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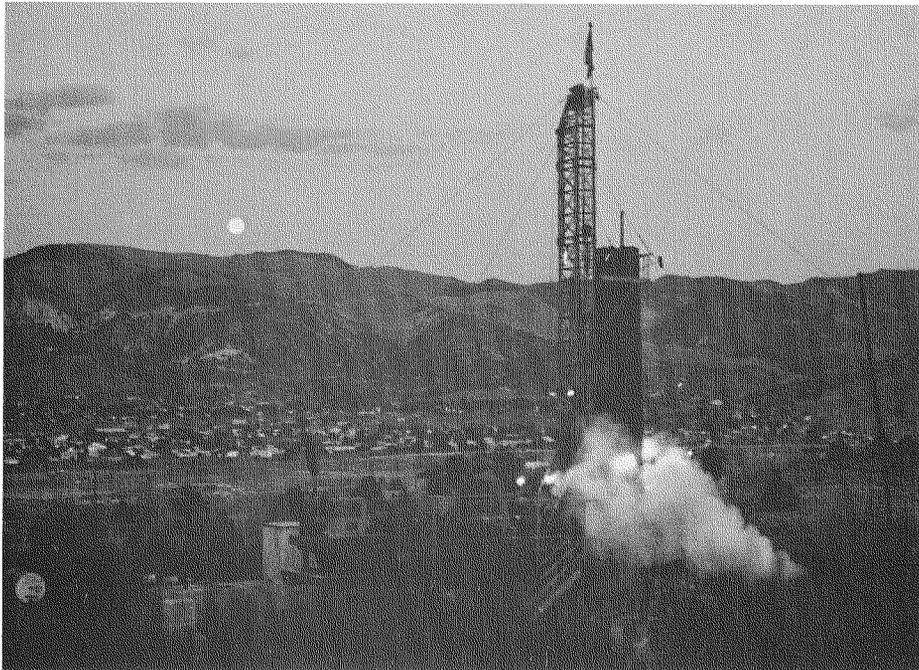
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## Steamboat Hills Exploratory Slimhole: Drilling and Testing

John T. Finger, Ronald D. Jacobson, Charles E. Hickox, Roger R. Eaton

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## STEAMBOAT HILLS EXPLORATORY SLIMHOLE: DRILLING AND TESTING

John T. Finger  
Ronald D. Jacobson  
*Geothermal Research Department*

Charles E. Hickox  
*Computational Fluid Dynamics Department*

Roger R. Eaton  
*Thermal and Fluid Engineering Department*

### ABSTRACT

During July-September, 1993, Sandia National Laboratories, in cooperation with Far West Capital, drilled a 4000' exploratory slimhole (3.9" diameter) in the Steamboat Hills geothermal field near Reno, Nevada. This well was part of Sandia's program to evaluate slimholes as a geothermal exploration tool. During and after drilling we performed four series of production and injection tests while taking downhole (pressure-temperature-spinner) and surface (wellhead pressure and temperature, flow rate) data. In addition to these measurements, the well's data set includes: continuous core (with detailed log); borehole televiewer images of the wellbore's upper 500'; daily drilling reports from Sandia and from drilling contractor personnel; daily drilling fluid record; numerous temperature logs; and comparative data from production and injection wells in the same field.

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.

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## 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.<sup>1</sup>

Sandia first established the basic feasibility of slimhole exploration with in-house analysis and field experiments on existing geothermal coreholes and then conducted an extensive survey of the geothermal industry to define its needs and priorities. Industry contacts specified lower-cost exploration as a high priority, and were generally enthusiastic over the slimhole idea. Further negotiations with Far West Capital, which operates the Steamboat Hills geothermal field, resulted in an agreement to drill and test an exploratory well on their lease. This exploratory well (number SNLG 87-29) was specifically designed for extensive production and injection tests so that those results could be compared with production and injection data from existing wells in this developed field. In fact, the exploratory well is drilled approximately 30 feet from an existing, but unused, production well. This report describes our drilling and testing activities, and gives a preliminary summary and interpretation of the data, as well as recommendations for future projects.

Steamboat Hills geothermal area is located about eight miles south of Reno, Nevada, and currently supports two power plants with a rated total output of approximately 36 MWe. Production zones for the power-plant wells are typically shallow (less than 1000'), of moderate temperature (~325°F), characterized by large, well-connected fractures in granodiorite (see Section VIII for more detail on the formation), and extremely permeable; test data<sup>2</sup> indicate values of transmissivity exceeding 1,000 Da-ft. Wells previously drilled here showed temperature reversals, with the maximum temperature above 1000' (see Figure 1 for temperature log from the exploratory slimhole), however, a nearby power plant on another operator's lease draws from a reservoir at approximately 420°F, indicating that a hotter resource might lie beneath the one currently produced for the Far West power plants. Extensive previous development in this field meant that drilling conditions were reasonably well-known, but because most of the existing wells are shallow, there was still an opportunity for slimhole exploration in search of a deeper, hotter reservoir.

The principal objectives for this test program were the following: development of slimhole testing methods, comparison of slimhole data with that from adjacent production-size wells, and definition of formation-temperature profiles below the existing wells. Although not all of these objectives were completely met, the exploratory well (which ended at a total depth (TD) of 4001') was generally successful in gathering a large amount of data useful to the slimhole development program and to the operator.

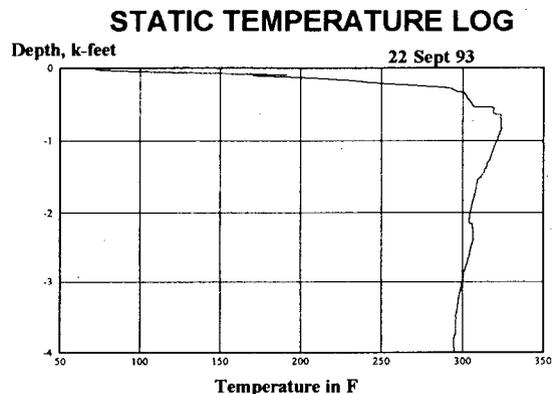


Figure 1

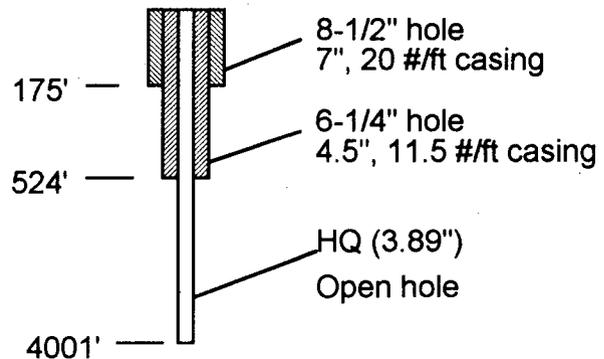
## II. SUMMARY OF OPERATIONS

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

- Recover continuous core from surface to TD.
- Obtain a competent cement job on all casing, to allow extended production testing.
- Maintain HQ hole diameter (3.89") as deep as possible, to allow setting packers for isolation of possible production/injection zones.

The well design (Figure 2) has 7" casing to nominal 150' and 4-1/2" casing to nominal 500 feet. Since regulatory agencies require at least 10% of the total depth to be cased, this casing program allows a maximum well depth of 5000', even though the drilling permit was for 4000 feet. To minimize the amount of reaming necessary, while still collecting continuous core, the drilling program was to (1) core the first 150' with HQ, (2) ream to 8-1/2" with roller bit, (3) set 7" casing, (4) drill out of 7" casing with BSF™ core bit (6-1/4" hole by 4" core) to 500', (5) set 4-1/2" flush joint casing, and (6) drill to TD with HQ core tools. This plan was followed to a total depth of 4001 feet. Total project time, from spud through completion of testing, was 58 days.

**WELL DESIGN: SNLG 87-29**



**Figure 2**

During the project we suspended drilling four times for a series of production/injection tests, each time taking downhole (pressure, temperature, spinner) and surface (wellhead pressure and temperature, James tube lip pressure, flow rate) data. These test series were done at well depths of 968, 1510, 2930, and 4000 feet. All production tests were initiated by air-lifting the fluid from a depth of approximately 250', at an air flow rate of approximately 150 scfm. In general, the surface data, including a comparison of different flow rate measurement techniques, were consistent and repeatable. Downhole data were more difficult to compare because of some malfunctions in the logging tools and because the two service companies which took measurements used different tools and different calibrations. By comparing the downhole readings with the corresponding surface data, however, and by comparing the service companies' tools with Sandia temperature logs, it appears that most of the ambiguities in the downhole data are resolved. The data and conclusions are discussed in Sections IV and V.

