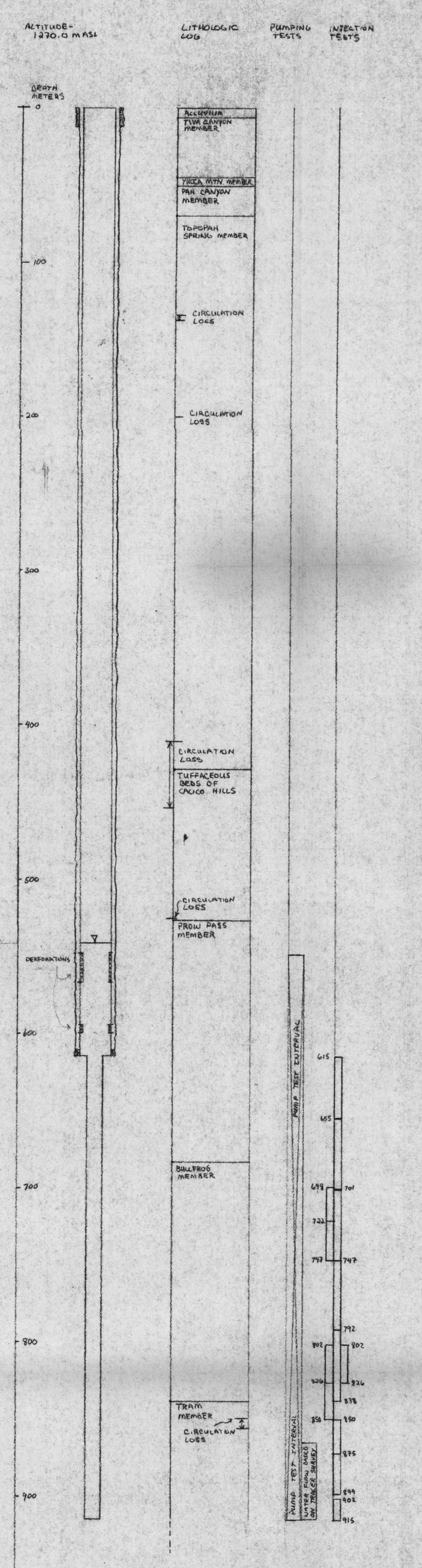
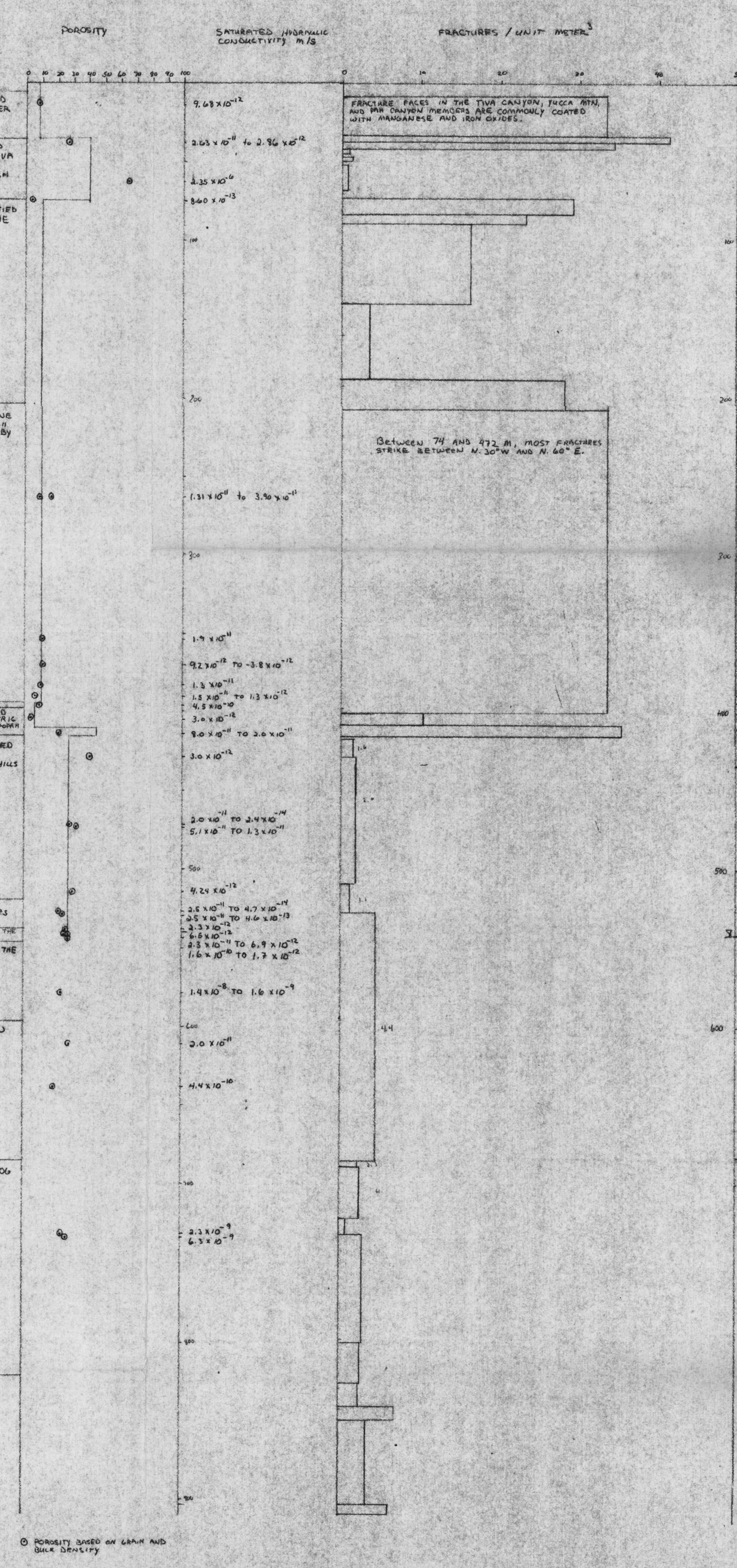
TEST WELL
USW 6-4



