GL01881

GEO CORE HOLE N-1

D.O.E. PHASE II SUBMITTAL

COOPERATIVE AGREEMENT

No. DE-FC07-85ID12612

NEWBERRY FLANK UNIT

by

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FIGURE 2A

GEOCHEMISTRY OF FLUIDS IN CORE HOLE GEO N-1. Fluid samples of the boreholes were routinely collected from the core barrel during core retrieval. Clearly, these fluids are primarily drilling muds. However, values above background suggest the presence of aquifers which contribute formation fluids. although figure 2A illustrates only silica values, analyses were conducted for a variety of constituents (Table 2A). Note that fluid samples were also collected from Baker tanks and with a down-hole sampling instrument.

CORE HOLE GEO N-1

SILICA CONTENT

NEWBERRY VOLCANO, OREGON

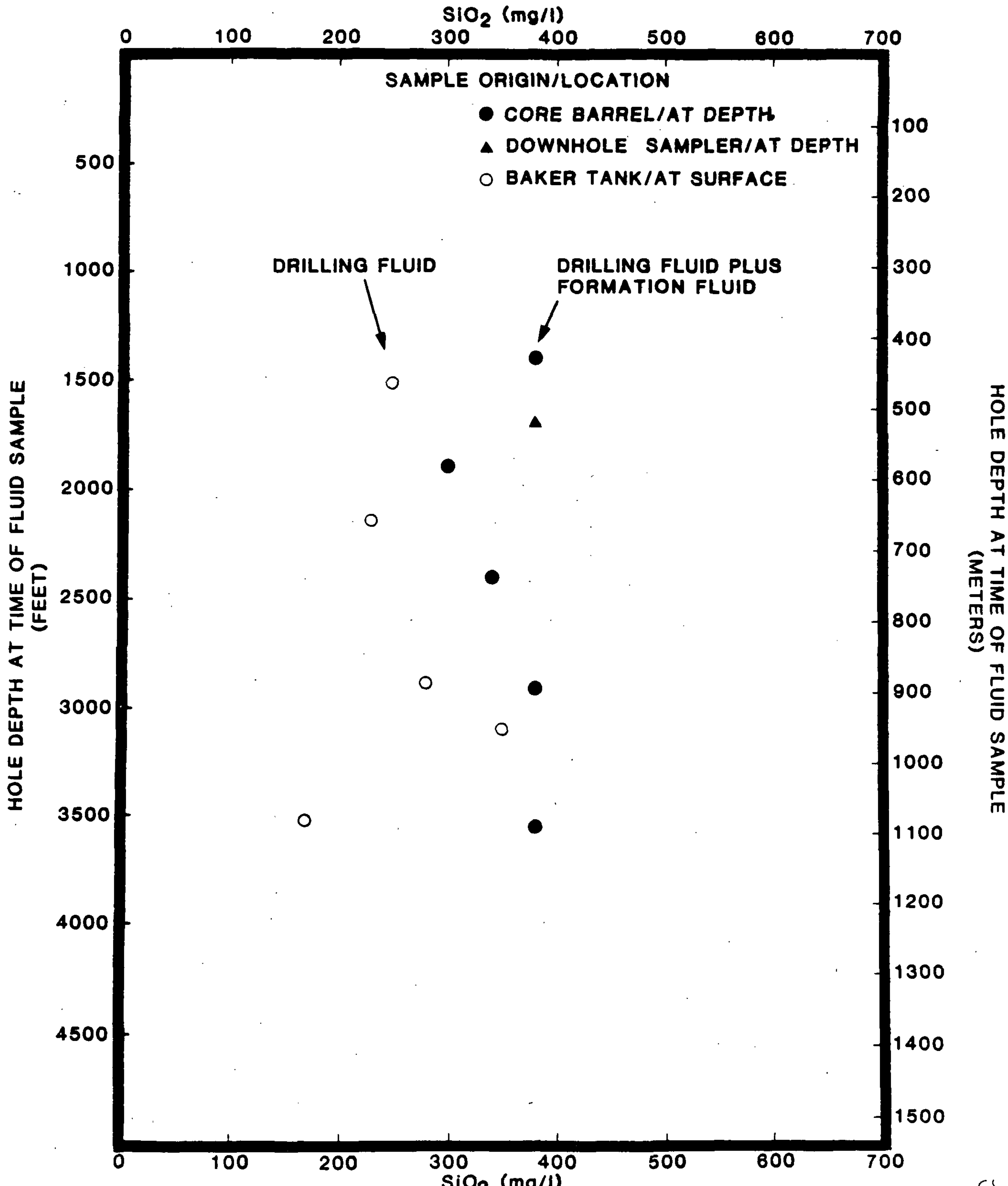


Figure 2A

There is one less sample than in Table

TABLE 2A

FLUID GEOCHEMISTRY FOR CORE HOLE GEO N-1 (mg/L) (see Fig. 2A)

General Chemical

Sample #	Descriptor* (feet)	Chloride (Cl^-)	Fluoride (F^-)	Inorganic Carbon(CO_2)	Sulfide (S^{2-})	Total Sulfur (S)	Remarks
1	1408	20	<1	650	<1	30	Core Barrel
2	1698	30	<1	720	<1	30	Sample Tool
3	1900	30	<1	820	<1	30	Core Barrel
4	2412	30	<1	600	<1	10	Core Barrel
5	2923	30	<1	760	<1	<10	Core Barrel
6	3545	40	<1	430	<1	10	Core Barrel
10	1512	40	<1	520	<1	7	Baker Tank
11	2294	20	<1	470	<1	20	Baker Tank
12	2800	20	<1	660	<1	20	Baker Tank
13	3102	20	<1	670	<1	10	Baker Tank
14	3468	10	<1	570	<1	20	Baker Tank

Elemental Constituents

Sample #	Descriptor* (feet)	Al	As	Ba	B	Ca	Fe	Pb	Li	Mg	Mn	Hg	K	SiO_2	Na	Remarks
1	1408	79	<0.1	5.0	<1	180	84	0.4	≤0.01	37	4.6	<0.01	21.0	380	1000	Core Barrel
2	1698	110	≤0.1	4.1	<1	180	87	0.4	0.04	43	4.0	<0.01	9.1	380	1100	Sample Tool
3	1900	80	<0.1	3.8	<1	210	81	0.5	<0.01	42	3.8	<0.01	9.1	300	1200	Core Barrel
4	2412	66	<0.1	7.6	<1	160	97	0.6	0.04	32	4.3	<0.01	5.3	340	900	Core Barrel
5	2923	28	<0.1	8.2	<1	89	72	0.4	<0.01	18	2.1	<0.01	5.6	380	1000	Core Barrel
6	3545	43	<0.1	2.9	<1	120	60	0.3	0.03	21	2.7	≤0.01	5.0	380	720	Core Barrel
10	1512	97	<0.1	3.2	1	210	72	0.3	≤0.01	38	3.8	<0.01	8.8	250	900	Baker Tank
11	2294	34	<0.1	1.5	<1	72	30	0.2	0.04	16	1.3	<0.01	5.0	230	620	Baker Tank
12	2800	49	<0.1	2.1	<1	83	41	0.2	<0.01	20	2.0	<0.01	6.2	280	820	Baker Tank
13	3102	33	<0.1	1.8	<1	110	32	0.2	<0.01	20	1.9	<0.01	5.6	350	920	Baker Tank
14	3468	48	<0.1	2.3	<1	120	41	0.3	<0.01	25	2.3	<0.01	6.8	170	720	Baker Tank

* Depth of sample or depth of bit when sample collected at surface

TABLE 2 A (continued)

FLUID GEOCHEMISTRY FOR CORE HOLE GEO N-1 (see Fig. 2A)

Gas Content

Sample #	Descriptor (feet)	Volume %			PPMV			
		Ar	O_2	N_2	CH_4	H_2	CO_2(g)	H_2S
1-A	1152	0.93	21	78	<100	<40	360	0.41
2-A	1698	0.96	21	78	<100	<40	740	0.12

FIGURE 2B

GEOCHEMISTRY AND STRATIGRAPHY OF CORE HOLE GEO N-1. Whole rock analyses of selected samples were conducted at the Washington State University (WSU) X-ray fluorescence (XRF) facility. The lithographic column and descriptions were generated by GEO personnel based on detailed geologic logging and comparisons to geochemical analyses. The silicic nature of the lithology below 3700 feet is clearly reflected in the Dresser Atlas gamma ray geophysical log of 11/2/85. The temperature data were recorded by the drillers from maximum-reading-thermometers (MRTs) taped to the wireline just above the overshot.

TEMPERATURE GRADIENT CORE HOLE SUMMARY

ame GEO CORE HOLE N-1

Company GEO-NEWBERRY Lease ______ County DESCHUTES

Location 3600' W AND 2750' N of SE Corner Sec 25 T 22S R 12E

Spud Date 8-24-85 Completed 11-6-85 Depth 4000'

BOTTOM HOLE TEMPERATURES WHILE DRILLING

☒ Feet ☐ Meters ☒ °F ☐ °C

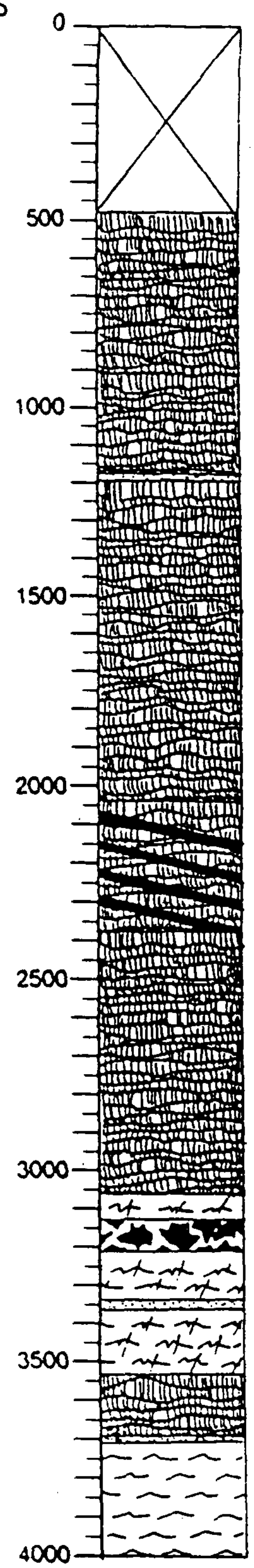
DEPTH	TEMP	DEPTH	TEMP	DEPTH	TEMP
100	<100	1600	54	3100	57
200	<100	1700	55	3200	58
300	<100	1800	54	3300	82
400	<100	1900	55	3400	60
500	<100	2000	54	3500	95
600	<100	2100	55	3600	97
700	<100	2200	<100	3700	114
800	<100	2300	<100	3800	128
900	<100	2400	<100	3900	140
1000	<100	2500	<100	4000	140
1100	<100	2600	<100		
1200	<100	2700	< 60		
1300	<100	2800	< 60		
1400	65	2900	64		
1500	54	3000	< 60		

COMMENTS:

BHT ABOVE ARE GENERALIZED; FOR SPECIFIC DEPTHS AND TEMPERATURE REFER TO WELL DATA PACKAGE.

WATER ENTRIES:

LITHOLOGY — MINERALOGY



INTERVAL/FT.	DESCRIPTION
0 - 487	No Sample
487-1172	Basalt and basaltic andesite flows with interflow breccias deposits.
1172-1188	Lithic crystal tuff with dacitic composition.
1188-2039	Basalt and basaltic andesite flows with intercalated interflow breccias and scoria deposits. Minor sporadic lithic tuffs and vitric tuffs of rhyodacitic composition.
2039-2370	Basalt and basaltic andesite flows with intercalated interflow breccias and scoria deposits. Basaltic intrusives with chilled margins and intermediate dip angles are common.
2370-3069	Basalt and basaltic andesite flows with intercalated interflow breccias and scoria deposits.
3069-3349	Andesite flows with minor sporadic tuffs of dacitic composition interval 3128-3218 is primarily breccias and scoria deposit.
3349-3365	Lithic tuff.
3365-3538	Andesite flows with intercalated breccias and scoria deposits.
3538-3691	Basalt and basaltic andesite flows with intercalated breccias and scoria deposits.
3691-3714	Lithic crystal tuff.

Figure 2B

TABLE 2B

WHOLE ROCK ANALYTICAL RESULTS OF CORE HOLE GEO N-1 (see Fig. 2B)

Sample # GEO	Depth in ft.	Name	SI02	AL203	TI02	FE203	FE0	MN0	CA0	MG0	K20	NA20	P205
			Reported as percentage										
1	531	B	53.71	17.57	0.98	3.86	4.42	0.13	9.34	5.75	0.53	3.48	0.244
2	597	BA	56.34	16.24	1.28	4.28	4.90	0.15	7.72	4.06	0.93	3.74	0.363
3	1061	BA	58.86	16.24	1.44	4.23	4.84	0.15	6.36	2.85	0.99	3.79	0.248
4	1175	D *(T)	67.48	15.61	0.84	2.25	2.58	0.12	3.35	1.21	2.12	4.20	0.237
5	1212	BA	58.40	15.74	1.61	4.55	5.22	0.16	6.17	2.82	1.05	3.93	0.334
6	1461	BA	56.44	16.11	1.52	4.73	5.41	0.16	7.13	3.52	0.92	3.82	0.236
7	1578	BA	57.49	15.95	1.37	4.25	4.87	0.15	7.35	3.81	0.99	3.48	0.270
8	1956	B	51.81	16.92	1.20	4.34	4.97	0.15	9.04	7.86	0.55	2.92	0.227
9	2168	RD*(T)	70.55	15.35	0.50	1.81	2.07	0.11	2.25	0.46	2.49	4.31	0.098
10	2301	B	53.39	15.78	2.08	5.14	5.88	0.18	8.42	4.41	0.68	3.68	0.365
11	2375	B	52.84	17.33	1.44	4.75	5.45	0.17	8.48	5.00	0.63	3.58	0.333
12	2478	B	51.42	17.50	1.23	4.38	5.02	0.14	9.61	6.85	0.43	3.13	0.288
13	2707	BA	56.35	16.43	1.47	4.31	4.94	0.15	7.78	4.00	0.94	3.31	0.325
14	2889	**BA	56.80	20.02	1.78	6.13	7.02	0.11	3.66	2.38	0.56	1.49	0.040
15	2927	B	54.94	17.14	1.22	4.30	4.93	0.15	8.50	4.54	0.68	3.37	0.230
16	3115	**A *(T)	60.79	27.16	0.78	3.10	3.55	0.02	1.40	1.73	0.69	0.71	0.064
17	3117	**D *(T)	66.32	20.74	0.64	2.41	2.76	0.04	1.60	1.44	1.95	2.04	0.059
18	3128	BA	55.13	16.08	1.65	4.85	5.56	0.20	8.24	3.31	1.04	3.62	0.314
19	3238	A	62.69	15.04	1.23	4.00	4.58	0.12	4.92	1.95	1.82	3.50	0.169
20	3350	**A *(T)	61.08	20.07	1.41	4.60	5.27	0.07	2.88	2.19	0.69	1.69	0.053
21	3548	BA	56.31	15.58	1.97	4.96	5.68	0.25	7.01	3.20	1.01	3.55	0.468
22	3595	BA	56.18	17.60	1.34	3.83	4.38	0.20	8.85	2.97	0.77	3.60	0.283
23	3802	RD	71.50	15.02	0.61	1.70	1.95	0.06	1.45	0.21	2.96	4.42	0.114
24	3816	RD	71.25	14.47	0.58	1.95	2.23	0.09	1.97	0.35	3.37	3.61	0.118
25	3859	RD	72.17	14.56	0.59	1.64	1.87	0.06	1.83	0.22	3.04	3.91	0.118
26	4180	B	53.95	18.47	1.11	3.97	4.55	0.12	8.50	5.01	0.70	3.31	0.320
27	4247	B	51.30	19.43	1.07	4.22	4.84	0.16	10.17	4.67	0.43	3.38	0.328
28	4351	A	63.16	15.86	0.91	3.16	3.62	0.08	5.14	2.40	1.89	3.60	0.174
29	4479	**RD	71.61	14.49	0.53	2.16	2.47	0.13	1.87	0.65	3.66	2.34	0.088
30	4549	RD	72.40	14.23	0.50	1.70	1.95	0.11	1.49	0.23	3.06	4.24	0.084