### III. DESCRIPTION OF TEST EQUIPMENT AND METHODS

The following descriptions cover the major pieces of equipment used during the project and, where applicable, explanations of their use.

**Drill rig:** The drill rig used for this hole was a Longyear truck-mounted Model HD602, with a 60' mast, capable of pulling 40' stands of pipe, and a hoist rated at 60,000 pounds. The rig was supported on a hydraulic jack-up substructure which provided approximately 8' clearance between the bottom of the substructure and ground level. Two mud pumps were available; a Gardner-Denver duplex (150 gpm @ 260 psi) for surface drilling and reaming, and an FMC Model M12 triplex (100 gpm @ 1000 psi) for coring. A 40' parts trailer contained tools, bits, spare parts, and a welder.

Although the granodiorite which comprised more than 3500' of the drilled interval is hard (most of it about 6 on the Mohs hardness scale), bit life averaged over 200' after settling on a Series 7, impregnated diamond bit specifically designed for this formation. Core recovery was very good, more than 99% for the entire well. Because we completely lost returns after drilling through a major void at 815', the upper part of the drillstring ran mostly dry, causing intermittent drillstring vibrations. This problem was mitigated by liberal applications of powdered Teflon and bio-degradable rod grease to the core rods as they were tripped into the hole.

This particular rig has a depth capability of approximately 8200' with the HQ rods used for this project, but heavier duty rigs can be equipped with CHD101 drill rods (approximately 4" diameter) to reach below 10,000' and CHD76 rods (approximately 3" diameter) to 14,000', enabling slimhole exploration to be used in most known geothermal areas.

**Wellhead:** The wellhead was designed to not only provide conventional pressure control while drilling, but to allow production testing from the well with minimum changes. The wellhead assembly comprised, from the bottom up, a double-gate BOP, a flow tee, a 4" gate valve, and an annular BOP. The inside diameter of the flow tee was large enough to pass all the HQ tools, allowing the tee to remain in place during normal drilling so

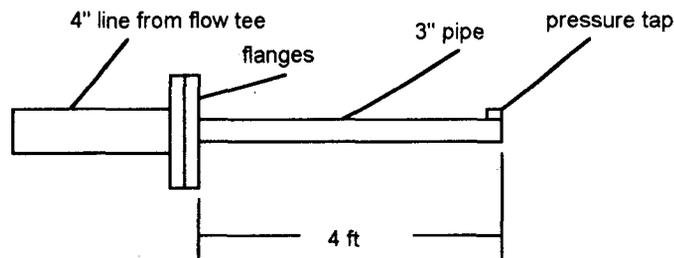
that there was no need to re-configure the wellhead for testing. The side leg of the flow tee fed, through another 4" valve, into a run of 4" pipe with a James tube (see Figure 3 for diagram of James tube) mounted at the end, and this exhausted into a flash tank. Given the downhole temperature and

pressure, or enthalpy, the lip pressure measurements from the James tube can be used to calculate the total flow rate from the well.<sup>3</sup>

**Flash tank/weir Box:** The flash tank was an open-topped 6' diameter by 7' high steel tank, equipped with internal baffles, which received the flow from the well through a tangentially-directed opening in its side. The liquid portion of the flow then passed from the flash tank into a 3" line, through a magnetic flow meter, and into a 5' x 3' x 3' weir box. The weir box has a V-shaped notch in an internal partition, and the height of water flowing through this notch is a measure of the liquid flow rate. The liquid flow rate measured in the weir box was consistent with that indicated by the magnetic flow meter.

**Surface instrumentation:** Instrumentation at and near the wellhead comprised the following:

**DIAGRAM OF JAMES TUBE DESIGN**



**Figure 3**

- Electronic pressure transducer (0-20 psi) for James tube lip pressure
- Pressure gauge (various) for James tube lip pressure (note: both James tube pressure measurements included approximately 1.2 psi from a water column above the transducer tee -- this water column prevented sub-atmospheric pressures at the transducers and damped pressure fluctuations.)
- Electronic pressure transducer (first 0-200, later 0-60 psi) in the wellhead flow tee
- Pressure gauge (0-100 psi) in the wellhead flow tee
- Electronic pressure transducer (0-200 psi) at the pump/drill rod connection (injection tests)
- Thermal well with thermocouple just downstream of the flow tee 4" valve
- Thermal wells with thermocouples in 3" line between flash tank and weir box and in injection line
- Magnetic flow meter in the 3" line between the flash tank and weir box
- Vortex flow meter in the water line from power plant (measure flow rates for injection)

All electrical transducers were connected to a signal-processing station at the drill rig and then, via a simple twisted-pair wire to the data-logging computer in the Sandia trailer. After each test was complete, data from the computer was down-loaded onto diskettes and distributed to other researchers.

**Downhole instrumentation:** Downhole data during production and injection tests were acquired using pressure/temperature/spinner (PTS) tools from two different service companies. Although details differed, all the commercial downhole instruments were designed to take data and to transmit that data uphole in real time. Since both companies use a single-conductor wireline, the individual signals must be multiplexed up the wire, requiring downhole electronics inside the tools. All the instruments (each company used more than one) employed a dewar, or thermal flask, to protect the electronics, but in spite of that, the internal tool temperature would rise significantly during the course of a normal test. If this effect is not compensated, heating the electronics will cause the signal output to drift, giving unreliable data. A properly calibrated tool accounts for the heating and provides accurately compensated data, but we were not always confident that this was the case with the instrumentation used in this project. This experience indicates to us that there is significant room for improvement in slimhole, high-temperature logging tools.

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 before each series of production/injection tests.

Two other Sandia instruments were used briefly: the acoustic borehole televiewer (BHTV) yielded wellbore images down to 520'; and a Sandia memory tool gave pressure-temperature data for a shut-in test at the end of the project. Because no oriented core has been collected in this field, the televiewer images giving fracture direction were extremely informative, but the BHTV could not be used at greater depths because of its temperature limitations (~250°F). The memory tool, which does not use an electric wireline but stores data downhole in an on-board computer, is still in development and was not ready for use until the very end of the project. It may, however, play a prominent role in future slimhole projects.

**Packers:** Part of our injection testing used downhole packers for isolating various zones and evaluating their permeability. By running the packers into the hole on N-rod (2.75" OD), we had an annulus with roughly the same cross-sectional area as inside of the pipe. This meant that we could inject into either the zone above the packer or the one below, and compare the injectivity of those intervals.

The packers were manufactured by TAM International and were inflated by pumping into the drill pipe with a wire-line-retrievable standing valve seated in the packer. Once proper inflation pressure was reached, the pump pressure was bled (a check valve holding pressure in the packer) and the standing valve retrieved with the drill rig's wireline. This standing valve arrangement left a large enough ID in the packer for the PTS logging tools to pass through, so we were able to take measurements below the packers while injecting.

#### IV. PRELIMINARY ANALYSIS OF AVAILABLE DATA

The results discussed below are based on data from the first series of tests, conducted during August 5-6, 1993, at a total well depth of 968 feet. A large fracture system identified at 815' was verified by spinner measurements to be the primary production zone for this series of tests and was later observed to be the major feed zone for the 4001' completed well. Hence, the flow and injection tests conducted during this first series are representative of the performance observed in subsequent tests when the well was deeper.

**Flow testing:** In Figures 4, 5, and 6 the temperature, pressure, and spinner response are plotted versus depth. These measurements were made at a total (liquid plus vapor) production rate of 7.1 kg/s (56,350 lb/hr). The liquid water flow rate through the magnetic flow meter and weir box was 6.1 kg/s at 192°F (100 gpm, 48,425 lb/hr). Numerical flow simulations are included in Figures 4 and 5 for comparison and are discussed later. The spinner response, which clearly shows a feed zone at 815', is proportional to the rotational speed of the impeller, but it was not calibrated as a quantitative measure of relative flow velocity. Based on *in situ* measurements, we have deduced a relation between spinner output and flow velocity which is consistent with observations in the flowing well.

A secondary objective of flow testing was evaluation of the James tube for slimhole application. The advantage of this method is that only simple equipment is needed to measure the total flow rate and heat rate of the well. Calculations using the James tube flow area, the water flow rate (measured with a weir box), and the lip pressure in the James tube (see Figure 3) will yield total mass flow rate and flow enthalpy, thus simplifying the necessary measurements for those performance criteria. Although there was considerable scatter in the James tube pressure data for these tests, flow rate calculations were in agreement with the measured flow rates.

