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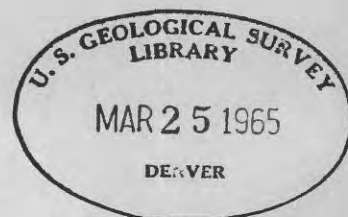
OUTLINE OF THE GEOLOGY OF THE U12i AND U12i.01 TUNNELS
AND LITHOLOGY OF THE U12i.01 DRILL HOLE,
NEVADA TEST SITE*

By

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November 1963

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This report has not been edited
for conformity with Geological
Survey nomenclature.

*Prepared on behalf of the
U.S. Atomic Energy Commission

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OUTLINE OF THE GEOLOGY OF THE U12i AND U12i.01 TUNNELS
AND LITHOLOGY OF THE U12i.01 DRILL HOLE,
NEVADA TEST SITE

By W. E. Bowers

Descriptive data for the U12i tunnel system are summarized in table 1.

The U12i and U12i.01 tunnels were driven northward beneath the mesa approximately 1 mile northeast of Survey Butte in tuffs of the Survey Butte Member of the Piapi Canyon Formation of early Pliocene or younger age (fig. 1). The 95 feet of this member exposed in the U12i tunnel system consists of vitric or vitric-crystal, fine to lapilli, well-bedded to structureless tuffs, which commonly show cyclic repetition of color, texture, and bedding characteristics. The lower part of rocks representing each cycle is usually lighter in color, coarser in texture, and more distinctly bedded than the upper part.

The stratigraphic section measured in the U12i and U12i.01 tunnels is shown in table 2 and on figure 2. Thickness of the subunits ranges from 3 to more than 13 feet.

Beds in the U12i tunnel strike predominantly N. 5° E., nearly parallel to the trend of the tunnel, and dip 20° to 25° NW. (fig. 3). In the U12i.01 tunnel the beds strike about N. 10° E. and dip 10° to 20° NW.

Table 1.--Descriptive data for the U12i and U12i,01 tunnels

	U12i	U12i,01	
		LOS No. 1	LOS No. 2
Nevada State coordinates (rounded):			
Portal of tunnel:			
North-----	899,052	899,319 ^{1/}	899,451 ^{1/}
East-----	647,677	647,677 ^{1/}	647,577 ^{1/}
Working point:			
North-----	899,489 ^{1/}	900,127	900,127
East-----	647,651 ^{1/}	647,602	647,602
Elevation (ft above sea level):			
Portal of tunnel-----	5,635	5,638 ^{1/}	5,639 ^{1/}
Working point-----	5,640	5,647 ^{1/}	5,647 ^{1/}
Length (ft)-----	456	887	693
Bearing (predominant)-----	N. 00°00'	N. 10°15' E.	N. 00°00'
Maximum vertical cover above working			
point (ft)-----	295	647	647
Minimum cover above working point			
(ft)-----	230	630	630

^{1/} Approximate.