* denotes analysis of ash in tuff unit

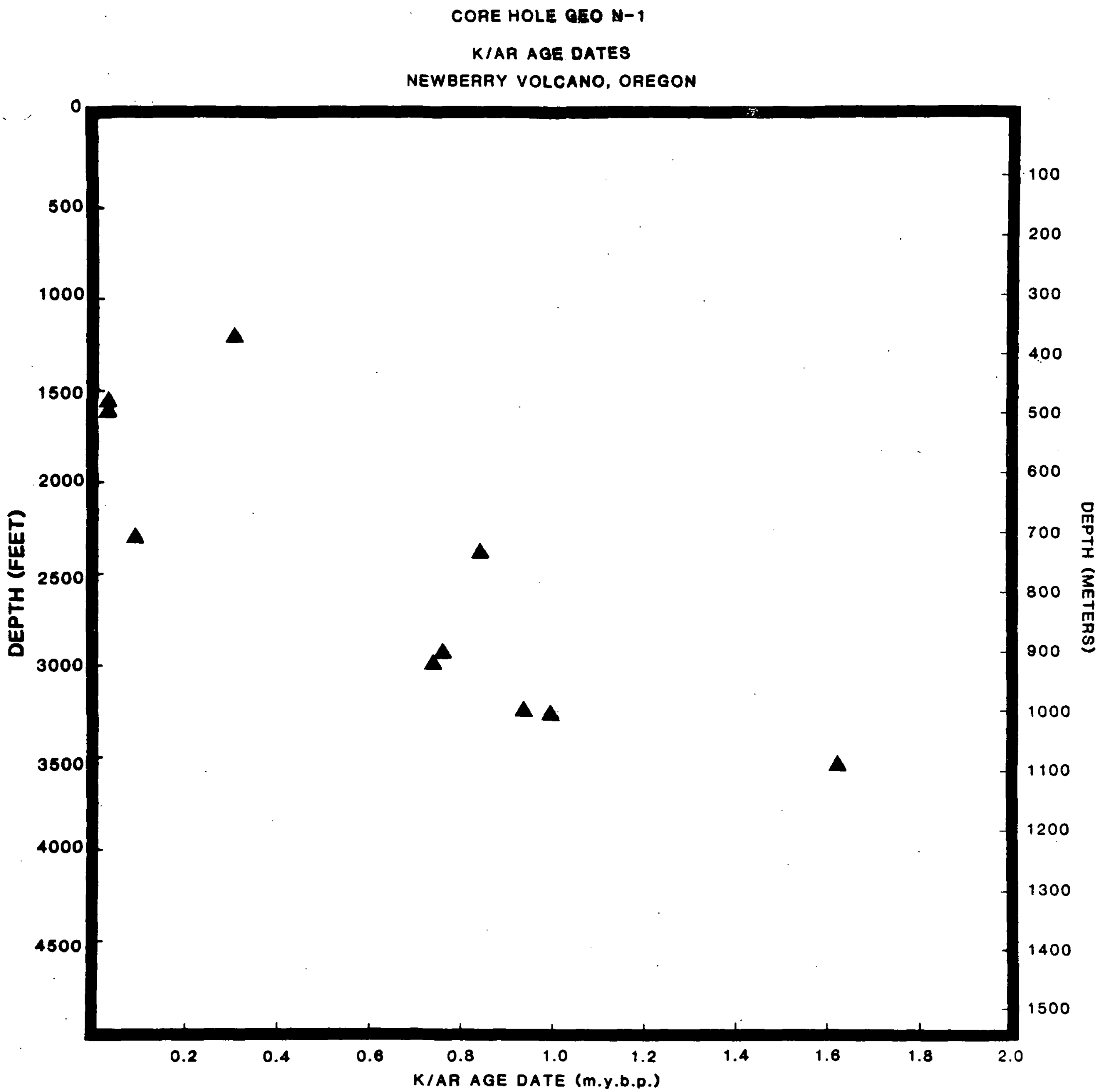
** denotes high volatile content

Analyses was conducted at Washington State University (WSU) x-ray fluorescence analytical facility.
Name assigned on the basis of:

Basalt	< 55%	Si02
Basaltic Andesite	55-60%	Si02
Andesite	60-65%	Si02
Dacite	65-70%	Si02
Rhyodacite	70-75%	Si02
Rhyolite	> 75%	Si02

FIGURES 2C-1, 2C-2

K/AR AGE DATES FOR CORE HOLE GEO N-1. Samples were submitted to the University of Arizona Laboratory of Isotope Geochemistry where rocks were ground, sieved to 100-150 mesh, and the feldspar-rich fraction concentrated using magnetic and heavy-liquid separation techniques. The dates for younger rocks are plotted as points (Fig. 2C-1, 2C-2), and the older date (Fig. 2C-2) is plotted with a two-sigma error bar. The apatite fission track data was provided by Shari Kelley. The suggestion that the older date represents pre-Newberry lithology is speculative because the older K/Ar date represents a sample which was altered and had anomalously high atmospheric argon for Miocene rock. In addition, the apatite estimate could easily be spurious, either resulting from contamination through assimilation or from mistaking defects for fission tracks.



CORE HOLE GEO N-1
K/AR AGE DATES
NEWBERRY VOLCANO, OREGON
DEPTH (FEET)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DEPTH (METERS)
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
K/AR AGE DATE (m.y.b.p.)

Figure 2C-1

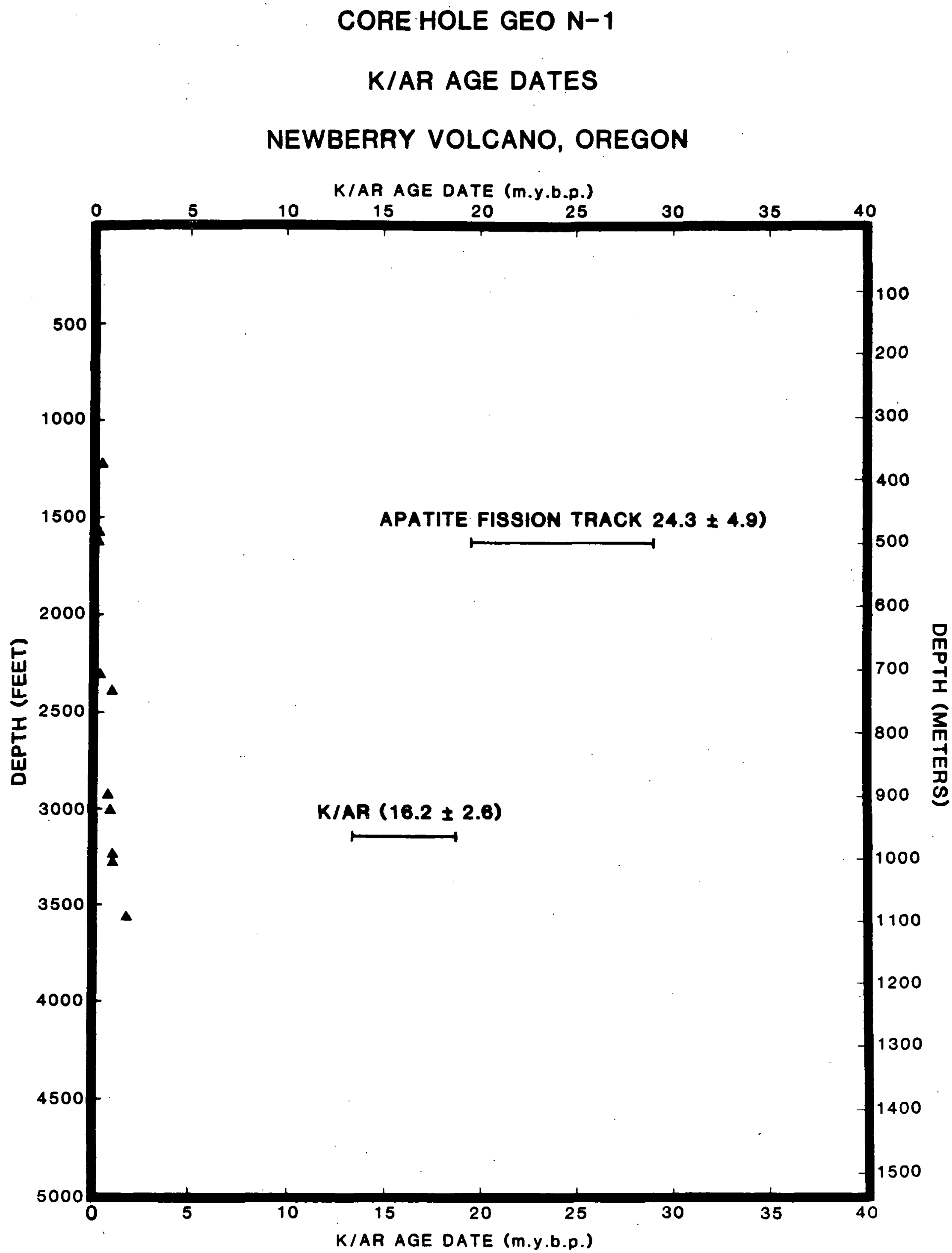

CORE HOLE GEO N-1
K/AR AGE DATES
NEWBERRY VOLCANO, OREGON
K/AR AGE DATE (m.y.b.p.)
0
5
10
15
20
25
30
35
40
DEPTH (FEET)
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
DEPTH (METERS)
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
APATITE FISSION TRACK 24.3 ± 4.9)
K/AR (16.2 ± 2.6)

Figure 2C-2

TABLE 2C

K-Ar AGE DATES: Core Hole GEO N-1 (see Figs. 2C-1, 2C-2)

NEWBERRY VOLCANO, OREGON

Sample # GEO	Sample # U. A.*	Depth/ft.	Description	Age (mybp)
5	86-41	1212.5	Basaltic andesite, groundmass feldspar concentrate; vesicular lava with flow structures.	0.306 ± 0.075
1	86-48	1578	Basaltic andesite; subhedral to anhedral plagioclase phenocrysts.	0.027 ± 0.009
110	86-50	1611.1	Basaltic andesite; same flow as GEO #1.	0.029 ± 0.081
18	86-42	2301	Basaltic intrusive; dark gray; sparse plagioclase phenocrysts; minor vesicularity.	0.090 ± 0.026
189	86-53	2375	Basaltic andesite; host to GEO #18.	0.847 ± 0.110
49	86-49	2927.5	Basalt with subhedral to anhedral plagioclase phenocrysts.	0.768 ± 0.147
256	86-54	2995.6	Basalt; same flow as GEO # 49.	0.746 ± 0.110
2	86-38	3128	Basaltic andesite intrusive; dark gray; minor vesicular trains; altered.	16.2 ± 2.6
28	86-45	3238.6	Andesite; smectite coated fractures.	0.943 ± 0.053
4	86-40	3261.4	Andesite; same flow as GEO # 28.	0.997 ± 0.050
22	86-44	3548.3	Basaltic andesite vitrophyre with feldspar microlites; Mn-siderite amygdules.	1.63 ± 0.13

TABLE 2C (continued)

K-Ar AGE DATES: Core Hole GEO N-1

NEWBERRY VOLCANO, OREGON

Sample # GEO	Sample # U. A.*	Depth/ft.	Description	Age (mybp)
111	Fission Track **	1625	Basaltic andesite; fine grained, sparse Feldspar (Apatite Fission Track)	24.3 ± 4.9

** No fission tracks were revealed in five or six apatite samples or in four epidote samples.

* University of Arizona

TABLE 2E (see Fig. 2E)

MERCURY RESULTS OF GEO CORE HOLE N-1

(Values reported in ppb)

Interval in feet	Description	Frac-turing	Hg (ppb)	Lab.
487- 496	Andesite	W	0	C
496- 503	Andesite	W	0	C
505- 515	Andesite	W	0	C
515- 524	Andesite	W	0	C
524- 532	*Basaltic Andesite	W	0	C
532- 541	Andesite	W	0	C
541- 553	Andesite	M	0	C
553- 565	Andesite	M	0	C
565- 575	Andesite/Basaltic Andesite	W	0	C
575- 584	Andesite/Basaltic Andesite	W	0	C
594- 603	*Basaltic Andesite/interflow Breccia	M	0	C
603- 613	Basaltic Andesite	M	0	C
693- 702	Basaltic Andesite/interflow Breccia	Mr	0	C
863- 875	Basaltic Andesite	Mr	0	C
923- 932	Basaltic Andesite	W	0	C
923- 932A	Basaltic Andesite	W	0	C
1217-1227	*Andesite	W	0	C
1256-1268	Basalt	Mr	0	C
1338-1347	Basalt/Basaltic Andesite	M	0	C
1397-1407	Basalt/Basaltic Andesite	Mr	0	C
1426-1436	Andesite/Basaltic Andesite	M	0	C
1457-1466	*Basaltic Andesite	M	0	C
1620-1630	Basalt/Basaltic Andesite	M	<5	B.C.
1770-1779	Basalt/Basaltic Andesite	M	0	C
1816-1825	Basalt	Mr	0	C
1844-1855	Basalt	Mr	<5	B.C.
1860-1870	Breccia	M	0	C
1966-1975	*Andesite	M	<5	B.C.
2050-2059	Basaltic Andesite	W	<5	B.C.
2103-2105	Basalt Dikelet	M	0	C
2207-2212	Basalt Dikelet	M	0	C
2267-2276.5	Basaltic Andesite Porphyry	M	<5	B.C.
2350-2359	Basalt Dikelet	W	<5	B.C.
2370-2380	*Basaltic Andesite	W	0	C
2422-2430	Basaltic Andesite	Mr	0	C
2452-2462	Basaltic Andesite	W	0	C
2515-2525	Ash and Cinders	W	<5	B.C.
2599-2608	Basaltic Andesite	W	<5	B.C.
2618-2625	Basaltic Andesite	Mr	0	C
2682-2691	Ash and Cinders	Mr	<5	B.C.
2764-2774	Basaltic Andesite	W	<5	B.C.
2881-2890	*Basaltic Andesite Tuff	W	0	C
2903-2914	Basaltic Andesite	M	<5	B.C.
3208-3217	Ash,Cinders,Basaltic Andesite	M	10	C
3208-3217A	Ash,Cinders,Basaltic Andesite	M	10	B.C.

TABLE 2E (continued)

MERCURY RESULTS OF GEO CORE HOLE N-1

(Values reported in ppb)

Interval in feet	Description	Frac-turing	Hg (ppb)	Lab.
3217-3226	*Dacite	M	6	C
3226-3235	*Dacite	M	2	C
3235-3245	*Dacite	W	2	C
3254-3263	*Dacite	M	2	C
3263-3272	*Dacite	M	0	C
3309-3318	*Dacite	M	21	C
3309-3318A	*Dacite	M	<5	B.C.
3328-3337	*Dacite/Ash and Cinders	M	<5	C
3337-3346	Ash and Cinders	W	2	C
3346-3354	Ash and Cinders/Andesite Ash Flow Tuff	W	1	C
3354-3364	Andesite Ash Flow Tuff	W	20	C
3354-3364A	Andesite Ash Flow Tuff	W	25	B.C.
3364-3374	Cinders and Ash	W	<5	C
3374-3383	Cinders and Ash	W	0	C
3383-3392	Andesite	W	1	C
3392-3402	Andesite	M	1	C
3516-3525	Ash and Cinders, Basaltic Andesite	M	<5	B.C.
3582-3591	*Basaltic Andesite	Mr	<5	B.C.
3630-3639	Basaltic Andesite	M	<5	B.C.
3685-3694	Andesite, Cinders	W	<5	B.C.
3714-3722	Dacite	W	<5	B.C.
3771-3780	Dacite	M	<5	B.C.
3826-3835	*Tuff and Rhyodacite Glass	W	<5	B.C.
3893-3902	*Dacite/Rhyolite	W	<5	B.C.
3939-3948	Dacite	M	<5	B.C.
3967-3977	Dacite	M	<5	B.C.
3996-4005	Dacite	M	<5	B.C.

