GL01936

#052 Drilling

RESEARCH CORING IN THE CASCADES
A STATUS REPORT

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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 location of these holes.

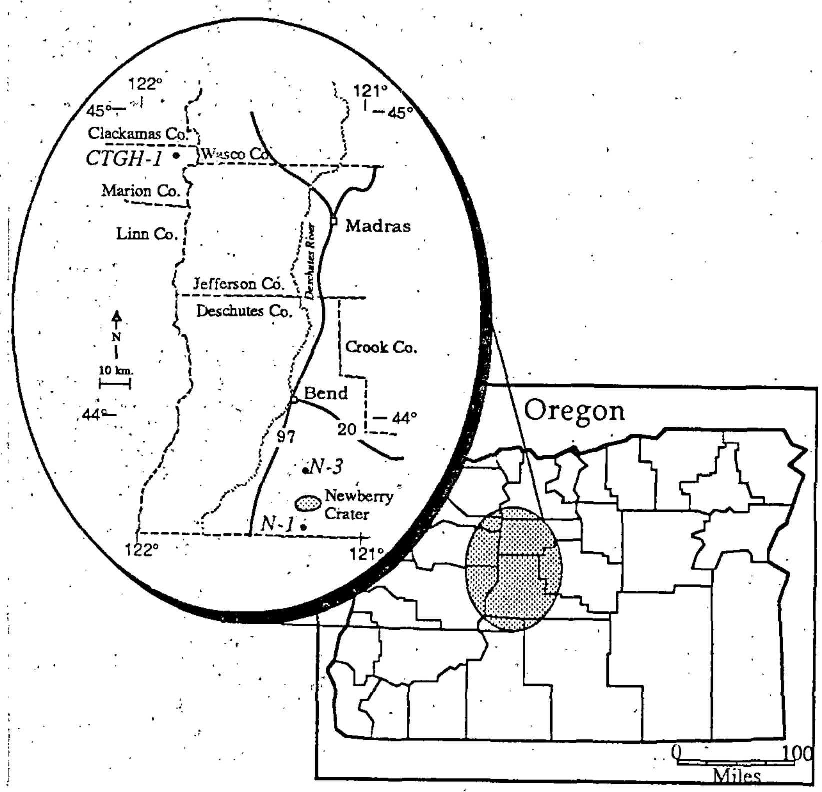

Figure 1. Location map of core holes.

