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SUBSURFACE MINERAL RESOURCE ANALYSIS, YUCCA MOUNTAIN, NEVADA, PRELIMINARY REPORT 1: LITHOLOGIC LOGS

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This information should be considered preliminary.
It has not been edited or checked for completeness
or accuracy.

INTRODUCTION

Miocene ash-flow tuff at Yucca Mountain, Nye County, Nevada, is a proposed site for a permanent repository for high-level nuclear waste. Because such waste may constitute an environmental threat for 10, 000 years or more, the long-term potential for human intrusion by drilling or mining must be considered during the evaluation of a repository site. Yucca Mountain is in the southwestern Nevada volcanic field, a large area of Miocene volcanism that contains several areas of precious-metal mineralization, including deposits with current production (Castor and Weiss, in press). Accordingly, personnel of the Nevada Bureau of Mines and Geology (NBMG) are involved in an evaluation of the potential for economic mineral deposits at Yucca Mountain.

Lithologic logs and petrographic studies of core and cuttings from Yucca Mountain have resulted in the identification of features indicative of hydrothermal activity that may or may not have produced economic mineralization in the immediate vicinity of the proposed repository site. Silicification and propylitization (chlorite + albite + carbonate + illite alteration) were reported for some drilled intervals (e.g., Caporuscio et al., 1982; Maldonado and Koether, 1983). Such alteration is commonly present in areas that contain volcanic-hosted epithermal precious-metal deposits (Bonham, 1988). Paleotemperatures of 200-300° C were estimated to have been attained during such alteration at depths greater than 5000 ft (ca. 1500 m) at Yucca Mountain on the basis of clay mineral species and fluid inclusion data (Bish, 1989). Fluid inclusion studies have shown that this temperature range includes the temperatures of fluids responsible for the deposition of epithermal precious-metal deposits (Roedder, 1984). Vein mineral assemblages that include quartz, carbonate, fluorite, and barite were reported in drill core from Yucca Mountain (e.g., Caporuscio et al., 1982; Scott and Castellanos, 1984). Similar vein assemblages are commonly present in epithermal precious-metal deposits (Bonham, 1988). In addition, disseminated pyrite was identified in core and cuttings from several drill holes in Yucca Mountain (e.g., Spengler et al., 1981; Caporuscio et al., 1982; Maldonado and Koether, 1983; Scott and Castellanos, 1984; M. D. Carr et al, 1986). The alteration and vein mineral assemblages, in conjunction with the presence of pyrite, have led to speculation that Yucca Mountain has potential for metallic mineral resources (Caporuscio et al., 1982).

Evaluation of the mineral potential at Yucca Mountain on the basis of geochemistry has mainly been confined to surface study of the Yucca Mountain Addition, an area that includes approximately the southern third of the proposed repository site (Fig. 1) and resulted in a finding of low mineral potential (Castor et al., 1990). However, Larson et al. (1989) reported elevated mercury, lead, zinc, and antimony contents in rocks from Trench 14 east of the proposed repository site (Fig. 1). Available subsurface geochemical data (e.g., Broxton et al., 1986) are, for the most part, not specifically applicable to mineral evaluation because they consist mainly of elemental analyses used in petrogenetic studies (e.g., major elements, rare earth elements) or have detection limits that are too high for metals exploration (e.g., gold and antimony detection limits at 0.12 and 1.5 ppm, respectively).

In 1991, the NBMG began a study funded by the U. S. Department of Energy through Science Applications International Corp. (SAIC) to examine core and cuttings from Yucca Mountain drill holes for evidence of hydrothermal activity and mineralization. Core and cuttings from 6 drill holes (Table 1, Fig. 1) were logged with emphasis on the description of alteration and mineralization (Appendix A-F). This report presents the results of the logging and preliminary petrographic work. Future study, including detailed petrographic and trace element analyses, is planned for drill samples requested from the Yucca Mountain Project Sample Management Facility.

In the following text, drill hole numbers have been shortened in the interest of brevity. The USW prefix has been dropped from holes USW G-1, USW G-2, USW G-3, and USW GU-3; and drill holes UE 25b 1H and UE 25p 1 are referred to as 25b and 25p, respectively. However, complete hole numbers are retained in all figures and tables.

METHODS

The results presented below are based mainly on visual lithologic logging of core and cuttings aided by hand lens and binocular microscope examinations (Appendix A-F). Thin section examinations and X-ray diffraction scans were used to provide mineral assemblage data on a few samples.

RESULTS

Our examination of core and cuttings from Yucca Mountain drill holes confirmed the presence of some of the alteration types, vein filling minerals, and sulfide occurrences previously reported. However, most of the sulfide was found to occur in ejecta in ash-flow and bedded tuff comprising the same stratigraphic sequence in three drill holes.

Figure 1. Location of drill holes and other features in the Yucca Mountain area. Caldera complex margins from W. J. Carr et al. (1986). Drill hole locations are from maps in the U. S. Department of Energy Nevada Nuclear Waste Storage Investigations Atlas of Field Activities, Holmes & Narver, Inc., Las Vegas, NV.

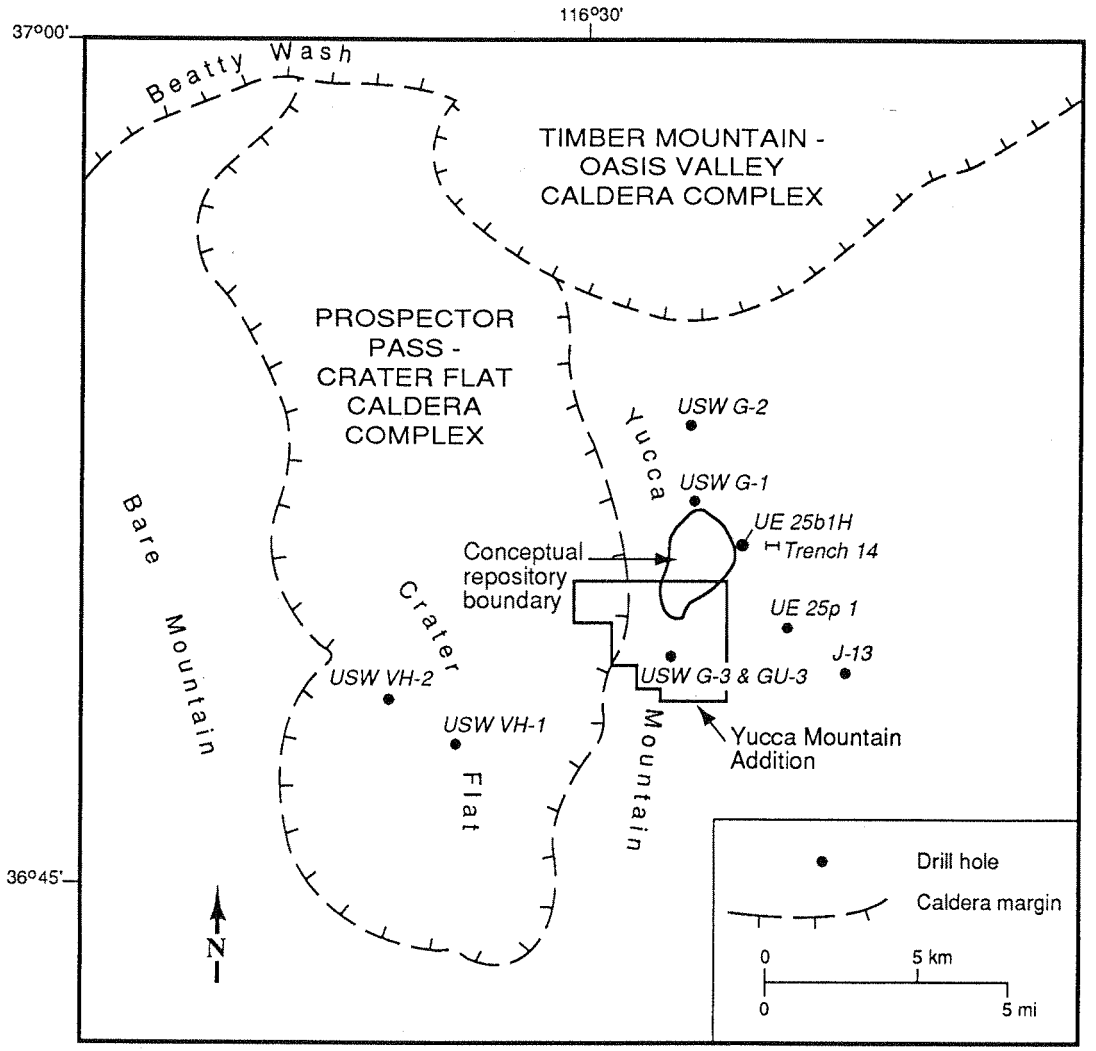


TABLE 1. Logging performed

DRILL HOLE	INTERVAL LOGGED, ft (m)	MATERIAL EXAMINED
USW G-1	3096-3607 (944-1099)	core
USW G-2	2704-6006 (824-1831)	core
USW GU-3	31-2644 (9-806)	core
USW G-3	2624-5031 (800-1534)	core
UE 25b 1H	2800-4002 (854-1220)	core
UE 25p 1*	4050-4180 (1235-1274)	cuttings
	5500-5610 (1677-1710)	cuttings

* In addition, a log was prepared for drill hole UE 25p 1 between 2860-4000 ft (884-1220 m) from examination of cuttings at 50-ft (ca. 15-m) intervals.

Alteration

Alteration of volcanic rocks intersected by the drill holes that we logged appears mostly to be of two types, both of which resulted from processes unrelated to ore-forming activity: devitrification and vapor-phase alteration during or shortly after deposition; and zeolite + expansive smectite alteration resulting from interaction with ground-water that was augmented in the deeper parts of the drilled rock mass by burial-induced temperature increases. However, examples of alteration types such as propylitization, which may indicate potential for economic metallization, were noted in core from the deeper portions of holes G-1, G-2, and 25b.

Identification of the various clay minerals present is beyond the scope of this report; however expansive clay (here clay that swells significantly following the addition of distilled water) was differentiated from nonexpansive clay during our core logging. For the clay mineralogy of holes G-1, G-2, and G-3 the reader is referred to Bish (1989).

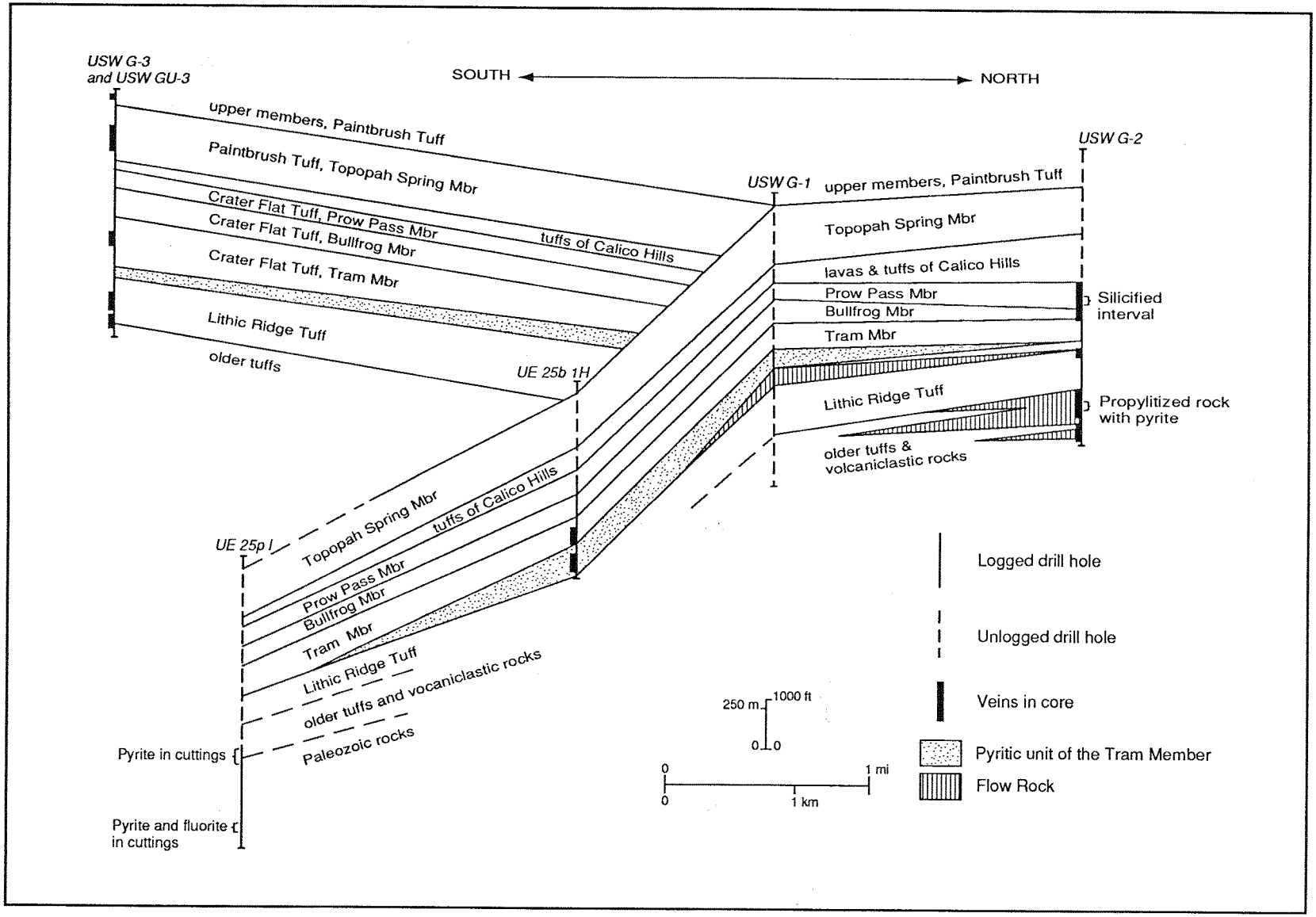
An interval of siliceous alteration was identified in core from hole G-2 between 3061 and 3132 ft (933-955 m). The upper part of this interval is almost completely altered to hard, brittle rock, but the lower part is only moderately or weakly altered. The silicified interval is in the basal part of the Prow Pass Member of the Crater Flat Tuff (Fig. 2), and lies within a 900-ft-thick (275 m) interval that contains chalcedony veins.

Propylitic alteration occurs in flow rock and ash-flow tuff from below 5200 ft (1585 m) in hole G-2. Chlorite, albite, illite, and carbonate occur in rock with variably altered feldspar and mafic phenocrysts and locally abundant carbonate ± quartz veins. Strongly propylitized dacite flow rock from 5205-5277 ft (1586-1608 m) also contains minor amounts of sulfide (Fig. 2). Chlorite was also found in core from below 3500 ft and 3850 ft (ca. 1070 m and 1175 m) in holes 25b and G-1, respectively, but was not identified in core from hole G-3.

Vein Mineral Assemblages

Quartz ± calcite occurs in veins and veinlets in volcanic rock in the five core holes that we logged. The quartz ranges texturally from chalcedony to fine comb quartz, and drusy veins with quartz crystals more than 1 cm long are present in core from depths greater than 5000 ft (ca. 1500 m) in hole G-2. Drusy quartz chips are associated with pyrite and limestone fragments in cuttings from below 3950 ft (ca. 1200 m) in hole 25p.