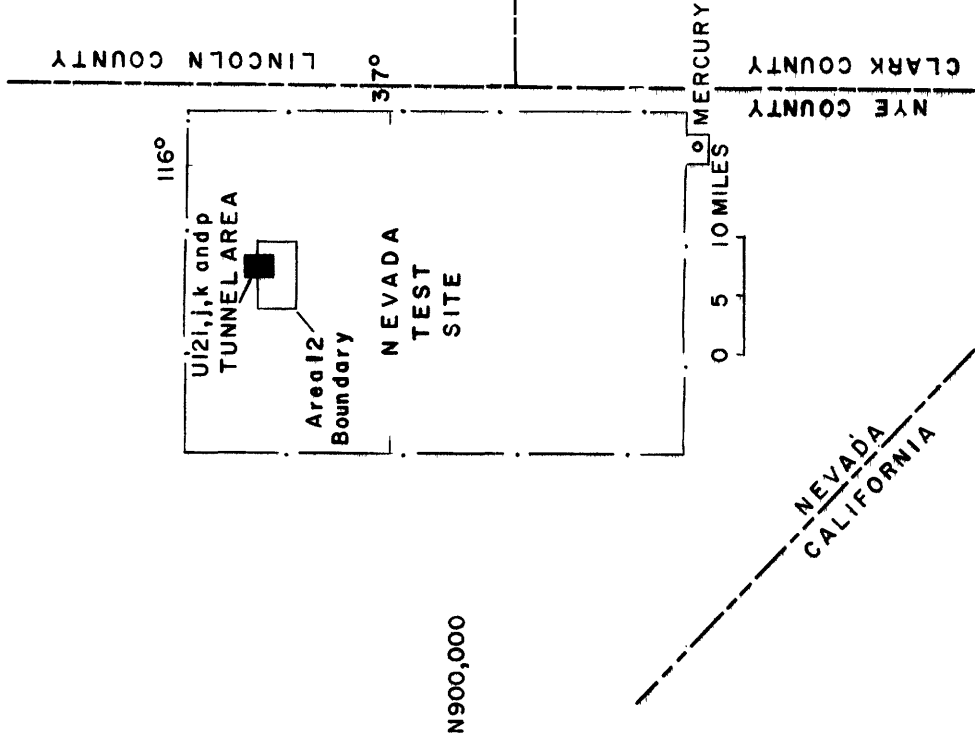
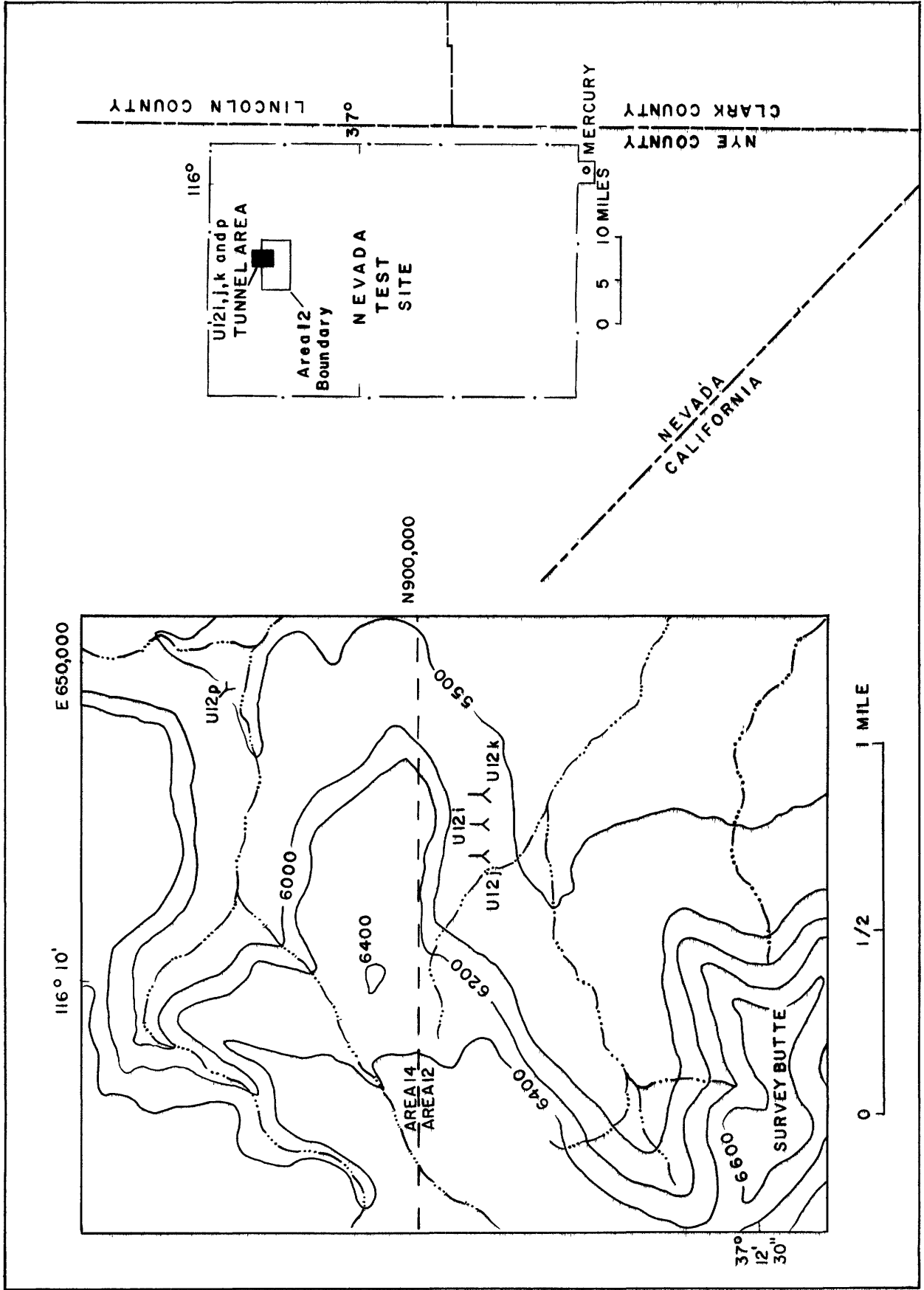