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

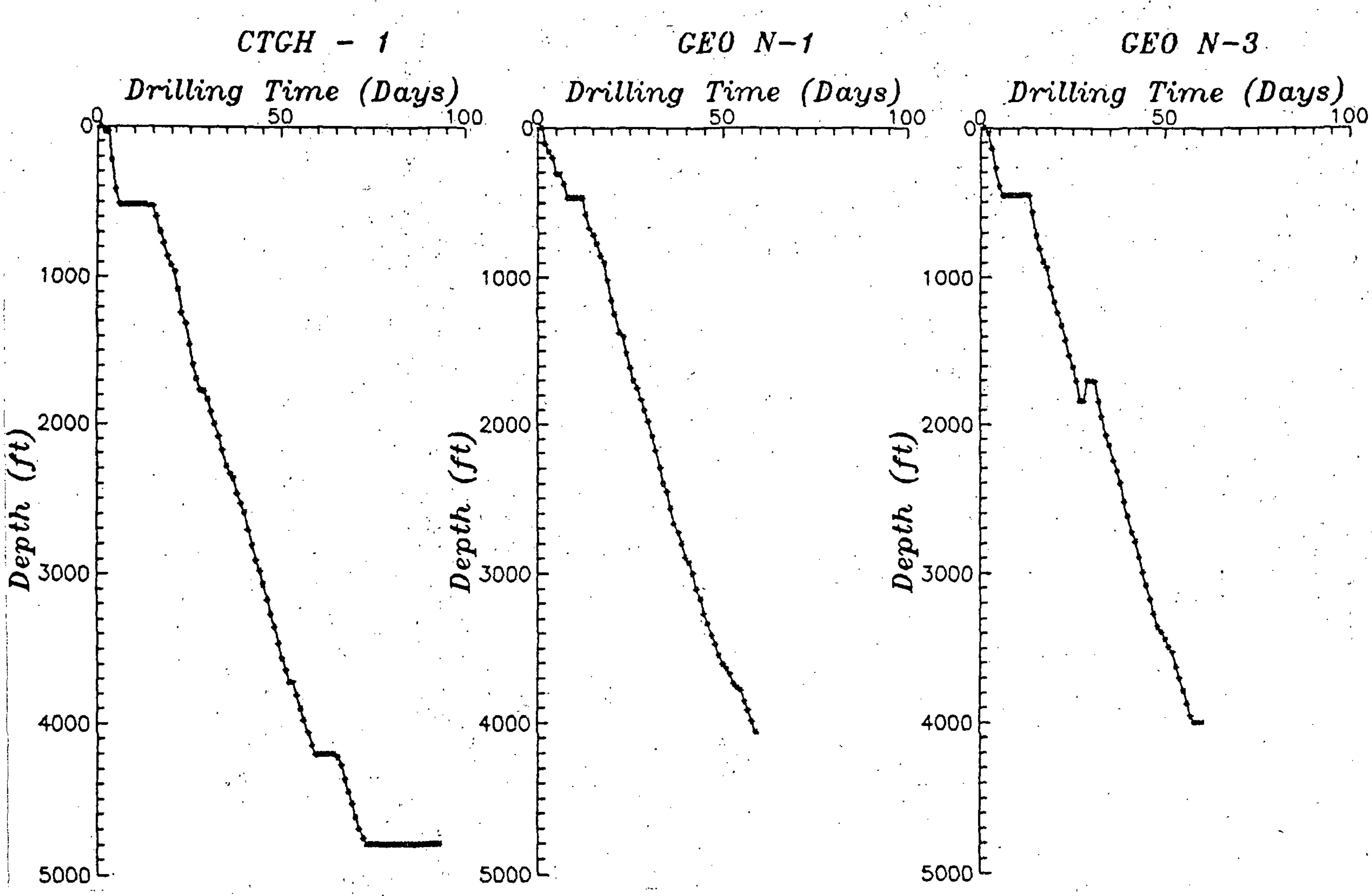

Figure 2. Depth penetration profile for CTGH-1, GEO N-1, and GEO N-3. Information based on daily drilling reports in open file data.

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 =	$456,456/4,000 ft
=	$95/ft

