GEOHYDROLOGIC DATA FROM A 4,403-FOOT GEOTHERMAL TEST HOLE, MOUNTAIN HOME AIR FORCE BASE, ELMORE COUNTY, IDAHO

By R.E. Lewis and M.A.J. Stone

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CONVERSION FACTORS

For readers who prefer to use metric (International System) units, factors for inch-pound units used in this report are listed below. Constituent concentrations are given in mg/L (milligrams per liter) or µg/L (micrograms per liter), which are equal to parts per million or parts per billion.

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.0630	liter per second
inch (in.)	25.40	millimeter
microsiemens per centimeter at 25 degrees Celsius (µS/cm)	1.000	micromhos per centimeter at 25 degrees Celsius
mile (mi)	1.609	kilometer

Temperature in °C (degrees Celsius) can be converted to °F (degrees Fahrenheit) as follows:

$$°F = (1.8)(°C) + 32$$

ACKNOWLEDGMENTS

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ABSTRACT

A 4,403-foot test hole was drilled on the Mountain Home Air Force Base in Elmore County, Idaho, for geothermal exploration. The hole was cored continuously below about 1,000 feet. Rock above 532 feet was principally basalt with interbedded sediment ranging in size from silt to coarse sand; from 532 to about 1,900 feet, rock was principally silty sand and silty clay. Below about 1,900 feet, rock was principally basalt. Selected geophysical and temperature logs were obtained; temperature at 3,960 feet was about 93 C. Logging below that depth was not possible because maximum depth capability of the logging unit was 4,000 feet. Thermal conductivity values (dry) of selected core samples ranged from 0.791 to 0.803 watts per meter degree kelvin in two fine-grained sedimentary rock samples and from 0.674 to 1.586 watts per meter degree kelvin in four basalt samples; values of saturated samples of the basalt ranged from 1.046 to 1.644 watts per meter degree kelvin. Dry density averaged 1.70 and 2.29 grams per cubic centimeter in two sedimentary and four basalt samples, respectively; wet density averaged 2.39 grams per cubic centimeter in the basalt. Two water samples were air lifted from below a mechanical packer set at 2,003 and at 3,462 feet. Chemical analyses were obtained for both samples; the shallower sample also was analyzed for deuterium and oxygen-18.

INTRODUCTION

Between November 1985 and July 1986, a 4,403-ft test hole on the Mountain Home Air Force Base in Elmore County was drilled, cored, and logged. The hole was drilled by the U.S. Air Force to determine the availability of water from geothermal aquifers to supply energy for space heating of military housing and other facilities on the base. The purpose of this report is to make data acquired from the test hole available to the public. Scope of this report includes generalized lithology, geophysical logs, temperature profile, thermal conductivity analyses, and chemical and isotopic analyses of water samples. U.S. Geological Survey participation in the work and publication of the data were funded by the U.S. Department of Energy, Geothermal Technology Division.

LOCATION, DRILLING, AND CONSTRUCTION

The drill site is located in the NW¼NE¼NE¼ section 27, township 4 south, range 5 east, on the Mountain Home Air Force Base about 8 mi southwest of Mountain Home (fig. 1). The site is in the western Snake River Plain, a broad, structural trough filled with as much as 10,000 ft of interbedded volcanic and sedimentary deposits (Lindholm, 1981). Target of the test hole was a series of silicic volcanic rocks, mostly rhyolite or quartz latite flows

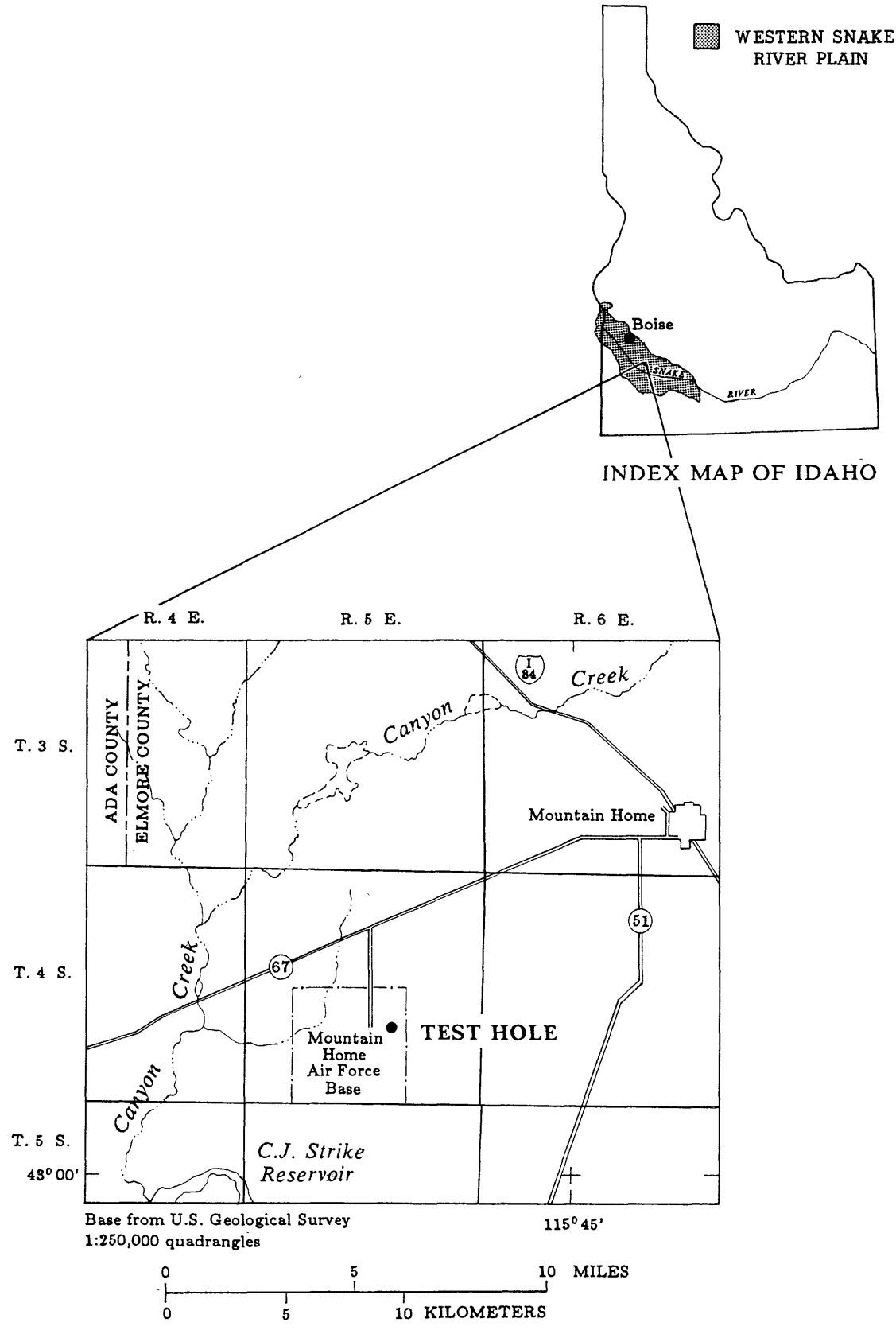

Figure 1.--Location of test hole.

with some tuff and ash, that commonly contain aquifers which yield water at temperatures greater than 80 °C (Young and Mitchell, 1973). McIntyre (1979, p. 8) reported encountering rhyolites at a depth of about 2,700 ft in an 11,125-ft test hole in Owyhee County about 25 mi west of the Air Base.

Drilling on the test hole began November 1, 1985, and was originally scheduled for a target depth of 3,500 ft. Depths, dimensions, and materials described in this report are from the driller's report (W.E. Stevens, written commun., 1987) and from communications with personnel from the engineering staff, 366th Combat Support Group, Mountain Home Air Force Base. An 8-in. hole was drilled to 40 ft using air-rotary equipment and was cased with 6-in. I.D. (inside diameter), 0.25-in.-thick steel casing. Drilling continued to 580 ft, where water and caving sand in the hole necessitated replacing the air-rotary drilling rig with a conventional hydraulic-rotary drilling rig. Drilling continued to 1,000 ft, where 4-in. I.D., 0.25-in.-thick steel casing was cemented in place. At this time, the hydraulic-rotary rig was replaced with a wire-line core rig, and drilling continued to 1,400 ft. Problems encountered with caving in the hole and lost circulation of drilling fluid made it necessary to install and cement HQ (3 ½ -in. I.D.) drill rods from 810 to 1,170 ft to serve as a liner; drilling continued with the same problems. Two and three-quarters inch (N) O.D. (outside diameter) drill rods were installed and cemented to 2,003 ft, and continuous core drilling continued to about 3,500 ft. At that time, Air Force engineers decided to continue drilling, and the hole was deepened to 4,000 ft. Reaching that depth, it was again decided to continue drilling, and the hole was deepened to 4,403 ft, where it was completed (fig. 2) on July 28, 1986.