UNIT	HYDROLOGIC UNIT	DESCRIPTION
I-A	TIVA CANYON WELDED UNIT	MODERATELY TO DENSELY WELDED, DEVITRIFIED ASH-FLOW TUFF IN THE TIVA CANYON MEMBER OF THE PAINTBRUSH TUFF.
I-B	PAINTBRUSH NONWELDED UNIT	PARTIALLY WELDED TO NONWELDED, VITRIC AND OCCASIONALLY DEVITRIFIED TUFFS OF THE TIVA CANYON, YUCCA MOUNTAIN, PAH CANYON, AND TOPOPAH SPRING MEMBERS OF THE PAINTBRUSH TUFF
II-L	TOPOPAH SPRING WELDED UNIT	MODERATELY TO DENSELY WELDED, DEVITRIFIED ZONE OF THE TOPOPAH SPRING MEMBER OF THE PAINTBRUSH TUFF THAT CONTAINS MORE THAN APPROX. 10% BY VOLUME OF VUGS
II NL	TOPOPAH SPRING WELDED UNIT	MODERATELY TO DENSELY WELDED, DEVITRIFIED ZONE OF THE TOPOPAH SPRING MEMBER OF THE PAINTBRUSH TUFF THAT CONTAINS LESS THAN APPROX. 10% BY VOLUME OF VUGS. THIS IS THE POTENTIAL REPOSITORY UNIT.
III	TOP. SPRING W. BASAL VITROPHYRE	BASAL VITROPHYRE OF THE TOPOPAH SPRING MEMBER
IV-AV	VITRIC CALICO HILLS NW.	NONWELDED ASHFLOWS, BEDDED AND REWORKED TUFFS, VITRIC AND PRIMARILY NONZEOLITIZED TOPOPAH SPRING MEMBER AND/OR THE CALICO HILLS
IV-AZ	ZEOLITIZED CALICO HILLS NONWELDED UNIT	NONWELDED ASHFLOWS, BEDDED AND REWORKED TUFFS, PRIMARILY ZEOLITIZED, FROM THE TOPOPAH SPRING MEMBER AND/OR THE CALICO HILLS
IV-BZ	ZEOLITIZED CALICO HILLS NONWELDED	BASAL, BEDDED AND REWORKED ZONE OF THE ZEOLITIZED TUFFS AND TUFFACEOUS SANDSTONES OF THE CALICO HILLS.
IV-CZ	" " "	UPPER ZEOLITIZED ZONE OF THE PROW PASS MEMBER OF THE CRATER FLAT TUFF
V	PROW PASS WELDED UNIT	MODERATELY WELDED, DEVITRIFIED ZONE OF THE PROW PASS MEMBER OF THE CRATER FLAT TUFF
VI	CRATER FLAT NONWELDED UNIT	ZEOLITIZED PORTIONS OF THE LOWER PROW PASS MEMBER AND OF THE UPPER BULLFROG MEMBER OF THE CRATER FLAT TUFF.
VII	BULLFROG WELDED UNIT	WELDED DEVITRIFIED ZONE OF THE BULLFROG MEMBER OF THE CRATER FLAT TUFF



