

SANTIAM PASS 77-24 DRILLING REPORT

by

Dick Benoit

Oxbow Power Corporation

September 26, 1990

Well 77-24 was drilled in two phases. Woytek Drilling Company drilled and cased (with 4" I.D. pipe) the top 460' with a rotary rig between October 31 and November 8, 1989. Drilling was done with foam and proceeded without significant problems, generally making about 100'/day after the 36' of 10 3/4" surface pipe was set. Upon completion of drilling circulation with mud was gained and there was surprisingly little in the way of mud losses. A good cement job was obtained with a top job needed to get the cement up from about 30' down the well to within 10' of the surface. The total cost of this operation was \$29,710. A more detailed memo of this operation dated November 10, 1989 is attached to this report.

The coring operation was conducted by Tonto Drilling Company between August 10 and September 17, 1990.

The move in and rig up commenced on the morning of August 10 and were completed with successful testing of the BOP stack late in the afternoon of August 13. The only problem with the move in was the refusal of the truckers to deliver the loads to the site. Instead we had to unload the trucks at some distance from the site and transfer the loads to a different truck to get them to the site. This resulted in increased crane and boom truck rental costs and cost several hours of additional time. During the cementing operations with the rotary rig cement flowed back into the casing and it was necessary to drill out cement from about 250' to 460'. This, mixing mud, tripping rods, and an additional BOP test required most of a day. Actual coring began at 10:30 pm on Tuesday August 14.

The coring proceeded smoothly with only one significant breakdown for a broken hydraulic line. The hole reached its total depth of 3046' in the mid morning of September 13. Thus 2586' of hole was cored in a total of 28 1/2 days giving an overall average penetration rate of 90.7 ft/day. The penetration rate remained relatively constant. This is a function of improved bit selection as the hole progressed. In fact the last bit used was a Hudy "blue" which made 1501' of hole and was still capable of additional drilling. A total of four bits and two reaming shells were used in drilling. Also one HQ rod shoe was used in running the completion tubing. There were intermittent mud returns only for the first few days so most of the coring was done with lost circulation.

The completion and moveout had a few glitches. The first was that the completion tubing was mistakenly sent to Oxbow, Oregon by the trucking company. It arrived on site a day later than expected but only caused a delay of a few hours. The trucks contracted to move the rig and associated equipment arrived about 6 hours later than expected and requested. Lastly a sub failed while stripping the HQ rods out over the completion tubing. This resulted in approximately 3000' of HQ rods falling about 50' to the bottom of the hole. This did break three teeth off the HQ rod shoe. The hole was completed by running 2" ID schedule 40 A 53 F black pipe with a plug in the bottom to the bottom of the hole. Once on bottom the tubing was filled to the surface with water and appeared to be holding water well with only a 12" decline in water level during the first day. The 2" pipe was not hung. The drilling was terminated on the morning of September 13 and the rig was off location by 9 pm September 17. The site was cleaned on Sept. 18.

All bills for the hole have not yet been received or processed but the following gives a preliminary idea of the costs associated with drilling this hole. Few of these numbers are absolutely final. There may be some small mud and grease credits.

Rotary Drilling in 1989	\$ 29,710
Mobilization and Demobilization (Tonto)	\$ 6,510
Substructure rental	\$ 3,325
Rotating head rental	\$ 1,330
Water truck rental	\$ 2,280
Water truck mileage	\$ 1,100
Rig hours	\$ 83,400
Extra labor	\$ 14,383
Bits and reamers	\$ 4,897
Footage charges	\$ 38,299
Rod grease	\$ 1,105
Core boxes	\$ 965
H2S equipment	\$ 1,535
Mud (not including left over from rotary)	\$ 8,181
Welding	\$ 600
Crane Service for move in	\$ 3,500
Dirt work	\$ 700
Misc (thermometers, UPS, plastic, etc)	\$ 330
High Country Disposal	\$ 300
Phone	\$ 700
2" black pipe	\$ 4416
Shipping mud	\$ 140
BOP	\$ 15,464
Travel charges for temperature logging	\$ 800
Preliminary Total	\$ 223,970

A final and accurate accounting will be provided within the next two months.

