Minor breccia
Fault	2334	70°	Very small	
Fault	2340.5	I		Broken, minor breccia

[1]Dips are corrected as follows for westerly drill-hole deviation (Scott and Castellanos, 1984), assuming all structures also dip westward: 0 to 820 ft: 0°; 820 to 2460 ft: -5°; 2460 to 3280 ft: -10°; 3280 to 4100 ft: -15°; 4100 to 5031 ft: -20°.

USW GU-3 and G-3
(Continued)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	2341.5-2343	60°-75°	Small	Tight
Fault	2382.5-2388	High-angle	Very small, horizontal	
Fracture	2470	20°		Planar
Fault	2542	45°-55°	Very small	
Fault	2555	65°	Small	Tight
Fault	2559	65°	0.5 cm	
Fault	2587	65°		Broken
Fault	2595	60°	Very small	
Fault	2606	65°	Very small, dip-slip	
Fault	2606.5	50°	Very small, dip-slip	
Fracture	2635	70°		Clay-coated
Fault	2653	50°	Small	
Fracture	2727	40°		Tight
Fault	2764-2768	75°	0.5 cm	Minor openings
Fault	2816	55°	Small, dip-slip	
Fault	2826	65°		Tight, minor breccia
Fault	2830	20°		Minor crushing
Fracture	2843	70°		Irregular
Fault	2847	70°	0.5 cm	
Fault	2876-2885	I		Fault zone, broken, clayey
Fractures	2897-2912	75°		Clay-coated
Fault	2931.5	65°		
Fault	2947	40°	Small	
Fracture	2981.5	60°		
Fracture	3002.5-3005	75°	Oblique, pull-apart	
Fault	3009-3012	75°	Small	
Fracture	3077-3080	75°		Calcite-filled
Fracture	3082-3084	75°		Calcite-filled
Fracture	3107	60°		Tight, planar
Fault	3290-3292	65°	3/8 in.	Tight
Fault	3363-3365	60°	Small	Broken
Fault	3366-3368	65°	Small	Broken
Fault	3770	55°	Small	
Fault	3891	50°	Small	Broken
Fault	4013	I		Clayey
Fault	4040	55°	Small, dip-slip	Tight
Fault	4052-4053	I		Broken, clayey
Fault	4115	55°	Small	Broken, clayey
Fault	4297.5	40°		Broken, clayey zone as much as 5 cm wide
Fault	4334	I	Small	Broken

[1]Dips are corrected as follows for westerly drill-hole deviation (Scott and Castellanos, 1984), assuming all structures also dip westward: 0 to 820 ft: 0°; 820 to 2460 ft: -5°; 2460 to 3280 ft: -10°; 3280 to 4100 ft: -15°; 4100 to 5031 ft: -20°.

USW GU-3 and G-3
(Concluded)

Structure	Depth (ft)	Dip[1]	Displacement	Characteristics
Fault	4339	50°	Small	
Fault	4353	55°	Small	Clay coating
Fault	4354	I	Small	Clay coating
Fault	4379	I		Broken, clayey
Fracture	4399	50°		
Fault	4455	45°	Small	Tight
Fault	4470-4472	35°-40°	Dip-slip	Clay, breccia
Fault	4476	50°	Small	Broken
Fault	4480	10°	Small	Tight
Fracture	4487	20°		Tight
Faults	4500-4504	65°-70°		Tight, filled
Faults	4514-4515	55°		Tight, filled
Fault	4540	55°	3/16 in.	Tight
Fault	4559	35°	Small, oblique	Clay-coated
Fault	4591	45°	Small, oblique	
Faults	4599.5-4600.5	45°	Dip-slip	15 cm wide, broken, silicified
Fault	4619.5	10°		0.5 cm wide, tight, silicified
Fracture	4649-4650	40°-45°		Tight
Fault	4652	45°	Small	Tight
Fractures	4658	20°		Tight
Fault	4671.5	30°	Dip-slip	Tight
Fault	4778	25°	Small, oblique	Clay and chlorite
Fault	4803	30°	Small	
Fractures	4813	40°		Tight
Fault	4818	40°	Small	Calcite-filled
Fault	4845.5	10°	Small, oblique	
Fault	4943	20°	Small	Clay-coated
T. D.	5031			

[1]Dips are corrected as follows for westerly drill-hole deviation (Scott and Castellanos, 1984), assuming all structures also dip westward: 0 to 820 ft: 0°; 820 to 2460 ft: -5°; 2460 to 3280 ft: -10°; 3280 to 4100 ft: -15°; 4100 to 5031 ft: -20°.