⊙ POROSITY BASED ON GRAIN AND BULK DENSITY

MANGANESE OXIDES AND IRON OXIDES ARE THE DOMINANT TYPE OF FRACTURE COATING IN THE DENSELY WELDED ZONE OF THE TIVA CANYON MEMBER AND UNDERLYING NON TO MODERATELY WELDED TUFF (BASAL PART OF TIVA CANYON, YUCCA MOUNTAIN, PAH CANYON, AND UPPER PART OF THE TOPOPAH SPRING MEMBERS. WITHIN THESE TWO INTERVALS, 83 AND 64% OF THE FRACTURES ARE STAINED WITH MANGANESE OXIDES AND IRON OXIDES. (A subordinate number of fractures also include silica.); 11 and 23 percent contain no coatings. These data agree with the compilation of fracture coatings reported in Spengler and others (1979) - for hole UE-25a#1. WWLNUM

In order of abundance, basic types of coatings are 1) manganese oxides (pyrolusite), manganates (cryptomelane, hollandite), iron oxides (hematite, maghemite) and iron hydroxides (goethite), 2) silica (quartz, cristobalite, opaline silica, and tridymite), (3) zeolites (mordenite and clinoptilolite), 4) smectites (montmorillonite and illite), and 5) carbonates (calcite and siderite).

In contrast to fracture surfaces observed in overlying stratigraphic intervals, 51% of the fractures examined in the densely welded zone of the Topopah Spring Member are free of any type of mineral coating. These fractures are believed to be natural and not the result of drilling or handling based on the presence of a subtle discoloration extending into the rock matrix which is probably a product of weathering.

The dominant type of coating within the Topopah Spring Member is silica, found along 22% of the fractures. Tridymite was identified on 10% of these fracture faces. The presence of this high-temp. form of quartz on fracture faces may suggest that some fracture development occurred during or soon after initial cooling of the ash-flow tuff. This stratigraphic interval also marks the first appearance of calcite-coated fractures beginning at a depth of 74 m.

Fracture-lining minerals in tuff may be very different from minerals in the surrounding rock matrix. In the unsaturated zone of USW G-4, the fracture mineralogy varies greatly with the nature of the host rock (devitrified, glassy, or zeolitized). The differences between host-rock and fracture mineralogy are greatest in the devitrified and glassy units.

In the devitrified zone, the earliest fracture-filling minerals are quartz and feldspar, which occur in fractures connected with lithophysae. Mordenite, the earliest zeolite formed in fractures occurs over the entire interval sampled in the devitrified zone. Some mordenite-lined fractures crosscut earlier, sealed quartz-feldspar fractures. Manganese oxides/hydroxides usually occur with or just beneath the mordenite. The single calcite fracture sampled crosscuts some mordenite-lined fractures. Slickensides striate mordenite and manganese oxides in many fractures. Heulandite and coarse mordenite that occur in fractures from 380 to 402 meters are not slickensided. Small smectite clusters and fragments of quartz and feldspar (possibly tuff pulverized during coring) coat all other fracture minerals.

In the glassy zone (including the vitrophyre and nonwelded vitric tuff) the zeolites are heulandite and mordenite, but they are fine grained and visually unidentifiable. Smectite accompanies the zeolites in some fractures. Zeolites in fractures in the devitrified and glassy zones thus occur at much shallower depths than in the host rock.

From the zeolitic zone in the nonwelded Topopah Spring to at least the top of the Prow Pass Member, fracture mineralogy is similar to the host-rock alteration. THIS ZONE MAY ONCE HAVE BEEN BELOW THE SWL.

Within the basal nonwelded to partially welded zone of the Topopah Spring Member and the tuffaceous beds of Calico Hills, 31 and 39 percent of the fracture faces are coated with manganese and iron oxides, and zeolites, respectively.

About 19 and 35% of the fractures in the tuffaceous beds of Calico Hills and the Crater Flat Tuff, respectively, are classified as healed and may not act as pathways for the migration of fluids. The likelihood that many fractures (particularly shear fractures) may not be healed along their entire length must be considered.

Aperture widths as large as 0.5 cm. were measured.

Zeolitic alteration of rock units occurs below a depth of 434.2 m. Above this depth, densely welded units are dominantly devitrified and non to moderately welded tuff units are dominantly vitric. Most of the rock assigned to the tuffaceous beds of Calico Hills and the Prow Pass Member contain 30 to as much as 70 percent clinoptilolite and (or) mordenite.

In the Prow Pass Member iron-rich minerals include hematite and maghemite. The only manganese-bearing mineral identified was pyrolucite.

The intervals from 546 to 576 m and 687 to 773 m, where neutron porosity and density porosity are significantly different, are anomalous and have the appearance of rock that is undersaturated.

In the Bullfrog and Tram Members iron-bearing minerals that were identified include hematite and geothite. Manganese-bearing minerals include cryptomelane and hollandite.