Laboratory:
B.C. = Bondar Clegg
C = Cascadia Exploration

Fracture Density: (Average over 10' intervals from review of photos)
W = weak (estimated fracture/foot less than 3)
M = moderate (estimated fracture/foot greater than 3).
Mr= estimated moderate (i.e. Rubble)

* Confirmed by a whole-rock chemical analysis

Figure 2 P/A

PRECIPITATION AND/OR ALTERATION MINERALOGY OF CORE HOLE GEO N-1. This figure was compiled by GEO personnel from the data in Table 2 P/A. This table includes x-ray diffraction work conducted for GEO by Keith Barger (USGS) and Terry Keith (USGS). In addition, Table 2 P/A contains results from x-ray diffraction work conducted for GEO by Portland State University (Mike Cummings, Geology Department) and Sonoma State University (Walt Vennum, Geology Department).

Note: USGS Open File Report 86-440 is included as a cross reference.

CORE HOLE GEO N-1

PRECIPITATION/ALTERATION MINERALOGY

NEWBERRY VOLCANO, OREGON

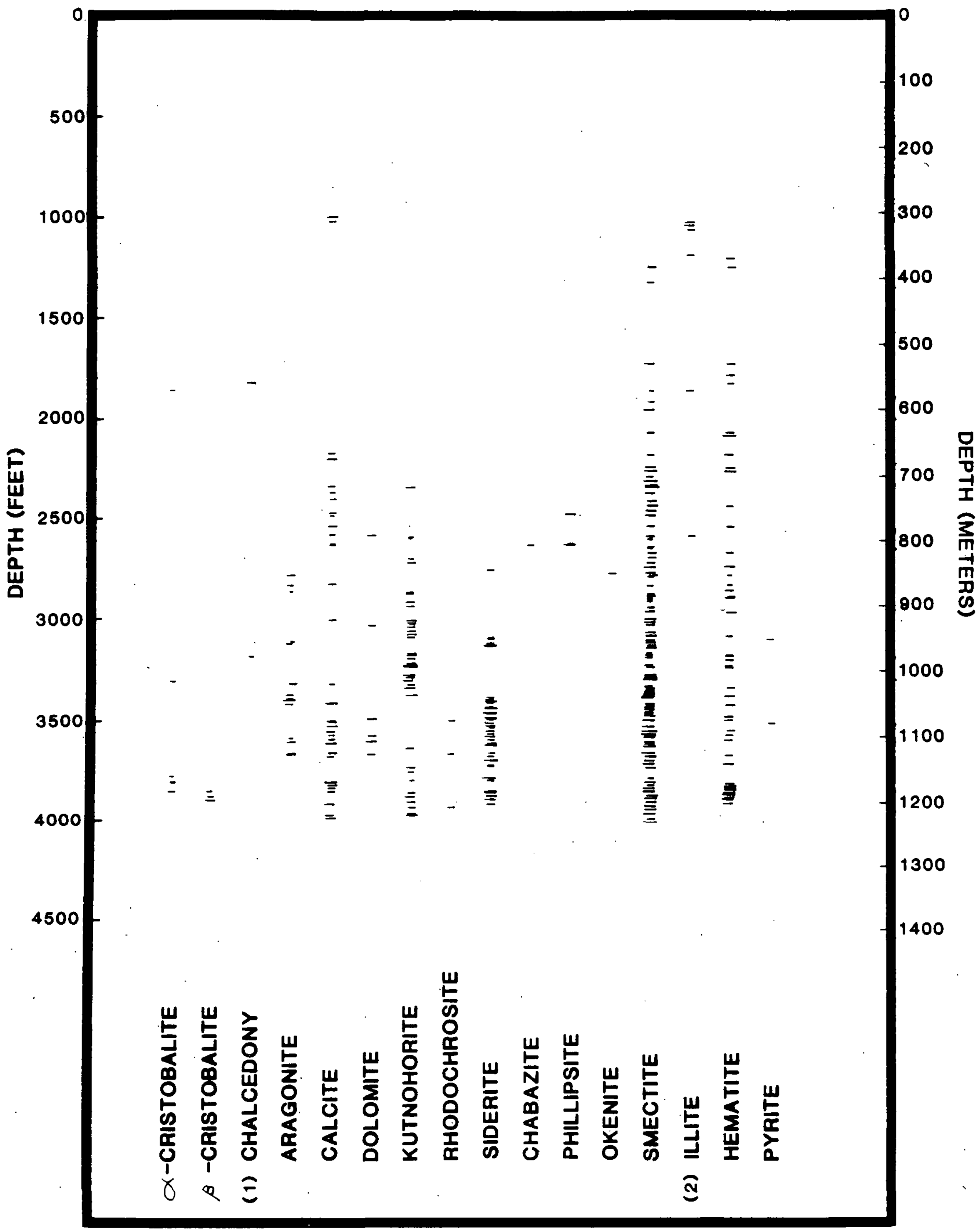


Figure 2 P/A

TABLE 2 P/A (continued)

Precipitation/Alteration Mineralogy

for GEO Core Hole N-1

Newberry Volcano, Oregon

Depth	Description	Mineralogy
1864.3	(clay-rich?)lithic tuff	plagioclase, alpha-cristobalite(?), illite-smectite(?), (mixed layer)
2481	fracture flg-$CaCO_3$?	calcite, phillipsite
2587	cream-colored botryoids	calcite plus some kutnohorite, smectite
2628	olive "clay" dep. on zeolite(?)	smectite, chabazite, plagioclase, calcite, phillipsite(?) illite
2630	clear to milky fracture coatings	phillipsite, chabazite, calcite(Mn?)
2636	pseudocubic min. H<4	PSU, chabazite
2638	clear xls, 2 dir.cleavage?	SSU, phillipsite
2680	yellow "clay"	plagioclase, smectite
2698	extr. small sample-radiating needles	kutnohorite
2705	cream-colored fracture flg.	kutnohorite
2774	white to pale green (clay?)	smectite, calcite
2776		smectite
2811	white min, small sample-in vugs	okenite
2864	cream-colored botryoids	kutnohorite
2865	acicular xls, radiating	aragonite
2868	cream-colored botryoid	kutnohorite
2875	green "clay"	smectite
2889	tuff unit, clay-altered	smectite, plagioclase
2906	pale olive green "clay"	smectite, plagioclase, ortho-pyroxene (?)
2917	cream to pale gr. scaley frac. flg.	Ca-kutnohorite plus Mg-kutnohorite
3084	cream col. min. fills ves. of dike	kutnohorite, siderite, smectite
3103	white (trigonal?) xls H3	SSU, aragonite
3115	pale green tuff	SSU, smectite
3134	olive green fractures coating	smectite, plagioclase, ortho-pyroxene (?)
3180		smectite
3181		chalcedony, smectite
3227		chalcedony, smectite

TABLE 2 P/A (see Fig. 2 P/A)

Precipitation/Alteration Mineralogy

for GEO Core Hole N-1

Newberry Volcano, Oregon

Depth	Description	Mineralogy
3312	green "clay" & calcite(?)	smectite + kutnohorite, aragonite, plagioclase,alpha-cristobalite
3323	green "clay" & calcite(?)	PSU, Mg-calcite or kutnohorite, smectite
3345	pale olive "clay" frac.flg.	PSU, smectite
3350.6	tuff unit, clay-altered	PSU, smectite
3367	yellow, transluc. H4	SSU Ca-kutnohorite
3397	clear, vitr. pseudocubic H5	SSU aragonite
3497	yellow fracture coating	Mn-siderite + Fe-rhodochrosite?, calcite
3537	greenish-yel. frac. coating	Mn-siderite
3555	brown botryoids in vugs	Mn-siderite, smectite, hematite
3587	fibrous "fuzz"-zeolite	Mn-siderite, calcite
3589	clear to pale yel. min, striated faces	SSU, aragonite plus calcite, dolomite, Mn-siderite
3589A	cream colored open space flg	SSU, Mn-siderite
3595	green "clay"	SSU, smectite
3600	yellow botryoids	Mn-siderite
3612	brown botryoids	siderite
3615	light brown botryoids	siderite
3635	white "fuzzy" min	kutnohorite
3646	green min, fracture flg.	smectite
3659	clear min 1 cleavage dir.	SSU aragonite
3679	yellow xls on yellow botryoids	Fe rhodochrosite (?)
3784	green "clay"	smectite plus plagioclase, alpha-cristobalite
3791	white fracture flg.	Mg-kutnohorite
3793	olive green fracture flg.	tridymite, Mn-siderite, smectite, kutnohorite
3808	green "clay" fracture flg.	smectite plus plagioclase, alpha-cristobalite, hematite

TABLE 2 P/A (continued)

Precipitation/Alteration Mineralogy

for GEO Core Hole N-1

Newberry Volcano, Oregon

Depth	Description	Mineralogy
3846	white min, H3	calcite
3850	tiny brown botryoids	Mn-siderite, plus calcite, plagioclase, alpha-cristobalite, kutnohorite

Mineral identifications by x-ray analysis at the following laboratories:

PSU	Portland State Univ.
SSU	Sonoma State Univ.
Not specified	USGS

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Hydrothermal Mineralization in GEO N-1 Drill Hole, Newberry Volcano, Oregon

by

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Open-File Report 86-440

This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards.

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ABSTRACT

GEO N-1 was drilled in November, 1985 by GEO-Newberry Crater, Inc., under a cost-sharing agreement with DOE, at a surface altitude of 1783 m on the south flank of Newberry Volcano, Oregon. Drill core, drilling data, and geophysical data from the upper 1219 m of GEO N-1 are available to the public; maximum measured temperature for the released interval is 71°C at 1219 m. The drill core intercepted mostly andesitic to basaltic lava flows with interlayers of ash-flow tuffs, lithic tuffs, cinders, and flow breccias; core recovery was about 95 percent. Twelve basalt dikes intrude the flows between 622 and 719 m but there is little alteration at the contacts. Intense fracturing and vesiculation are common in the basal and upper portions of most flows whereas the flow interiors are generally very dense with few fractures.

Very little evidence for hydrothermal alteration was found in the upper 500 m of drill core; however, pre-hydrothermal, low temperature, amorphous clay-like material and amorphous silica occur as fracture or vug fillings. Below 500 m, most ash-flow tuffs contain smectite, and, although the lavas generally show little alteration, many fractures and vesicles are lined with secondary minerals: hematite, smectite, and carbonates (siderite, kutnohorite, dolomite, rhodochrosite, calcite, and aragonite). Locally, small amounts of ß-cristobalite, chalcedony(?), chabazite, phillipsite, okenite, illite(?), and pyrite were identified. The hydrothermal minerals were probably deposited at the <71°C temperatures measured following drilling of GEO N-1.

INTRODUCTION

Geothermal drill hole GEO N-1, located on the southern flank of Newberry Volcano about 4.5 km outside the caldera rim at an elevation of about 1783 m, was completed by GEO-Newberry Crater, Inc. (subsidiary of GEO Operator Corporation) in November, 1985. This 1219+ m drill hole is the first Cascade geothermal drill hole to be finished under a new program of the U. S. Department of Energy (DOE). In this program, the U.S. government shares geothermal exploration drilling costs with industry at approved drill sites.

A brief summary of data from the GEO N-1 drill hole by the University of Utah Research Institute (UURI) Earth Science Laboratory, including abbreviated descriptions of temperature and selected geophysical logs, is given in a newsletter (UURI, 1986). GEO N-1 was rotary drilled to about 148 m, and then was cored to 1219 m with about 95 percent core recovery. Below 1219 m, information from this drill hole is proprietary, and has not been released by GEO-Newberry Crater, Inc. Swanberg and Combs (1986) present preliminary lithologic and temperature logs for the GEO N-1 drill hole; they also discuss the results of several geophysical tests conducted in GEO N-1 and indicate that such geophysical data may be of great importance to future geothermal exploration in the Cascades.

The drill core was logged and photographed upon recovery by GEO-Newberry

Crater, Inc. and a split of the core was sent to UURI. A selection of the UURI core (222 samples) including vein fillings, vug fillings, or representative samples of stratigraphic intervals was studied by us for hydrothermal alteration mineralogy. In addition, GEO-Newberry Crater, Inc., provided 49 hydrothermal mineral samples, geophysical logs, and a color photo log of the entire drill core. Altogether, 271 samples of the GEO N-1 drill core were studied by binocular microscope, petrographic microscope (15 thin sections), and X-ray diffraction methods (more than 300 X-ray diffractograms).

LITHOLOGY

A lithologic log of the GEO N-1 drill core was compiled by GEO-Newberry Crater, Inc., and made available through UURI. The log contains detailed lithology notes and tentative rock identifications (pending receipt of thin sections and chemical analyses). The GEO-Newberry terminology will be followed in this report, modified only slightly on the basis of our observations of the entire split of UURI core. Age data are not available for any of the rocks recovered from the drill hole. The majority of core samples consist of basaltic to andesitic lava flows and associated flow breccia, pyroclastic, and ash-flow material (Fig. 1). Primary minerals in the lavas vary with the chemical composition of the lava but are predominantly plagioclase with varying amounts of olivine, clinopyroxene, orthopyroxene, magnetite, and α-cristobalite; minerals such as hornblende or biotite are noteably absent. Several lava flows contain vapor-phase tridymite, alkali-feldspar(?), and magnetite that has altered to hematite. The deepest lava flow available for study (1170.4-1219.2 m depth) is probably dacitic and contains trace amounts of primary quartz. Textures of the lava flows may be perlitic, massive, flow-banded, diktytaxitic, vesicular, or scoriaceous. Between 622 and 719 m depth, 12 moderate to steeply dipping basaltic dikes (up to about 12 m apparent core thickness) intrude the lava flows.

The lava flows are commonly vesicular at the top and bottom, dense in the interior and have intervening fractured intervals consisting of steeply dipping tight fractures. Ash and cinder layers and lithic tuffs appear to have good permeability where unaltered; one layer (567-572 m) retained significant water in the pore spaces several months after recovery of the drill core. At deeper intervals, below 830 m, ash-flow tuffs are pervasively altered to smectite and the present permeability is presumably quite low.

PRE-HYDROTHERMAL ALTERATION

Many secondary minerals, not hydrothermal in origin, were deposited along narrow fractures and in vesicles throughout the upper 610 m of the drill core, especially above about 520 m. The deposits consist of thin coatings of reddish iron oxide (mostly amorphous iron hydroxide but some hematite), yellow, green, and pale blue soft amorphous material (which may be, in part, a precursor to smectite), and scattered small amounts of amorphous silica. Hematite was deposited at high temperatures during cooling of the lava flows and ejecta; amorphous silica, amorphous iron hydroxide, and at least some of the amorphous clay-like deposits are probably deuteric and formed at low temperatures. Below 520 m depth some of these pre-hydrothermal minerals, especially hematite, persist intermingled with hydrothermal deposits. Amorphous clay-like material coating fractures and vesicles is similar in appearance to hydrothermal clay coatings but lacks the smectite structure. The abundant iron oxides, including some hematite in ash-flow tuffs, may have formed by oxidation of primary magnetite during deuteric alteration.

HYDROTHERMAL ALTERATION

The lava flows are mostly very little altered. Below about 670 m depth, thin fracture fillings or vesicles contain hydrothermal deposits, dominantly carbonates (aragonite, calcite, dolomite, kutnohorite, rhodochrosite, and siderite), smectite, and hematite with local minor amounts of silica minerals (ß-cristobalite and chalcedony?), zeolites (chabazite, and phillipsite), okenite (one occurrence of the calcium silicate hydrate mineral), illite(?), and pyrite (Fig. 2).