Figure 1.- INDEX MAP SHOWING THE TUNNEL AREA NORTHEAST OF SURVEY BUTTE, NEVADA TEST SITE

Table 2.--Stratigraphic section measured in U12i and U12i.01 tunnels

[All subunits are in the Survey Butte Member of the Piapi Canyon Formation. Top of section is in stub of chamber access drift. Base of section is at tunnel portal. Measured by F. N. Houser, W. L. Emerick, and V. R. Wilmarth]

Subunit	Description (all percentages are approximate)	Thickness (ft)
I-13	Tuff, vitric, white in lower 2 ft to light-brown above; exposed in end of 35-ft stub off access drift-----	5.5 (min)
I-12	Tuff, vitric-crystal, fine to coarse, brown; structureless in upper part with fine glass shards (65 percent), coarse to lapilli white pumice (1 to 2 percent), quartz and feldspar crystals (30 percent), and black obsidian fragments (2 percent); opal nodules (0.02 to 0.2 ft in diameter) with colorless to dark-gray cores and pink to white soft rinds are concentrated about 1 ft below top of unit. Lower 2 ft is vitric-crystal, well-bedded, white to light-gray, fine tuff (some coarse beds) with fine glass shards (70 percent), coarse white pumice, obsidian fragments, crystals of quartz and feldspar (25 percent), and brown and black lithic fragments (5 percent); basal 0.1 ft coarse to lapilli with coarse black obsidian. Basal contact is sharp and slightly irregular through 0.3 ft stratigraphically at 0+17R and 0+24L in stub off access drift between LOS No. 1 and chamber-----	4.6
I-11	Tuff, vitric-crystal, fine to coarse, brownish-gray in upper part; glass (60 percent) is fine shards, coarse white pumice, and coarse gray obsidian fragments; crystals (20 to 30 percent) of quartz and feldspar, brown to black lithic fragments (5 percent); upper 3 to 4 ft slightly coarser and has lapilli white pumice (1 to 2 percent) with thin yellowish-brown rinds. Lower 3 ft is well laminated (0.03 to 0.3 ft thick), coarse, and interbedded white and brownish-gray. Basal contact at 84L and 101R in access drift between LOS No. 1 and chamber-----	12.5 (est.)

Table 2.--Stratigraphic section measured in U12i and U12i.01 tunnels--
Continued

Subunit	Description (all percentages are approximate)	Thickness (ft)
I-10	Tuff, vitric-crystal, fine to coarse, brownish-gray; contains crystals (60 percent) of quartz and feldspar, fine glass shards (20 to 30 percent), sparse pumice, and brown and black lithic fragments (5 to 10 percent); well laminated (0.01 to 0.05 ft thick). Lower 0.2 to 0.5 ft is white, lithic, vitric, pumiceous, fine to coarse; contains glass as lapilli white pumice (65 percent) and obsidian (10 to 15 percent), coarse, brown to black lithic fragments (5 to 20 percent); bed is locally scoured or slumped out and beds normally 0.5 to 1.0 ft higher deposited in depressions, resulting in moderately high primary dips; opal nodules (0.2 to 0.4 ft in diameter) with white cores and dark-gray or brown rinds common. Basal contact at 0+50L and 0+80R in access drift between LOS No. 1 and chamber-----	3.0
I-9	Tuff, vitric, fine to coarse, brownish-gray, laminated to well-bedded (0.01 to 0.8 ft thick), with thinner beds of white or light gray; contains gray glass fragments (10 to 30 percent), brown and black lithic fragments (5 to 10 percent); upper contact sharp but slightly irregular through 0.2 ft stratigraphically. Lower 2 ft is vitric, coarse to lapilli, light gray, well bedded; beds 0.05 to 0.4 ft thick; grades into upper brownish bed; fine tuff layer (0.2 ft thick) occurs 1.1 ft above base. Basal contact at about 6+88L in U12i.01L (LOS No. 1)-----	5.0
I-8	Tuff, vitric-crystal, coarse, brownish-gray, thick-bedded; dark brownish gray in upper 1.7 ft except uppermost 0.3 to 0.5 ft which is rusty brown; contains lithic fragments (10 to 15 percent) in lower part, lapilli white pumice (<1 percent), black obsidian fragments (<1 percent). Lower 0.5 ft is vitric-crystal, lithic, fine to coarse, light gray; contains lithic fragments (10 percent), glass as gray obsidian and coarse white pumice (50 percent),	

