ESL-88012 -JP
GL01946

RESEARCH CORING IN THE CASCADES
A STATUS REPORT

Michele M. Lemieux[1] and Philip M. Wright[1] and Joseph N. Moore[1]

[1] University of Utah Research Institute, Earth Science Laboratory, 391 Chipeta Way, Suite C; Salt Lake City, UT 84108

ABSTRACT

The High Cascades volcanic province has long been suspected to contain considerable geothermal potential. However, few deep wells have been drilled, and much of the data that have been accumulated are proprietary. In response to the need to obtain a better understanding of the Cascades region, the U.S. Department of Energy, Geothermal Technology Division, sponsored a cooperative research program with industry based around obtaining data from research coreholes. This paper is a progress report on the three coreholes completed to date, including a summary of drilling histories and a description of the scientific studies underway and of the open file data available.

INTRODUCTION

The Cascades is an area with high geothermal potential, but with few surface manifestations. The lack of widespread surface geothermal activity is generally believed to result from the masking of systems by downward and lateral movement of cold meteoric water. In 1986, the U.S. Department of Energy, Geothermal Technology Division, initiated the Caldera Reservoir Investigation Program to evaluate the effects of the near-surface hydrologic regime and to obtain lithologic, hydrologic, and structural data on the Cascades.

The DOE program has four main elements: 1) cost sharing with industry in coring research holes; 2) acquisition of lithologic, geophysical, and hydrologic data within and below the shallow hydrologic regime; 3) data interpretation and integration; and, 4) open file release of data and core, as well as publication of technical reports and case histories.

Summaries of drilling histories and descriptions of the available data and scientific studies are presented in this paper for three holes drilled under the DOE program: Clackamas Thermal Gradient Hole #1 (CTGH-1), drilled by Thermal Power Co.; and GeoNewberry holes # 1 and # 3 (GEO N-1 and GEO N-3), drilled by GEO Operator Corporation. CTGH-1 is located approximately 10 miles north of Mt. Jefferson, while GEO N-1 and GEO N-3 are located on the southern and northern flanks, respectively, of the Newberry volcano. Figure 1 shows the locations of these holes.

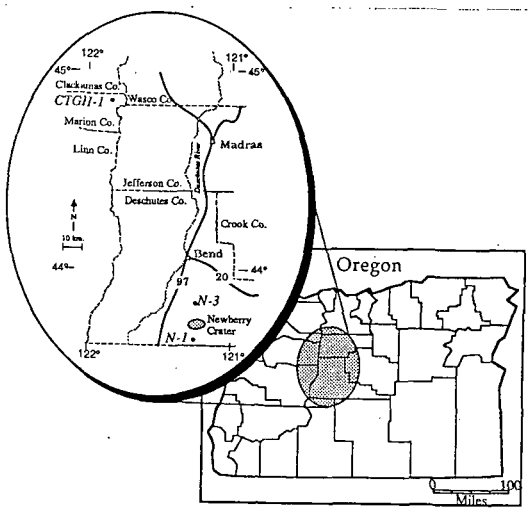

Figure 1. Location map of core holes.

CORING SUMMARY

CTGH-1

CTGH-1 was rotary drilled to a depth of 527 feet, and then diamond cored to a total depth of 4,800 feet. The hole

required 93 days to complete; however, only 58 days were spent drilling. CTGH-1 has not been plugged and abandoned at this point. The hole condition is believed to be good so that deepening may be possible.

There were several unanticipated delays during the drilling of CTGH-1. First, the attempt to run a conductor into the top 40 feet of glacial boulders and till was not initially successful. Later, during the change-over from rotary drilling to wireline coring, there were problems setting the casing to the bottom of the hole. In addition, the initial test of the BOP detected a leak, requiring a new flange. Another significant delay occurred during coring at a depth of 4,203 feet, when the HX rods parted at 823 feet. After unsuccessful attempts at retrieval, coring was continued with NX rods, and the HX rods were left in the hole as casing. This precluded the collection of a full suite of geophysical logs, since some logs can not be run in a cased hole. Finally, at a depth of 4,800 feet, the U.S. Forest Service shut down rig operations because of a Class E fire risk. The results of a temperature survey run nine days after the shutdown, in which the bottom-hole temperature was found to be 99°C (210°F), led to a decision not to drill.

GEO N-1

GEO N-1 was rotary drilled to a depth of 487 feet, and then diamond cored to a total depth of 4,550 feet (Swanberg and Combs, 1986). Data and core obtained to a depth of 4,000 feet are in the public domain. Drilling progressed smoothly; out of the 59 days required to reach a depth of 4,000 feet, 54 days were spent drilling. GEO N-1 has been scheduled to be plugged and permanently abandoned before September of 1988.

