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Vale Exploratory Slimhole: Drilling and Testing

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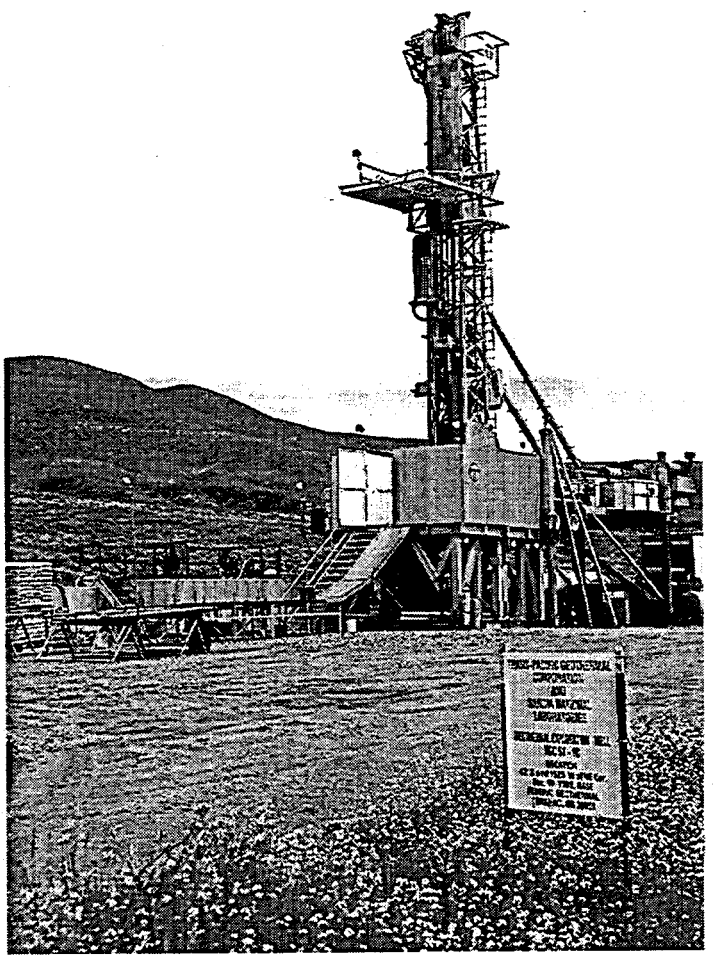

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VALE EXPLORATORY SLIMHOLE: DRILLING AND TESTING

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ABSTRACT

During April-May, 1995, Sandia National Laboratories, in cooperation with Trans-Pacific Geothermal Corporation, drilled a 5825' exploratory slimhole (3.85" diameter) in the Vale Known Geothermal Resource Area (KGRA) near Vale, Oregon. This well was part of Sandia's program to evaluate slimholes as a geothermal exploration tool. During drilling we performed several temperature logs, and after drilling was complete we performed injection tests, bailing from a zone isolated by a packer, and repeated temperature logs. In addition to these measurements, the well's data set includes: 2714' of continuous core (with detailed log); daily drilling reports from Sandia and from drilling contractor personnel; daily drilling fluid records; numerous temperature logs; pressure shut-in data from injection tests; and comparative data from other wells drilled in the Vale KGRA.

This report contains: (1) a narrative account of the drilling and testing, (2) a description of equipment used, (3) a brief geologic description of the formation drilled, (4) a summary and preliminary interpretation of the data, and (5) recommendations for future work.

CONTENTS

I. INTRODUCTION AND BACKGROUND

The Geothermal Research Department at Sandia National Laboratories is working with industry to evaluate slimhole drilling as a geothermal exploration technique. Traditionally, diamond-cored "slimholes" -- usually 3" to 4" in diameter -- have been used to measure temperature gradients while selecting sites for production-size exploration wells. If we can demonstrate that improved testing in slimholes reliably identifies a productive geothermal resource, the cost savings and reduced environmental impact, compared to production-size holes, are compelling incentives to use slimholes for exploration.[1]

Sandia first conducted an extensive survey of the geothermal industry to define its needs and priorities, and then confirmed the basic feasibility of slimhole exploration with in-house analysis and field experiments on existing geothermal coreholes. Industry contacts specified lower-cost exploration as a high priority, and were generally enthusiastic over the slimhole idea. Further negotiations with Trans-Pacific Geothermal Corporation (TGC), which owns leases in the Vale KGRA, resulted in an agreement to drill and test an exploratory slimhole on their lease. In addition to possible discovery of a new geothermal resource, this situation offered an opportunity for direct cost comparison between an exploration slimhole drilled with "hybrid" techniques on a diamond coring rig and a previous exploration well, which was conventionally drilled but would be considered a slimhole in that technology. TGC drilled this previous well, approximately two miles away, in early 1994, and completed it to roughly the same depth as that planned for this project.

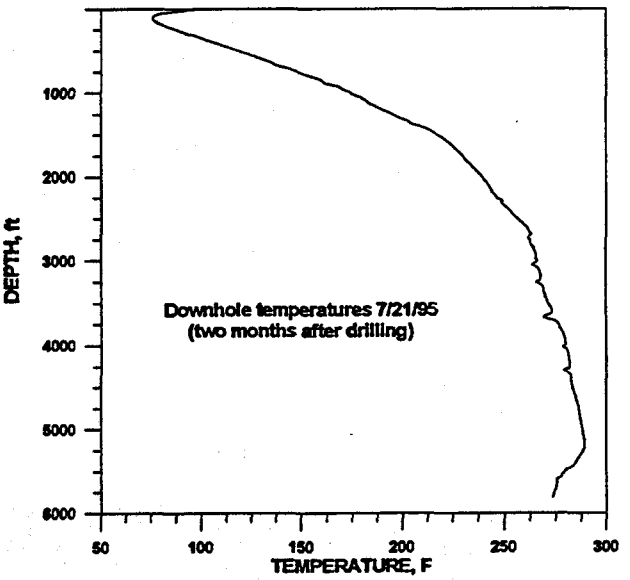

Figure 1

The exploratory slimhole (number TGC 61-10) was specifically designed to evaluate the geothermal potential at this location, and to provide additional data on drilling practices, costs, and testing in slimholes. This report describes the drilling and testing operations, gives a preliminary summary and interpretation of the data, and makes a few recommendations for future projects.

The principal objectives for this project were the following: development of slimhole drilling and testing methods, cost comparison with a recent, near-by, conventionally-drilled exploratory well, comparison of reservoir and performance data from this well with that from subsequent production-size wells, and evaluation of commercial geothermal potential at this location. Although formation temperatures were lower than expected (see Figure 1), and it is unlikely that commercial development will take place in this location, the drilling and testing here successfully demonstrated slimhole technology and the principal objectives have been met.

II. SUMMARY OF OPERATIONS

To meet our testing and data collection goals for this well, it was designed to satisfy the following criteria:

- Drill to TD at minimum cost consistent with necessary testing.

- Obtain a competent cement job on all casing, to allow extended production testing.

- Maintain HQ hole diameter (3.85") as deep as possible, to allow setting packers for isolation of possible production/injection zones.

WELL DESIGN: TGC 61-10

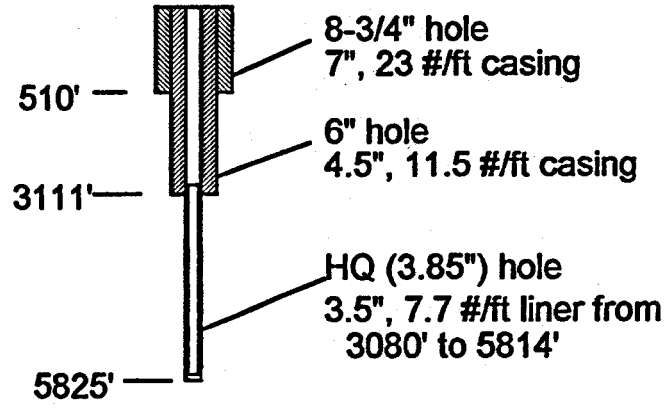

Figure 2

The well design (Figure 2) has 7" casing to 510' and 4-1/2" casing to 3111 feet. The drilling program used a core rig (see Section III) with conventional rotary tools to drill the top 3112 feet of hole and to then core the interval of interest from casing shoe to TD. This approach combined the cost savings of a slimhole drill rig, doing fast rotary drilling in the upper part of the hole, with the scientific and reservoir data obtained from core in the potential production zone.

Drilling was relatively continuous, with all testing (other than temperature logs) reserved until hole TD at 5825 feet. The following tests were then performed: wireline logs before casing; post-casing injection tests into the complete open hole section, with pressure shut-in data; bailing from the bottom 500' of the hole, which was isolated with an inflatable packer, and then measuring temperature change in that section; repeated temperature logs in the hole, following well completion with a 3-1/2" liner from 3080' to 5814'.

ABANDONMENT DESIGN: TGC 61-10

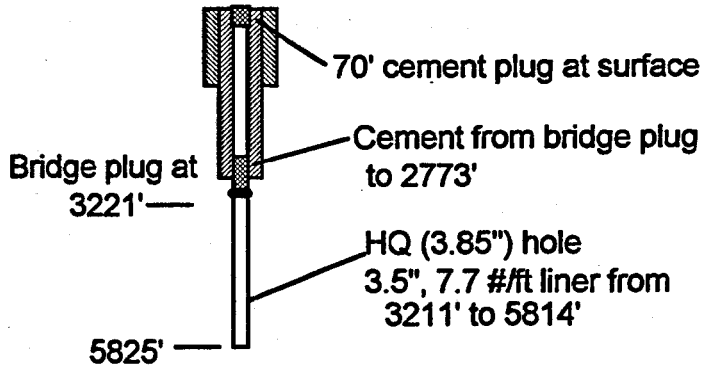

Figure 3

Since neither the tests performed just after drilling nor repeated temperature logs over the following four months indicated that this hole was in a promising geothermal resource, the hole was plugged and abandoned during September, 1995. The HQ liner was cut 100' below the casing shoe, the cut liner was pulled from the hole, a bridge plug was pushed down to the top of the remaining liner, and a cement plug was pumped from that point back up into the casing. The P&A configuration for the hole is shown in Figure 3; see Appendix A for further details of the P&A operations.

III. DESCRIPTION OF TEST EQUIPMENT AND METHODS

This section covers the major items of equipment used in the drilling and testing, and, where appropriate, describes their operation.

Drill rig: The drill rig used for this hole was a Tonto Drilling UDR5000 top-drive coring rig. This is a trailer-mounted derrick which can pull 40' stands of pipe and has a depth rating of 9700' with CHD101 coring tools.

During the rotary drilling part of the operation, the drillstring comprised CHD134 core rods (5" OD) turning a conventional bottom-hole assembly (BHA) with stabilizers, drill collars, and roller-cone bits. (See Appendix B for detailed descriptions) During the rotary drilling, a rental mud system was also used, since the drill rig's pumps normally used for coring did not have sufficient volume delivery for the designed bit hydraulics.

After the 4-1/2" casing was set to 3111', the remainder of the hole was drilled with HQ (hole diameter 3.85", core diameter 2.5", rod diameter 3.5") drill rods and diamond-impregnated bits.

Surface flow instrumentation: As part of Sandia's ongoing Lost Circulation Program[2], the drill rig was instrumented with flow transducers which were used to measure and record drilling fluid inflow rate and temperature, outflow rate and temperature, pump strokes and pressure, drillstring rotary speed, and depth. All these values were displayed on video monitors at the driller's station and in the Sandia mobile office. In addition to their designed function of detecting lost circulation and calibrating various flow measuring devices, these instruments were used to collect pressure data during the injection tests and also proved to be valuable diagnostics in understanding drilling performance and the nature of the interval being drilled. Some of the phenomena which can be identified with this instrumentation are the following:

- Lost (or gained) circulation: This was the original purpose of the measurement system. When non-transient outflow rate falls below inflow, then drilling fluid is being lost to the formation. Conversely, when outflow rate is higher, the formation is producing fluid into the wellbore.
- Drill-string washouts: Sudden drop in pump pressure at a constant flow rate frequently indicates a washout in the drillstring.
- Pump efficiency: If flow rate measured by non-intrusive flow sensors decreases relative to the calculated flow rate based on pump strokes, this indicates that pump efficiency is declining.
- Temperature difference between inflow and outflow: Bottomhole temperature cannot be inferred directly from an increase in flow line (outflow) temperature, because there are many different temperature gradients in the formation that will produce the same outflow temperature or ΔT between inflow and outflow, but rapid changes are a signal that something has changed downhole. For example, in a known lost circulation situation, with outflow a variable fraction of inflow, a change in the outflow temperature while the inflow temperature remains constant can mean that the wellbore has penetrated a producing formation with water hotter or colder than the drilling fluid.
- Drilling optimization: Having all readings available on one monitor makes it easier for the driller to optimize the combination of drilling parameters such as rotary speed and circulation rate.

Downhole instrumentation: Numerous temperature logs were taken with Sandia's platinum-resistance-thermometer (PRT) tool which, along with a Sandia logging truck, remained on-site for the entire project. This instrument uses a simple resistance bridge, with changes in resistance measured from the surface through a four-conductor cable. Since there are no downhole electronics, temperature drift with time is negligible and the PRT temperature measurements were considered the reference standard for these tests. Static temperature logs (no flow in hole) were done with this tool when coring operations were suspended for bit trips, rig maintenance, or other time intervals that would permit the hole to warm up near its static temperature gradient.

After the hole reached TD, a pressure-temperature storage, or "memory", tool was also used to compare temperature data with that previously taken by the PRT tool and to collect downhole pressure data during the injection and shut-in tests. This tool, part of Sandia's on-going program in Instrumentation Development[3], has a Dewar flask around an electronic memory which stores data (approximately 10,000 data points total capacity) that can later be downloaded into a laptop computer. This tool's primary advantage is its ease of operation, since it can be run into the hole on the rig's wireline and specialized logging trucks are not required. As an experiment, the tool was also run into the hole inside a core-barrel "cage" while tripping the drillstring and gave good results.

A prototype temperature/spinner tool was also run during injection tests. The tool appeared to be collecting good data in the upper part of the hole, but as it entered the lower section, where the wellbore wall was heavily coated with rod grease, the impeller became clogged with grease and would not turn. The problem was probably not unique to this tool, since commercial spinner tools would likely have plugged in the same way. Grease plugging would have been eliminated or greatly reduced if we had first been able to do a production flow test, which would have cleaned the wellbore.

IV. ANALYSIS OF DATA

Overview: Two injection tests were performed during the two day period, May 11-12, 1995. The test procedure involved establishing a constant injection-flow rate which was maintained for a sufficient period to eliminate the effects of initial variations in the flow. The well was then shut in and the pressure decay monitored with downhole instrumentation positioned near the postulated feed zone. The location of the feed zone was inferred from prior temperature logs of the well. Details of the instrumentation used are provided above. This section is concerned with interpretation of the test results and the resulting estimates of the permeability-depth product (transmissivity) for the well. Important details of the two injection tests are summarized in Table 1. The terms P_{wh}, P_{dh}, Q, T_{dh} denote the wellhead pressure, downhole pressure, volumetric flow rate, and downhole temperature, respectively. The pressures in the table are the values immediately preceding shut-in.

Test No.	Injection start	Shut-in	Elapsed time, hr	P_{wh} psi	P_{dh} psia	Q gpm	T_{dh} °F	Depth ft
1	18:32:57	20:51:38	2.311	145	1748	26	69	3700
2	08:39:56	10:05:49	1.431	240	1584	42	57	3109

Pressure Fall Off Analysis: The pressure fall off ΔP for the first injection test is plotted in Fig. 4 as a function of the log of the Horner time, $(t_p+\Delta t)/\Delta t$, where ΔP is the pressure drop, t_p is the total injection time prior to shut-in, and Δt is the elapsed time after shut-in. [Note that, in the horizontal axes of Figures 4 and 5, increasing time runs from right to left.] A curve fit to the late-time, straight line, segment of the response yields

$$(1) \qquad \Delta P = 358.74 - 267.26 \log\left(\frac{t_p + \Delta t}{\Delta t}\right)$$

The slope m of this line can be used to determine the effective value of the transmissivity

kh from the relation

$$(2) \qquad kh = \frac{2.303 Q\mu}{4\pi m}$$

where Q is the volumetric flow rate and μ is the viscosity. For the first injection test, the numerical values of the various parameters are: Q = 26 gpm = 1.64×10^{-3} m^3/s, μ = 4.71×10^{-4} kg/m s, m = 267.26 psi/cy = 1.843×10^{6} N/m^2/cy. The estimated value for *kh* is then

$$(3) \qquad kh = 7.68\times10^{-14} m^3 = 0.077 \text{ Da-m} = 0.253 \text{ Da-ft}$$

For the second injection test, a straight line fit to the late time portion of the response curve in Fig. 5 yields

$$(4) \qquad \Delta P = 422.17 - 468.94 \log\left(\frac{t_p + \Delta t}{\Delta t}\right)$$

Performing the same analysis as that applied to the first injection test results in the following estimate for the transmissivity

$$(5) \qquad kh = 7.07\times10^{-14} m^3 = 0.071 \text{ Da-m} = 0.232 \text{ Da-ft}$$

A brief summary of the basics of injection testing is given in Appendix D.

Pressure Buildup Analysis: An additional measure of the effective transmissivity can be obtained from the initial pressure response obtained when the injection flow is established. The downhole pressure buildup is available only for the second injection test. In Fig. 6, the pressure rise is plotted as a function of the log of the elapsed time since the start of injection. A curve fit to the late time response yields

$$(6) \qquad \Delta P = -62.84 + 77.48 \ln(\Delta t)$$

The effective transmissivity can be obtained by using the slope m in the relation

$$(7) \qquad kh = \frac{Q\mu}{4\pi m}$$

which is essentially identical to Eq. (2) except for the factor 2.303 which is the conversion between the natural log and the log to base ten. Eq. (7) yields the following estimate for the transmissivity

$$(8) \qquad kh = 1.858\times10^{-13} m^3 = 0.186 \text{ Da-m} = 0.610 \text{ Da-ft}$$

which is approximately a factor of 2.5 larger than the estimate based on the pressure fall off analysis. Variations of this magnitude are not uncommon when analyzing field data.