USW G-4
(No core 0 to 41 ft)

Structure	Depth (ft)	Dip	Displacement	Characteristics
Fractures	64.5-65.5	80°		
Fault	125	30°		Slickensides
Fault	197	55°		Broken
Fault	202	75°		

USW G-4
Continued

Structure	Depth (ft)	Dip	Displacement	Characteristics
Fault	275.5	45°	Very small	
Fractures	1182-1182.5	70°		Planar
Fracture	1205.5	80°		Planar
Fault	1315	I		Clay
Faults	1318-1320	85°	More than 2.0 ft	Clay
Fractures	1341-1346	85°-90°		Planar
Fractures	1346.5-1353.5	85°-90°		Planar
Fault	1406-1407	70°		Breccia
Faults	1557-1557.5	75°		Planar
Faults	1670.5-1671	70°	Small, oblique	
Faults	1895-1896	70°-90°	Small, horizontal	Irregular
Faults	1921-1925	I		
Fault	1947	40°	Very small, oblique	
Fault	1956.5	50°	Small, horizontal	
Fault	1991.5	70°-80°	Oblique	Breccia, gouge
Fracture	2066	40°		
Faults	2244-2247	75°		
Fractures	2342-2346	85°		
Faults	2438-2442.5	85°-90°	Very small, oblique	
Fractures	2438.5-2446.5	85°		
Fracture	2563-2571.5	85°		
Fault	2813	70°	Small, dip-slip	
Fault	2886	40°	Small, dip-slip	
Faults	2919-2923	80°-90°	Very small, horizontal	
T.D.	3001			

APPENDIX B

SECONDARY CALCITE OCCURRENCES IN CORE
FROM FIVE DRILL HOLES AT YUCCA MOUNTAIN
(see text for discussion of observations)

Depth (ft)	UE-25 a#1 (No core 0 to 54 ft)
54-200	Some high-angle and many low-angle fractures with calcite coatings
270-271	Calcite and opal fracture coatings
347	Calcite on fractures
361	Calcite on fractures
401.5	Calcite on fractures
641	Calcite in cavities
647.5	Calcite in cavities
678	Calcite on fracture
683.5	Calcite on low-angle fracture
692	Calcite on low-angle fracture
697.5	Calcite on fracture
715.5	Calcite on fracture
718-719	2 cm wide breccia with calcite
731.5	Planar fracture with calcite
735.5	Calcite in cavity
737	Calcite on fracture
745.5	Calcite on fracture
781	Calcite in cavity
797	Calcite in cavity
801	Calcite in cavity
830	Calcite in cavity
844.5	Calcite in cavity
846	Calcite in cavity
901	Calcite and/or fluorite in cavities
907	Calcite in cavity
924.5-925	Calcite in cavities
927	Calcite in cavity
939	Calcite in cavity
1074	Calcite in cavities
1080.5	Calcite in cavity
1105	Calcite in cavity
1135	Calcite on fracture
1172.5	Calcite on fracture
1181	Calcite on fracture

Only minor calcite below this point.

Depth (ft)	USW G-1 (No core 0-292 ft)
315-322	Calcite coatings on fractures
425.5	Calcite in cavity
439	Calcite in lithophysae
491.5	Calcite on irregular fracture
568	Very thin (<1mm) carbonate coating on fracture
579	Calcite crystals in cavity
619	Calcite in cavity
668.5	Calcite in lithophysae
681.5	Calcite in lithophysae
695.5	Calcite in lithophysae
725.5	Calcite coating on planar fracture
960.5	Calcite in cavity
1017	Calcite in cavity
1025.5	Calcite in cavity
1029	Calcite in cavity
1113	Calcite in cavity
1161	Calcite in low-angle fracture
1199	Calcite in cavity
1228.5	Calcite in cavity
1265.5	Calcite in fracture
1280-1285	Calcite on low-angle fractures
Thick interval with little or no calcite.	
3586-3587	Calcite in irregular fractures
3588-3590	Calcite sealing fault zone
3596.5	Calcite filling irregular fracture
3638-3640	Calcite coating on irregular fault
3641.5	Calcite in irregular fracture
3642	Calcite in irregular fracture
3648.5	Calcite in small fault
3676	Calcite in tight fault
3822-3825	Calcite in irregular fracture
3868-3870	Calcite between clasts in tightly healed breccia
3896	Calcite between clasts in breccia
4680.5-4686	Calcite filling tight fault
5086.5	Calcite coating on fracture
5368	Calcite-filled fracture

USW G-2
(No core 0 to 290 ft)

Depth (ft)	Occurrence
300	Minor calcite in fracture
314.5	Thin calcite coating on planar fracture
586	Calcite coating on irregular fractures
619-620	Calcite coating on irregular fractures
630-639	Calcite coating on irregular fractures