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 occurr before

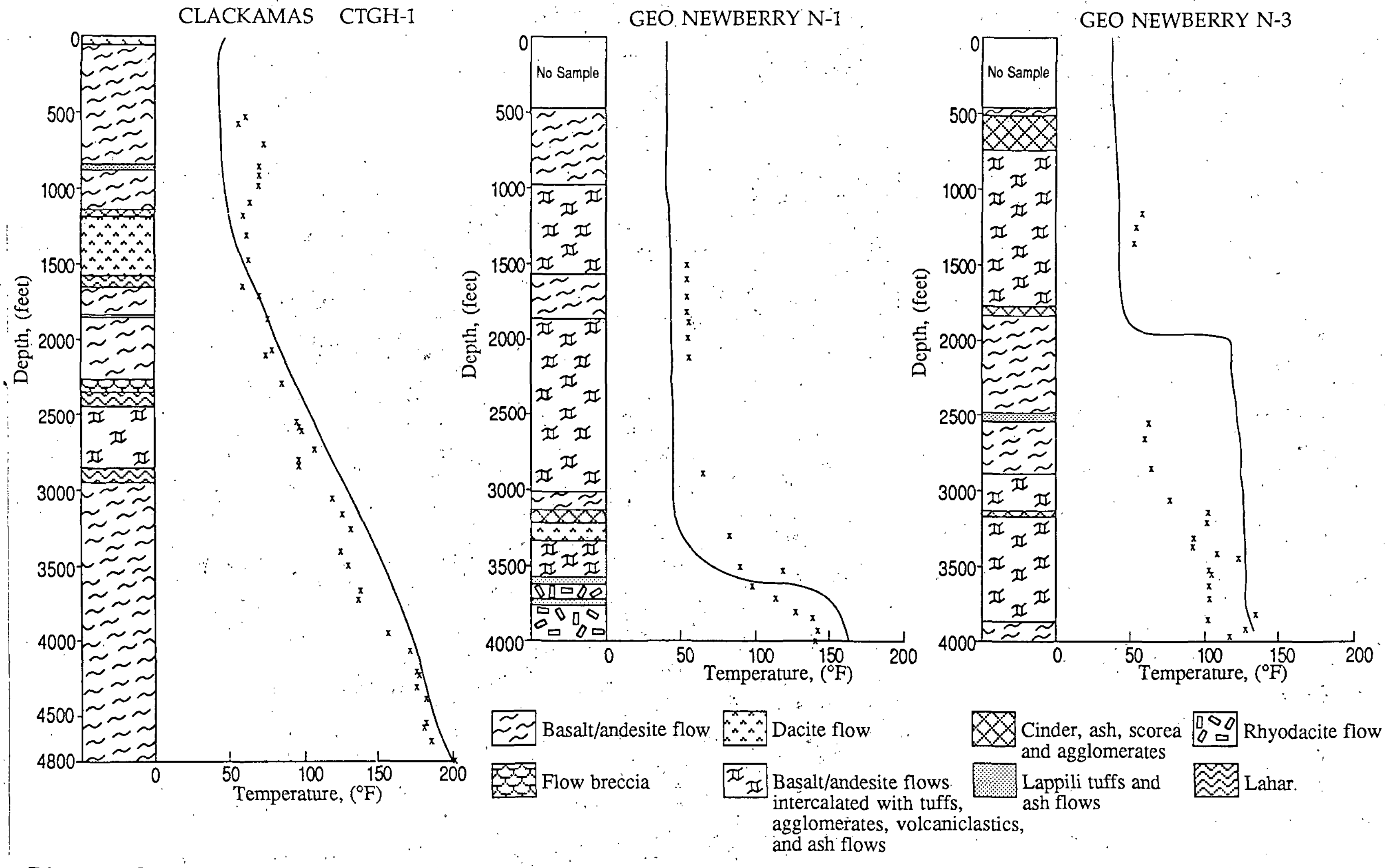

Figure 3. Generalized lithologic columns and temperature-depth profiles for CTGH-1, GEO N-1, and GEO N-3. Temperature-depth curves based on Blackwell and Steele (1987); MRT data, shown by "x"s, from open file reports. CTGH-1 and GEO N-1 lithologic columns modified from Sibbett, unpublished data.

the drilling of 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, appears 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 had begun, MRT data should provide are 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 at 1,600 feet in CTGH-1.

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	--	--

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.

GEOTHERMAL RESOURCES COUNCIL

#052

DAVID N. ANDERSON
Executive Director

June 27, 1988

Michele Lemieux
UURI
391 Chipeta Way, #C
Salt Lake City, UT 84108

Dear Author/Speaker:

The 1988 Annual Meeting Paper Review Committee has approved your paper entitled "Research Coring in the Cascades a Status Report" for Publication in the Transactions and Oral Presentation in the Drilling Technology Session on October 12, 1988 at 9:40 am. See enclosed schedule for approximate date and time of all scheduled talks.

I have enclosed a copy of the reviewers comments.

Authors that submitted an abstract for review that are going to write a paper on the blue line sheets are due by **July 8, 1988**; also, Corrections to Original Papers (papers already submitted) should be made by **July 8, 1988.**

All Papers Withdrawals should be made by **July 8, 1988.**

If you have any questions or problems with the above or the enclosed, please do not hesitate to call us at 916/758-2360.

Sincerely,

Grace

Graciela Mata
Meeting Coordinator

Enclosures

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Pub + Oral

GEOTHERMAL RESOURCES COUNCIL

PAPER EVALUATION SHEET

Paper Title Research Coring in the Cascades A status report

Authors Name Lemieux, Wright & Moore Speaker Name Lemieux

Quality of Technical Content: ok

Technical Content is Adaptable to Oral Presentation: yes

Use of Figures, Tables, etc. will aid Viewer Comprehension: yes

Timeliness of Subject Matter: Very

Importanct of Topic to Industry as a Whole, or to a discrete, Significant Portion of It: Very

Originality of Work: OK

Comments: fix author/affiliation and (3) grammatical/typos —

Disposition: Return to author for corrections - assigned to Drilling — T.F.

Accepted for Presentation Session: YES ✓ NO____ SESSION Drilling

Rejected: (if so why)____

Reviewed b[redacted]