Wellhead pressures, measured during production for all test series, are plotted versus total mass flow rate in Figure 7. Mass flow rate and total enthalpy were calculated from measurements made with James tubes of various diameters, according to the procedure described by Grant, et al.<sup>3</sup> For those cases when we could not attain critical flow in the James tube, total fluid enthalpy was estimated from downhole temperature measurements. Knowing total enthalpy, the steam-flash fraction could then be calculated from the enthalpy of the flashed water in the weir box and the latent heat of vaporization at the local atmospheric pressure, total mass flow rate following from this. Unsteadiness of the two-phase flow in the James tube and flash tank created significant scatter in the measurements of James tube lip pressure, flow rate, and wellhead pressure. Nevertheless, the data in Figure 7 are typical of two-phase flow from a liquid-dominated geothermal well. For example, a weak wellhead-pressure maximum apparent in the data at a mass flow rate of approximately 1 to 4.5 kg/s is reflected in the superposed curves obtained from numerical simulations of flow in the well.

**Reservoir transmissivity:** The fracture system at 815' has such large apparent permeability that only very small pressure increases were observed when relatively large volumes of water were injected. Difficulties with downhole instrumentation and with the injection equipment precluded an accurate estimate of reservoir transmissivity based on these injection tests, but we can estimate

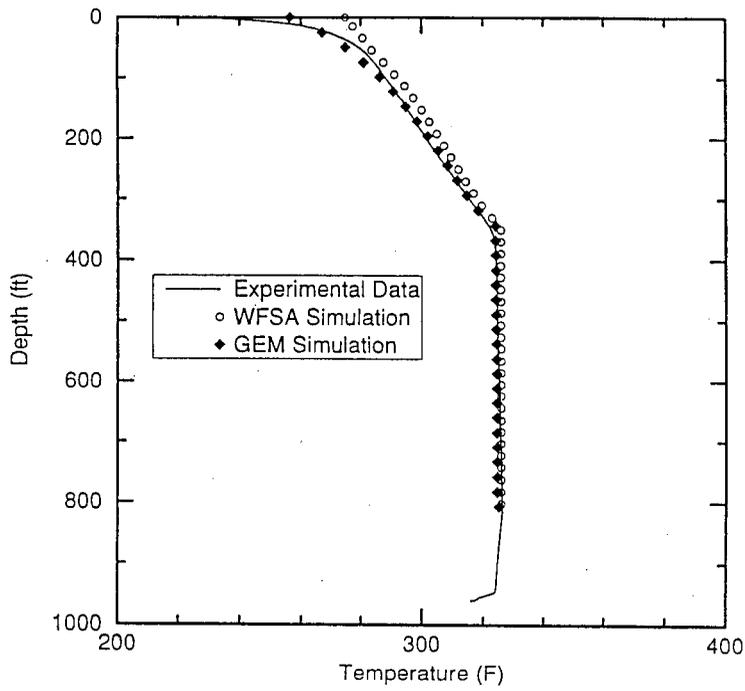


Figure 4. Downhole temperature versus depth; field data and numerical simulation.

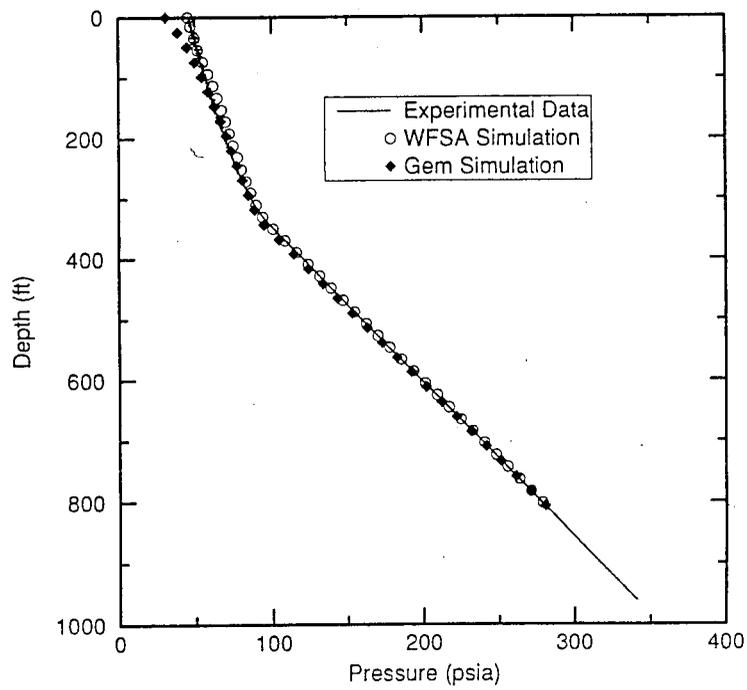


Figure 5. Downhole pressure versus depth; field data and numerical simulation.

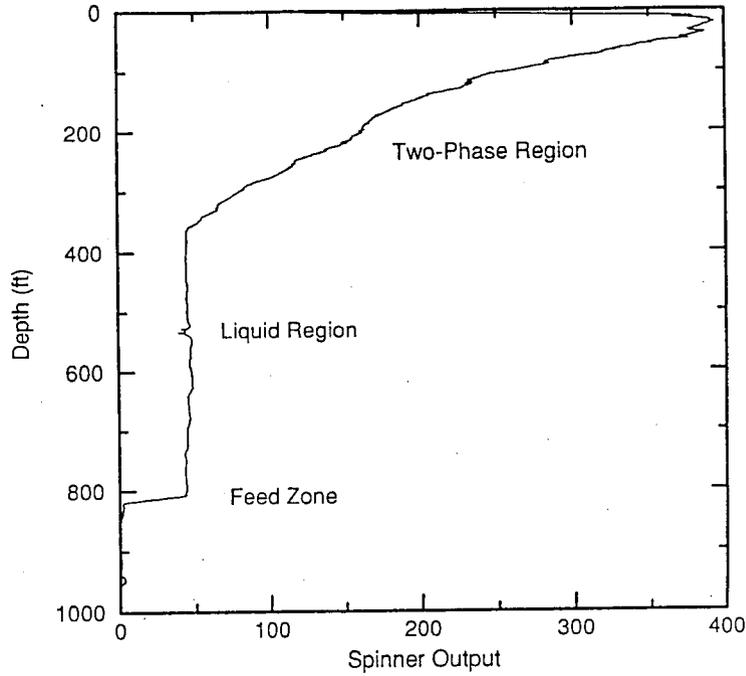


Figure 6. Spinner response versus depth while flowing 56,000 lb/hr.

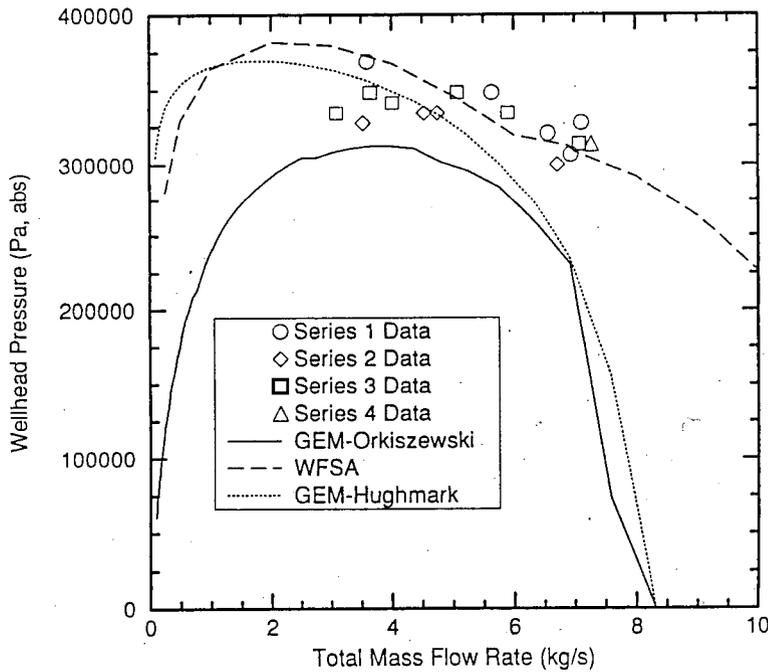


Figure 7. Wellhead pressure versus mass flow rate; field data and numerical simulation.

some reservoir properties by considering the downhole pressure response during flow rate changes in production tests.<sup>4</sup> During the first series of flow tests, very small, abrupt, changes in downhole pressure were observed when the flow rate was varied in relatively small increments. For flow rate changes between 6 and 16 gpm, pressure changes ranged from 0.05 to 0.07 psi. If we assume steady-state conditions, the apparent effective transmissivity, or permeability-depth product,  $kh$ , can be estimated from the Dupuit, or Theim, formula<sup>5</sup>

$$\Delta p = \frac{\mu \Delta Q}{2\pi kh} \ln \frac{r_o}{r_w},$$

where  $\Delta p$  is the pressure change,  $\mu$  is the fluid viscosity,  $\Delta Q$  is the change in volumetric flow rate,  $r_w$  is the well radius, and  $r_o$  is the outer radius of the reservoir. An arbitrary value of 100 m is selected for the outer radius, recognizing that the logarithmic term makes the Dupuit formula relatively insensitive to this parameter. Using the fluid viscosity evaluated at downhole conditions, the transmissivity is then estimated to lie in the range 160-600 Da-m, with an average value of approximately 400 Da-m. This estimated average value of transmissivity indicates a pressure increase of only 0.5 psi for an increment of 100 gpm in the injection rate of liquid water.

