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CLACKAMAS THERMAL POWER HOLE CTGH-1

Drilling History

by

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The Clackamas hole is located in the western part of the high Cascade graben in Sec. 28, T8S, R8E, near Detroit, Oregon. The hole was spudded on June 7 and completed on September 7, 1986. Out of 80 days of operation, 59 days were spent actually drilling, and 21 days involved rigging up, installing the BOP setting casing, technical problems, logging the hole and rigging down. During August, drilling was suspended for 13 days, (not included in the above figures) due to forest fire danger.

In general, the drilling of the Clackamas thermal gradient hole progressed smoothly with excellent core recovery. Drilling averaged 81 feet per day (not including days lost for technical problems). The overall drilling rate (including days lost for technical problems) is 66 feet per day. Two significant lost-time problems occurred. The first was failure of the BOP to pass initial tests due to a faulty flange. This problem cost 3 days of time and could have been avoided by pre-assembly and test of the BOP by the supplier, prior to delivery to the drill site.

The second problem was parting of the HX drilling pipe. This was probably caused by a combination of metal fatigue and drag or torque forces in the drill string. Quality inspections of the drill pipe connections during trips out of the hole may have prevented the failure. In any drilling operation, failure of pipe connections is always a possibility, however. Of the five down days resulting from the HX rod failure, about three were lost while waiting on the NX rods to be transported to the site. Loss of these three days could have been prevented by having NX rods on site beforehand as a precaution. However, this would have incurred additional mobilization cost unnecessarily if the NX had not been needed.

Continual total drilling fluid loss while coring greatly increased the cost of the mud program and may have contributed to problems such as sanding-in the core barrel and parting of the HX rods due to poor hole cleaning. Only minor efforts were made to regain circulation. Lost circulation is a typical problem when drilling volcanic rocks, especially basalt flows. Core drills have very limited ability to control lost circulation because of their small mud system and low pump rate. A limiting factor is that the close tolerance of the rods in the hole does not allow use of coarse matting lost circulation materials (LCM) while drilling. However, the cost of the large volumes of LCM and mud, and rig time that would be required to try to cure lost

circulation could equal the cost of continual mud loss without ensuring success.

A brief summary of the events, problems and cost of each segment of CTGH-1 is given in Appendix I, and a daily list of depth and events during drilling is given in Appendix II. Figures provided by Thermal Power Company of casing completion and the casing head assembly are provided in Appendix III. A tabular presentation of costs and ~~average penetration rates~~ are given in Appendix IV.

APPENDIX I

CTGH-1 Drilling History - Summary

June 7 - 13

Tricone drilled to 517 ft., set 35<sup>PL</sup> of 10 3/8 in. conductor in 12 1/4 in. hole. Set 519 ft. of 7 in. K-55 BT & C, 26 lb. casing in 8 3/4 in. hole and cemented with 181 cu. ft. of cement mix (see Daily Activities).

~~The~~ <sup>There were three</sup> main problems: ~~were~~ getting the conductor set into the 40 ft. of glacial boulders in till; some lost circulation in the basalts (which was overcome); and having the 7 in. casing hung up ~~some~~ in the basalt flows. {The 8 3/4 in. bit cut 482 ft. of hole.}

↓ next paragraph

Costs to this point were \$49,390, including a mobilization cost of \$14,505. Drilling cost averaged about \$67 per ft. (this figure does not include mobilization cost). Costs and drilling time were controlled more by hole problems and setting casing than penetration rate.

June 14-19

Nippled up BOP and rigged up for coring. The first test of the BOP failed due to a flange leak, requiring a new flange. Costs for this phase of the project were \$18,733, equipment not included.

June 20-  
Aug 18

Cored 4283 ft. to a depth of 4800 ft. Circulation was lost at 540 ft. and never regained while drilling with HX rods to 4203 ft., although LCM efforts brought the water level to within 20 ft. of the surface. Most of the time the static water level was at a depth of about 70 ft.. Core recovery was virtually 100% for the entire hole.

The penetration rate averaged 71 feet per day. If technical delays are not included, penetration averaged 80 feet per day. The cost for this section of the hole was \$317,140 or \$74/ft. The total cost to this point was \$385,263. Six HX core bits cut an average of 600 ft. each, although individual performance was highly variable. For example, <sup>while</sup> one bit cut 1385 ft., ~~but~~ the first <sup>HX</sup> bit run cut only 61 ft. and was not used for the average above. The short 61 ft. run is probably due to non-lithology factors such as driller <sup>ft.s?</sup> error, junk in the hole after drilling out the casing shoe or a defective bit. <sup>too much space</sup> ~~Note~~ Also that the first NX bit run cut only 23 ft. due to milling out the HX bit left in the hole. ↓ The  
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second NX bit cut 574 ft. to T.D. A total of 9 core bits was used.

