



d.b.a. COLORADO WELL LOGGING

1019-8th ST., SUITE 308 • GOLDEN, CO 80401 • (303) 279-0171 • TELEX: 45-0286

June 23, 1986

Mr. Joe Iovenitti
Thermal Power Co.
Suite 120
3333 Mendocino Avenue
Santa Rosa, CA 95401

Re: Borehole Geophysical Logging for Clackamas Geothermal Well-
Shallow Logging Run.

Dear Joe,

The following letter serves as a report on the shallow logging run for Thermal Power's Clackamas Geothermal Well recorded June 13th, 1986.

The Clackamas Geothermal Well was drilled to 517 feet at 8 3/4 inches and was then logged before running 7" casing and beginning core drilling. The logging suite consisted of Temperature, Fluid Resistivity, Gamma, Guard Resistivity, Dual G-G Density, Caliper, 16-64" (short and long) Normal Resistivity, Spontaneous Potential, and Deviation. Drilling was completed June 12th, 1986 and the well had not been circulated for 14.5 hours prior to logging.

The initial logging run consisted of Temperature and Fluid Resistivity. This probe was recorded from the surface (measured at ground level) downward. The temperature log was recorded at a very sensitive scale - 2.0 degrees Kelvin full scale (273 degrees Kelvin = zero degrees Celcius) to help identify near surface hydrologic effects. Depth was set to the temperature log, the fluid resistivity log was offset slightly due to recorder pen configuration. Key points on the temperature log include overall cooling with depth - the bottom hole temperature was 282 degrees Kelvin (9 degrees C, 48 degrees F) versus a fluid temperature at 18 feet (fluid level) of 289 degrees Kelvin. There was a major cooling zone, 3 degrees K, at 130-135 feet. This is indicative of a significant fracture zone. The temperature gradient from 30 to 126 feet and 444 to 490 feet are nearly the same - rapid cooling with depth. The zone from 126 to 355 feet shows significant temperature changes foot by foot, including the zone at 130-135 discussed earlier and a zone from 200-298 which warmed slightly.

The fluid resistivity was approximately 19-20 ohm-M except for the zone at 130 feet in which the fluid resistivity increased to 23 ohm-M. This indicates that this zone was making fresh water.

The second logging run in the well recorded Spontaneous Potential and 16-64" normal resistivity. The depth was set with respect to the 16" normal resistivity log and the other logs were offset slightly due to recorder pen configuration. The initial logging run showed resistivities from 300 to 7000 ohm-M. The log appears to have some high frequency noise superimposed on top of the log response. This noise is a result of the very high resistivity scale used. The SP log also showed what appeared to be noise. The SP and 16-64" logs were repeated to verify the data. The SP log was repeated with a different probe, module, and surface electrode. Therefore, I have a high degree of confidence that the log is valid. Considering that the fresh water (low TDS) used was also the same type of water encountered in the borehole and the unaltered andesitic formations drilled, this SP response is not unusual.

With the rerun of the SP log, a single point resistance log was attempted. However, the formation resistivity was too high and this log could not be recorded. It has a maximum full scale of 1000 ohms with up to 1000 ohms displacement.

A deviation survey was recorded with the rerun of the SP log. This log was run at this time because the deviation can not accurately be made through steel casing. Steel casing has an artificial magnetic field that distorts apparent tool orientation. Digital inclination and orientation readings were made every 10 feet. The borehole was near vertical at the top of the well and from 290-430 feet. There was a small (up to 1.5 degree) inclination to the north from 80-290 feet and an inclination to the south below 430 feet. The bottom 20 feet are inclined up to 2.6 degrees. A magnetic declination of minus 20 degrees East was used for the deviation survey.

The next logging run recorded gamma ray and guard resistivity both digitally and analog. The gamma log was uneventful and repeatable. The gamma log was also the basis for depth calculation. The guard resistivity log showed the same basic signatures as the normal resistivity log but at much lower resistivity values. This is a result of tool design. Highly resistive formations require more power to focus the current at depth. In this case, the tool was seeing very shallow effects of the borehole wall. It is valuable to more accurately pick bed boundaries, but doesn't approximate formation resistivity.

The last logging run recorded dual G-G density and caliper. This log was also simultaneously recorded in both digital and analog format. There was a mistake in recording the analog caliper calibration initially, but was detected during logging and upon post-logging calibration. A repeat section was made and the calibration repeated. The digital data was not effected by this mistake. The only effect of this is that the caliper log doesn't fall exactly on even lines; e.g. 4" is not on the 4th line of the paper.




The dual density data shows lower density (higher apparent porosity) to the right. The depth was set to the long spaced G-G detector. On the analog, the short (near) spaced G-G log is offset downward because of recorder pen configuration. The short spaced G-G log also goes off scale frequently on the analog. It was recorded only to help correlate formation breaks and validate the long density log. It should be noted that the lower density zones were frequently associated with small washouts and significant borehole rugosity.