Upon completion of testing and sampling, the test hole was filled with a slurry of bentonite gel and cement (six sacks each), and the N rods were removed from 1,603 ft. An additional bentonite/cement slurry (six sacks each) was added and the HQ rods were removed from 810 ft. Three hundred gallons of water were added to force the seal down, and a cap was welded on top of the 4-in. casing at land surface.

LITHOLOGY

The test hole was cored continuously using wire-line drilling equipment from about 1,000 ft to the total depth of 4,403 ft reported by the driller. In general, core recovery was excellent and ranged from about 60 to 75 percent above 2,000 ft to 90 to 100 percent below that depth. Rock above 532 ft was principally basalt with interbedded sediment ranging in size from silt to coarse sand; from 532 to about 1,900 ft, rock was principally silty sand and silty clay. Below about 1,900 ft, rock was principally basalt.

The core obtained during drilling operations was accumulated at the site and transported periodically to the U.S. Geological Survey facility in Boise, Idaho, where it was examined megascopically and described. Generalized descriptions of the core are given in table 1 (back of report).

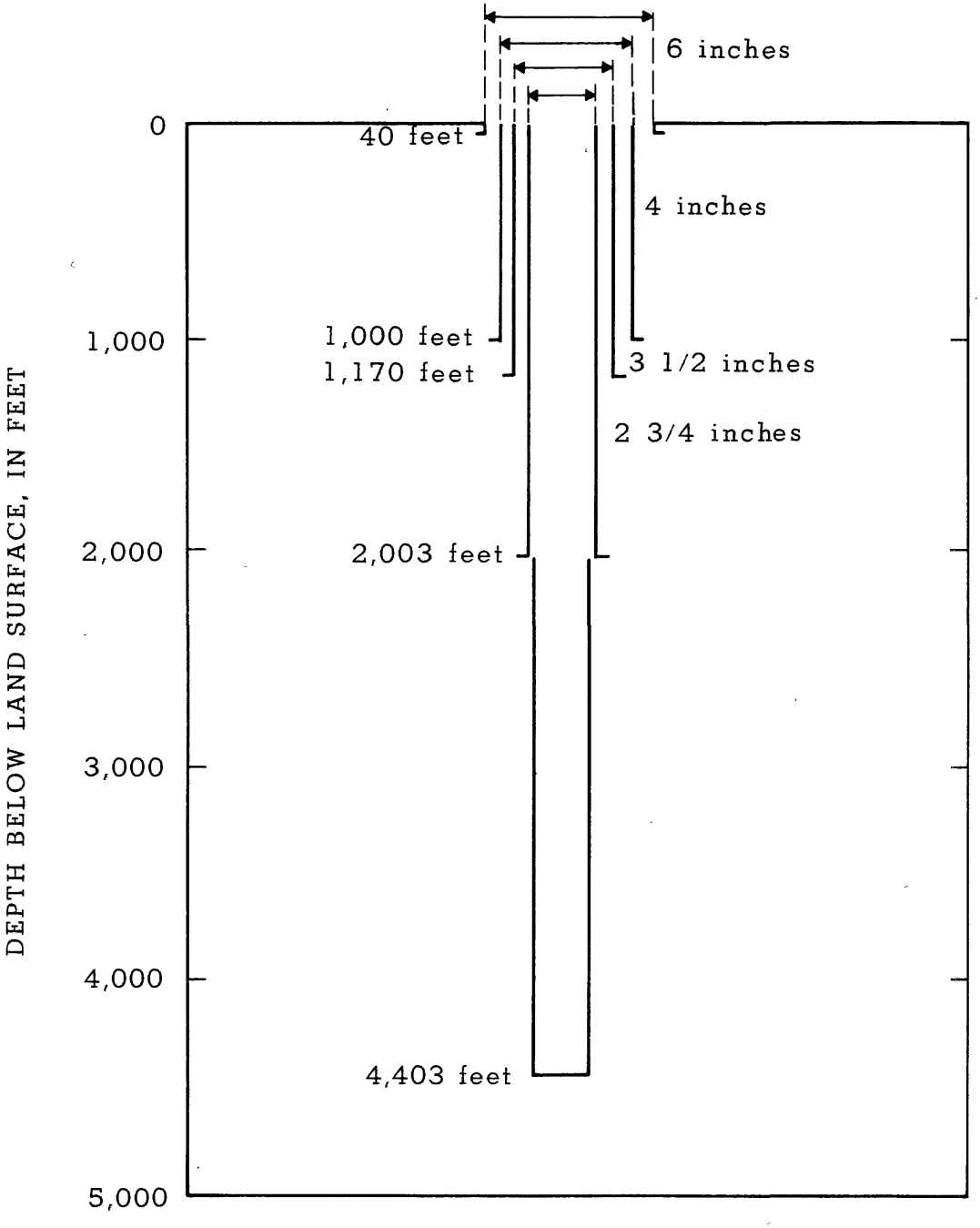

Figure 2.--Completion of test hole.

TEMPERATURE AND GEOPHYSICAL LOGS

Eighteen hours after drilling was completed, personnel from the U.S. Geological Survey Project Office at the INEL obtained temperature and geophysical logs from the test hole using INEL equipment. Although complete thermal equilibrium in the hole probably was not yet attained, the basic character of the temperature log probably is reflective of equilibrium conditions. In addition to temperature, other logs included natural gamma, gamma-gamma, and neutron. All logs, reduced and generalized to accommodate publication, are shown in figure 3. Copies of the original logs may be inspected at the U.S. Geological Survey office in Boise, Idaho.

Maximum depth capability of the logging unit was 4,000 ft; decisions to drill beyond the original target depth of 3,500 ft prevented timely acquisition of additional cable. Logging was done inside the drill rod to ensure that the hole remained open. Temperature and neutron logs were obtained to 3,960 ft. Natural gamma and gamma-gamma logs were obtained to about 2,500 ft; at that depth, temperatures were about 70 °C and the electronics in the probes ceased to function. Several attempts were made to obtain logs below 2,500 ft but were unsuccessful. No electrical logs could be obtained inside the drill stem.

THERMAL CONDUCTIVITY, DENSITY, AND POROSITY

Six core samples were analyzed for thermal conductivity, density, and porosity (table 2) in the laboratory at the Department of Geological Sciences at Southern Methodist University, Dallas, Texas.

Sample intervals were selected to best represent the various rock types over the entire depth of the core hole. Thermal conductivity values (dry) ranged from 0.791 to 0.803 and averaged 0.797 W/m °K (watts per meter degree kelvin) for two samples of fine-grained sedimentary rock; values ranged from 0.674 to 1.586 and averaged 1.036 W/m °K for four samples of basalt. Dry density ranged from 1.70 to 1.74 and averaged 1.72 gm/cm^3 (grams per cubic centimeter) for the two samples of fine-grained sedimentary rock; density ranged from 1.95 to 2.85 and averaged 2.29 gm/cm^3 for the four samples of basalt. Wet density ranged from 2.12 to 2.87 and averaged 2.39 gm/cm^3 for the four samples of basalt. Porosity ranged from 1 to 17 percent and averaged 10 percent for the four samples of basalt.

WATER CHEMISTRY

After completion of the hole, a mechanical rubber packer on B rods ($1^{13}/_{32}$-in. I.D.) was set at 3,462 ft in the uncased part of the hole. A $^3/_4$-in. air line was installed inside the B rods at 800 ft and water was air lifted from the hole for about 15 hours. During the operation, discharge was about 3 to 5 gal/min and water remained cloudy throughout the testing; temperature never exceeded 20 °C.