While drilling the main section of the hole, 10 non-drilling days resulted from technical or equipment problems. ~~These problems were as follows:~~ <sup>such as the</sup> core barrel jammed in defective rods or sanded in; parted wireline; and the biggest lost-time problem, broken or twisted off drill pipe. The first time the rods broke while drilling at a depth of 527 feet with a 6 in. tricone bit. Drill pipe failure was probably due to a combination of stresses from the 6 in. bit and the HX rods "whipping" around in the 7 in. casing. After the bit and lost drill pipe were fished out, 4.5 in. core guide casing was set to 527 feet. Once the casing was in place, coring continued to 4203 feet with only minor problems.

The second twist off of the HX drill pipe occurred at a depth of 4203 <sup>(ft)</sup> and may have been caused by general metal fatigue and friction drag in the hole. It was decided at this time that it would be best to switch to NX drill pipe, rather than attempt fishing out the HX. Six days were lost waiting on the NX drill pipe to arrive and retrieving the HX core barrel.

Aug. 19 -  
Sept 7

The final T.D. of the hole was determined when the U.S. Forest Service shut down all operations in the area due to extreme fire danger. After the shut down, the hole was conditioned for logging, then geophysical logs were run. Then the drilling company rigged down and moved off site. The discouraging results of a temperature survey run on August 27th (~~Table II~~), nine days after drilling ceased, led to the decision not to drill any deeper. All of the HX drill pipe was left in the hole. ~~The costs of logging and rigging down were \$121,578.~~ The total project costs were \$438,718.

456,506

APPENDIX II

Daily Drilling Activities

Thermal Power CTGH-1

<u>Date</u> <u>Day/Mo.</u>	<u>Footage</u> <u>Drilled</u>	<u>Depth</u>	<u>Activity</u> ↓
7 June	35'		12 1/4 in. bit - Spud, used air hammer 12-35 ft. in boulders. 10 3/4 in. conductor hung up at 12 ft.
8 June	35	35'	Moved rig 6 ft.-12 1/4 bit to 35 ft. Conductor hung up at 28 ft.-54 ft., vis mud
9 June	0 <del>35'</del>	↑ 35'	Cleaned hole <sup>lower case</sup> to 35 ft., set 35 ft. 10 3/8 in. Conductor and cemented with 32 sacks cement, 3% CaCl.
10 June	185 <del>220'</del> → 220'		8 3/4 in. bit, 6 in. D.C. Drilled to 220 ft., deviation 1/2° at 160 in.
11 June	200 <del>420'</del> → 420'		61 vis mud, 9.2 wt; 400-410 L.C. 50% 1000 gal.
12 June	97 <del>517'</del> →		70 vis, 8.8 wt. Lost 60 bbl at 425 ft., Geophy log 517-35 ft.
13 June	0 <del>517'</del> →		Problems setting 7 in. casing to 488 ft., 127 ft <sup>3</sup> G cement 1:1 perlite + 40% silica flour, plus 32 ft <sup>3</sup> tail slurry. Good returns.
14 June	0 <del>517'</del> →		Top job cement, 4 bbl class G 1:1 perlite, cut off 7 in. casing, dug cellar.
15 June	0 <del>517'</del> →		Nippled up casing head and BOP.
16 June	0 <del>517'</del> →		Nippled up BOP, test <sup>ed</sup> found leak, ordered new flange.
17 June	0 <del>517'</del> →		Worked on 8 5/8 in. X 6 in. flange.
18 June	0 <del>517'</del> →		Installed new flange, tested BOP and approved.
19 June	0 <del>517'</del> →		Rig <sup>ged</sup> up and align <sup>ed</sup> core rig.

Date	Footage/ Drilled	Depth	Activity
20 June	10	527'	6 in. tricone bit, drilled out cement, lost bit and 4.5 in. joint on bottom.
21 June	0	527' →	Pulled fish out with Bowen overshot, set 4.5 in. core guide casing with 11 stabilizer.
22 June	70'	597'	Started coring with 3.937 in., HX rods, lost circulation at 530 ft., bit cut 61 ft.
23 June	971'	694'	Cored with no fluid returns, -30 GPM mud in. 45 vis.
24 June	801'	774'	Cored, no fluid returns, tried LCM but no results.
25 June	85'	859'	Replaced bit at 859 ft. it cut 271 ft.
26 June	59	918' →	Cored, ran in hole with new bit, mud 45 vis.
27 June	44	962' →	POH, to grease rods, then sanded in core barrel and POH again.
28 June	121	1083' →	Cored, no fluid returns, greased rods.
29 June	162	1245' →	100% core recovery, no fluid returns.
30 June	71	1316' →	Replaced bit (412 ft. cut) at 1271 ft. depth.
1 July	137	1453' →	Cored, no fluid returns, 100 % core, water level in hole 45 ft.
2 July	137	1590' →	Cored.
3 July	100	1690' →	Cored.
4 July	75	1765' →	Cored.
5 July	10	1775' →	POH, replaced bit, RIH, 560 ft.-963 ft. interval partially blocked.
6 July	53	1828' →	POH to service coring assembly, bridge at 660 ft. when re-entering hole.