GEOTHERMAL RESOURCES COUNCIL

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Executive Director

1988 ANNUAL MEETING

PRELIMINARY PROGRAM/SCHEDULE

TECHNICAL/POSTER PRESENTATIONS

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MONDAY, OCTOBER 10, 1988

	POWER PRODUCTION	HYDROLOGY ALTERATION
1:30 pm	88-012 Short Cut To Economical Geothermal Power Generation with Wide Range Portable Turbines Hibara, Y., M. Ikegami and K. Obinata	88-045 The Dynamics of Silica Deposition in Fractures: Oxygen Isotope Ratios in Hydrothermal Silicia from Yellowston Drill Core Y-13 Sturchio, N.C., T. Keith, and K. Muehlenbachs
1:55 pm	88-032 Report on the October 1987 Hawaiian HGP-A Power Plant Overhaul and Production Bell, D., and D. Thomas	88-049 Clay Mineralogy and Zoning in CSDP Corehole VC-2A: Further Evidence For Collapse of Isotherms in the Valles Caldera Hulen, J.B. and D.L. Nielson
2:20 pm	88-063 Optimized H^2S Treatment at Pacific Gas and Electric Company's Geysers Geothermal Project Unit 11 Dorighi, G.P., W.A. Conner and L.H. Kirby	88-050 Secondary Mineralogy of Core from Geothermal Drill Hole CTGH-1, High Cascade Range, Oregon Bargar, K.E.
2:45 pm	88-022 Geothermal Heat Cycle Research - Supercritical Cycle with Counterflow in Differenct Orientations Bliem, C.J., and G.L. Mines	88-060 Hydrothermal Alteration Patterns in the Breitenbush Hot Springs Area, Cascade Range, Oregon Keith, T.E.C.
3:10 pm	BREAK	
3:35 pm	88-030 Evaluation of a Site-Specific Commercial Hot Dry Rock Geothermal Power Plant Cochrane, F., C.A. Tosaya, and J.L. Owen	88-007 Alteration Age Mapping of some Japanese Geothermal Fields with Improved Thermoluminesence Dating Method Takashima, I. and Sakur Honda
4:00 pm	88-013 Achievable Improvements in Geothermal Power Generation Cycle Saulson, S.H. and J.H. Rosenblatt	
4:25 pm	88-062 Site Specific Needs Affect Process Choices for H^2S Abatement in Geothermal Power Plants Kenny, K., T.R. Bacon and L. Kirby	

	GEOCHEMISTRY	ECONOMIC, FINANCING AND MARKETING
8:00 am	Introduction Salton Sea Elders, W.A.	
8:25 am	88-041 Fluid Chemistry and Hydrology of the Heber Geothermal System, California Adams, M.C., M.M. Lemieux, J.N. Moore and S.D. Johnson	88-040 Western States' Market for Geothermal Power in the 1980s Sifford, A.
8:50 am	88-065 $^{10}Be-^{9}Be$ in the Salton Sea Geothermal Systems (U.S.A.) Valette-Silver, N.J., F. Tera, M.G. Pavich, J. Klein and R. Middleton	88-056 Economic Effects of Geothermal Development Geyer, J.D.
9:15 am	88-073 Salinity Stabilization for Non-Advecting Brine in a Temperature Gradient with Application to the Salton Sea Geothermal System Michels, D.E.	88-014 Estimating the Cost-Of-Power Impacts of Federal Geothermal R&D Entingh, D.J., R.K. Traeger, S. Petty and B. Livesay
9:40 am	88-018 Delineation of a Brine Interface in the Salton Sea Geothermal Field, California Williams, A.E.	
10:05 am	BREAK	DIRECT USE
10:20 am	88-019 Sulfur and Base Metal Transport in the Salton Sea Geothermal System McKibben, M.S., C.S. Eldridge, A.E. Williams	88-067 Status and Trends of Geothermal Direct Use Projects in the United States Lunis, B.C. and P.J. Lienau
10:45 am	88-072 Probable Occurrence of the Bishop Tuff in the Salton Sea Scientific Drilling Project Borehole, Salton Sea Geothermal System, California Herzing, C.T. and W.A. Elders	88-039 Direct Heat Debuts in Hawaii: The Community Geothermal Technology Program Beck, A.G.
11:10 am	88-025 Geochemical Evidence of a Thermal Component in the Groundwater of the San Juan Londo Valley, Baja California Sur, Mexico Prol-Ledesma, R.M., and A. Ortega	88-058 Absorption Heat Pumps by using Geothermal Energy for a Application to Rural Area Heating Gu, C. and Z. Qi

11:30 am LUNCHEON (Buffet Luncheon Exhibit Area)/POSTER PRESENTATION

GEOLOGY/HYDROLOGY SESSION

2:35 pm

88-061
Exploration for Geothermal Energy Resources at Mt. Spurr, Alaska
Wescott, E.M., D.L. Turner, C.J. Nye, R.J. Motyka and P. Moore´R

3:00 pm

88-035
A Mixing-Cell Model Of The Hydrothermal Flow System, Northern Dixie Valley, Nevada
Karst, G.B., M.E. Campana, and R.L. Jacobson

3:25 pm

88-057
Zunil, Guatemala Geothermal Project (overview and update)
Mink, L., L. Merida and A. Caicedo

3:50 pm

BREAK

4:05 pm

88-011
The La Primavera, Jalisco, Mexico, Geothermal Field
Guiterrez-Negrin, L.C.A.