There were only a few minor problems in the drilling of GEO N-1. During rotary drilling, the rods parted, leaving the rods, sub and bit in the hole, and requiring removal with a tap. An additional delay occurred during the change-over from rotary drilling to wireline coring, when leaks were detected in the BOP.

GEO N-3

GEO N-3 was rotary drilled to a depth of 454 feet and then diamond cored to the total depth of 4,002 feet. Of the 60 days on site, 46 were spent drilling. GEO N-3 is scheduled to be plugged and abandoned before September, 1988.

There were several technical problems encountered in the drilling of GEO N-3. During the change-over from rotary drilling to wireline coring, the initial attempts at cementing the casing were not successful. In addition, the BOP tested negative due to faulty equipment. One significant problem the other two holes did not have was consistent caving in the cinder/ash units. This was particularly a problem when pulling out of the hole to change bits. In one instance, the caving caused the HQ rods to stick. After futile attempts at retrieval, as well as a loss of 138 feet of previously drilled hole, the HQ rods were cemented in place and the hole was reentered with NQ rods. Once again, this limited geophysical logging.

Comparison of Drilling Histories

Depth penetration profiles are shown in Figure 2 for the three holes. The overall daily penetration rate ~~for~~ CTGH-1 was 88 feet/day. For GEO N-1, the overall daily penetration rate to 4,000 feet was 69 feet/day. Finally, for GEO N-3, the overall penetration rate was 68 feet/day. According to Thermal Power Co. (1987), no systematic relationship between penetration rate, rock type and/or degree of fracturing was discerned. This seems to apply to the Newberry volcano holes as well.

Core recovery was excellent in CTGH-1 and GEO N-1, averaging nearly 100%. In GEO N-3, core recovery was equally good in the basaltic-andesite flows. However, GEO N-3 had several thick sections of cinders and ash where core recovery was significantly lower. During rotary drilling of the upper portions of the hole, cuttings were collected only in CTGH-1. There was continual loss of circulation during rotary drilling of the Newberry holes, with no returns.

A detailed itemization of project expenditures for CTGH-1 is given in Table 1a. Approximate expenditures for GEO N-1 and GEO N-3 are given in Table 1b. The overall unit cost for CTGH-1 was $95/foot; for GEO N-1 the overall cost was $72/foot (not including logging and demobilization); and for GEO N-3 the cost was $90/foot.

DATA ACQUISITION AND AVAILABILITY

A significant amount of data has been obtained on the lithologies, temperature gradients, and hydrologic regimes of the areas penetrated by the coreholes. Simplified lithologic columns for CTGH-1, GEO N-1 and GEO N-3 are given in Figure 3. For more detailed information, ~~refered~~ refer