DENSELY TO NONWELDED TUFFS

TUFF, ASH-FLOW, GRAYISH-RED, DENSELY WELDED, DEVITRIFIED; PUMICE, GRAYISH-RED, MEDIUM GRAY, DEVITRIFIED; 2% PHENOCRYSTS (SANIDINE); RARE VERY-LIGHT-GRAY RHYOLYTIC LITHIC FRAGMENTS; OCCASIONAL LITHOPHYSAL CAVITIES (OPEN AND FLATTENED), IN UPPER 12 METERS.

TUFF, ASH-FLOW, PALE-BROWN, PALE-RED, MODERATELY TO DENSELY WELDED, devitrified; pumice, pale-red, brownish gray, devitrified with sparse to abundant moderate reddish-orange pumice altered to smectite (swelling) clay, less than 2-4% phenocrysts

BEDDED AND NONWELDED TUFFS

TUFF, ASH-FLOW, DARK-YELLOWISH-ORANGE, PARTIALLY-TO-NONWELDED, VITRIC; ABUNDANT BLACK AND very yellowish-orange glass shards

CAPROCK

VAPOR PHASE ZONE

TUFF, ASH FLOW, PALE RED, LIGHT BROWNISH-GRAY, DENSELY WELDED, DEVITRIFIED; PUMICE, MIXTURE OF VERY-LIGHT-GRAY, LIGHT-GRAY AND BROWNISH-GRAY, DEVITRIFIED, COMMONLY 5 TO 50 mm IN SIZE, brownish-gray pumice commonly the larger size, devitrified and some vapor phase; 1 to 4% phenocrysts (sanidine and plagioclase); lithophysal cavities, abundant at top, sparse at base.

UPPER LITHOPHYSAL ZONE

TUFF, ASH-FLOW, PALE-RED TO GRAYISH-RED MODERATE-BROWN (MOTTLED), DENSELY WELDED, DEVITRIFIED; PUMICE, PALE RED, GRAYISH RED, DEVITRIFIED; less than 2% phenocrysts (sanidine and plagioclase); rare light-gray rhyolytic-lithic fragments; abundant (more than 30%) lithophysal cavities, commonly open, cavities subrounded and flattened; in upper 15.2 m, cavities are commonly less than 20 mm in size, commonly lined with feldspar, quartz; below 15.2 m, cavities commonly 10-60 mm in size, with pale red alteration rims;

MIDDLE NON-LITHOPHYSAL ZONE

TUFF, ASH FLOW, PALE-BROWN, LIGHT-BROWN, GRAYISH-RED, AND PALE-RED (MOTTLED), MODERATELY TO DENSELY WELDED, DEVITRIFIED; PUMICE, PALE-RED, LIGHT-BROWN, LIGHT-GRAY, DEVITRIFIED, COMMONLY 5-80 mm, AS LARGE AS 60 mm IN LENGTH; 1 TO 2% PHENOCRYSTS (SANIDINE AND PLAGIOCLASE); rare very-light-gray and light-gray rhyolytic-lithic FRAGMENTS INCREASING TOWARD BASE; LITHOPHYSAE COMMON, MOSTLY FLATTENED CAVITIES WITH LARGE ALTERATION RIMS; FRACTURING AND BROKEN CORE INTERVALS COMMON (LOWER CONTACT GRADATIONAL)

LOWER LITHOPHYSAL ZONE

LOWER NON-LITHOPHYSAL ZONE

TUFF, ASH FLOW, LIGHT BROWN, DARK-YELLOWISH-BROWN TO DARK-YELLOWISH-ORANGE, MODERATELY TO DENSELY WELDED, DEVITRIFIED, BUT PARTIALLY VITRIC, ARGILLIC AND ZEOLITIC (?) (ALTERED VITROPHYRE IN LOWER 7 METERS); PUMICE LIGHT BROWN, DUSKY-YELLOWISH-BROWN, PALE-YELLOWISH-ORANGE, DARK-YELLOWISH-ORANGE, DEVITRIFIED VITRIC (LOWER 7 m), COMMONLY 8-50 mm; 1% PHENOCRYSTS OF SANIDINE AND PLAGIOCLASE; SPARSE-VERY-LIGHT-GRAY RHYOLITIC-LITHIC FRAGMENTS, COMMONLY RANGE FROM 5 mm TO AS LARGE AS 84 mm; TWO FAULT ZONES WITH MODERATE TO INTENSE ALTERATION [SMECTITE (?)] ALONG NEARLY VERTICAL FAULT PLANES AT 400.5 – 400.9 m AND 401.8 – 402.3 m, 0.6 m OR MORE OF DISPLACEMENT ALONG SECOND FAULT ZONE, AS INDICATED BY CORE SAMPLE AT 401.9 m.