Figure 2. Fence diagram showing geologic units, pyritic ash-flow tuff, and vein intervals in drill holes USW G-1, USW G-2, USW GU-3/USW G-3, UE 25b 1H, and UE 25p 1, Yucca Mountain.



Fluorite was identified in core from four holes, and in cuttings from hole 25p. White or light purple to green fluorite forms fracture coatings or occurs in veins in volcanic rock from holes G-2, GU-3, G-3, and 25b. It was not noted in the short segment of hole G-1 that we logged. In hole GU-3, finely crystalline, crustiform fluorite was found coating fractures in core from relatively shallow depths of 1043 to 1211 ft (318-369 m). It is present in core from greater depths in hole G-2 (5296 ft or 1614 m) where it is more coarsely crystalline and occurs in a quartz + carbonate veins. In cuttings that include Paleozoic carbonate chips from below 3950 ft (1204 m) in hole 25p, fluorite is present in a different form from that in volcanic rock from the other holes: here it occurs as clear to gray cubes up to 2 mm in diameter, in some cases dusted by fine sulfide.

Other minerals identified in veins or on fractures were tridymite, analcite, dolomite, barite, kutnohorite ($CaMn\{CO_3\}_2$), opal, clay, ilmenite, limonite, hematite, and manganese oxide. In addition to the barite occurrence in a vein from 5696 ft (1736 m) in hole G-2 reported by Caporuscio et al. (1982), we found barite in veins from 5636 ft (1718 m) in hole G-2 and from 3938 ft (1200 m) in hole 25b.

Sulfide

Pyrite was identified in core or cuttings from five of the six holes that we logged. We found it to be relatively abundant in parts of holes G-1, G-3, 25b, and 25p (Fig. 2).

As much as 2.8% pyrite is present in lithic-rich ash-flow tuff in the basal part of the Tram Member of the Crater Flat Tuff in core from holes G-1, G-3 and 25b. The top of this pyritic tuff is at depths of 984, 1122, and 1024 m in these holes, respectively. Lesser amounts of pyrite are present in bedded tuff beneath the Tram Member in holes G-3 and 25b, but pyrite is lacking in bedded tuff from the same stratigraphic position in hole G-1. The basal part of the Lithic Ridge Tuff from hole G-3 also contains minor amounts of pyrite.

Pyrite is mostly present in accidental lithic fragments in Tram Member ash-flow tuff (as originally noted by Spengler et al., 1981, in a log of hole G-1), but it also occurs as small grains in the tuff matrix. Pyrite is not present in pumice fragments or in quartz-carbonate veins that cut the ash-flow tuff. In general, the pyrite shows little or no evidence of oxidation, although a few limonite-rimmed pyrite grains occur in the tuff matrix and limonitic haloes are present around pyritic lithic fragments in some intervals. In core from 3723 to 3734 ft (1135-1138 m) in hole G-3, pyritic lithic fragments have white rinds from which the sulfide appears to have been leached.

Most of the pyritic lithic fragments are of mafic to intermediate volcanic or subvolcanic rocks that are unaltered to variably altered. Pilotaxitic texture is common in these lithic fragments, which contain calcic plagioclase + biotite ± amphibole ± pyroxene phenocrysts. Quartz and potash feldspar phenocrysts are lacking, except in rare fragments of pyritized ash-flow tuff. Pyribole is generally altered in pyritic lithic fragments, but biotite is unaltered in some cases. Plagioclase ranges from unaltered bytownite-labradorite to thoroughly argillized pseudomorphs in pyritic fragments. Plagioclase crystals in the matrix, which are mainly oligoclase and andesine, are almost always unaltered. Alteration types identified in the pyritic fragments include silicification, argillization, and propylitization.

The pyrite in the lithic fragments occurs mostly as disseminated grains or grain clusters and in veinlets. In some fragments, it is in or along quartz or magnetite + calcite + chlorite veinlets (Figs. 3A and 3B). Pyrite occurs with chalcedony in some lithic fragments (Fig. 3C). Botryoidal pyrite was found lining chalcedony- and calcite-filled cavities in an apparently unaltered lithic fragment in core from hole G-1. Most of the pyrite is in very fine grains, but masses up to 2 mm in diameter are present. Pyrite grains disseminated in lithic fragments range from irregular anhedra to perfect cubes. Although pyrite is present, generally as anhedral grains, in the tuff matrix (Fig. 3D), pyrite veinlets similar to those in the lithic fragments are not present in the matrix and pyrite veins in the fragments are terminated at contacts with the surrounding tuff (Figs. 3A & 3B).

In many lithic fragments, pyrite partially replaces mafic phenocrysts that are slightly to completely altered. Biotite in the tuff matrix, where it is generally the only mafic mineral, is unaltered and does not contain pyrite. Titanomagnetite is present in lithic fragments and in the matrix of pyritic ash-flow tuff, apparently as primary grains. Although pyrite partially replaces

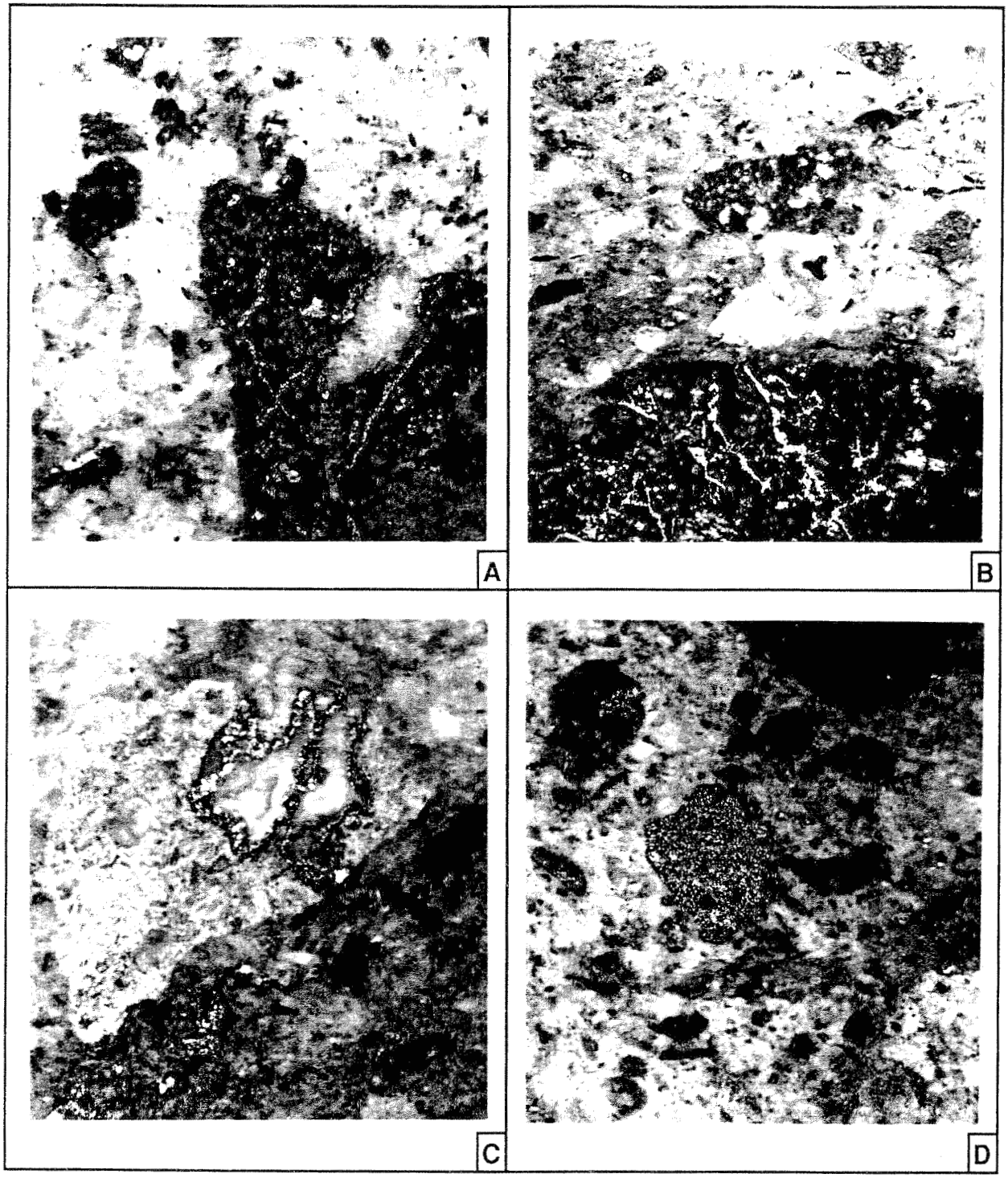


Figure 3. Pyritic ash-flow tuff in the Tram Member of the Crater Flat Tuff in drill core from Yucca Mountain: A) Pyrite and quartz veinlet in lithic fragment, 3457' depth, hole USW G-1, vertical field of view ca. 1 cm. B) Stockwork veins of pyrite in lithic fragment, 3757' depth, hole USW G-3, vertical field of view ca. 14 mm. C) Altered lithic fragment with pyrite and chalcedony filling cavity, 3778' depth, hole UE 25b 1H, clast length ca. 5 mm. D) Pyrite in matrix of ash-flow tuff, 3746' depth, hole UE 25b 1H, pyrite grain ca. 2 mm long.

titanomagnetite in some lithic fragments, most of the fragments that contain titanomagnetite carry little or no pyrite. Hematite-rich lithic fragments that contain pyrite are also present, but the tuff matrix is generally devoid of hematite.

On the basis of point counts performed microscopically under reflected light, pyrite comprises 0.4-2.8% and magnetite <0.1-0.8%, by volume, of the pyritic ash-flow tuff. Pyritic bedded tuff beneath the Tram Member ash-flow tuff generally contains only minor amounts of pyrite, but more than 1% pyrite was found in a 10-cm-thick layer of dark greenish-gray, well-sorted, fine-grained tuff from the bedded tuff unit below the Tram Member in hole 25b.

Lithic fragments comprise 5 to 40% of the basal part of ash-flow tuff in the Tram member in holes G-1, G-3, and 25b (Spengler et al., 1981; Scott and Castellanos, 1984). By our estimate, lithic fragments comprise an average of about 20%, by volume, of this subunit, and at least 50% of the lithic fragments contain pyrite. Therefore, pyrite-bearing fragments comprise at least 10%, by volume, of the basal, pyritic portion of ash-flow tuff in the Tram Member. Pyrite-bearing lithic fragments similar to those in the Tram member, but much less abundant, occur over a 150-ft-thick (45 m) interval near the base of the Lithic Ridge Tuff in hole G-3.

Ash-flow tuff in the Tram Member that contains significant amounts of pyrite is about 539 ft (164 m) thick in hole 25b, 294 ft (90 m) thick in hole G-1, and 197 ft (60 m) thick in hole G-3 (Fig. 2). Pyrite is also present in part of the bedded tuff unit underlying the Tram Member in holes 25b and G-3, generally in lesser amounts than in the overlying ash-flow tuff. During logging, traces of very fine disseminated pyrite were tentatively identified in the basal part of the Tram Member and the underlying bedded tuff from drill hole G-2, but during subsequent microscopic examinations this was found to consist of magnetic metal shavings (undoubtedly drill tool material) that had been forced into cavities and fractures in the core. Pyrite was not reported in cuttings from the interval thought to include the Tram Member in hole 25p (M. D. Carr, et al., 1986); we did not log this interval.

Veins do not cut the pyritic ash-flow tuff of the Tram Member in core from holes G-1 or G-3 (Fig. 2). However, veins are present, cutting both lithic fragments and the ash-flow matrix, in part of the pyritic interval in hole 25b. These veins do not contain pyrite except for trace amounts along their borders or in included pieces of lithic fragment.

Significant sulfide occurrences were found in two other drill holes at Yucca Mountain. Strongly propylitized dacite flow rock from 1586 to 1608 m in hole G-2 contains disseminated and vein pyrite (Fig. 2). Chips of pyrite were found in some cuttings samples from depths of 3950 to 5610 (1204-1710 m) in hole 25p. This pyrite, which is present as finely granular to spongy chips or disseminated in chips of bluish gray altered carbonate, does not resemble that found in cored volcanic rock from the other holes. It is associated with chips of limestone, fluorite cubes, and drusy quartz. In some intervals in hole 25p (e.g., 5530-5540 ft or 1686-1689 m) sulfide chips appear to comprise about 1% of the cuttings.

DISCUSSION

On the basis of our examination of drill core and cuttings, veins and hydrothermal alteration suggestive of mineralization in volcanic rocks at Yucca Mountain are most strongly developed in hole G-2. Silicified, propylitized, and pyritized intervals in this hole may be the result of lateral movement of hydrothermal fluids. A likely source for such fluids would be hydrothermal activity along the margin of the Timber Mountain - Oasis Valley caldera complex about 2 km north of hole G-2 (Fig. 1). In addition, pyrite along with crystalline fluorite and quartz in cuttings from hole 25p indicate potential for mineralization in Paleozoic carbonate at depths greater than 3300 ft (1000 m). The presence of chloritic alteration in core from depths greater than 1000 m in holes G-1 and 25b may be the result of regionally enhanced geothermal gradients rather than specific incursions of hydrothermal fluids related to mineralization.

In the core and cuttings that we logged, sulfide in amounts exceeding 1% by volume is restricted to intervals in the lower part of the Tram Member of the Crater Flat Tuff in holes adjacent to the proposed Yucca Mountain nuclear waste repository site (compare Figs. 1 and 2). We believe that the pyrite in the basal part of the Tram Member was introduced as ejecta, rather than by

in-situ hydrothermal activity. The pyrite veins, chalcedony, silicification, and alteration of plagioclase that are present in lithic fragments but not in the enclosing matrix argue for such an origin. Such pyrite that does occur in the matrix appears to be fragmental and is also interpreted as ejecta.

We consider sulfidization of ferrous minerals following ash-flow deposition to be an untenable alternative in the pyritic ash-flow tuff at Yucca Mountain because titanomagnetite grains in the tuff matrix are not pyritized. In addition, mafic minerals such as biotite, which are partially replaced by pyrite in the lithic fragments, are not pyritized in the tuff matrix. Sulfidization of titanomagnetite and other ferrous minerals has been reported in uranium-gold conglomerates of the Witwatersrand, South Africa (Clemmey, 1981), argillized and sericitized zones adjacent to veins at Butte, Montana (Guilbert and Zeihen, 1964), roll-type uranium deposits in Texas and Wyoming (Reynolds and Goldhaber, 1983), and volcanic-hosted uranium deposits of central Italy (Locardi and Mittemberger, 1971). In these cases, which represent a range of physical and chemical conditions, partial to complete replacement of ferrous minerals seems to be ubiquitous. For example, essentially all titanomagnetite grains in reduced rock at the Benavides uranium deposit, Texas, have been affected by iron disulfide replacement (Reynolds and Goldhaber, 1978).