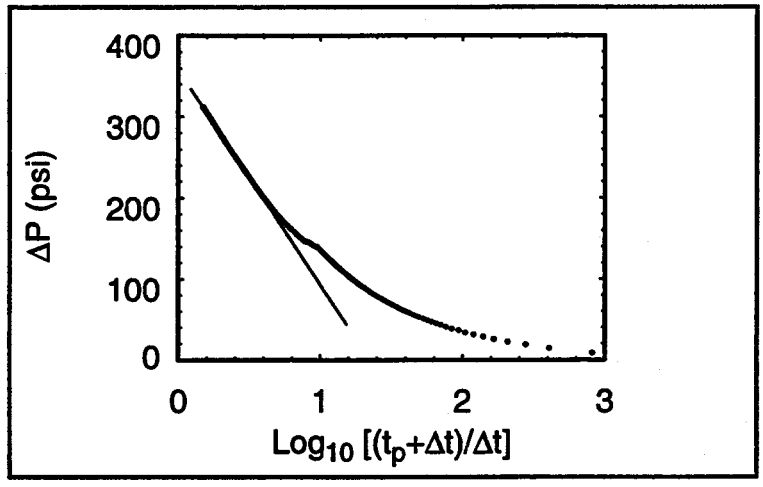

Figure 4. Downhole pressure fall off response for first injection test, 5/11/95.

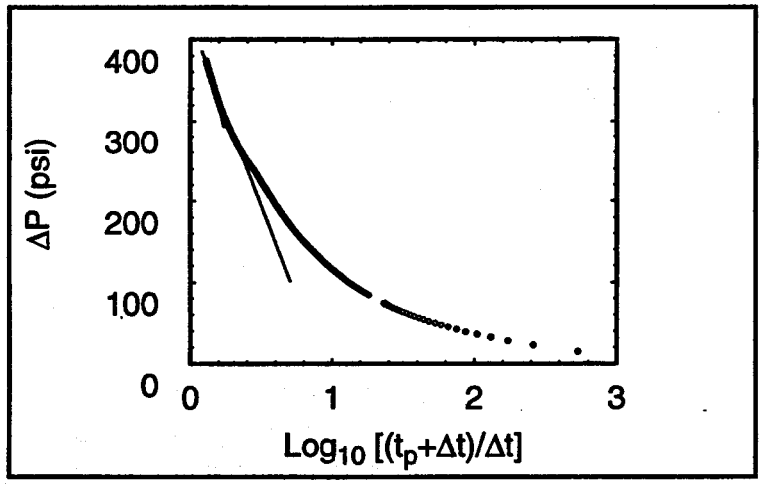

Figure 5. Downhole pressure fall off response for second injection test, 5/12/95.

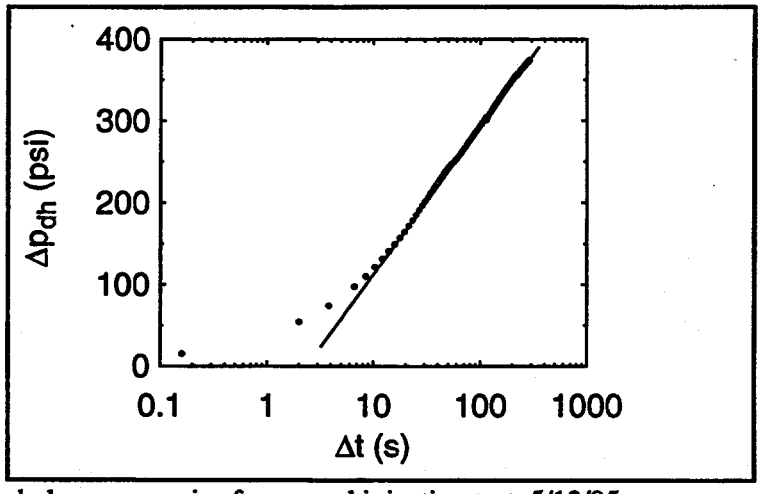

Figure 6. Downhole pressure rise for second injection test, 5/12/95.

Productivity Index: The productivity index is defined by

$$(9) \qquad PI = \frac{\dot{m}}{p_{dh} - p_{\infty}}$$

where $\dot{m}$ is the injected mass flow rate, p_{dh} is the downhole pressure (at the feed zone), and p_{∞} is the ambient reservoir pressure. Based on the information in Table 1 and an estimated ambient pressure of 1475 psi, the productivity index is 0.09 kg/s/bar for test 1 and 0.35 kg/s/bar for test 2. These results are only approximate since the position of the downhole tool was not exactly the same for each test and the estimate for the downhole pressure is based on an average density rather than on an actual static measurement. These estimates are substantially lower than prior estimates for the nearby A-Alt well which were on the order of unity. Based on the work of Pritchett[7], it is assumed that the productivity index can be determined from an injection test and the productivity index for a production well can be scaled geometrically, based on the ratio of well diameters, from the result for a slimhole.

V. DISCUSSION

Test results: Analysis of the two injection tests performed at the exploratory slimhole site during May, 1995 yielded estimates for the permeability-thickness product (transmissivity) *kh* of 0.25 and 0.23 Da-ft, based on pressure fall off after injection. Using the pressure buildup for the second test, a transmissivity of 0.610 Da-ft was estimated. These estimates are approximately an order of magnitude smaller than the *kh* values estimated for the nearby A-Alt well which was tested in 1994. The model used to estimate *kh*, given in Eqs. (2) and (7), is based on the Theis solution which assumes an infinite reservoir of constant thickness and permeability and a line source injection well. The reservoir tested is fractured and of finite extent, so the model used does not convey explicit information on the geothermal reservoir geometry or the distribution of fractures and feed zones. The estimated value for *kh* is, however, useful for comparing reservoirs and for identifying potentially productive reservoirs. It is generally assumed that the *kh* value must be at least 10 Da-ft for a potentially productive reservoir. Hence, the low *kh* values measured for this well are indicative of a very tight reservoir which is unlikely to be an effective, developable, geothermal resource.

Drilling technology: Although the UDR5000 drill used for this hole is considered a "hybrid" rig, capable of either conventional rotary drilling or minerals-type core drilling, it is used far more often for coring, and there are significant differences in the two kinds of drilling. These differences affect the equipment required for the job, the logistics of handling the equipment around the rig, and the training that the drill crews should have to successfully do both kinds of drilling. See Appendix C for a more detailed discussion of this topic.

Cost comparison: A major objective of the slimhole program is to demonstrate not only that the smaller wells give sufficient data to evaluate a reservoir, but that they do it more cheaply than conventionally-drilled large holes. The Vale slimhole presented an ideal situation for cost comparison because a rotary-drilled exploration hole had been completed less than two miles away, to approximately the same depth, in February 1994. The table below gives a breakdown of costs for both wells, and helps to define where major cost differences occur.

Well Name:	A-Alt	TGC 61-10
Depth	5757'	5825'
Completion	14" line pipe to 62'	10" line pipe to 29'
	9-5/8" casing to 506'	7" casing to 510'
	7" casing to 3010'	4-1/2" casing to 3111'
	5" slotted liner, 2902'-5723'	3-1/2" H-rod, 3080'-5814'
Rig days	31 + 5 standby	40

WELL	A-Alt	TGC 61-10
Rig Charges (day rate, footage, crew per-diem)	184,955	254,837
Rig mobilization and de-mob	87,860	43,560
Site construction and maintenance	57,700	29,998
Mud logging	26,040	13,490
Bits and downhole tools	67,279	27,978
Directional	37,374	0
Fishing	3,200	1,695
Rentals	28,090	20,182
Fuel and water	10,350	5,570
Drilling fluids	48,421	48,468
Casing, casing crews, and cement	172,817	107,076
Logging	58,376	14,929
Trucking and additional labor	36,723	12,895
Equipment maintenance	11,530	1,260
Drilling engineering	56,940	13,790
Wellhead and miscellaneous	32,670	42,555
TOTAL	920,325	638,334
Cost per foot (*excluding* directional costs)	$153	$110

There are several points to note in this comparison:

- Even though charges by the drilling contractor were considerably greater for the slimhole than for A-Alt, lower ancillary costs for the slimhole made the total project much cheaper. Part of the greater rig cost was caused by the longer time required for the slimhole, and the remainder is due to the rig day-rates. It is not obvious that the core rig for the slimhole ($4990/day plus $5-$9/foot) should be more expensive than the rotary rig for A-Alt ($5640/day), but day-rates for drill rigs obey the same principles of supply and demand as other commodities. At the time A-Alt was drilled, rotary rigs were available in abundance and consequently were bid at relatively low prices, while core rigs, mostly employed by the minerals industry, were in short supply when bids for TGC 61-10 were solicited.
- The only aspect of the earlier well which made it inherently more expensive was the directionally drilled interval. Beside the explicit costs of directional tools and services, there may have been additional rig days and bit costs, but even after deducting these items, there are clear savings for the smaller hole.
- The drilling-fluids expense for the slimhole was slightly greater than for A-Alt, but it was inflated by the complete loss of circulation in the lower part of the hole. This meant that we were continually pumping 10 to 15 gpm of mud down the hole for the last 20 days of drilling. A slimhole which did not lose total returns would have a much smaller mud cost.

- Even though more than half the total footage was rotary-drilled, the smaller bits used in the rotary section and the less expensive core bits in the cored section greatly reduced the cost of bits and tools. In the cored section, the simplified BHA also eliminated the cost of stabilizers and drill collars.
- Smaller sizes of the rig, pad, and sump reduced rig mobilization and site construction costs.
- A mud logging service company was only used for the rotary section of the hole, although we did continue to rent their H_2S monitors for the duration of the project. Once core was being retrieved, cuttings analysis was no longer required. Similarly, contract drilling supervision was only used during rotary drilling. While outside consultation was useful for design of bit hydraulics and BHA programs, these activities are considerably simplified in core drilling and the drillers are accustomed to making these choices independently.
- Smaller casing sizes, with correspondingly smaller cement volumes, were less expensive for the slimhole. Normally, there would be even more of a cost advantage to the smaller hole, but the 6" hole was washed-out over several intervals, requiring more cement for the 4-1/2" casing than originally estimated. Washed-out intervals may have been caused by excessive bit hydraulics, designed in an effort to increase drilling performance. If this was the case, then the trade-off with a $66,000 cement job was not cost-effective.

VI. CONCLUSIONS

Although this hole was geologically informative and the drilling went well, it was, unfortunately, drilled in a location which holds little promise for commercial geothermal development. Still, several useful conclusions can be drawn from this project.

- Drilling this hole to the same depth as a nearby rotary hole provided information of the same quality at substantially lower cost.

- With some refinement of techniques (hydraulics, etc.) used in the rotary part of the hole, cost savings could have been even greater.

- Total well cost is sensitive to the ratio of rotary-drilled interval to core-drilled interval. For example, see the table to the right. If rotary drilling had only gone to 2000', then the extra 1100' feet of coring would have increased the total cost by approximately $32/foot for that interval. (These costs-per-foot are much lower than shown above because they only count cost during drilling, i.e. no casing, cement, site preparation or other non-drilling costs.)

Type of drilling	Avg hole advance/day, feet	Avg daily cost, dollars	Avg cost per foot
Rotary	289	14,408	$50
Coring	129	10,573	$82

- Given the availability of a storage-type logging tool, the method of taking a temperature log with the tool in a core barrel while tripping pipe has several advantages. It takes almost no extra rig time, it happens when the hole has not seen circulation for a period of several hours, and it is extremely safe (for the logging tool) compared to running the tool in an open hole, which might be fractured, caving, or sloughing.

- If a hole has several intervals which appear (from core examination) to have high permeability, then an inflatable packer is useful in evaluating these intervals individually. If significant lost circulation has been treated by pumping LCM, which may have plugged some of the fractures,

then swabbing the hole can relieve this situation and give a better indication of that interval's true permeability. To do this, a specifically designed swabbing tool would have been more effective than the make-shift one used on this hole.

VII. RECOMMENDATIONS

Since this operation supported the validity of slimhole drilling as a lower-cost exploration technique, we should seek other opportunities for cost-shared projects in geothermal reservoirs where subsequent production wells will give comparisons between slimhole tests and production data. This would be part of a general effort to do exploratory drilling and testing in reservoirs with different flow characteristics, and to compare those results with production wells in the new reservoirs.

A consequence of moving to other types of reservoirs will be the increasing need for flow modeling capability, especially in terms of coupling a reservoir simulator to a wellbore simulator. Although little modeling was done for this well testing, it will be important to simulate the flow from the reservoir into and up the wellbore when working in a reservoir where production tests can be done. This subject is discussed more fully in Reference 6.

The pressure-temperature log taken while tripping drill pipe with the memory tool in a core barrel (see Narrative and Daily Drilling Report for 9 May) was successful, having as a principal defect the necessity for hand entry of drill pipe length during the trip. A simple drill-pipe-length encoder should be developed to expand the opportunities for this type of logging on core rigs. An encoder would produce time-depth data which could be merged with the logging tool's time-pressure/temperature data to generate a curve of depth versus pressure and temperature.

VIII. GLOSSARY

The following terms are common in drilling practice; many of them are used in this report:

annular preventer - part of the BOP stack; an inflatable bladder which seals around drillpipe, casing, drill collars, or irregularly shaped components of the drillstring.

Bowen spear - a fishing tool which expands inside a fish when the drillstring is pulled up

BOP - blow out preventer; one or more devices used to seal the well at the wellhead, preventing uncontrolled escape of gases or steam. Also BOPE - blow-out prevention equipment
See *annular preventer, rams*.

block, or blocked run - a core run is blocked when fractured rock wedges into the core tube and prevents further drilling before the tube is full.

cave - debris that falls off the wellbore walls and accumulates in the bottom of the hole

fish - any part of the drillstring accidentally left in the hole

fishing - trying to retrieve a fish

float collar - a coupling with check valve; placed near the bottom of a casing string to prevent the heavy cement column in the annulus from flowing back into the casing after displacement

Geoset - a type of synthetic diamond cutter used in impregnated bits

H or HQ - designation of a coring tool size; rod outside diameter is 3.5", bit is approximately 3.8" OD and 2.5" ID

H_2S - hydrogen sulfide; a poisonous gas frequently found in geothermal drilling

jars - tools which apply an impulse force to the bottom of the drillstring when the string is pulled up; usually used for fishing, but sometimes included in the string for normal drilling

lay down - to take a piece of equipment out of service; e.g., to lay down a worn core rod

LCM - lost circulation material; any material used for plugging formation fractures to avoid loss of drilling fluid

lubricator - sealing element attached to the wellhead which allows a wireline to pass up and down, or which allows a logging tool to be transferred into or out of the wellbore, while there is pressure in the wellbore

matrix - the hard metal portion of a bit which holds the diamond cutting elements in place

mislatch - the condition when the core tube, or inner barrel, is not latched into the outer rotating barrel, sometimes caused by core dropped out of the core tube. If the core tube can't be worked down over the core in the barrel, then the drillstring must be tripped to clear it.

MRT - maximum reading thermometer; a mercury thermometer which retains the reading of the highest temperature it has seen (which may not be at the bottom of the hole)

N or NQ - coring tool size; rod OD is 2.75", bit is 2.98" OD and 1.875" ID (N fits inside H)

nipple up - to assemble something; usually applied to the wellhead or BOP stack

overshot - in general, any tool that latches around the outside top of another tool; usually refers to the assembly which retrieves the core tube with the wireline, or to a fishing tool which extracts a fish by gripping it around the top

PTS - pressure-temperature-spinner tool; downhole instrumentation to measure these quantities (spinner output is an indication of velocity or flow rate)

pick up - to put any piece of equipment into use; e.g., to pick up a new bit

pitcher nipple - the vertical tube around the top of the blow-out preventer; it collects the drilling mud returns and empties them back into the mud tanks

POOH - pull out of hole; bringing the drill string and tools out of the hole

rams, pipe or blind - rams are part of the blow-out preventer; pipe rams close around the drill pipe if it is in the hole, blind rams seal against each other if the pipe is not in the hole

RIH - run in hole; inserting the drillstring and tools into the hole

rod - drillpipe used in core drilling is commonly called "rods"

rod grease - in deep core drilling, especially when lost circulation causes part of the wellbore to be dry, the outside surface of the rods is greased to reduce drillstring vibration

shoe - a heavy, tapered cap that attaches to the bottom of the casing string and protects it as the casing is lowered into the hole

spud - to begin drilling a well

stand - more than one joint of drill pipe screwed together; when tripping, pipe is handled in stands to avoid making and breaking every connection - for a coring rig, a typical stand is four ten-foot joints (40 ft), but for a large rotary rig, a stand is three thirty-foot joints (90 ft).

strip - to wear away the matrix in an impregnated diamond bit; the bit must strip to expose the diamond cutting surfaces

swage, inside or outside - a fishing tool which grabs the inside or outside of a fish by forcing an interference fit

TD - Total depth; the final depth of the drilled hole

trip - any event of pulling the drillstring or core barrel out of the hole and/or returning it

washout - a leak in the flow path through the drillstring, usually at a threaded connection. The hole is enlarged by high-pressure drilling fluid passing through it, and frequently causes the drillstring to fail and separate.

wiper trip - running the drill string, with a bit, to the bottom of the hole to make sure there are no obstructions in the hole

WOC - wait on cement, time spent waiting on cement

xover or xo - crossover; a coupling used to adapt from one thread size to another

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APPENDIX A

The following day-by-day narrative represents notes made by Sandia field personnel during the drilling operations. Definitions of abbreviations and jargon are given in the Glossary, Section IX. This narrative is complementary to the Daily Drilling Reports in Appendix B.

VALE EXPLORATORY SLIMHOLE
DAILY NARRATIVE

5 April 95

1800 - All pad and road construction complete; 10" conductor to 40' below ground level is in place; sumps and landing for rental mud system dug. Tonto UDR5000 rig is in place. Tecton (mud logging), Desert Drilling Fluids (mud engineering), and office trailers in place. Weatherford/H&H have delivered drill collars, bits, tools, BOP, accumulator, casing accessories, and wellheads. Unloading material; will spud in the morning with no problems.

6 April 95

0700 - Mixing mud, picking up 8-3/4" drilling tools, finishing wiring for electric power and flow instrumentation.

1200 - Spud hole in 10" conductor. Will drill out conductor to 51' below kelly bushing (KB)

KB = 11' above ground level; all depth measurements will be referred to this datum.

1400 - At recommended hydraulics (240 gpm, 50-60 viscosity, 40 mesh shaker screens) shaker is blinding off, with approximately 30% of returns going off the slide. This is filling the sump far too quickly, so reduce flow to ~ 150 gpm at 40-41 viscosity. Get new 20 and 30 mesh screens coming on overnight delivery. Some mud still spilling over, but much better than before.

2100 - Preparing to run Totco and MRT survey at approximately 250' depth.

7 April 95

0330 - Drill ahead to 510'. Formation is still relatively soft, mostly siltstone with some stringers of sandstone conglomerate. Circulate hole.

0500 - Made wiper trip and circulated hole.

0600 - POOH

0730 - Begin laying down drilling assembly.

1030 - Weld on casing shoe and begin RIH with 13 joints (512') of 7" casing.

1200 - There is some fill in hole; Halliburton is rigged up and is circulating water through casing to wash casing down to desired depth.

1500 - Casing is at correct depth, approx. 9" off bottom with 2-1/2' stickup. Howco pumping 10 bbl sodium silicate pre-flush.