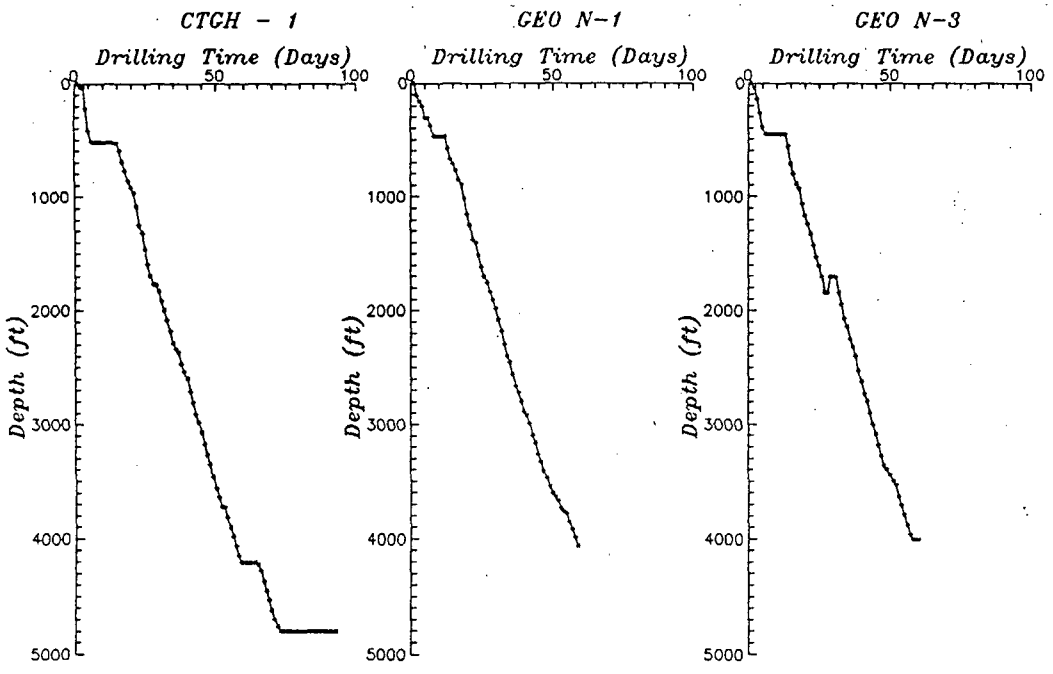

Figure 2. Depth penetration profile for CTGH-1, GEO N-1, and GEO N-3. Information based on daily drilling reports in open file data.

TABLE 1a.

Detailed Itemization of Expenditures for CTGH-1 (based on CTGH-1 Final Technical Report by Thermal Power Co., 1987).

ROAD, SITE AND LOCATION	$11,544.00
RIG MOB/DEMOB	$10,000.00
RIG	$296,807.00
TRUCKING & HAULING	$3,890.00
DRILL SITE GEOLOGISTS	$26,560.00
MUD & CHEMICALS	$24,618.00
CEMENT MATERIALS	$9,141.00
GEOPHYSICAL LOGGING	$10,032.00
DRILL BITS & TOOLS	$23,493.00
OUTSIDE LABOR	$1,424.00
OTHER EVALUTATION	$6,954.00
OTHER	$14,125.00
CONDUCTOR CASING	$419.00
SURFACE CASING	$10,589.00
WELLHEAD EQUIPMENT	$2,589.00
CAMP & CATERING	$4,271.00
TOTAL:	$456,456.00
OVERALL COST/FT =	$456,456/4,00 ft
=	$95/ft

4800.

TABLE 1b.

Estimate of Expenditure for GEO N-1 and GEO N-3 (based on daily drilling reports by GEO Operator Corp.)

	GEO N-1	GEO N-3
RIG MOBILIZATION	$3,000	$8,723
ROTARY DRILLING	$31,953	$24,957
CEMENTING CASING®		
INSTALLING BOP	$17,830	$33,682
WIRELINE CORING	$233,776	$255,462
LOGGING AND		
DEMOBILIZATION	?	$37,619
TOTAL COST	$286,559 (to 4000')	$360,443
OVERALL COST/FT	$72/FT	$90/FT

to the open file reports. In general, the lithologies are similar, consisting of basalt/basaltic-andesite flows. All of the holes have interbedded pyroclastic and volcaniclastic units. In GEO N-3, these units are thicker than in the other holes, and since they are poorly consolidated as well, caving occurs ~~before~~ during

ed.