Table 2.--Stratigraphic section measured in U12i and U12i:01 tunnels--
Continued

Subunit	Description (all percentages are approximate)	Thickness (ft)
I-8--Continued	and crystals of quartz and feldspar (95 percent); lapilli pumice bed 0.02 ft thick at 1.1 ft above base. Basal contact 6+80R in U12i:01L, and 5+76L to 6+00R in U12i:01R (LOS No. 2)-----	4.0
I-7	Tuff, vitric-crystal, coarse, white, except about 10 percent brown and tan interbeds, well-bedded; beds 0.2 to 0.8 ft thick in lower 1.5 to 2.8 ft, 0.01 to 1.2 ft thick in middle of unit; some beds contain as much as 15 percent lithic fragments whereas other beds contain less than 1 percent. From 4.0 to 6.3 ft above base unit grades to very well sorted, laminated to bedded (0.01 to 2.0 ft thick), medium-gray, fine to coarse, crystal tuff with vitric groundmass (10 percent) and fine brown lithic fragments (1 percent). Basal contact at 2+41L and 2+47R in U12i:01L (LOS No. 1) tunnel-----	10.0
I-6	Tuff, vitric-crystal, fine to coarse, tan to tannish-gray, structureless; contains crystals (60 to 70 percent), glass as lapilli gray obsidian fragments in lower part; coarse to lapilli lithic fragments (5 to 10 percent), opal nodules 4.6 ft above base; bottom of a moderately well bedded light-gray interval 1.2 ft thick with gradational upper and lower contacts is 5.0 ft above base of unit; middle of 1.2 ft interval contains 0.2 ft bed of very fine tuff free of megascopic crystals and lithic fragments. Lower 2.4 ft is crystal, fine to coarse, light-gray (lower 0.7 ft) tuff grading to tannish-gray lapilli (0.03 to 0.05 ft thick) tuff at 0.7 ft above base; layer of lapilli lithic fragments (20 to 40 percent) at 0.7 ft above base; glass includes medium- to light-gray obsidian fragments; finely laminated in lower 0.7 ft with beds 0.05 to 0.3 ft thick. Lower contact gradational to moderately sharp at 1+86L and 2+17R in U12i:01R (LOS No. 2)-----	13.7

Table 2.--Stratigraphic section measured in U12i and U12i.01 tunnels--
Continued

Subunit	Description (all percentages are approximate)	Thickness (ft)
I-5	Tuff, crystal, coarse, friable, brown, indistinctly bedded in upper part of unit; grades to tannish-gray pumiceous crystal tuff at 2.8 ft above base; contains coarse to lapilli white pumice (< 5 percent) and groundmass shards (30 percent) in upper part. Lower 2 ft is vitric-crystal, coarse to lapilli, white structureless tuff; contains crystals (45 percent), fine glass shards (45 percent), and dark-gray and brown coarse to lapilli lithic fragments (10 percent); lapilli lithic fragments in lower 0.3 ft; contact with overlying brownish beds sharp. Basal contact moderately sharp at 1+55L and 1+61R in U12i.01 tunnel-----	8.0
I-4	Tuff, pumiceous, brownish-gray in upper 3.0 ft; contains white pumice (10 percent). Lower 6.0 ft is vitric coarse white tuff; contains crystals (<5 percent) of quartz, feldspar, and biotite, brown and black lapilli lithic fragments (5 percent); yellow blotches 0.02 to 0.1 ft across are common in lower part; tannish-gray irregular inclusions of vitric tuff containing lithic fragments and biotite occur 5.0 to 5.5 ft above base. Basal contact at 1+29R and 1+16L in U12i.01 tunnel-----	9.0
I-3	Tuff, vitric-crystal, structureless in upper 5.5 ft of unit; bed 1.0 to 1.7 ft from top is light-gray, coarse to lapilli, well-bedded, pumiceous, lithic tuff with white pumice (5 to 30 percent) and lithic fragments (5 to 20 percent) in beds 0.05 to 0.2 ft thick. Lower 2.5 ft is vitric-crystal, coarse, friable to moderately hard, white tuff; contains fine glass shards (40 percent), quartz and feldspar crystals (55 percent), bronze-colored biotite (<1 percent), and coarse lithic fragments; inclusions 0.2 to 0.4 ft wide in upper 0.5 ft. Basal contact is moderately sharp at 0+83L and 0+94R in U12i.01 tunnel-----	8.1