4:30 pm

88-026
Fluid Inclusion Analysis in Core Samples from the Los Humeros Geothermal Field, Mexico
Prol-Ledesma, R.M., and P.R.L. Browne

4:55 pm

88-047
Hawaiian Program for the Confirmation and Stimulation of Geothermal Resources Development
Olson, H.J.

	GEOPHYSICS	DRILLING TECHNOLOGY
8:00 am	88-053 Design of a Borehole-to-surface Resistivity Survey for the Magma Energy Dept., Exploration Well — LaBrecque, D.	88-051 The Use of BETA-C Titanium for Downhole Production Casing in Geothermal Wells — Love, W., C. Cron and D. Holligan
8:25 am	88-043 Detection of a Target in a Rock Formation Using the Radar Fracture Mapping Tool — Duda, L.E., J.E. Uhl, J. Gabaldon, and H.T. Chang	88-020 Field Cementing Practices Help Control Lost Circulation At The Geysers — Evanoff, J.K., S.W. Dunkle, R.J. Crook
8:50 am	88-028 Induced-Polarization Response of Selected Cascades Core Samples — Tripp, A.C., M.M. LeMieux, P.M. Wright and J.N. Moore	88-024 Cementing Operations on Fenton Hill During FY87, 1 October, 1986 to 30 September, 1987 — Cocks, G.G., D.S. Dreesen, R.L. Root, and P.J. Gill
9:15 am	88-074 Thermal Analysis of The Breitenbush Geothermal System — Blackwell, D.D. and S.L. Baker	88-054 Innovative Technique for Abandoning Geothermal Wells at the Geyser, Northern California — Emslie, R.A.
9:40 am	88-015 Analysis of Heat Flow and Groundwater Flow in the South Dakota Geothermal Anomaly — Gosnold, W.D., Jr.	88-052 Research Coring in the Cascades a Status Report — Lemieux, M.M., P.H. Wright and J.N. Moore
10:05 am	BREAK	ENVIRONMENTAL ASPECTS
10:20 am	88-070 Coldwater Creek Automated Microseismic Systems, The Geysers, CA — Ziagos, J. and J. Combs	99-029 The Lake County Geothermal Resource and Transmission Element — Hinds, A., and M. Dellinger
10:45 am	88-075 Analysis of P- and S-Wave VSP Data from the Salton Sea Drilling Project — Daley, T.M., T.V. McEvily and E.L. Majer	88-003 Ecological Aspects of Cerro Prieto Geothermal Field — Mercado, S. and F.J. Bermejo
11:10 am	88-027 Application of Borehole Breakouts to Geothermal Exploration and Development; and Example from Cove Fort-Sulphurdale, Utah — Nielson, D.L., and M. Lee Allison	88-005 Stabilization of Geothermal Residues by Encapsulation in Portland cememnt-Based Composites — Webster, R.P. and L.E. Kukacka
11:30 am	88-023 Televiewer Measurement of In-Situ Stress Direction At The Fenton Hill Hot Dry Rock Site, New Mexico — Burns, K.	88-021 Some Aspects of Geothermal Water Treatment Biotechnology — Premuzic, E.T., and Mow Lin

12:00 noon OPTIONAL LUNCHEON AWARDS AND BUSINESS MEETING

	RESERVOIR TECHNOLOGY	LEGAL AND INSTITUTIONAL ASPECTS
1:30 pm	88-046 Determination of Fracture Aperture - A Multi-Tracer Approach Fox, C.E., and R.N. Horne	Fenning, A.
1:55 pm	88-009 Inflow Performance Relationships for Geopressured Geothermal Wells Chu, M.H.	Olpin, O.
2:20 pm	88-008 Preproduction Simulation of Thermal Decline at La Primavera First 5-MW Wellhead Units Kruger, P., A. Aragon, R. Maciel, C. Lucio and J. Villa	Lamson, J.
2:45 pm	88-031 Reservoir Design for a Site-Specific Commercial Hot Dry Rock Geothermal Prospect Tosaya, C., A. Findikakis, and F. Cochrane	88-017 Cultural Resource Law and Permitting Transmission & Pipelines Orser, L.L.
3:10 pm	88-010 Behavior of an Artifical Reservoir Created in a Formation with a Natural Fracture Network for HDR Geothermal Heat Extraction Hayashi, K., K. Kumazawa and H. Abe	Knapp, G.