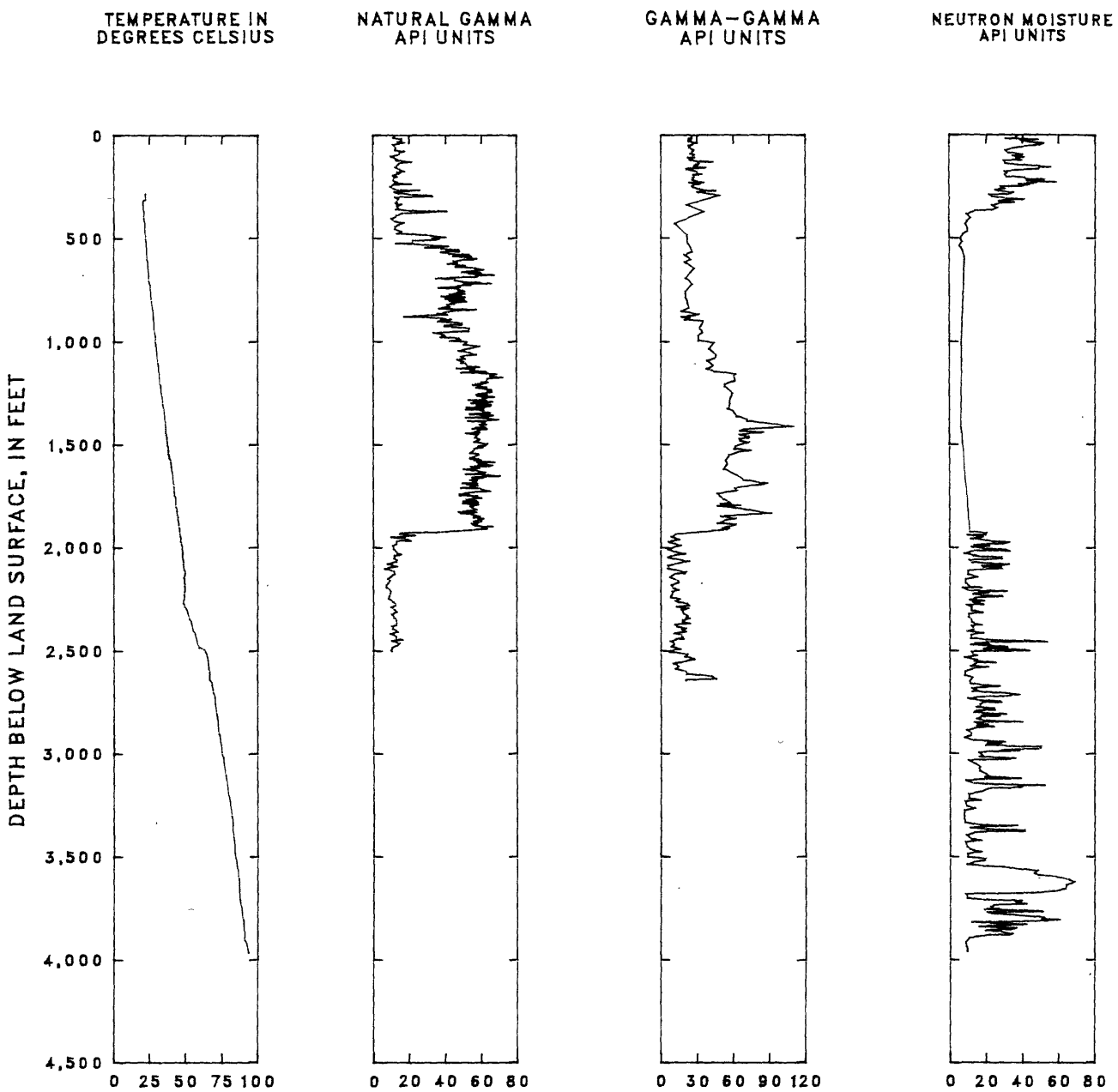

Figure 3.--Temperature and geophysical logs.

Table 2.--Thermal conductivity, density, and porosity analyses

[W/m°K, watt per meter degree kelvin; gm/cm^3, gram per cubic centimeter; -, not analyzed]

Sample depth (feet)	Thermal conductivity (W/m°K)		Density (gm/cm^3)		Porosity (percent)
	Dry	Saturated	Dry	Saturated	
1,676	0.791	-	1.74	-	-
1,835	.803	-	1.70	-	-
3,394	.820	1.142	2.07	2.22	15
3,413	1.063	1.23	2.27	2.34	6
3,986	.674	1.046	1.95	2.12	17
4,200	1.586	1.644	2.85	2.87	1

The rubber packer was reset at 800 ft inside the 3½-in. drill pipe (HQ rod) that was installed as a liner during the drilling to 2,003 ft. Air-lift operations were resumed and continued for the rest of the shift, and again the next day. By noon the second day, discharge was about 35 gal/min; the water was clear, and the temperature was 45 °C. A water sample from each depth was obtained and prepared for chemical analyses at the U.S. Geological Survey Central Laboratory in Denver, Colo. The integrity of the sample from 3,462 ft may be questionable because of the low temperature of the water. The sample from 2,003 ft was sent to the U.S. Geological Survey laboratory in Menlo Park, Calif., for stable isotope analysis. Chemical and stable isotope analyses are shown in table 3.

Table 3.--Chemical and stable isotope analyses

[Chemical constituents in milligrams per liter, except where noted; gal/min, gallons per minute; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; µg/L, micrograms per liter; --, no data available; <, less than. Stable isotope compositions are in parts per thousand, expressed in delta units relative to Standard Mean Ocean Water]

Sample number	Date of collection	Flow rate (gal/min)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness as $CaCO_3$	Noncarbonate hardness	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Silica (SiO_2)	Dissolved solids (calculated)	Nitrite plus nitrate as nitrogen ($NO_2 + NO_3$)	Boron (B) µg/L	Lithium (Li) µg/L	Oxygen-18	Deuterium
1	8/ 8/86	<5	817	7.9	20.0	17	0	6.5	0.10	110	2.0	100	0	83	45	97	1.1	68	380	0.10	420	5	--	--
2	8/14/86	35	565	9.9	45.0	15	0	6.3	.09	109	2.1	0	63	96	46	88	1.0	58	439	.59	410	--	-14.6	-126

1 - Sample from below packer set at 3,462 feet.

2 - Sample from below packer set at 2,003 feet.

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Table 1.--Description of core

Description[1]	Depth, in feet below land surface
Not cored. Drilled by conventional air-rotary methods. Principally basalt with some interbedded sediments. Sediments range in size from silt to coarse sand; generally uncemented. Significant thicknesses of relatively finer grained material about 10 ft at 290 and 365 ft and about 30 ft at 492 ft.	0-532
Not cored. Drilled by conventional air-rotary methods to 580 ft; hydraulic mud-rotary to 1,000 ft; wire-line core drilling below 1,000 ft. Clayey silt to fine sand. Relatively finer overall grain size below 1,140 ft.	532-1,325
Silty sand. Light-olive-gray (5Y 6/1). Fine to very fine sand. Quartz, feldspar with abundant micas; calcareous matrix. Consolidated to loosely consolidated. Black (0) organic debris (plant material?) at 1,347.5 and 1,375 ft.	1,325-1,432
Sandy silt and clay. Light-olive-gray (5Y 6/1). Very fine sand. Matrix slightly calcareous. Consolidated.	1,432-1,586
Silty clay. Light-olive-gray (5Y 6/1). Calcareous and consolidated.	1,586-1,587
Sandy silt and clay. Light-olive-gray (5Y 6/1). Grades from very fine sand into coarser sand, then back to very fine sand and silt with clay but no distinct bedding planes. Calcareous and consolidated.	1,587-1,683
Silty clay. Greenish-gray (5G 6/1). Abundant ferromagnesium mineral fragments. Calcareous and well consolidated. Some core shrinkage.	1,683-1,691
Sandy silt. Light-olive-gray (5Y 6/1). Very fine sand. Calcareous and well consolidated.	1,691-1,740.5
Basalt. Greenish-black (5G 2/1). Vesicular. Vesicles are very small, visible under hand lens. Sharp upper and lower contacts with no baked zone apparent.	1,740.5-1,741.5
Sandy silt. Light-olive-gray (5Y 6/1). Very fine sand. Calcareous and consolidated. Stringers (2-6 in.) of dark-greenish-gray (5G 6/1) clay or silty clay at 1,746, 1,790, 1,798.5, and 1,801 ft. Broken and faulted zone 1,828.5 to 1,833 ft; 45-degree fault plane with slickenside surface. Dark-greenish-gray (5GY 4/1) to black (0) mineral coating 0.10 in. on fracture surface.	1,741.5-1,835.5