Fractures frequently have a smectite coating and may also contain one or more of the several carbonate minerals. Most vesicles do not contain any secondary minerals, but thin clay coatings and clusters of carbonate crystals are sporadically abundant.

Hydrothermal alteration of the pyroclastic layers and flow breccias is somewhat irregular. The flow breccias, ash-flow tuffs, and other pyroclastic layers are not altered above 567 m (but do contain deuteric minerals). From 567 to 820 m minor clay alteration is present in three layers of ash and cinders but one ash-flow tuff (659 to 664 m) and two layers of ash and cinders (797 to 800 m and 816 to 820 m) are unaltered. Below 830 m, the pyroclastic deposits are extensively altered to smectite; however, layers of ash and cinders at 860 to 869 m, 897 to 901 m, 949 to 979 m, and 1125 to 1132 m have only minor smectite alteration. Iron oxide is abundant in many of the pyroclastic layers and usually stains the layers an earthy brick-red color. Some of the iron oxides are amorphous but most were identified as hematite by X-ray diffraction.

Silica Minerals

Several cavities in samples from 1124 and 1172 m are partly coated by bluish botryoidal ß-cristobalite along with smectite, calcite, and siderite. X-ray diffraction analysis of a massive green fracture filling deposit at 1178 m shows the presence of ß-cristobalite and minor smectite, siderite, hematite, and kutnohorite. ß-cristobalite, smectite, and siderite were also identified on an X-ray trace of a clayey fracture filling at 1185 m. The only other hydrothermal(?) silica mineral in drill core GEO N-1 is yellowish botryoidal chalcedony which coats flow breccia fragments at 555 m. Several samples of white to clear amorphous silica deposits in the upper half of the drill core may be of deuteric origin.

Carbonate Minerals

Several carbonate minerals (aragonite, calcite, dolomite, kutnohorite, rhodochrosite, and siderite) occur as vesicle or fracture fillings in the lower half of the drill core; and calcite appears to replace plagioclase at about 1200 m depth. Aragonite can generally be distinguished from the other carbonates by its typical clear acicular crystals (as much as 1 cm long). However, white powdery, clear massive, or white cauliflower-like aragonite deposits were also verified by X-ray diffraction analyses.

Siderite, a fairly abundant carbonate mineral in the drill core, usually occurs as distinctive light to dark caramel-colored or rarely greenish discoidal, hemispherical, or spherical aggregates of rhombic crystals. 'Towery' stacked rhombic crystal clusters occur at 1090 and 1121 m. The color of GEO N-1 siderite probably reflects its composition. Lighter caramel or pale yellow siderite crystals have their most intense X-ray diffraction peak at about 2.82 Å corresponding to a manganese siderite (X-ray diffraction identification of carbonate minerals is based on data of the Joint Committee on Powder Diffraction Standards. No internal standard was used in any of the X-ray diffraction measurements; however, accuracy of the measurements is within about ±0.02Å.). In darker caramel-colored siderite crystals (Fe-rich), the most intense X-ray peak occurs between 2.78 - 2.80 Å.

The remaining four carbonate minerals (calcite, dolomite, kutnohorite, and rhodochrosite) have no distinctive color or crystal habit. These open-space deposits may be clear, white, pink, or yellowish in color; and they may consist of powdery or massive deposits, blocky or acicular crystals, or spherical to hemispherical crystalline aggregates. Most carbonate mineral identifications in this study (including siderite) are based on the position of the most intense X-ray diffraction peak as follows: siderite (2.78 - 2.80 Å), Mn-siderite (2.82 Å), rhodochrosite (2.84 - 2.86 Å), dolomite (or possibly ankerite) (2.88 - 2.90 Å), kutnohorite (2.91 - 2.98 Å), and calcite (3.02 - 3.05 Å). Only a few samples of rhodochrosite or dolomite (ankerite?) were identified in the GEO N-1 drill core (Fig. 2). Characteristic X-ray peaks for these two minerals are fairly distinctive. However some difficulty was found in distinguishing between calcite and kutnohorite because the presence of manganese in the calcite structure expands the range of positions of the most intense X-ray peak from typical calcite (3.02 - 3.05 Å) to at least the upper border of the kutnohorite range (2.94 - 2.98 Å) (Krieger, 1930). A further complication is that although kutnohorite has a dolomitic structure, the X-ray peaks which are characteristic of dolomitic structure may be too weak to detect, at least in Ca-kutnohorite (Gabrielson and Sundius, 1965). In this study, the mineral was identified as kutnohorite if the highest X-ray peak ranged between 2.94 and 2.98 Å and calcite if the peak occurred at 2.99 to 3.05 Å; even though data in Krieger (1930) indicate that the most intense X-ray peak in calcite with high manganese content may extend to 2.95 Å.

In the GEO N-1 drill core, kutnohorite and calcite were not deposited in distinctive zones; instead they overlap in their distribution throughout the lower half of the drill hole (Fig. 2). In some fractures or vugs, the two minerals are found together or are closely associated with up to three other carbonate minerals. This suggests that the fluids that deposited the carbonate minerals may have varied somewhat in cation composition with time.

Zeolite and Related Minerals

Chabazite and phillipsite are the only zeolite minerals found in the GEO N-1 drill core. Flow rock between 801 and 802 m depth contain trace amounts of clear to white, twinned, pseudorhombic chabazite crystals. Tiny, clear, prismatic crystals from a lava flow at 756 m and three samples of open-space fillings in a lava flow between 801 and 804 m were identified as phillipsite by X-ray diffraction. The two zeolite minerals occur together in two of the samples; calcite and smectite are the only other associated hydrothermal minerals.

Okenite, a hydrous calcium silicate mineral, occurs as a soft white vug filling in a lava flow at 857 m. Okenite typically is found in basalt cavities in association with zeolite minerals (Heller and Taylor, 1956).

Clay Minerals

Smectite is the most abundant hydrothermal mineral found in the GEO N-1 drill core (Fig. 1). This white, yellow, green, brown, blue, or black clay mineral ranges from poorly crystalline (low, broad X-ray peaks) to well-crystallized with sharp (001) X-ray diffraction peaks that generally fall within the range from about 15.2 - 16.7 Å and expand to between about 17.0 and 18.3 Å with glycolation (average values for 91 samples are 15.7 Å untreated and 17.6 Å glycollated). No correlation was found between poor or well-developed crystallinity, or position of the (001) X-ray peak, with depth of smectite formation in the GEO N-1 drill core. In the GEO N-1 drill core, smectite occurs as whole rock (glass) alteration in pyroclastic samples and as open-space (fracture and vug fillings) in the lava flows and flow breccias. Smectite was deposited at several different times, occurring both earlier than (beneath) and later than (above) some carbonate cavity and vein fillings.

Illite is provisionally identified (based on a low, usually broad, approximately 10 Å X-ray diffraction peak that showed no significant change with glycolation) in a few X-ray diffraction analyses of whole-rock, vesicle, and fracture filling samples from lava flows and pyroclastic deposits at 310-362 m, 568 m, 789 m, and 1217 m depth. The 10 Å illite(?) mineral formed later than calcite in one vesicle filling and is associated with calcite, dolomite, and smectite in other samples.

Iron Oxide and Sulfide Minerals

Small patches of disseminated, very minute (≈ 0.02 mm), yellow, metallic, cubic pyrite crystals were identified only at 943, 945, and 1068 m in the GEO N-1 drill core. At 1068 m a pyrite veinlet crosscuts iron oxide deposits, and pyrite crystals formed later than smectite in vesicles. Associated minerals are smectite, calcite, siderite, and hematite.

Red deuteric amorphous iron oxide stains flow breccias, ash, and tuffaceous layers and coats fractures in lava flows in the upper part of the drill core. In contrast, crystalline hematite (identification based on X-ray diffraction analyses) occurs below about 300 m in red-stained tuffs, altered vapor-phase magnetite grains, and fracture coatings.

PARAGENETIC SEQUENCE

Deposition of the major secondary minerals began with vapor-phase hematite, which formed during cooling of the lava flows and pyroclastic intervals. During late-stage cooling and pre-hydrothermal circulation of meteoric waters, amorphous iron hydroxides, and amorphous clay-like deposits were precipitated. Hydrothermal smectite and carbonate minerals were deposited later than vapor-phase minerals. Smectite alteration of the pyroclastic layers occurred prior to carbonate deposition. Most open-space smectite formed earlier than the carbonates; however, smectite is also found locally deposited later than carbonate minerals. The several carbonate minerals appear to have been deposited from fluids that varied greatly in cation content with respect to time. Aragonite, however, formed later than the other carbonates. Silica minerals, zeolite minerals, and okenite all formed later than most smectite but their sequence relative to carbonates and to each other are unknown. Pyrite formed later than hydrothermal hematite in the single vein occurrence, and it formed later than smectite but earlier than carbonate in the disseminated occurrences.

DISCUSSION

A maximum temperature of about 71°C was reported following drilling of the GEO N-1 drill hole at 1219 m depth (UURI, 1986). Hydrothermal alteration minerals identified from the drill core are consistent with these low temperatures. The minerals form a nearly identical hydrothermal mineral suite to that found at temperatures of less than 100°C in the upper 650 m of the U.S.G.S. Newberry 2 drill core (Bargar and Keith, 1984; Keith and others, 1984) from a site about 7.5 km NNE of the GEO N-1 drill site. In both drill holes hydrothermal silica, zeolite, carbonate, and clay minerals were deposited from migrating fluids, mostly in open-spaces of vugs, fractures, and voids in flow breccias. Permeable ash-flow tuff and lithic tuff locally display more intense alteration of glass to smectite. Some replacement of plagioclase by calcite appears to have occurred in the vicinity of 1200 m in the drill core from GEO N-1.

In drill core GEO N-1, the numerous carbonate phases are not confined to discrete zones. Instead, the minerals may vary from fracture to fracture. Such abrupt changes are especially true for calcite and kutnohorite; a sequence of three fractures can have fracture #1 coated by calcite, fracture #2 by kutnohorite, and fracture #3 by calcite. The fluids from which the minerals were deposited must have varied somewhat in chemical composition between at least two of the three adjacent fractures, and, consequently, the fracture fillings probably resulted from at least two separate fluid pulses. In fact, it is likely that fluctuations in fluid cation (Mg, Ca, Mn, and Fe) composition occur over a period of time because as many as four different carbonate minerals (aragonite, siderite, calcite, and dolomite) were identified in a single open-space filling. Aragonite is always the last carbonate phase to be deposited, but, locally, it appears to have been partly reordered to the more stable calcite phase.

The presence of 12 basaltic dikes between 622 and 719 m show that a transient heat source was introduced near the area when the dikes intruded the volcanic pile. Some of the dikes have chilled margins preserved, but there is no evidence of significant alteration directly adjacent to the contacts. The dikes occur near the upper limit of the occurrence of hydrothermal alteration minerals in the drill core.

Although the temperature gradient begins to increase at about 1000 m, there are no changes in hydrothermal mineralogy at that depth. The existence of smectite and amorphous clay-like material rather than mixed-layer clays indicates that temperatures probably were never hotter than the present measured temperature of about 71°C at 1219 m.

ACKNOWLEDGMENTS

We would like to thank GEO-Newberry Crater, Inc. and in particular M. J. Johnson and C. A. Swanberg for providing us with complete sets of lithologic, temperature, and geophysical logs for the GEO N-1 drill hole. P. M. Wright and D. L. Nielson at UURI provided access to their split of the GEO N-1 core and facilities for observing and sampling the core. The assistance of M. H. Price with X-ray diffraction analyses is gratefully acknowledged.

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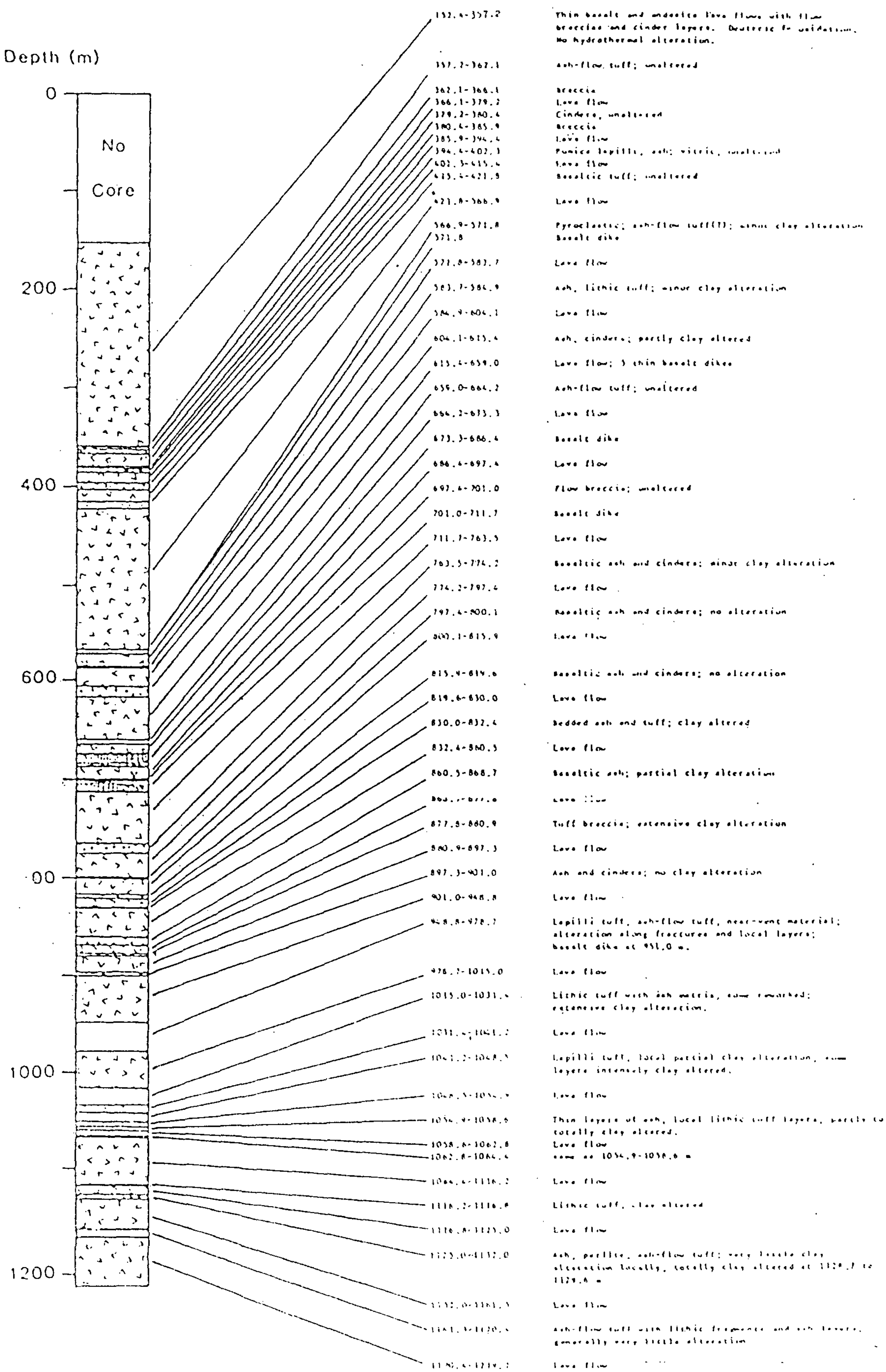
FIGURE CAPTIONS

Figure 1. Preliminary lithologic log of core from drill hole GEO N-1, based on stratigraphic data made available by GEO-Newberry Crater, Inc.