The following steps will be made to this data for the final report:

1. Attempt to correct the normal resistivity data for borehole fluid resistivity and better approximate formation resistivity.
2. Digitize the analog data not recorded digitally in the field. Replot this data corrected for probe offset.
3. Compensate the dual density data.
4. Make a plan and profile view plot of the deviation data.
5. Integrate this log data with data from the next logging phases.

It is anticipated that most of the processing of this data will be done shortly. I am forwarding several copies of the final analog prints recorded in the field. I will also forward copies of the initial processed logs. If you have any questions about this letter or the data, please call.

Sincerely,



Robert E. Crowder
President

thermall.rep

To: J. Iovewith
From: D. GOODWIN/A. MCDANNEL

Re: Summary of Field Operations for CTGH-1 Shallow Logging Run

Geophysical borehole surveys were run in CTGH-1 on the morning of June 13, 1986. Surveys were performed by Colorado Well Logging employees Robert E. Crowder, Jr., and Robert E. Crowder, Sr. The surveys prescribed by the CTGH-1 Logging Program (temperature, fluid resistance, sp, 16"-64" resistivity, natural gamma, gamma-gamma density, guard resistivity, caliper), along with a deviation survey and an additional sp survey, were completed in five logging runs.

Three maximum recording thermometers (MRT) were run with the logging tool during the first trip. Due to a sustained temperature reversal with depth an ambient temperature which was greater than downhole temperatures, MRT's were not included in subsequent trips.

The hole was open and unobstructed to its total depth at 517 feet. Hole diameter was 8 3/4 inches. Thirty-five feet of 10 3/4 inch ^{diameter} casing was in the top part of the hole. Static water level was 18 feet below ground level.

Trip (1) Temperature and Fluid Resistance 0' - 517'

3 Maximum Registering Thermometers (reading 50°, 52°, and 55°F)

06:38 - 07:03 Log on R1H @ 20 fpm

07:03 - 07:11 Stop on bottom

07:11 - 07:20 POH

Comments: MRT results: 1 broken - hit casing shoe @ 35' hard.

60°F - casing open to hole fluids

55°F - thermometer isolated from fluids

It was decided not to run MRTs on later trips due to ~~the~~ sustained temperature reversal below a maximum temperature at the top of the hole fluid column.

Trip (2) Spontaneous Potential and 16-64 Resistivity 35' - 517'

07:40 - 07:54 R1H to BH

07:54 - 08:15 Logging 00H @ 25 fpm

08:15 - 08:22 R1H to relog 16-64 resistivity without S.P. - potential noise interference between the two instruments

08:22 - 08:40 POH logging 16-64 resistivity only 517' - 475', turn on S.P. @ 475' - looks the same as 1st pass (logging rates: 517' - 450' @ 25 fpm, 450' - 35' @ 30 fpm)

Trip (3) Spontaneous Potential, Single Point Resistivity, and Deviation Tool 35' - 517'

09:02 - 09:10 R1H to BH

09:10 - 09:30 POH logging @ 25 fpm

Comments: Using new S.P. tool (Trip(2) tool appeared to drift but Trip(3) S.P. had similar response: noisy, flat, drifting).

No Single Point Resistivity record (Maximum deflection for tool is $1,000 \Omega$ and formation resistivity is $> 1,000 \Omega$).

Using $20^\circ E$ declination with Deviation Tool.

Trip (4) Natural Gamma 0' - 514' and
Guard Resistivity 18' - 514'

09:50 - 10:00 R1H to BH

10:00 - 10:22 POH, logging @ 25 fpm

10:22 - 10:25 R1H to 150' to check for repeatability

10:25 - 10:30 Relogging 150' to surface @ 25 fpm (same response)

Comments: Sampling analog record at 0.5' spacing for digital record of log.

Trip (5) Caliper and Gamma - Gamma Density 35' - 517'

10:30 - 11:05 Calibrating both tools

11:05 - 11:15 R1H to BH

11:15 - 11:40 POH, logging @ 20 fpm

Comments: Caliper not functioning, readings systematically narrower than hole by 2" - 3"

11:40 - 11:53 Recalibrate caliper and R1H to 150'



11:53 - 11:59 POH; relogging hole @ 20 fpm from 150'
to 35'

Comments: Good repeatability on both gamma-gamma resistivity
and caliper. Caliper scale adjusted to accurately reflect hole
diameter. Digital record again sampled at 0.5' spacing.

11:59 - 12:15 Recalibrate gamma-gamma resistivity tool

12:15 - 12:30 Logging operations complete, Rig down and mob
to Detroit to copy field logs.

POLYNOMIAL

DEGREE	PATTERN
1	
2	

CALIPER CALIBRATION