A shut-in test was also performed immediately following a 100 gpm production test, and this produced a pressure change of 0.2 psi. Based on the Dupuit formula, this latter pressure rise indicates a transmissivity in the range of 900 Da-m. Conventional practice for a shut-in test after production, assuming that a significant pressure rise can be observed over an extended period, is to use the Theis equation<sup>6</sup> for analysis of this transient flow. For a sufficiently large time following shut-in, the Theis equation can be expressed as,

$$\Delta p = \left( \frac{2.3}{4\pi} \right) \left( \frac{Q\mu}{kh} \right) \log \left( \frac{t_s + \Delta t}{\Delta t} \right)$$

where  $t_s$  is the total time of the flow test and  $\Delta t$  is the elapsed time since shut-in. A plot of pressure versus the log-term can provide an estimate for the transmissivity  $kh$ , since all other parameters in the equation are known. Application of this analysis to the shut-in data above indicated a transmissivity on the order of only 25 Da-m, however, the apparent temperature-induced drift in the pressure-measurement electronics and the very small overall pressure increase detract from the validity of this approach for this particular test. In reservoirs with much lower apparent transmissivity, application of the Theis equation would be the preferred method to estimate reservoir properties.

It is informative to note that laminar, axisymmetric, creeping flow in a horizontal fracture is described by an equation similar to the Dupuit formula if the transmissivity is replaced with the quantity  $b^3/12$ , where  $b$  is the fracture aperture. Assuming flow occurs in a single fracture, and using the same numerical values used to estimate the transmissivity, the predicted fracture aperture lies in the range 1-4 mm, which is consistent with fractures observed in the core samples, but much less than the apparent size of the production zone based on drilling data (drillstring dropped approximately 2', without rotation, when it reached this interval.) This indicates that, although we may have penetrated a large void, a much smaller fracture can carry the amount of fluid produced. The ability of the large fracture to carry much more fluid than was actually produced, along with the simulations described below, indicate that the wellbore diameter, not the reservoir, was the parameter limiting flow rate.

**Analysis of spinner data:** Spinner data, in some cases, can be the most informative measurement taken in a flowing well. In holes which penetrate several potential production or injection zones, it is frequently difficult to analyze internal flow in the wellbore, and good spinner data can be extremely useful in this aspect of interpretation. Obtaining fine resolution is difficult, however, because spinners are not usually calibrated to give absolute flow velocity, or even velocity relative to the tool, but instead to give a number of counts that measures how fast the impeller on the tool is rotating. In some instruments, such as those used in our tests, it is not even possible to determine flow direction relative to the tool.

There are, however, two features of the test configuration which make it possible to, in effect, calibrate the spinner after the fact: (1) the logging line speed, or tool velocity, is known in all cases, and (2) total mass flow rate is known and, in the casing where flow is single-phase, fluid velocity can be accurately calculated. Combination of the logging tool speed and absolute fluid velocity gives the fluid velocity relative to the logging tool, and repetition of this procedure at several flow rates produces a "calibration curve" for the spinner tool. In deriving these calibration curves, only the cases in which the relative fluid velocity was toward the bow of the spinner tool were considered; generally, we felt that the tool body shadowed the impeller when relative flow was from the tool's stern. Use of these calibration curves to analyze flow test data<sup>12</sup> revealed that flow from the major production zone at 815' is divided, with the majority of the fluid going up the well and the remainder going down. The down-going flow rate, which varies from approximately 20 to 50 gpm, is a very weak function of the wellhead flow rate.

**Simulations:** Numerical simulation of flow in a wellbore is critically dependent on the correlation or mathematical model used to describe the two-phase flow regime. Depending on well depth and temperature of the surrounding formation, representation of heat transfer between the formation and the wellbore may be equally important. We are currently investigating the three computational packages described below for numerical simulation of flow in slimholes.

- GEM requires input of downhole pressure, formation-temperature profile, and wellhead pressure, and then calculates flow rate. It allows simulations<sup>7</sup> with no slip in the two-phase region or with either of the slip models proposed by Orkiszewski<sup>8</sup> and Hughmark.<sup>9</sup> In GEM, heat conduction in the surrounding formation is simulated using finite differences.
- WFSM requires input of downhole pressure, formation temperature, and flow rate, and then predicts wellhead pressure. It allows for multiple feed zones and the effects of dissolved solids, is based on the work of Hadgu<sup>10</sup>, and uses a specially developed two-phase flow model. Heat transfer between the formation and the wellbore is described with an analytical model.
- GEOTEMP2 simulates drilling processes,<sup>11</sup> with some capability for injection and two-phase production. For production, the program requires input of downhole pressure (or temperature and quality, if feed is two-phase), formation temperature, and flow rate, then calculates wellhead pressure. This program uses the Orkiszewski two-phase slip model and treats heat transfer between the wellbore and the surroundings with a finite difference numerical model.

The codes agree reasonably well with each other and with the field data, except that the surface temperature calculated by GEOTEMP2 is noticeably lower than the other codes. All codes predicted transition to two-phase flow at approximately the same point. Effort required to set up the input files, and computer run time (cpu), are similar for all three codes.

Each of these codes can be used to iterate a series of solutions with varying initial conditions to produce a curve of flow rate versus wellhead pressure, along with the associated predictions of downhole pressure and temperature. This predictive capability can be scaled up to a

larger well in the same reservoir, if we assume that the downhole pressure remains the same. In this highly permeable situation, that assumption was valid, but in other reservoir types the pressure drawdown during production might seriously distort the predicted output. This phenomenon emphasizes the need for a coupled wellbore-reservoir simulator.

Both GEM and WFSA were used for our initial simulations of flow in the slimhole. In Figures 4 and 5, the pressure and temperature distributions with depth, assuming adiabatic flow, are compared with downhole measurements for the first test series (well depth is 968'). The GEM simulations used the Orkiszewski two-phase flow option. Most of the calculations are in good agreement with the measurements, but near the surface we suspect that unmodeled heat transfer mechanisms are responsible for the difference between predictions by WFSA and observed temperature distributions. The two-phase flow correlation used in GEM apparently causes it to under-predict wellhead pressure, as shown in Figures 5 and 7, and there is a slight variation of temperature with depth in the single-phase region, shown in Figure 4, as contrasted with the constant-temperature assumption in WFSA; otherwise, temperature and pressure distributions predicted with GEM differ little from those predicted with WFSA.

Predictions made with GEM and WFSA of wellhead pressure as a function of mass flow are shown in Figure 7, and those predictions are compared with the experimental measurements from all flow tests. The WFSA prediction compares best with the experimental data, although the simulation has a local minimum, most likely attributable to a change in flow correlation, near a flow rate of 6 kg/s. The GEM prediction, using the Orkiszewski correlation, consistently underpredicts the pressure, but if the downhole pressure at the feed zone is increased by 5%, the GEM prediction then passes through the experimental data. The prediction from GEM using the Hughmark correlation tends to agree with the WFSA prediction for mass flow rates less than 6 kg/s, but predicts significantly lower wellhead pressures for larger flow rates. The agreement among the computational approaches and experimental data is reasonable, considering the variability of the measurements involved and the sensitivity of the simulations to the two-phase flow correlations employed. These comparisons should be viewed as preliminary since we are still evaluating various approaches to the simulation of wellbore flows.

Keeping all parameters except wellbore diameter fixed, GEM and WFSA predictions were applied to a full size production wellbore with diameter of 12.25 inches. For a mass flow rate of 62 kg/s, wellhead pressures of 56, 66, and 55 psia were predicted, respectively, with WFSA, GEM(Orkiszewski), and GEM(Hughmark). The flow rate of 62 kg/s corresponds to a 1990 test<sup>2</sup> of the nearby 12.25" production well Hot Air-4 (HA-4), which produced 900 gpm of liquid water at a wellhead pressure of 72.5 psia. When corrected for flashing, that measured flow rate corresponds to a total mass flow rate of approximately 62 kg/s. The production from well HA-4 is associated with a production zone at 729', which is somewhat shallower than the slimhole production zone at 815'. However, tracer tests in the Steamboat Hills geothermal field indicate pervasive interconnections between fracture zones, so it does not seem unreasonable to expect similar production rates among nearby fracture zones. Based on a single test, simulation of a production well extrapolated from a slimhole tends to indicate a lower wellhead pressure at a specified mass flow rate than that observed experimentally. The results are, however, encouraging since the differences appear to be within a normal range of variation for the experimental measurements and the models used in the simulations.