Table 2.--Stratigraphic section measured in U12i and U12i.01 tunnels--
Continued

Subunit	Description (all percentages are approximate)	Thickness (ft)
I-2	Tuff, crystal, coarse, friable, light brownish-gray, structureless; coarsens to lapilli at top; includes glass as coarse white pumice (10 percent), coarse lithic fragments (1 to 2 percent), and indistinct rounded inclusions (similar to lower part of unit) 0.2 by 1.0 ft across whose elongate dimensions are commonly disoriented with respect to bedding attitude; contact gradational with lower part. Lower 1 ft is crystal, coarse, friable, very light gray to white, well-bedded tuff; crystals include bronze-colored biotite (1 to 2 percent); coarse brown lithic fragments (5 percent), coarse black obsidian fragments (1 percent); very little groundmass; beds are 0.01 to 0.1 ft thick. Basal contact at 0+47R and 0+27L in U12i.01 tunnel-----	7.0
I-1	Tuff, vitric, fine to coarse, friable, tan to light-brown, structureless; contains fine lithic fragments (5 percent), coarse to lapilli pumice (5 to 15 percent), and crystals (5 to 10 percent) of feldspar and quartz; indistinctly bedded in upper 2 ft; upper contact moderately sharp at 0+47R and 0+27L in U12i.01 tunnel; base not exposed-----	5.0 (min)

Minor faults occur only in the first 200 feet of the U12i tunnel. Joints also are minor, with 55 percent trending northeastward and 45 percent northwestward. Most joints dip 70°, or more, either to the east or to the west, but some are vertical (fig. 3).

Physical properties, chemical compositions, and spectrographic analyses of samples from the vicinity of the U12i.01 chamber are shown in tables 3, 4, and 5, respectively. No significant differences exist in the physical or chemical nature of the tuffs near the chamber.

The dry-bulk density for seven samples ranges from 1.22 to 1.58 g/cc and averages 1.44 g/cc. Porosity ranges from 32.1 to 47.0 percent and averages 37.4 percent. Sample U12i.01-5 from subunit I-12, which is exposed in the end of the westerly trending stub from the access drift west of the chamber (fig. 3), shows a slightly higher Fe_2O_3 and MgO content plus a trace of La which is not found in the other samples.

X-ray diffractometer analyses of seven samples are shown in table 6. All samples are composed mainly of glass, but also contain from 1 to 10 percent quartz and from 1 to 25 percent feldspar. Four samples, K35-1 through K35-4, which were collected from the same stub as sample U12i.01-5, have a clay content ranging from 1 to 25 percent. Two of the samples contain from 1 to 10 percent cristobalite. Nodules of silica occur in the upper part of subunit I-12 from which the samples were collected. Neither clay nor cristobalite was found in the 3 samples from the U12i.01 chamber.

Table 3.--Density, porosity, water content, and magnetic susceptibility values for samples from the vicinity of the UL2i.01 chamber

[Analysts: D. R. Cunningham, John Moreland, and E. F. Monk]

Sample number	Thickness represented (ft)	Dry bulk density (mercury method, g/cc)	Grain density (powder method, g/cc)	Porosity (percent)	Water content (percent by weight)	Water content (percent by volume, g/cc)	Natural-state bulk density (g/cc)	Magnetic susceptibility (air-dried chips, 10^{-6} cgs units)
UL2i.01-1	3.0	1.58	2.33	32.1	6.3	0.107	1.69	36.5
2	4.0	1.36	2.32	41.1	10.5	.161	1.53	64.2
3	3.0	1.50	2.30	34.8	7.7	.124	1.62	60.9
4	3.0	1.44	2.28	37.0	10.6	.171	1.61	62.3
5	2.0	1.45	2.30	36.6	6.9	.107	1.56	65.1
6	2.0	1.56	2.33	33.0	10.7	.188	1.75	67.6
7	2.6	1.22	2.30	47.0	16.0	.233	1.45	49.2
Average---	2.8	1.44	2.31	37.4	9.8	.156	1.60	58.0

Table 4.--Chemical analyses of samples from the vicinity of the U12i.01 chamber

[Analyzed by methods similar to those described in USGS Bulletin 1036-C, Rapid analysis of silicate rocks, by Leonard Shapiro and W. W. Brannock, 1956, p. 19-56. Analysts: P. L. D. Elmore, S. D. Botts, and G. W. Chloee]