Figure 2. Distribution of selected secondary minerals with depth in geothermal drill hole GEO N-1. Left column shows a generalized stratigraphic section of rock units encountered in the drill hole including: basaltic or andesitic lava flows (star pattern), tuffaceous or pyroclastic material (solid), basaltic dikes (diagonal lines), and dacitic lava flow (horizontal lines). The column is blank above 148 m where no core was recovered. Filled circles are temperatures measured during drilling from the log provided by GEO-Newberry Crater, Inc. The temperature curve is dashed where measurements were imprecise. The maximum measured temperature was 61.1°C at 1208.2 m; however, maximum temperatures of 68.3°C and 71.1°C were recorded at 1219.2 m on subsequent temperature logs (Swanberg and Combs, 1986; UURI, 1986).

Fig. 1

GEO N1 Annotated Lithologic Log



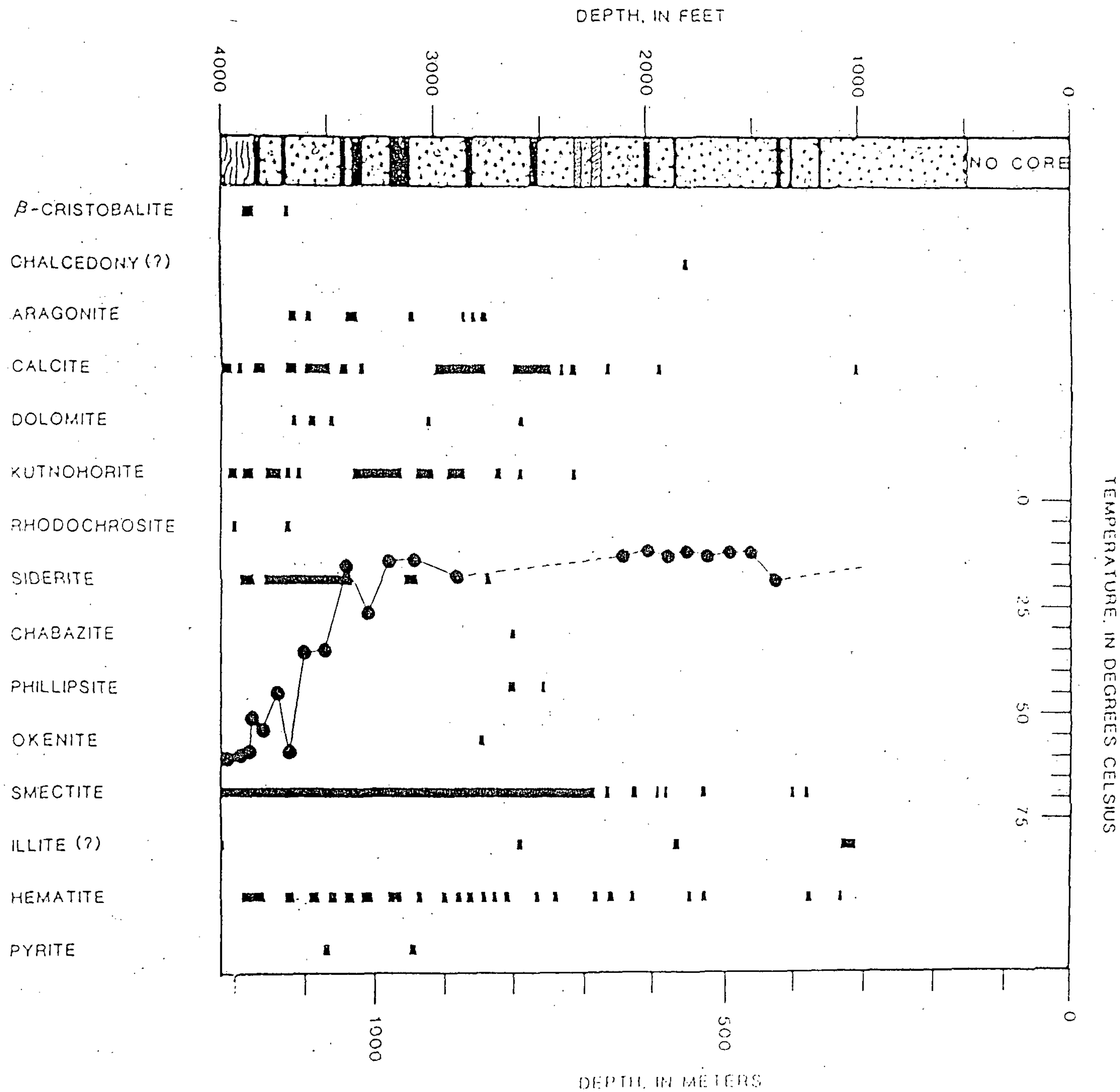

DEPTH, IN FEET
4000
3000
2000
1000
0
NO CORE
β-CRISTOBALITE
CHALCEDONY (?)
ARAGONITE
CALCITE
DOLOMITE
KUTNOHORITE
RHODOCHROSITE
SIDERITE
CHABAZITE
PHILLIPSITE
OKENITE
SMECTITE
ILLITE (?)
HEMATITE
PYRITE
TEMPERATURE, IN DEGREES CELSIUS
0
25
50
75
1000
500
0
DEPTH, IN METERS

Fig. 2

Half-splits of core from GEO N-1 (0-4000) feet were provided to the University of Utah Research Institute (UURI) personnel on November 21, 1985 in Bend, Oregon.

FIGURE 2G-1

DRESSER ATLAS TEMPERATURE LOG OF 11/3/85 FOR CORE HOLE GEO N-1. This profile was constructed by GEO personnel from data taken from a continuous temperature log (see table 2G-1) which began 15 hours after the last circulation of the core hole.

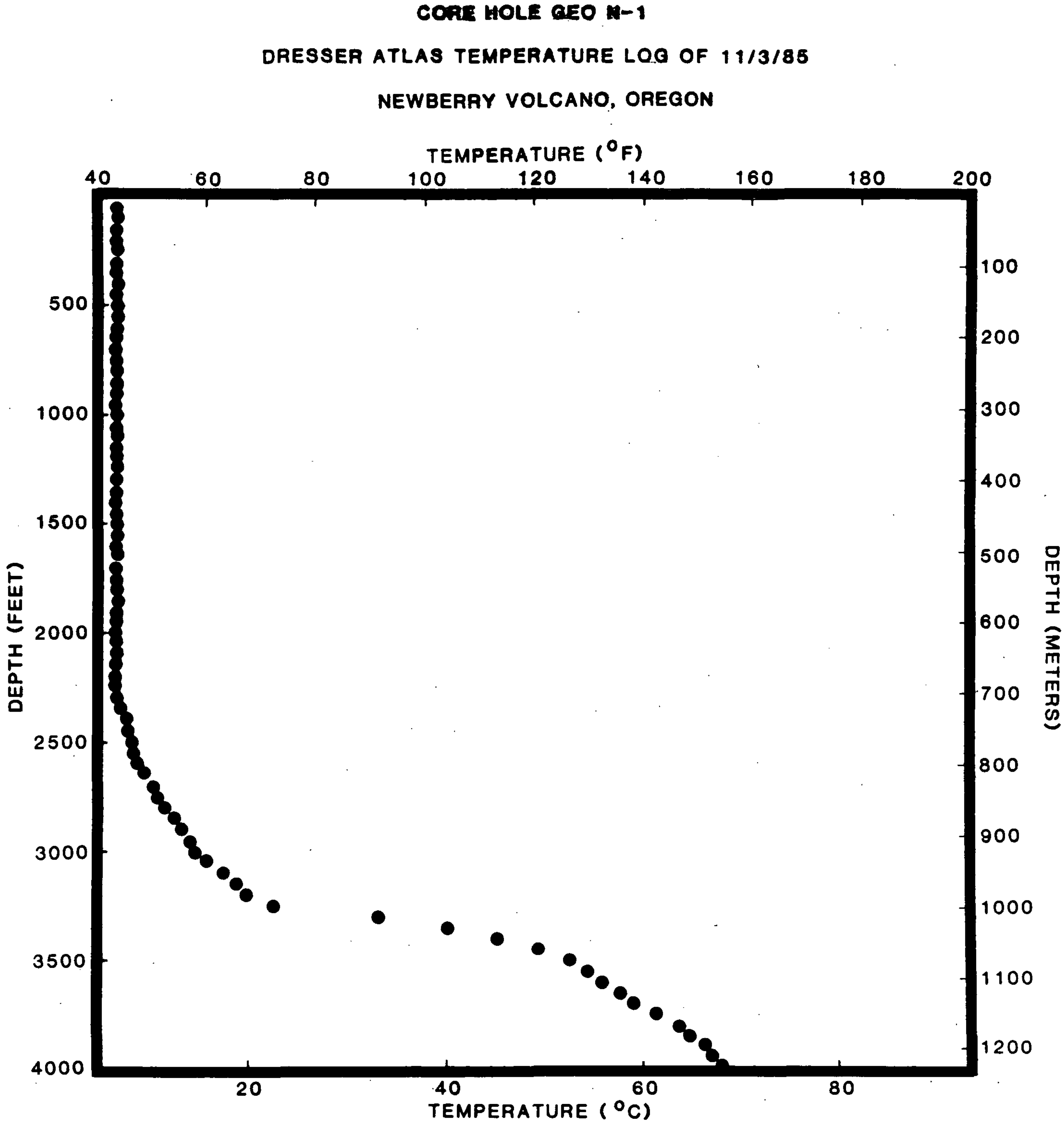

CORE HOLE GEO N-1
DRESSER ATLAS TEMPERATURE LOG OF 11/3/85
NEWBERRY VOLCANO, OREGON
TEMPERATURE (°F)
40
60
80
100
120
140
160
180
200
DEPTH (FEET)
500
1000
1500
2000
2500
3000
3500
4000
DEPTH (METERS)
100
200
300
400
500
600
700
800
900
1000
1100
1200
20
40
60
80
TEMPERATURE (°C)

Figure 2G-1

TABLE 2G-1

GEO CORE HOLE N-1 (see Fig. 2G-1)

Temperature (F°) Log From Dresser Atlas Data of 11/3/85

Depth	0	10	20	30	40	50	60	70	80	90
10 to 2290 = 43°										
2300	43	43	43	43	44	44	44	44	44	44
2400	45	45	45	45	45	45	45	45	45	45
2500	45	45	45	45	45	46	46	46	46	46
2600	46	47	47	47	47	47	47	48	48	49
2700	49	50	50	50	50	50	50	51	51	51
2800	51	52	52	52	52	53	53	53	54	54
2900	54	55	55	55	55	55	56	56	56	57
3000	57	58	58	59	60	60	61	62	63	63
3100	63	63	63	64	64	65	65	66	66	66
3200	67	67	68	68	70	72	74	79	83	87
3300	91	93	96	99	102	103	105	107	109	111
3400	113	114	116	117	118	119	121	122	123	124
3500	126	127	127	128	128	129	130	130	131	132
3600	133	134	134	134	135	136	137	138	138	138
3700	138	139	140	141	142	142	142	143	144	145
3800	145	145	145	146	147	148	148	148	149	150
3900	151	152	152	152	152	153	154	154	154	154
4000	154									

Note: This table was compiled from an analog record and was rounded to the nearest degree.

Logging operations begin 15 hours after last circulation of core hole.

FIGURE 2G-2

GEOTECH DATA TEMPERATURE LOG OF 11/9/85 FOR CORE HOLE GEO N-1. This profile was constructed by GEO personnel from selected data in table 2G-2. The precision and accuracy of the temperature measurements are respectively 0.01°F and 1°F. Temperatures were measured at 20 foot intervals.

CORE HOLE GEO N-1

GEOTECH DATA TEMPERATURE LOG OF 11/9/85

NEWBERRY VOLCANO, OREGON

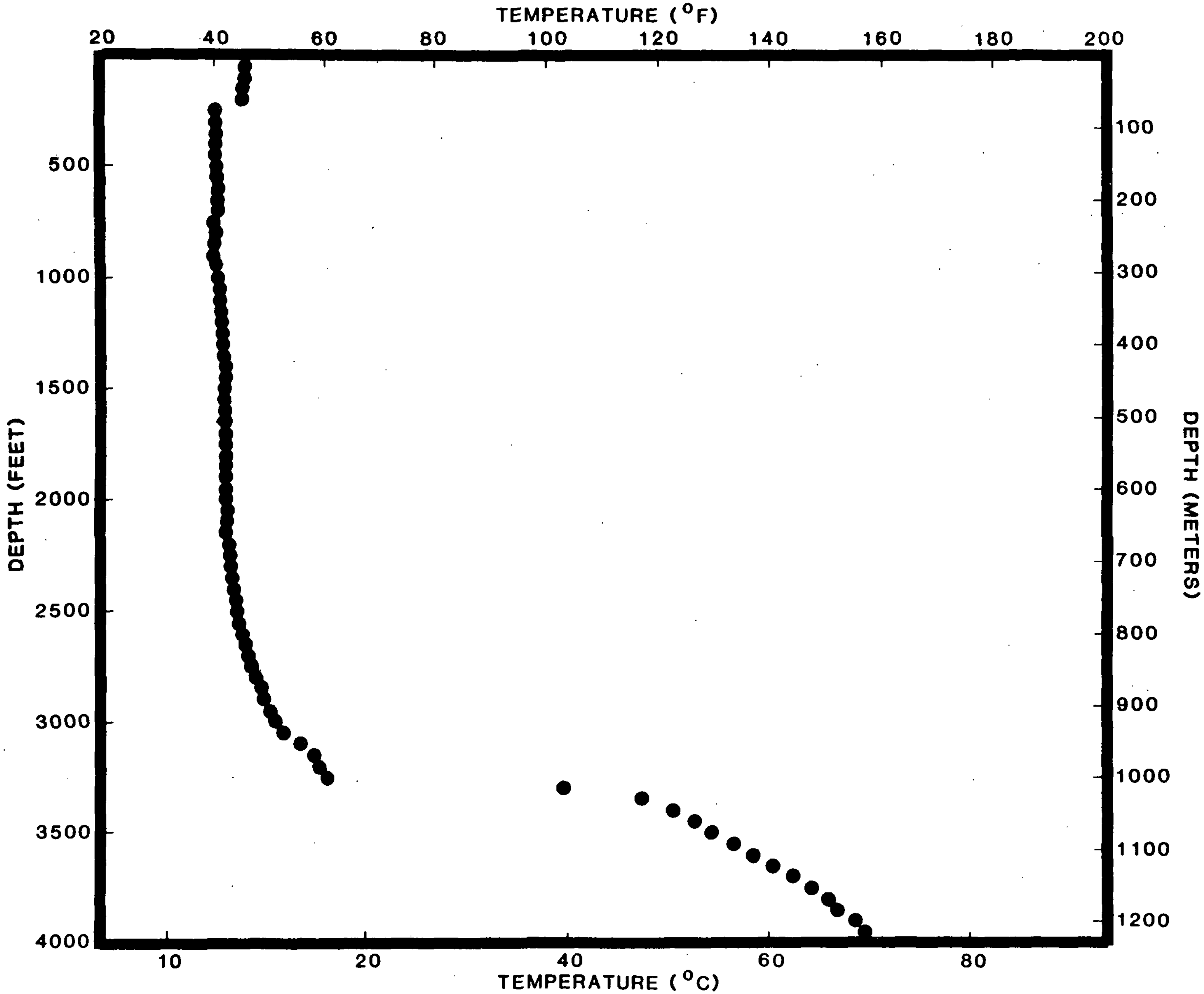


Figure 2G-2

TABLE 2G-2

GEO-N-1

Temperature/Depth Data (see Fig. 2G-2)