## V. DISCUSSION

Drilling is cheaper for slimholes than for production wells because the rigs, crews, locations, and drilling fluid requirements are all smaller; because site preparation and road construction in remote areas is significantly reduced, up to and including the use of helicopter-portable rigs; and because

it isn't necessary to repair lost-circulation zones before drilling ahead. As a comparison, the Steamboat Hills slimhole, including all testing and overhead, cost approximately \$150/foot while the neighboring production well (12-1/4" production diameter) cost \$377/foot. Although the slimhole's greater total depth reduced its overall cost per foot, the intermediate cost of drilling the slimhole to the same depth as the large well was less than 60% of the large well's total cost.

If the resource evaluation program calls for production or injection tests from an exploratory well, these are also easier with a slimhole because they involve handling much less fluid than a larger well. Finally, the same attributes that reduce the cost also greatly reduce the environmental impact. As exploration expands into new areas such as the Pacific Northwest, this may become the critical criterion in regulatory agencies' decisions on whether to issue permits. This technology appears to be the best hope of increasing exploration in an attempt to enlarge the nation's proven geothermal reserves.

## VI. CONCLUSIONS

We believe that field results validate our testing strategy for this slimhole. Because drilling and testing conditions are so site-specific, we do not claim that the procedures described here are a universal recipe, but this is a solid first step toward developing a general method for slimhole exploration. In particular, we have compared test measurements with wellbore models, and have made a convincing case for the ability to predict flow in this type of reservoir.

We have reached the following conclusions concerning slimhole testing; the last two items below are specific to the Steamboat Hills geothermal field and the others are more generic.

1. Slimholes can be flow-tested, with successful surface and downhole measurements. Relatively cheap and simple surface measurements (James tube and weir box) can give flow rate and enthalpy.
2. The internal flow in the wellbore (described in the section on spinner data) greatly complicates the analysis of attempted pressure transient (build-up or fall-off) tests. This emphasizes the need for better definition of intra-wellbore flow.
3. The strategy used for these tests appears to have produced the necessary test data, taken with appropriate accuracy, to evaluate the commercial potential of a larger well at this location.
4. Numerical simulation of flow in the wellbore can yield a predictive curve of flow rate versus wellhead pressure, as shown in the slimhole data. Applied to a larger diameter well, this same simulation will give the same kind of production curve, giving a measure of the reservoir's commercial potential. Extrapolation from the slimhole data to the wellbore diameter of a nearby production well gave a reasonable estimate of the larger well's actual flow rate for a given wellhead pressure.
5. It is desirable to develop a coupled wellbore-reservoir simulator, and to extend this exploration strategy into other reservoir types, to validate the predictive capability of that model.
6. The deeper, hotter reservoir postulated in this location was not encountered down to 4000'. There is, however, significant permeability below the 815' production zone, implying that water hotter than 300°F can be pumped from deeper zones, or water from a power plant could be injected into these zones.

7. The existing reservoir is extremely permeable; calculations of transmissivity are probably lower bounds.

## VII. RECOMMENDATIONS

Although the test results here are encouraging, the highly fractured, highly permeable, reservoir may not be generally representative of other geothermal resources. The next step in the slimhole program should be exploratory drilling and testing in reservoirs with different flow characteristics, and comparison of those results with production wells in the new reservoirs. From preliminary negotiations with geothermal operators, we are confident that this can be done, given adequate funding in the near term.

A consequence of moving to other types of reservoirs will be the increasing need for better modeling capability, especially in terms of coupling a reservoir simulator to a wellbore simulator. As described in Section VI, the assortment of wellbore models used to date give reasonable predictions of flow behavior, but the codes' performance is enhanced, or perhaps even made possible, by the extreme transmissivity of this specific reservoir, which allows the assumption of a fixed pressure at the feed zone to be realistic. In other reservoirs, this may not be the case. We recommend, therefore, that a coupled reservoir-wellbore model be developed to aid further analysis.

There are also areas in which the instrumentation and data-collection strategy used in these tests could be improved. An enhanced instrumentation development could be a collaborative effort between Sandia and industry, or could be stimulated in industry alone by increased commercial slimhole exploration. Specifically, the following concerns should be addressed:

- Spinner measurements should be done with a tool which can distinguish flow direction (up or down); this feature is presently available in some commercial logging services, but is not always used. Data from most spinner tools is probably only good when the tool is moving bow-on into the flow (logging down), so data acquired logging up (flow stern-on) should be disregarded. Logging at a slower line speed will increase the probability that flow is bow-on to the tool, but the lower relative velocity makes the spinner more likely to stick. Careful analysis of the internal flow seems to be more important for slimhole exploration than in conventional production-size well testing because of the increased emphasis on down-hole instrumentation in the slimhole testing.
- As an aid to interpretation of the internal flow, accurate static pressure-temperature logs should be run at regular intervals, particularly when drilling data or core indicate that new high-permeability zones have been penetrated. Examination of the points on these logs where deviation of the pressure gradient coincides with changes in the temperature gradient should reveal sources and sinks of intra-wellbore flow.
- Optimum logging speed should be established; most of the service companies run their tools at 50 to 100 feet/min, which may be too fast for the pressure and temperature resolution needed in comparison of modeling and field data.
- Data drift caused by internal heating of the downhole electronics became significant because of the distortion of the data and because of the limitation this placed on the time available to do certain tests, particularly pressure transients. If these tests are thought to be valuable, a different testing technique, perhaps capillary tubing from the surface, or the use of tools with longer high-temperature residence times may be necessary.

- During development of slimhole testing methodology, commercial PTS logging tools should do static temperature logs at the beginning and end of each test series. These temperature logs could then be compared with some reference standard, such as the Sandia temperature tool, to evaluate the drift in the tool during the tests.
- Static water level in the well should be measured at regular intervals, probably daily, to keep track of the formation pressure in the permeable intervals penetrated to date.

Finally, the experience during the Steamboat Hills project showed the value of real-time, on-site data analysis. Software which could have compared downhole data with a wellbore simulator during the test sequence would have indicated malfunctioning instrumentation, or reservoir anomalies, quickly enough to have either taken remedial action or have changed the testing methodology appropriately.

### VIII. BRIEF GEOLOGIC DESCRIPTION (after reference 13)

The Steamboat Hills geothermal area, which covers approximately four square miles and includes active hot springs and fumaroles, has been studied for several decades. The oldest known rocks in this area are metamorphosed sedimentary and volcanic rocks, known collectively as the Peavine sequence. These rocks outcrop south and west of the drill site, and are believed to be of Triassic-Jurassic age.

The Peavine sequence is extensively intruded by Cretaceous-age plutonic rocks, of which granodiorite is the most abundant. There are also numerous outcrops of the granodiorite around the drill site. Next oldest are the Tertiary Alta and Kate Peak Formations. These formations primarily comprise volcanic flows, mud flow breccias, and sedimentary deposits. The Alta Formation is approximately 22 million years old (myo) and the Kate Peak is about 13 myo.

Youngest rocks are the Quaternary flows, domes, and sedimentary deposits, including the Steamboat Hills Rhyolite, believed to be associated with four small domes on a line that runs southwest to northeast of the drill site. A so-far-undetected shallow rhyolite intrusion is believed by some to be the heat source for the Steamboat Hills hydrothermal system.

All the different rocks in the Steamboat Hills geothermal area have been hydrothermally altered to a greater or lesser extent. Hydrogen sulfide rises, oxidizes to sulfuric acid and chemically attacks silicate minerals, replacing them with opal and cristobalite. Below the water table, silicate minerals are generally replaced by alunite and kaolinite.

Three principal lithologies were penetrated during drilling: Quaternary hot spring siliceous sinter deposits with intercalated alluvium; a series of Tertiary volcanic breccias and lahars; and an extensive Cretaceous-age granodioritic plutonic complex. Minor lithologic features include at least two andesite dikes, a probable ash fall or siltstone, pervasive calcite-chlorite veining, druzy quartz veins, stibnite, pyrite, and other sulfide mineral deposits, xenoliths, and possible plant fossils within the siliceous sinter.

Structurally, the pre-Cenozoic metamorphic rocks are intensely folded and faulted. Dips range from 45 to 90 degrees, while bedding strikes range from northeast to northwest. At least three systems of normal faults have been recognized in the Steamboat Hills. One set, which is still active, strikes northeast, parallel to the axis of the Hills. Another set strikes northwest, almost perpendicular to the first set. The third set of faults strikes nearly north and is prominent on the main terrace of hot springs. The Steamboat Hills hydrothermal system has been active, possibly intermittently, for approximately the last 2.5 million years, and faulting appears to be the principal structural control for fluid flow.