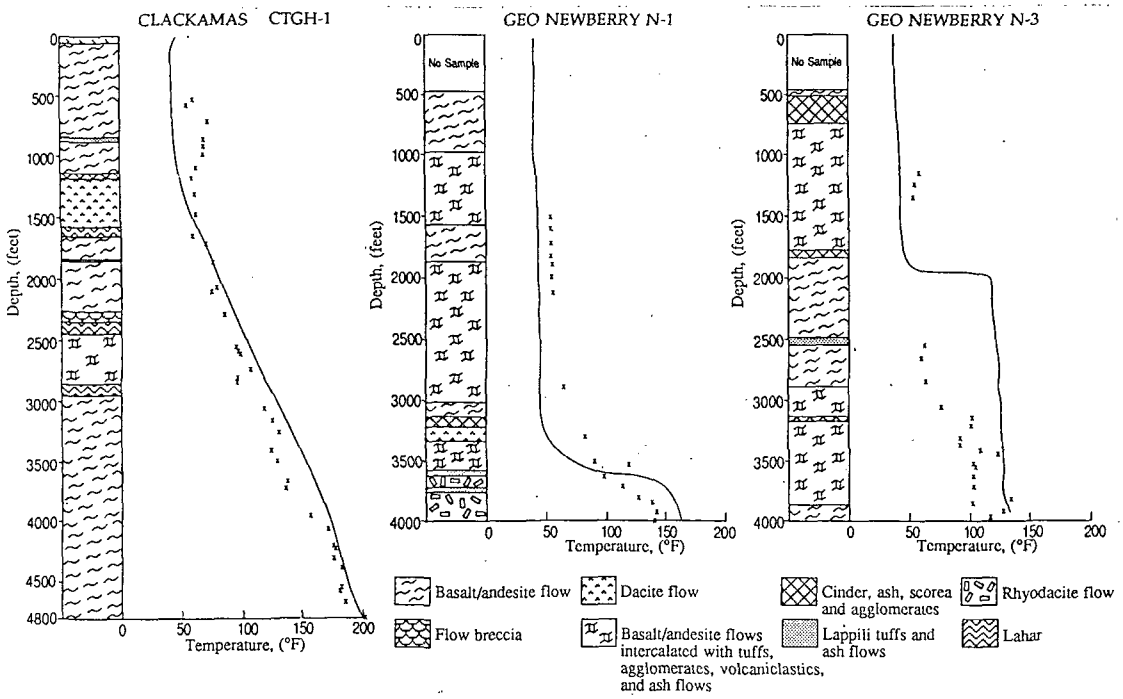

Figure 3. Generalized lithologic columns and temperature-depth profiles for CTGH-1, GEO N-1, and GEO N-3. *Temperature-depth curves based on Blackwell and Steele (1987);* MRT data, shown by "x"s, from open file reports. CTGH-1 and GEO N-1 lithologic columns modified from Sibbett, unpublished data.

the drilling of GEO N-3 that was not present in GEO N-1 and CTGH-1.

Figure 3 also compares the temperatures measured by Blackwell and Steele (1987) with those recorded using a maximum recording thermometer (MRT) during drilling. The temperature profiles for GEO N-1 and GEO N-3, after allowing the wells to stabilize, appear to reflect intra-hole fluid flow (Blackwell and Stead, 1987). In GEO N-3, they suggest that the temperature distribution results from upward movement of water in the wellbore. Similarly, the thermal profile of GEO N-1 could be produced by downward flow of water within the wellbore.

Since temperatures measured during drilling may be recorded before any significant intra-hole fluid flow has begun, MRT data should provide an indication of the depth to the base of the cold-water hydrologic regime. Figure 3 shows that the MRT temperatures are nearly constant with depth in the upper portions of all three holes. Below this zone, the gradients increase and higher temperature are recorded. We suggest, based on these measurements, that the lower boundary of the cold water regime is located at depths of about 3,600 feet in GEO N-1, GEO N-3, and about 1,600 feet in CTGH-1. 3,000 feet in

Comparison of the thermal profiles with the lithologic logs demonstrates that fluid movement may be influenced by rock type. For example, in GEO N-3, flow out of the wellbore occurs around 1,800 to 1,900 feet in an unconsolidated cinder and ash unit. The water appears to enter this well in interbedded pyroclastics and basalts. Additional information on GEO N-1 and GEO N-3 is given by Blackwell and Steele (1987). GEO N-1 has also been summarized by Swanberg and Combs (1986).

Geophysical well logs were run in all three holes shortly after hole completion. In both CTGH-1 and GEO N-3, it was not possible to obtain complete logs due to the casing. Table 2 lists the logs available, and the corresponding depth intervals.

TABLE 2.

Geophysical Well Logs Available. For copies contact: Rocky Mountain Well Log Service; P.O. Box 3150; Denver, Colorado 80201.

	CTGH-1	GEO N-1	GEO N - 3
TEMPERATURE	16 - 516.5 ft; 0 - 4785 ft	0 - 4000 ft	50 - 4002 ft
CALIPER	10 - 514 ft; 4100 - 4800 ft	0 - 4000 ft	1690 - 3999 ft
GAMMA RAY	0 - 4800 ft	0 - 4000 ft	50 - 1692 ft
SPONTANEOUS POTENTIAL	35 - 516 ft; 4200 - 4798 ft	0 - 4000 ft	--
RESISTIVITY 16" - 64"	35 - 515.5 ft; 4200 - 4799 ft	0 - 4000 ft	--
INDUCTION	--	0 - 4000 ft	--
ACOUSTIC	4225 - 4425 ft	0 - 4000 ft	--
ACOUSTIC FRACLOG	--	0 - 4000 ft	1700 - 4001 ft
NEUTRON	0 - 4800 ft	--	50 - 4000 ft
GAMMA - GAMMA DENSITY	0 - 510 ft; 775 - 900 ft	--	--
INDUCED POLARIZATION	4200 - 4799 ft	--	--
LATERALOG	4200 - 4798 ft	--	--
DENSILOG, NEUTRON	--	--	50 - 1692 ft
GUARD RESISTIVITY	20 - 514 ft	--	--

better alignment

Analysis of the well logs is presently being conducted. There are several other scientific studies underway on the three coreholes. Table 3 lists these studies as well as the entities that are conducting the studies. In addition, an attempt will be made to obtain a fluid sample from GEO N-3 before the hole is plugged and abandoned.