Clay. Light-olive-gray (5Y 6/1), some silt. Highly calcareous and consolidated. Bed of sandy silt from 1,850 to 1,851 ft.	1,835.5-1,861.5
Clay. Dark-greenish-gray (5GY 4/1). Calcareous and consolidated. Scattered fragments up to 0.13 in. of vesicular basalt with calcite filling in vesicles. Bottom 2 in. contains 10 to 20 percent dark mineral.	1,861.5-1,862
Sandy silt. Light-olive-gray (5Y 6/1). Very fine sand. Calcareous and well consolidated. From 1,867 to 1,869 ft. up to 5 percent angular basalt fragments to 0.04 in. Bed of dark-greenish-gray (5GY 4/1) clay from 1,870.5 to 1,871 ft.	1,862-1,871
Fault. Approximately 45 degrees. Calcite filling along fault surface.	1,869
Sandy silt. Light-olive-gray (5Y 6/1). Very fine sand. Calcareous and well consolidated. Basalt fragments up to 20 percent of rock, decreasing to 5 percent downward. Silty clay beds at 1,880.5 to 1,881 ft and 1,882 to 1,886 ft; less consolidated.	1,871-1,886
No core.	1,886-1,927
Basalt. Medium-gray (N5) to medium-dark-gray (N4). Dense. Plagioclase laths, some partly altered, 10 percent; olivine about 5 percent. Pyrite and chalcopyrite <0.1 percent.	1,927-1,934
Fault. Approximately 45 degrees. Calcite crystals, pyrite, and chalcopyrite filling along fault surface.	1,927.5
Sand. Brown to light-brown. Very fine sand. Slightly calcareous and consolidated.	1,934-1,936.5
Basalt. Medium-gray (N5) to medium-dark-gray (N4). Vesicular. Vesicles up to 40 percent; decomposed 1,938 to 1,944 ft. Phenocrysts of plagioclase and pyroxene (augite?) <5 percent. Some vesicles filled with soft-grayish-black (N2) mineral, calcite, or bluish-white (5B 9/1) zeolites. Pyrite and chalcopyrite abundant at 1,936.5 ft.	1,936.5-1946
Basalt. Medium-gray (N5) to medium-dark-gray (N4). Vesicular. Vesicles <70 percent, up to 0.04 in., filled with calcite or soft-grayish-black (N2) mineral.	1,946-1,958
Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Vesicular. Vesicles <50 percent, up to 0.06 in., about half of which are filled with calcite.	1,958-1,968

Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Dense. Phenocrysts of plagioclase and brown and green olivine. Crystalline and powdered calcite <5 percent, increasing toward base of flow. Vein (3/4 in. thick) of dark-greenish-black (5G 2/1) hard mineral.	1,968-1,986
Flow boundary.	1,986
Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Vesicular. Vesicles up to 1 in., calcite-filled, comprising up to 75 percent of core. Calcite crystals 0.2 to 0.4 in. Grades to less than 10 percent vesicles with plagioclase laths covered with dark-reddish-brown (10R 3/4) calcareous powder.	1,986-1,988
Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Decomposed. Vesicular. Vesicles <80 percent of core, up to 0.04 in., about 80 percent filled with bluish-white (5B 9/1) calcareous powder.	1,988-1,991
Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Dense. Phenocrysts of plagioclase and brown and green olivine; about 5 percent reddish calcareous powder. Fractured; surfaces coated with dark-greenish-black (5G 2/1) glassy mineral.	1,991-1,997
Basalt. Olive-gray (5Y 4/1) to olive-black (5Y 2/1). Vesicular. Vesicles up to 50 percent of core, about 80 percent filled with bluish-white (5B 9/1) calcareous powder. Few crystals.	1,997-1,998
No core.	1,998-2,008
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent, some filled with black (0) decomposed basalt.	2,008-2,019
Basalt. Light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1). Vesicular. Vesicles <50 percent of core, 80 percent filled with bluish-white (5B 9/1) calcareous powder.	2,019-2,020
Basalt. Light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1). Dense. About 10 percent of core is decomposed.	2,020-2,022
Basalt. Light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1). Vesicular. Vesicles, 0.04 to 0.2 in., filled about 60 percent with calcite and about 30 percent with decomposed basalt.	2,022-2,023.5
Basalt. Grayish-black (N2) to olive-black (5Y 2/1). Vesicular. Vesicles, 0.04 to 0.20 in., filled about 30 percent with calcite and about 60 percent with decomposed basalt. Some euhedral calcite crystals up to 0.2 in. Smaller quartz crystals are present.	2,023.5-2,027

Basalt. Grayish-black (N2) to olive-black (5Y 2/1). Dense.	2,027-2,028
Flow boundary.	2,028
Basalt. Dusky-yellowish-brown (10YR 4/2), grading to dark-yellowish-brown (10YR 2/2). Fractured; decomposed. Euhedral calcite crystals to 0.04 in. in fractures; compose about 80 percent of core at 3,034.5 ft. Smaller quartz crystals are present.	2,028-2,034.5
Basalt. Dark-yellowish-brown (10YR 4/2) to olive-black (5Y 2/1). Vesicular. Vesicles about 0.04 in. compose about 75 percent of the core; about 75 percent filled with euhedral crystals of calcite and quartz.	2,034.5-2,035.5
Basalt. Grayish-black (N2) to olive-black (5Y 2/1). Vesicular. Vesicles about 0.04 in. compose about 75 percent of core. About 75 percent of vesicles contain euhedral crystals of calcite and quartz.	2,035.5-2,040.5
Basalt. Dusky-yellowish-brown (10YR 4/2), grading to dark-yellowish-brown (10 YR 2/2). Fractured; decomposed. Euhedral calcite crystals to 0.04 in. in fractures; smaller quartz crystals are present. Bluish-white (5B 9/1) zeolite crystals up to 0.8 in., 0.2 in. in length; fibrous.	2,040.5-2,045
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent of core; about half filled with calcite and quartz. Abundant fractures, commonly filled with calcite; several exhibit a veneer of glossy-greenish-black (5G 2/1) mineral on the fracture surface.	2,045-2,062
Basalt. Brownish-gray (5YR 4/1) to olive-gray (5Y 4/1). Altered. Vesicles filled with decomposed basalt and calcite, 60:30. Euhedral crystals of calcite and quartz. Calcareous powder also present. Proportion of calcite crystals:powder decreases downward.	2,062-2,071
Basalt. Dark-gray (N3) to grayish-black (N2). Vesicles filled with decomposed basalt and calcite, 60:30. Euhedral crystals of quartz and fine-grained calcite; proportion of crystals:powder decreases downward.	2,071-2,077
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent of core; about half filled with calcite and quartz. Abundant fractures, commonly filled with calcite; several exhibit a glossy greenish-black (5G 2/1) fracture surface.	2,077-2,090
Basalt. Black (0) to moderate-brown (5YR 3/4) to dark-yellowish-brown (10YR 4/2). Dense, decomposed. Some cavities filled with calcite, bluish-white (5B 9/1), and fibrous zeolite, bluish-white (5B 9/1). Fibers are acicular, up to 0.1 in., and radiating.	2,090-2,096

Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent of core; about half filled with calcite and quartz. Highly fractured; several fractures exhibit a glossy-greenish-black (5G 2/1) surface.	2,096-2,110
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent of core; 80 percent filled with calcite and quartz crystals, up to 0.08 in. Up to 40 percent of crystals replaced with a calcareous powder.	2,110-2,144
Basalt. Black (N1). Dense. Vesicles <5 percent of core; about half filled with calcite and quartz. Abundant fractures, commonly filled with calcite; glossy-greenish-black (5G 2/1) surface.	2,144-2,149
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent of core; 80 percent filled with calcite and quartz crystals. Calcite crystals up to 0.25 in., quartz crystals up to 0.06 in. Moderate amounts of alteration to grayish-olive (10Y 4/2) chlorite.	2,149-2,158
Basalt. Black (N1). Dense. Layered with altered dense basalt, light-olive-gray (5Y 5/2).	2,158-2,168
Basalt. Black (N1). Dense, altered. Highly fractured; secondary filling with calcite and quartz, 75:25 in fractures.	2,168-2,171
Basalt. Black (N1). Dense.	2,171-2,172
Basalt. Black (N1). Dense, altered. Highly fractured; secondary filling with calcite and quartz, 75:25 in fractures.	2,172-2,178
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Vesicles <5 percent. Altered: Highly fractured dense with secondary filling of calcite and quartz, 75:25 in fractures. Sparse cavities filled with quartz crystals up to 0.1 in. Grayish-olive (10Y 4/2) chlorite <5 percent.	2,178-2,228
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Vesicles <5 percent. Altered: Highly fractured, pieces up to 1 in. Black (0) to light-olive-gray (5Y 5/2) bands are fairly distinct. Crystals (secondary) in localized areas up to 50 percent of core. Calcite and quartz, 75:25 in fractures. Sparse cavities filled with quartz crystals up to 0.2 in. Grayish-olive (10Y 4/2) chlorite <5 percent.	2,228-2,405.5

Fault. Approximately 45 degrees. Glossy-greenish-black (5G 2/1) fault surface. Quartz and calcite are also present on the fault surface.	2,259.5
Fault. Approximately 45 degrees. Surface coated 0.059 in. with grayish-olive (10Y 4/2) chlorite and white (N 9) quartz.	2,383
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Vesicles <5 percent. Altered: Fractured, black (0) to light-olive-gray (5Y 5/2) banding is fairly distinct. Filling in fractures varies from calcite and quartz to greenish-black (5G 4/1) decomposed basalt. Sparse cavities filled with quartz, calcite crystals, and bluish-white (5B 9/1) calcareous powder. Crystals up to 0.1 in., powder up to 50 percent. Grayish-olive (10Y 4/2) chlorite <5 percent.	2,405.5-2,463
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Vesicles <5 percent. Altered: Fractured, black (0) to light-olive-gray (5Y 5/2) banding is distinct. Fractures filled with calcite, quartz, and greenish-black (5G 4/1) to black (0) decomposed basalt. Sparse staining; dark-yellowish-orange (10YR 6/6), moderate-yellowish-brown (10YR 5/4), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2). Chlorite, grayish-olive (10Y 4/2), <5 percent. Plagioclase laths <5 percent.	2,463-2,541
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Vesicles <5 percent. Altered: Fractured to highly fractured. Inclusions of alternate layers up to 3 in. Black (0) to olive-black (5Y 2/1) banding. Fracture filling of calcite and quartz, 75:25. Sparse, localized cavities lined/filled with calcite, quartz, very-pale-orange (10YR 8/2) zeolite and grayish-olive (10Y 4/2) chlorite. Percent of each varies. Zeolite is characteristically radial and fibrous.	2,541-2,571
Basalt. Black (N1), brownish-black (5YR 2/1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Chiefly black (N1) to brownish-black (5YR 2/1). Altered: Fractured, black (0) to light-olive-gray (5Y 5/2) banding is distinct. Fracture filling of calcite and quartz, 25:75. Sparse, localized cavities lined/filled with calcite, quartz, white (N9) to very-pale-orange (10Y 8/2) zeolite, and olive (10Y 4/2) chlorite. Percent of each varies. Zeolites are radiating fibers and tabular crystals. Plagioclase laths <5 percent.	2,571-2,627
Flow boundary. Sharp contact.	2,627

Ash. Medium-light-gray (N6) to medium-dark-gray (N4). Subangular to round. Up to fine sand size. Calcareous cement.	2,627-2,632
Ash. Medium-light-gray (N6) to medium-dark-gray (N4). Subangular to round. Up to coarse sand size. Calcareous cement.	2,632-2,637.5
Tuff. Grayish-orange-pink (5YR 7/2), yellowish-gray (5Y 7/2), light-gray (N7), to grayish-black (N2). Subangular to round. Up to coarse sand size. Calcareous cement.	2,637.5-2,639
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Vesicular. Vesicles <30 percent, up to 0.6 in. Vesicles filled with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	2,639-2,713.5
Basalt. Grayish-black (N2) to black (0). Dense. Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	2,713.5-2,728
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Vesicular. Vesicles >5 percent, <20 percent, up to 0.4 in. About 75 percent of vesicles filled with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	2,728-2,744
Basalt. Grayish-black (N2) to black (0). Dense. Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	2,744-2,756
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Layering of dense and vesicular. Dense: Inclusions of black (0) decomposed basalt up to 0.2 in. <5 percent. Plagioclase laths, percent varies up to 20 percent. Vesicular: Vesicles <50 percent, up to 0.6 in. Vesicles filled/lined with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	2,756-2,884.5
Fault. Approximately 60 degrees.	2,824

Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense, vesicular, and some alteration. Dense: Chiefly grayish-black (N2) to black (0). Inclusions of black (0) decomposed basalt <5 percent, up to 0.2 in. Vesicular: Vesicles <50 percent, up to 0.6 in. Vesicles filled/lined with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent. Degree of alteration varies. Black (0) to light-olive-gray (5Y 5/2) banding is distinct. Secondary filling in fractures varies from calcite, quartz, to greenish-black (5G 4/1) to black (0) decomposed basalt. Sparse staining; dark-yellowish-orange (10YR 6/6), moderate-yellowish-brown (10YR 5/4), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2). Chlorite, grayish-olive (10Y 4/2), <5 percent. Plagioclase laths <5 percent.	2,884.5-2,916
Basaltic tuff. Grayish-olive-green (5GY 3/2) to olive-black (5Y 2/1). Calcareous cement, percent varies. Fossil shell fragments.	2,916-2,924
Basaltic tuff and basalt. Grayish-olive-green (5GY 3/2) to olive-black (5Y 2/1) tuff. Calcareous cement, percent varies. Black (N1), brownish-black (5YR 2/1) to olive-black (5Y 2/1) altered vesicular basalt. Fractured; black (0) to light-olive-gray (5Y 5/2) banding is distinct. Fractures filled with calcite and quartz, 25:75. Alternate layers of tuff and altered vesicular basalt.	2,924-2,926
Basalt. Black (N1), brownish-black (5YR 2/1) to olive-black (5Y 2/1). Altered vesicular. Fractured; black (0) to light-olive-gray (5Y 5/2) banding is distinct. Fractures filled with calcite and quartz, 25:75. Sparse, localized, cavities lined/filled with calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and grayish-olive (10YR 4/2) chlorite. Percent of each varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	2,926-2,939
Zeolite. White (N9) crystals up to 0.6 in.	2,935.5
Basalt Grayish-black (N2) to black (0). Dense. Rounded inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	2,939-2,964

Zeolite. White (N9) crystals up to 0.1 in.	2,961
Basalt. Grayish-black (N2) to black (0). Dense. Fragments of black (0) basalt up to 2 in. Rounded inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	2,964-2,995
Basalt. Black (N1), brownish-black (5YR 2/1) to olive-black (5Y 2/1). Altered vesicular. Fractured; black (0) to light-olive-gray (5Y 5/2) banding is distinct. Fractures filled with calcite and quartz, 25:75. Sparse, localized cavities lined/filled with calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and grayish-olive (10YR 4/2) chlorite. Percent of each varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	2,995-2,999
Basalt. Grayish-black (N2) to black (0). Dense. Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	2,999-3,001
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Vesicular. Vesicles >5 percent, up to 0.6 in. Vesicles filled with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	3,001-3,008.5
Basalt. Black (N1) to olive-black (5Y 2/1). Layering of dense and altered. Dense: Black (0) to grayish-black (N2). Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent. Plagioclase laths, percent varies, up to 20 percent. Altered: Degree varies. Fractured; black (0) to light-olive-gray (5Y 5/2) banding is distinct. Secondary filling in fractures varies from calcite, quartz, and greenish-black (5G 4/1) to black (0) decomposed basalt. Sparse staining; dark-yellowish-orange (10YR 6/6), moderate-yellowish-brown (10YR 5/4), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2). Grayish-olive (10Y 4/2) chlorite <5 percent. Plagioclase laths <5 percent.	3,008.5-3,021
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Vesicular. Vesicles >5 percent, up to 0.6 in. Vesicles filled with brownish-black (5YR 2/1) decomposed basalt, calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Percent of vesicles filled and composition of fill varies. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	3,021-3,026