VITRIC TUFF

TUFF, ASH FLOW — DARK-GRAY TO BLACK, DENSELY WELDED, VITROPHYRE; PUMICE, BLACK, GLASSY, 1 TO 2% PHENOCRYSTS (SANIDINE AND PLAGIOCLASE); SPARSE-VERY-LIGHT-GRAY RHYOLITIC-LITHIC FRAGMENTS, COMMONLY 4 TO 18 mm, OCCAS. AS LARGE AS 30 mm; MODERATELY-OLIVE-BROWN WITH LIGHT-BROWN PUMICE FRAGMENTS; MODERATELY ALTERED FROM 401.9 TO 402.2 m; INTERVAL CONTAINS SEVERAL NEAR VERTICAL, SILICA-COATED, FRACTURES (CONCHOIDAL MICRO-FRACTURES COMMON) (LOWER CONTACT GRADATIONAL)

ZEOLITIC NONWELDED TUFF

ZEOLITIC NONWELDED AND BEDDED TUFFS

TUFF, ASH FLOW, MODERATE-ORANGE-PINK, GRAYISH-ORANGE-PINK, LIGHT BROWN, GRAYISH-ORANGE, AND DUSKY-YELLOW, NON-WELDED ZEOLITIC; PUMICE, VERY-PALE-ORANGE, PALE-RED, MODERATE PINK, GRAYISH-ORANGE-PINK, YELLOWISH-GRAY, GRAYISH-YELLOW, GRAYISH-ORANGE, ZEOLITIC, COMMONLY RANGE FROM 20 TO 45 mm; 1% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BIOTITE); RARE TO SPARSE MODERATE-BROWN AND GREYISH-RED RHYOLYTIC-LITHIC FRAGMENTS, COMMONLY LESS THAN 20 mm IN SIZE; LOWER 3.4 m OF UNIT INDICATES A SLIGHT INCREASE IN CONTENT OF LITHIC FRAGMENTS; FAULT PLANE WITH SLICKENSIDES PRESENT FROM 474.4 – 474.6 m INCLINED 77°

TUFF, ASH FALL AND REWORKED, MODERATE-ORANGE-PINK AND GRAYISH ORANGE, MODERATELY INDURATED, ZEOLITIC; DOMINANTLY COMPOSED OF PUMICE, GREYISH-YELLOW, GRAYISH-ORANGE-PINK, DUSKY-YELLOW, AND VERY-PALE-ORANGE, ZEOLITIC, COMMONLY LESS THAN 20 mm IN SIZE, SUBANGULAR TO SUBROUNDED, POORLY SORTED

TUFF, ASH FLOW, GRAYISH-ORANGE, LIGHT BROWN, AND MODERATE-REDDISH-ORANGE, AND OCCASIONALLY DARK YELLOWISH-BROWN, NONWELDED ZEOLITIC; PUMICE, VERY-PALE-ORANGE, GRAYISH-YELLOW, DUSKY-YELLOW, MODERATE-GREENISH-YELLOW, ZEOLITIC, COMMONLY RANGE IN SIZE FROM 2 TO 310 mm, AS LARGE AS 570 mm; 1 TO 2% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BIOTITE); SPARSE (1-2%) RHYOLITIC-LITHIC FRAGMENTS, BROWNISH-GRAY AND BROWNISH BLACK, COMMONLY LESS THAN 5 mm IN SIZE; ASH-FALL PARTING 10 mm THICK, PRESENT AT 489.8 m, INCLINED 7°; FAULT PLANE PRESENT FROM 497.2-497.3 m, SLIGHTLY OFFSET, INCLINED 77°

ZEOLITIC TUFF

BEDDED TUFF, ASH-FALL, REWORKED (TUFFACEOUS SANDSTONE) GRAYISH YELLOW, YELLOWISH-GRAY, LIGHT BROWN, GREENISH GRAY... ZEOLITIC (IN PLACES, SILICIFIED) MODERATELY TO WELL INDURATED, PUMICE, ZEOLITIC, COMMONLY LESS 5 mm IN SIZE, RHYOLYTIC-LITHIC FRAGMENTS; INDIVIDUAL BEDS AS MUCH AS 1.5 m THICK. BASAL PART OF UNIT FROM 536.1 – 536.9 m, CONSISTS OF TUFFACEOUS SANDSTONE

ZEOLITIC NON-WELDED TUFF

TUFF, ASH FLOW, NON-WELDED, ARGILLIC, ZEOLITIC; 5-10% PHENOCRYSTS (SANIDINE, QUARTZ, PLAGIOCLASE, BIOTITE, PYROXENE PSEUDOMORPHS RARE VOLCANIC AND MUDSTONE LITHIC FRAGMENTS LESS THAN 5 mm IN SIZE. POSSIBLE SHEAR FRACTURE AT 546.5 m