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correct

<u>Date</u>	<u>Footage/ Drilled</u>	<u>Depth</u>	<u>Activity</u>
7 July	89-1917		Cored.
8 July	81-1998		Cored.
9 July	85 <sup>1</sup> / <sub>A</sub> 2083		Cored.
10 July	98-2181		100% core recovery, no fluid returns.
11 July	105-2286		Cored, mud was 45 vis.
12 July	50-2336		Wireline parted, POH, fixed line, RIH with new bit.
13 July	32-2368		Washed from 1000 ft.-2336 ft.
14 July	98-2466		Cored.
15 July	69-2535		Core barrel jammed in rods at 500 ft., POH, bad joint of core tubing, bridge at 1776 ft.
16 July	59-2594		Core barrel jammed in rods again, at 400 ft. bad joint of tubing
17 July	114-2708		Cored.
18 July	101-2809		100% core recovery, no fluid returns.
19 July	103-2912		Cored.
20 July	68-2980		Cored.
21 July	89-3069		Cored.
22 July	104-3173		Cored, water level 80 ft. in hole.
23 July	96-3269		Cored.
24 July	86-3355		Cored.
25 July	106-3461		Cored.
26 July	101-3562		Cored, water level up to 70 ft.
27 July	79-3641		Cored.
28 July	80-3721		Cored.

<u>Date</u>	<u>Footage/ Depth</u>	<u>Drilled</u>	<u>Activity</u>
29 July	2-3723		POH put on new bit, core barrel latch and reamer shell.
30 July	88-3811		Cored.
31 July	90-3901		Cored with HX bit.
1 Aug	81-3982		Cored.
2 Aug	80-4062		Cored.
3 Aug	81-4143		Cored.
4 Aug	60-4203		Cored, HX drilling rods broke in the hole at 823 ft.
5 Aug	0-4203		Waited on NX rods.
6 Aug	0-4203	4203'	Waited on NX rods.
7 Aug	0-4203	4203	Nx rods arrived, RIH to locate break at 823 ft.
8 Aug	0-4203		Ran latching assembly on NCC rods to pull HX core barrel, POH without core barrel.
9 Aug	0-4203		Modified latching assembly, RIH, POH with core barrel.
10 Aug	23-4226		Milled through lost HX bit with new NX bit, cored 23 ft. then POH for new bit.
11 Aug	53-4279'		Cored with NX bit.
12 Aug	92-4371'		Cored.
13 Aug	79-4450		Cored, torque increased at 4405 ft.
14 Aug	80-4530		Cored.
15 Aug	90-4620		Cored.
16 Aug	80-4700		Cored.
17 Aug	60-4760		Cored-Temp. survey, recovered and repaired broken wireline.
18 Aug	40-4800'	TD →	Shut down by Forest Service due to dry forest condition.



Date	Footage/		Activity
	Drilled	Depth	
27 Aug	0	4800	Temperature-pressure survey ran.
2 Sept	0	4900	Crew moved on site and run NX rods to bottom.
3 Sept	0	4800	Conditioned hole for loggers.
4 Sept	0	4800	Geophysical logs ran.
5 Sept	0	4800	Completed logging, shipped core to UURI.
6 Sept	0	4800	Rigged down.
7 Sept	<del>4800</del> TD	4800 TD	Finished rigging down. Drilling costs to date: <del>\$438,718.</del> \$456,506

APPENDIX III

Well Completion Diagrams

Table 2. ~~Itemization of CTGH-1 Expenditure.~~

Appendix III

<u>Item</u>	<u>Total Cost (\$)</u>
Road, site and location	11,544.39
Rig Mob./Demob.	10,000.00
Rig	296,807.04
Trucking & hauling	3,889.84
Drill site geologists	26,560.00
Mud & chemicals	24,618.32
Cement materials	9,140.65
Geophysical logging	10,031.91
Drill bits & tools	23,492.83
Outside labor	1,423.85
Other evaluation	6,954.20
Other	14,125.20
Conductor casing	418.80
Surface casing	10,588.64
Wellhead equipment	2,589.46
Camp & catering	4,270.89
TOTAL	\$456,506.02

note about reference

APPENDIX IV

CTGH-1 Cost and Penetration Rates

	Rotary 6/7-6/13	BOPE/Casing 6/14-6/19	Coring 6/20-8/18	Logging/ Derigging 9/2-9/7	Overall
Cost per Phase	\$34,885	\$18,773	\$317,140	\$121,578	<del>456,506</del>
<del>Cummul.</del> Cummul. Cost	\$49,390	\$68,123	\$385,263	\$438,718	<del>\$437,718</del>
Drilling Rate (including delays)	86.1 ft/d	---	71 ft/d	---	66 ft/d**
Drilling Rate *** (excluding delays)	129.3 ft/d	---	80 ft/d	---	81 ft/d
Cost/ft (includes delays; does not include mobilization logging, or derigging)	\$67/ft	---	\$74/ft	---	<del>\$86.5/ft**</del> \$95

- \* Includes mobilization cost of \$14505.
- \*\* Includes time spent setting up BOPE and cementing casing.
- \*\*\* Does not include any other time than days actually drilling.

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