Exposures of the Tram Member occur in the Beatty Wash and northern Bare Mountain areas (Fig. 1), about 15 km west and northwest, respectively, of hole G-3 on Yucca Mountain (W.J. Carr et al., 1986; Monsen et al., 1990). Neither pyrite nor evidence of oxidized pyrite were identified during our examinations of these exposures. According to W. J. Carr et al. (1986), the Tram Member, as a whole, comprises a northwest-trending wedge with its thickest part extending from the Beatty Wash area on the northwest to drill hole USW G-3 on the southeast, and they speculated that its source was the northern part of the Prospector Pass - Crater Flat caldera complex about 15 km northwest of the proposed repository (Fig. 1). However, evidence supporting this caldera complex is questioned by some workers (e.g. Scott, 1986).

The pyritic ash-flow tuff in the Tram Member under Yucca Mountain is thickest in holes 25b and G-1, thinner in hole G-3 to the south, and does not appear to have been intersected by holes G-2 to the north and 25p to the southeast (Fig. 1). No sulfide was reported in core or cuttings from hole J-13 (Byers and Warren, 1983) 6 km east of hole G-3. Drilling in Crater Flat west of Yucca Mountain (holes USW VH-1 and USW VH-2, Fig. 1) stopped short of penetrating the lower part of the Tram member. It is not possible, using these data, to determine a source direction for the pyritic sequence in the Tram Member on the basis of thickness distributions. The source vent(s) may have been directly under Yucca Mountain or some distance from it. Sparse pyritic ejecta present in the basal part of the Lithic Ridge Tuff in hole G-3 suggest eruption from the same area as the basal part of the Tram Member. According to W. J. Carr et al. (1986), the distribution of the Lithic Ridge Tuff is similar to that of the Tram Member of the Crater Flat Tuff.

We believe that pyritic ejecta in the Crater Flat and Lithic Ridge Tuffs came from a sulfide-bearing hydrothermal deposit that formed prior to their eruption. The presence of chalcedony and the lack of hydrothermal alteration in some pyritic lithic fragments indicate that this deposit was, at least in part, the result of epithermal activity. The metal contents of this deposit are not known, but the apparent lack of sulfides other than pyrite suggest that it was essentially barren of base metals. However, it may have contained precious metals. The sulfide deposit must have been present in the wall or roof of the magma chamber or in the vent area from which the basal part of the Tram Member was expelled.

The eruption that produced the lower part of the Tram member expelled a large amount of pyritic rock. On the basis of intersections in holes G-1, G-3, and 25b, ash-flow tuff with significant pyrite contents has an average thickness of about 100 m over a minimum area of 5 km^2 - a volume of 5×10^8 m^3. If the pyritic tuff contains 10% pyritic lithic fragments by volume, it includes 5×10^7 m^3 or 130 million metric tons of pyrite-bearing rock (at a conservative density of 2.6 t/m^3). This is a minimum tonnage: it does not take into account pulverized ejecta in the matrix of the pyritic ash-flow tuff, pyritic ejecta in the underlying bedded tuff, or extensions of pyritic tuff that lie outside the triangle formed by holes G-1, G-3, and 25b.

Initial dismantling of the sulfide deposit must have begun during early stages of eruption of the Lithic Ridge Tuff, followed by considerably more destruction during eruption of the Tram Member of the Crater Flat Tuff. Several hypotheses can be advanced to account for restriction of pyritic fragments to the lower parts of both ash-flow units. If the rocks of the pyritized hydrothermal system were in the roof of the magma chamber from which both the Lithic Ridge Tuff and Tram Member ash-flows were erupted, fragments that fell into the chamber may only have sunk a short distance before eruption, subsequently being ejected with the earliest ash flows of each unit. However, the absence of juvenile rinds around pyritized lithic fragments suggests that the lithic fragments were not immersed in magma, and the lack of alteration in some pyritic fragments indicates that they were not subjected to magmatic temperatures for significant amounts of time. Eruption of both ash-flow units from a single vent area that included a pyritized system extending from thoroughly altered rock at depth to nearly unaltered near-surface rock seems most likely. Eruption of the lower part of both units from a vent area containing pyritized rock, followed by eruption of the upper part of both units from different non-pyritized vent areas is possible but unlikely. Pyritic ejecta in the upper part of each ash-flow unit could have been oxidized during devitrification and vapor phase activity after deposition, or oxidation may have taken place in the vadose zone following cooling, with pyritic fragments in the lower parts of each unit remaining unoxidized by virtue of location beneath the water table, which probably moved up section following each addition to the volcanic sequence.

Exposed areas of hydrothermal activity in the region around Yucca Mountain are too young to have been incorporated in the Tram Member of the Crater Flat Tuff which is thought to be about 13.5 Ma (W. J. Carr et al., 1986). The oldest known volcanic-hosted hydrothermal activity in the Yucca Mountain region consists of epithermal gold, mercury, and fluorite mineralization hosted by both pre-Tertiary sedimentary rocks and 14 Ma felsic volcanics in the Bare Mountain area about 10 km west of Yucca Mountain, and silver veins in 13.2 Ma or younger intermediate to felsic volcanic rocks at Wahmonie 25 km east of Yucca Mountain. Both areas contain altered volcanic rock with disseminated pyrite (Castor and Weiss, in press). However, hydrothermal minerals in both areas are about 12.9 Ma or younger (Jackson, 1988).

Although abundant pyritic ejecta in the basal part of the Tram Member of the Crater Flat Tuff suggest the presence of mineralizing hydrothermal activity in the Yucca Mountain area, they do not provide evidence for mineral potential within 1000 m of the surface. The pyritic tuff is 600 to 800 m below the proposed repository in the basal part of the Topopah Spring Member of the Paintbrush Tuff (Fig. 2), and the source of included pyritic ejecta must be stratigraphically lower if it underlies Yucca Mountain. Uncertainty as to the source area for this tuff permits mineralization at Yucca Mountain well below the proposed repository level.

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APPENDIX A. USW G-1 LOG

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3096.4-3128.5	943.8-953.6	3120.2-3120.4 ash-flow tuff.	TRAM MEMBER, CRATER FLAT TUFF	Ash-flow tuff, slt. welded, lt. brown to ochre matrix. Abund. lithic frags. (10-90%) to 7 cm., mainly intermed. volc. Mod. abund. quartz, feldspar, and biotite crystals.	White expansive clay after pumice frags., feldspar & biotite appear unaltered.	No veins, thin rims of brown to reddish brown limonite on some lithics and in veinlets cutting lithics. No sulfide.	3097'-3100': No core. 3100.0'-3100.9': lithic frags. to 5 cm 80-90% rock. 3121' & 3125': lithic frags. 50-80% rock. 3127.3'-3128.5': soft and shattered, possible fault.
3128.5-3228	953.6-983.9	3162.7-3163.0 ash-flow tuff, pyrite(?). 3189.9-3190.3: limonite rpl. pyrite(?) in lithic frag. 3217.6-3217.8: pyrite in lithic frags. 3227.3-3227.6 pyrite in lithic frags.		Ash-flow tuff, slt. welded, brown or ochre to purplish-gray or reddish-purple matrix, mod. abund. lithic frags. (20-50%) to 9 cm., mod. abund. biot. xls, sparse qtz & fspar. xlsposs. minor pyribo. Lithics mainly intermed. volc., many altered.	White to lt. tan expansive clay replacing pumice frags., feldspar & biotite look unaltered. Olive-green clay ± zeolite rims some lithic frags.	No veins, rims of brown limonite on some lithics. 3163': trace pyrite(?) in matrix. Possible limonite after pyrite in some lithic frags. Trace pyrite in lithic fragments below 3208'.	3178'-3228': abund. lithic frags. (ca. 20%, 80% in basal 1' of unit) to 5 cm (generally smaller than above 3178'). 3227-3228': soft with a little rubble - possible fault.
3228-3522	983.9-1073.5	3250.0-3250.3: pyrite in lithic frags. 3281.3-3281.6: pyrite in large lithic frag. 3304.9-3305.3: dk. lithic frag. containing pyrite and altered feldspar. 3338.4-3338.7: lithic frag. with pyrite and secondary biotite(?).		Ash-flow tuff, slt. welded to unwelded, lt. pinkish to greenish tan matrix. 5-40% lithic frags. up to 15 cm. Mod. abund. biot and fspar xls., sparse qtz and pyribole phenos. Lithics mainly intermed. volc., many altered. Upper contact gradatational.	Lt. olive green expansive clay after pumice frags. Feldspar, biotite, and pyribole fresh. Lithic frags altered, feldspar-destructive argillic and(or) sericitic, possible secondary biotite.	Pyrite mostly in lithic frags., but also disseminated in matrix. No pyrite in pumice frags. Irreg. veinlets of quartz ± carbonate in lithic fragments, but none in matrix.	3228'-3371': lithic frags. 5-40% of rock.
		3378.4-3378.7: pyrite veins in lithic frag. 3411.6-3412.1 pyrite in white lithic frag. 3456.7-3457.1: pyrite veins in lithic frag.		Below 3371', quartz phenocrysts rare or lacking; lithic frags. generally smaller than in above unit, most <0.5 cm diam.		Limonitic halos in matrix around some sulfide-bearing clasts below 3307'. 3371'-3522': pyrite more abund. than above.	3371'-3522': lithic frags. 20-40% rock.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3228-3522 (cont.)	983.9-1073.5 (cont.)	3476.5-3476.8: pyrite in lithic frags. 3506.7-3507.0 pyrite in lithic frags. 3521.2-3521.5: top of welded airfall & base of ash-flow tuff, silicified(?).	TRAM MEMBER, CRATER FLAT TUFF				Below 3458.5' 20-30% lithic frags. Thin zone along basal contact may be silicified.
3522-3558	1073.5-1084.5	3525.0-3525.2: bedded tuff. 3534.0-3534.3: bedded tuff, green alteration.	BEDDED TUFF	Bedded tuff. Lt. brownish gray to buff, fine- to med.-grained, poorly bedded to massive to 3532'; tan to lt. green, well bedded to 3535'; v. lt. buff, fine grained, massive to poorly bedded to 3552'; med. grained airfall v. lt. greenish tan 3552'-3552.5; fine to med. grained, massive to poorly bedded, v. lt. greenish tan to gray 3552.5'-3558'.	Argillic ± zeolitic. Biotite and feldspar appear unaltered.	No pyrite noted. V. minor disseminated limonite.	Top = 1cm welded air-fall tuff. Possible fault 30 deg/core at 3552.5' separating med. air-fall tuff from underlying fine tuff. Basal contact ca. 40deg/core, not depositional on irreg. surface.
3558-3580	1084.5-1091.2	3564.8-3565.1: tuffaceous breccia.	DACITE BRECCIA	Tuffaceous breccia, rounded clasts of dk. intermed. volcanic rock and pyroclastics in yellowish green tuffaceous matrix. Clasts up to 14 cm. Small, sparse pumice frags.	Olive green expansive clay after pumice frags. Otherwise appears unaltered.	No veins or sulfide.	
3580-3606.8	1091.2-1099.4	3604.6-3605.0: quartz + carbonate vein in breccia.		Breccia, intermed volcanic frags. in matrix of flow rock and comminuted rock. In part flow breccia, in part phreatic breccia. Color olive green to dk. purplish gray. Frags. angular-rounded, to 20 cm diam.	Minor non-expansive clay (?).	3577'-3606.8': irreg. calcite ± quartz veins, most subparallel/core. Generally <0.5 cm thick, but locally up to 4 cm.	3588.8'-3589.2': irreg. carbonate vein in breccia.

TOTAL
DEPTH CORE
LOGGED
3606.8'

APPENDIX B. USW G-2 LOG

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2704- 2764	824.2-842.5		PROW PASS MEMBER, CRATER FLAT TUFF	Lt. buff welded ash-flow tuff.	Devitirified with white argillic alteration, biotite unaltered.		2704'-2704'.5: sheared and rubbly, probable fault with breccia
2764-2829	842.5-862.3	SAMPLE 59, 2777.0-2777.3: Mn oxide + silica vein ca. 10deg/core.		Pinkish-gray to gray welded ash-flow tuff. Similar to above unit, but slightly coarser pumice fragments.	Devitrified.	2817.7'-2719.0': webby breccia with red-brown, hematitic matrix. 2823'-2879': sparse fractures with Mn oxide.	2793'-2794.5': rubble zone, missing 1 ft of core.
2829-2980	862.3-880.9	SPL 60, 2878.2-2878.6: MnOx + qtz. vein, 1-2cm thick, ca. 20deg/core. SPL 61, 2886.8-2887.1: MnOx + hematite + zeolite on fract. SPL 62, 2939.2-2939.5: red-brown chalcedony vein, ca. 2mm thick. SPL 63, 2959.4-2959.9: MnOx and qtz.along irreg. fracture parallel/core.		Lt. brown to lt. gray or lt. pink ash-flow tuff, welded to ptly. welded, spherulitic groundmass.	Devitrified with pumice partially replaced by non-expansive clay. Biotite black to brassy, feldspar unaltered.	2834'-2843': sps. fracts. with MnOx ± hematite.2874': MnOx on fract, ca. 20deg/core. 2915'-2928': irreg. MnOx-filled fracts., 0-30deg/core. 2941'-2945': abund. hematite-filled fracts.	
2980-3000	880.9-914.4			Light pinkish gray to gray, ptly. welded ash-flow tuff.		3000': MnOx filling, 0.5cm thick, 25deg/core.	