Sample number-----	U12i.01-1	U12i.01-2	U12i.01-3	U12i.01-4	U12i.01-5	U12i.01-6	U12i.01-7	Average
	Access drift			LOS No. 1				
Location-----	306L+1	305L+6.5	299L+2.4	290R+6	35R+3.5	762L+1	762L+4	
Thickness repre- sented (ft)-----	3.0	4.0	3.0	3.0	2.0	2.0	2.6	2.8
SiO ₂ -----	73.2	73.4	73.3	71.0	70.2	72.8	73.4	72.5
Al ₂ O ₃ -----	12.4	12.5	12.4	12.6	12.9	12.4	12.2	12.5
Fe ₂ O ₃ -----	.63	.64	.59	.79	.86	.73	.55	.68
FeO-----	.28	.27	.29	.28	.22	.25	.28	.27
MgO-----	.40	.39	.43	.58	.90	.55	.22	.50
CaO-----	.54	.60	.46	.70	.72	.60	.45	.58
Na ₂ O-----	2.4	2.4	2.4	2.2	2.2	2.3	2.4	2.3
K ₂ O-----	5.1	5.3	5.2	5.1	4.9	5.1	5.4	5.2
H ₂ O-----	5.1	5.1	5.0	6.0	7.5	5.6	5.0	5.6
TiO ₂ -----	.12	.12	.12	.14	.16	.12	.12	.13
P ₂ O ₅ -----	.02	.02	.02	.01	.01	.01	.01	.01
MnO-----	.07	.06	.07	.06	.06	.06	.05	.06
CO ₂ -----	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Sum-----	100	100	100	100	100	100	100	100

Table 5.--Semi-quantitative spectrographic analyses, in percent, of samples from the vicinity of the UL2i.01 chamber

[Results are reported in percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc., which represent approximate midpoints of group data on a geometric scale. The assigned group for semi-quantitative results will include the quantitative value about 30 percent of the time. Looked for but not detected: Ag, As, Au, Bi, Cd, Ce, Co, Cr, Ge, Hf, Hg, In, Li, Mo, Ni, Pd, Pt, Re, Sb, Sc, Sn, Ta, Te, Th, Tl, U, V, W, Zn. Analyst: J. C. Hamilton]

Sample number---	UL2i.01-1	UL2i.01-2	UL2i.01-3	UL2i.01-4	UL2i.01-5	UL2i.01-6	UL2i.01-7
	Access drift				Access stub	LOS No. 1	
Location-----	306L+1	305L+6.5	299L+2.4	290R+6	35R+3.5	762L+1	762L+4
B-----	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Ba-----	.01	.02	.015	.015	.007	.015	.007
Be-----	.0003	.0003	.0003	.0003	.0003	.0002	.0003
Cu-----	.0007	.0007	.0007	.0007	.0005	.0005	.0007
Ga-----	.003	.003	.002	.003	.003	.003	.003
La-----	<u>1/0</u>	<u>1/0</u>	<u>1/0</u>	<u>1/0</u>	.007	<u>1/0</u>	<u>1/0</u>
Nb-----	.003	.003	.002	.002	.002	.002	.002
Pb-----	.003	.005	.005	.003	.003	.003	.003
Sr-----	.005	.005	.005	.007	.005	.007	.005
Y-----	.003	.003	.003	.003	.003	.003	.003
Yb-----	.0003	.0003	.0003	.0003	.0003	.0003	.0003
Zr ^{2/} -----	.007	.007	.007	.007	.007	.007	.007
Pr ^{2/} -----	-----	-----	-----	-----	0	-----	-----
Nd ^{2/} -----	-----	-----	-----	-----	0	-----	-----
Sm ^{2/} -----	-----	-----	-----	-----	0	-----	-----
Eu ^{2/} -----	-----	-----	-----	-----	0	-----	-----

1/ Looked for but not detected.

2/ Looked for only when La or Ce found.

Table 6.--X-ray diffractometer analyses of seven samples from the vicinity of the U12i.01 Chamber

[The amounts of the constituents are estimated by the intensity of X-ray diffractometer pattern and are at best only rough approximations: 1 = >75 percent, 2 = 50 to 75 percent, 3 = 25 to 50 percent, 4 = 10 to 25 percent, and 5 = <10 percent. Analyst: Theodore Botinelly]

Sample number ^{1/}	Glass	Quartz	Feldspar		Clay	Cristobalite
			Potassium ^{2/}	Plagioclase		
K34-1	1-2	4-5	-----	5	-----	-----
2	1-2	5	-----	4	-----	-----
3	1-2	5	-----	5	-----	-----
K35-1	2	5	-----	5	4	-----
2	2	5	-----	5	5	-----
3	2	5	5	4	4	5
4	2-3	5	-----	4-5	4	5

1/ Samples K34-1 through K34-3 are from the northeast corner of the chamber. Samples K35-1 through K35-4 are from the stub of the access drift between LOS No. 1 and the chamber (fig. 3).