USW G-2
(Continued

Depth (ft)	Occurrence
645-647	Calcite in open fracture
670	Thin calcite coating on tight fracture
672	Thin calcite coating on irregular fracture
762-763.5	Thin calcite coating on fracture
774-775	Calcite filling anastomosing fractures
787.5	Calcite and opal coating on irregular fracture
789	Calcite in very small fault
790	Calcite in very small fault
791-793	Calcite coatings on irregular fractures
809-811	Calcite in irregular fractures
813-818	Calcite in irregular fractures
846	Calcite and silica minerals in irregular fracture
847.5-849	Calcite and silica minerals in irregular fracture
853	Calcite and silica minerals in irregular fracture
921-930	Calcite in numerous cavities
985.5	Minor calcite and quartz in tight fault
985-1006	Calcite in lithophysae and other cavities
1065	Calcite and quartz in cavities
1137	Calcite in cavities
1170	Calcite in cavity
1183-1185	Calcite in cavities
1248	Calcite in cavities
1338-1353	Thin calcite(?) coatings on anastomosing fractures
1398-1403	Calcite filling in fractures
1426-1428	Calcite filling in fractures
1434	Coarse calcite in 2 in. diameter cavity
1585	Calcite-coated fractures
1642	Calcite coating on fault
1643-1645	Calcite coating on fault
1674	Calcite coating on fault
Thick interval with little or no calcite	
4107-4115	Calcite-coated fractures and small faults
4117	Calcite in tight fracture
4122	Calcite-coated small fault
4143.5	Minor calcite in irregular fracture
4908	Calcite-filled fracture
4910-4918	Calcite veins in fractures and small faults
5019	Calcite in vugs
5107	Calcite in vug about 2 in. diameter
5116	Calcite in tight fracture
5308-5318	Calcite in vugs and fractures
5327-5330.5	Calcite in vugs and fractures
5418	Thin calcite coatings on fractures
5432-5433	Calcite filling tight anastomosing fractures
5438-5440	Calcite filling tight anastomosing fractures
5460-5462	Calcite filling tight anastomosing fractures
5473-5475	Calcite in vugs and fractures

USW G-2
(Concluded)

Depth (ft)	Occurrence
5631-5637	Calcite filling openings and irregular tight fractures
5682-5686	Calcite filling irregular fractures
5696	Calcite filling irregular fractures
5747-5750	Calcite filling voids and fractures
5757	Calcite filling voids and fractures
5765-5780	Calcite filling tight fractures
5864-5865	Calcite in large voids
5879-5885	Calcite in fractures and voids

USW GU-3
(No core 0 to 31 ft)

37-52	Calcite-coated lithophysae
57	Calcite in cavity and fractures
139	Thin calcite coating on fault
165	Calcite in lithophysal cavity
182.5-207	Thin calcite coatings on irregular fractures
223-237.5	Minor calcite on fractures
240-241	Calcite on fracture and in cavity
248	Calcite coatings on cavities
260-263	Calcite in broken zone
268	Calcite in lithophysae and coating fractures

Note: Nearly every opening in the Tiva Canyon Member above this depth has a little calcite.

448-449	Minor calcite in broken zone
470-472	Minor calcite in broken zone
479.5	Calcite in irregular fracture
499	Calcite-coated fracture
521	Calcite in cavities
545.5	Calcite in cavities
548.5	Calcite in cavities
562	Calcite in cavities
636	Calcite in lithophysal cavity
1121	Calcite in irregular opening
1709.5	Calcite-coated openings
2206.5	Calcite(?) in lithophysae
2465	Thin calcite coatings on two low-angle fractures

USW G-3
(Concluded)

Depth (ft)	Occurrence
2931	Calcite-coated small fault
2931.5-2939.5	Calcite-coated irregular fractures
2947	Calcite coating void along small fault
2955-2957	Calcite-coated irregular fracture
2962-2966	Calcite-coated irregular fracture
2980.5	Calcite in fracture
2981.5	Calcite in fracture
2997	Calcite-coated fracture
3009-3012	Calcite-coated small fault and opening with 3/8 in. calcite
3022	Calcite-coated fracture
3025-3030	Calcite-coated fracture with voids up to 3/16 in. partly filled with calcite
3077-3080	Calcite-filled fracture
3082-3084	Calcite-filled fracture
3107	Minor calcite in fracture
3236-3241	Minor calcite in partially open irregular fractures
3244.5-3251	Minor calcite in partially open irregular fractures
3290-3292	Minor calcite coating small fault
4316-4318	Calcite-filled tight fracture
4331.5	Calcite-filled irregular fracture
4347	Calcite-filled fractures
4365-4370	Calcite-filled fractures
4403-4405	Calcite-filled fractures
4406-4408	Calcite-filled fractures as much as 3/8 in. wide
4416-4416.5	Calcite-filled fractures as much as 3/8 in. wide
4420.5	Calcite in tight irregular fracture
4540	Minor calcite in small tight fault
4619.5	Minor calcite in fault
4729-4732.5	Calcite in tight fracture
4778	Minor calcite in small fault
4818	Calcite-filled small fault
4989	Irregular thin calcite vein
5019.5	Irregular thin calcite vein

USW G-4
(No core 0 to 41 ft)

Depth (ft)	Occurrence
746	Calcite on fracture
871	1/8 in.-thick calcite on fracture

APPENDIX C

INFORMATION FROM THE REFERENCE INFORMATION BASE USED IN THIS REPORT

This report contains no information from the Reference Information Base.

Candidate Information for the Reference Information Base

This report contains no candidate information for the Reference Information Base.

Candidate Information for the Site & Engineering Properties Data Base

This report contains no candidate information for the Site and Engineering Properties Data Base.

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