1730 - Cement in place: 95 cf Class G mixed 1:1 with perlite and 40% silica flour plus 20 cf tail w/o perlite. WOC.

1800 - Cement has fallen back.

2100 - Halliburton back for top job; will not use tremi line but will pump slowly into side port on conductor approximately 2' above ground level.

2115 - Top job (2-3 bbl = 40-60' original fallback) in place. Held level for 10 min. Opened 2" valve on conductor and drained cement back to that level.

8 April 95

0130 - Nipple down flow line and 10" riser, cut off conductor and 7" casing approximately 2' above ground level and start installing wellhead.

0800 - Wellhead welding complete, start nippling up BOP stack.

1100 - BOP testing begins, witnessed by Dennis Simontacchi, BLM, and Dennis Olmstead, DOGAMI.

1430 - Pipe rams and blind rams hold pressure, minor leak in choke line. Attempting to repair.

1540 - BOP test complete. Welder on location for pitcher nipple.

1800 - Picking up 4-3/4" drill collars for 6" drilling assembly; RIH.

2000 - Tagged top of cement at 469' and drilled ahead with mud. Diverting cement-laden mud over slide (not back into circulating mud system)

2200 - Drilled to 515' (5' of new hole, as required by permit), ready for leak-off test. BLM and DOGAMI here to witness. Pump slowly (~3 gpm) into hole but can't develop any pressure. This is because hole isn't full; driller pulled up 20' off bottom before starting pressure test, and we've just been filling that volume. Fill up hole.

2225 - Close pipe rams and pump surface pressure to 120 psi (350 psi bottom-hole pressure, per permit). Shut in wellbore.

2250 - Surface pressure has increased to 145 psi because of mud warming, but formation and shoe are still holding the pressure. BLM and DOGAMI sign tour sheets, approving test.

9 April 95

0200 - Drilling ahead at 700', lose circulation at 705'. Slug hole with LCM (Maxi-seal and cottonseed hulls), by-pass shakers, and get ~50% returns. Pump pressure indicates one bit nozzle is plugged.

0800 - Drilling ahead at 814', still partial returns. Inclination and MRT survey: inclination = 0.5°, temperature = 72°F.

1115 - Drilling ahead at 932'. Rig is down for short repair (broken bracket on head), start pulling back into casing so we can shut off pumps and reduce vibration. Hole is producing approximately 40 gpm; close pipe rams, no pressure in annulus. Open rams, resume trip back into casing.

1230 - Complete rig repair. Circulate hole

1500 - Run back in hole.

1630 - Drilling ahead at 940'

10 April 95

0700 - Preparing to POOH from 1286' for possible bit change.

1200 - Laying down BHA to measure ID's and OD's of all BHA components. Bit is almost untouched, will re-run.

1800 - Have run back in hole to 1286'. Spent approximately 6 hours measuring components and tightening drill collars and stabilizers. Drilling ahead.

11 April 95

0700 - Drilling ahead at 1710'.

1200 - Drilling ahead at 1892'.

1510 - Bit is showing some torque at 1945', will come out of hole.

1800 - Bit is 1/16" under gage and dull. Will change out bit and will also remove two crossovers: CHD134 pin x 3 1/2 reg box and 3 1/2 reg pin x 3 1/2 IF pin, and replace them with CHD134 box x 3 1/2 IF pin.

1900 - Finish modifying bit breaker and remove bit. Rig up tongs and Totco torque indicator.

2015 - Finish picking up collars and RIH to 1931'. Run temperature (188°F) and inclination (0.75°) survey.

2315 - Back on bottom, drilling ahead at 1945'.

12 April 95

0325 - Drilling ahead at 2034', pump pressure dropped from 750 to 440 psi. Worked pipe and circulated. Mixing pump on mud mixer is broken.

0327 - Over the next ~10 minutes (until 0338) flow line temperature jumps sharply, from 115°F to 126°F. No obvious correlation between pump pressure and temperature.

0500 - Pumped carbide indicator and got returns in 8 minutes; bottoms-up time should be 13 minutes.

0800 - POOH

1030 - Washout is in crossover between CHD134 and drill collars. Pin on bottom joint of CHD fails when trying to break the connection. Replace with original crossover combination. Pump into BHA to make sure there are no other washouts.

1325 - Drilling ahead at 2035', pump pressure suddenly went up to >1700 psi. Bit jet probably plugged.

1700 - Drilling ahead at 2061'. Rate of penetration has dropped to <2 ft/hr since 1500, possibly from bit balling or hard formation, but that is consistent with performance in Well A-Alt.

1900 - Have only made 1.5' of hole in last 2 hours, and string is seeing severe vibration even when off bottom. POOH

2200 - Bit is out of hole, all three cones are gone. Half of one cone stuck between shanks. Ends of shanks worn flat 1" wide. Pick up 5" fishing magnet.

13 April 95

0130 - RIH

0415 - Fill hole and circulate.

0445 - Work magnet at 2062'

0500 - POOH.

0800 - Clean and lay down magnet. It has bearings, portions of cones, and other junk. Gouges on sides of magnet housing indicate that some junk has been pushed back into the wellbore walls. Will RIH with new bit.

0930 - Pick up collars and tools. RIH

1330 - RIH to 2027'; wash to bottom.

1400 - Drilling ahead at 2070'

1600 - Drilling ahead at 2077'; have only made 2' since 1500. Pump pressure has dropped from ~800 psi to about 500 psi. Pressure returns when bit comes off bottom, falls when bit is on bottom rotating, i.e., it appears that something leaks when the drillstring is torqued.

1630 - POOH.

1930 - Connections are bad on several of the CHD134 heavy-weight drillpipe and on the transition from the HW to regular CHD134. Second collar has severely washed box (and pin of stabilizer above it); metal is parted for more than half the circumference. Bit is severely worn, almost all teeth worn off. Laid down bad collar and stabilizer, inspected HW drillpipe.

2100 - Picked up Hughes ATJ-11 insert bit and run in hole.

14 April 95

0230 - Broke circulation and plugged pipe (float or bit jet) with LCM. POOH

0500 - Laid down BHA and cleaned out cottonseed hulls.

0700 - RIH

0900 - Circulate and bit plugs again. POOH

1030 - Clean bit and add one jet. Previous drilling had been with one jet blank to aid bottomhole cleaning. RIH, stopping to circulate every 400'.

1530 - Wash last 100' to bottom.

1630 - Triplex pump down, apparently got a rag sucked into it.

1715 - Pump cleaned out, drilling ahead at 2080'.

2300 - Drilling ahead at 2185'; good progress. Running at lower rotary speed (~75 rpm) and higher flow rate (130 gpm) through the three jets.

15 April 95

0000 - Triplex pump down again, clean valves and flush

0245 - Totco survey and MRT at 2246', inclination = 1° and temperature = 162°F

0700 - Still drilling ahead at 2334'.

1000 - Drilling ahead at 2403'.

1300 - Drilling ahead at 2460'.

1900 - Drilling ahead at 2618'.

2200 - Lost complete returns at 2699', pumped LCM. Regained partial returns. Resume drilling.

2400 - Lost returns again at 2727', repeated LCM. Regained partial returns.

16 April 95

0700 - Drilled to 2935'.

0900 - Drilled to 2987'.

1045 - Lost complete returns at 3043', pumped LCM

1115 - Drilled to 3053', pumped LCM, pumped gel pill. Pull 600' of rods, wait for gel to hydrate.

1400 - Fill pipe and hole (~ 35 bbl). RIH, stop every 200' to circulate.

1600 - Drill to 3070'.

1730 - Bottom of 6" hole at 3112'. Will POOH back to shoe, count stands, and make wiper trip.

17 April 95

0700 - Trying to rig up Halliburton Logging Services for electric logs (natural gamma, dual induction, X-Y caliper, temperature.) Blind rams closed and frozen.

0945 - Got rams open, RIH with logging tool. Could not get past 923', hole appears to be bridged, tried twice to break through. POOH with tool and find that caliper arms are open, possible that caliper was hanging up on a ledge. Close caliper arms and RIH, no hang-ups, pull back to casing and log to bottom.

1200 - Rig down HLS, rig up for Sandia temperature log.

1930 - Have logged down into undisturbed hole (BHT = 217°F @ 3082'), then POOH with temperature tool and pump >100 bbl fresh (cold) mud into hole. Log down again and back up; comparison makes it clear that much of the fluid is going out the loss zone at 3043'. By looking at travel time of the "cold mud front" down the wellbore in the time interval between logging down and back up, volume loss from the 3043' zone appears to be less than half the volume pumped into the well. This indicates that we can still lift cement approximately half-way up the casing. Since there will still be at least 70' of tight hole above the 4-1/2" casing shoe we will displace cement through the shoe in the normal way, wait on cement, and do a surface squeeze.

2000 - Will run in hole for wiper trip and come out laying down CHD134 drillpipe.

18 April 95

0700 - Almost finished laying down drillpipe.

1015 - All drillpipe and tools laid down.

1130 - Begin running 4-1/2" casing.

1730 - Finish running casing, circulate casing bottoms up. Rig up Halliburton for cementing.

1915 - Begin pumping 10 bbl of 10% $CaCl_2$ water, 1 bbl H_20, 10 bbl double-strength Superflush, 1 bbl water, 600 cf 11.2 ppg lead slurry (G cement with 50#/sack spherelite and 40% silica flour, 1.4% gel, 0.5% H22-A), followed by 50 cf tail slurry (G cement with 40% silica flour, 0.5% CFR-3, 1% $CaCl_2$. Displace with 285 cf water.

2000 - Pumping approximately 3 bbl/min, getting ~ 50% mud returns to surface, down to ~ 20% when begin lifting cement.

2045 - Cement in place. No cement returns to surface, but pump truck pressure indicates lifting cement at least 1000'.

19 April 95

0600 - Closed pipe rams and annular preventer, performed top job through side outlet valve: 10 bbl double-strength Superflush, 1 bbl water, 250 cf G cement (with 1:1 perlite and 40% silica flour, 4% gel, 3% $CaCl_2$, 0.65% CFR-3), followed by 25 cf G cement (with 40% silica flour, 0.5% CFR-3, 3% $CaCl_2$.)

0700 - Cement in place. No pressure buildup while pumping. Keep BOPE closed. WOC.

0810 - Begin temperature log.

1100 - With pipe rams and annular preventer closed; choke line open, Halliburton pumps second top job (50 cf G cement with 40% silica flour, 0.65 CFR-3, and 3% $CaCl_2$; followed by 75 cf G cement 1:1 perlite with 40% silica flour, 1.4% gel, 0.65% CFR-3, 3% $CaCl_2$) through side outlet. Begin another temperature log during top job.

1210 - Cement in place. No cement to surface. Premixed for another top job, but annulus was full of cement; held 75 psi. WOC

1450 - Begin temperature log.

1600 - Lifted pitcher nipple, cut off casing, laid down pitcher nipple, lifted BOP stack, cut casing again, welded on centering ring between 7" and 4-1/2" casings. Left ~12" of the 4-1/2" sticking up inside the mud cross; it will get a flange and valve after the BOP stack is removed from the 7" flange.

2330 - Begin testing BOPE.

20 April 95

0230 - Finish testing BOPE. All tests witnessed by Dennis Simontacchi, BLM.

0330 - Begin picking up HQ rods and running in hole.

1130 - Tagged top of cement in casing at 3063'.

1630 - Cored through cement, float shoe, cement and 3' fresh rock to 3115'. Shoe is at 3111'. Will core another 2' and perform shoe leak-off test.

1715 - Turn hole over to fresh mud, attempt to raise surface pressure (to give fracture gradient of 0.7 psi/ft) to 820 psi for leak-off test. Pressure reached >750 psi and bled back to 450 psi when well was shut in. This gives fracture gradient of 0.59 psi/ft, and was approved by BLM. Resumed drilling at 3117'.

21 April 95

0330 - Coring ahead at 3160'. Broken latch ear on overshot.

0800 - Repair completed. Drilling ahead.

1330 - Rigging up for acoustic-while-drilling experiment at 3205'.

1630 - Rig down acoustic test. Resume drilling.

1900 - Drilling ahead at 3245'.

22 April 95

0700 - Drilling at 3326'. Hole is starting to flow back when pumps are stopped to retrieve core. Install lubricator. Drilling performance is good, averaging 7 ft/hr including tripping core tube.

1430 - Drilling at 3400'.

1615 - Rig up acoustic test. Drill ahead.

1830 - Rig down acoustic test. Drill ahead.

23 April 95

0700 - Drilling at 3535'. We are losing more than 50% returns while drilling, but pit volume has not gone down significantly because hole is flowing back when pumps are stopped to retrieve core.

0900 - Survey at 3552'. Inclination = 2°, temperature = 276°F.

1500 - Drilling at 3595'. Temperature = 270°F.

2200 - Begin losing circulation at ~3650'.

24 April 95

0700 - Drilling at 3715'. Losing almost all returns (1-2 gpm back).

1300 - Pulling core from 3755', dropped 16' of it inside rods.

1530 - Worked core barrel back over core and retrieved it. Ground up 5' of core.

1900 - Drilling at 3780'.

25 April 95

0700 - Drilling at 3855'. Inclination survey = 2.5°, downhole temperature (MRT) = 200°F. Temperature measured by MRTs has declined steadily since 3615' but it's unclear why this is happening. During the ~1/2 hour between the temperature measurement by MRTs in the overshot used to retrieve the core barrel and the temperature measured during the inclination survey, the bottomhole temperature recovered to approximately 230°F. This indicates that at least part of the low temperature seen at the bottom is caused by cooling of the inflow fluid on its way down the drillpipe. This speculation is supported by the inflow and outflow mud temperatures, since at times the outflow temp is lower than the inflow.

1900 - Still drilling at 3930', with generally good performance. Bottom-hole temperatures from MRTs remain around 200°F, with inflow and outflow in the mid-60s and losing ~70-80% returns.

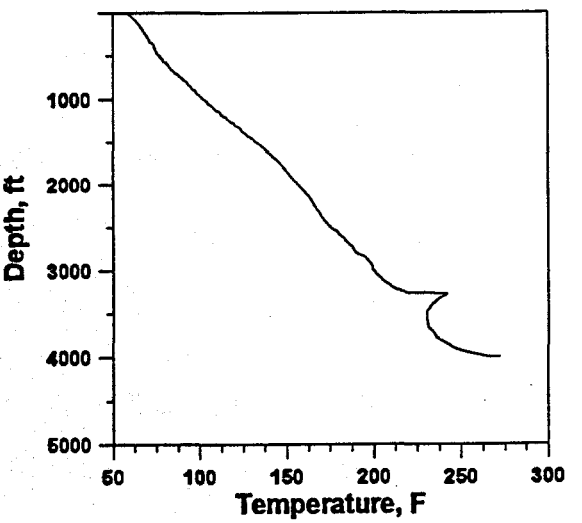
26 April 95

0830 - POOH to check bit and pipe. High torque.

1100 - Bit worn down to carbides in inside and outside gauge. Change to Fordia #9 bit and new reamer shell. Will grease rods on trip in.

1330 - Rods have been tripped out and back in to ~200' above the casing shoe, leaving the bottom of the hole undisturbed for approximately 6 hours. Run in hole for temperature log.

1600 - Temperature log shows major loss zone at approximately 3260' with an apparently sharp temperature reversal below that. This almost certainly does not represent the static temperature below 3260', however, because the hole was warming fairly rapidly (at 3600', temperature increased ~2.4°F in 30 minutes between the down log and the up log.) Most likely explanation is that relatively cool, fresh drilling fluid comes down the drillpipe and back up the annulus to the loss zone, thereby cooling the bottom of the hole.



1900 - Drilling at 4015'.

27 April 95

0700 - Drilling at 4095'. Mostly good drilling performance with MRT temperatures remaining around 215°F.

1315 - Survey at 4153'. Inclination =1.5°, MRT temperature = 250°F.

1830 - Drilling at 4195'.

28 April 95

0700 - Drilling at 4262'. Rate of penetration has slowed.

1230 - Drilling at 4291'. Pressure has increased sharply, appears that bit may be gone. POOH.

1600 - Inside gauge of bit is worn out; carbides gone. Pick up Longyear #6 bit and RIH

1900 - Back on bottom drilling.

29 April 95

0700 - Drilling at 4373'. Vibrations at high RPM and bit weight. Trying to increase pump rate and decrease RPM to control vibrations.

1000 - Change mud mix to include more gel and Tork-ease. This increased pressure and decreased torque. Drilling better.

1900 - Steady all day, 87' at shift change.

2100 - Survey at 4455', inclination = 1.2° and MRT temperature = 270°F

30 April 95

0700 - Drilling at 4495', rock getting blocky. Three blocked runs on night tour.

1800 - Have drilled steadily through the day; now pulling blocked tube (with 17' core) from 4573'. MRT temperatures have run 235-250°F with each core tube.

1 May 95

0700 - Drilling at 4655'; generally good performance. Slow drilling for the last 6' (pushing a block).

0800 - Bad rain storm, still drilling but cannot box core.

1100 - Start reducing Tork-ease to 1/2 bag per tube to cut mud costs.

1500 - Finish acoustic experiments.

1900 - Day shift gets 99.5', night tour left them 20. Another very heavy rain with lightning. Bob Brown (Desert Drilling Fluids) arrives with mud.

2 May 95

0700 - Still good drilling; 4795' at shift change. No torque or vibration problems. Remove bad wire line at ~3000' and redo long splice at 0300. Run Totco survey at 4755'; inclination = 1°, BHT = 278°F.

0800 - Remove power from 3" mag meter and "0" channel. Electronics full of water.

1900 - Drilling at 4865'.

3 May 95

0700 - Drilling at 4939'. Two blocked core runs during night tour. MRT temperatures have fallen from 280°F at 1700 yesterday to 260°F at 0400 this morning, indicating some permeability in the lowest part of the hole.

0900 - Rig up for temperature log while Tonto mud system is being exchanged.

1300 - Log completed. Bottomhole temperature is 280°F, roughly the same as the log done at 4000'. Loss zone at 3260' still shows temperature spike, but the constant loss of drilling mud at unknown depths makes interpretation difficult.

1330 - Lower rods from shoe. Tight spot at 4850'. Wash last 20' down; ~1' of cave at bottom.

4 May 95

0050 - All runs since 1330 have been blocks, with a maximum core of 8.5'. Drilling on a mislatch at 4985'. POOH

0700 - Clear core tube, pick up new bit, and RIH

0930 - Back on bottom, prepared to drill.

1845 - Drilling at 5039'.

1910 - Drilled into void (approximately 1.5-2') at 5044'. Pulled tube because it was full. Run back in hole, bottom of void at ~5046'.

5 May 95

0700 - Drilling at 5105'.

1900 - Drilled through day tour with mostly good core runs. 5185' at shift change.