A summary of open-file data is given in Table 4. Core from the three holes is also available for inspection at the University of Utah Research Institute sample library by appointment.

An additional core hole has been drilled along the east side of Crater Lake National Park, Oregon by California Energy as part of the DOE/Industry cost-share program (located south of area shown in Figure 1). The hole has been drilled to approximately 1,500 feet, with a temperature at TD of 107°C (Blackwell and Steele, 1987). However, drilling has been halted while possible effects of geothermal development on Crater Lake are evaluated. Some of the issues surrounding this evaluation are discussed by La Fleur (1987) and Sammel and Benson (1987). If continued drilling is approved, studies and data similar to acquired on the other holes under the DOE cost-share program will become available for the Crater Lake hole.

SUMMARY

As part of a DOE-industry cooperative research program, three deep holes were cored in the Cascades to depths of 4,000 to 5,000 feet. The main objective of the program was to penetrate the near-surface hydrologic regime and obtain lithologic,

hydrologic and structural data on the Cascades that would be available to the public. The near-surface hydrologic regime was penetrated by all three holes, and the appropriate data collected. At the present, studies on these three holes are still underway.

Table 3.

Scientific Studies Underway or Reported

	CTGH -1	GEO N-1	GEO N-3
HEAT FLOW	SMU	SMU GEO	SMU GEO
DOWNHOLE Hg	--	GEO	GEO
ALTERATION	USGS	USGS GEO	USGS GEO
VOLCANIC STRATIGRAPHY	DOGAMI	Univ. of Wyo	Univ. of Wyo
CORRELATION OF ELECTRIC LOGS WITH ALTERATION ANALYSIS OF WELL LOGS	UURI	UURI	UURI
GEOCHEMISTRY OF FLUIDS AND ROCKS	--	GEO	GEO
AGE DATA	--	GEO	GEO
PETROGRAPHIC ANALYSIS	--	GEO	GEO
SYNTHESIS OF DATA TO DEVELOP MODEL	DOGAMI	--	--
CORE STUDIES	UURI	UURI	UURI

SMU - Southern Methodist University

GEO - GEO Operator Corp.

USGS - United States Geological Survey

DOGAMI - Oregon Dept. of Geology and and Mineral Industries

Univ. of WYO - University of Wyoming Dept. of Geology

UURI - University of Utah Research Institute - Earth Science Laboratory

Table 4.

Open File data available. For copies contact the authors.

	CTGH -1	GEO N-1	GEO N-3
DAILY DRILLING REPORT	X	X	X
DRILLING AND COMPLETION HISTORY	X		
LITHOLOGIC LOG	X	X	X
CORE RECOVERY LOG	X	X	X
CORE PHOTOS		X	X
TEMPERATURE DURING DRILLING	X	X	X
STANDING FLUID LEVEL	X	X	X
TEMPERATURE LOG		X	X
GRAPHIC DRILLING LOG (lithology, temp. from MRT, penetration rate, water level, lost circulation zones)	X		
SECONDARY MINERALOGY DESCRIPTION	X	X	X
HOLE COMPLETION SCHEMATIC	X	X	X
TABLE OF MEASURED THERMAL CONDUCTIVITY		X	
FINAL REPORTS	X	X	

ACKNOWLEDGEMENTS

This program has been supported by the U. S. Department of Energy, Geothermal Technology Division and Idaho Operations Office. Marshall Reed and Susan Prestwich of DOE have managed the program. UURI has been supported under Contract No. DE-AC07-85ID12489.

REFERENCES

Blackwell, D.D., and Steele, J.L., 1987, Geothermal data from deep holes in the Oregon Cascade range: Geothermal Resources Council, Trans., v. 11, p. 317-322.

La Fleur, J.G., 1987, Legend of the Crater Lake hot springs; a product of model mania: Geothermal Resources Council, Trans., v. 11, p. 267-279.

Sammel, E.A., and Benson, S., 1987, An analysis of the hydrologic effects of proposed test drilling in the Winema National Forest near Crater Lake, Oregon: Geothermal Resources Council, Trans., v. 11, p. 293-303

Swanberg, C.A., and Combs, J., 1986, Geothermal drilling in the Cascade Range: Preliminary results from a 1,387 m core hole, Newberry Volcano, Oregon, EOS, Trans. Amer. Geophys. Union, v. 67, p. 578-580.