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October 12, 1990

Mr W.R. Benoit
Oxbow Geothermal Corp.
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Reno, Nevada 89501

OXBOW GEOTHERMAL CORP



Dear Dick:

Enclosed are copies of the logs for the Santiam Pass well. I have enclosed a floppy disk with the results included as well for your use. We ran a caliper log over a depth range of 105 to 230 m and about 400 to 929 m. The segment between 400 and 840 m seems to have disappeared, however. There were no enlargements of the hole over 3.95 inches within the missing interval so no really useful data was lost. We ran a natural gamma ray log in the tubing after the hole was complete from the surface to 921 m. There is some character to the log and I suspect that there will be a correlation with the geology when Britt gets a summary log done. We ran temperature logs from the surface to 920 m (9/19/90) and to 929 m (9/27/90). The bottom stands of pipe must have leaked mud as we had great difficulty getting the tools to go below 920 meters and on the 9/27/90 log the temperature equilibration of the tool in the bottom of the hole was anomalously slow. We ran a sonic log in the hole between 400 and 929 m, but as you know we had trouble getting the tool to pick the velocities properly. We recorded the waveforms on videotape and will work with the tape to try to pick some typical velocities for the hole using the videotape.

Between the two temperature logs the temperatures in the upper part of the hole cooled about 1 to 1.5 °C with the exception of the depth range 160 to 180 m and below 910 m. This is the response of the well the drilling disturbance. The shallow zone that shows little drilling effect must be a zone of active groundwater flow and the flow of the water past the hole has caused the hole to recover more rapidly than the areas of the hole not so effected. When the recovery is complete the temperatures in the groundwater zone will probably be about the 3°C now characteristic of the 170 m zone. The volume and rapidity of the flow is emphasized by the fact that we presumably lost most of the drilling fluid into this zone with virtually no temperature effect.

The results are disappointing because the temperatures are so low. The worst thing though is the downflow that effects most of the interesting part of the hole. As best I can tell the flow enters the hole at above 350 m (perhaps as shallow as 160 m) and exits the hole between 900 and 905 m. The best evidence of the undisturbed temperatures in the well are the BHT's measured during the drilling. These are shown on one of the plots. These imply that the gradient in the hole might be on the order of 15°C/km between 160 and 750 m, about 60°C/km between 750 and 850 m, and about 100 to 120°C/km at the bottom of the hole. The 50°C/km gradient is slightly below regional for the area while the gradient of 120°C/km is about 50 to 100% high. We will rework these BHT's to get the most accurate numbers possible during the next few weeks.

The average gradient in the depth range 900 to 920 m is $120^{\circ}\text{C}/\text{km}$. The minimum gradient in the bottom third of the hole is $50^{\circ}\text{C}/\text{km}$. The high gradient in the bottom zone may or may not be the best to use in further extrapolation to depth. Two examples to illustrate possible interpretations are shown in a separate figure based on two other holes on the Cascades. One hole is from the Mt Hood area (USGS-PUC) and one hole is about 25 km northwest of the Santiam Pass hole (EWEB-2). In the EWEB-2 hole (elevation 3920 ft) the regional gradient of $65^{\circ}\text{C}/\text{km}$ starts immediately below the groundwater effect at 250 m. In the USGS-PUC hole the regional gradient is reached at about 400 m, below about 200 m of higher-than-regional gradient.

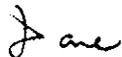
The nearest hole to the Santiam Pass well is about 12 km to the west at the EWEB-CL site near Fish Lake (elevation 3200 ft, the Santiam pass hole is at 4800 ft so the difference is about 600 m, see the enclosed map). The temperature-depth data are plotted with the Santiam Pass data for comparison. Both wells appear to be in areas of recharge as the temperatures are below normal and the gradients are mostly below normal (unless the bottom part of the Santiam Pass well is a measure of the true geothermal gradient there. The high temperatures at 200 m in EWEB-CL (28°C) are evidence of some flow of warm water from as yet unlocated direction.

If you want additional plots, data, or have questions let me know. Interpretation is our goal in the next couple of months as we continue to work on the data sets, measure thermal conductivity, etc. We'll keep you informed of the results.

I've enclosed a copy of a photo of the Three Sisters, you happen to be in the foreground. If you're interested in a blowup let me know.

I've also enclosed an invoice for the extra log. I think that it was a good thing that we did it, I'm not sure that there'll be anything left to measure of the original temperatures next spring! At least we know for sure the gradient in the bottom of the hole.

Sincerely yours,



David D. Blackwell
Hamilton Professor of Geophysics