TUFF, ASH-FLOW, GRAYISH-ORANGE-PINK IN UPPER 3 m OF UNIT GRADING DOWNWARD INTO LIGHT GRAY, INTO LIGHT-BROWNISH GRAY, PARTIALLY WELDED, VAPOR PHASE; PUMICE, VAPOR-PHASE CRYSTALLIZATION DOMINANT (DEVITRIFIED), COMMONLY LESS THAN 10 mm IN SIZE; 7% PHENOCRYSTS [QUARTZ, SANIDINE, PLAGIOCLASE, BRONZE BIOTITE, PYROXENE (?)]. SHEAR FRACTURE WITH SLICKENSIDES AT 547.7 m, HIGH-ANGLE FRACTURES WITH PALE-REDDISH-BROWN IRON OXIDE (?) STAINING CORE CUT FROM 564.5 – 565.9 m

TUFF, ASH FLOW, PARTIALLY WELDED DEVITRIFIED; PUMICE DEVITRIFIED (SOME VAPOR PHASE CRYSTALLIZATION) VAPOR PHASE CRYSTALLIZATION COMMON IN UPPER 7.3 m AND DECREASES DOWNWARD, SHEAR FRACTURES PRESENT AT 577.4 – 578.5 m, 582.3 – 582.7 m; FAULT PLANE INDICATED BY ABRUPT TERMINATION OF PUMICE FRAGMENTS ALONG PLANE; SLICKENSIDES OBSERVED ALONG FAULT.

TUFF, ASH FLOW, PARTIALLY WELDED DEVITRIFIED, PUMICE IN LOWER 1.1 m OF UNIT EXTENSIVELY ALTERED TO CLAYS AND ZEOLITES (?)

TUFF, ASH-FLOW, NON TO PARTIALLY WELDED, MODERATELY TO HIGHLY ZEOLITIC; PUMICE, MODERATE SIZE FROM 2-20 mm, AS LARGE AS 30 mm; 5-7% PHENOCRYSTS, 2 to 4% MUDSTONE, MINOR GRAYISH-RED VOLCANIC LITHIC FRAGMENTS, COMMONLY 2-20 mm, AS LARGE AS 73 mm; VERY THIN CLAY PARTING AT 603.2 m; SHEAR FRACTURE AT 596.2 – 596.5 m, POSSIBLE FAULT WITH BRECCIA ALONG PLANE AT 606.6 – 607.2 m, ABRUPT CONTACT AT BASE

TUFF, ASH-FLOW, PARTIALLY WELDED, DEVITRIFIED, SLIGHTLY TO MODERATELY ZEOLITIC, SLIGHTLY TO MODERATELY SILICIFIED; PUMICE, ZEOLITIC [SLIGHTLY SILICIFIED], COMMONLY RANGE IN SIZE FROM 5-35 mm, AS LARGE AS 65 mm, 10-15% PHENOCRYSTS; RARE (1-2%) LITHIC FRAGMENTS; MODERATELY TO WELL INDURATED [SILICIFIED (?)] FROM 630.5 – 640.5 m, 640.8 – 643.7 m, 646.6 – 649.2

TUFF, ASH FLOW — NONWELDED; SLIGHTLY TO HIGHLY ZEOLITIC; PUMICE, ZEOLITIC AND ARGILLIC, COMMONLY RANGE IN SIZE FROM 3-25 mm, AS LARGE AS 65 mm; NOTICEABLE INCREASE IN ABUNDANCE OF LARGER PUMICE FRAGMENTS RELATIVE TO UNIT ABOVE; LOWER 2.4 m CONTAINS NUMEROUS, VERY ALTERED PUMICE FRAGMENTS (30-50 mm), 5-7% PHENOCRYSTS [QUARTZ, SANIDINE, PLAGIOCLASE, BIOTITE, HEMATITE AND (OR) MAGNETITE]

BEDDED TUFF, ASH FALL, REWORKED, UPPER 0.5 m CONSISTS OF TUFFACEOUS SILTSTONE AND VERY FINE TUFFACEOUS SANDSTONE LOWER 1.4 m CONSISTS OF ASH-FALL AND REWORKED TUFF, SLIGHTLY TO MODERATELY ZEOLITIC.