Basalt. Grayish-black (N2) to black (0). Dense. Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	3,026-3,035
Basalt. Grayish-black (N2) to black (0). Altered dense. Bluish-white (5B 9/1) calcareous powder <5 percent. Moderate-brown (5YR 4/4) sphene, up to 0.04 in. <5 percent. Inclusions of black (0) decomposed basalt up to 0.2 in. <1 percent.	3,035-3,038
Basalt. Grayish-black (N2) to brownish-black (5YR 2/1). Vesicular. Vesicles >5 percent, up to 0.2 in., filled chiefly with black (0) decomposed basalt. Plagioclase laths up to 20 percent.	3,038-3,039
Tuff. Pale-olive (10Y 6/2) to grayish-olive (10Y 4/2). Fragment sizes not well sorted.	3,039-3,039.5
Basalt. Black (0), grayish-black (N2), to brownish-black (5YR 2/1). Vesicular. Vesicles >5 percent, up to 0.6 in. Approximately 75 percent of vesicles filled with black (0) decomposed basalt, 25 percent filled with calcite, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10YR 6/2) chlorite. Zeolite crystals commonly radiating and/or tabular. Plagioclase laths <5 percent.	3,039.5-3,046
Basalt. Black (0), grayish-black (N2), brownish-black (5YR 2/1), grayish-red (5Y 4/2), to grayish-red-purple (5RP 4/2). Layering of dense and vesicular. Some of the dense has inclusions of black (0) decomposed basalt up to 0.2 in. <5 percent. Vesicular: Vesicles >5 percent, up to 0.6 in.; generally <50 percent. Vesicles lined/filled with brownish-black (5YR 2/1) to black (0) decomposed basalt, calcite, and quartz. Plagioclase laths <5 percent.	3,046-3,133
Basalt. Black (N1) to grayish-red (5R 4/2). Layering of dense and altered. Dense: Chiefly black (N1). Altered: Degree varies. Soft, flakey. Fractured with filling varying from calcite, quartz, greenish-black (5G 4/1) to black (0) decomposed basalt. Grayish-olive (10Y 4/2) chlorite <5 percent. Plagioclase laths <5 percent.	3,133-3,138.5
Basalt. Very-pale-orange (10YR 8/2) to olive-gray (5Y 3/2). Altered. Soft, flakey, fractured.	3,138.5-3,145
Basalt. Grayish-black (N2) to black (0). Dense and vesicular. Dense: Inclusions of black (0) decomposed basalt up to 0.2 in. <5 percent. Vesicular: Vesicles >5 percent, up to 0.2 in., lined/filled with brownish-black (5YR 2/1) to black (0) decomposed basalt, calcite, and quartz. Plagioclase laths <5 percent.	3,145-3,156

Basalt. Black (0). Dense.	3,156-3,159
Basalt. Grayish-black (N2) to black (0). Vesicular. Vesicles >5 percent, up to 0.2 in., chiefly lined/ filled with brownish-black (5YR 2/1) to black (0) decomposed basalt. Plagioclase laths <5 percent.	3,159-3,161
Basalt. Black (0). Dense.	3,161-3,163
Basalt. Grayish-black (N2) to black (0). Vesicular. Vesicles >5 percent, up to 0.2 in., chiefly lined/ filled with brownish-black (5YR 2/1) to black (0) decomposed basalt. Plagioclase laths <5 percent. Vesicularity decreases with depth.	3,163-3,168
Basalt. Light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1). Vesicular. Vesicles >5 percent, up to 0.04 to 0.02 in., about 60 percent filled with calcareous material and about 30 percent with decomposed basalt.	3,168-3,170
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent, some filled with black (0) decomposed basalt.	3,170-3,172
Basalt. Grayish-black (N2), brownish-black (5YR 2/1), to black (0). Vesicular. Vesicles >5 percent, size increasing with depth up to 0.4 in. Vesicles chiefly filled/lined with brownish-black (5YR 2/1) decomposed basalt. Plagioclase laths <5 percent.	3,172-3,175
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent, some filled with black (0) decomposed basalt.	3,175-3,179
Basalt. Grayish-black (N2), brownish-black (5YR 2/1), to black (0). Vesicular. Vesicles >5 percent, up to 0.4 in. Vesicles chiefly filled/lined with brownish-black (5YR 2/1) decomposed basalt. Plagioclase laths <5 percent.	3,179-3,182
Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent, some filled with black (0) decomposed basalt.	3,182-3,183
Basalt. Black (0). Vesicular. Vesicles <30 percent, up to 0.2 in. Approximately 75 percent of vesicles filled with black (0) decomposed basalt; 25 percent filled with pale-yellowish-green (10GY 7/2) chlorite and white (N9) calcareous powder.	3,183-3,184.5
Basalt. Black (0). Vesicular. Vesicles <30 percent, up to 0.2 in. Vesicles filled with black (0) decomposed basalt.	3,184.5-3,185.5

Basalt. Grayish-black (N2) to black (0). Dense. Vesicles <5 percent, some filled with black (0) altered basalt.	3,185.5-3,187
Fault. Approximately 45 degrees. Sparse, about 5 percent, coating of pyrite and chalcopyrite on fault surface.	3,187
Basalt. Black (0). Vesicular. Vesicles <30 percent, up to 0.2 in. Vesicles filled with black (0) decomposed basalt, and pale-yellowish-green (10GY 7/2) chlorite and white (N9) calcareous powder, 50:50.	3,187-3,188
Basalt. Black (0) to greenish-black (5G 2/1). Vesicular. Vesicles <30 percent, up to 0.2 in. About 75 percent of vesicles filled with calcareous powder, some white (N9) calcite crystals up to 0.1 in.	3,188-3,191.5
Basalt. Greenish-black (5G 2/1). Vesicular. Vesicles <50 percent, up to 0.1 in. About 50 percent of vesicles filled with bluish-white (5B 9/1) calcareous powder, 20 percent with calcite and quartz crystals, 10 percent with pinkish-gray (5YR 8/1) zeolite. Calcite, quartz, and zeolite crystals up to 0.1 in. Zeolite crystals fibrous and radiating.	3,191.5-3,193
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured; very small banded fragments are greenish-black (5G 2/1).	3,193-3,195
Basalt. Black (0). Vesicular. Vesicles <30 percent, size increasing with depth up to 0.2 in. Approximately 75 percent of vesicles filled with black (0) decomposed basalt and white (N9) calcareous powder, 25 percent with yellowish-green (10GY 7/2) chlorite.	3,195-3,200.5
Basalt. Black (0) to greenish-black (5G 2/1). Vesicular. Altered. Vesicles <10 percent, <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies.	3,200.5-3,210.5
Zeolite. White (N9). Radiating, needles up to 0.2 in.	3,203.5
Basalt. Olive-black (5Y 2/1) to black (0). Vesicular. Vesicles <30 percent, up to 0.1 in. About 75 percent of vesicles filled with black (0) decomposed basalt, 20 percent with bluish-white (5B 9/1) calcareous powder. Some bluish-white (5B 9/1) calcite crystals up to 0.1 in.	3,210.5-3,212
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Fractured. Fractures filled with white (N9) to bluish-white (5B 9/1) calcite, quartz, and zeolite. Some fracture cavities have white (N9) radiating acicular zeolite crystals up to 0.2 in.	3,212-3,214

Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured; small banded fragments are greenish-black (5G 2/1).	3,214-3,223.5
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Fractured. Fractures filled with white (N9) to bluish-white (5B 9/1) calcite, quartz, and zeolite.	3,223.5-3,224.5
Basalt. Black (0) to olive-gray (5Y 4/1). Dense.	3,224.5-3,227.5
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured; greenish-black (5G 2/1) fragments <0.2 in.	3,227.5-3,267
Basalt. Black (0). Dense. Isolated fractures, filled with white (N9) quartz crystals up to 0.1 in.	3,267-3,268
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured; small, greenish-black (5G 2/1) banded fragments <0.2 in.	3,268-3,268.5
Basalt. Black (0). Dense.	3,268.5-3,269.5
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured; small, greenish-black (5G 2/1) banded fragments <0.2 in.	3,269.5-3,270
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Fractured. Bluish-white (5B 9/1) calcite and quartz line the fractures of greenish-black (5G 2/1) banded fragments. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies.	3,270-3,271
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Fractured. Fractures filled with white (N9) to bluish-white (5B 9/1) calcite, quartz, and zeolite. Some fracture cavities have white (N9) radiating acicular zeolite crystals up to 0.2 in.	3,271-3,272
Basalt. Black (0) to olive-gray (5Y 4/1). Dense.	3,272-3,276
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Fractured into very fine grained greenish-black (5G 2/1) banded fragments. Friable.	3,276-3,310

Basalt. Black (0). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) alteration. Composition of fill and percent varies. Fractured into greenish-black (5G 2/1) banded fragments. Friable.	3,310-3,313
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies.	3,313-3,326
Basalt. Black (0) to greenish-black (5G 2/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Rounded inclusions, up to 2.4 in. of black (0) to olive-gray (5Y 4/1) dense decomposed basalt; vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt.	3,326-3,329
Fault. High angle.	3,334-3,337.5
Basalt. Black (0), olive-gray (5Y 4/1), brownish-black (5YR 2/1), and grayish-black (N2). Layering of dense and vesicular. Percent of composition and fill varies. Dense: Altered. Vesicles <5 percent, up to 0.1 in., filled with white (N9) calcareous powder, black (0) decomposed basalt, calcite, and quartz. Vesicular: Vesicles <50 percent, up to 0.2 in., filled up to 80 percent with white calcareous powder, black (0) decomposed basalt, calcite, quartz, and white (N9), bluish-white (5B 9/1), to moderate-yellowish-brown (10YR 5/4) zeolite. Crystals of calcite and quartz up to 0.2 in. Zeolite is acicular, radiating, and massive. Plagioclase laths <5 percent.	3,329-3,386
Basalt. Olive-black (5Y 2/1). Dense. Fractured.	3,386-3,388
Basalt. Olive-black (5Y 2/1) to black (0). Vesicular. Vesicles <30 percent, up to 0.4 in. About 50 percent filled with calcite and quartz; 50 percent lined with black (0) decomposed basalt. Some calcite crystals up to 0.1 in.	3,388-3,412.5
Basalt. Black (0). Vesicular. Vesicles <20 percent, 50 percent filled with white (N9) calcareous powder and quartz crystals up to 0.2 in. Some cavities filled with bluish-white (5B 9/1) to moderate-yellowish-brown (10YR 5/4) radiating acicular zeolite crystals up to 0.2 in. and white (N9) tabular zeolite crystals up to 0.1 in., <10 percent.	3,412.5-3,415
Zeolite. White (N9). Radiating acicular crystals filling a cavity.	3,415

Basalt. Olive-black (5Y 2/1), black (0), brownish-black (5YR 2/1) to greenish-black (5G 2/1). Layering of dense and vesicular. Dense: Vesicles <5 percent. Localized areas of alterations and fractures. Greenish-black (5G 2/1) broken fragments up to 0.2 in. in localized areas. Vesicles and fractures variably filled with black (0) decomposed basalt, white (N9) calcareous powder, quartz, white (N9) to very-pale-orange (10YR 8/2) zeolite, and pale-olive (10Y 6/2) chlorite. Sparse staining; dark-yellowish-orange (10YR 6/6), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2) <5 percent. Vesicular: Vesicles <30 percent, up to 0.1 in., up to 80 percent filled with black (0) decomposed basalt, bluish-white (5B 9/1) calcite, bluish-white (5B 9/1) quartz, greenish-black (5G 2/1) chlorite, and bluish-white (5B 9/1) zeolite. Plagioclase laths <5 percent.	3,415-3,549
Zeolite. White (N9). Radiating acicular crystals filling a cavity.	3,421
Fault. Approximately 45 degrees. Lined with quartz and greenish-gray (5G 6/1) chlorite.	3,422
Basalt. Black (0) to dark-gray (N3). Vesicular. Vesicles <10 percent, up to 0.6 in. filled with black (0) decomposed basalt. Vesicle percent decreases with depth.	3,549-3,565.5
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some fracturing.	3,565.5-3,679
Basalt. Black (0) to olive-gray (5Y 4/1). Dense.	3,679-3,712
Basalt. Dark gray (N3). Dense. Plagioclase laths up to 0.1 in.	3,712-3,727.7
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some pyrite and chalcopyrite. Some white (N9) quartz or zeolite.	3,727.7-3,770.3
Basalt. Dark-gray (N3). Vesicular. Vesicles <30 percent, decreasing to <10 percent and size increasing up to 0.4 in. Vesicles filled with bluish-white (5B 9/1) calcite, bluish-white (5B 9/1) quartz, bluish-white (5B 9/1) zeolite, and olive-black (5Y 2/1) chlorite.	3,770.3-3,779.4
Basalt. Olive-black (5Y 2/1) to black (0). Dense. About 10 percent covered with unidentified light-olive-gray (5Y 6/1) to greenish-gray (5GY 6/1) alteration.	3,779.4-3,784.4
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in.	3,784.4-3,788.8

Basalt. Olive-black (5Y 2/1) to black (0). Dense. About 10 percent covered with unidentified light-olive-gray (5Y 6/1) to greenish-gray (5GY 6/1) alteration.	3,788.8-3,794
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in.	3,794-3,814.2
Fault. Approximately 45 degrees. Lined by soft-black (0) mineral.	3,796
Basalt. Olive-black (5Y 2/1). Vesicular. Vesicle size up to 0.08 in.; 90 percent filled with black (0) decomposed basalt.	3,814.2-3,816.2
Basalt. Moderate-brown (5YR 3/4), olive-gray (5Y 4/1), to black (0). Dense.	3,816.2-3,818
Basalt. Dark-gray (N3). Vesicular. Vesicles <30 percent, decreasing to <10 percent and size increasing up to 0.4 in. Vesicles 90 percent filled with black (0) decomposed basalt.	3,818-3,821.6
Basalt. Dark-gray (N3). Layering of vesicular and dense. Vesicular: Vesicles <10 percent, with depth increasing to <30 percent. Ninety percent filled with black (0) decomposed basalt. Vesicle size decreases from 0.4 in. and grades into dense basalt. Dense: Inclusions of black (0) altered dense basalt up to 0.4 in., <10 percent. Grades back into vesicular.	3,821.6-3,837.1
Fault. Bidirectional. Approximately 45 degrees, lateral, and vertical. Lined by soft-black (0) mineral.	3,836
Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.1 in. About 50 percent filled with calcite, quartz, and white (N9) zeolite.	3,837.1-3,838.1
Basalt. Dark-gray (N3). Vesicular. Vesicles <30 percent, up to 0.4 in. Filled with black (0) decomposed basalt.	3,838.1-3,841.7
Basalt. Dark-gray (N3). Dense. Inclusions of black (0) decomposed basalt up to 0.4 in., <5 percent. Plagioclase laths up to 0.1 in.	3,841.7-3,853.4
Basalt. Dark-gray (N3). Vesicular. Vesicles <30 percent, up to 0.2 in. Filled with black (0) decomposed basalt. Fractured throughout. Fractures lined with soft-black (0) mineral.	3,853.4-3,869
Fault. Approximately 45 degrees. Lined with soft-black (0) mineral.	3,855.4