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3000-3061.5	914.4-933.2	SAMPLE 0, 3019.8-3020.0	PROW PASS MEMBER, CRATER FLAT TUFF	Lt. gray or v. lt. pink to pink and purplish pink welded ash-flow tuff. Appears to be poorly welded below 3030'.	Devitrified, contains expansive clay ± zeolite, particularly after pumice frags., lithic frags. appear to be limonitized. Below 3050' pumice frags. not as obviously replaced by clay, probable zeolite in white patches.	3004-3007 and 3014-3015: hematite and minor Mn oxides. 3033-3049: more abund. hematite, especially along fracts.	
3061.5-3073	933.2-936.7	SAMPLE 1, 3069.8-3070.0: silicified rock with chalcedony veins.		Hard, densely welded ash-flow tuff, highly silicified and shattered into hundreds of "poker chips". Brownish gray to olive green color.	Silicified, feldspar-stable alteration (glassy minor clinoptilolite (?). Biotite altered or absent.	Gray to white banded chalcedony veinlets to 2mm thick.	Chalcedony veins ca parallel/core.
3073-3100	936.7-944.9			Core missing, interval drilled by rock bit, probably because of hard, broken nature.			
3100-3113	944.9-948.8			Silicified ash-flow tuff as in interval above. Missing some core, but not as hard or badly shattered.	Partly silicified, pumice frags. replaced by green clay ± clinoptilolite.	White clay and green mineral on fracts., no chalcedony veinlets.	3104.2': near horiz. clay & carbonate filled fract. cutting high-angle fract. with green coating.
3113-3132.5	948.8-954.8	SAMPLE 2, 3122.5-3122.7: chlorite(?) on fracture, clinoptilolite + clay after pumice.		Ptly. welded ash-flow tuff, brownish-gray to olive green, not as hard as above unit.	Partly silicified, clinoptilolite(?) + clay after pumice fragments. 3127'-3132.5' bleached.	Chlorite (?) on near vert. fracts., some with horiz. slickensides. 3130'-3132': MnOx on fract.	Drill equip. dust on some fracts. (e.g., @ 3122.5') - looks like pyrite. 3127'-3133': vert. fracts.
3132.5-3160	954.8-963.2	SAMPLE 3, 3155.0-3155.5		Ptly. welded ash-flow tuff, brownish grey to green.	Devitrified, not silicified, partly altered to yellow and green clay ± zeolite.	Clay ± zeolite on fracts. Green mineral on irreg. fracts. below 3144'. 3136.3' & 3155.5': stubby, clear analcite(?) crystals on fracts.	
3160-3248	963.2-990.0	SAMPLE 4, 3168.3-3169.1: limonite on fract.		Pinkish-gray to gray ptly. welded ash-flow tuff with brown lithic frags. Gradational contact with above unit. 3246'-3248': darker gray rock with black lithic fragments, gradational into unit below.	Devitrified. lt. yellow-green to cream colored expansive clay, especially after pumice fragments.	3167.5'-3171.0': limonite on fracture surfaces and slightly limonitized rock. No veins or filled fracts. below 3171'.	3167.9-3168.7: high-angle hematitic fractures
3248-3281.5	990.0-1000.2	SAMPLE 5, 3263.0-3263.5: silica vein.	BEDDED TUFF	White to lt. green , pink, or purple, fine to coarse, poorly to well sorted bedded tuff. Mostly unwelded, but compressed pumice at base of some beds. Air-fall, ash-flow, surge, and(or) water-laid tuff. 3280'-3281.5': lithic breccia, clasts to 6cm.	Expansive white to lt. green clay ± zeolite, especially after pumice frags. Clay alteration locally pervasive. Limonite/hematite staining in places.	3250': near vert. fract. with analcite + hematite. 3257.5'-3269': fine-grained quartz vein, near vert., 2mm-2cm thick, some drusy coatings.	3248'-3250': fine, cross-bedded surge tuff. 3250.5'-3252.5': coarse air-fall tuff. 3279'-3280': 1 cm thick fine tuff dike, 20deg/core. 3257'-3269': ash-flow

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3281.5-3447	1000.2-1050.7	SAMPLE 6, 3288.8-3289.3: limonite ± carbonate ± silica ± zeolite vein. SAMPLE 7, 3337.7-3338.0: limonite + mica on fract. SAMPLE 8, 3362.1-3362.4: clusters of dissem. limonite grains. SAMPLE 9, 3407.4-3408.1: limonitic fract.	BULLFROG MEMBER, CRATER FLAT TUFF	Lt. pink (locally lt. tan or lt. green), moderately welded ash-flow tuff. Lithic fragments generally sparse and < 2cm diamter. Relatively abundant biotite below 3351.5'.	Devitrified, pumice fragments and some of lithic fragments argillized, biotite unaltered. Clay is lt. pink to lt. green and expansive. 3303'-3351': vuggy vapor-phase minerals replacing pumice frags. 3351"-3447': pumice fragments devitrified, but generally not vuggy and not replaced by clay.	3290'-3326': sparse limonitized fracts. 3326'-3353': irreg. to planar limonitized fracts. 3353'-3423': iron-stained fracts. 3387'-3408': mod. abund. limonite ± MnOx-coated fracts. No pyrite observed in this interval, some limonite, mostly along fractures	3282'-3290': Volcanic and pre-Tertiary lithic frags. abund., up to 10 cm diam. 3290'-3291': rubble, ca. 1' missing. 3351'-3351.5': nonwelded tuff with brick red 1-2-cm-thick fine air-fall (interp. as fault on USGS log).
3447-3503.5	1000.2-1067.8	SPL 10, 3448.2-3448.6. SPL 11, 3466.1-3466.5. SPL 12, 3503.1-3503.4: ash-flow tuff, trace pyrite.		Ptly. welded ash-flow tuff, lt. green to mottled lt. green and lt. pink, mod. hard to hard. 3457'-3503.5': nonwelded according to USGS log, but similar texture to above unit with distinctly flattened pumice frags.	3447-3503.5: strong expansive clay ± clinoptilolite alteration, pumice frags. replaced by off-white to bright or light olive green clay and clinoptilolite, biotite and feldspar appear unaltered. 3500'-3503.5': light brown clay ± zeolite after pumice frags.	Very sparse, very fine pyrite. 3458'-3476': sparse, thin (<2mm), gray chalcedony veinlets, low-angle (80deg/core) and mod.-angle (45deg/core), no other veins or fracture fillings. 3476'-3500': no pyrite noted, but v. fine-grained pyrite may be present.	3448.5'-3448.7': spotted apple-green clinoptilolite(?) layer perpendicular to core
3503.5-3580	1067.8-1091.2	SPL 13, 3526.0-3526.4: air-fall tuff. SPL 14, 3575.6-3575.9: altered ash-flow(?) tuff.	BEDDED TUFF	Gray to lt. green bedded tuff, nonwelded to poorly-welded, v. fine- to crs.-grained. Includes beds of well-sorted air-fall or surge tuff and poorly sorted ash-flow tuff. Biotite and plagioclase relatively abundant, sanidine sparse.	Lt. green expansive clay ± clinoptilolite after pumice frags., but not as obvious as in unit below because they are smaller. Biotite and feldspar appear unaltered.	Possible trace amounts of v. fine disseminated pyrite, no fracture fillings or veins.	3503.5'-3505.5': well-sorted, med.-grained with basal 0.1' v. fine, cross-bedded water-laid(?) tuff. 3510'-3515': ash-flow tuff. 3515'-3526.5': air-fall tuff. 3526.5'-3571': poorly sorted, soft, welded, probable ash flow. 3571'-3575': tuff is well-bedded with flattened pumice fragments. 3575-3580: poorly-sorted nonwelded tuff, probable ash-flow origin.
3580-3588	1091.2-1093.6			Gray mod. welded to nonwelded ash-flow tuff. Mod. abund. lithic frags. (mostly of intermed. volc.) up to 2cm diam. Grades into unit below.	Expansive white clay after pumice frags.	No pyrite, no fracture fillings or veins.	Basal contact gradational. Pumice frags. flattened at top to equant at bottom.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3588-3714.5	1093.6-1132.2	SPL 15, 3593.5-3594.0: moderately altered selvage. SPL 16, 3638.5-3638.8: limonitic ash-flow tuff. SPL 17, 3674.0-3674.2: shattered with green mineral (chlorite?).	TRAM MEMBER, CRATER FLAT TUFF	Purplish-brown welded to unwelded(?) ash-flow tuff. Lithic frags. (mostly of intermed. volc. composition) comprise large part of unit. Pumice frags. range from flattened to non-flattened and are protected by surrounding lithics to some extent.	Pumice frags. replaced by off-white to lt. green expansive clay. Minor green mineral (zeolite or chlorite?) in lithic frags. Possible chlorite in shattered zones.	Traces of pyrite may be present locally in fract. fillings or veins. Dk. brown FeOx in matrix: minor 3600'-3625'; more abund. 3625'-3626'; minor 3626'-3637'. 3637'-3644': yellow-brown limonite stain. Limonite stains in matrix generally absent below 3657'. Pyrite may be present in lithic frags. below 3606'. 3677.7': fract. with green mineral 50deg/core.	Above 3593' pumice frags. not flattened; below 3593', pumice flattened. Lithic frags. comprise large part of unit, especially below 3596' where tuff may average >50% lithics. 3600'-3603': >90% lithics.
3714.5-3773.5	1093.6-1150.2	SAMPLE 18, 3722.8-3723.1: red-brown clay gouge with some slickensides.		Lithology essentially the same as above; however matrix is reddish-brown, almost purple, and lithic frags. are mostly white. Lithic frags, which may be less abund. than in overlying unit, are smaller below 3725', rarely exceeding 2cm.	Matrix appears hematitic. Lithic frags. bleached relative to above unit. Pumice frags. replaced by lt. green expansive clay ± zeolite. Biotite appears unaltered.	Some planar fractures coated with reddish-brown clay (e.g. 3720.4', 3722.7', 3723.0'); otherwise no veins or fracture fillings.	3727.3'-3728': fault breccia. 3755': Fault zone with clay gouge. 3756': fault zone rubble.
3773.5-3816.5	1150.2-1163.2	SAMPLE 19, 3807.5-3808.0.		Lithology similar to above unit but matrix is generally mottled reddish-brown and light pinkish-gray, lithic frags. about same size and abundance as bottom part of above unit.	Pumice fragments replaced by expanding clay, light green clay +/- zeolite; unitmay contain more zeolite than above unit; biotite and feldspar fresh	No fracture fillings or veins, no sulfides observed.	
3816.5-3889	1163.2-1185.4	SAMPLE 20, 3882.0-3882.4: ash-flow tuff.		Poorly to mod. welded lithic ash-flow tuff. Lithic frags. mostly small (<1cm, locally up to 4cm), pumice frags. small and generally flattened. Matrix red-brown, but below 3836' some pinkish-gray matrix. Gradational contact with unit below.	Light green smectite ± zeolite, matrix hematitic (?). Biotite and feldspar phenocrysts look unaltered.	May contain trace pyrite.	

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3889-3914	1185.4-1193.0	SAMPLE 21, 3911.5-3911.8: ash-flow tuff.	TRAM MBR.	Gray mod. welded ash-flow tuff with less lithics than in above unit.	Pumice frags. altered to smectite ± zeolite, light green to off-white; biotite and feldspar appear unaltered.	May contain local v. fine-grained pyrite.	
3914-3984	1193.0-1214.3	SAMPLE 22, 3967.8-3968.1: med.-grained air-fall tuff with white clay and unidentified green mineral.	BEDDED TUFF	Nonwelded bedded tuff, v. lt. gray to v. lt. greenish gray, most pumice frags. not flattened.	Strong expansive smectite alteration, white to light green color, local green spots, biotite and feldspar appear unaltered.	No sulfides noted; no fract. fillings or veins.	3914'-3916': fine, well-sorted air-fall tuff. 3916'-3917': crs. bedded tuff. 3917'-3923': Poorly-sorted ash-flow tuff. 3923'-3934': fine, massive air-fall tuff. 3934'-3948.5': well-bedded air-fall tuff, mostly fine. 3948.5'-3974': fine- to med.-grained air-fall tuff, faintly bedded to massive. 3974'-3983.5': lost core. 3983.5'-3984': med.-grained air-fall tuff.
3984-4015	1214.3-1223.8	SAMPLE 23, 4002.8-4003.2: low-angle shear zone.		Brown-gray tuff, mostly nonwelded ash flow with minor air fall at top. More mafic than above unit. Contains abund. biotite + some amphibole, and lithic frags. of intermediate volcanic rock.	Argillization weaker than above, green clay after some pumice frags., K-spar ± zeolite after others. Biotite looks unaltered, amphibole slt. altered.		3984'-3988': fine-grained air-fall tuff. 3988'-4015': poorly-sorted ash-flow tuff similar to above air-fall tuff.
4015-4031	1223.8-1228.7			Med.- to crs.-grained air-fall or surge tuff with abundant pumice ± lithic frags.	Minor green expansive clay after some pumice frags., mafic minerals appear unaltered.		4019.5'-4024': thin beds of med.-crs. air-fall tuff. 4024'-4031': med. to crs., massive air-fall tuff.
4031-4061	1228.7-1237.8			Greenish-gray nonwelded ash-flow with angular lithic frags. and sparse unflattened pumice.	Green argillized pumice or lithic frags. more abund. than above, mostly zeolitic ± feldspar alteration in rest of rock.	No veins or fract. fillings. Possible trace pyrite near base of unit.	
4061-4079	1237.8-1243.3	SAMPLE 24, 4075.0-4075.2: altered lithic frag.		Bedded tuff, fine to med.-grained green and purplish gray to lt. gray air-fall or surge tuff.	Clasts argillized, possible chlorite after mafic phenocrysts and calcite in matrix.	Calcite veins.	4065'-4079': abundant frags. of rhyodacite flow rock 1-5cm in diam.
4079-4099	1243.3-1249.4	SAMPLE 25, 4090.0-4090.6: breccia.	RHYODACITE FLOW	Breccia of lt. greenish gray angular frags. of biotite-amphibole rhyodacite in fine, brown-gray matrix of comminuted rock.	Clasts argillized; calcite after plagioclase and amphibole; possibe chlorite.	Thin, irreg. carbonate veins in matrix and clasts; one zeolite vein. Magnetite abund. in clasts, but no pyrite.	
4099-4150	1249.4-1264.9			Rhyodacite flow breccia, light greenish-gray, abundant amphibole and biotite phenocrysts in both clasts and matrix, lots of magnatite	Pyribole partly altered to calcite + FeOx + fine bronze-colored biotite. Mostly unaltered greenish to black biotite, but some partly converted to bronze oxybiotite. Clay minor, nonexpansive. Possible zeolite and calcite.	Irreg., discontinuous calcite veinlets, no pyrite noted.	
4150-4195	1264.9-1278.6	SAMPLE 26, 4171.0-4171.3.	BEDDED TUFF	Greenish-gray bedded ash-flow + air-fall ± surge tuffs, nonwelded to welded, pumice and lithic frags. are of intermediate composition.	Feldspar partly altered to soft white mineral, (zeolite?), possible calcite after feldspar. Gray-green argillic alteration after pumice.		4070.5": moderate-angle fracture with vertical slickensides. Fine- to med.-grained air-fall tuffs @ 4190'-4190.5' and 4194'-4195'.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4195-4203	1278.6-1281.1		LITHIC RIDGE TUFF	Gray, densely-welded ash-flow tuff	Pumice altered to gray clay.	Abundant fine carbonate veinlets.	
4203-4801.5	1281.1-1463.5	SAMPLE 27, 4271.4-4271.8. SAMPLE 28, 4357.4-4357.8. SAMPLE 29, 4463.6-4463.9. SAMPLE 30, 4533.8-4534.2: gray clay filling high-angle (20deg/core) fract. SAMPLE 31, 4672.0-4672.5: moderate-angle fault with 1-cm-thick breccia. SAMPLE 32, 4745.2-4745.7: calcite + hematite vein at 45deg/core.		Light greenish-gray lithic ash flow with gray-green collapsed pumice fragments, lithic fragments dominated by intermediate volcanic rock types. 4733'-4755': pinkish-gray color.	Pumice frags. replaced by greenish gray to v. lt. yellowish green or white expansive clay. Biotite appears to be unaltered. 4733'-4755': slight hematitic alteration of matrix and some lithic frags.	No pyrite noted. No veins or fracture fillings above 4356', 4356'-4359': high-angle clay-filled fracts.	4264.5': 0.5cm thick gouge on fract. @ mod. angle/core. 4354'-4356': rubble zone, lost 1.5' of core. 4634'-4634.5': rubble zone. 4794.7'-4794.9': gouge zone.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4203-4801.5 (cont.)	1281.1-1463.5 (cont.)		LITHIC RIDGE TUFF				