TUFF, ASH FLOW, PARTIALLY WELDED, DEVITRIFIED (SLIGHTLY ALTERED); PUMICE, DEVITRIFIED (OCCASIONAL VAPOR PHASE, SLIGHTLY ARGILLIC) 10-15% PHENOCRYSTS; FRACTURES INDICATE OFFSET INTERVAL MODERATELY ALTERED, APPEARS TO CONTAIN FRAGMENTS OF REWORKED TUFF FAULT PLANE DIPS AT 73° RELATIVE TO AXIS OF CORE; SHEAR FRACTURES AT 685.8, 686.3, 694.4 AND 694.7 m.

TUFF, ASH FLOW, PARTIALLY WELDED, VAPOR-PHASE CRYSTALLIZATION; PUMICE, VAPOR PHASE CRYSTALLIZATION DOMINANT; 10-15% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, HORNBLENDE PSEUDOMORPHS, BRONZE BIOTITE) FIRST UNIT WHERE BRONZE BIOTITE IS DOMINANT TYPE OF BIOTITE, SUBORDINATE MUDSTONE (5-7 mm) CONSPICUOUS NEAR VERTICAL-SHEAR FRACTURE EXTENDING ALONG CORE FROM 713.8 – 715.0 m, IN PLACES, APERTURE ALONG FRACTURE IS AS LARGE AS 5 mm IN WIDTH

TUFF, ASH FLOW, MODERATELY WELDED, DEVITRIFIED; PUMICE, DEVITRIFIED (SUBORDINATE VAPOR-PHASE CRYSTALLIZATION)

TUFF, ASH FLOW, PARTIALLY WELDED, VAPOR PHASE CRYSTALLIZATION; PUMICE, VAPOR PHASE CRYSTALLIZATION DOMINANT, 12-15% PHENOCRYSTS (SANIDINE, QUARTZ, PLAGIOCLASE, BIOTITE). NEAR VERTICAL-SHEAR FRACTURES OCCUR FROM 743.2 – 744.5 m, AND FROM 745.3 – 745.7 LOWER 1.7 m IS TUFF, ASH-FALL INTERBEDDED WITH ASH-FLOW (?), WELL-INDURATED, DEVITRIFIED

TUFF, ASH FLOW — NONWELDED, DEVITRIFIED; PUMICE, DEVITRIFIED, (7-17 mm) 8-10% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE)

TUFF, ASH FLOW, PARTIALLY TO DENSELY WELDED, DEVITRIFIED; PUMICE, DEVITRIFIED AND ZEOLITIC, (2-30 mm) EUTAXITIC STRUCTURE, MODERATELY DEVELOPED; 9-15% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE, HORNBLENDE, PSEUDOMORPHS); SHEAR FRACTURES PRESENT FROM 781.2 – 783.8 m AND 809.0 – 809.6 m; 2 LOW-ANGLE, MANGANESE OXIDE COATED FRACTURES,

TUFF, ASH FLOW — PARTIALLY WELDED, SLIGHTLY INDURATED, MOSTLY ARGILLIC; PUMICE, ALTERED TO SWELLING CLAY, COMMONLY 2-55 mm 5-7% SPARSE LITHIC FRAGMENTS

TUFF, ASH FLOW — PARTIALLY WELDED, DEVITRIFIED (WELL INDURATED); PUMICE, DEVITRIFIED, COMMONLY RANGE IN SIZE FROM 4-35 mm, AS LARGE AS 60 mm; 8-10% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BIOTITE)

TUFF, ASH FLOW — NONWELDED, DEVITRIFIED (SLIGHTLY ZEOLITIC); PUMICE, DEVITRIFIED [SLIGHTLY ZEOLITIC (?)], COMMONLY RANGE IN SIZE FROM 2-40 mm; 7-8% PHENOCRYSTS (QUARTZ, PLAGIOCLASE, BLACK BIOTITE);

BEDDED TUFF, ASH FALL, REWORKED, MODERATELY INDURATED, MODERATELY SORTED; THIN CLAY PARTING OCCURS AT 839.7 m, AND AT BASE OF INTERVAL

TUFF, ASH-FLOW — TUFF, ASH FLOW, NONWELDED, DEVITRIFIED; PUMICE, DEVITRIFIED [SLIGHTLY ZEOLITIC (?) AND ARGILLIC], PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE)

TUFF, ASH-FLOW — NON-TO-PARTIALLY WELDED, DEVITRIFIED; PUMICE, DEVITRIFIED, COMMONLY RANGES IN SIZE FROM 1-8 mm, RARELY AS LARGE AS 13 mm; 7-9% PHENOCRYSTS OF QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE; ASH-FALL TUFF, 30 mm THICK AT 841.9 m.