6 May 95

0700 - Drilling at 5252'. Drilling has been reasonably good through night tour, but fractured rock has produced some blocks (10, 20, 12, and 18' runs since 1900 yesterday.)

1900 - Drilling at 5342'; good drilling through day.

7 May 95

0700 - Good drilling through night; 5418' at shift change. Surveyed hole at 5365', inclination = 2°, MRT temperature = 299°F but reading may be high because of downhole pressure.

1500 - Good drilling through day with mostly full 20' core runs. Drilled through a void (~1') at 5478' and lost returns. Static water level fell approximately 200' in the next few hours after this void. Although core was fractured at this zone, there were no indications of a single, large fracture.

1900 - Drilling ahead at 5501'.

8 May 95

0700 - Just pulled core from 5585'. Good drilling through the night.

1545 - Drilling at 5646', pump pressure is up and erratic. Will POOH for bit change.

2100 - Picked up new bit and rotated reamer shell. Will run back in hole with pressure-temperature memory tool inside a core tube which is latched into the core barrel. This will effectively be a pressure/temperature log as the pipe is tripped into the hole. Because there is no depth encoder associated with the pipe handling, it is necessary to manually input the depth (pipe length) count during the trip.

9 May 95

0130 - Bit is 20' off bottom; RIH with wireline to retrieve core tube/memory tool.

0300 - There is a difficulty in merging the depth file with the temperature/pressure file. We have data, the numbers are there, but software problems prevent data plot.

0600 - Survey hole: inclination = 2°, MRT temperature =270°F. Drill ahead.

1900 - Drilling at 5725'; fairly slow going, but rock is fairly competent and we are getting full 20' core runs.

10 May 95

0700 - Drilling at 5777'. Still moderately good performance although the core tube wasn't retrieved on one run because overshot was sanded in.

2030 - Continued drilling to 5825'. Began pulling out with core rods and laying them down in 10' lengths. The string we have been using to drill will be replaced with old drill pipe for setting the packer and/or for a liner pipe.

11 May 95

0700 - Almost finished laying down pipe.

0830 - Finished laying down drillpipe; rigging up to run temperature-spinner tool.

1030 - Ran in hole with new T-S tool, got to ~1600' and something began shorting out in the tool's electrical circuit. Pulled out of hole and picked up old RTD temperature tool. Ran back in hole.

1115 - More shorts in wireline circuit; will continue running tool in hole because data points between shorts are good.

1230 - Discover that problem is in logging truck's DVM, connect to different meter and re-log from 3000' to 5825'. Log shows that bottom of hole is cooling (approximately 20°F cooler than on previous logs.)

1445 - Rig up to run RTD temperature tool with P-T memory tool hanging below it. Will pump into hole and traverse open-hole section in an attempt to determine where fluid is going. Begin pumping into hole with pump on mud mixing tank; flow rate is only about 30 gpm at wellhead pressure of 75 psig. This is unexpectedly low flow for what appeared to be high-permeability fracture zones.

1545 - Logging ahead, watching temperature of logging tool to assure that it does not get ahead of the fluid front. Flow rate gradually drops to less than 20 gpm, so temperature data is hard to interpret. POOH with logging tools.

1700 - Rig up rental pump rated at 160 psi/400 gpm.

1843 - Begin pumping into hole; maximum pump pressure is 145 psi, which gives an initial flow rate about 80 gpm. Logging tools are in hole at 3000'.

1850 - Still at 145 psi, flow down to 36 gpm.

1930 - Flow has gradually decreased to 26 gpm and is stable at that rate.

2052 - Stop pump and shut-in well.

12 May 95

0200 - PT memory tool ends taking shut-in data: leave in hole

0600 - Log to bottom of hole and POOH. Lay down memory tool and retrieve data.

0840 - Hook up rig pumps (which are positive displacement and will maintain a constant flow rate) to run into wellhead. Pick up second memory tool with RTD tool and RIH. Hang tool at 3800' and start second injection test. Begin pumping 42 gpm; initial pressure is ~100 psi.

0900 - Pressure up to 150 psi.

0920 - Pressure up to 200 psi.

1040 - Pressure at ~250 psi. Shut in well until 1530.

1600 - POOH with logging tools. Begin RIH with used pipe for wiper run.

1730 - Drillstring loses weight with 1440' of rods in the hole. POOH to inspect.

1815 - Remaining string is approximately 780'; lower 660' of pipe is in hole. Begin picking up new drill pipe (the string that was used to drill the hole) to fish. RIH with Bowen spear.

13 May 95

- Stabbed into fish; POOH.

1000 - Have recovered complete fish.

1215 - Pick up inflatable packer and RIH to 5331' (which is a competent zone separating the intervals of apparent permeability.) We will try to swab the hole by pulling a core tube rapidly up the drill pipe; this will draw some water into the zone below the packer. This is the zone which showed large fractures and apparent permeability.

1545 - Set packer. Pull up with 10,000 lb to check set; packer holds.

1630 - Retrieve standing valve from packer and RIH to 2500' with 10' core tube and latch-head on wireline to attempt swabbing the hole.

2400 - Have swabbed the hole with different combinations of wipers, swab depths, etc. Best results come from running in hole to below 5000' and pulling out as fast as possible. Water appears at surface when core tube is at 2200-2500', but flow only lasts for a couple of minutes. Based on velocity, this indicates that each swab is getting only about 100 gallons. Continue swabbing.

14 May 95

0100 - Loop in wireline breaks; core tube and latch-head fall in hole. Rig up overshot and fish for swab assembly.

1130 - Have tried several different overshots, but have not picked up core tube. Release packer and POOH with drillpipe.

1445 - Packer back to surface, it has lost all the outer rubber sealing surface. RIH with temperature tool; attempt to log to bottom.

1600 - Temperature log completed. Bottom of hole has warmed up approximately 10°F in two days, but maximum temperature in hole is 280°F. POOH with logging tool.

1730 - RIH with drillpipe for wiper trip.

2230 - Set down on 20' of fill and packer rubber. Drill to 5815' with water. Pull tube full of rubber and cave.

15 May 95

0030 - Too much vibration to drill cave, POOH, 10' fill in hole.

0430 - Pick up scrap 10' core barrel with rung Fordia #9 bit and a reamer shell blank with a float built-in complete with landing ring. RIH with 630' of scrap HMQ core rod, sub to H-Tuff rod, 1880' H-Tuff rod, sub back to HMQ, 210' good HMQ, back off sub (HMQ pin to left hand NWL casing thread box with mating sub back to HMQ box), 3100' HMQ drill rods.

0945 - Break circulation with water 10' off bottom. Pump 350 gal. of Enviroplug mud to cover backside back to liner with ~ 50 gal excess. Chase with 2250 gal fresh water to displace to float shell. Pressure rise indicates plug lifting - 800 psi.

1200 - Set rods on bottom, Pressure decays slowly. Pick up half string weight and turn to right to back-off sub. Displace backside from 3080' to surface to circulate out excess completion mud. Good returns of water, then mud, and changing back to clear water.

1230 - Break out 3100' HMQ rods in 10' lengths.

1630 - RIH with 640' of HQ stands still in derrick and break out in 10's.

1730 - RIH with rig wireline and tag bottom at 5814'.

1800 - Nipple down BOP stack and clean mud tanks.

2100 - Release rig.

16 May 95

0700 - Rigging down.

1000 - Rain-for-Rent is loading out pump and frac tank.

END OF DRILLING OPERATIONS. PERFORM REPEATED TEMPERATURE LOGS OVER THE NEXT THREE MONTHS, BUT HOLE DOES NOT RECOVER SIGNIFICANTLY FROM TEMPERATURE AT THE END OF DRILLING. RESUME OPERATIONS TO PLUG AND ABANDON HOLE.

8 September 95

1700 - Tonto UDR 1500 arrives and starts rigging up.

1900 - Rig in position over hole.

9 September 95

0700 - Continue rigging up rig and mud system. No CHD 76 rods have arrived, so will use BQ rods until larger rods get here.

1000 - Start to pick up pipe and rig develops hydraulic leak. Return filter plugged with old hose parts from rig re-work in Tonto yard. Wait on filter (being air-shipped from Salt Lake City.)

1730 - Filter arrives from Boise airport. Install filter and RIH with BQ rods.

1900 - There is only one crew for this job. End of day with rods at 750'; hit water level at ~400'.

10 September 95

0700 - Resume picking up BQ rods and RIH.

1100 - Have RIH to 2800' when truck arrives with CHD 76 rods.

1300 - Finish unloading CHD 76 rods and continue RIH, now with these rods.

1730 - Tag bottom at 5811' (measured from ground level.) Start pumping abandonment mud to fill the HQ liner up to 100' below the casing shoe.

1900 - Finish pumping mud and begin POOH.

2000 - End of day with rods pulled back to 5000'.

11 September 95

0700 - Continue POOH.

1130 - Rods out of hole. Pick up cutter and start RIH with CHD 76 rods. Mainline winch not holding, work on hydraulic brake.

1530 - Finish repairs and RIH.

1700 - Cut HQ liner at 3221' KB (110' below casing shoe.) Cut went well. Begin POOH with cutter.

1900 - End of day with rods pulled back to 2200'.

12 September 95

0700 - Continue POOH.

0900 - Pick up Bowen spear and RIH on CHD 76 rods.

1130 - Lock onto cut liner top at 3080' KB and work it free. POOH with rods and cut HQ liner.

1400 - Top of HQ liner arrives at surface; liner top was at 2813', not 3080' as previously believed. This means that there is ~270' of CHD 76 rod inside the HQ liner, and it is necessary to hold both strings while laying down the pipe. Cut off top of 4-1/2" casing so that we can land a clamp for the HQ there while holding the CHD 76 rods in the rig's foot clamp.

1630 - Finish laying down the HQ liner. Start pushing a 4" plug with an internal float down the hole. This plug will sit on top of the cut HQ stub and will be at the bottom of the cement.

1900 - End of day with plug at 2900'.

13 September 95

0700 - Continue pushing plug down.

0800 - Plug stops moving and takes rod weight at 3107'. Try pushing with drill-rig head, but can't push too hard because there is 400' of small diameter BQ rod just above the plug. We use this small rod at the bottom so it will minimize disturbance of the cement when pulling out after pumping the cement. Decide to POOH and replace BQ.

1300 - Set rod weight on plug with CHD 76 rods on bottom of string. Plug goes down easily to 3220'. Try filling hole with water, but it is apparently leaking past the plug.

1400 - Pump 100 gallon LCM pill on top of bridge plug and pull back 5' in preparation for cementing. Wait on water.

1600 - Mix 200 gal (300 linear feet) of Type G cement with 40% silica flour. Pump and displace with 350 gal water using a trash pump. Pull back 6 stands (240') and pump another 300 gal water. Pull another 5 stands and circulate with rig pump.

1700 - Start POOH with CHD 76 rods, laying them down in 40' lengths.

1900 - End of day, laying down rods.

14 September 95

0700 - Continue laying down rods.

0900 - RIH with BQ rods to tag cement plug.

1000 - Tag cement at 2731', somewhat higher than expected. Apparently some cement was strung out when circulating at 2740'.

1030 - Start circulating hole full of abandonment mud.

1300 - Hole full of abandonment mud, pumped ~1890 gal mud. Start laying down BQ in 40' lengths.

1500 - Mix and pump 75 linear-foot cement plug at top of casing. Good cement returns to surface. Lay down remaining drill pipe.

1600 - Rig down drilling equipment and move off location.

1930 - End of day, most equipment loaded and moved.

15 September 95

0700 - Dig out cellar to 6' depth. Finish moving equipment to A-Alt location.

1000 - Cut off 10", 7" and 4-1/2" casings at ~ 6' below ground level.

1200 - Weld cap on 4-1/2" casing, weld identification plaque on cap. Site ready for restoration.

APPENDIX B

The following appendix contains the daily drilling records, including detailed information about drilling fluids, drill bits, lithology, and other activities conducted each day. These reports were prepared and distributed each day to Sandia staff and management, DOE program managers, Trans-Pacific Geothermal Corporation, and other interested researchers. The reports were compiled primarily by the Sandia on-site project leaders, with valuable input from Desert Drilling Fluids and Tonto Drilling field engineers.

DAILY DRILLING REPORT - 7 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 1 | Depth today - 510' | Hole advance last 24 hr - 510'| Core recovered - N/A '
Last casing - 10" conductor @ 51'

BITS -- Now drilling 8-3/4" hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - avg 50 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5

Drilling Assembly: Bit, bit sub, 6" drill collar, stabilizer, DC, stab, 2-DC, crossover, HeavyWeight CHD134 drillpipe, regular CHD drillpipe

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Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	250'	< 1°	N/A	77°F

Drilling fluid - water, bentonite, polymer
Flow rate - 186 gal/min | Pressure - 700 psi | Returns temp - 86°F max |
Wt - 8.5 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8.5
Lost circulation - none

Lithology of past day's drilling: primarily siltstone, with occasional stringers of sandstone conglomerate

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Summary of events last 24 hours:

Mixed mud, picked up tools, and spudded hole at 1230 yesterday. Some problems with shaker screens, but reduced flow rate alleviated most of that. Drilled ahead at very good rates of penetration, above 200 ft/hr at times. Reached casing point (510') at 0330 hours. Pulling out of hole and laying down 8-3/4" tools at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 8 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 2 | Depth today - 510' | Hole advance last 24 hr - 0'| Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS -- Now drilling " hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5

Drilling Assembly:

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	250'	< 1°	N/A	77°F

Drilling fluid - water, bentonite, polymer
Flow rate - 186 gal/min | Pressure - 700 psi | Returns temp - 86°F max |
Wt - 8.5 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8.5
Lost circulation - none

Lithology of past day's drilling: NA

Summary of events last 24 hours:

Laid down 8-3/4" drilling tools. Welded on casing shoe, and RIH with 13 joints (512') of 7" casing. Some fill in hole, so .circulated through casing and washed to bottom. Rigged up Halliburton; pumped ~115 ft^3 of cement. Good cement returns to surface, but cement fell back approximately 50'. WOC for 4 hours and pumped approximately 12 ft^3 cement into annulus. Cement level held steady. WOC for 4 hours, cut off conductor and 7" casing, and weld on wellhead flange. Nippling up BOP at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 9 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 3 | Depth today - 814' | Hole advance last 24 hr - 304'| Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS -- Now drilling 6" hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD, 8 jts CHD134 Heavy-weight

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Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	250'	< 1°	N/A	77°F
	510'	0°	N/A	62°F
	814'	0.5°	N/A	72°F

Drilling fluid - water, bentonite, polymer | Flow rate - 186 gal/min | Pressure - 700 psi |
Returns temp - 86°F max | Wt - 8.5 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8.5
Lost circulation - complete loss at times, but generally healed with LCM

Lithology of past day's drilling: Mostly siltstone with at least 10' sandstone conglomerate; no sample 720-740' (no returns)

Summary of events last 24 hours:

Tested BOPE; witnessed by Dennis Simontacchi, BLM, and Dennis Olmstead, DOGAMI. Picked up 6" drilling assembly and RIH. Tagged top of cement at 469' and circulated at varying rates to calibrate Rolling Float Meter. Drilled out cement to shoe and drilled new hole to 515'. Leak-off test successful, witnessed by BLM and DOGAMI. Drilled ahead, began losing circulation (50-60%) at 720'. Pumped LCM, getting intermittent returns.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 10 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 4 | Depth today - 1286' | Hole advance last 24 hr - 472' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 200 rpm; WOB - 5K lb; Rate of Penetration - avg 30 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1286	817	23.5

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD, 8 jts CHD134 Heavy-weight

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Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	250'	< 1°	N/A	77°F
	510'	0°	N/A	62°F
	814'	0.5°	N/A	72°F
	1050'	<0.5°	N/A	82°F

Drilling fluid - water, bentonite, polymer
Flow rate - 92 gal/min | Pressure - 1700 psi | Returns temp - 92°F max |
Wt - 8.5 lb/gal | Vis - 46 sec | PV - 14 cP | YP - 8 lb/100ft^2 | pH - 7.5
Lost circulation - complete loss at times, but generally healed with LCM

Lithology of past day's drilling: Mostly siltstone to 930'. Limestone and tuff to 980'. Primarily basalt from 980' - 1280' with some tuff, sediment, and altered zones

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Summary of events last 24 hours:

Drilled ahead to 882', lost complete returns. Built pit volume and pumped LCM, drilled blind to 912'. Regained partial returns and drilled to 932'. Bracket broke on drill rig; needed to stop circulation to re-weld it. When trip back into casing began, hole began producing approximately 40 gpm. Closed pipe rams, developed no pressure. Resumed trip. Repaired bracket, washed back to bottom, and resumed drilling. Pumped viscous pill at 0445 and started POOH. Tripping at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 11 Apr 95

VALE EXPLORATORY SLIMHOLE

Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level

Days since spud - 5 | Depth today - 1730' | Hole advance last 24 hr - 444' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 200 rpm; WOB - 5K lb; Rate of Penetration - avg 44 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD | BHA length = 258.68'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	1050'	<0.5°	N/A	82°F
	1266'	0.5°	N/A	95°F
	1597'	0.5°	N/A	106°F

Drilling fluid - water, bentonite, polymer, LCM
Flow rate - 92 gal/min | Pressure - 800 psi | Returns temp - 106°F max |
Wt - 8.7 lb/gal | Vis - 48 sec | PV - 18 cP | YP - 14 lb/100ft^2 | pH - 8.5
Lost circulation - averaging 10 bbl/hr, adding LCM

Lithology of past day's drilling:

1280' - 1400'	Mostly claystone and siltstone, minor basalt
1400' - 1440'	Limestone, some siltstone
1440' - 1500'	Majority basalt, some limestone and siltstone
1500 - 1580'	Basalt
1580 - 1710'	Majority basalt, some siltstone and sandstone

Summary of events last 24 hours:

POOH to measure all BHA components. Bit is very good, will re-run. Laid down all BHA tools to measure ID's and OD's. Picked up BHA again and torqued all connections. RIH and drilled ahead; losing some circulation (~10 bbl/hr) but LCM is controlling it.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 12 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 6 | Depth today - 2034' | Hole advance last 24 hr - 304' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 200 rpm; WOB - 10K lb; Rate of Penetration - avg 44 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD | BHA length = 258.68'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	1597'	0.5°	N/A	106°F
	1892'	0.8°	N/A	136°F
	1931'	0.8°	N/A	188°F

Drilling fluid: water, bentonite, polymer, LCM | Flow rate - 92 gal/min | Pressure - 750 psi |
Returns temp - 117°F max | Wt - 8.7 lb/gal | Vis - 46 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8.5
Lost circulation - averaging 10 bbl/hr, adding LCM

Lithology of past day's drilling:

1710 - 1770	Majority basalt, some siltstone
1770 - 1780	Mostly ash, some basalt
1780 - 1830	Mostly siltstone, some basalt
1830 - 1880	Siltstone and ash
1880 - 1890	Tuff and siltstone
1890 - 1960	Mostly basalt, some tuff and siltstone
1960 - 2030	Basalt, tuff, and siltstone

Summary of events last 24 hours:

POOH to measure all BHA components. Bit is very good, will re-run. Laid down all BHA tools to measure ID's and OD's. Picked up BHA again and torqued all connections. RIH and drilled ahead; losing some circulation (~10 bbl/hr) but LCM is controlling it. Bit showing some torque at 1945', will POOH to change bit. Picked up new bit and RIH for temperature (188°F) and inclination (0.75°) survey at 1931'. Drilling ahead at 2034' when pump pressure drops from 750 psi to 440 psi. Coming out of hole at report time to look for probable washout.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 13 Apr 95

VALE EXPLORATORY SLIMHOLE

Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level

Days since spud - 7 | Depth at report time - 2062' | Hole advance last 24 hr - 28' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 160 rpm; WOB - 10K lb; Rate of Penetration - <10 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	12.5

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD | BHA length = 258.68'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	1597'	0.5°	N/A	106°F
	1892'	0.8°	N/A	136°F
	1931'	0.8°	N/A	188°F

Drilling fluid: water, bentonite, polymer, LCM
Flow rate - 72 gal/min | Pressure - 1750 psi | Returns temp - 123°F max |
Wt - 8.7 lb/gal | Vis - 46 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8.5 | Lost circulation - none

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Lithology of past day's drilling:

2030 - 2050	Approximately half basalt, remainder tuff and siltstone
2050 - 2060	Mostly basalt

Summary of events last 24 hours:

Pulled out of hole to check for washout. Crossover between CHD134 drillpipe and top of collars was belled and drillpipe pin was washed almost in two (pin sheared off drillpipe when trying to break the connection.) Picked up original crossover and ran back in hole. Drilled ahead, pump pressure increased to >1700 psi, probably a plugged jet. Rate of penetration down to <2 ft/hr at times, possibly bit balling or hard formation, but this performance is consistent with previous well. Bit starts torquing at 2062', decide to POOH. Bit has lost all three cones. Pick up fishing magnet and RIH. Work magnet at bottom of hole. POOH with magnet at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 14 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 8 | Depth at report time - 2077' | Hole advance last 24 hr - 15' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 160 rpm; WOB - 10K lb; Rate of Penetration - ~10 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ	2077			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD | BHA length = 258.68'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	1931'	0.8°	N/A	188°F
	2027'		N/A	166°F

Drilling fluid: water, bentonite, polymer, LCM
Flow rate - 90 gal/min | Pressure - 800 psi | Returns temp - 126°F max |
Wt - 8.7 lb/gal | Vis - 45 sec | PV - 12 cP | YP - 12 lb/100ft^2 | pH - 8 |
Lost circulation - losing up to 40 bbl/hr while drilling, pumped gel pill and cut to 20 bbl/hr

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Lithology of past day's drilling:
2060 - 2070 30% Basalt, 20% Tuff, 50% Siltstone

Summary of events last 24 hours:

Came out of hole with junk magnet; magnet carried bearings, portions of cones, and other junk. Gouges on sides of magnet housing indicate that some junk has been pushed back into the wellbore walls. RIH with new bit. Rate of penetration drops very quickly, to <2 ft/hr, and pump pressure falls from ~800 psi to ~500 psi. POOH. Connections are bad on several of the CHD134 heavy-weight drillpipe and on the transition from the HW to regular CHD134. Second collar has severely washed box (and pin of stabilizer above it); metal is parted for more than half the circumference. Bit is severely worn, almost all teeth worn off. Laid down bad collar and stabilizer, inspected HW drillpipe. Picked up insert bit and RIH. Broke circulation mid-trip and plugged bit with LCM. POOH and cleaned out bit, RIH at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 15 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 9 | Depth at report time - 2334' | Hole advance last 24 hr - 257' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS: Now drilling 6" hole | Rotary speed - 70 rpm; WOB - 10K lb; Rate of Penetration - 24 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 5-DC, crossover to CHD | BHA length = 258.68'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	1931'	0.8°	N/A	188°F
	2027'		N/A	166°F
	2246'	1.0°	N/A	162°F

Drilling fluid: water, bentonite, polymer, LCM
Flow rate - 128 gal/min | Pressure - 270 psi | Returns temp - 134°F max |
Wt - 8.8 lb/gal | Vis - 49 sec | PV - 12 cP | YP - 10 lb/100ft^2 | pH - 8 | Lost circulation - none

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Lithology of past day's drilling:

2070 - 2080	Basalt 70%, siltstone 30%
2080 - 2170	Basalt
2170 - 2190	Basalt 70-90%, siltstone 10-30%
2190 - 2240	Basalt
2240 - 2280	Basalt 40-80%, tuff 20-50%, siltstone <20%
2280 - 2320	Basalt

Summary of events last 24 hours:

RIH with periodic circulation to check for bit plugging. Bit plugs on way in, POOH. Clean out bit and add one jet; had been drilling with one jet blanked for better bottom-hole cleaning. Run back in hole, stopping every 400' to circulate. Wash last 100' to bottom. Drill ahead with lower rotary speed than before, gradually increasing bit weight. Good drilling performance, ranging from 15 to 60 ft/hr. Drilling ahead at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 16 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 10 | Depth at report time - 2935' | Hole advance last 24 hr - 601' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS | Now drilling 6" hole | Rotary speed - 70 rpm | WOB - 10K lb | Rate of Penetration - avg 24 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077			

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 7-DC (including 9' lead collar), 2 crossovers to CHD134 | BHA length = 297.91'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	2246'	1.0°	N/A	162°F
	2560'	1.2°	N/A	162°F

Drilling fluid: water, bentonite, polymer, LCM
Flow rate - 128 gal/min | Pressure - 750 psi | Returns temp - 142°F max |
Wt - 8.8 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 11 lb/100ft^2 | pH - 7.5 | Lost circulation - lost complete returns at 2699' and 2727', regained with LCM. Losing up to 50% returns since then.

Lithology of past day's drilling:

2320 - 2540	Basalt
2540 - 2570	Tuff
2570 - 2610	Predominantly basalt and tuff, <20% siltstone
2610 - 2660	Majority basalt, some tuff
2660 - 2710	Majority basalt, some tuff
2710 - 2750	Basalt; 20' interval with no returns
2750 - 2850	Basalt and crystal lithic tuff, in varying proportions
2850 - 2900	Primarily ash tuff, some basalt

Summary of events last 24 hours:

Drilled from 2334' to 2699' in 15 hours. Lost complete returns. Pumped LCM and regained circulation. Lost again at 2727', regained at 2739'. Drilled ahead to 2935' at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 17 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 11 | Depth at report time - 3112' | Hole advance last 24 hr - 177' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS | Now drilling 6" hole | Rotary speed - 70 rpm | WOB - 10K lb | Rate of Penetration - avg 26 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40

Drilling Assembly: 6" bit, bit sub, 4-3/4" drill collar, integral blade stabilizer, DC, IBS, DC, IBS, 7-DC (including 9' lead collar), 2 crossovers to CHD134 | BHA length = 297.91'

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	2246'	1.0°	N/A	162°F
	2560'	1.2°	N/A	162°F
	2935'	1.8°	N/A	142°F

Drilling fluid - water, bentonite, polymer, LCM
Flow rate - 105 gal/min | Pressure - 750 psi | Returns temp - 100°F max |
Wt - 8.6 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 8 lb/100ft^2 | pH - 7.5 | Lost circulation - lost complete returns at 2699' and 2727', regained with LCM. Complete loss at 3053'. Losses ranging from 40% to total since then.

Lithology of past day's drilling:

2910 - 3060	Basalt (no sample from 3040 - 3050)
3040 - 3090	Basalt 60-80%, tuff 10-30%, siltstone 0-30%
3090 - 3112	Basalt 30-80%, siltstone 20-70%

Summary of events last 24 hours:

Drilled from 2935' to 3043'. Lost complete returns, pumped LCM, pumped gel pill. Lost circulation 40% to total from 3050' to bottom of 6" hole at 3112'. POOH to top of collars, then wiper trip. Rigging up to run Halliburton Logging Services at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 18 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 12 | Depth at report time - 3112' | Hole advance last 24 hr - 0' | Core recovered - N/A '
Last casing - 7", 23# casing @ 510'

BITS | Now drilling 6" hole | Rotary speed - xx rpm | WOB - xx lb | Rate of Penetration - avg xx ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40

Drilling Assembly:

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	2935'	1.8°	N/A	142°F

Drilling fluid - water, bentonite, polymer, LCM
Flow rate - 105 gal/min | Pressure - 750 psi | Returns temp - 100°F max |
Wt - 8.6 lb/gal | Vis - 42 sec | PV - 12 cP | YP - 8 lb/100ft^2 | pH - 7.5 | Lost circulation - lost complete returns at 2699' and 2727', regained with LCM. Complete loss at 3043'. Losses ranging from 40% to total since then.

Lithology of past day's drilling:
N/A

Summary of events last 24 hours:

Ran in hole with Halliburton Logging Services tool, logged to bottom (natural gamma, dual induction, temperature, caliper.) Rigged down HLS, ran Sandia temperature log, bottomhole temperature = 217°F at 3082'. POOH with logging tool. Pumped fresh (cold) mud into hole and re-logged, identifying some loss zones. We will run 4-1/2" casing, displace cement through the shoe, WOC, then do a surface squeeze. Pulling out of hole and laying down drillpipe at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 19 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level .
Days since spud - 13 | Depth at report time - 3112' | Hole advance last 24 hr - 0' | Core recovered - N/A '
Last casing - 4-1/2", 11.6# casing @ ~3110'

BITS | Now drilling x" hole | Rotary speed - xx rpm | WOB - xx lb | Rate of Penetration - avg xx ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40

Drilling Assembly:

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**

Drilling fluid - N/A

Lithology of past day's drilling: N/A

Summary of events last 24 hours:

Laid down all CHD134 drillpipe and 6" drilling tools. Ran 4-1/2" casing. Displace ~ 650 ft^3 cement through shoe, no cement returns to surface, but pump pressure indicated lifting cement at least 1000'. WOC and pump 275 ft^3 cement down annulus for top job, and it fell away. Will WOC and pump another top job. Rigging up for temperature log, to locate top of cement, at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 20 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 14 | Depth at report time - 3112' | Hole advance last 24 hr - 0' | Core recovered - N/A '
Last casing - 4-1/2", 11.6# casing @ 3110'

BITS | Now drilling x" hole | Rotary speed - xx rpm | WOB - xx lb | Rate of Penetration - avg xx ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40

Drilling Assembly: xxx

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	3050'			244°F

Drilling fluid - N/A

Lithology of past day's drilling: N/A

Summary of events last 24 hours:

Pumped second cement top-job, took approximately 125 cubic feet. WOC, then cut off 4-1/2" casing. Nipple down BOP, weld in centering ring between 7" and 4-1/2" casing, and nipple up BOP.on original 7" wellhead. Test BOP for BLM witnesses. All tests successful. Began picking up HQ core rods to RIH and drill out cement and shoe. In hole to 2515' at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 21 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 15 | Depth at report time - 3160' | Hole advance last 24 hr - 48' | Core recovered - 48'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS | Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - xx lb | Rate of Penetration - ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	3050			244°F

Drilling fluid - - water, bentonite, polymer
Flow rate - 20 gal/min | Pressure - 460 psi | Returns temp - 104°F max |
Wt - 8.5 lb/gal | Vis - 38 sec | PV - 10 cP | YP - 8 lb/100ft^2 | pH - 8.5 | Lost circulation - minor

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Lithology of past day's drilling:
3112 - 3160 Basalt

Summary of events last 24 hours:

Run in hole and tag cement at 3063'. Drill out cement, insert float, cement in bottom joint of casing, float shoe, cement below casing, and 5' of fresh rock. Turn hole over to fresh mud, attempt to raise surface pressure (to give fracture gradient of 0.7 psi/ft) to 820 psi for leak-off test. Pressure reached >750 psi and bled back to 450 psi when well was shut in. This gives fracture gradient of 0.59 psi/ft, and was approved by BLM. Resumed drilling at 3117'. Coring ahead at 3160' at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 22 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 16 | Depth at report time - 3325' | Hole advance last 24 hr - 165' | Core recovered - 165'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS | Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Rate of Penetration - ~7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	3265'	2.7°	N/A	276°F
	3285'			266°F
	3305'			268°F
	3325'			268°F

Drilling fluid - - water, bentonite, polymer
Flow rate - 24 gal/min | Pressure - 250 psi | Returns temp - 98°F max |
Wt - 8.5 lb/gal | Vis - 38 sec | PV - 12 cP | YP - 7 lb/100ft^2 | pH - 8 | Lost circulation - losing >50%

Lithology of past day's drilling:

3160 - 3186	Basalt
3186 - 3236	Basalt flow breccia
3236 - 3326	Basalt

Summary of events last 24 hours:

Cored ahead from 3160' with good drilling performance. Instantaneous rate of penetration is over 10 ft/hr but time required for pulling core reduces the overall average to ~7 ft/hr. We are losing more than 50% returns while drilling, which is almost ideal for drilling because it keeps the mud fresh and cool. Rigged up and ran acoustic experiment.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 23 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 17 | Depth at report time - 3535' | Hole advance last 24 hr - 209' | Core recovered - 209'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS | Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Rate of Penetration - ~9 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	3345'			276°F
	3385'			270°F
	3415'			272°F
	3455'			268°F
	3495'			275°F

Drilling fluid - - water, bentonite, polymer
Flow rate - 24 gal/min | Pressure - 250 psi | Returns temp - 80°F max |
Wt - 8.5 lb/gal | Vis - 38 sec | PV - 14 cP | YP - 10 lb/100ft^2 | pH - 8 | Lost circulation - losing >50% returns while drilling, but regaining most of it in the pits because hole flows back when pulling core

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Lithology of past day's drilling:

3325 - 3354	Basalt
3354 - 3372	Basalt flow breccia
3372 - 3398	Basalt
3398 - 3440	Basalt flow breccia
3340 - 3535	Basalt

Summary of events last 24 hours:

Cored ahead from 3325' with good drilling performance. Instantaneous rate of penetration is 13-15 ft/hr but time required for pulling core reduces the overall average to ~9 ft/hr. We are losing more than 50% returns while drilling, but pit volume has not gone down significantly because hole is flowing back when pumps are stopped to retrieve core. Ran acoustic experiment again.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 24 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 18 | Depth at report time - 3695' | Hole advance last 24 hr - 160' | Core recovered - 160'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Rate of Penetration - ~9 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	3552'	2°	N/A	276°F
	3595'			270°F
	3635'			268°F
	3655'			250°F
	3675'			236°F

Drilling fluid: water, bentonite, polymer
Flow rate - 24 gal/min | Pressure - 250 psi | Returns temp - 80°F max |
Wt - <8.5 lb/gal | Vis - 36 sec | PV - 10 cP | YP - 4 lb/100ft^2 | pH - 8 |
Lost circulation - losing >60% returns below 3675'

Lithology of past day's drilling:

3535 - 3695 Basalt and basalt flow breccia, interception of open fracture with drusy quartz lining at 3669'

Summary of events last 24 hours:

Drilled from 3535', still with good drilling performance. Lost circulation at ~3665', getting less than 20% returns. Well is not flowing back at core retrieval. Bottom-hole temperatures have decreased, caused by lost circulation and possibly by interception of a cooler aquifer.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 25 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 19 | Depth at report time - 3855' | Hole advance last 24 hr - 160' | Core recovered - 155'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	3552'	2°	N/A	276°F
	3855'	2.5°	N/A	230°F

Drilling fluid: water, bentonite, polymer
Flow rate - 24 gal/min | Pressure - 250 psi | Returns temp - 70°F max |
Wt - <8.5 lb/gal | Vis - 36 sec | PV - 10 cP | YP - 4 lb/100ft^2 | pH - 8 |
Lost circulation - losing >80% returns

Lithology of past day's drilling:

3695 - 3735'	Basalt
3735 - 3848'	Lithic tuff

Summary of events last 24 hours:

Drilled from 3695', still with good performance. Bit is cutting well, with instantaneous penetration rates above 10 ft//hr. Dropped 16' of core inside drillpipe, but were able to work over it and retrieve 11' without tripping rods. Lost 5' of core in process. Bottomhole temperatures (measured by maximum-reading-thermometers in wireline ovreshot) continued to fall, possibly due to lost circulation, but during the period of approximately 30 minutes between core retrieval and the inclination survey at 3855', the bottom of the hole recovered about 30°F. This indicates that low temperatures measured may be caused by the cooling effect on down-going fluid in the drillpipe, but if the fluid is static in the hole, it will tend toward the undisturbed formation temperature.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 26 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 20 | Depth at report time - 3975' | Hole advance last 24 hr - 120' | Core recovered - 120'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 5 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	3855'	2.5°	N/A	230°F

Drilling fluid: water, bentonite, polymer
Flow rate - 18 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 38 sec | PV - 10 cP | YP - 8 lb/100ft^2 | pH - 8.5 | Lost circulation - losing >80%

Lithology of past day's drilling:
3848 - 3955' Basalt

Summary of events last 24 hours:

Drilled from 3855' with little change in drilling conditions except that rate of penetration is gradually decreasing due to increased downhole torque. Tripped back into casing, rotated rods, and torque was still high. Changed mud mix but torque still high. Will POOH to check tools and lubricate rods. Temperatures from MRTs continue to be about the same, but these may not reflect true bottom-hole conditions.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 27 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 21 | Depth at report time - 4095' | Hole advance last 24 hr - 120' | Core recovered - 117'
Last casing - 4-1/2", 11.6# casing @ 3111'

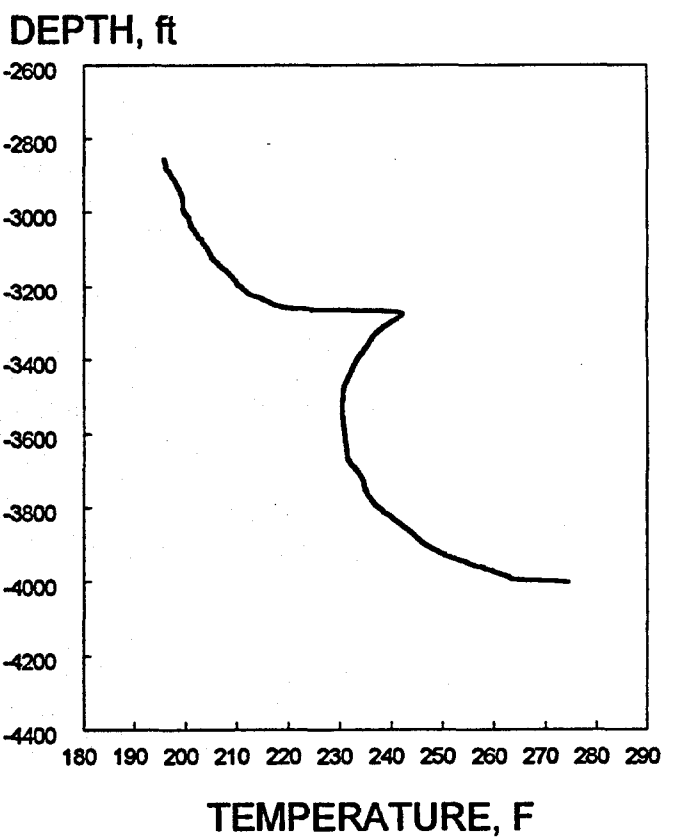
BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 5 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	fin
7	#9 impreg	3995			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	3855'	2.5°	N/A	230°F

Lithology of past day's drilling:
3955 - 4095 Basalt, with major, calcite-filled fracture from 4028 to 4037'.