Swanberg, C.A., Walkey, W.C., Woodruff, M.S., and Combs, J. 1987, GEO Core Hole N - 1, DOE Phase II Submittal-Cooperative Agreement No. DE-FC07-85ID12612: open file report submitted on 12 May 1987 to Idaho Operation Office, U.S. Department of Energy.

Thermal Power Company, 1987, Cascades geothermal drilling, Clackamas 4,800-foot thermal gradient hole, final technical report: open file report submitted on 30 September 1987 to Idaho Operation Office, U.S. Department of Energy.

TECHNICAL PROBLEMS AND DELAYS

CTGH - 1

1) Spudding hole - 2 day delay due to difficulty in running conductor into glacial boulders in till

2) Rotary to Wireline - 8 day delay due to problems cementing casing and testing the BOPE

3) Parting of HX rods - 5 day delay; continued coring with NX rods

4) Rig operations shut down due to high fire risk - 13 day delay

5) minor problems - sanded in core barrel; parted wireline; core barrel jammed in rods at bad joint of tubing

GEO N - 1

1) Parting of rods during rotary drilling - 1 day delay

2) Rotary to wireline - 4 day delay due to cementing problems and testing of the BOPE

3) minor problems - core tube stuck causing wireline to snap; mud pump breakdown; core barrel sanded in

GEO N - 3

1) Rotary to wireline - 7 day delay due to cementing problems and failure of BOPE test

2) Extensive caving - causing slow penetration rate, core loss, core barrel mislatch, and in one case a loss of previously drilled corehole, when HQ rods stuck and had to be cemented in and hole reentered with NQ rods.

3) minor problems - water truck breakdown; broken wireline, dropping the core out of the core barrel; bad rod vibrations; lost circulation

Only estimates available for GEO N-1, N-3

Options

① Call Newberry for data

or

② Print CTGH-1 data as "typical case" and briefly refer to cost/ft estimate for GEO's

③ include rough table of all three

TABLE 1a)

Table 1b

Drilling costs:

CTGH-1 → Final Technical Report

GEO N-1 → Daily Drilling reports
+ phone call from M. Johnson on Sept 4 (see Sept. 3rd report)

instal. BOPE/cement casing flg. = Sept. 3rd - mob
- 31,953

Total cost = 286,559 Oct 20

GEO N-3 → Daily drilling reports

inst BOP/cement casing (6/13) 57,180 - (6/7) 33,680
= 23,500

coring (7/29) 328,824 - (6/13) 57,180
= 265,644

demob/logging (9/1) 360,443 - (7/29) 322,824
= 37,619

Depth Penetrat. Profiles:

daily penet. rates

CTGH-1 not including logging or shutdown by Forest service
6/07 - 8/18

GEO N-1 not including logg / mob / demob
8/23 - 10/20

GEO N-3 not includ. logging / demob mob
6/02 - 7/29

although shown on profiles

MRT data

CTGH-1 - pick off graph of MRT in Final Technic. Report

GEO N-1 - picked off graph of temp while drilling from GEO N-1 final technical report

GEO N-3 daily drilling reports and Tabulated temp. during drilling (N-3-6)

Lithologic Col.

CTGH-1, GEO N-1 } B. Sibbetts general. col., chem. analys done on GEO N-1

GEO N-3 - M. Lemieux from detailed logs

DAILY PENETRATION RATES

	CTGH-1	GEO N-1	GEO N-3
OVERALL	88 ft/day	68.9 ft/day	67.5 ft/day
DRILLING DAYS ONLY	110 ft/day	76.7 ft/day	85.1 ft/day

93 days on site - 58 actual drilling days

22 { 2 days spudding + setting casing
8 days inbetween rotary & wireline
5 days after Hx rods parted
7 days logging + demobiliz.