Geotech: 11/9/85

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
20	46.26		1020	41.21	1.6
40	45.97	-1.4	1040	41.59	1.9
60	45.85	-.6	1060	41.41	-.9
80	45.72	-.6	1080	41.43	.1
100	45.63	-.5	1100	41.48	.2
120	45.57	-.3	1120	41.55	.3
140	45.51	-.3	1140	41.68	.7
160	45.40	-.5	1160	41.78	.5
180	45.24	-.8	1180	41.94	.8
200	45.14	-.5	1200	41.93	-.0
220	40.15	-24.9	1220	41.93	0.0
240	40.62	2.3	1240	41.94	.0
260	40.43	-.9	1260	41.97	.2
280	40.36	-.3	1280	42.04	.3
300	40.47	.6	1300	42.06	.1
320	40.48	.0	1320	42.07	.0
340	40.88	2.0	1340	42.07	0.0
360	40.50	-1.9	1360	42.14	.3
380	40.33	-.8	1380	42.18	.2
400	40.59	1.3	1400	42.16	-.1
420	41.04	2.3	1420	42.17	.0
440	40.96	-.4	1440	42.17	0.0
460	40.89	-.3	1460	42.18	.1
480	41.13	1.2	1480	42.17	-.1
500	40.51	-3.1	1500	42.18	.1
520	40.37	-.7	1520	42.18	0.0
540	40.24	-.6	1540	42.20	.1
560	40.61	1.8	1560	42.19	-.1
580	40.68	.3	1580	42.19	0.0
600	41.00	1.6	1600	42.19	0.0
620	41.22	1.1	1620	42.19	0.0
640	40.46	-3.8	1640	42.19	0.0
660	40.53	.3	1660	42.19	0.0
680	41.06	2.7	1680	42.19	0.0
700	40.82	-1.2	1700	42.19	0.0
720	40.37	-2.3	1720	42.19	0.0
740	40.42	.2	1740	42.20	.1
760	40.34	-.4	1760	42.21	.0
780	40.42	.4	1780	42.21	0.0
800	40.58	.8	1800	42.23	.1
820	40.60	.1	1820	42.23	0.0
840	40.59	-.0	1840	42.23	0.0
860	40.69	.5	1860	42.23	0.0
880	40.63	-.3	1880	42.24	.1
900	40.55	-.4	1900	42.24	0.0
920	40.50	-.2	1920	42.25	.0
940	40.30	-1.0	1940	42.25	0.0
960	40.42	.6	1960	42.27	.1
980	40.63	1.1	1980	42.29	.1
1000	40.88	1.2	2000	42.30	.0

TABLE 2G-2 (continued)

GEO-N-1

Temperature/Depth Data

Geotech: 11/9/85

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
2020	42.34	.2	3020	52.79	7.1
2040	42.37	.1	3040	53.11	1.6
2060	42.44	.3	3060	53.86	3.7
2080	42.50	.3	3080	55.20	6.7
2100	42.56	.3	3100	56.48	6.4
2120	42.62	.3	3120	56.58	.5
2140	42.69	.3	3140	57.82	6.2
2160	42.75	.3	3160	58.78	4.8
2180	42.78	.1	3180	58.84	.3
2200	42.86	.4	3200	58.93	.5
2220	42.91	.2	3220	59.24	1.6
2240	43.00	.5	3240	60.39	5.7
2260	43.42	2.1	3260	62.46	10.3
2280	43.13	-1.4	3280	86.16	118.5
2300	43.23	.5	3300	103.72	87.8
2320	43.32	.5	3320	112.89	45.8
2340	43.42	.5	3340	116.35	17.3
2360	43.56	.7	3360	118.57	11.1
2380	43.68	.6	3380	120.65	10.4
2400	43.81	.7	3400	122.61	9.8
2420	43.97	.8	3420	124.23	8.1
2440	44.14	.8	3440	125.43	6.0
2460	44.28	.7	3460	127.16	8.7
2480	44.44	.8	3480	128.23	5.3
2500	44.50	.3	3500	130.05	9.1
2520	44.71	1.0	3520	131.86	9.0
2540	44.83	.6	3540	132.57	3.6
2560	44.97	.7	3560	134.71	10.7
2580	45.16	.9	3580	135.93	6.1
2600	45.50	1.7	3600	137.50	7.9
2620	45.62	.6	3620	138.99	7.5
2640	45.84	1.1	3640	140.18	5.9
2660	46.07	1.1	3660	141.59	7.1
2680	46.31	1.2	3680	143.03	7.2
2700	46.53	1.1	3700	144.34	6.5
2720	46.81	1.4	3720	145.79	7.2
2740	47.14	1.6	3740	147.37	7.9
2760	47.09	-.2	3760	148.75	6.9
2780	47.35	1.3	3780	149.87	5.6
2800	47.84	2.5	3800	150.64	3.9
2820	48.41	2.8	3820	151.12	2.4
2840	49.31	4.5	3840	151.80	3.4
2860	49.03	-1.4	3860	153.49	8.5
2880	49.28	1.2	3880	154.74	6.2
2900	49.76	2.4	3900	155.71	4.9
2920	50.03	1.4	3920	157.02	6.5
2940	50.52	2.5	3940	157.96	4.7
2960	50.85	1.6	3960	158.81	4.2
2980	50.89	.2	3980	159.62	4.0
3000	51.37	2.4	4000	160.54	4.6

FIGURE 2G-3

GEOTECH DATA TEMPERATURE LOG OF 6/12/86 FOR CORE HOLE GEO N-1. This profile was constructed by GEO personnel from selected data in table 2G-3. The precision and accuracy of the temperature measurements are respectively 0.01°F and 1°F. Temperatures were measured at 20 foot intervals from the surface to 3000 feet and at 10 foot intervals thereafter.

Figure 2G-3

CO[illegible] HOLE GEO N-1

GEOTECH DATA TEMPERATURE LOG OF 6/12/86

NEWBERRY VOLCANO, OREGON

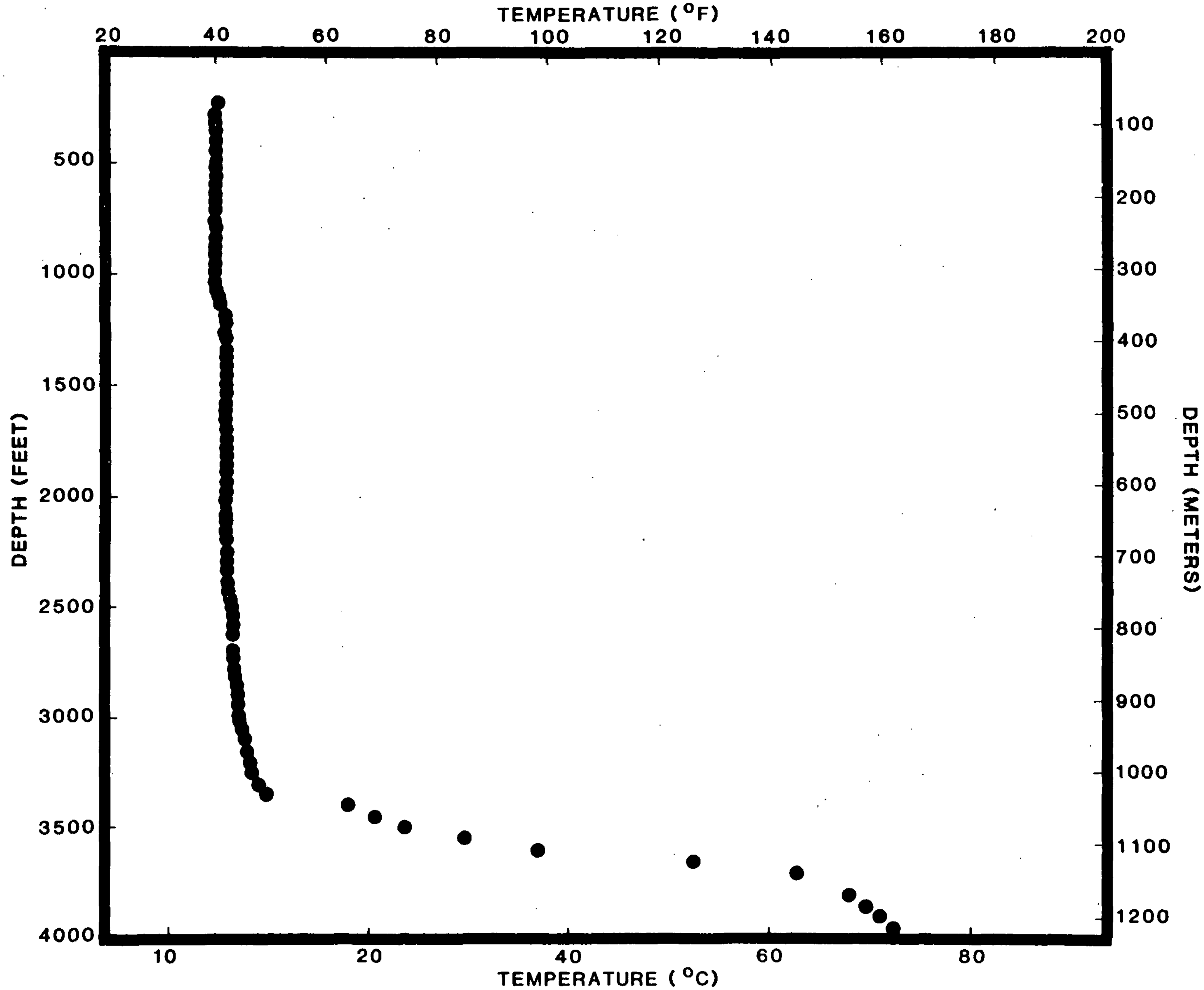


TABLE 2G-3

GEO-N-1

Temperature/Depth Data (see Fig. 2G-3)

Geotech: 6/12/86

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
240	40.35		1240	41.99	.1
260	39.64	-3.5	1260	42.08	.5
280	39.55	-.5	1280	42.15	.3
300	39.57	.1	1300	42.16	.0
320	39.64	.3	1320	42.16	0.0
340	39.74	.5	1340	42.17	.0
360	39.59	-.8	1360	42.27	.5
380	39.59	0.0	1380	42.28	.0
400	39.61	.1	1400	42.29	.1
420	39.66	.2	1420	42.29	0.0
440	39.59	-.3	1440	42.28	-.1
460	39.54	-.2	1460	42.29	.1
480	39.54	0.0	1480	42.29	0.0
500	39.41	-.7	1500	42.29	0.0
520	39.37	-.2	1520	42.30	.0
540	39.40	.2	1540	42.30	0.0
560	39.54	.7	1560	42.30	0.0
580	39.53	-.1	1580	42.30	0.0
600	39.68	.8	1600	42.30	0.0
620	39.59	-.5	1620	42.30	0.0
640	39.49	-.5	1640	42.30	0.0
660	39.50	.0	1660	42.30	0.0
680	39.57	.3	1680	42.30	0.0
700	39.82	1.2	1700	42.31	.1
720	39.62	-1.0	1720	42.31	0.0
740	39.55	-.3	1740	42.31	0.0
760	39.49	-.3	1760	42.31	0.0
780	39.50	.0	1780	42.31	0.0
800	39.55	.2	1800	42.31	0.0
820	39.58	.2	1820	42.32	.0
840	39.61	.1	1840	42.31	-.0
860	39.66	.2	1860	42.32	.0
880	39.69	.1	1880	42.32	0.0
900	39.71	.1	1900	42.32	0.0
920	39.76	.2	1920	42.32	0.0
940	39.80	.2	1940	42.32	0.0
960	39.84	.2	1960	42.33	.1
980	39.90	.3	1980	42.33	0.0
1000	39.98	.4	2000	42.33	0.0
1020	40.13	.8	2020	42.34	.0
1040	40.37	1.2	2040	42.36	.1
1060	40.76	1.9	2060	42.38	.1
1080	40.83	.4	2080	42.40	.1
1100	40.90	.3	2100	42.42	.1
1120	41.03	.6	2120	42.44	.1
1140	41.24	1.1	2140	42.46	.1
1160	41.46	1.1	2160	42.48	.1
1180	41.96	2.5	2180	42.49	.1
1200	41.97	.1	2200	42.50	.0
1220	41.98	.0	2220	42.53	.1

TABLE 2G-3 (continued)

GEO-N-1

Temperature/Depth Data

Geotech: 6/12/86

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
2240	42.56	.2	3120	45.94	1.2
2260	42.58	.1	3130	46.06	1.2
2280	42.67	.4	3140	46.30	2.4
2300	42.61	-.3	3150	46.33	.3
2320	42.65	.2	3160	46.65	3.2
2340	42.69	.2	3170	46.82	1.7
2360	42.72	.2	3180	46.65	-1.7
2380	42.75	.1	3190	46.64	-.1
2400	42.80	.2	3200	46.64	0.0
2420	42.89	.5	3210	46.64	0.0
2440	42.90	.1	3220	46.63	-.1
2460	42.94	.2	3230	46.79	1.6
2480	42.99	.3	3240	46.70	-.9
2500	43.03	.2	3250	46.74	.4
2520	43.09	.3	3260	46.91	1.7
2540	43.12	.1	3270	46.94	.3
2560	43.17	.2	3280	47.81	8.7
2580	43.22	.3	3290	48.66	8.5
2600	43.26	.2	3300	50.48	18.2
2620	43.28	.1	3310	52.10	16.2
2640	43.31	.2	3320	55.12	30.2
2660	43.38	.3	3330	57.09	19.7
2680	43.43	.2	3340	57.17	.8
2700	43.51	.4	3350	56.97	-2.0
2720	43.56	.3	3360	59.41	24.4
2740	43.58	.1	3370	58.99	-4.2
2760	43.58	0.0	3380	60.94	19.5
2780	43.61	.1	3390	62.02	10.8
2800	43.71	.5	3400	62.74	7.2
2820	43.82	.6	3410	63.20	4.6
2840	43.94	.6	3420	64.25	10.5
2860	44.05	.6	3430	66.19	19.4
2880	44.16	.6	3440	67.76	15.7
2900	44.27	.6	3450	69.63	18.7
2920	44.37	.5	3460	69.22	-4.1
2940	44.48	.6	3470	69.62	4.0
2960	44.51	.1	3480	71.44	18.2
2980	44.52	.1	3490	73.39	19.5
3000	44.54	.1	3500	74.73	13.4
3010	44.59	.5	3510	77.66	29.3
3020	44.66	.7	3520	79.28	16.2
3030	44.74	.8	3530	80.31	10.3
3040	44.85	1.1	3540	82.43	21.2
3050	44.99	1.4	3550	85.72	32.9
3060	45.16	1.7	3560	87.56	18.4
3070	45.42	2.6	3570	90.61	30.5
3080	45.44	.2	3580	91.58	9.7
3090	45.51	.7	3590	94.53	29.5
3100	45.65	1.4	3600	98.44	39.1
3110	45.82	1.7	3610	102.61	41.7

TABLE 2G-3 (continued)

GEO N-1

Temperature/Depth Data

Geotech: 6/12/86

DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)	DEPTH (FEET)	TEMPERATURE (DEG F)	GRADIENT (DEG F/100 FT)
3620	105.40	27.9			
3630	110.45	50.5			
3640	122.70	122.5			
3650	126.51	38.1			
3660	130.56	40.5			
3670	138.15	75.9			
3680	140.47	23.2			
3690	141.92	14.5			
3700	145.49	35.7			
3710	147.40	19.1			
3720	149.79	23.9			
3730	150.86	10.7			
3740	151.55	6.9			
3750	152.12	5.7			
3760	153.18	10.6			
3770	153.65	4.7			
3780	154.08	4.3			
3790	154.39	3.1			
3800	154.65	2.6			
3810	154.96	3.1			
3820	155.51	5.5			
3830	156.12	6.1			
3840	156.83	7.1			
3850	157.63	8.0			
3860	158.12	4.9			
3870	158.56	4.4			
3880	159.01	4.5			
3890	159.53	5.2			
3900	159.95	4.2			
3910	160.47	5.2			
3920	160.74	2.7			
3930	161.11	3.7			
3940	161.54	4.3			
3950	161.99	4.5			
3960	162.37	3.8			
3970	162.80	4.3			
3980	163.14	3.4			
3990	163.60	4.6			
4000	164.04	4.4			

FIGURE 2G-4

BLACKWELL TEMPERATURE LOG OF 9/25/86 FOR CORE HOLE GEO N-1. This profile was constructed by GEO personnel from selected data in table 2G-4. Temperatures were measured at 2 meter intervals (6.6 feet) with an accuracy of 1°F and a precision of 0.01°F.