1988 ANNUAL MEETING POSTER PRESENTATIONS

88-001 Gu, C. and C. Lu
Thermodynamic Principles of Total Flow Power Production from Hot-Water Geothermal Resources

88-006 Hernandez,-Galan, J.I.
Graphic representation of Geothermal Apparatus

88-015 Gosnold, W.D.
Analysis of Heat Flow and Groundwater Flow in the South Dakota Geothermal Anomaly

88-023 Burns, K.
Televiewer Measurement of In-Situ Stress Direction at the Fenton Hill Hot Dry Rock Site, New Mexico

88-055 Nonokuchi, M.
Geothermal Development Promotion Survey of Akuaizu Area

88-057 Mink, L., L. Merida and A. Caicedo
Zunil, Guatemala Geothermal Project (overview and update)

88-068 Davarzani, J. and M. Sloan
Simultaneious TPS Logging System

88-069 Cowan, C.J.
A Decade of Geothermal Development in Nevada 1978-1988

88-071 Ripperada, M. and G.S. Bodvarsson
A Database for The Geysers Geothermal Field

ESL-88012-JP

RESEARCH CORING IN THE CASCADES
A STATUS REPORT

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

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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 location of these holes.

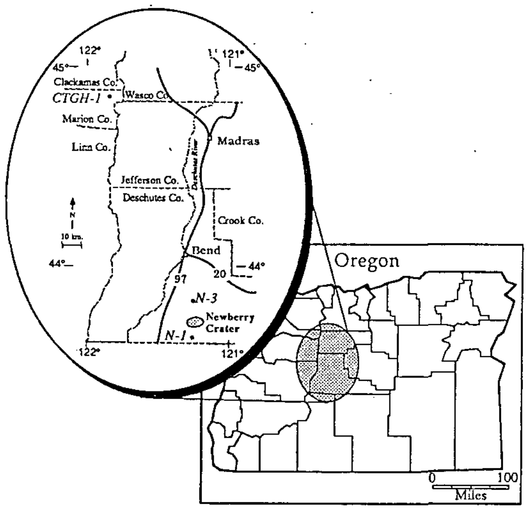


Figure 1. Location map of core holes.

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 continue drilling.

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

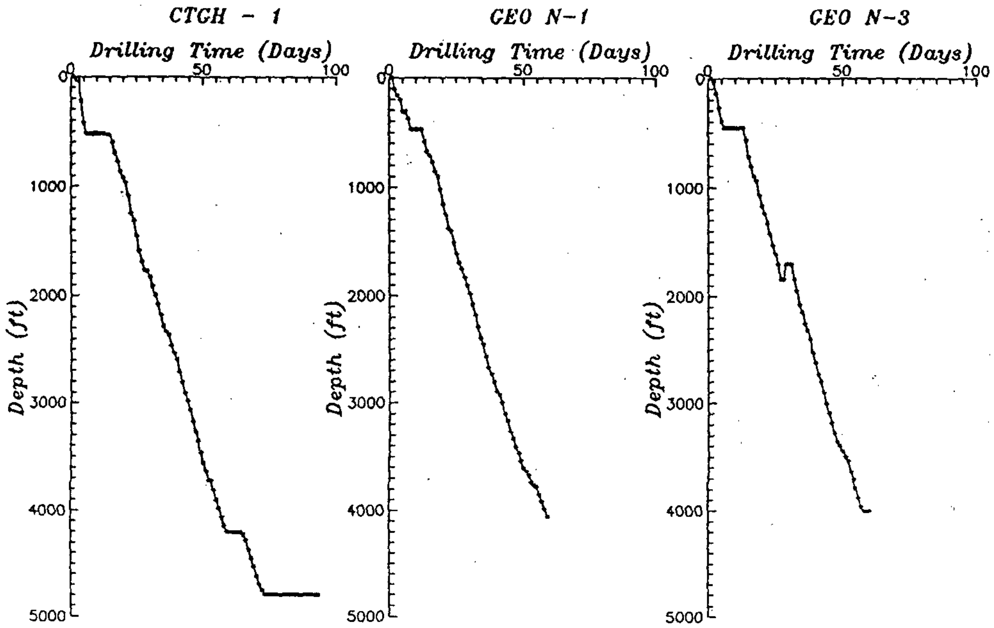
Depth penetration profiles are shown in Figure 2 for the three holes. The overall daily penetration rate for CTGH-1 was 88 feet/day. For GEO N-1, the overall daily penetration rate to 4,000 feet was 69 feet/day. Finally, for GEO N-3, the overall penetration rate was 68 feet/day. According to Thermal 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, refer



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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 =	$456,456/4,800 ft
=	$95/ft

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	$23,500
WIRELINE CORING	$233,776	$265,644
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 occurred in