13 days down for fire danger

ERALL

PENETRATION RATES FOR CLACKAMAS HOLE

DATE	DAYS SINCE SPUD	FOOTAGE DRILLED (OVERALL)	FOOTAGE DRILLED (ONLY DAYS OF ACTUAL DRILLING)	DEPTH
06/07	1	0		0
06/08	2	35	35	35
06/09	3	0		35
06/10	4	185	185	220
06/11	5	200	200	420
06/12	6	97	97	517
06/13	7	0		517
06/14	8	0		517
06/15	9	0		517
06/16	10	0		517
06/17	11	0		517
06/18	12	0		517
06/19	13	0		517
06/20	14	10	10	527
06/21	15	0		527
06/22	16	70	70	597
06/23	17	971	971	694
06/24	18	801	801	774
06/25	19	85	85	859
06/26	20	59	59	918
06/27	21	44	44	962
06/28	22	121	121	1083
06/29	23	162	162	1245
06/30	24	71	71	1316
07/01	25	137	137	1453
07/02	26	137	137	1590
07/03	27	100	100	1690
07/04	28	75	75	1765
07/05	29	10	10	1775
07/06	30	53	53	1828
07/07	31	89	89	1917
07/08	32	81	81	1998
07/09	33	85	85	2083
07/10	34	98	98	2181
07/11	35	105	105	2286
07/12	36	50	50	2336
07/13	37	32	32	2368
07/14	38	98	98	2466
07/15	39	69	69	2535
07/16	40	59	59	2594
07/17	41	114	114	2708
07/18	42	101	101	2809
07/19	43	103	103	2912
07/20	44	68	68	2980
07/21	45	89	89	3069
07/22	46	104	104	3173
07/23	47	96	96	3269
07/24	48	86	86	3355
07/25	49	106	106	3461
07/26	50	101	101	3562

DATE	DAYS SINCE SPUD	FOOTAGE DRILLED (OVERALL)		FOOTAGE DRILLED (ONLY DAYS OF ACTUAL DRILLING)	DEPTH
07/27	51	79		79	3641
07/28	52	80		80	3721
07/29	53	2		2	3723
07/31	54	88		88	3811
07/30	55	90		90	3901
08/01	56	81		81	3982
08/02	57	80		80	4062
08/03	58	81		81	4143
08/04	59	60		60	4203
08/05	60	0			4203
08/06	61	0			4203
08/07	62	0			4203
08/08	63	0			4203
08/09	64	0			4203
08/10	65	23		23	4226
08/11	66	53		53	4279
08/12	67	92		92	4371
08/13	68	79		79	4450
08/14	69	80		80	4530
08/15	70	90		90	4620
08/16	71	80		80	4700
08/17	72	60		60	4760
08/18	73	40	AVERAGE FOR	40	4800
09/02	88	AVERAGE	ACTUAL DRILLING		4800
09/03	89	OVERALL: 87.6027397	DAYS ONLY:	110.2586	4800
09/04	90				4800
09/05	91				4800
09/06	92				4800
09/07	93				4800

out of 60 days on site, 46 spent actually drilling

11 non drilling days:
- 7 days in between rotary + wireline
- 4 days with stuck HQ rods
- 2 days logging
- 1 day spudding hole

PENETRATION RATES FOR GEO N - 3

DATE	DAYS SINCE SPUD	FOOTAGE DRILLED (OVERALL)	FOOTAGE DRILLED (ONLY DAYS OF ACTUAL DRILLING)	DEPTH
06/02	1	0		0
06/03	2	35	35	35
06/04	3	105	105	140
06/05	4	130	130	270
06/06	5	120	120	390
06/07	6	64	64	454
06/08	7	0		454
06/09	8	0		454
06/10	9	0		454
06/11	10	0		454
06/12	11	0		454
06/13	12	0		454
06/14	13	0		454
06/15	14	111	111	565
06/16	15	151	151	716
06/17	16	86	86	802
06/18	17	95	95	895
06/19	18	37	37	932
06/20	19	134	134	1066
06/21	20	101	101	1167
06/22	21	74	74	1241
06/23	22	86	86	1327
06/24	23	97	97	1424
06/25	24	105	105	1529
06/26	25	78	78	1607
06/27	26	95	95	1702
06/28	27	138	138	1840
06/29	28	0		1840
06/30	29	0		1702
07/01	30	0		1702
07/02	31	0		1705
07/03	32	1	1	1841
07/04	33	106	106	1947
07/05	34	125	125	2072
07/06	35	69	69	2141
07/07	36	111.5	111.5	2252.
07/08	37	66.5	66.5	2319
07/09	38	83	83	2402
07/10	39	126	126	2528
07/11	40	97	97	2625
07/12	41	106	106	2731
07/13	42	63.5	63.5	2794.
07/14	43	103	103	2897.
07/15	44	100.5	100.5	2998
07/16	45	91	91	3089
07/17	46	94	94	3183
07/18	47	3	3	3276
07/19	48	81	81	3357
07/20	49	40	40	3397
07/21	50	47	47	3444
07/22	51	51.5	51.5	3495.