## **IX. GLOSSARY**

*The following terms are common in drilling practice and are used in this report:*

**Bowlin 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

**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<sub>2</sub>S** - 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 with pressure in the wellbore

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

**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 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

**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

sanded in - solid particles, such as cuttings, have filled the annulus between the drill rods and the wellbore, or between the core tube and the outer barrel, locking them in place

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 this rig, a stand was 4 joints

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

trip - any event of pulling the drillstring out of the hole and returning it

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 log represents notes made by Sandia personnel at the times of the events described. Definitions of abbreviations and jargon are given in the Glossary, Section IX. This narrative is complementary to the Daily Drilling Reports given in Appendix B.

### **20 Jul 93**

Continue rigging up, most components of rig are here and assembled. Road and pad are prepared and water line is laid from injection well to location.

1630 - Picked up 12-1/4" roller-cone bit and spudded hole. Drilled to approximately 3-1/2' and cemented short piece of 9-5/8" casing for mud riser. WOC till morning.

### **21 Jul 93**

0700 - Complete rigging up: tie down guy wires, connect pumps, etc. Weld pitcher nipple to mud riser.

1400 - Finally finish welding nipple. Hold H<sub>2</sub>S safety meeting.

1600 - Begin drilling HQ; losing some circulation.

1650 - First 5' core out; 100% recovery. Drilling second 5' tube, will pick up 10' tube for next run. Still losing circulation but under control.

### **22 Jul 93**

0700 - Have cored HQ to 161', with clay zone near bottom. Will core another 5', trying to get into more competent formation for casing shoe.

1100 - Reach 172', circulate hole. POOH with HQ.

1400 - Pick up 8-1/2" roller-cone bit and begin reaming HQ hole. Reaming is slow at first because of hard formation near surface and because can't get much weight on bit. Casing arrives: 4 joints nominal 42' lengths. Cut off approximately 2' to make cementing head, but remaining casing adds up to 167.3' with float and float collar. Requires drilling about 4' past bottom of core hole to make casing length reach the proper height for cementing.

### **23 Jul 93**

0700 - Drill to casing point, make wiper trip and circulate hole. Lay down 8-1/2" tools and start running casing. Casing is fairly tight, but does get down to calculated height.

1300 - Nipple up cementing head and begin circulating through casing. Bottoms-up temperature is 135°F. Mixing cement: Portland, 40% silica flour, friction reducer.

1530 - Pump 49 cu. ft. cement, release plug, and displace with water. WOC.

### **24 Jul 93**

0130 - Checked cement in sample cups and it appears to be curing properly.

0400 - Welder arrives for wellhead.

0800 - Begin nipping up BOP. Accumulators are electrically connected and plumbing is complete except for final connections to BOP.

1330 - Completed pressure tests on BOP; pipe and blind rams each pressurized to 500 psi for 15 minutes, each fell off slightly but held enough to pass test. Tests witnessed and approved by Dick Whiting, Nevada Department of Minerals. Begin picking up 5-1/2" core rods for coring BSF (6-1/4") hole.

1600 - Tagged top of cement at 110'. Begin drilling (coring) out cement.

1830 - Drilled through float collar at 132'.

2230 - Drilled through shoe at 173'.

### **25 Jul 93**

0800 - Coring ahead at 212'; getting fairly good core recovery, but still a lot of clayey, highly altered formation.

0845 - Coming into top of granodiorite at about 220'.

0930 - Complete lost circulation at about 225'; losing about 40 gpm.

1030 - Regained about 40% returns.

1300 - Coring ahead at 240'; lost returns averaging 40-60%.

1730 - Begin bit trip from 255'.

### **26 Jul 93**

0700 - Coring ahead at 295'; ROP is 5-6 ft/hr, but there was a trip to lay down a bad rod which apparently snagged the wireline and broke it. Getting nearly full returns.

0900 - Longyear safety meeting: all Sandia personnel attended.

1300 - Coring ahead at 320'.

1800 - Coring ahead at 345'.

### **27 Jul 93**

0700 - Coring ahead at 414'; drilling well but mud returns have gotten hot (about 165°F).

1200 - Fluid temperatures have dropped some, probably aided by the "cooling tower" built on the mud tank. Hole appears to be producing some fluid; viscosity is down, chlorides are up, and flow instrumentation shows frequent excess returns.

1730 - Coring ahead at 451'; returns have dropped back to about 147°F and hole doesn't seem to be either taking or losing fluid

**28 Jul 93**

0700 - Coring ahead at 495'. Returns temperature stabilized at ~ 145°F. Bit change at 462'; inside gage on old bit was completely gone.

0915 - Complete lost circulation at 507'; pumping LCM.

1215 - Regained returns after slugging hole with paper, cedar fiber, and cottonseed hulls.

1400 - Flash tank arrives from Mammoth Lakes; 4-1/2" casing arrives from Longyear. Mud pump is down, plugged with fragments of a rubber glove. These fragments have been showing up in the mud system since the first day, and it is not obvious where they're coming from.

1600 - Complete loss of returns again, still from the same fracture as before. Trying to get below it to try sealing with LCM or cement. Core returned from this interval shows a massive fracture, approximately 3" wide, filled with calcite but broken either in the formation or in the core barrel.

1800 - POOH

1900 - Cement mixing tank on the rig floor. Will pump open-ended through H-rod, leading with a slug of cottonseed hulls. Tracking static fluid level with echo-meter; now about 160'.

2100 - Mixing 10 sacks cement; pipe on bottom. Will pump next to fracture.

2200 - Pump cement and POOH. WOC.

**29 Jul 93**

0700 - Cement has set and hole is holding fluid. Tag cement with drill pipe at ~ 480'. POOH with H, RIH with 5-1/2" pipe and clean out cement with 6-1/4" bit. Drill ahead to 525'; this depth will allow the televiewer to get deep enough to view the fracture, and will make the casing length come out correctly.

1300 - Rigged up for temperature log; RIH through drill pipe and out bit. Will do another log after pipe is out of hole. Most of hole shows less than 90°C, with temp slightly over 100°C when the probe rests on the bottom of the hole.

1400 - Laying down 5-1/2" drill pipe.

1800 - Run another temperature log with pipe out of hole; similar to first log. Running in hole with H-rod, will circulate briefly and then run televiewer.

2300 - Televiewer log complete and successful. Fractures were evident, mostly dipping southwest, although some were at other orientations, including northeast.

2330 - Rigging up to run 4-1/2" casing and pump cement.

### 30 Jul 93

0300 - Ran casing to 524' and pumped 120 cu ft cement mixed 1:1 with perlite. tailed with neat cement. Got returns (perlite) but formation apparently broke down and cement fell back.

0800 - Surface cement samples show that cement has not even begun to set. Call to Halliburton office reveals that cement included a fluid-loss additive which also acts as a retarder. Howco engineer estimated 16-20 hours for a surface sample to harden. At 160°F or greater, however, it should start to set in 6-8 hours (i. e. cement in hole should be starting to set.)

1000 - Rig up for temperature log.

1100 - Put "cold" water down the annulus and log again. Hole takes water freely at first, but soon slows down to < 1gpm. Log shows that upper part of hole has cooled considerably, but no cooling below ~ 220'.

1600 - Repeated logs, while continuing to trickle "cold" water down the annulus, show the upper hole continuing to cool, with all temperature lines crossing at about 220'. Perforating crew is on the way; will perforate from about 230' to 220'. Nippling up BOP to do pressure test before perforation.

### 31 Jul 93

0400 - Pressured up blind rams/wellbore to test BOP; small leaks in various valves.

0800 - Complete pressure tests (500 psi for 30 min) on blind rams and pipe rams. Rigging up to perforate from 230' to 220'. Perforations complete, water level fell to static.

1000 - Rigged up for Halliburton to pump cement through one stand open-ended drill pipe held in the BOP pipe rams. Pumped cement until we got good returns at surface (~ 85 cu ft), shut off cement and pumped 70 gal mud through drill pipe with rig pump. This is the calculated volume to displace cement out of drill pipe and halfway down casing to perforations. Shut in drill pipe. Kept filling annulus with cement from top as it fell back, but very little (< 10 gal) was required. Released Halliburton. WOC.

1800 - RIH with HQ tools and clean out to top of firm cement. Core ahead, look at cored cement samples, it appears well cured and competent. Drill ahead.

### 1 Aug 93

0700 - Have drilled past perforations to float collar. Pressure test to 100 psi at the wellhead. Perforations do not leak. Drill ahead.