2/ Distinction between potassium feldspar and plagioclase made only where peaks for potassium feldspar were distinct. Potassium feldspar may be present in small amounts in all samples.

A vertical hole drilled from the top of the mesa to the U12i.01 chamber was cored from a depth of 451 feet to the bottom of the hole at 647 feet. Core recovery for this 196-foot interval averaged 68 percent.

A lithologic log of this drill hole (table 7) shows 56 feet of dark-gray to pinkish-gray welded tuff in the upper part, underlain by about 77 feet of pink vitric ash-flow tuff, which in turn is underlain by 63 feet of light-gray to brown bedded tuff in the lower part. Core recovery in the well-bedded tuff was poor, averaging about 17 percent. In the intervals above, however, the recovery averaged 76 percent.

Figure 4 is a graphic section constructed from the lithologic log of the U12i.01 drill hole. True thickness of units may be as much as 5 percent less than drilled thickness because of dips as steep as 20°. A change in lithology at a depth of 635 feet is tentatively correlated with the contact between subunits I-11 and I-12 in the U12i.01 tunnel.

Physical properties of some samples taken from the U12i.01 core are shown in tables 8 and 9. Significant differences are noted in the physical property values for welded tuff compared with nonwelded tuff.

The dry bulk density for six welded-tuff samples averages 2.29 g/cc compared with an average of 1.64 g/cc for three nonwelded tuff samples. Average porosity is 4.7 percent for the welded tuff compared with 30.5 percent for the nonwelded tuff. Gas permeability is less than 0.01 millidarcy in all welded-tuff samples and ranges from 12.0

Table 7.--Lithologic log of the U12i.01 vertical drill hole

Logged by: F. N. Houser
 Nevada State coordinates: N. 900,129.47 and E. 647,595.33
 Ground elevation: 6,304 ft
 Total depth (driller): 647 ft

Description (all percentages are approximate)	Interval (ft)
Core begins at 451 ft	
Piapi Canyon Formation (incomplete):	
Rainier Mesa Member:	
Tuff, welded, vitric, fine, dark-gray; contains glass (85 percent) as fine welded shards and perlitic obsidian (formed from pumice) in lenticular masses with length-to-thickness ratio of 4:1 to 20:1, fine to coarse crystals (15 percent) of iridescent sanidine, plagioclase, and biotite; core recovery 54 percent-----	451-467
Tuff, welded, brownish-gray, with lithophysae (as large as 1 by 2.5 by 2.5 cm), largest and most numerous in middle; compaction foliation and planar orientation of lithophysae nearly horizontal; groundmass has stony appearance; core recovery >75 percent-----	467-479
Tuff, welded, pinkish-gray with brown and black wisps of glass (15 percent), crystals (25 percent); collapsed pumice is partly crystallized; lithophysae in lower 7 ft; core recovery >80 percent-----	479-507
No core-----	707-521
Survey Butte Member:	
Tuff, vitric, fine to coarse, structureless, pale-pink and pale orange-gray; contains glass (85 to 90 percent) as fine shards and coarse to lapilli white pumice, slightly collapsed in upper part; some crystals (10 percent); coarse to lapilli dark-brown lithic fragments (<2 percent); core recovery >80 percent-----	521-584

Table 7.--Lithologic log of the U12i:01 vertical drill hole--Continued

Description (all percentages are approximate)	Interval (ft)
Piapi Canyon Formation (incomplete)--Continued	
Survey Butte Member--Continued	
Tuff, vitric-crystal, fine to coarse, well-bedded white to light-gray; contains crystals (25 percent) and coarse to lapilli dark-brown lithic fragments (4 to 5 percent); pumice slightly smaller and less abundant than in interval above; core recovery <50 percent-----	584-603
Tuff, vitric, fine, structureless, orange-brown; glass is fine shards and sparse coarse white pumice; contains coarse, commonly rounded crystals (20 to 30 percent) of quartz and feldspar, and coarse dark-gray lithic fragments (5 to 10 percent); core recovery 10 percent-----	603-618
Tuff, interbedded vitric and crystal, fine, light brownish-gray; contains glass (35 to 75 percent) as fine shards partly altered to clay; coarse white pumice and coarse obsidian fragments; fine to coarse crystals (25 to 45 percent) of quartz, feldspar, and biotite; some fine magnetite, biotite, or dark lithic fragments (1 to 2 percent) more conspicuous than percentage suggests; coarse dark-gray to black lithic fragments (5 to 10 percent); very friable; core recovery 12 percent-----	618-635
Tuff, vitric, fine, light tannish-gray; contains glass as fine shards, coarse white pumice, and colorless obsidian fragments; fine to coarse feldspar crystals (30 to 50 percent); fine to coarse dark-gray and brown lithic fragments (5 percent); friable; core recovery 42 percent--	635-647
Bottom of core 647 ft.	