Summary of events last 24 hours: POOH for bit trip. Inside and outside gauge on bit were worn. Picked up #9 bit and RIH to 2800' (above casing shoe.) Ran temperature log. Log shows major loss zone at 3270', which has probably been responsible for lower bottom-hole temperatures. Cool drilling fluid has been traveling down the drillpipe, coming up to the loss zone, and out into the formation. This has cooled the interval below the loss, but with circulation stopped, this interval warms up. The up log was measurably warmer than the down log, indicating that the hole is warming relatively quickly.



Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 28 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 22 | Depth at report time - 4255' | Hole advance last 24 hr - 160' | Core recovered - 160'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 10 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	#9 impreg.	3995			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	3855'	2.5°	N/A	230°F
	4153'	1.5°	N/A	250°F

Drilling fluid: water, bentonite, polymer
Flow rate - 12-14 gal/min | Pressure - 120 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 38 sec | PV - 10 cP | YP - 8 lb/100ft^2 | pH - 8.5 |
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Drill ahead from 4095' with no returns except when pumping tube down. Work on mud mix to reduce torque and vibrations. Drilling still generally good, although formation appears to be getting somewhat harder.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 29 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 23 | Depth at report time - 4355' | Hole advance last 24 hr - 100' | Core recovered -100 '
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	4153'	1.5°	N/A	250°F

Drilling fluid: water, bentonite, polymer
Flow rate - 14-16 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 35 sec | PV - 6 cP | YP - 5 lb/100ft^2 | pH - 8 to 8.5 |
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Drilled from 4255'. Pump pressure went up sharply at 4291', POOH for new bit. Inside gauge on bit was rung. Picked up new bit and RIH. Drilled to 4355' at report time with vibration problems. Fluid level staying at ~ 120' while pulling core tube and fair returns while pumping core tube down.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 30 Apr 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 24 | Depth at report time - 4495' | Hole advance last 24 hr - 140' | Core recovered -140 '
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	4153'	1.5°	N/A	250°F
	4455'	1.2°	N/A	270°F

Drilling fluid: water, bentonite, polymer
Flow rate - 14-16 gal/min | Pressure - 140 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 40 sec | PV - 10 cP | YP - 9 lb/100ft^2 | pH - 8.5 |
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Drilling steady with low torque and no vibration problems. Three blocked core runs. Returns up and temperatures up a bit.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 1 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 25 | Depth at report time - 4635' | Hole advance last 24 hr - 140' | Core recovered - 140'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	4153'	1.5°	N/A	250°F
	4455'	1.2°	N/A	270°F

Drilling fluid: water, bentonite, polymer
Flow rate - 14-16 gal/min | Pressure - 140 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 40 sec | PV - 10 cP | YP - 9 lb/100ft^2 | pH - 8.5 |
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Drilled from 4495' with generally good performance. Rate of penetration is running 6-7 ft/hr, including pulling the core tube. MRT temperatures from the wireline overshot continue to be 240-250°F

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 2 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 26 | Depth at report time - 4795' | Hole advance last 24 hr - 160' | Core recovered - 160'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	4455'	1.2°	N/A	270°F
	4755'	1°	N/A	278°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 38 sec | PV - 10 cP | YP - 7 lb/100ft^2 | pH - 8.5-9 |
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Working to reduce mud costs. Drilled from 4635' with good penetration rate and no torque or vibration problems. Rock has lots of high-angle fractures and rubble but is causing surprisingly few blocked tubes. Rigged up acoustic experiment and listened to rig/drillpipe noise. Inclination survey showed hole is still very straight (1°) and MRT temperatures at that survey were up slightly (278°F.)

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 3 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 27 | Depth at report time - 4932' | Hole advance last 24 hr - 137' | Core recovered - 137'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	4755'	1°	N/A	278°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 40 sec | PV - 10 cP | YP - 7 lb/100ft^2 | pH - 8.5
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Not yet logged

Summary of events last 24 hours:

Drilled from 4795' with fairly good rate of penetration, but with two blocked core runs. Core is more highly fractured and appears to be permeable. Rigging up for temperature log during mud system changeout.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 4 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 28 | Depth at report time - 4985' | Hole advance last 24 hr - 53' | Core recovered - 46'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291	4985	694	
9	Fordia #6 impreg.	4985			

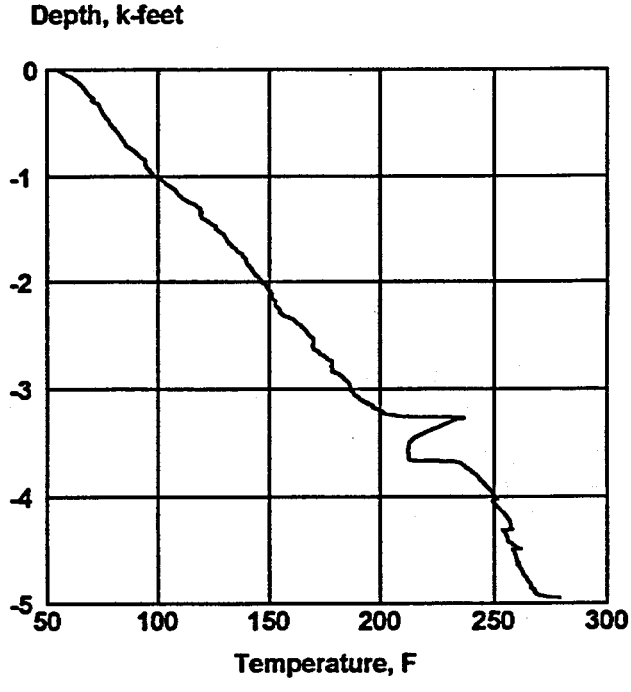
Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	4755'	1°	N/A	278°F

Lithology of past day's drilling:
Basalt

Summary of events last 24 hours:

Drilled from 4932' to 4942' and pulled rods up to casing shoe for Tonto mud system exchange. Ran temperature log and POOH with logging tool. Ran back in hole with coring tools and drilled to 4985'. Runs were all short, from 3' to 9', because of core blocks. Core tube mislatched at 0200 hours, POOH with rods and pick up new bit.

Report by: John Finger/Ron Jacobson



DAILY DRILLING REPORT - 5 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 29 | Depth at report time - 5105' | Hole advance last 24 hr - 120' | Core recovered - 119'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291	4985	694	
9	Fordia #6 impreg.	4985			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	5065'	2°	N/A	292°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 39 sec | PV - 10 cP | YP - 7 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Basalt

Summary of events last 24 hours:

Run in new bit and core ahead with partial returns. Rock badly broken causing some short runs. Void from 5044' to 5046'. Fracture surfaces show new mineralogy. Core more competent, with 20' runs, at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 6 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 30 | Depth at report time - 5245' | Hole advance last 24 hr - 140' | Core recovered - 140'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	
7	Fordia #9 impreg.	3995	4291	296	
8	Longyear #6 impreg.	4291	4985	694	
9	Fordia #6 impreg.	4985			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	5065'	2°	N/A	292°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 39 sec | PV - 9 cP | YP - 8 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Basalt

Summary of events last 24 hours:

Drilled from 5105' with generally good drilling performance except for some short core runs caused by fractured rock. Current plan is to stop drilling on 10 May, do temperature-pressure-spinner logs and injection tests on 11 May, hang liner in lower part of hole and release rig on 12 or 13 May.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 7 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 31 | Depth at report time - 5405' | Hole advance last 24 hr - 160' | Core recovered - 160'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985			

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	5065'	2°	N/A	292°F
	5365'	2°	N/A	299°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - 40 sec | PV - 10 cP | YP - 7 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:

5245 - 5328	Basalt
5328 - 5405	Silicified rhyolite flow breccia, with pervasive fractures

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Summary of events last 24 hours:

Drilled from 5245' with generally smooth drilling (occasional high torque) and complete core runs.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 8 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 32 | Depth at report time - 5585' | Hole advance last 24 hr - 180' | Core recovered - 179'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	5065'	2°	N/A	292°F
	5365'	2°	N/A	299°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - 150 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - <40 sec | PV - 11 cP | YP - 5 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Rhyolite flow breccia and lithic tuff

Summary of events last 24 hours:

Drilled from 5405' with good drilling performance in rhyolite. Drilled through ~1' void at 5478' and lost returns. Continued pumping and got some fluid back. This zone probably has high permeability, which will be more fully evaluated with injection test. Continued drilling with good performance - 180' day.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 9 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 33 | Depth at report time - 5665' | Hole advance last 24 hr - 80' | Core recovered - 80'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985	5646	661	
10	Fordia #6 impreg.	5646			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	5365'	2°	N/A	299°F
	5665'	2°	N/A	270°F

Drilling fluid: water, bentonite, polymer
Flow rate - 11-14 gal/min | Pressure - <20 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - <40 sec | PV - 11 cP | YP - 5 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:
Rhyolite flow breccia and lithic tuff, less permeable than interval just above

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Summary of events last 24 hours:

Drilled from 5585' to 5646', pump pressured up, bit gone. Pulled out for bit change, inner gauge on bit was completely gone. Ran back in hole with pressure-temperature memory tool in inner core barrel. When bit was 20' off bottom, ran in with wireline, retrieved inner barrel with memory tool, and pumped down another inner barrel. Resumed drilling. Difficulty with merging depth and temperature data files from log, no log data at report time. Log will be available later.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 10 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 34 | Depth at report time - 5765' | Hole advance last 24 hr - 100' | Core recovered - 100'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985	5646	661	60
10	Fordia #6 impreg.	5646			

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	5365'	2°	N/A	299°F
	5665'	2°	N/A	270°F

Drilling fluid: water, bentonite, polymer
Flow rate - ~14 gal/min | Pressure - <20 psi | Returns temp - 70°F max |
Wt - 8.4 lb/gal | Vis - <40 sec | PV - 10 cP | YP - 11 lb/100ft^2 | pH - 8.5$^+$
Lost circulation - no returns when pumping <14 gpm

Lithology of past day's drilling:

Rhyolite flow breccia and lithic tuff. Fluid inclusion analysis in calcite (the last mineral deposited) indicates a deposition temperature of ~338°F

Summary of events last 24 hours:

Drilled from 5665' with higher torque and slower penetration than previously. Still no pump pressure when pumping ~15 gpm, indicating that fluid is going out of the hole near the bit. Waiting on a shipment of pipe from Tonto. This is used pipe which will be used for testing and to hang the packer, and then left in place for several months until well is abandoned. When this pipe arrives we will begin laying down the pipe now in the hole and picking up the testing pipe. Drilling ahead at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 11 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 35 | Depth at report time - 5825' | Hole advance last 24 hr - 60' | Core recovered - 60'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985	5646	661	60
10	Fordia #6 impreg.	5646	5825	179	

Surveys:	**Depth**	**Inclination**	**Direction**	**Bottom-hole Temperature**
	5665'	2°	N/A	270°F

Drilling fluid: N/A

Lithology of past day's drilling:
Rhyolite flow breccia and lithic tuff.

Summary of events last 24 hours:

Drilled from 5765' to 5825' with reasonably good performance. Began POOH at 2030 yesterday. Laying down drillpipe in 10' joints and loading it on truck. Will begin testing, doing static temperature log first, after all pipe is laid down; hole will have had ~12 hours without circulation when log begins..

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 12 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 36 | Depth at report time - 5825' | Hole advance last 24 hr - 0' | Core recovered - 0'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS: Now drilling 3.85" hole | Rotary speed - 250 rpm | WOB - 2-3K lb | Penetration Rate - avg 6-7 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985	5646	661	60
10	Fordia #6 impreg.	5646	5825	179	

Surveys:	Depth	Inclination	Direction	Bottom-hole Temperature
	5665'	2°	N/A	270°F

Summary of events last 24 hours:

Finished laying down drillpipe; rigged up and ran temperature-spinner tool to ~1600'; short in circuit, POOH. Ran back in hole with RTD temperature tool, more shorts. Found problem in surface instrumetation, pulled up to shoe and re-logged from 3000' to TD. Ran in using RTD tool with pressure-temperature memory tool hanging below it; pumping into hole while logging. Were not able to maintain constant flow rate, so POOH with logging tools. Switched to larger pump and ran back in hole with same logging tools. Parked tool at 3000' while running pump at maximum pressure (145 psi) until flow rate stabilized at 26 gpm. This means that open-hole permeability is very low. Traversed to bottom with logging tools, came back up to 3800', parked tools, and shut well in for approximately 5 hours. Traversed back to bottom for temperature log and POOH. Retrieving data from memory tool at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 13 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 37 | Hole Total Depth - 5825'
Last casing - 4-1/2", 11.6# casing @ 3111'

BITS:

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	STC 8-3/4" FDS	47	510	463	9.5
2	HTC 6" GT-1	469	1945	1446	47.0
3	STC 6" FDT	1945	2062	117	10.5
4	HTC 6" GT-1	2062	2077	15	2.5
5	HTC 6" ATJ-11	2077	3112	1035	40
6	Longyear #6 impreg.	3063	3995	932	88
7	Fordia #9 impreg.	3995	4291	296	43
8	Longyear #6 impreg.	4291	4985	694	95
9	Fordia #6 impreg.	4985	5646	661	60
10	Fordia #6 impreg.	5646	5825	179	

Summary of events last 24 hours:

First injection test and shut-in test were done after injecting water with a large centrifugal pump which wasn't able to hold a constant flow rate. It eventually stabilized at 26 gpm with a wellhead pressure of 145 psi. In an attempt to get a higher flow rate, we plumbed the rig pump (positive displacement) through the Doppler flow meter into the well. Used this pump to inject at the higher rate of 42 gpm at ~235 psi. Shut well in for approximately 5 hours. POOH and laid down memory tool. Preliminary analysis of shut-in data indicates that transmissivity is about 600 mDa-ft. Began running in hole with used drill pipe (which will be the packer-set string) for wiper trip. Connection failed on drill pipe, 660' of fish in hole. Picked up new drillpipe again for fishing; RIH with Bowen spear. Stabbed into fish, coming out of hole with fish at report time.

Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 14 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 38 | Hole Total Depth - 5825' | Last casing - 4-1/2", 11.6# casing @ 3111'

Summary of events last 24 hours:

Pulled out of hole with complete fish. Laid down fish, which contained a large amount of cave (rock fragments sucked out of the wellbore wall as the fish went by.) Picked up inflatable packer and ran in hole to 5331'; set packer at that depth (which is an interval of competent rock separating the upper and lower loss zones), retrieved standing valve from packer, and rigged up to swab the hole with a core tube on the wireline. Swabbed until 0100, when wireline loop broke and dropped core tube in hole. Difficult to get a count on total water removed from hole, but based on time and velocity it appears to be 500-1000 gallons. Fishing for core tube at report time.

Report by: John Finger/Ron Jacobson

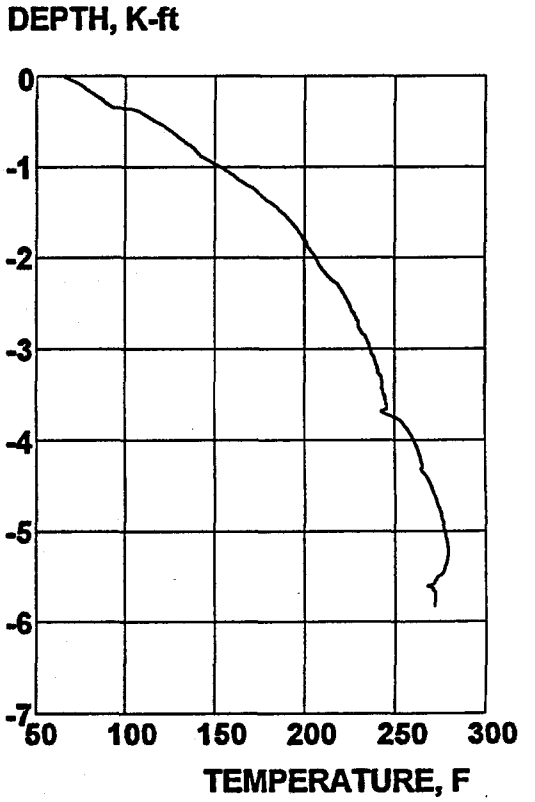
DAILY DRILLING REPORT - 15 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 39 | Hole Total Depth - 5825' | Last casing - 4-1/2", 11.6# casing @ 3111'

Summary of events last 24 hours:

Continued fishing for dropped core tube until 1130, could not retrieve it. Release packer and POOH with drill pipe. Packer lost outer rubber sealing surface. RIH with temperature tool for log to bottom. Bottom of hole has warmed up approximately 10°F in two days, but maximum temperature in hole is 280°F. POOH with logging tool. RIH with drillpipe for wiper trip. Drilled up rubber from packer and brought it back in core tube. Circulated hole. POOH, laid down bit and core barrel, picked up used bit, reamer shell case with float, and short core barrel. Ran in hole to 2745' with 630' of HMQ liner pipe, 1880' of HQ core rod (good quality but non-standard thread), and 210' of the drilling-string rods. Running in hole at report time. Will pick up left-hand-thread backoff sub at 2745' and run to bottom. Next step is to circulate a heavy, abandonment mud up the annulus of the liner and displace with water behind a rubber plug. Turning the drillstring to the right will then release at 3080'. POOH with drillstring from 3080' and lay down pipe. Will nipple down BOP and release rig within the next 24 hours.



Report by: John Finger/Ron Jacobson

DAILY DRILLING REPORT - 16 May 95
VALE EXPLORATORY SLIMHOLE
Time of report - 0700

Well number - TGC 61-10 | Location - Section 10, T19S, R45E, Malheur County, OR

All depth measurements refer to KB; KB = 11' above ground level
Days since spud - 40 | Hole Total Depth - 5825' |
Last casing - 4-1/2", 11.6# casing @ 3111', HQ liner from 3080' to 5815'

Summary of events last 24 hours:

Ran in hole with 14.5'-long core barrel with built-in float, reamer shell blank and landing ring; 2730' of HQ liner pipe; left-hand-thread backoff sub; and 3100' of HQ drill pipe. Circulated 350 gallons of abandonment mud and displaced with 2250 gallons of water. Set string on bottom at 5815.5'; 9.5' of fill in hole. Backed off sub at 3080' and circulated excess mud out hole. POOH with rest of drillpipe, laying it down. Nippled down BOP, released rig at 2100 hours.