Fault. Approximately 45 degrees. Lined with soft-black (0)mineral.	3,857.4
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in.	3,869-3,880.4
Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.4 in. About 90 percent filled with black (0) decomposed basalt.	3,880.4-3,882
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in.	3,882-3,885.4
Basalt. Dark-gray (N3). Vesicular. Vesicles <10 percent, up to 0.1 in. Filled with black (0) decomposed basalt.	3,885.4-3,886.4
Basalt. Light-olive-gray (5Y 6/1) to black (0). Vesicular. Altered. Vesicles <75 percent, up to 0.1 in., <50 percent filled with white (N9) calcareous material.	3,886.4-3,888
Basalt. Olive-gray (5Y 4/1). Vesicular. Altered. Vesicles <50 percent, up to 0.1 in. Filled with black (0) decomposed basalt with a slightly calcareous filling. Friable.	3,888-3,896
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Friable along greenish-black (5G 2/1) banded fragments.	3,896-3,918.5
Basalt. Black (0). Altered. Glassy inclusions of altered dense basalt up to 2 in. <10 percent. Calcareous fillings <5 percent. Stains of dark-yellowish-orange (10YR 6/6), moderate-yellowish-brown (10YR 5/4), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2).	3,918.5-3,956.9
Basalt. Medium-dark-gray (N4) to grayish-black (N2). Dense.	3,956.9-3,978.5
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some pyrite and chalcopyrite crystals. Some white (N9) quartz or zeolite.	3,978.5-3,979
Basalt. Light-olive-gray (5Y 6/1) to olive-black (5Y 2/1). Altered. Highly fractured. Fifty percent of fractures filled with a black (0), slightly calcareous material.	3,979-3,981
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some pyrite and chalcopyrite crystals. Some white (N9) quartz or zeolite.	3,981-3,992

Basalt. Light-olive-gray (5Y 6/1) to olive-black (5Y 2/1). Altered. Highly fractured. Seventy-five percent filled with a black (0), slightly calcareous material.	3,992-3,993
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some pyrite and chalcopyrite crystals. Black (0) inclusions of basalt up to 0.8 in. <5 percent. Some white (N9) quartz or zeolite.	3,993-3,994.5
Basalt. Dark-gray (N3). Dense. Layered with dense basalt that has sparse massive pyrite, chalcopyrite, and white (N9) quartz or zeolite. Both basalts have plagioclase laths up to 0.1 in., and inclusions of black (0) material up to 0.8 in. <5 percent.	3,994.5-4,001
Basalt. Black (0). Dense. Sparse crystals of pyrite and white (N9) zeolite up to 0.06 in. Some white (N9) to colorless crystals of quartz and calcite.	4,001-4,005
Basalt. Black (0) to olive-gray (5Y 4/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Composition of fill and percent varies. Friable along greenish-black (5G 2/1) banded fragments.	4,005-4,028
Basalt. Light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1). Dense. Altered. Vesicles <0.1 in., filled with white (N9) calcareous powder and black (0) decomposed basalt. Grayish-red-purple (5RP 4/2) fragments <1 percent. Composition of fill and percent varies. Friable along greenish-black (5G 2/1) banded fragments.	4,028-4,031
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in. Some pyrite and chalcopyrite crystals. Inclusions of black (0) basalt up to 0.8 in. <5 percent. Some white (N9) quartz.	4,031-4,035
Basalt. Black (N1) to olive-black (5Y 2/1). Altered. Fractured; filled with calcite and quartz, 75:25. Some cavities filled with quartz crystals up to 0.12 in. Grayish-olive (10Y 4/2) chlorite <5 percent.	4,035-4,037
Basalt. Dark-gray (N3). Dense. Plagioclase laths up to 0.1 in.	4,037-4,044
Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.04 in., 75 percent filled with black (0) decomposed basalt. Vesicle size increases with depth up to 0.2 in.	4,044-4,047.4

Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.2 in., up to 90 percent filled with black (0) decomposed basalt. With depth, vesicle size increases up to 0.2 in., percent of black (0) decomposed basalt fill varies up to 75 percent. Random grayish-orange (10YR 7/4) acicular zeolite crystals up to 0.1 in., <10 percent, in black (0) decomposed basalt filling.	4,047.4-4,051.4
Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.04 in., filled 75 percent with black (0) decomposed basalt. Sparse grayish-red-purple (5RP 4/2) alteration in filling. Some massive chalcopyrite. With depth, vesicle size increases up to 0.2 in., percent of black (0) decomposed basalt and grayish-red-purple (5RP 4/2) alteration fill varies up to 75 percent.	4,051.4-4,055.4
Basalt. Dark-gray (N3). Vesicular. Vesicles <20 percent, up to 0.2 in., filled 90 percent with black (0) alteration. From 4,060 to 4,062 ft, linear fractures filled with calcite, quartz, and white (N9) zeolite.	4,055.4-4,062
Basalt. Dark-gray (N3). Dense. Vesicles <5 percent, up to 0.2 in., filled 90 percent with black (0) decomposed basalt.	4,062-4,069
Basalt. Dark-gray (N3). Vesicular. Vesicles <50 percent, up to 0.04 in., filled 75 percent with black (0) decomposed basalt. Sparse grayish-red-purple (5RP 4/2) alteration in filling. Some massive chalcopyrite. With depth, vesicle size increases up to 0.2 in., percent of black (0) decomposed basalt and grayish-red-purple (5RP 4/2) alteration fill varies up to 75 percent.	4,069-4,071.3
Basalt. Dark-gray (N3). Vesicular. Vesicles <30 percent, size varies from 0.1 in. to 0.2 in., filled 75 percent with black (0) decomposed basalt, 20 percent lined with black (0) shard-like material. White (N9) massive calcite, up to 2.4 in., occurs in cavities <5 percent.	4,071.3-4,095
Basalt. Dark-gray (N3). Vesicular. Vesicles <20 percent, size varies from 0.1 in. to 0.2 in., filled 50 percent with black (0) decomposed basalt, 25 percent with greenish-gray (5GY 6/1) chlorite alteration. Chlorite alteration is zoned, center is greenish-gray (5GY 6/1) grading into black (0) on the outside. Some vesicles lined with black (0) shard-like material. White (N9) massive calcite, up to 2.4 in., occurs in cavities <5 percent.	4,095-4,110.5

Basalt. Dark-gray (N3). Vesicular. Vesicles range from <10 to <30 percent, size varies from 0.1 in. to 0.2 in., filled 50 percent with black (0) decomposed basalt, 25 percent with greenish-gray (5GY 6/1) chlorite alteration. Chlorite alteration is zoned, center is greenish-gray (5GY 6/1) grading into black (0) on the outside due to alteration. Some vesicles lined with black (0) shard-like material. White (N9) massive calcite, up to 2.4 in., occurs in cavities <5 percent.	4,110.5-4,118.5
Fault. Approximately 45 degrees.	4,118.5
Basalt. Olive-gray (5Y 4/1). Vesicular. Vesicles <50 percent, up to 0.1 in., filled with olive-black (5Y 2/1) to black (0) decomposed basalt.	4,118.5-4,120.3
Basalt. Black (0). Glassy. Inclusions of altered basalt up to 2 in. <10 percent. Calcareous fillings <5 percent. Stains of dark-yellowish-orange (10YR 6/6), moderate-yellowish-brown (10YR 5/4), pale-yellowish-brown (10YR 6/2), and dark-yellowish-brown (10YR 4/2).	4,120.3-4,121.3
Basalt. Olive-gray (5Y 4/1). Vesicular. Vesicles <50 percent, size ranges from 0.1 in. to 0.2 in., filled with olive-black (5Y 2/1) to black (0) decomposed basalt.	4,121.3-4,139
Zeolite. White (N9) to grayish-orange-pink (5YR 7/2). Acicular.	4,129
Basalt. Dark-gray (N3). Dense. Vesicles <5 percent, up to 0.2 in., 90 percent filled with black (0) decomposed basalt. With depth, vesicular percent decreases.	4,139-4,151
Basalt. Olive-gray (5Y 4/1). Vesicular. Vesicles <50 percent, size ranges from 0.1 in. to 0.2 in., filled with olive-black (5Y 2/1) to black (0) decomposed basalt.	4,151-4,153
Basalt. Olive-gray (5Y 4/1). Vesicular. Altered. Vesicles <50 percent, up to 0.1 in., filled with dark-gray (N3) to black (0) decomposed basalt and calcareous cement.	4,153-4,158.5
Basalt. Black (0), medium-dark-gray (N3), olive-gray (5Y 4/1) to greenish-gray (5GY 6/1). Dense. Altered. Localized fracturing. Vesicles <0.1 in., filled with white (N9) calcareous powder, black (0) decomposed basalt, quartz, and calcite. Crystals of quartz and calcite up to 0.2 in. Composition of fill and percent varies. Friable.	4,158.5-4,403

[1]Goddard and others (1948).