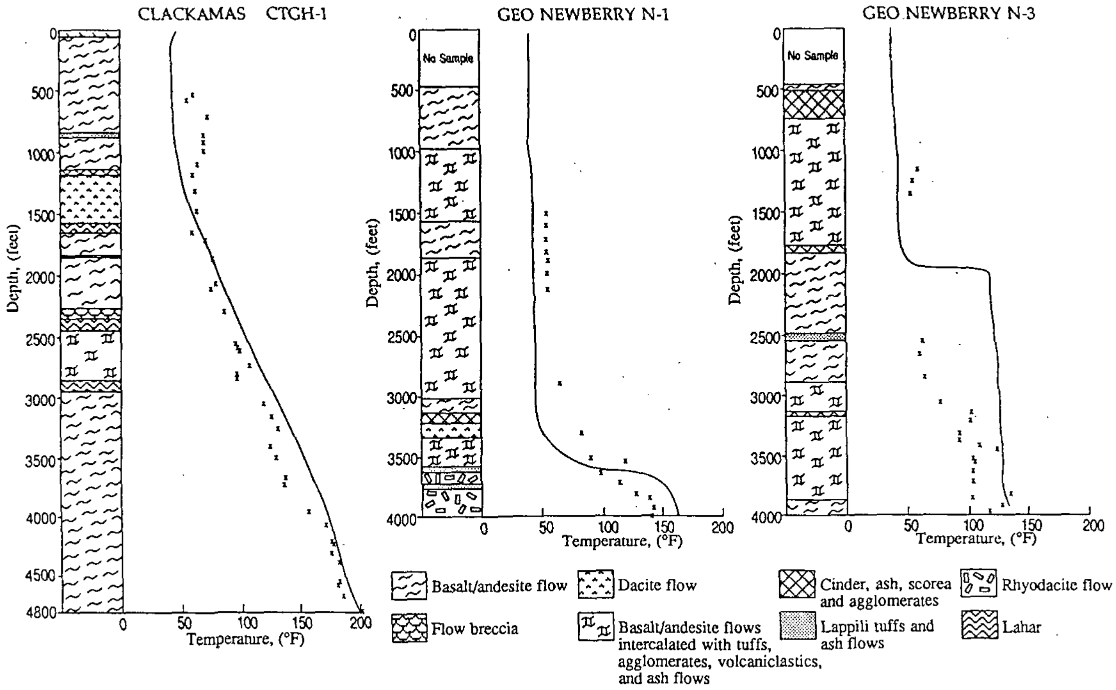

Figure 3. Generalized lithologic columns and temperature-depth profiles for CTGH-1, GEO N-1, and GEO N-3. Temperature-depth curves based on Blackwell and Steele (1987); MRT data, shown by "x"s, from open file reports. CTGH-1 and GEO N-1 lithologic columns modified from Sibbett, unpublished data.

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, appears to reflect intra-hole fluid flow (Blackwell and Steele, 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 had 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 at 1,600 feet in CTGH-1.

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	--	--

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 1,400 feet, with a temperature at TD of $107^{\circ}C$ ($225^{\circ}F$) (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 that acquired on the other holes drilled 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 - 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.

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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.

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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.

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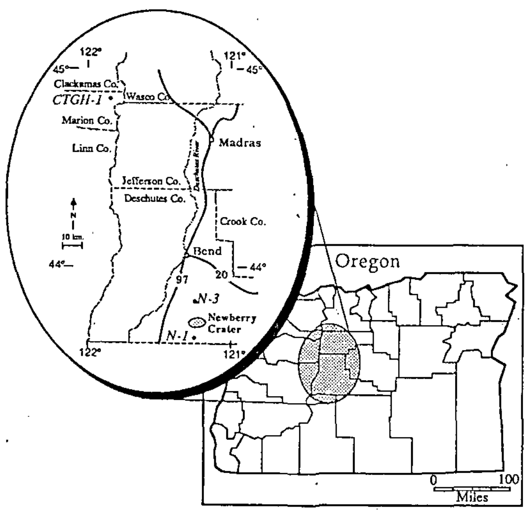

Figure 1. Location map of core holes.