This is the final Daily Drilling Report from the Vale Exploratory Slimhole.

Report by: John Finger/Ron Jacobson

APPENDIX C -- COMPARISON OF ROTARY AND CORE DRILLING

This appendix describes some of the differences between conventional rotary drilling and minerals-type core drilling, and how those differences affect operations for holes where one rig does both types of drilling.

Typical rotary drill rigs, mostly used for fossil-fuel exploration and production, use full diameter bits to drill holes between 6" to 26" in diameter to depths occasionally more than 20,000 feet. The drill string comprises the bit, the drill pipe, and an often complex bottom-hole assembly (BHA) made up of drill collars, stabilizers, reamers, crossovers, and other special tools. The string is turned by a rotary table, which engages the kelly, which applies torque to the string while allowing it to travel downward under its own weight. If coring is done with this kind of rig, the complete drill string must be tripped to retrieve the core sample.

Core rigs, most often used to explore for ore bodies for the minerals industry, use bits which cut a cylindrical kerf in the rock, leaving a core sample protruding up the center of the drill string. Hole diameters are from 2 to 6 inches with corresponding core diameters of 1 to 4 inches. After drilling through some interval (usually 5 to 20 feet), the drill string is raised, breaking off the core, and a wireline is dropped down the inside of the drill string to retrieve the core in its core tube, thus avoiding the necessity for tripping the drill string to get the core sample. The drill string is turned either by a top drive, which uses a hydraulic motor to rotate the entire drill string from its topmost connection, or a chuck, which grips the outside diameter of the drill rod and not only applies torque but can put a down-force on the drill string.

There are tradeoffs between the two kinds of drilling, but in the slimhole program the small hole sizes have favored the use of core rigs. From a cost standpoint, these rigs are sometimes ineffective because in many formations rotary drilling has much faster penetration and can therefore drill those intervals more cheaply. Some drill rigs, such as the UDR5000 and its smaller version the UDR1500, are designed to be used for both types of drilling (UDR is an acronym for "Universal Drill Rig"), which is highly attractive for the applications common to slimhole geothermal exploration. Although these rigs can do both kinds of drilling, they are far more often used for core drilling, and that predominant use is reflected in the tools and procedures normally used in operating these drills. The effect of this on hybrid drilling is described in the topics below.

Drill pipe, tools, and handling: An individual piece of rotary drillpipe is approximately 30' long and has "tool joints" at each end. For added strength, the tool joints are larger in outside diameter than the body of the pipe and are cut with API (American Petroleum Institute) standard threads. These threads are sharply tapered, so that few turns are required to make or break a connection, but to avoid fatigue it is extremely important for the threads' shoulders to be in tight contact, and this requires large make-up and break-out torques (several thousand foot-pounds.) Because of this, rotary rigs use power tongs or tongs with a line from the drawworks to make and break the drill string connections.

Core rods are exactly 10' long and have a constant outside diameter. The thread on these rods is much less tapered than an API thread, with smaller torques for connections, and the rods are often made up with pipe wrenches. If a core rig is to be used extensively for rotary drilling with full BHAs, then be sure when planning the job that the rig and crew will be able to apply the proper torques to the drill string. This can usually be done by rigging some sort of snatch block on the rig floor and using either a rented load-cell or the rig's pressure gauges to measure torque. It's also essential to have the proper bit breaker for the rotary bit, and, equally important, a way to anchor the bit breaker to the rig.

Drill collar length can also present a problem on core drills. If a core drill is large enough for hybrid drilling, it will probably pull 40' stands of pipe, so 30' conventional rotary drill collars can

not be stood back in the derrick and the mast is not tall enough to accept a stand of two collars. Therefore, the collars must be laid down for each trip, which is quite time-consuming. The best solution for this is 20' drill collars, which some core drills already have, but an alternative is to use a combination of "lead" collars (which are about 9' long) and conventional collars to form an assembly which is about the length of a stand of core rods and can be more easily handled. Lead collars, which are normally run just behind the bit, can be in short supply, so if this method is to be used the collars must be ordered early. When rotary drilling, the neutral point in the drill string should always be in the collars, because the core rod threads should not be in compression when drilling a hole with enough annulus to allow them considerable side play.

Since core-rod threads don't make up to rotary tools, there will be (usually several) cross-overs in the drill string; check inside and outside dimensions of these to make sure that they can be fished in the size hole that will be drilled. Check the outside diameters on drill collars, too; it may be necessary to machine fishing necks on them if the drill collar OD is too large to be fished in the planned hole size. It is also important that the rig crew keep records of the dimensions (length, inside diameter, outside diameter, thread sizes) on every tool that goes into the hole. This is normal practice in rotary drilling, but may require some training for coring crews. The project planner should get as many of these dimensions as possible in advance so that an inventory of fishing tools can be specified. Core rigs will usually have spears or swages to go inside core rods or barrels, but will not have overshots or grapples. If a drill site is remote from a fishing service-company, and if a reasonable price can be negotiated, it is probably prudent to specify fishing tools for all parts of the drillstring and to have them on standby at the rig.

When doing rotary drilling with a top-drive rig such as the UDR, it is also possible to use rotary-type drillpipe with tool joints. This will eliminate many of the problems with crossovers and possible thread fatigue, but few coring rigs have a string of rotary drill pipe, and there is still the handling problem with nominal 30 foot lengths of pipe.

Yet another possibility is the use of a conventional rotary rig modified or retrofitted to use coring tools. Top-drive conventional rigs can turn a string of core rods and, with the proper wireline, can retrieve the core tubes. These rigs would need a drive system which turns the drill string fast enough for effective drilling with the diamond tools, and would probably need a mud system designed for the smaller application. It is also possible to set a minerals-type, chuck-driven drilling unit into a conventional rig so that the coring unit rotates the drill string and controls weight-on-bit, while the rotary rig's draw-works are used to trip pipe. This method was used successfully during Phase II drilling at the Long Valley Exploratory Well (Reference 5) and a similar system is being used in overseas geothermal exploration.

Casing and cement: When it is time to run and cement casing, some of this work can usually be done by the drill rig and its crew without calling in service companies. Much of this will depend on the rig's pipe-handling and cement mixing capabilities.

Rotary rigs use elevators for tripping drill pipe, but because core rods are a uniform OD, they can not be directly tripped with this method. Generally, core rigs either raise the drill string by screwing a fitting from the main line into the upper end of the string or, if the rig does have elevators, by screwing larger-OD lifting plugs into the end of the rods. If the rig has its own elevators and casing slips, it will not be necessary to rent them, and if the rig has power tongs which can be used to make up the casing couplings, then a tong service will not be required. The tongs must not only be able to apply the proper torque to the connections, but must be able to measure the torque to assure proper make-up.

Casing length is also important, since Range 3 casing (the most common designation) is often more than 40' long and these lengths cannot be handled by many core rigs. The project planner

should get definite information from the drilling contractor on the maximum pipe length which the rig can handle, and then order casing accordingly.

For conductor or shallow surface casing (down to ~150'), the rig pumps can be used to cement the casing. Rig pumps will almost always have adequate pressure capability, but if it is planned to use them for cementing casing, make sure that the flow rate and mix tank volumes are sufficient for the casing job. These capabilities will also bear on the ability to pump cement for sealing lost-circulation zones. For the casing, it will also be necessary to have a cementing head and plug, or some other method for displacing the cement from inside the casing.

Mud systems: Although drilling fluids are used, and for basically the same purposes, in both types of drilling, the priorities and practices are somewhat different between core drills and rotary. In an oversimplified distinction, the most important function of drilling fluid in rotary drilling is to clean the hole bottom (improving penetration rate) and stabilize the wellbore, while in core drilling it is crucial that the fluid lubricate the drill string and bit, thus preventing vibration, overheating, and excessive bit wear.

Flow rates are much lower in core drilling than in rotary drilling; e.g., 12-15 gpm in coring a 4" hole compared to hundreds of gallons per minute in rotary drilling an 8" hole. In addition to the smaller hole size, there are three other reasons for this: (1) the annulus is very small in core drilling (typically 3.5" drill pipe in 3.78" hole) so low flow rates give enough annular velocity for hole cleaning, (2) the cuttings are much finer in core drilling, so little velocity is required to lift them, and (3) a large part of the drilled-hole volume is removed in the form of core. This means that a rig normally used only for coring will not have large enough pumps for rotary drilling. If a core rig is to be used for hybrid drilling, make sure that its mud system has adequate flow rate, pressure capability, and solids handling. Most core rigs do not have shakers, which are necessary for the larger cuttings and the lost-circulation material generally used in geothermal drilling.

Because of the smaller flow rates and smaller system volume, errors in maintaining the mud are frequently more serious in core drilling. One of the most important criteria for the mud in a core drilling job is to contain a low solids-fraction. The high rotary speed (300^+ rpm) of the drill pipe can cause "mud rings", where the solids are centrifuged out of the mud onto the inside of the drill pipe. These rings can then prevent retrieval of the core tube.

The smaller flow rates also mean that, in high temperature formations, the mud in a core hole will reach higher temperature than in a rotary hole at the same depth in that formation. If there are components in the drilling fluid which break down at some threshold temperature, then it is quite possible for that to happen in a core hole but not in a subsequent rotary hole. These unique mud requirements mean that it is extremely useful to have a mud engineer who is experienced in both core and rotary drilling at high temperatures.

Supervision: Rotary drilling projects are usually managed by consultants or drilling engineers hired by the operator to direct the operation. The consultant will, in general, give directions to the driller, specifying bottom-hole-assemblies, desired mud properties, bit selection, and drilling parameters such as rotary speed and weight-on-bit. There are also usually a mud-logger, who analyzes the rock cuttings to identify the formation being drilled and who frequently provides required safety equipment for the rig, such as H_2S detectors and pit-level indicators, and a mud engineer, who advises the consultant on mud properties and is in charge of mixing the mud to obtain those qualities. In addition, the drilling contractor will provide a tool pusher to supervise the operation and maintenance of the rig itself. Some of these responsibilities overlap, and many decisions are made in consultation among these individuals.

In contrast, the driller on a core rig makes most of decisions that a consultant would make on a rotary job. Bottom-hole-assembly is usually just the core barrel and two stabilizers, so there is no

need for designing the complex BHAs of rotary drilling, and there are also fewer choices in bit selection. There may still be need for a mud engineer, especially at high-temperatures, but most of the mud-logger's rock identification function is served by having core available. If a mud logger is not used, however, make sure that all the safety equipment required by regulations and the drilling permit is available.

In a hybrid drilling job, such as the one at Vale, it is probably appropriate to have a consultant who will design BHAs and suggest drilling parameters (bit hydraulics, rotary speed, weight-on-bit, mud properties, etc.) for the rotary part of the job. In some cases it is also useful to have a mud-logger for the rotary part of the hole, but not for the cored section. In general, a core-drilling contractor can supply a full-time supervisor on site and he, in consultation with the driller, will provide acceptable management of the job.

APPENDIX D – BRIEF THEORETICAL BACKGROUND FOR SIMPLE INJECTION TESTING

After drilling a geothermal well, it is clearly essential to evaluate its potential for commercially viable production. The two most important parameters in this evaluation are temperature and permeability. If flow from the well can be established, flow data can be used to calculate not only the permeability but the potential productivity. In many cases, however, either the temperature or depth do not allow self-supporting flow from the well and other methods to estimate the permeability must be used. Although it is not always possible to correlate injection permeability with production permeability, injection testing is the most common and useful way to gain this information. Injection testing is based on the following principles.

Governing Equations: When a rigid porous medium is saturated with a "slightly" compressible, low-velocity liquid, the transient pressure distribution based on Darcy's Law is described[10] (Collins) by

$$(1) \qquad \nabla^2 p = \frac{1}{\alpha}\frac{\partial p}{\partial t}$$

where p is the pressure, t is the time, and $\alpha = k/\phi\mu c$ is the apparent diffusivity for the saturated medium. In the definition of α, k is the intrinsic permeability, ϕ is the porosity, and μ is the fluid viscosity. The fluid compressibility c is defined by

$$(2) \qquad c = \frac{1}{\rho}\frac{\partial \rho}{\partial p},$$

where ρ is the fluid density. In practice, the compressibility of the formation can be accommodated by combining the formation and fluid compressibilities into a single, effective, compressibility. The form of the governing equation is unchanged. In typical applications, the effective geometry of the formation is not known. Hence, it is generally possible to estimate only the products kh (transmissivity) and ϕch (storativity) from field tests, where h is the effective thickness of the reservoir which is assumed to consist of a single, uniform, porous, layer.

Mathematical Models: Eq. (1) is of the same form as the parabolic transient heat conduction equation, provided p is replaced by the temperature and the apparent diffusivity α is identified with the thermal diffusivity. Hence, solutions for transient thermal conduction can be interpreted in terms of transient flows in porous media. Based on results for heat conduction given by Carslaw and Jaeger[11], several flow problems of interest can be analyzed. Since the book of Carslaw and Jaeger will be cited several times, we will henceforth denote this reference by C&J.

Constant flux: If a constant flux q, from a core hole to the surrounding formation, is established at the wall of the core hole, then the nondimensional pressure distribution at large time is given by (C&J, pg. 338)

$$(3) \qquad p'(\eta,\tau) = \frac{kp}{a\mu q} \approx \frac{1}{2}\left\{\ln\left(\frac{4\tau}{C\eta^2}\right) + \frac{1}{2\tau}\ln\left(\frac{4\tau}{C\eta^2}\right) + \frac{1}{4\tau}\left[1+\eta^2 - 2\ln\left(\frac{1}{\eta}\right)\right] + \ldots\right\}$$

where $\eta = r/a$, $\tau = \alpha t/a^2$, a = core-hole radius, C=exp(γ), γ is Euler's constant (0.57721...), and Eq. (3) is restricted to values of η for which $4\tau/C\eta^2 > 1$. The leading term in Eq. (3) corresponds to the solution for the pressure distribution established by a continuous line source (C&J, pg. 261), a result which can be used to advantage in the subsequent shut-in analysis.

Shut-in analysis: Based on the result given in Eq. (3), the core hole is represented by a continuous line source. If flow is established from the core hole at a constant flow rate Q over the thickness h, then the pressure response is given by (C&J, pg. 261)

$$(4) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\int_{\eta^2/4\tau}^{\infty} \exp(-u)\frac{du}{u} = \frac{\mu Q}{4\pi kh} E_1\left(\frac{\eta^2}{4\tau}\right)$$

where E_1 denotes the exponential integral and it is assumed that the initial formation pressure is zero. Equation (4) is generally referred to as the Theis solution[12]. For large time, the solution can be approximated by

$$(5) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\left[\ln\left(\frac{\eta^2}{4\tau}\right) + \gamma\right].$$

The core hole radius cancels in the nondimensional term $\eta^2/4\tau$, as it should, since there is no physical length scale in the solution for a line source. However, as pointed out by Collins, reasonable results can be obtained upon evaluation of Eq. (4) at $r=a$, corresponding to conditions which exist at the physical core hole radius. If the volumetric flow rate from the core hole is constant at a value Q over the period $0 \le \tau \le \tau_s$ and is then zero for subsequent time, the core hole is said to be shut-in. Using superposition, the subsequent pressure response is

$$(6) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\left\{E_1\left(\frac{\eta^2}{4\tau}\right) - E_1\left[\frac{\eta^2}{4(\tau-\tau_s)}\right]\right\},$$

or for large time

$$(7) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\ln\left(\frac{\tau}{\tau-\tau_s}\right)$$

where Eqs. (6) and (7) are valid for $\tau > \tau_s$.

A useful interpretation of Eq. (5) is obtained by rewriting the equation in dimensional form as

$$(8) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\ln\left(\frac{4kht}{Ca^2\mu\phi ch}\right)$$

The coefficient $\frac{\mu Q}{4\pi kh}$ can be estimated from the slope of a plot of pressure versus ln(t), thus providing an estimate of the transmissivity kh, since Q and μ are known. Extrapolation to obtain the intercept t_0 with the time axis for zero pressure change from a plot of pressure versus ln(t) allows for the estimation of ϕch from

$$(9) \qquad \frac{4kht_0}{Ca^2\mu\phi ch} = 1.$$

The shut-in analysis is interpreted in a similar manner. If τ_p is the total, constant-rate, injection time prior to shut-in and $\Delta\tau$ is the elapsed time since shut-in, Eq. (7) can be written in the equivalent form

$$(10) \qquad p(\eta,\tau) = \frac{\mu Q}{4\pi kh}\ln\left(\frac{\tau_p + \Delta\tau}{\Delta\tau}\right),$$

where the term in parentheses is referred to as the Horner time.

In the practical application of results based on these approximate models, numerous restrictions must be observed. Specifically, the porous layer must be uniform and of infinite extent and the saturating fluid must be a slightly compressible liquid. For the shut-in analysis, the injection must have been at a constant rate prior to shut-in. The shut-in process is assumed to occur within the well, rather than at the surface, which is typically several thousand feet above the formation investigated. For large shut-in times, the reservoir boundary can affect the results. Simple modifications to this basic result can be used to help explain deviations from the ideal case which are frequently observed in the field.

APPENDIX E – BRIEF GEOLOGIC AND GEOPHYSICAL DESCRIPTION
(after References 4, 8)

Geologic: The Vale geothermal system is at the west edge of the Western Snake River sedimentary basin, within the western third of the Yellowstone hot spot track. In this area the volcanic and structural parts of the hot spot track are separated, with the silicic volcanics to the south and west of the area (the Owyhee Lake volcanic center, the Owyhee Plateau volcanics in southwest Idaho, and the McDermott caldera volcanics in northern Nevada) and basalts and sediments to the north. An extensive volcanic episode occurred in this region about 15 million years ago (Ma). Four major calderas formed within 50 miles, roughly in the quadrant from west to south, centered at the town of Vale. Each of these produced voluminous ash flows that probably covered at least part of the Vale area. At about the same time, large Columbia River group/Owyhee basalt flows were entering the area from the north and west. Subsequent volcanic activity was of lesser magnitude on a regional basis, but may have been closer to Vale. Silicic rocks approximately 10-12 million years old and slightly younger basalts (as young as 7.4 Ma) are exposed to the south of Vale, but igneous activity in this area had essentially ended by 5 Ma. The Pliocene rocks (2-6 Ma) are composed of lake-bottom sediments, dominated by siltstone, which are called the Idaho Group. The thickness of these sediments is highly variable. A well 10 miles east of Vale encountered 4600 feet of the sediment and then 2500 feet of interbedded sediment and basalt, but deeper wells in the Vale area have encountered only 750 to 950 feet of the same sediment.