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4801.5-4831	1463.5-1472.5	SAMPLE 33, 4810.5-4811.0.	BEDDED TUFF	Fine- to med.-grained bedded tuffs, mostly air-fall tuff, v. lt. green to purple or gray, possibly some ash-flow tuff, some units have collapsed pumice frags.	Light green argilllic alteration, some finely-divided, spangly pink to white illite(?), clay is expansive and locally absent. Pyribole and biotite appear unaltered.	No veins or fract. fillings.	4810.5': mod.-angle calcite vein, 1-6mm thick.
4831-4855	1472.5-1479.8			V. lt. gray to greenish gray, mod. welded ash-fow tuff, moderately sorted.	As above, but no illite, clay is light bluish-green expansive, pyribole and biotite appear slightly altered.		
4855-4877	1479.8-1486.5	SAMPLE 34, 4858.6-4858.9		Lt. greenish yellow to lt. greenish gray, fine- to crs.-grained (mostly med. to crs.) bedded tuff.	Lt. green or lt. yellow to white clay, mostly expansive.		
4877-4968	1486.5-1514.3	SAMPLE 35, 4914.5-4914.8: irreg. carbonate vein in rhyolite flow. SAMPLE 36, 4949.0-4949.5.	RHYOLITE FLOW	Lt. green to lt. buff massive rhyolite flow rock with fine biotite and plagioclase phenocrysts.	Argillic alteration generally restricted to fractures, biotite generally appears unaltered. 4929'-4958': local pervasive clay alteration.	Carbonate veins 4927'-4939'.	4889'-4890': rubble zone. 4927': fract. zone. 4929-4951.6: rubble zone. 4936'-4936.9': spherulitic zone. 4941.4'-4946.1': rubble zone. 4954'-4954.7': spherulitic zone. 4956.7-4957.7: salmon-colored zone.
4968-5078	1514.3-1547.8	SAMPLE 37, 5018.4-5019.2. SAMPLE 39, 5039.1-5039.5. SAMPLE 40, 5072.9-5073.3.		Buff to salmon-colored flow-banded rhyolite with variable amounts of brown to red-brown spherulites. Distinct flow-banding below 4975'.	5018'-5068': variable argillic alteration.	Local quartz-carbonate veins. 5039.2': vein with crystalline carbonate + quartz and blue chalcedony. 5058.7'-5060.7': thin carbonate veins with some drusy quartz. 5072.6'-5073.0': quartz-carbonate veins and clots, open spaces lined with crystals.	4968.0'-4968.4': fracturing @ 60deg/core. 5029.0'-5029.4': fault zone. 5068.3'-5069.0': rubble zone.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
5078-5133	1547.8-1564.6	SAMPLE 41, 5082.0-5082.7.	RHYOLITE FLOW	Flow-banded, lt. purplish gray rhyolite with no spherulites. Sparse biotite phenocrysts.	5078: local white to buff argillic alteration and local silicification. Biotite is bronze-colored. 5080.7'-5082.2': silicified zone.	5078.1': quartz + carbonate open space filling. 5081.9'-5082.9': breccia zone. 5088.5'-5088.7': drusy quartz veins. 5091.9'-5092.5': drusy quartz veins.	5089.3'-5099.8': fracture zone. 5100'-5101': fracture zone. 5130'-5133': rubble zone, surface of core FeOx-stained (staining extends to about 5150').
5133-5205	1564.6-1586.5			Lt. gray to lt. purple brecciated rhyolite. Locally flow banded; flow foliation indistinct below 5196'.	Off-white argillic alteration in places; local silicification; biotite bronze-colored. 5182'-5194': argillic alteration.	5141.0'-5141.5': carbonate veins, mod. angle. 5170'-5175': lt. green waxey mineral on fracts.	5134.4'-5174.1': breccia zone, rock solid but displays web-like breccia structure. 5171.2': gouge zone with some slickensides. 5174'-5197': rubble zone, gradual change to more competent rock.
5205-5637	1586.5-1718.2	SAMPLE 42, 5224.5-5225.0. SAMPLE 43, 5255.0-5255.4. SAMPLE 44, 5295.6-5296.1.	RHYODACITE FLOW	Lt. green or greenish gray to reddish gray, light gray, or reddish brown rhyodacite flow rock.	Unit partly green propylitized rock with biotite altered to chlorite(?); this alteration is rare below 5277', but occurs locally to 5305'. Biotite generally bronze colored and plagioclase cloudy. Minor nonexpansive clay. Green propylitic alteration rare between 5305' and 5637'.	Altered rock contains pyrite in quartz ± chlorite veinlets, in altered plagioclase and mafic minerals, and as dissem. grains. Little or no sulfide below 5277', but LANL reports it at 5305'. 5222'-5223': thin carbonate vein, ca. parallel/core. 5295.8': carbonate vein ca. 60deg/core. 5298.9': carbonate vein. 5315.8' : carbonate clots. 5325.3': FeOx-staining on core surface. 5328'-5329': carbonate veins 60deg/core.	5205'-5277': alternating intervals of greenish altered rock with less altered intervals of gray, purplish gray, or reddish gray rock. 5266.7'-5264.7': fract. ca. 85deg/core, coated with chloritic gouge.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
5205-5637 (cont.)	1586.5-1718.2 (cont.)	SAMPLE 45, 5372.2-5372.4: hematitic rhyodacite, no veins or fracts.	RHYODACITE FLOW	Lt. green or greenish gray to reddish gray, light gray, or reddish brown rhyodacite flow rock.		5356.3'-5361': sparse carbonate veining, ca. parallel to core 5400.8': carbonate clots. 5404.3'-5406': prominent, near-vertical carbonate veins. 5418.6': calcite-filled fracture.	5367.1': high-angle (ca. 70deg) fracture with slickensides and hematite stain.
		SAMPLE 46, 5418.3-5418.8.				5428.3' and 5431.6'-5432.2': carbonate veining. 5462'-5499.5': scattered clots of calcite.	5437.8'-5439.3': broken zone.
		SAMPLE 47, 5527.5-5528.0.			5527'-5528': pistachio-green clay alteration.	5499.5'-5505': Irregular disseminated magnetite. 5544.4': calcite veins, perpendicular to mod.-angle/core. 5474'-5475.5': abundant patches of calcite.	5505'-5637': webby, phreatic(?) breccia. 5505'-5637': Grayish-green rhyodacite flow breccia, matrix is purplish-gray.
		SAMPLE 48, 5597.0-5597.4.					5596.5'-5606': healed breccia, matrix purplish brown, webby breccia, matrix is comminuted rock(?).
		SAMPLE 49, 5636.3-5636.8: breccia with reddish brown matrix, irreg. white qtz + calcite + barite vein.					5618.6'-5622': brecciation. 5628.6': rusty stain. 5628'-5637': irreg. white qtz + calcite veins
5637-5670.5	1718.2-1728.4	SAMPLE 50, 5638.9-5639.3: abund. lithic frags. SAMPLE 51, 5665.5-5665.9.	BEDDED TUFF	Mod. welded, massive tuff to bedded tuff. Dk. brown, greenish gray, and gray. Mostly ash-flow tuff. Contains lithic frags. of intermediate composition.	Plagioclase strongly altered, biotite replaced by chlorite(?). Possible chlorite in lithic fragments.		5637'-5649.5' abund. feldspar, mafic minerals indistinct. 5649.5'-5653': bedded tuff.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
5670.5-5682.0	1728.4-1731.9		DACITE FLOW	Flow or pyroclastic breccia. Dk. greenish gray dacite in fine matrix.		Abund. magnetite.	
5682.0-5885.5	1731.9-1793.9	SAMPLE 52, 5695.8-5696.2: irreg. carbonate vein. SAMPLE 53, 5748.6-5749.1: stockwork breccia with white carbonate matrix.		Fine-grained greenish to purplish gray dacite, plagioclase laths to 3mm, mafic minerals inconspicuous. Relatively abund. magnetite.	Propylitic alteration. Cloudy plagioclase (altered to chlorite ± albite). Mafics altered (no biotite or amphibole cleavage noted) probably to chlorite ± calcite ± quartz.	Irreg. to 1cm calcite veinlets, especially abund. 5686'-5687'. 5727'-5753' and 5763'-5777': abund. planar to irregular carbonate veinlets parallel/core to mod. angle/core.	5748.2': Photos 1-3, white carbonate ± quartz veins in chloritized flow rock.
		SAMPLE 54, 5786.0-5786.5: irreg. fract. filling to 2cm thick with carbonate + silica + pink clay. SAMPLE 55, 5855.5-5856.0: carbonate ± chlorite vein, <1mm to 1cm thick, 30deg/core.			5777'-5859.5': Plagioclase not altered as in above unit (good twinning, distinct cleavage), but pyribole replaced by green & brown material.	5777'-5859.5': veins less abund. than above, but prominent mod.-angle carbonate fracture fillings @ 5813.6' and 5815.1'. 5800'-5859.5' chlorite and carbonate-filled fracts with chloritic selvages, variously oriented carbonate veinlets.	5786.0'-5786.5': Photos 4-7 of vein material, white carbonate, pink clay(?), & chlorite(?). 5828.5'-5829': rubble zone. 5828.5'-5855': distinctly more fractures in this interval than above or below.
		SAMPLE 56, 5863.0-5863.6: banded vein, carbonate with quartz center, 1.5cm thick				5859.5'-5885.5': abundant carbonate in veins and breccia.	
5885.5-5942	1793.9-1811.1	SAMPLE 57, 5910.4-5910.9.	BEDDED TUFF	Bedded volcaniclastic and pyroclastic sequence. Mostly fine- to med.-grained reworked tuff. Some lt. to dk. green, well-sorted volcanic conglomerate.	Probable propylitic alteration. Chlorite after feldspars and mafics. Locally abund. clay, some calcite.	Filled fractures & veins rare; possible trace disseminated pyrite. 5912.3': calcite-filled fracture, ca. 20deg/core. 5925'-5929': scattered thin carbonate veins at 30deg/core.	5885.5'-5889' dk. green-gray cgl., mostly well sorted angular volcanic clasts, avg. 5mm diam. 5889'-5915': fine- to med.-grained, locally well bedded, reworked tuff. 5915'-5919.5': lt. green cgl.; angular, well-sorted. 5919.5'-5942': Bedded tuff, mostly fine-grained. 5920.9'-5921.1': rubble zone.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
5942-6006	1811.1-1830.6	SAMPLE 58, 6005.1-6005.5: ash-flow tuff.	ASH-FLOW TUFF	Partly welded lt. gray ash-flow tuff with mod. abund. lithics up to 2cm diam. composed of a variety of volcanic types.	Calcite after feldspar, biotite altered to dark brown mineral, pumice altered to light green clay.	No veins or fracture fillings	

TOTAL
DEPTH 6006'

APPENDIX C. USW GU-3 LOG

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
0-31	0-9.4		TIVA CANYON MEMBER, PAINTBRUSH TUFF				No core.
31.0-36.5	9.4-11.1			Brownish-gray welded ash-flow tuff.	Devitrified. Biotite unaltered, black to bronze colors, feldspar appears unaltered. Vapor-phase alteration.		No core 32-36.5.
36.5-57.5	11.1-17.5			Gray moderate to densely welded ash-flow tuff, flattened devitrified pumice frags., abund. lithophysal cavities.		Lithophysal cavities lined with crystalline and amorphous silica phases.	
57.5-137	17.5-41.8			Brownish-gray devitrified, welded as above, no lithophysal cavities.		Devitrified pumice fragments contain vapor-phase veins.	
137-220	41.8-67.1	SAMPLE 64, 138.7-139.3: 0.5cm carbonate ± zeolite fracture filling @ 40deg/core. SAMPLE 65, 156.6-157.0: irregular carbonate veins about 0.5cm thick.		Lithology as above but brownish-gray devitrified pumice fragments with vapor phase crystals. Minor lithophysal cavities near base.		Sparse, irregular fracture fillings with carbonate ± zeolite ± crystalline silica phases. Carbonate-filled fractures, 153.5'-156.5'.	173'-175': fracture zone. 184'-186': fracture zone. 195'-196': fracture zone.
220-281	67.1-85.6			As above, , but abundant lithophysal cavities lined with vapor-phase minerals.		No veins or fracture fillings.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
281-343.5	85.6-104.7	SAMPLE 66, 322.1-322.5: irregular breccia zone cemented with carbonate parallel to core	TIVA CANYON MEMBER, PAINTBRUSH TUFF	As above, sparse lithophysal or absent, pumice fragments partly to wholly glass below 334'.	Devitrified. Biotite and feldspar look unaltered.	No veins or fracture fillings.	
343.5-348	104.7-106.1	SAMPLE 67, 343.7-344		Vitrophyre, gray with black fiamme.			
348-374	106.1-114.0			Moderately welded to nonwelded, pinkish to orange brown, glassy ash-flow tuff with brown and black shards and clear sanidine crystals. Nonwelded base (370'-374')			
374-423	114.0-128.9	SAMPLE 68, 390.4-390.7: argillic altered coarse air-fall tuff SAMPLE 69, 408.2-408.7: bright salmon-red hematitic, argillized air-fall tuff	BEDDED TUFF	Bedded tuff: white to brown or pink, fine to coarse, well-sorted base surge or air-fall tuff; and brown, pink, or purplish-gray, fine to coarse, poorly-sorted, unwelded to poorly welded ash-flow tuff.	Argillic alteration of pumice fragments in airfall, expandable clay, possible white zeolite. 388'-423': bronze biotite.		374'-378': fine- to med.-grained air-fall tuff; 378'-390.5': brown to white, poorly to well sorted, crs. tuff. 390.5'-401': tan to white poorly sorted tuff; 401'-409': reddish-brown crs. air-fall tuff. 409'-423': purple-gray poorly welded ash-flow tuff. 398'-408': lost 6' of core. 408'-418': lost 2' core.
423-427	128.9-130.1		TOPOPAH SPRING MEMBER, PAINTBRUSH TUFF	White to v. lt. gray ash-flow tuff	Devitrified		unwelded to mod. welded
427-448	130.1-136.5			Welded ash-flow tuff with two types of pumice fragments(light and dark colored).	Devitrified, vapor-phase alteration.		427-432: lt. brownish gray to gray 432-448: lt. reddish brown
448-575	136.5-175.3	SAMPLE 70, 514.2-514.4: irreg. breccia with Mn oxide patches, breccia fills fracture parallel/core.		Welded ash-flow tuff with sanidine, plagioclase, biotite, trace quartz crystals, brown pumice fragments.	Devitrified, local vapor-phase alteration.	No fracture fillings or veins, except for irreg. breccia with MnOx at 514'.	448'-507': lt. reddish brown 507-575': light gray 507'-516': rubble zone