1130 - Drill contact between cement and formation. Very good interface, no signs of mud contamination or other problems. Run temperature log in Hot Air #4 (production well next to corehole); log is the same shape as previous log (last year) and matches maximum temperature (339°F).

1730 - Coring ahead in granodiorite at 575'.

## **2 Aug 93**

0330 - Lost circulation at 637', drilled ahead enough to get core from that depth, core had some fractures but none that appeared to have had large water flows. Circulated LCM and regained partial (~50%) returns. Consensus is that this fracture is too small to try a flow test.

1400 - Continue rigging up equipment for flow/injection tests.

2000 - Still coring ahead at 718', formation continues to be fractured with returns varying from 50% to 10%, but still have not encountered the total and irretrievable loss expected near this depth.

## **3 Aug 93**

0700 - Coring ahead at 783'; same as above. Some returns, no massive loss.

1100 - Drilling break at 816'; driller lowers string 2+ feet without rotating, water level falls below 300'. Complete loss of returns. Recover 7.4' core in 10' run. Will drill ahead, and get next core run, then drill some rathole below fracture.

1415 - Drilled to 838', POOH and began nipping up flow tee and connections.

1800 - Run temperature log while flow connections in progress; hole has cooled by 40°F compared to log after first cement on 4-1/2" casing (i.e., flow may be hard to start) probably because of pumping lots of cold water into formation with no returns.

2100 - Pressured up to 100 psi at wellhead, let sit for an hour, and released pressure. Well did not flow. Ran temperature log, well had heated up approximately 30°F since previous log.

2230 - Re-pressurized wellhead to 100 psi, will leave until 0630.

## **4 Aug 93**

0700 - All instrumentation working, release pressure on wellhead, well does not flow. Try 8 cycles of pressure/quick release, well still does not flow. Will try to get higher-pressure compressor to force fluid deeper.

0930 - New compressor pumps 205 psi at wellhead, leave pressurized for 30 minutes and release, well still doesn't flow.

1030 - Re-configure wellhead so that we can drill with flow tee in place. Test vortex flow meter against weir box; have good agreement.

1215 - Since there is apparently low permeability and/or little fluid in fractures, we will drill ahead to a more promising opportunity.

2000 - Drilling ahead at 878'

**5 Aug 93**

0700 - Drilling ahead at 958'. Core from 868' down contains many steeply-dipping, highly mineralized fractures that do not fit closely when core is reassembled. This indicates that there should be significant apertures downhole in this interval.

0750 - Pull back into casing and rig up to do temperature log to bottom at 968'.

0900 - Log shows high temperature (>160°C) in fractured interval from 868' to 948', indicating high permeability in that interval.

1015 - Will pull back to about 200' and try air-lifting from inside casing. Compressor is rated at 100 psi, 100 scfm.

1300 - Air lift is producing about 4-5 gpm, outflow temperature has risen from about 135°F to 162°F.

1500 - Outflow temperature is up to 180°F, but the small annulus between the H-rod and wellbore will probably prevent flow even if temperature gets near boiling. Will pull rods and pressurize wellhead.

1600 - Left wellhead at 100 psi for 30 min, released pressure, well did not flow. Will run back in with N-rod (2-3/4" OD) and air lift again, hoping that the larger annulus will allow lifting more water. Rig for temperature log through N-rod before air-lift.

1700 - Temperature log shows temperatures below about 150' almost identical to yesterday's last log. Begin air lift with 100 psi compressor. Temperature in flow line reaches about 199°, flow rate ~ 25-28 gpm.

1800 - Add larger compressor (200 psi, 300 scfm) into line - compressors in parallel. Temperature drops to 190°F and flow rates becomes very erratic, from 12 to 28 gpm. Speculation is that both compressors are blowing too much air past the water. Will take small compressor out of the circuit.

1821 - When both compressors are turned off, well begins to flow on its own. Temperature goes to 203°F and flow rate remains erratic at 10 - 30 gpm, probably because of the drill pipe in the hole. Let the well flow to clean up the fluid (get rid of drilling mud, etc.) and shut in. POOH with N-rods and pressurize wellhead to 150 psi with compressor.

2008 - Release wellhead pressure and well flows. Beginning flow rate indicated on magmeter is approximately 60 gpm (liquid), but it builds to 100+ gpm within 25 minutes. Actual flow from well does not take this long to stabilize, but time for reaching steady-state conditions between the flash tank and weir box causes readings to lag flow.

2130 - Rigging up to run wireline pressure, temperature, spinner (PTS) logs. Spinner log shows most production from major fracture at 815'.

2250 - Choking flow to approximately 80 gpm by closing wellhead valve; flow rate and wellhead temperature go down, wellhead pressure goes up.

2327 - Choke to approximately 50 gpm.

**6 Aug 93**

0010 - Open valve for full flow.

0039 - Shut well in.

0700 - Open well, POOH with downhole PTS tool, RIH with downhole fluid sampler, take water samples below production zone, POOH, RIH with SNL temperature tool, temperature log, rig up for injection test. Injection will be hot (~195°F) water from power plant injection line, step-wise injection at four flow rates (maximum first, then step down and back up), then shut in.

1345 - Start injecting at about 470 gpm, drawing water from the power plant injection well line. Water temperature is > 220°F, so it's flashing to steam in the injection line because of low back pressure.

1430 - Increase flow rate to 630 gpm; wellhead pressure is about 26 psi.

1500 - Stop injection; line has blown off injection pump. Consensus of personnel here is that they don't trust hose again at high temperature; we will rig up to inject cold water.

1610 - Start cold water injection. Inject at three flow rates: 260, 500 (start at 1640), 600 (start at 1716) gpm; get data from all runs. After flow stabilizes at each rate, run logging tool up and down interval from 805' to 960' trying to define where the water is going below the production zone. Shut in well, do static downhole log, and log out of hole.

1900 - Resume drilling.

**7/8 Aug 93**

Have drilled from 978' to 1232' in these two days. We are, in general, looking for potential production zones while waiting for logging tools to be repaired and/or calibrated. When we do the next set of tests, it is likely that production test results will be very similar to the first set because the large production at 815' may suppress flow from lower zones.

**9 Aug 93**

0900 - Received downhole packers for isolating flow zones in wellbore. If packers are run in hole on N-rod (2.75" OD) the annular area will permit injection down the annulus and down the rod, allowing comparison of injectivity above and below the packer. This test will be done after the next production/injection series.

1200 - Drilling ahead at 1328'. Will continue drilling until logging tools are available for tests.

**10 Aug 93**

- 0700 - Drilling ahead at 1478', good rate of penetration (up to 10 ft/hr)
- 1255 - Begin POOH for bit change at 1510'; rig up for temperature log with SNL tool.
- 1530 - SNL log over; RIH with N-rod to begin air-lifting fluid for production test. Using small (100 psi) compressor, we are lifting about 20-25 gpm from the hole.
- 1630 - Well starts self-flowing at ~ 30 gpm; shut off air. Will let well flow briefly to get hot, then kill.
- 1700 - POOH with N-rod, pressurize wellhead to 100 psi, rig up loggers.
- 1734 - Release pressure, well does not flow; repeat pressurized to 150 psi for 15 minutes (until 1600) well still did not flow.
- 1830 - Pressurized to 150 psi for 30 minutes; well still did not flow. Run temperature log; will RIH with N-rod and air-lift again.
- 2000 - Begin air-lift; will lift for ~ 2 hours.
- 2200 - POOH with N-rod, pressurize wellhead.
- 2245 - Release pressure, well flowing at 85+ gpm.
- 2300 - Flow rate readings are no good because weir box is overflowing; suction pump is not working to drain back side of weir. Drain weir box overflow into trash pit and pump into drilling sump. Continue flow.

**11 Aug 93**

- 0215 - Do PTS traverse in wellbore (up and down) and shut in well.
- 0730 - Open wellhead, POOH with logging tool, and rig up for injection test Will do hot water injection into full hole first, followed by injection into zones isolated by packer.
- 0918 - Begin flow at ~335 gpm with 195° water; wait for flow to stabilize.
- 1034 - Hose blows off injection pump. Test over, got good data from test, but only at one flow rate. Begin re-plumbing pump with pipe to replace hose, rigging up to run packers.
- 1730 - RIH with packer on N-rod, set packer at 690', between production zone at 815' and apparent injection zone at ~ 640'.
- 1817 - Begin pumping 202°F water down the annulus outside the drill pipe at 220 gpm. Log down pipe, through packer, and into open hole. Data are anomalous, temperature appears almost constant through packed-off zone.

1928 - Log out of hole and stop pumping. Pull up on drill string and get no resistance. Packer is deflated. POOH with packer and lay it down.