Geophysical: The well was targeted for the highest probability of encountering commercial production at temperatures in excess of 300°F. The targeting study performed by TGC consisted of a comprehensive suite of geophysical and geological studies including the following:

- Review of existing geologic and geophysical data.
- Detailed gravity survey.
- Detailed ground magnetic survey.
- Controlled source audiomagneto telluric survey (CSAMT)
- Detailed geologic mapping.
- Detailed self potential (SP) survey.
- Drilling of 17 temperature gradient holes of 300' to 500' in depth.
- Drilling of exploration well A-Alt to a depth of 5757'.

The following is a brief discussion of the study's findings and how these findings were applied to targeting the TGC 61-10 exploration slimhole.

Temperature: The Vale geothermal resource is defined by one of the largest thermal anomalies in the Western United States. Indications of geothermal potential in this area come principally from hot springs, shallow temperature gradient wells and from geophysical (gravity and magnetic) data. The temperature gradient map (Figure 7) shows an area of more than 19 square miles with a temperature gradient greater than 7°F/100' and an area of 9 square miles with gradients greater than 9°F/100'. This map is based on a data set of 17 shallow gradient wells drilled by TGC along with more than 40 additional gradient holes drilled by several other exploration entities prior to TGC acquisition of the resource. Gradients in these wells can be used to infer a total heat flow over a large area. In conjunction with measured or assumed thermal conductivity of the rock, this flux can then be extended downward to calculate thermal gradients at greater depths. Because thermal conductivity in the deeper igneous rocks is higher than that in the surface sediments, the

thermal gradient decreases with depth, but this kind of gradient extension indicates that temperatures >300°F at depths between 3000 and 4000 feet are a reasonable expectation.

Volume: Based both on volume and electrical generating potential, as calculated by the United States Geological Survey[9], the Vale geothermal resource is one of the largest geothermal resources in the U.S. As seen from the table below, the Vale resource ranks high among the U.S. geothermal fields which are currently producing power or which contain commercial discoveries.

SELECTED U. S. GEOTHERMAL RESOURCES

Resource Area	Volume, cubic km	Energy Content, MWe/30 yrs	Status
Salton Sea, CA	116	3400	220 MW on-line
Long Valley, CA	135	2100	34 MW on-line
Surprise Valley, CA	210	1490	Discovery well drilled
Roosevelt, UT	47	970	20 MW on-line
Vale, OR	***117***	***870***	***3 exploration wells drilled***
Desert Peak, NV	52	750	9 MW on-line
Newberry, OR	47	740	Discovery well drilled
Coso, CA	46	650	252 MW on-line
Heber, CA	175	650	75 MW on-line
East Mesa, CA	36	360	102 MW on-line

Surface Geological Manifestations: Massive hydrothermally mineralized fracturing is observed in faults exposed at the surface within the Vale geothermal prospect. These fractures are direct evidence that the faults associated with both Vale and Rhinehart Buttes have in the past been conduits for prolific flows of high-temperature, silica-saturated geothermal fluid. Association of the large thermal anomaly with these faults indicates that the faults are permeable at depth and therefore represent highly attractive exploration drilling targets . These fracture systems are probably fed laterally by regional hot aquifers contained within deep basalt units including the Owyhee and Columbia River Basalts which extend over an area of several thousand square miles.

Previous Exploration Drilling: Previously, two deep exploration wells have been drilled within the KGRA, one by Unocal (47-10) and one by TGC (A-Alt). Unocal 47-10 had a temperature of 277°F at a depth of 3855' and encountered several zones of significant fracture permeability. Extrapolation of the bottomhole gradient in 47-10 indicated that a temperature of 300°F would be encountered at a depth of 5000'. This well was located approximately 1 mile SE of the center of the central Vale thermal anomaly. The A-Alt well was drilled at the northern end of the thermal anomaly and encountered significant fracture permeability below a depth of 4000'. However, fluid temperatures of 224°F were far below the 300°F target temperature. Fracture permeability in both wells was found primarily in rhyolite flows associated with a local silicic eruptive center.

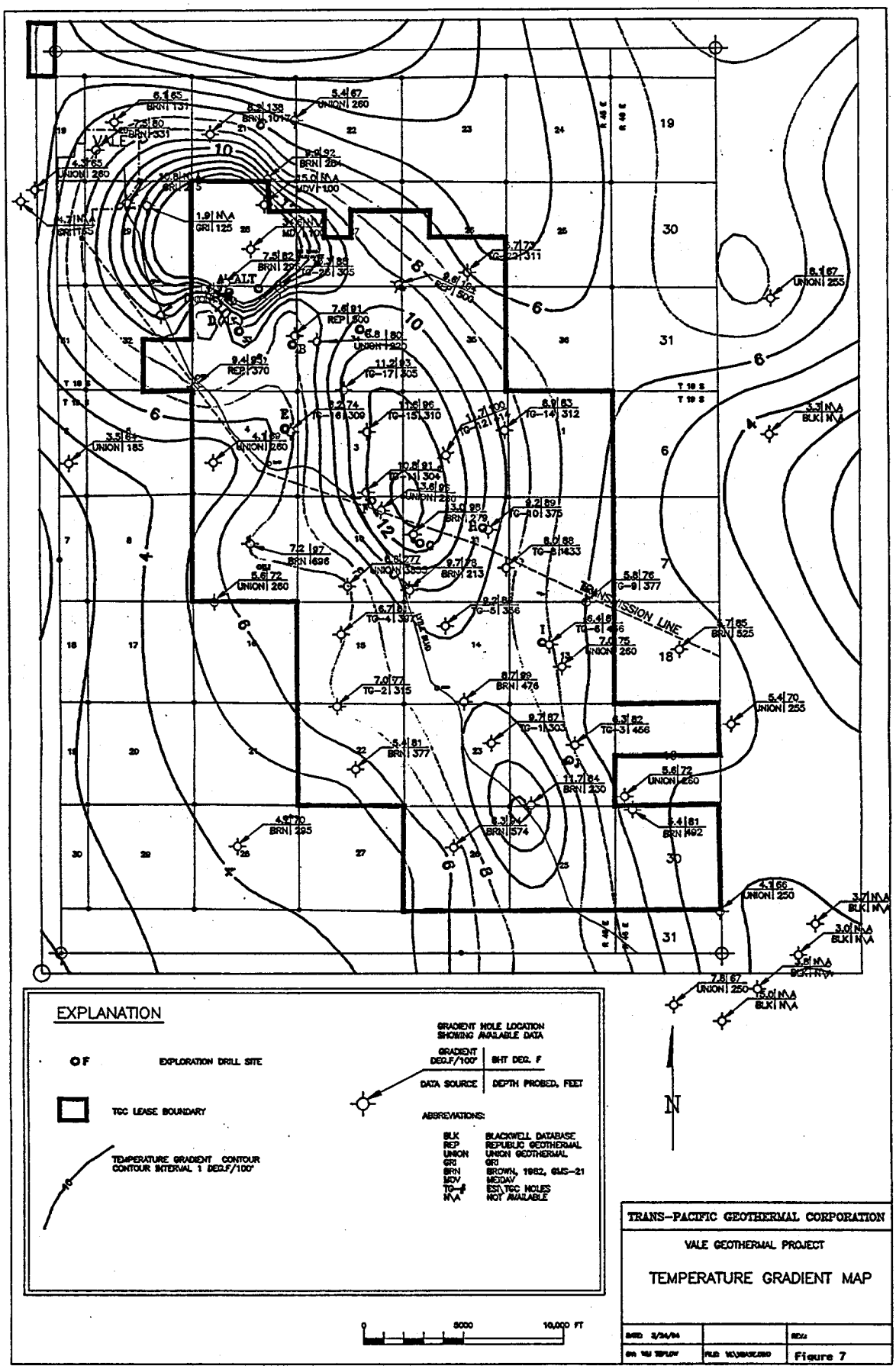
Geophysical Anomalies: The prospect area is characterized by broad positive magnetic and gravity anomalies (Figures 8 and 9) Superimposed on these large anomalies are features of much shorter wave length. The superposition of these shorter wavelength anomalies was used to infer the location of faults and fractures that may contain circulating geothermal fluid. The detailed

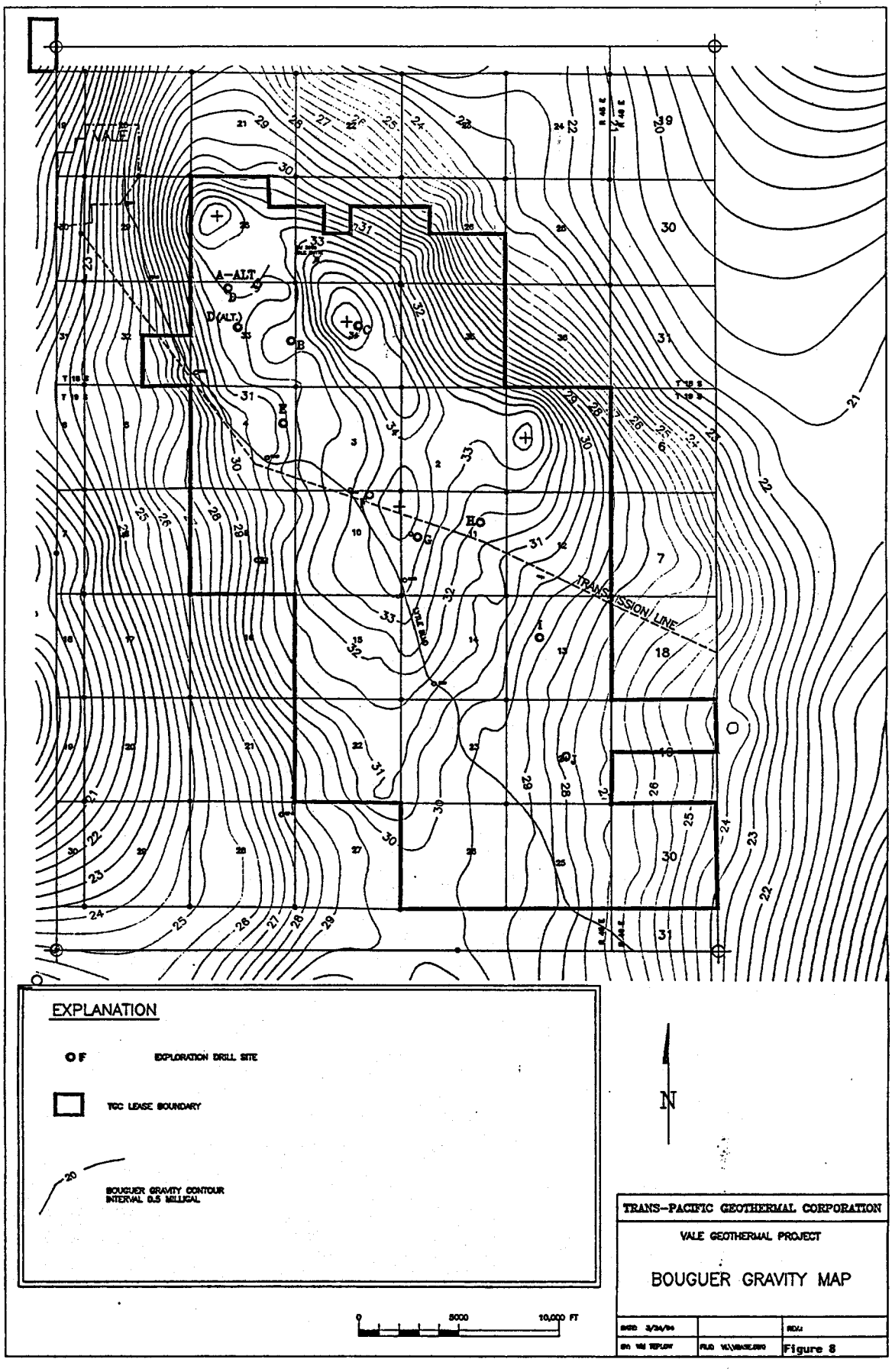
gravity and magnetic survey data were modeled using the PC based GMSYS™ modeling program. Results of the modeling showed that certain segments of faults defined by the gravity data are associated with steep magnetic gradients. This correlation was interpreted as zones of intense hydrothermal alteration along steeply dipping fracture zones of high permeability. These zones correlated closely with the central thermal anomaly.

It is possible that the difference in sediment thickness mentioned above could account for the gravity anomaly (sediment density = 2.25 g/cc, basalt density = 2.6-2.7 g/cc), but this is not a unique answer. The western edge of the gravity ridge is parallel to a much stronger gravity anomaly which shows a buried fault, and the overlay of gravity data with high thermal gradient and high elevation is a strong indicator of upward-flowing hot water along the structure defined by the gravity anomaly. The positive magnetic anomaly centered on the peak of the thermal gradient contours also supports the concept of fluid circulation controlled by permeability distribution in volcanics known to be in this location.

Summary: The Vale thermal anomaly is comparable in size to many U.S. geothermal resources currently sustaining major commercial geothermal production. Close correlation between the central Vale thermal anomaly and gravity and magnetic anomalies indicated that the flow of hot water was fault-controlled at depth. Deep drill holes to the north and southwest of the central anomaly contained fractured, permeable silicic volcanics indicating that the central anomaly also contained this type of permeable lithology.

Although the combination of these factors does not guarantee a geothermal reservoir with potential for commercial development, the geophysical and geologic investigation of this region has been more thorough than in many other developed locales, and is representative of the pre-drilling exploration done by most geothermal operators.


EXPLANATION
EXPLORATION DRILL SITE
TGC LEASE BOUNDARY
TEMPERATURE GRADIENT CONTOUR
CONTOUR INTERVAL 1 DEG.F/100'
GRADIENT HOLE LOCATION SHOWING AVAILABLE DATA
GRADIENT DEG.F/100' | BHT DEG. F
DATA SOURCE | DEPTH PROBED, FEET
ABBREVIATIONS:
BLK BLACKWELL DATABASE
REP REPUBLIC GEOTHERMAL
UNION UNION GEOTHERMAL
GRI GRI
BRN BROWN, 1982, GMS-21
MDV MEIDAV
TG-# EST. TGC HOLES
N/A NOT AVAILABLE
TRANS-PACIFIC GEOTHERMAL CORPORATION
VALE GEOTHERMAL PROJECT
TEMPERATURE GRADIENT MAP
Figure 7

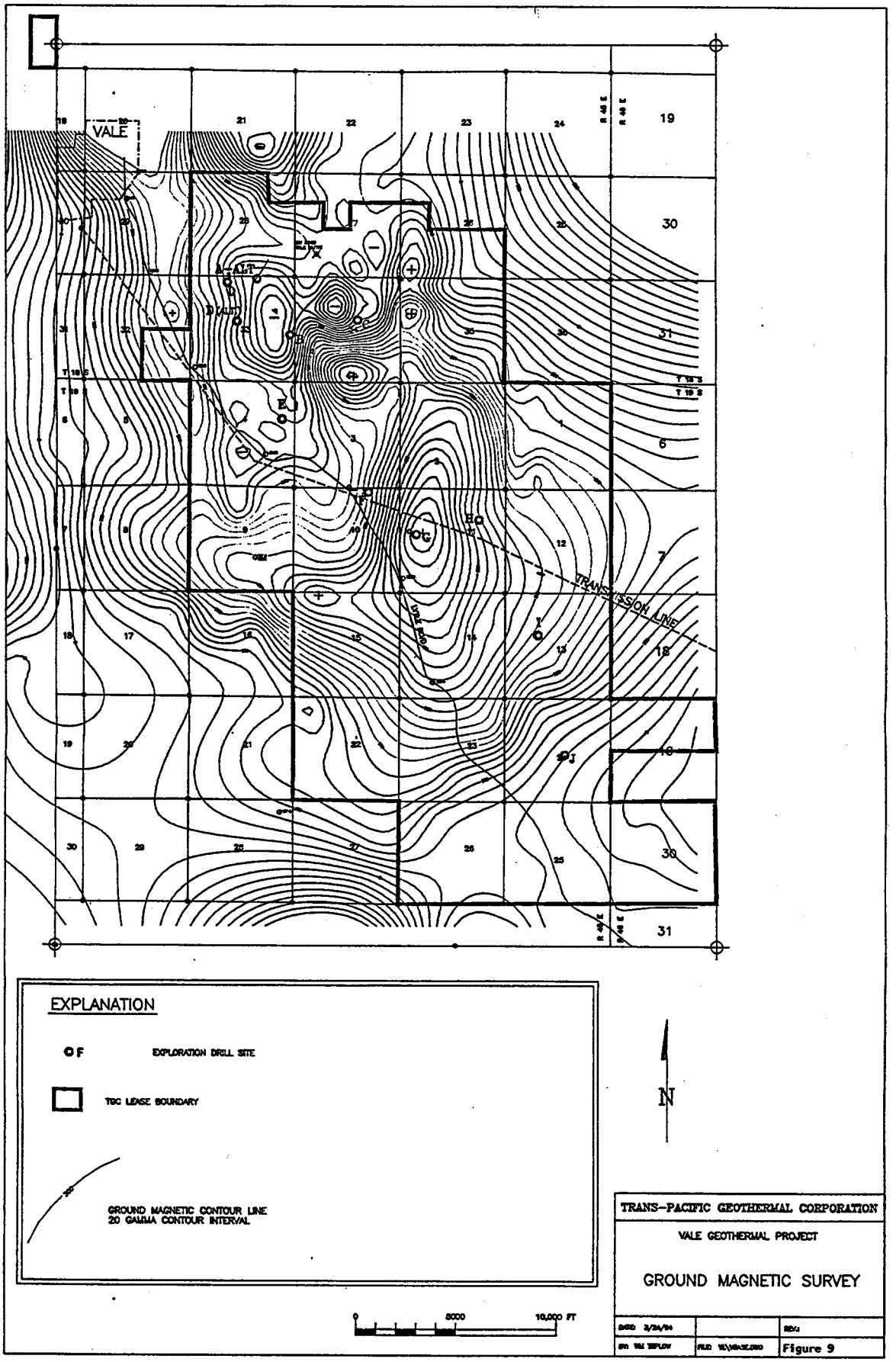


TRANS-PACIFIC GEOTHERMAL CORPORATION

VALE GEOTHERMAL PROJECT

BOUGUER GRAVITY MAP

Figure 8


VALE
TRANSMISSION LINE
EXPLANATION
EXPLORATION DRILL SITE
TGC LEASE BOUNDARY
GROUND MAGNETIC CONTOUR LINE
20 GAMMA CONTOUR INTERVAL
N
5000
10,000 FT
TRANS-PACIFIC GEOTHERMAL CORPORATION
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GROUND MAGNETIC SURVEY
Figure 9

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