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
575-688	175.3-209.7	SAMPLE 71, 636.4-636.9: calcrete breccia in lithophysal tuff.	TOPOPAH SPRING MEMBER, PAINTBRUSH TUFF	Welded lithophysal ash-flow tuff, lt. brown to lt. pinkish orange.	Devitrified, vapor-phase minerals in cavities.	No veins or fracture fillings.	
688-726	209.7-221.3			As above, but only sparse lithophysal cavities.	Devitrified.		
726-1000	221.3-304.8	SAMPLE 72, 857.4-857.6: silica ± Fe oxide vein, photos 7 & 8		726-1000: as above, but no lithophysal cavities.	Devitrified. Vapor-phase alteration.	Scattered irreg. fractures filled with white, lt. gray and clear minerals, probably silica phases ± zeolites. Vapor-phase veins in pumice fragments.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
726-1000 (cont.)	221.3-304.8 (cont.)	SAMPLE 73, 898.3-898.6: mod. angle silica vein	TOPOPAH SPRING MEMBER, PAINTBRUSH TUFF			928.5': irreg. vein with white crystals and ilmenite(?); Photos 9 & 10, 25x.	989'-1013': highly fractured.
1000-1130	304.8-344.4	SPL74, 1042.7-1043.0: fluorite ± quartz ± zeolite on irreg. fract.; Photo 11, 6x, Photo 12, 25x; Photo 13, 12x. SPL 75, 1072.7-1073.2: fluorite + quartz on fract. SPL 76, 1097.8-1097.9: pale green and purple fluorite on fract.		As above, but no vapor phase alteration.	Devitrified.	Fluorite, quartz, and zeolite on irregular fractures.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
1130-1187	344.4-361.8		TOPOPAH SPRING MEMBER, PAINTBRUSH TUFF	As above, but mottled lt. brown and dk. brown.	No vapor-phase alteration or cavity linings.	Platy white mineral and clay on planar fractures.	
1187-1269	361.8-386.8	SAMPLE 77, 1195.4-1195.7: devitrified selvage 3cm wide about a 0.5mm planar limonitized fracture about 35 deg to core. SAMPLE 78, 1229.1-1229.4: vitrophyre.		Gray to dk. gray vitrophyric ash-flow tuff with abundant flattened pumice fragments which are composed of black glass. Minor crystals.	Unaltered.	Thin clay + fluorite + zeolite ± carbonate coatings on sparse, irregular fractures.	1211.4': Photo 14, 25x, fluorite on fracture in vitrophyre; Photo 15, 12x, shows perlitic cracks.
1269-1310	386.8-399.3			Densely to poorly welded, glassy, mottled light yellow brown and gray (top) to tan (base) ash-flow tuff.	Partly devitrified, possible white clay alteration in pumice frags. below 1300'.	No fracture fillings or veins.	Pumice frags. from 1269' to 1280' are dark gray glass.
1310-1338	399.3-407.8			Tan to pinkish tan unconsolidated to well consolidated, nonwelded ash-flow tuff.	Possible clay alteration of pumice frags.		
1338-1406	407.8-428.5			White to tan ash-flow tuff(?), unconsolidated, sandy, glassy.	Some clay.		Pinkish-tan 1336'-1376', light tan 1376'-1396', off-white 1396'-1406'.
1406-1412	428.5-430.4	SPL 80, 1408.0-1408.2		Friable white to pink air-fall or base surge tuff.	Possible clay alteration.		Well-sorted.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
1412-1507	430.4-459.3		TUFFACEOUS BEDS OF CALICO HILLS	Poorly sorted unconsolidated to poorly indurated nonwelded ash-flow tuff, lt. tan to off-white; 1496' to base is non-indurated.	Possible nonexpansive clay and zeolite. Pumice frags. appear to be devitrified, but some gray and black glass frags. are present.	No veins or fracture fillings.	
1507-1560	459.3-475.5	SAMPLE 81, 1540.7-1541.2: moderately well-sorted air-fall or base-surge tuff.	BEDDED TUFF	Very light tan to off-white bedded tuff, well sorted to moderately well-sorted, fine-grained.	Possible clay (non-expansive) + zeolite, black to brassy biotite.		Well-sorted fine layers at1506.8'-1506.9', 1515.5'-1518.4', and1525.3'-1525.4', some may be reworked by water.
1560-1600	475.5-487.7		PROW PASS MEMBER, CRATER FLAT TUFF	Light tan ash-flow, poorly sorted, poorly indurated, some glass fragments, non-welded, no flattened pumice.	Possible minor clay and zeolite.		
1600-1603	487.7-488.6	SPL 82, 1601.3-1601.6		Welded ash-flow tuff, v. light gray.	Clay after pumice, vapor-phase alteration.		
1603-1754	488.6-534.6			Poorly to densely welded ash-flow tuff, light pink, gray or brown to white, sparse lithic fragments. Pumice fragments flattened in most of unit, but equant near base.	Clay ± zeolite alteration, but feldspar crystals look unaltered. Vapor-phase altered pumice below 1675'. Below 1700' devitrified, no glass, v. lt. pink to white expansive clay after pumice frags.		Partly glassy above 1614', but devitrified below that. Poorly welded and friable 1603'-1675'. Moderately welded and harder 1675'-1700'. Hard, densely welded 1700'-1732'.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
1603-1754 (cont.)	488.6-534.6 (cont.)		PROW PASS MEMBER, CRATER FLAT TUFF			No veins or fracture fillings.	Progressively softer and less welded 1732'-1754'.
1754-1991.5	534.6-607.0	SAMPLE 83, 1759.4-1759.6: minor Feox in matrix and lithic frags. SAMPLE 84, 1776.0-1776.5: Mnox clots and hematite, no fractures. SAMPLE 85, 1915.3-1915.6: clay-filled fractures about 30deg/core.		V. lt. pink to white poorly to moderately welded ash-flow tuff.	Unaltered hornblende, sanidine; minor expansive clay, probable strong zeolite, especially below 1768', vapor-phase alteration of pumice strong to 1768', local and weak below that.	Clay on fractures.	Moderately welded, 1754' to 1768'; fairly hard, very light pinkish-gray to off-white poorly-welded and poorly indurated below1768'.
1991.5-2004	607.0-610.8	SPL 86,1993.5-1993.8: hematitic bedded tuff. SPL 87, 2000.7-2001.4: quartz + clay + MnOx vein, 40deg/core.	BDD TUFF	Bedded tuff, white to pink or lt. gray, moderately sorted.	Clay + hematite stain. Extreme clay alteration 2001.2'-2002'.	Sparse clay-coated fractures, MnOx + quartz filled.	V. lt. pink to off-white 1991.5'-1993'; pink 1993'-2000'; white to lt. gray 2000'-2004'.
2004-2021.5	610.8-616.2			Nonwelded ash-flow tuff, very lt. brown.	Fresh biotite to slightly brassy, minor clay.	No veins or fracture fillings.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2021.5-2091	616.2-637.3	SAMPLE 88, 2042.5-2042.7: irregular fracture perpendicular to hole, Mnox + limonite + white mica coating.	BULLFROG MEMBER, CRATER FLAT TUFF	Very light gray, poorly welded ash-flow tuff, sparse lithic fragments.	Bronze biotite, strong vapor-phase alteration. Limonitic 2042.0'-2042.8'.	No veins or fracture fillings.	Core missing 2042.8'-2046'. 2065'-2067': rubble zone. 2078'-2089': rubble zones, 2' core lost.
2091-2161	637.3-658.7	SAMPLE 89, 2109.0-2109.4: minor slickensided fracture with Mnox + limonite +clay		Lt. brownish gray hard, welded ash-flow tuff with abundant crystals and v. sparse lithic fragments. Light purplish-gray near base.	No vapor-phase alteration. Bronze biotite. Little or no clay below 2110'.	V. sparse planar clay-lined fractures 20-30deg/core, slickensides, thin Feox ± MnOx.	
2161-2380	658.7-725.4	SAMPLE 90, 2295.0-2295.3		Welded ash-flow tuff, lt. red-brown to purplish gray. More lithic and pumice fragments than in above unit; lithic fragments sparse, but up to 4cm diameter. Sparse crystals.	Bronze biotite, little or no clay after pumice and in groundmass, devitrified, but otherwise essentially unaltered.	Magnetic metal grains that look like sulfide are on some fractures, but must be from drilling. Irregular to planar fractures at low-angles/core with v. thin white clay coatings.	Lt. purplish gray above 2170'; light brownish gray to light reddish brown below 2170'. 2227'-2242': lithic fragments v. sparse. 2238'-2240': rubble zone, lost 1'+ of core. 2283'-2293': rubble, lost 3+' of core.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2161-2380 (cont.)	658.7-725.4 (cont.)		BULLFROG MEMBER, CRATER FLAT TUFF				
2380-2515	725.4-766.6	SAMPLE 91, 2383.8-2384.2: irreg. fracture, 10deg/core, extends 4' down hole, green crystalline coating. SAMPLE 92, 2435.1-2435.5: limonitic ash-flow tuff SAMPLE 93, 2456.1-2456.4: 1mm-thick white vein 70deg with core, dark gray mineral in places		As above, but mottled brown and tan color, brown pumice fragments well flattened and more abundant than in above unit, abundant crystals as in above unit.	Biotite unaltered, no argillic alteration, essentially unaltered (other than devitrification).	Minor white clay on fractures. 2435'-2445': red brown limonite on discontinous fractures.	2435'-2445' poor core recovery (dropped 8').
2515-2547	766.6-776.3			Light reddish-brown welded and poorly-welded ash-flow tuff, as above but less pumice frags. and more lithic frags. that are up to 5cm diameter, lighter color below 2527' to lt. tan at base, pumice unflattened at base.		No fracture fillings or veins.	
2547-2549.5	776.3-777.1			Lt. brown-gray medium to coarse, well-sorted air-fall or surge tuff.	Clay ± zeolite replacing pumice fragments.		
2549.5-2617	777.1-797.7			Unwelded to densely welded, greenish- to v. lt. pinkish-tan ash-flow tuff.		Very minor white clay on planar fractures.	V. lt. greenish-tan spongeycap rock 2549.5'-2552' , pumice flattened below 2554', lt. pinkish tan below 2559, v. lt. pinkish tan 2585' to base.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2617-2637	797.7-803.8	SAMPLE 94, 2629.1-2629.3: hematitic bedded tuff.	BDD TUFF	Pink to lt. green bedded tuff, mostly fine- to medium-grained.	Clay ± zeolite alteration, hematitic stain.		Crs. air-fall tuff 2628'-2629', mottled pink and lt. greenish tan fine to med. tuff 2617'-2624'; pink tuff below 2624'.
2637-2644	803.8-805.9			Top Tram Mbr, pink ash-flow tuff	See G-3	See G-3	Poorly welded.

TOTAL
DEPTH 2644'

APPENDIX D. USW G-3 LOG

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2609-2624.5	795.2-799.9			Bedded tuff.			Begin hole, see GU-3 for bedded tuff detail
2624.5-2627	799.0-800.7		TRAM MEMBER, CRATER FLAT TUFF	Pink ash-flow tuff, nonwelded.	Devitrified, abund. clay.		
2627-2719	800.7-828.7			Light pink ash-flow tuff, moderately abundant lithic frags., <1cm diam., poorly to moderately welded, essentially unwelded below 2696'.	Devitrified, minor clay, probable zeolite, fresh biotite	No veins or fracture fillings.	Lt. pink 2627'-2640'; v. lt. pinkish tan 2640' and below.
2719-2890	828.7-880.9			Nonwelded to moderately welded, nearly white ash-flow tuff, less lithic frags. than above unit but larger (up to 4cm diameter). More abund. lithic frags. above 2723', welding distinct below 2727'; gradational change to interval below 2890'.	Devitrified, feldspar and biotite phenocrysts unaltered, some biotite bronze colored, minor clay, probable zeolite.	Minor thin clay coatings on irreg. fractures near base of unit.	Well-indurated bedded tuff 2820'-2823' (USGS log); interval now missing.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2890-2987	880.9-910.4	SAMPLE 95, 2907.1-2907.6: irregular fracture sub-parallel to core, carbonate ± opal. SAMPLE 96, 2953.5-2954.0: irreg. fracture, quartz + carbonate coating.	TRAM MEMBER, CRATER FLAT TUFF	2890-2987: Welded ash-flow tuff, light brown-gray to 2896.5', light gray to light purplish gray below that; spherulitic matrix.	Devitrified, unaltered biotite, little or no clay. Some non-expansive clay after pumice fragments at base of unit.	2890'-2933': irreg. white carbonate ± quartz ± zeolite ± opal coated fractures parallel or sub-parallel to core; below 2933' silica in irreg. fractures at variable angles to core. 2952'-2970': scattered quartz-carbonate veins, planar-irregular, variable orientations. 2970'-2971': dark breccia vein up to 3cm thick sub-parallel to core. 2981.5': coarsely xlline carbonate vein along planar fract. <1mm to 1cm thick at 30deg/core.	
2987-2988 ↓	910.4-910.7			Hard, welded bedded tuff, cross-bedded, fine- to med.-grained. lt. purplish gray to white.	Devitrified.		
2988-3065	910.7-934.1	SAMPLE 97, 3002.6-3003.1: hydrothermal breccia vein approx. parallel to core, 0-0.5cm thick, about 75deg/core; Photos 16-18, 6x SAMPLE 98, 3028.2-3028.4: irreg. quartz-carbonate-limonite vein, parallel to core.		Welded ash-flow tuff similar to unit above 2987', but pumice larger and more abundant, spherulitic matrix.	Devitrified, unaltered biotite, little or no clay.	2993'-3012': quartz-carbonate veins, sparse, most subparallel/core. 3002.4'-ca.3005': hydrothermal breccia vein, gray quartz matrix; 3022'-3023' and 3028'-3030': Quartz-carbonate veins, low-angle or sub-parallel/core 3038-3057: sparse quartz-carbonate veins, sub-parallel/core	Lithics more abundant below 3015, most small, 1cm or less. 3003.7'-3005.7', core missing. At base of unit (3064.8'-3065.0') fine- to med.-grained, bedded, welded air-fall tuff.
3065-3087	934.1-940.9	SAMPLE 99, 3079.5-3079.8: carbonate-quartz vein parallel/core.		As above, but larger, more abund. lithic frags. (up to 3cm) and less pumice frags.	Devitrified, unaltered biotite and feldspar; local expansive clay replacing pumice.	3077'-3087': carbonate-quartz on irregular planar fracture, subparallel/core.	At base (3084'-3087') unit is pumice-rich.
3087-3123	940.9-951.9	SAMPLE 100, 3107.0-3107.5: thin MnOx + carbonate vein (1-2mm), 30deg with core		Welded ash-flow tuff, v. lt. tan, relatively abundant lithic frags. up to 3cm, pumice frags. smaller, darker (lt. gray-brown) than above unit, not spherulitic.	Devitrified, little or no clay, unaltered biotite.	3087'-3107.5': v. sparse white carbonate ± Mn oxide veins. No veins or fracture fillings below 3107.5'.	3105'-3109': fewer lithics, more abundant pumice fragments.
3123-3125 ↓	951.9-952.5			Welded bedded tuff, mostly fine grained.	Devitrified.		
3125-3200	952.5-975.4	SAMPLE 101, 3164.3-3164.6: ash-flow tuff.		Moderately welded, relatively lithic-rich (up to 2cm) welded ash-flow. Basal contact gradational.	Devitrified, with unaltered biotite, minor clay in matrix and after some pumice fragments, probable zeolite. 3171'-3173' and 3184'-3221': pink clay replacing pumice fragments.	No veins or fracture fillings.	3140 and below, lithic fragments more abundant and larger (up to 4cm).