Table 8.--Density, porosity, and magnetic susceptibility values for samples from the U12i.01 drill hole

[Analyzed by kerosene saturation method and magnetic susceptibility bridge. Analysts: D. R. Cunningham, John Moreland, and E. R. Monk]

Sample number (number indicates depth in feet)	Dry bulk density (g/cc)	Grain density (g/cc)	Saturated bulk density (g/cc)	Porosity (percent)	Magnetic susceptibility (10^{-6} cgs units)
Welded tuff					
I-453	2.34	2.36	2.35	0.7	287.3
466	2.37	2.46	2.41	3.7	331.8
474	2.37	2.46	2.40	3.6	301.8
487	2.16	2.28	2.21	5.5	276.7
494	2.15	2.40	2.25	10.4	281.6
500	2.34	2.45	2.39	4.6	255.1
Average--	2.29	2.40	2.33	4.7	289.0
Nonwelded tuff					
I-524	1.81	2.37	2.04	23.7	241.0
532	1.51	2.34	1.87	35.5	228.3
535	1.59	2.35	1.92	32.4	222.8
Average--	1.64	2.35	1.94	30.5	230.7

Table 9.--Gas permeability values for seven samples from the U12i.01 drill hole

[Values obtained using Ruska gas permeameter No. 6549 with nitrogen gas at 0.5 atmospheres. Analyst: E. F. Monk]

Sample number (number indicates depth in feet)	Gas permeability (millidarcys)	
	Horizontal	Vertical
Welded tuff		
I-464	<0.01	<0.01
482	<0.01	<0.01
505	<0.01	<0.01
Nonwelded tuff		
I-537 ^{1/}	15.7	12.0
548 ^{1/}	23.9	-----
580 ^{1/}	-----	26.5
583 ^{1/}	-----	49.1

^{1/} Sample not susceptible to water saturation.

to 49.1 millidarcys in the nonwelded samples that were susceptible to analysis.

X-ray analyses of three welded-tuff samples and seven nonwelded-tuff samples from the U12i.01 core are given in table 10. In general, the welded-tuff samples had less content of glass and more content of quartz, feldspar, and cristobalite than the nonwelded samples.

Four samples of nonwelded ash-flow tuff from a 13-foot interval, beginning about 15 feet below the base of the welded tuff, show clay content ranging from 1 to 25 percent. Three of these samples contain from 1 to 10 percent cristobalite. Pumice fragments in the upper part of this interval are slightly collapsed. Three samples of the nonwelded tuff from a 45-foot interval below this contain no clay or cristobalite but are more than 75 percent glass.

These X-ray data and the presence of partly crystallized fiamme in the welded tuff indicate a zone of slight to moderate devitrification extending from the upper part of the nonwelded ash flow into the lower part of the welded tuff.

Table 10.--X-ray diffractometer analyses of 10 samples from the
U121.01 drill hole

[The amounts of the constituents are estimated by the intensity of X-ray diffractometer pattern and are at best only rough approximations: 1 = >75 percent, 2 = 50 to 75 percent, 3 = 25 to 50 percent, 4 = 10 to 25 percent, and 5 = <10 percent. Samples are mostly glass with phenocrysts of quartz and feldspar. Distinction between potassium feldspar and plagioclase made only where peaks for potassium feldspar were distinct. Potassium feldspar may be present in small amounts in all samples. Analyst: Theodore Botinelly]

Sample number (number indicates depth in feet)	Glass	Quartz	Plagioclase feldspar	Clay	Cristobalite
Welded tuff					
I-494	2	4-5	4	----	3-4
500	3	4	4	----	3
505	3	4	4	----	3
Nonwelded tuff					
I-524	2	5	5	5	5
532	2	5	5	5	5
535	2	5	5	4	-----
537	2	5	5	4	5
548	1	5	5	----	-----
560	1	5	5	----	-----
583	1	5	5	----	-----