07/24	53	99.5	99.5	3632
07/25	54	77	77	3709
07/26	55	83.5	83.5	3792.
07/27	56	86	86	3878.
07/28	57	82.5	82.5	3961
07/29	58	41	41	4002
07/30	59			4002
07/31	60			4002

AVERAGE OVERALL: 67.482

AVERAGE FOR ACTUAL DRILLING DAYS ONLY: 85.086

out of 59 Total days to drill to 4000'

5 non-drilling days:
- 4 days in between rotary and wireline
- 1 day parting of drill rods during rotary drilling
- 1 day spudding hole

PENETRATION RATES FOR GEO N - 1

DATE	DAYS SINCE SPUD	FOOTAGE DRILLED (OVERALL)	FOOTAGE DRILLED (ONLY DAYS OF ACTUAL DRILLING)	DEPTH
08/23	1	0		0
08/24	2	110	110	110
08/25	3	50	50	160
08/26	4	40	40	200
08/27	5	105	105	305
08/28	6	0		305
08/29	7	75	75	375
08/30	8	95	95	470
08/31	9	0		470
09/01	10	0		470
09/02	11	0		470
09/03	12	0		470
09/04	13	109	109	579
09/05	14	93	93	672
09/06	15	42	42	714
09/07	16	55	55	769
09/08	17	82	82	851
09/09	18	45	45	896
09/10	19	121	121	1017
09/11	20	135	135	1152
09/12	21	98	98	1250
09/13	22	125	125	1375
09/14	23	27	27	1402
09/15	24	110	110	1512
09/16	25	100	100	1612
09/17	26	86	86	1698
09/18	27	53	53	1751
09/19	28	79	79	1830
09/20	29	75	75	1905
09/21	30	75	75	1980
09/22	31	98	98	2078
09/23	32	99	99	2177
09/24	33	117	117	2294
09/25	34	104	104	2398
09/26	35	54	54	2452
09/27	36	112	112	2564
09/28	37	104	104	2668
09/29	38	56	56	2724
09/30	39	76	76	2800
10/01	40	91	91	2891
10/02	41	32	32	2923
10/03	42	73	73	2996
10/04	43	106	106	3102
10/05	44	65	65	3167
10/06	45	96	96	3263
10/07	46	69	69	3332
10/08	47	80	80	3412
10/09	48	56	56	3468
10/10	49	78	78	3545
10/11	50	59	59	3605
10/12	51	30	30	3635

10/13	52			
10/14	53	37		
10/15	54	64	37	
10/16	55	26	64	3672
10/17	56	22	26	3736
10/18	57	73	22	3762
10/19	58	61	73	3784
10/20	59	72	61	3857
10/21	60	69	72	3918
10/22	61		69	3990
10/23	62 AVERAGE	AVERAGE FOR		4059
10/24	63 OVERALL: 68.88135	ACTUAL DRILLING		
10/25	64	DAYS ONLY: 76.6792		

isothermal regime ⇒ (1) low & fairly uniform gamma ray log
electrical con. log on N-1

(2) MRT Temp < surface ambient

(3) drilling fluids whose chemistry does not reflect influx of geothermal fluids

thermally conductive (1) high variable γ ray log / elect. cond. log

(2) MRT data > ambi

(3) geothermal component in drilling fluid chemistry

Lava curtain Thicknesses

Newberry Volcano

< 300 m ( ) in Caldera

~1000 m on south flank (N-1)

in N-1 isothermal temps measured way below the WT. Is this water percolating down annulus?

N-1 3300'

N-3

hole Temp

w/in Caldera ⇒ 265°C @ 932 m

160°C @ 424 m

N-1 BHT @ 4000' =

GTG H- BHT @ 4800' = 206°F (97°C)

HEAT FLOW

are

ave heat flow values based on thermally conductive regime

Water table depth ⇒ Geothermal fluids migrating laterally near W.T. are likely to promote alteration +/- weakness

N-3 455-565m
ave 525m

∴ water table may lie close to the depth that which drilling problems were encountered

non of geophysical logs indicate WT

N-1 non of geophysical logs indicate WT

possible that WT lies 378-550 m which was never logged ← (all of drillers estimates are w/in unlogged interval)

N-1 most common estimate (490m)

Closeness of WT to incompetant rocks → may allow difficult drilling conditions to be predicted

Hole siting

GEO N-1 major mercury anomalie which is used as a surface condition for subsurface geothermal activity

GEO N-3

CTGH-1 major structural intersection associated w/ a low resistivity anomaly interpreted as locus of upwelling geothermal fluids

water table (cont)

N-3 - below the R.C. washout zones, in caliper log, are well correlated with zones of slightly elev. MRT (as thermal water is moving) above R.C. no such correlation - washouts permit lateral flow of groundwater

GTH-1 ranged 15-75' below surface