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3200-3221	975.4-981.8		TRAM MEMBER, CRATER FLAT TUFF	Densely welded ash-flow tuff with more abundant pumice than in above unit.			
3221-3227	981.8-983.6			Dark brown ash-flow tuff with partly glassy pumice frags.	Matrix devitrified, otherwise unaltered.		
3227-3503	983.6-1067.7	SAMPLE 102, 3244.6-3244.8: irreg. fracture with white clay		Ash-flow tuff, welded, relatively abundant lithics, light reddish-brown above 3262'.	Devitrified, white clay after pumice frags. 3227'-3229', biotite fresh, abund. zeolites. 3257'-3262': pumice altered to light pink to white clay, biotite unaltered.	Irregular fractures with white clay ± carbonate.	3257'-3262': more abund. pumice fragments.
		SAMPLE 103, 3281.9-3282.4: ash-flow tuff with pink clay partly replacing pumice.		Below 3262', color changes gradually from lt. reddish-brown to v. lt. pinkish gray. 3325'-3367': v. lt. gray.	3262'-3325': pumice partly to wholly replaced by pink clay 3325'-3503': clay replacing pumice is off-white to white.		
		SAMPLE 104, 3370.5-3370.9: purple-pink clay on fracture, mod. angle/core, vertical slickensides.		3403'-3490': lt. purplish gray.		3364'-3371': broken zone with clay along irregular fractures. No veins or fracture fillings below 3371'.	
		SAMPLE 105, 3496.3-3496.6: ash-flow tuff with white clay after pumice.			3403': pumice replaced by off-white to very light purple clay, biotite unaltered. Pumice fragments altered to white clay.	No veins or fracture fillings.	3490'-3503': lt. pink ash-flow tuff.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3503-3521	1067.7-1073.2		TRAM MEMBER, CRATER FLAT TUFF	Welded ash-flow tuff with abund. lithic fragments, matrix is mottled light yellow green and light purple to light purple.			
3521-3545	1073.2-1080.5	SAMPLE 106, 3537.0-3537.2: ash-flow tuff, yellow-brown matrix.		Welded ash-flow tuff with abund. lithic fragments, yellow-brown matrix.			
3545-3583	1080.5-1092.1			Welded ash-flow tuff with abund. lithic fragments, gray to lt. purplish-gray.			
3583-3723	1092.1-1134.8	SAMPLE 107, 3673.9-3674.1: ash-flow tuff with abundant lithics.		Unwelded to poorly welded ash-flow tuff with abund. lithic frags., mottled green and light purple matrix.	Devitrified, unaltered biotite and feldspar phenocrysts, off-white to v. lt. greenish-gray clay after pumice.	No veins or fracture fillings. 3680' and below, pyrite in lithic fragments.	
3723-3734	1134.8-1138.1	SAMPLE 108, 3725.6-3726.1: abund. pyrite in lithic frags.		Unwelded ash-flow tuff with abund. lithic fragments as above, but with green matrix.	Lt. gray to lt. green expansive clay after pumice and in matrix.	Pyrite in lithics, no veins or fracture fillings, probable clinoptilolite.	3727': Photo 19, pyrite; Photos 21-25, pyritic clasts with white rims, 6x, roll 2.
3734-3849	1138.1-1173.2	SAMPLE 109, 3756.9-3757.8: ash-flow tuff with pyritic lithics. SAMPLE 110, 3778.2-3778.4: ash-flow tuff with pyritic lithics. SAMPLE 111, 3847.3-3847.7: ash-flow tuff with pyritic lithics.		3734-3849: as above, but light gray matrix, unwelded to poorly welded.	white to lt. green to olive green to lt. gray clay after pumice frags., clay expansive, biotite unaltered.	No fracture fillings or veins, pyrite in lithics and sparsely disseminated in matrix, lithic fragments that carry pyrite are altered intermediate to felsic volcanic rocks.	3546': photo 20, 6x, pyritic lithics. 3756.5': photo 21, pyritic lithics, also photos 26-28, 6x, roll 2. 3766', pyritic lithics, photos 34-36, 12x, roll 2. 3789', pyritic lithics, photos 29-31, 6x, roll 2. 3800', pyritic lithics, photos 32 & 33,12x.

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3734-3849 (cont.)	1138.1-1173.2 (cont.)		TRAM MEMBER				
3849-3877	1173.2-1181.7	SAMPLE 112, 3864.8-3865.1: fine-grained bedded tuff with sparse disseminated pyrite.	BDD. TUFF	Greenish gray bedded tuff, mostly fine-grained, some med.- to crs.-grained, locally welded.	Biotite unaltered, lt. tan to green clay, some blue-green clay (probable abund. zeolite).	Minor disseminated sulfide in bedded tuff, no fracture fillings or veins.	3850.5': friable clayey bed of med.-grained air-fall tuff with charcoal frags.
3877-3880	1181.7-1182.6			Welded ash-flow tuff, v. lt. green color.	Green clay rpl. pumice.	No pyrite identified.	Abund. lithic frags.
3880-4054	1182.6-1235.7	SAMPLE 113, 3908.7-3909.1: ash-flow tuff, no pyrite. SAMPLE 114, 4005.0-4005.3: ash-flow tuff, poorly welded. SAMPLE 115, 4038.5-4038.9: shear zone ca. 30deg/core, 0.5-1cm thick with silica & hematite.	LITHIC RIDGE TUFF	Ash-flow tuff, slightly to densely welded, lt. purplish to greenish gray or lt. tan colors. Abundant biotite, some sphene. Sparse to abund. lithic fragments. Large pumice fragments, especially below 4010'. V. little biotite below 4021'.	Devitrified, lt. tan to lt. gray or lt. green expansive clay after pumice, biotite fresh. Clay abundant below 3900'.	No pyrite observed except one grain in lithic fragment at 4008'; no fracture fillings or veins.	3380'-3950': densely welded; 3950'-3965': moderately welded; poorly welded below 3965'; lt. tan above 3884', lt. gray 3884'-3945', lt. purplish gray 3945'-3985', lt. greenish-gray below 3985'. 4020.7'-4026': lost 2.5"core. 4021': unit break (as per USGS log) possibly moderately welded between 4026'-4030', otherwise similar to ash-flow tuff above 4021'.
4054-4135	1235.7-1260.3			Poorly to moderately welded ash-flow tuff, light red-grown color, abundant lithics to 3cm diameter, sparse biotite.	Devitrified, pumice replaced by light tan to light ochre, expansive clay, biotite unaltered.	no veins or fracture fillings.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4054-4135 (cont.)	1235.7-1260.3 (cont.)		LITHIC RIDGE TUFF		Devitrified, pumice replaced by light tan to light ochre, expansive clay, biotite unaltered.	no veins or fracture fillings.	
4135-4229	1260.3-1289.0	SAMPLE 116, 4165.4-4165.8: carbonate veinlets.		Moderately to poorly welded ash-flow tuff similar to that in above unit, but color is lt. tan and this tuff is harder and possibly more strongly welded. Abund. lithics to 5cm diameter, sparse biotite.		4165.7'-4166.1': discontinuous, white carbonate veinlet, moderate angle to core, planar to irregular.	
4229-4249	1289.0-1295.1			Ash-flow tuff as above, but color v. lt green to v. lt. gray.	Devitrified, pumice replaced by very light green to off-white, expanded clay.	no veins or fracture fillings.	4229'-4234': v. lt. green; 4234'-4249': v. lt. gray.
4249-4315	1295.1-1315.2	SAMPLE 117, 4276.1-4276.6: carbonate + silica ± fluorite vein, irregular, 5deg/core. SAMPLE 118, 4297.0-4297.3: 1cm-thick, planar calcite + quartz vein ca. 20deg/core.		Gray, poorly welded ash-flow tuff, slightly less lithics than in above unit, color becomes lighter gray below 4288, welding possibly stronger near base.	Devitrified, pumice fragments replaced by white to tan or lt. purple clay.	Sparse, irregular carbonate veins.	
4315-4410	1315.2-1344.2	SAMPLE 119, 4335.0-4335.5: 1mm to 1cm irreg. breccia vein, hematitic matrix 20deg/core. SAMPLE 120, 4366.8-4367.3: fracture zone with carbonate vein, crumbly, about 10deg/core, 2mm - 1cm thick. SAMPLE 121, 4399.6-4400.0: fracture lined with carbonate ± zeolite ± fluorite, 10deg/core, Photo 22, 50x.		Lt. greenish-gray to v. lt. gray or gray ash-flow tuff, poorly welded, similar to above unit. Welding is stronger and rock harder below 4374'.	Devitrified, white to lt. tan or lt. purple clay after pumice, biotite unaltered.	Some irreg. carbonate ± quartz ± fluorite veins.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4410-4435	1344.2-1351.8	SAMPLE 122, 4415.3-4415.8	LITHIC RIDGE TUFF	As above but lt. brownish gray color, moderately welded.	Devitrified, pumice replaced by off-white clay, partly expansive, biotite and feldspar appear unaltered.	Some irregular carbonate-quartz veins and fracture fillings, but none below 4430'.	
4435-4489	1351.8-1368.2			Mod. to poorly welded ash-flow tuff, mottled white and lt. gray. Mod. abund. to abund. lithic frags.	Devitrified, pumice replaced by off-white clay, partly expansive, biotite and feldspar appear unaltered.	No veins or fracture fillings above 4480'. At 4480', vein along shear, 70deg/core, 0.5cm thick.	
4489-4602	1368.2-1402.7	SAMPLE 123, 4501.8-4502.3: vein along shear. SAMPLE 124, 4599.8-4600.0: purple hematitic shear, silicified, 30deg with core, 3cm thick		Ash-flow tuff, v. lt. greenish brown to v. lt. olive green color, poorly welded above 4552', unwelded below that. Mod. abund. to abund. lithic frags. up to 2 cm diam.		Some hematite + carbonate ± quartz along shears 30deg/core. 4500'-4505': hematitic shear zone, 1-2cm thick, parallel/core, some carbonate ± silica, vertical slickensides. 4540'-4596': no veins or fract. fillings along shears.	4504': Photos 23 & 24, 6x. 4596'-4599.8': some soft shear zones.
4602-4695	1402.7-1431.0	SAMPLE 125, 4663.4-4463.7': grey ash-flow tuff.		As above, but gray color.	As above, but pumice replaced by gray to light olive green clay	4641'-4642': vein-carbonate along shear at about 30deg/core, sparse moderate- to high-angle/core hematitic shears to 4674'. 4674'-4679': no veins or fracture fillings.	

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4695-4748	1431.0-1447.2	SAMPLE 126, 4731.4-4731.7: irreg. carbonate-silica vein ca. 1cm thick, parallel/core.	LITHIC RIDGE TUFF	Ash-flow tuff, brownish red, mottled, sparse pumice fragments, lithics finer than in unit above.	Devitrified, pumice replaced by light olive green clay, biotite unaltered.	4729'-4732': irreg. carbonate-silica vein parallel/core. No veins or fracture fillings below 4737'.	
4748-4820	1447.2-1469.1	SAMPLE 127, 4750.7-4751.9: ash-flow tuff with green mineral and sparse sulfides. SAMPLE 128, 4767.1-4767.4: ash-flow tuff with silicified lithic fragment with pyrite ± molybdenite. SAMPLE 129, 4803.3-4803.6: carbonate + fluorite veins in green ash-flow tuff with pyrite in silicified lithics, Photo		Light greenish-gray ash-flow tuff, moderately welded.	Devitrified, pumice frags. replaced by expansive olive green to lt. green clay, biotite and feldspar apparently unaltered.	Sparse, v. fine grains of pyrite disseminated in matrix, v. sparse silicified lithic fragments with pyrite.	4756.5': sulfide in silicified lighic, Photo 25, 6x.
4820-4873	1469.1-1485.3	SAMPLE 130, 4850.5-4851.0: sparse pyrite in small lithic frags. in ash-flow tuff.		Ash-flow tuff as above, but v. lt. green color, mottled with green near top, sparse lithics. Appears to be welded; contains v. flat altered pumice fragments.		Trace disseminated sulfides in silicified lithics. 4864': thin, discontinous carbonate vein at mod. angle/core.	
4873-4883	1485.3-1488.3	SAMPLE 131, 4880.3-4880.5: bedded tuff, trace pyrite.	BDD. TUFF	Bedded tuff, mostly moderately sorted lt. reddish brown to light green, but some thin layers of fine, gray, graded volcaniclastic and one layer of well-sorted med.-grained air-fall tuff.	Devitrified, lt. apple green clay after pumice.	Trace pyrite.	Charcoal at 4873'.
4883-4991	1488.3-1521.2	SAMPLE 132, 4965.3-4965.5: ash-flow tuff.	OLDER TUFFS	Welded ash-flow tuff, v. lt. greenish gray to lt. pinkish tan or tan, but mottled tan and purple between 4924' & 4982' and lt. pink between 4982' & 4991'.	Devitrified, biotite and feldspar appear unaltered. 4883'-4911': pumice replaced by tan and lt. green clay + zeolite. 4911'-4991': pink to lt. purple clay after pumice.		

DEPTH(ft)	DEPTH(m)	SAMPLES	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4991-5031	1521.2-1533.4	SAMPLE 133, 5020.0-5020.4: carbonate + silica veins, possible fluorite.	OLDER TUFFS	Ash-flow tuff, as above, but pink.	Devitrified, pumice fragments replaced by purple clay, biotite and feldspar apparently unaltered.	5019'-5022': irreg. carbonate + silica veins.	

TOTAL
DEPTH 5031'.

APPENDIX E. UE 25b 1H LOG

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2800-2852.5	853.4-869.5	SAMPLE 154, 2805.5-2805.7.	BULLFROG MEMBER	Densely welded ash-flow tuff, bright pink at top to lt. green at bottom, sparse lithics.	Devitrified, pumice pinkish-brown with little or no clay down to 2839'; lt. olive-green to lt. pink with some expansive clay below 2839'. Biotite looks unaltered.	No veins, fract.fillings, or sulfide.	
2852.5-2882	869.5-878.4		BDD. TUFF	Lt. purplish gray to lt. green bedded tuff, mostly fine- to med.-grained air-fall or surge tuff, some med.- to crs.-grained, basal 2' poorly sorted.	Minor lt. green clay after pumice, biotite appears unaltered.	No veins or fracture fillings, no pyrite.	
2882-2943	878.4-897.0	SAMPLE 155, 2923.2-2923.4.	TRAM MEMBER, CRATER FLAT TUFF	Welded ash-flow tuff, sparse lithic frags., lt. pink at top to lt. gray or tan at bottom.	Devitrified. Pumice partly altered to off-white to tan clay; biotite appears unaltered.		
2943-3094	897.0-943.1	SAMPLE 156, 3033.4-3033.9: v. irreg. MnOx + carbonate ± quartz vein.		Lt. pink, mod. welded ash-flow tuff, more lithics than in above unit.	Devitrified. V. little other alteration, not even much clay.	3015'-3036': irreg. carbonate + MnOx veins. 3084'-3100': irreg. carbonate + MnOx veins, low-angle/core, <4mm thick.	2943'-2946': ash-flow tuff with abund. crs. lithic frags., probable interflow unit.
3094-3096	943.1-943.7			Bedded tuff.			