CORE HOLE GEO N-1

BLACKWELL TEMPERATURE LOG OF 9/25/86

NEWBERRY VOLCANO, OREGON

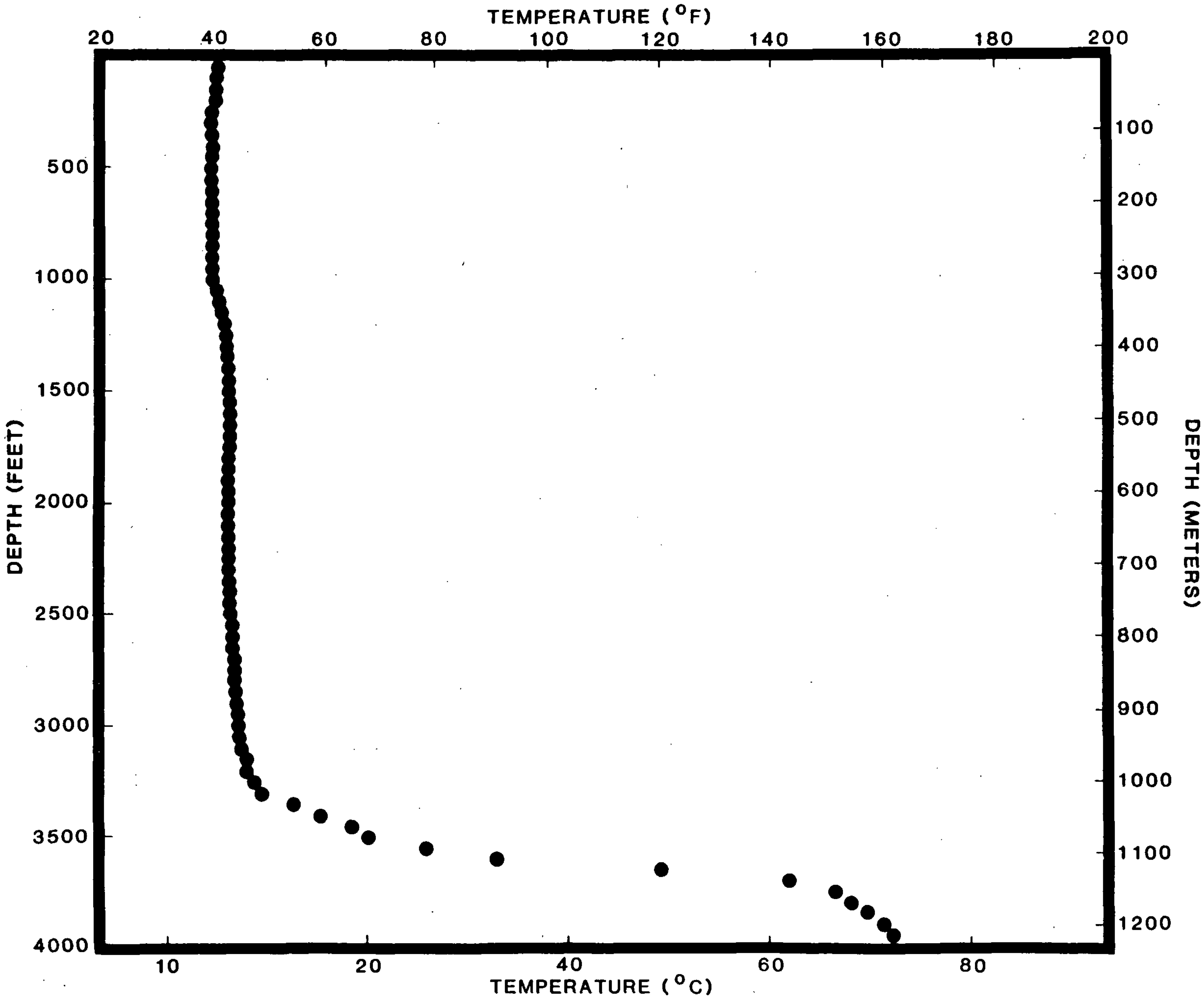


Figure 2G-4

TABLE 2G-4

GEO N-1

Temperature/Depth Data (see Fig. 2G-4)

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
13.1	39.13	0.0	282.2	39.48	-0.1
19.7	39.67	8.2	288.7	39.46	-0.2
26.2	39.93	4.0	295.3	39.47	0.1
32.8	40.11	2.7	301.8	39.48	0.2
39.4	40.24	2.0	308.4	39.49	0.1
45.9	40.55	4.7	315.0	39.50	0.1
52.5	40.56	0.2	321.5	39.50	0.1
59.1	40.57	0.1	328.1	39.58	1.3
65.6	40.57	0.1	334.6	39.63	0.7
72.2	40.57	0.0	341.2	39.65	0.3
78.7	40.57	0.0	347.8	39.61	-0.7
85.3	40.56	-0.1	354.3	39.57	-0.6
91.9	40.55	-0.1	360.9	39.55	-0.3
98.4	40.53	-0.4	367.5	39.53	-0.3
105.0	40.51	-0.3	374.0	39.52	-0.2
111.5	40.50	-0.2	380.6	39.52	0.1
118.1	40.49	-0.1	387.1	39.56	0.6
124.7	40.48	-0.1	393.7	39.56	0.0
131.2	40.49	0.1	400.3	39.56	0.0
137.8	40.48	0.0	406.8	39.56	-0.1
144.4	40.49	0.1	413.4	39.57	0.2
150.9	40.50	0.1	419.9	39.59	0.2
157.5	40.49	-0.1	426.5	39.60	0.1
164.0	40.48	-0.2	433.1	39.57	-0.4
170.6	40.46	-0.3	439.6	39.54	-0.4
177.2	40.43	-0.5	446.2	39.52	-0.4
183.7	40.39	-0.5	452.8	39.50	-0.2
190.3	40.34	-0.7	459.3	39.49	-0.3
196.9	40.30	-0.7	465.9	39.47	-0.2
203.4	40.26	-0.7	472.4	39.48	0.1
210.0	40.22	-0.6	479.0	39.48	0.1
216.5	40.18	-0.5	485.6	39.44	-0.6
223.1	40.15	-0.5	492.1	39.41	-0.5
229.7	39.93	-3.4	498.7	39.38	-0.4
236.2	39.51	-6.3	505.2	39.36	-0.3
242.8	39.53	0.2	511.8	39.35	-0.2
249.3	39.52	-0.1	518.4	39.34	-0.2
255.9	39.52	-0.1	524.9	39.35	0.1
262.5	39.50	-0.3	531.5	39.35	0.1
269.0	39.49	-0.2	538.1	39.36	0.0
275.6	39.48	-0.1	544.6	39.37	0.2

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet.	Temperature Deg. F	Gradient Deg.F/100 Ft
551.2	39.40	0.5	820.2	39.56	0.1
557.7	39.45	0.6	826.8	39.58	0.3
564.3	39.50	0.9	833.3	39.59	0.1
570.9	39.52	0.4	839.9	39.59	0.1
577.4	39.48	-0.7	846.5	39.61	0.2
584.0	39.47	-0.1	853.0	39.61	0.0
590.6	39.47	-0.1	859.6	39.63	0.3
597.1	39.49	0.3	866.1	39.64	0.2
603.7	39.60	1.7	872.7	39.66	0.2
610.2	39.53	-1.0	879.3	39.68	0.3
616.8	39.53	-0.1	885.8	39.68	0.1
623.4	39.51	-0.3	892.4	39.70	0.2
629.9	39.49	-0.3	899.0	39.71	0.1
636.5	39.47	-0.2	905.5	39.71	0.1
643.0	39.46	-0.2	912.1	39.72	0.1
649.6	39.46	0.0	918.6	39.73	0.2
656.2	39.46	0.0	925.2	39.74	0.1
662.7	39.48	0.3	931.8	39.76	0.3
669.3	39.51	0.5	938.3	39.77	0.2
675.9	39.56	0.7	944.9	39.79	0.2
682.4	39.62	1.0	951.4	39.80	0.2
689.0	39.67	0.7	958.0	39.82	0.2
695.5	39.69	0.2	964.6	39.83	0.2
702.1	39.71	0.3	971.1	39.85	0.2
708.7	39.70	-0.1	977.7	39.87	0.3
715.2	39.69	-0.2	984.3	39.88	0.2
721.8	39.65	-0.6	990.8	39.90	0.3
728.3	39.62	-0.5	997.4	39.93	0.4
734.9	39.60	-0.3	1003.9	39.97	0.5
741.5	39.58	-0.3	1010.5	40.01	0.7
748.0	39.57	-0.1	1017.1	40.07	0.9
754.6	39.54	-0.5	1023.6	40.09	0.3
761.2	39.52	-0.3	1030.2	40.16	1.1
767.7	39.51	-0.2	1036.7	40.24	1.2
774.3	39.50	-0.1	1043.3	40.33	1.4
780.8	39.49	-0.1	1049.9	40.50	2.7
787.4	39.50	0.1	1056.4	40.73	3.5
794.0	39.51	0.2	1063.0	40.76	0.3
800.5	39.53	0.3	1069.6	40.77	0.3
807.1	39.54	0.2	1076.1	40.80	0.3
813.6	39.55	0.1	1082.7	40.82	0.4

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
1089.2	40.84	0.4	1364.8	42.32	0.1
1095.8	40.87	0.4	1371.4	42.34	0.2
1102.4	40.89	0.4	1378.0	42.36	0.3
1108.9	40.92	0.4	1384.5	42.37	0.3
1115.5	40.98	0.9	1391.1	42.38	0.2
1122.0	41.02	0.5	1397.6	42.40	0.2
1128.6	41.05	0.6	1404.2	42.40	0.1
1135.2	41.09	0.6	1410.8	42.41	0.1
1141.7	41.15	0.9	1417.3	42.41	0.1
1148.3	41.17	0.3	1423.9	42.42	0.1
1154.9	41.19	0.4	1430.4	42.42	0.0
1161.4	41.23	0.6	1437.0	42.43	0.1
1168.0	41.25	0.3	1443.6	42.43	0.0
1174.5	41.78	8.0	1450.1	42.43	0.0
1181.1	41.98	3.0	1456.7	42.43	0.1
1187.7	41.99	0.2	1463.3	42.43	0.0
1194.2	41.99	0.0	1469.8	42.43	0.0
1200.8	41.99	0.0	1476.4	42.43	0.0
1207.3	41.99	0.0	1482.9	42.43	0.0
1213.9	41.99	0.0	1489.5	42.44	0.1
1220.5	41.99	0.0	1496.1	42.43	-0.1
1227.0	41.99	0.0	1502.6	42.44	0.1
1233.6	41.99	-0.1	1509.2	42.44	0.1
1240.2	42.00	0.1	1515.7	42.43	-0.1
1246.7	42.00	0.0	1522.3	42.43	0.0
1253.3	42.03	0.5	1528.9	42.44	0.0
1259.8	42.10	1.2	1535.4	42.44	0.1
1266.4	42.19	1.2	1542.0	42.44	0.0
1279.5	42.27	0.6	1548.6	42.44	0.0
1286.1	42.28	0.1	1555.1	42.44	0.0
1292.7	42.28	0.1	1561.7	42.44	0.0
1299.2	42.28	0.1	1568.2	42.44	0.0
1305.8	42.29	0.1	1574.8	42.44	0.0
1312.3	42.30	0.1	1581.4	42.44	0.0
1318.9	42.30	0.0	1587.9	42.45	0.1
1325.5	42.31	0.1	1594.5	42.44	-0.1
1332.0	42.31	0.0	1601.0	42.45	0.1
1338.6	42.31	0.1	1607.6	42.45	0.0
1345.1	42.31	0.0	1614.2	42.45	-0.1
1351.7	42.32	0.0	1620.7	42.44	0.0
1358.3	42.32	0.0	1627.3	42.45	0.0

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
1633.9	42.45	0.1	1902.9	42.47	0.1
1640.4	42.45	0.0	1909.4	42.47	0.0
1647.0	42.45	0.0	1916.0	42.47	0.0
1653.5	42.45	0.0	1922.6	42.47	0.0
1660.1	42.45	0.0	1929.1	42.47	0.0
1666.7	42.45	0.0	1935.7	42.47	0.0
1673.2	42.45	0.0	1942.3	42.47	0.0
1679.8	42.45	0.1	1948.8	42.47	0.1
1686.4	42.45	0.0	1955.4	42.47	0.0
1692.9	42.45	0.0	1961.9	42.48	0.1
1699.5	42.46	0.1	1968.5	42.47	-0.1
1706.0	42.45	-0.1	1975.1	42.47	0.0
1712.6	42.46	0.1	1981.6	42.47	0.0
1719.2	42.46	0.0	1988.2	42.47	0.0
1725.7	42.46	0.0	1994.8	42.47	0.0
1732.3	42.45	0.0	2001.3	42.48	0.1
1738.8	42.46	0.0	2007.9	42.48	0.0
1745.4	42.45	0.0	2014.4	42.48	0.1
1752.0	42.46	0.1	2021.0	42.48	0.0
1758.5	42.46	0.0	2027.6	42.48	0.1
1765.1	42.46	0.0	2034.1	42.48	0.0
1771.7	42.46	0.0	2040.7	42.48	0.0
1778.2	42.46	0.0	2047.2	42.49	0.1
1784.8	42.46	0.0	2053.8	42.49	0.1
1791.3	42.46	0.0	2060.4	42.49	0.0
1797.9	42.46	0.0	2066.9	42.50	0.1
1804.5	52.46	0.0	2073.5	42.50	0.0
1811.0	42.47	0.1	2080.1	42.51	0.1
1817.6	42.46	0.0	2086.6	42.52	0.1
1824.1	42.46	0.0	2093.2	42.52	0.1
1830.7	42.46	0.0	2099.7	42.52	0.0
1837.3	42.46	0.0	2106.3	42.53	0.1
1843.8	42.46	0.0	2112.9	42.53	0.0
1850.4	42.46	0.0	2119.4	42.54	0.1
1857.0	42.46	0.0	2126.0	42.54	0.0
1863.5	42.46	0.0	2132.5	42.55	0.1
1870.1	42.47	0.0	2139.1	42.55	0.1
1876.6	42.47	0.0	2145.7	42.56	0.1
1883.2	42.47	0.0	2152.2	42.57	0.2
1889.8	42.47	0.0	2158.8	42.57	0.0
1896.3	42.47	0.0	2165.4	42.58	0.1

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
2171.9	42.58	0.1	2447.5	42.89	0.2
2178.5	42.58	0.0	2454.1	42.90	0.2
2185.0	42.59	0.1	2460.6	42.92	0.2
2191.6	42.60	0.1	2467.2	42.93	0.2
2198.2	42.60	0.0	2473.8	42.94	0.2
2211.3	42.62	0.1	2480.3	42.96	0.3
2217.8	42.62	0.1	2486.8	42.97	0.2
2224.4	42.63	0.1	2493.4	42.99	0.2
2231.0	42.63	0.0	2500.0	43.00	0.2
2237.5	42.64	0.1	2506.6	43.02	0.3
2244.1	42.64	0.0	2513.1	43.03	0.2
2250.7	42.65	0.1	2519.7	43.04	0.1
2257.2	42.66	0.1	2526.2	43.05	0.2
2263.8	42.66	0.0	2532.8	43.06	0.2
2270.3	42.66	0.1	2539.4	43.08	0.3
2276.9	42.67	0.0	2545.9	43.10	0.4
2283.5	42.67	0.1	2552.5	43.10	0.0
2290.0	42.68	0.2	2559.1	43.12	0.2
2296.6	42.70	0.2	2565.6	43.13	0.2
2303.1	42.71	0.2	2572.2	43.15	0.2
2309.7	42.71	0.0	2578.7	43.17	0.3
2316.3	42.71	0.0	2585.3	43.18	0.1
2322.8	42.71	0.1	2591.9	43.19	0.2
2329.4	42.72	0.0	2598.4	43.20	0.1
2336.0	42.72	0.0	2605.0	43.20	0.1
2342.5	42.73	0.1	2611.5	43.21	0.0
2349.1	42.73	0.1	2618.1	43.21	0.1
2355.6	42.74	0.1	2624.7	43.21	0.0
2362.2	42.75	0.1	2631.2	43.21	0.1
2368.8	42.76	0.1	2637.8	43.22	0.0
2375.3	42.77	0.2	2644.4	43.24	0.3
2381.9	42.77	0.1	2650.9	43.25	0.3
2388.5	42.76	-0.2	2657.5	43.27	0.3
2395.0	42.77	0.2	2664.0	43.29	0.3
2401.6	42.79	0.2	2670.6	43.31	0.3
2408.1	42.80	0.2	2677.2	43.32	0.3
2414.7	42.82	0.2	2683.7	43.34	0.2
2421.3	42.83	0.2	2690.3	43.35	0.1
2427.8	42.90	1.0	2696.9	43.36	0.3
2434.4	42.86	-0.6	2703.4	43.40	0.6
2440.9	42.86	0.1	2710.0	43.41	0.2