NON-TO-PARTIALLY WELDED, DEVITRIFIED; PUMICE, DEVITRIFIED, COMMONLY 2-25 mm, AS LARGE AS 60 mm; 10-12% PHENOCRYSTS OF QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE;

TUFF, ASH-FLOW, LIGHT-BROWNISH-GRAY, LIGHT-OLIVE-GRAY, AND GRAYISH-ORANGE-PINK, UPPER 1.5 m; MOTTLED PALE RED, MODERATE-RED, AND LIGHT-BROWNISH-GRAY, DEVITRIFIED; PUMICE, GRAYISH-ORANGE, VERY-PALE-ORANGE, LIGHT-BROWNISH GRAY, DOMINANTLY VAPOR-PHASE CRYSTALLIZATION, COMMONLY 2-17 mm, AS LARGE AS 40 mm; 12-17% PHENOCRYSTS (QUARTZ, SANIDINE, PLAGIOCLASE, BLACK BIOTITE). PROMINANT SHEAR FRACTURES OCCUR AT 885.3 m, 887.0 m, 889.9 – 891.3 m, 893.0 – 893.6 m, 894.0 – 894.4 m, 909.9 – 911.2 m AND 914.4 m.

SUMMARY OF GEOPHYSICAL WELL LOGS

WELL LOGS	DEPTH (METERS)
ACOUSTIC FRACTURE	12 - 138
CALIPER	0 - 603 556 - 914
DENSITY, BOREHOLE COMPENSATED	12 - 138 142 - 541 533 - 912
ELECTRIC	12 - 138 143 - 541 457 - 603 600 - 911
GAMMA RAY	3 - 138
GEOPHONE SURVEY	143 - 541 30 - 136 143 - 546 564 - 907
GYROSCOPIC	0 - 907
NEUTRON, COMP.	12 - 138 51 - 541 457 - 604 600 - 912
SPECTRALOG	0 - 913
TELEVISION, OPTICAL	0 - 137 261 - 412 411 - 472 471 - 579
TEMPERATURE (STATIC)	0 - 914
(PUMPING)	152 - 913
3-D VELOCITY	564 - 603 588 - 912

PUMPING TESTS

TYPE OF TEST	RATE (L/S)	PERIOD (MIN)
DRAWDOWN	16	5740
RECOVERY	16	120
DRAWDOWN	13	1660
RECOVERY	13	120

(DATA NOT ANALYZED)

BOREHOLE FLOW SURVEY
- WAS MADE DURING THE DRAWDOWN PHASE OF PUMPING TEST 2

PACKER INJECTION TESTS
13 TESTS WERE MADE IN WELL BETWEEN 615 m AND 915 m DECLINE OF HYDRAULIC HEAD WITH TIME WAS MONITERED. (DATA NOT ANALYZED)

PROPERTIES FOR REPRESENTATIVE SAMPLES TAKEN FROM THE UNSATURATED ZONE HYDROLOGIC UNITS.

UNIT	SAMPLE CODE	GRAIN DENSITY g/cm³	POROSITY	K m/s	Sr	α 1/m	B
I-A	64-1	2.49	0.08	9.7E-12	0.0020	0.821E-2	1.558
I-B	643-7	2.35	0.40	3.9E-07	0.1001	0.150E-1	6.872
II	64-6	2.58	0.11	1.9E-11	0.0801	0.567E-2	1.789
III	643-11	2.38	0.07	1.5E-12	0.0804	0.441E-2	2.058
IV-V	643-14	2.37	0.46	2.7E-09	0.0405	0.160E-1	3.872
IV-Z	64-11	2.23	0.28	2.0E-11	0.1095	0.308E-2	1.602

EQUATION FOR SATURATION

$$S = (S_s - S_r)\left[\frac{1}{1 + |\alpha h|^{B}}\right]^{\lambda} + S_r$$

EQUATION FOR UNSAT. HYDRAULIC CONDUCTIVITY

$$K(h) = K_s \frac{\left[1 - |\alpha h|^{B-1} \cdot \left(1 + |\alpha h|^{B}\right)^{-\lambda}\right]^2}{\left(1 + |\alpha h|^{B}\right)^{\lambda/2}}$$

where
h = suction head
S = SATURATION
S_s = MAX. SATURATION
S_r = RESIDUAL SATURATION
$\lambda = 1 - 1/B$
α, B } CURVE FIT PARAMETERS

SUMMARY DATA FOR FRACTURED TUFF SAMPLES

SAMPLE CODE	COMPUTED FRACTURE CONDUCTIVITY m/s	COMPUTED APERTURE
64-1F	378 x 10^-5	67 MICRONS
64-2F	3.5 x 10^-5	6 MICRONS
64-3F	43 x 10^-5	22 "
64-4F	79 x 10^-5	31 "
64-5F	3.1 x 10^-5	6 "

WWLNUM 169 WWLNUM 56 WWLNUM 169 WWLNUM 169 WWLNUM 27

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