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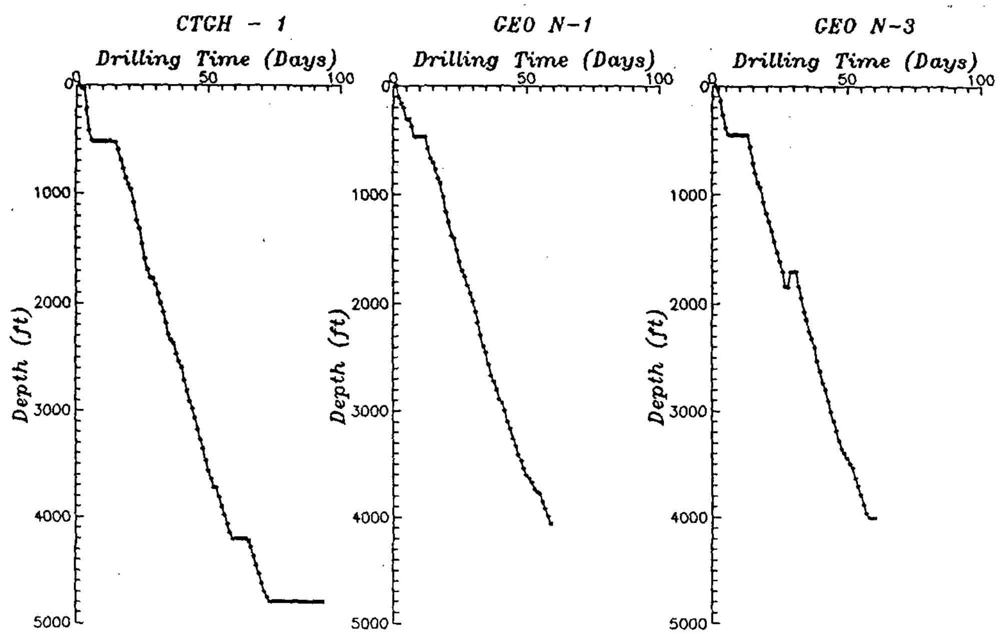

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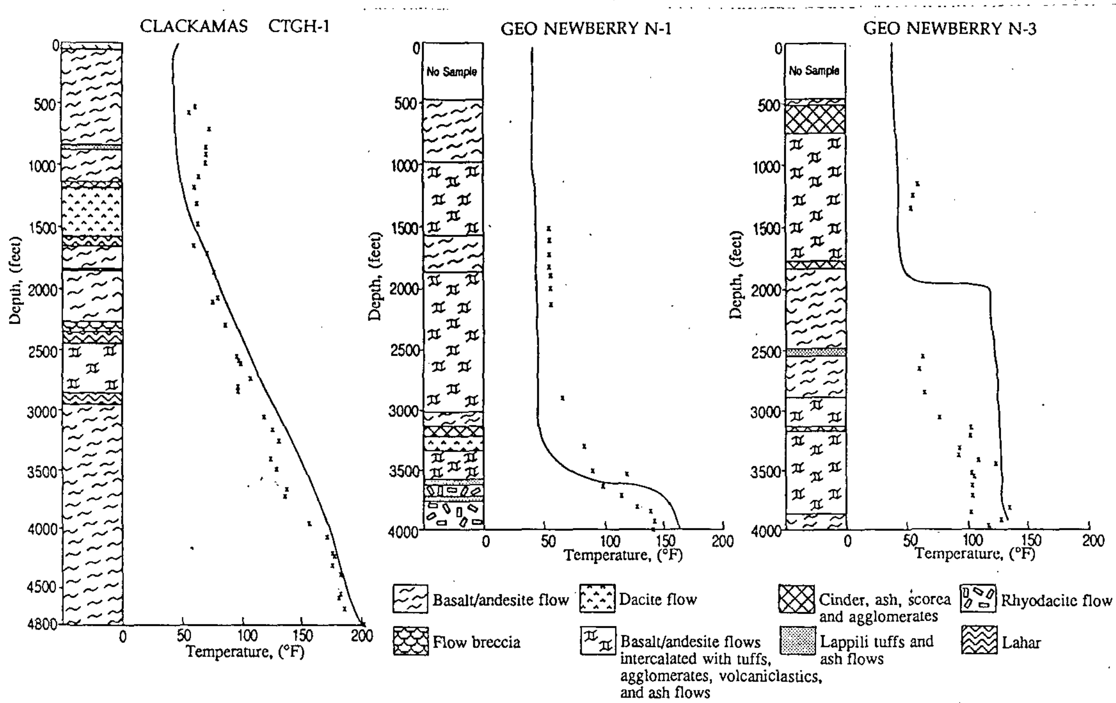

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the drilling of GEO N-3 that was not present in GEO N-1 and CTGH-1.

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, appears *to reflect intra-hole fluid flow* (Blackwell and Steele, 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 had 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 at 1,600 feet in CTGH-1.

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	--	--

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 1,400 feet, with a temperature at TD of 107°C (225°F) (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 that acquired on the other holes drilled 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 - 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.

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