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
2716.5	43.43	0.2	2992.1	44.27	0.1
2723.1	43.44	0.2	2998.7	44.28	0.1
2729.7	43.44	0.0	3005.2	44.29	0.2
2736.2	43.45	0.1	3011.8	44.31	0.3
2742.8	43.45	0.0	3018.4	44.32	0.2
2749.3	43.45	0.0	3024.9	44.36	0.6
2755.9	43.45	0.0	3031.5	44.39	0.5
2762.5	43.45	0.0	3038.1	44.46	1.0
2769.0	43.45	0.1	3044.6	44.52	0.9
2775.6	43.46	0.1	3051.2	44.59	1.1
2782.2	43.47	0.2	3057.7	44.71	1.7
2788.7	43.49	0.3	3064.3	44.77	1.0
2795.3	43.52	0.4	3070.9	44.92	2.3
2801.8	43.55	0.5	3077.4	44.96	0.5
2808.4	43.59	0.5	3084.0	45.04	1.3
2815.0	43.62	0.6	3090.6	45.03	-0.2
2821.5	43.67	0.7	3097.1	45.11	1.1
2828.1	43.71	0.6	3103.7	45.23	1.8
2834.6	43.74	0.4	3110.2	45.31	1.3
2841.2	43.76	0.4	3116.8	45.40	1.3
2847.8	43.78	0.4	3123.4	45.43	0.5
2854.3	43.81	0.4	3129.9	45.52	1.3
2860.9	43.84	0.5	3136.5	45.59	1.2
2874.0	43.93	0.7	3143.0	45.74	2.2
2880.6	43.97	0.6	3149.6	45.82	1.3
2887.1	44.00	0.5	3156.2	45.81	-0.2
2893.7	44.03	0.4	3162.7	46.01	3.1
2900.3	44.05	0.3	3169.3	46.04	0.5
2906.8	44.07	0.4	3175.9	46.02	-0.4
2913.4	44.10	0.5	3182.4	45.99	-0.5
2919.9	44.14	0.5	3189.0	45.98	-0.1
2926.5	44.19	0.8	3195.5	45.99	0.0
2933.1	44.21	0.3	3202.1	45.99	0.0
2939.6	44.24	0.4	3208.7	45.99	0.0
2946.2	44.26	0.3	3215.2	45.99	0.0
2952.8	44.26	0.1	3221.8	45.99	0.0
2959.3	44.26	0.0	3228.3	46.01	0.3
2965.9	44.26	0.0	3234.9	46.17	2.4
2972.4	44.26	0.0	3241.5	46.03	-2.0
2979.0	44.26	0.0	3248.0	46.07	0.5
2985.6	44.26	0.0	3254.6	46.09	0.3

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
3261.2	46.16	1.2	3530.2	73.54	6.0
3267.7	46.20	0.6	3536.7	74.14	9.2
3274.3	46.23	0.3	3543.3	76.43	34.8
3280.8	46.95	11.0	3549.9	78.63	33.6
3287.4	46.90	-0.7	3556.4	79.33	10.6
3294.0	47.51	9.2	3563.0	80.74	21.5
3300.5	48.46	14.5	3569.6	82.29	23.7
3307.1	49.45	15.1	3576.1	83.25	14.7
3313.6	50.28	12.7	3582.7	83.79	8.2
3320.2	51.60	20.1	3589.2	86.08	34.9
3326.8	54.51	44.5	3595.8	89.06	45.4
3333.3	54.96	6.8	3602.4	91.14	31.7
3339.9	54.45	-7.8	3608.9	94.55	52.0
3346.5	53.78	-10.1	3615.5	97.41	43.6
3353.0	54.20	6.4	3622.0	99.05	25.0
3359.6	56.65	37.4	3628.6	101.30	34.3
3366.1	56.19	-7.1	3635.2	109.52	125.3
3372.7	55.90	-4.4	3641.7	117.88	127.5
3379.3	56.86	14.6	3648.3	120.30	36.9
3385.8	58.08	18.6	3654.9	123.36	46.6
3392.4	58.79	10.8	3661.4	127.10	57.0
3399.0	59.15	5.5	3668.0	131.57	68.0
3405.5	58.41	-11.3	3674.5	136.04	68.1
3412.1	58.64	3.5	3681.1	137.63	24.2
3418.6	59.29	9.9	3687.7	139.38	26.7
3425.2	60.27	14.9	3694.2	140.96	24.2
3431.8	61.80	23.3	3700.8	143.00	31.0
3438.3	62.28	7.3	3707.3	144.09	16.6
3444.9	64.38	32.1	3713.9	146.73	40.3
3451.4	64.95	8.7	3720.5	148.82	31.8
3458.0	64.49	-7.0	3727.0	149.16	5.3
3464.6	63.80	-10.5	3733.6	150.27	16.9
3471.1	64.25	6.7	3740.2	150.90	9.6
3477.7	65.14	13.7	3746.7	151.30	6.2
3484.3	67.11	30.0	3753.3	151.92	9.4
3490.8	68.19	16.4	3759.8	152.99	16.4
3497.4	67.83	-5.4	3766.4	153.30	4.7
3503.9	69.83	30.4	3773.0	153.63	5.0
3510.5	71.84	30.7	3779.5	153.94	4.6
3517.1	72.39	8.3	3786.1	154.22	4.3
3523.6	73.15	11.6	3792.7	154.39	2.6

TABLE 2G-4 (continued)

GEO N-1

Temperature/Depth Data

Blackwell: 9/25/86

Depth Feet	Temperature Deg. F	Gradient Deg.F/100 Ft	Depth feet	Temperature Deg. F	Gradient Deg.F/100 Ft
3799.2	154.55	2.5	3917.3	160.73	3.3
3805.8	154.74	2.9	3923.9	160.87	2.1
3812.3	154.90	2.4	3930.4	161.12	3.8
3818.9	155.26	5.4	3937.0	161.44	5.0
3825.5	155.70	6.7	3943.6	161.71	4.1
3832.0	156.06	5.5	3950.1	162.03	4.8
3838.6	156.48	6.4	3956.7	162.24	3.3
3845.1	157.01	8.1	3963.3	162.50	3.9
3851.7	157.55	8.2	3969.8	162.78	4.3
3858.3	157.91	5.5	3976.4	163.06	4.3
3864.8	158.26	5.3	3982.9	163.33	4.2
3871.4	158.55	4.5	3989.5	163.59	4.0
3878.0	158.81	3.9	3996.1	163.88	4.4
3884.5	159.17	5.4			
3891.1	159.57	6.2			
3897.6	159.85	4.2			
3904.2	160.17	4.8			
3910.8	160.51	5.2			

FIGURE 2G-5

COMPARISON OF TEMPERATURE PROFILES BELOW 2,000 FEET FOR GEO N-1. The data of this figure is compiled from the following temperature logs:

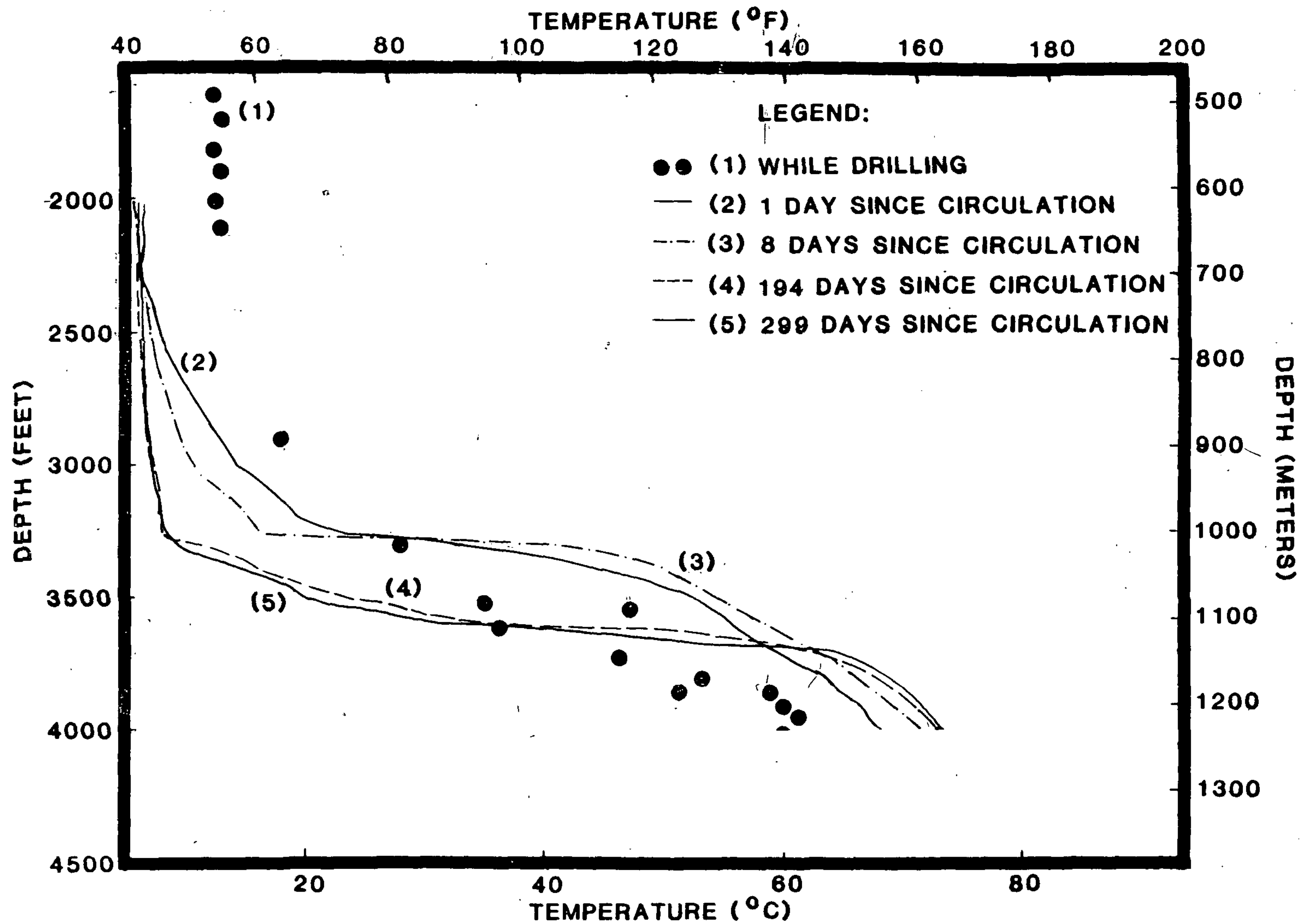
KEY: (1) Data from daily drilling reports
(2) Dresser Atlas log of 11/3/85 (table 2G-1)
(3) Geotech Data log of 11/9/85 (table 2G-2)
(4) Geotech Data log of 6/12/86 (table 2G-3)
(5) Blackwell log of 9/25/86 (table 2G-4)

Note the large (up to 80°F) decrease in temperature with time over the interval 3,000-3,700 feet, apparently is related to cold water migrating down the annulus of the core hole over this interval. Note also the conductive gradient below 3,700 feet.

Figure 2G-5

CORE HOLE GEO N-1

TEMPERATURE VS. DEPTH
NEWBERRY VOLCANO, OREGON



Form 9-1970

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY, CONSERVATION DIVISION

Form Approved
Budget Bureau No. ______

GEOTHERMAL SUNDRY NOTICE

The U.S. Geological Survey requests this form or other Supervisor approved form to be prepared and filed in triplicate with requisite attachments with the Supervisor. The Supervisor must approve this permit prior to any lease operations.

4. LEASE SERIAL NO.: OR-12004

5. SURFACE MANAGER: BLM ( ) FS (X) Other ( )

1a. WELL TYPE: PRODUCTION ( ) INJECTION ( ) HEAT EXCHANGE ( ) OBSERVATION (X) OTHER ( )

6. UNIT AGREEMENT NAME: Newberry Volcano Flank

1b. WELL STATUS: Permanent Abandonment

7. WELL NO.: N-1

8. PERMIT NO.: OR920-85-DNF 001

2. NAME OF LESSEE/OPERATOR: GEO Newberry Crater, Inc.

9. FIELD OR AREA: Newberry Volcano

3. ADDRESS OF LESSEE/OPERATOR: 61419 S. Hwy 97, Suite A, Bend, Oregon 97702

10. SEC. T., R., B.& M.: S25, T22S, R12E

13. LOCATION OF WELL OR FACILITY: 3600' W and 2750' N of SW corner of S25, T22S, R12E

11. COUNTY: Deschutes

12. STATE: Oregon

14. TYPE OF WORK

CHANGE PLANS	( )	CONVERT TO INJECTION	( )	PULL OR ALTER CASING	( )
SITE AND ROAD CONSTRUCTION	( )	FRACTURE TEST	( )	MULTIPLE COMPLETE	( )
CONSTRUCT NEW PRODUCTION FACILITIES	( )	SHOOT OR ACIDIZE	( )	ABANDON	(X)
ALTER EXISTING PRODUCTION FACILITIES	( )	REPAIR WELL	( )	OTHER	( )

15. DESCRIBE PROPOSED OPERATIONS (Use this space for well activities only. See instructions for current well conditions on reverse)

Proposed operations for permanently abandoning GEO N-1 include the following:

1. Separate 1.9" O.D. tubing (J-55) from 4" LP Fange by cutting with torch.
2. Remove 7 1/16 x 4½" HW well head, 2" Ball valves, and 4" LP Flange from 4½" HW regular casing.
3. Cement from surface 4½" HW casing to a minimum depth of 15 meters (50 feet) measured from 2 meters (6 feet) below ground level with ASTM type 1 & 11 Portland cement.
4. Cap casing by welding steel plate on stub.
5. Remove cellar cribbing.
6. Backfill cellar and restore surface area as specified by USFS.

16. DESCRIBE PROPOSED OPERATIONS (Use this space for all activities other than well work)

(See reverse side if needed)

17. I hereby certify that the foregoing is true and correct

SIGNED Michael J. Cat[illegible] TITLE SEC DATE 4-22-87

(This space for Federal use)

APPROVED BY ______ TITLE ______ DATE ______

CONDITIONS OF APPROVAL, IF ANY:

This permit is required by law (30 U.S.C. 1023), regulations: 30 CFR 270.34, 30 CFR 270.35, 30 CFR 270.45, 30 CFR 270.71-1, 30 CFR 270.72, Federal Geothermal Lease Terms and Stipulations and other regulatory requirements. The United States Criminal Code (18 U.S.C. 1001) makes it a criminal offense to make a willfully false statement or representation to any Department or Agency of the United States as to any matter within its jurisdiction

GW/IS

(See instructions on reverse side)