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3096-3150	943.7-960.1	SAMPLE 157, 3098-3098.5: MnOx + carbonate veins parallel/core.	TRAM MEMBER, CRATER FLAT TUFF	Ash-flow tuff, densely welded, v. lt. pink to lt.purplish-gray.		3120'-3125': carbonate + limonite veins, low-angle/core. 3132'-3148': sparse carbonate + limonite + MnOx veins, 20 to 30deg/core.	
3150-3217	960.1-980.6	SAMPLE 158, 3184.2-3184.7: irreg. carbonate ± quartz ± fluorite vein parallel/core, up to 1cm thick (extends from 3178-3189).		Densely welded lt. purplish gray to lt. gray spherulitic ash-flow tuff.	Devitrified, biotite and feldspar appear unaltered, spherulites replace pumice frags. Argillization of pumice v. minor.	3168'-3189': irreg. carbonate ± quartz ± fluorite veins subparallel/core.	3200'-3217': lt. reddish gray, lithic frags. locally abundant.
3217-3220	980.6-981.5			As above, but lithic-rich, abund. frags. to 3cm diam.			
3220-3360	981.5-1024.1	SAMPLE158, 3226.0-3226.3: ash-flow tuff. SAMPLE 160, 3301.4-3301.8: irreg. thin carbonate veinlet parallel/core. SAMPLE 161, 3309.1-3309.8: not taken.		Lt. gray to gray welded ash-flow tuff, spherulitic groundmass, mod. abund. to abund.lithic frags. to 3cm diam.	Devitrified, spherulitic alteration of pumice fragments minor, biotite and feldspar unaltered	3205-3210: sparse irreg. coalescing carbonate veinlets ± limonite, mod. angle/core, no pyrite. 3271'-3301': Sparse irreg. carbonate veinlets, various orientations.	3258.5'-3259.5' and 3262'-3263.5': v. abund. lithic frags. (>50%), probable lithic partings between ash flows. 3309'-3310': low-angle shear zone 1-2cm thick with limonite-coated fractures and breccia, 75deg/core.
		SAMPLE 162, 3326.3-3327.6: ash-flow tuff with silicified lithic frag. containing sulfide(?).		Gradational color change from lt. gray to lt. purple below 3321'. Basal 3' is purplish-gray.	3242'-3277': pumice replaced by v. lt. pinkish tan expansive clay.	3309' and 3310': low-angle shear zones with limonite. 3326': highest sulfide-bearing lithic, but little or no sulfide in unit below that. 3350'-3351': carbonate vein, discontinous, 10-20deg/core.	
3360-3400	1024.1-1036.3	SAMPLE 163, 3369.2-3369.7: air-fall(?) tuff layer or clast in ash-flow tuff, abund. disseminated pyrite.		V. lt. green to green to mottled light green and lt. purple lithic-rich ash-flow tuff; slightly welded, most pumice fragments flattened.	Light olive green to dark grass green expandable clay replacing pumice fragments	Pyrite disseminated in lithics, no veins or fracture fillings. 3369'-3370': lithic-rich air-fall tuff(?), contains abund. disseminated pyrite (cubes and broken grains) in matrix and some in lithic frags.	3369'-3370': layer or clast of lithic-rich air-fall(?) tuff. 3374.5'-3375.5': lithic-rich (>90%) layer or large clast; may be ash-flow or air-fall tuff.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3400-3550	1036.3-1082.0	SAMPLE 134, 3407.6-3408.0: sulfide in lithic frags. SAMPLE 135, 3449.0-3449.3: pyritic lithic frags. SAMPLE 136, 3488.6-3489.0: irreg. discontinous carbonate veinlet, ca. parallel/core.	TRAM MEMBER, CRATER FLAT TUFF	Lt. greenish gray, poorly welded ash-flow tuff with abund. lithic frags., pumice equant to somewhat flattened, relatively sparse biotite, quartz, and feldspar crystals. Abund. hornblende-biotite dacite porphyry lithics.	Pumice fragments altered to olive-green clay, probably expandable, biotite black to brassy. Lithic frags. variably altered with hornblende completely replaced.	Disseminated pryite in tuff and in silicified lithic frags. (latter is more common). Some frags. contain v. abund. pyrite. Irreg. carbonate veinlets below 3480'.	3449.5': shear with horizontal slickensides at 70deg/core.
		SAMPLE 137, 3533.6-3534.0: limonitic ash-flow tuff from rubble zone. SAMPLE 138, 3543.5-3543.9: quartz + carbonate vein and chloritic (?) breccia. SAMPLE 139, 3545.5-3546.0: chloritic (?) breccia vein.			Pumice fragments altered to olive green to dark grass green clay (chloritic?).	3522'-3550': limonitic and chloritic (?) breccia zones. Pyrite is not in veins or chloritic breccia, scattered quartz-carbonate veins are cut by chloritic (?) breccia.	3521'-3522': lost 1' core. 3524'-3529': lost 5' of core, rubble limonitic. 3531': 0.3' chloritic(?) breccia, mod. angle/core. 3531.5'-3534': limonitic rubble. 3536'-3544': rubble to solid core. 3545'-3546': chloritic breccia vein ca. 30deg/core.
3550-3899	1082.0-1188.4	SAMPLE 140, 3570.4-3571.0: carbonate + silica vein and chloritic (?) breccia. SAMPLE 141, 3584.0-3584.4: quartz vein, 1-3mm thick, planar-irreg., ca. parallel/core.		Slt. welded to unwelded ash-flow tuff, lt. greenish gray to lt. gray, abund. lithic frags., sparse biotite, v. similar to 3300'-3521' unit. Lithic frags. to 5cm, most are of intermediate volcanic rock.	Pumice fragments altered to v. lt. green to v. lt. olive green clay. Biotite sparse, but unaltered.	Pyrite in lithic frags. and disseminated in matrix, none in pumice frags. 3569'-3574.5': carbonate ± silica veins; no pyrite in veins, but some on edge of veins. 3569.5'-3574': chloritic (?) breccia. 3582'-3597': quartz ± carbonate veins, white to glassy lt. gray , mostly irreg., fairly sparse, do not appear to carry sulfide, most parallel-subparallel/core, some mod. angle/core. 3608'-3618': abund. quartz veins (±carbonate), mostly irreg., parallel/core, up to 2cm thick.	
		SAMPLE 142, 3613.8-3614.3: quartz vein cutting pyritic ash-flow tuff.			Minor limonitic staining locally below 3630'.	3620': LANL shows fluorite here, none observed by us.	
		SAMPLE 143, 3672.7-3673.0: fract. with slickensides. SAMPLE 144, 3688.7-3689.3: ash-flow tuff with pyritic lithics, possible sphalerite.				3655'-3665': planar-irreg. quartz veins. 3672'-3695': irreg. fracts. with horiz. or near-vert. slickensides and minor carbonate ± quartz. 3689': possible sphalerite in lithic frag.	Rubble in 3602'-3617.5' run, minor core lost. 3699'-3712': run has some rubble, especially 3706'-3709', where rock is soft and limonitic.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3550-3899 (cont.)	1082.0-1188.4 (cont.)	SAMPLE 145, 3745.8-3746.1: quartz + fluorite vein.	TRAM MEMBER, CRATER FLAT TUFF		3746'-3554': limonite stain.	3719'-3722': sparse, irreg., thin carbonate ± quartz veinlets. 3745': clear quartz + green fluorite vein, low angle/core; quartz veins to 3747'. 3750': drusy quartz vein in pyritic lithic frag.	3729'-3732': fracts. with horiz. to oblique slickensides. 3746': sulfide in lthic frags., Roll 2, Photos 4 and 5, 6x.
		SAMPLE 146, 3778.2-3778.6: pyritic ash-flow tuff.			3764'-3772': quartz-carbonate veins irreg., high-angle/core, especially abund. 3767'-3769'. 3780'-3797': patches of v. lt. brown limonite stain.	3799'-3800': quartz-carbonate vein, low angle/core.	3769': pyrite in lithic frag., Photos 6 and 7, 6x. 3799': Photo 8, 6x, pyritic lithic cut by vein.
		SAMPLE 147, 3825.7-3826.1: quartz + fluorite + carbonate vein.		May be mod. welded near base (relatively flat pumice frags.).	3831'-3840': mottled limonite stain.	3822'-3829': mod. abund. irreg. veins of quartz + carbonate + fluorite at 25deg/core, 2mm to 1cm thick.	3829': Photo 9, fluorite + quartz + carbonate vein, 6x; Photo 10, 6x; Photo 11, 12x, pyritic lithic cut by vein.
		SAMPLE 148, 3881.8--3882.2: pyritic ash-flow tuff, limonitic.			3876'-3884': strong limonite staining. 3884'-3892': weaker limonite.		3866': Photo 12, 6x, pyritic lithic frag. with carbonate vein and altered feldspar.
3899-3960	1188.4-1207.0	SAMPLE 149, 3902.4-3902.6: fine black tuff with abund. dissem. pyrite; Roll 2, Photos 1-3, 12x. SAMPLE 150, 3921.6-3921.9: tuff with dissem. pyrite. SAMPLE 151, 3934.5-3934.8: poorly-sorted tuff, no pyrite. SAMPLE 152, 3938.2-3938.6: carbonate + barite vein	BEDDED TUFF	Bedded tuff, thinly bedded to massive, v. lt. greenish gray to dk. gray, fine- to crs.-grained. Air-fall ± ash-flow ± surge ± reworked tuff. Top 2' is mod. sorted air-fall(?) tuff that grades into overlying ash-flow tuff.	Pumice replaced by very light green to light olive green clay, biotite ok	3902'-3902.7' (3902.7'-3902.9' missing): abund. pyrite in dk. fine tuff. No pyrite below 3927', but some magnetite. 3936'-3939': qtz. + calcite ± fluorite ± barite veins, mod. to high angle/core with horiz. slickensides. 3938.2'-3938.6': 1cm white carbonate + barite vein, ca. 35deg/core.	3899': pyritic lithic frags. in bedded tuff, Photos 13 &14, 6x; Photo 15, 12x. 3901'-3902.9': Thin bedded, well-sorted tuff with large welded pumice frags. at top. 3903'-3903.5': welded, crs. air-fall tuff. 3903.5'-3932': gray, fine- to med.-grained bedded tuff, some reworked, carbon frags. @ 3913'. 3932'-3957': mod. to poorly sorted, gray volcaniclastic (or possible ash-flow tuff). 3957'-3960': bedded tuff, lt. green to gray, med.-grained air-fall tuff to poorly sorted ash-flow tuff.
3960-4002.3	1207.0-1219.9	SAMPLE 153, 3976.3-3976.6: welded ash-slow tuff, no sulfides.	LITHIC RIDGE TUFF	Lt. pink to lt. greenish gray, strongly welded ash-flow tuff with sparse lithic frags.	Lt. olive green to greenish gray clay replacing pumice frags., biotite and feldspar appear unaltered.	No pyrite	

TOTAL DEPTH 4002.3'

APPENDIX F. UE 25p 1 LOG

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2860-2870	871.7-874.8			Bedded tuff, lt. purple, sandy.		No sulfide or vein material	
2870-2950	874.8-899.2		LITHIC RIDGE TUFF	Ash-flow tuff, nonwelded to slightly welded, lt. greenish gray with lt. brown and black lithic frags.		2870'-2910': no sulfide. 2910'-2920': quartz vein chips, limonite, pyrite(?) in lithic frag. 2920'-2960': no sulfide.	
2950-2960	899.2-902.2			Bedded tuff, tan, sandy.		No sulfide or vein material.	
2960-3300	902.2-1005.8			Ash-flow tuff, poorly welded, lt. green to lt. purple.			

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
2960-3300 (cont.)	902.2-1005.8 (cont.)		LITHIC RIDGE TUFF				
3300-3390	1005.8-1033.3			Bedded tuff (?), lt. purple to reddish brown, sandy.			
3390-3500	1033.3-1066.8			Ash-flow tuff, poorly welded, v. lt. green to lt. purple, minor brown lithic frags.			Sandy material and reddish brown chips in upper part of unit may be from overlying bedded tuff.

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3390-3500 (cont.)	1033.3-1066.8 (cont.)		LITHIC RIDGE			No sulfide or vein material.	
3500-3610	1066.8-1100.3		OLDER TUFFS	Ash-flow tuff or flow rock, white to lt. green or pink.			
3610-3700	1100.3-1127.8			Ash-flow tuff, mod. welded, lt. purple.			
3700-3860	1127.8-1176.5		CONGLOMERATE	Mostly lt. green to v. lt. purple volcanic rock chips. A few % gray limestone chips. USGS log mostly refers to this interval as "conglomerate."			

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
3700-3860 (cont.)	1127.8-1176.5 (cont.)		CONGLOMERATE			No sulfide or vein material.	
3860-3950	1176.5-1204.0		CALCIFIED ASH-FLOW TUFF	Ash-flow tuff, mod. welded, mostly lt. greenish gray. Trace gray limestone chips.			
3950-4080	1204.0-1243.6	SAMPLE 169, 4000-4010 (chips): ash-flow tuff + limestone + pyrite.	TUFF OF YUCCA FLAT (?)	Mostly ash-flow tuff chips, mod. welded, pink. Trace to 25% white to lt. brown or lt. bluish gray carbonate chips.		Pyrite in some lt. bluish gray carbonate chips. Minor drusy quartz chips.	

DEPTH(ft)	DEPTH(m)	SAMPLE	UNIT	LITHOLOGIC DESCRIPTION	ALTERATION	MINERALIZATION	DETAIL
4080-4180	1243.6-1274.1	SAMPLE 167, 4100-4110 (chips): mostly carbonate, some with pyrite. SAMPLE 168, 4170-4180 (chips): mostly carbonate, some with pyrite.	LONE MOUNTAIN DOLOMITE	Mostly carbonate chips (60-99%), white to lt. brown, lt. bluish gray or lt. greenish gray. Some white to pink ash-flow tuff chips.		Minor pyrite in carbonate.	

4180-5500 Not logged.

5500-5530	1676.4-1685.6	SAMPLE 164, 5500-5510 (chips): carbonate, no pyrite.	ROBERTS MOUNTAIN FORMATION	Carbonate, black to lt. gray		No pyrite or fluorite. Minor limonite, 5510'-5520' interval.	
5530-5590	1685.6-1703.8	SAMPLE 165, 5530-5540 (chips): mostly carbonate, trace fluorite cubes up to 1 mm and finely crystalline pyrite.		Brownish gray to dark gray or white carbonate.		Trace of finely crystalline pyrite chips. Trace white to grey or lt. purple fluorite, some cubic crystals to 2 mm diam., some fluorite crystals with pyrite dusting.	5530'-5540': Photos 15, 16 & 19, roll 2, fluorite cube, 12x; Ph. 17 & 18, pyrite; Ph. 20, pyrite on fluorite, 50x. 5570'-80': Ph. 21, py. + lim. 5580'-90': Ph. 22, fluorite, 12x.
5590-5610	1703.8-1710.0	SAMPLE 166, 5590-5600 (chips): carbonate, trace pyrite.		Brown to gray or white carbonate.		Minor limonite, trace pyrite, no fluorite.	

TOTAL DEPTH LOGGED 5610'