2030 - Disassemble packer; O-rings at the ends of the inflation element are stretched and gummy, indicating that they were not suitable for high temperature. Will get Viton O-rings and refurbish both packers.

2100 - RIH to resume drilling at 1510'.

#### 12 Aug 93

1900 - At 1600' after drilling throughout the day. Reasonable rate of progress, although drillstring vibration has been a problem. Most likely cause is water inflow to the wellbore, diluting or washing away the mud and creating friction in the upper part of the hole. Have tried pumping mud down the annulus, Tork-Ease on rods, other rod lubricant, and checkout of rig hydraulic system. Both packers re-dressed with Viton O-rings.

#### 13 Aug 93

0720 - Drilling ahead at 1670'. Bit has been in use since 1600'. Still some torque and vibration in drillstring.

1300 - Rig up to run televiewer in 3" corehole (TH-2); will use water truck to pump cold water down hole and try to cool BHTV. Centralizers need adjustment; set for 4-1/8", they will not go in smaller hole.

1800 - BHTV runs are successful; get good picture of borehole. Tool has reliable performance at 110°C, but is about to quit at 130°C.

#### 14 Aug 93

0700 - Drilling ahead at 1750'. Eighty feet since yesterday, with third bit change now in progress.. Still being plagued by drill string vibration; will try slugging hole with LCM to improve the fluid column in the annulus.

1800 - Drilling has improved somewhat, but there is still noticeable vibration in the drillstring. Will continue trying combinations of rod lubricant and LCM.

#### 15 Aug 93

1700 - At 1858' after continued drilling through the day with generally the same problems and performance as yesterday. Still good core recovery, essentially all granodiorite.

#### 16 Aug 93

0800 - Have drilled 90' since 0800 yesterday. Low rotary speeds (~100 rpm) have reduced vibration, but also penetration.

0900 - Short trip out of hole to grease rods; using environmentally benign rod lubricant.

1815 - Drilling ahead at 1958'.

### 17 Aug 93

0700 - Just passed 2000'; still on same bit in at 1837'. Performance reasonably good.

1500 - Preparing for flow tests; plumbed system together so that we could compare flow rates in the vortex meter (water injection line from power plant), magmeter (line between flash tank and weir box), and weir box. Magmeter and vortex meter were within 1-2 gpm at 100 gpm flow rate, with weir box indicating ~90-95 gpm. Will check level and zero on weir box.

2100 - POOH for bit change.

### 18 Aug 93

0300 - After running back in the hole with a new bit and beginning rotation, drillstring experienced severe torque, enough to stall rotation. Pipe apparently parted then, either from a twist-off or by unscrewing from torque release, but driller did not realize it immediately. Driller sent down wireline overshot to pull core tube, but could not get on it and thought that the "tree" was leaning over. Sent down the tool to set the tree straight, came out, and sent the overshot down again. Latched onto the core tube, but could not get the overshot back through the broken bottom of the drill string. Released core tube, and pulled wireline out of the overshot, leaving about 20' of wire in the hole. Pulled rest of string out of hole, break is about 140' off bottom.

0700 - RIH to tag top of fish and find out whether the overshot is on top of the parted pipe or has fallen back into it.

0930 - Good news is that we tag top of fish at top of parted pipe; that is, the wireline release tube and the overshot have fallen into the pipe. This means that we don't have to fish the line. Will RIH with inside swage (piece of N-rod brought to bullet point, with weld bead on the sides), then try to swage into the pipe and retrieve it.

1145 - RIH with swage + 1 joint N + Xover to H on drillstring.

1330 - Swage goes in fish, try several times pulling 5,000 lb over string weight, but fish stays stuck. Will POOH and build up weld beads on swage.

1600 - RIH with built-up swage. Pull 10,000 lb on fish, still stuck. Work pipe, can't rotate.

1815 - POOH. Will RIH with N-rod outside swage and try to pick up wire and/or overshot.

2330 - Feels as though the tool grabs the overshot and/or wireline, but no fish in the tool when back at surface. Will cut slots and "teeth" in the end of the swage and RIH.

### 19 Aug 93

0100 - RIH with overshot swage; work up and down and rotate  
0400 - POOH with wire rope, jar staff, and slide rod.  
0430 - Rebuild outside swage to fish release and picker  
0500 - Fish for picker and release until 1530 (two trips.) No material retrieved from hole.  
1500 - Decide to cut rods 14' above core barrel, RIH with cutter  
1600 - Call Midway fishing tool, order Bowlin spear, bumper sub and fishing jars. Should arrive at 0600 in the morning  
1800 - Cut rods at 2050'; POOH with cutter.  
2100 - RIH with inside swage to retrieve cut-off rods.  
2300 - POOH with swage and cut rods  
**20 Aug 93**

0030 - Lay down 120' H-rods plus 6' cut rod.  
0100 - RIH with overshot swage and worked fish.  
0545 - POOH with no fish.  
0630 - Pick up spear and jars, RIH.  
0830 - Lock into fish and jar on fish, after 8 jars fish starts to move up hole.  
0900 - After pulling up three stands with 8000 lb over pull, weight drops to string weight.  
1030 - POOH; no fish on spear.  
1100 - Pick up inside swage to try to lock into fish and rotate, RIH.  
1230 - Tag fish 120' of bottom and push back to bottom to set swage.  
1300 - POOH with fish.  
1440 - Fish on deck; got all but 2 bit segments and the overshot release.  
1500 - Run open hole temperature log while reworking core barrel. Bit is burned and tube is sanded in. After checking it appears sand came from bad mica LCM  
1900 - RIH with new bit and wash to bottom  
2300 - Core 1 ft and retrieve tube.

### **21 Aug 93**

- 0030 - Tube contains both missing bit segments and 1' of core
- 0830 - Cored 41 ft since fishing, vibration problems in upper hole. Pull and grease 12 stands.
- 1600 - Drilling void at 2149'; short run (blocked). Drilled 3.2' - recovered 2.6', then drilled 6.9' and got 7.6'. Lots of cave. BHT = 316°F
- 2200 - At 2168' bad vibrations, pull back and grease rods.
- 2240 - Try to drill but won't go; POOH for bit change. RIH with series 8 bit at 2168 ft.

### **22 Aug 93**

- 0030 - Still won't go. POOH to grease rods at 2168'.
- 0830 - POOH for stuck inner tube at 2188'. Roll pin on latch head loose, bit looks like new.
- 1645 - POOH for pressure and vibration at 2203'. Bit OK but water-ways plugged. Function test BOP. Grease rod on RIH. BHT = 314°F.
- 2115 - Back on bottom drilling.

### **23 Aug 93**

- 0800 - Drilled 50' last 24 hours, going slow but with less vibration.
- 1200 - Run SNL PTS tool tests in TH-2, ran tool for 3 hours. Pressure is stair-stepped because of potentiometric transducer, but temperature and spinner are working.
- 1300 - Pulled back 13 stands and greased rods. TD at 2268'.
- 1500 - Postpone flow tests until we can solve hole vibration and torque problems. Try to test in a week.
- 1600 - Pull back and grease 20 stands at 2278'.
- 2120 - Grease not lasting, pull back 25 stands and grease at 2288.

### **24 Aug 93**

- 0015 - Grease not lasting. POOH from 2293 to check bit. RIH and grease from core barrel all the way with grease loaded with Tork-ease and inverted pipe order - newest pipe now on bottom.
- 0800 - At 2298'; have drilled 60' in last 24 hours. Rods spinning smoothly, Tork-ease or pipe order may have helped.

1015 - BHT is 310°F at 2318'. Drilling is good with 300+ rpm.

1100 - Start planning for possible hole size reduction to NQ if drilling does not improve. Would cement bottom of old HQ casing shoe, stretch pipe, and weld donut in BOP flange. Looking for pipe and bits. Won't reduce until after next flow test or later.

2215 - BHT is 318°F at 2358'; rods still spinning.

**25 Aug 93**

0815 - BHT is 315°F at 2398'.

1510 - Pressuring up, looks like bit is gone. POOH

1700 - Bit is rung, center has groove 1/4" deep. Will service rig then RIH with series 9 bit while greasing rods with Tork-ease and rod grease.

1955 - On bottom drilling with good rotary speed.

**26 Aug 93**

0040 - Drilling 5 hours for 11'; POOH to check new bit.

0300 - Bit like new but matrix is not stripping, pick up series 7 and RIH while greasing.

0545 - Back on bottom drilling.

0720 - BHT is 315°F at 2448'.

1300 - Ran SNL 7-pin temperature tool for log in TH-2 to compare with PTS tool and with previous log while pumping cold water.

**27 Aug 93**

0100 - Run Totco survey, hole is 2° off vertical at 2508'.

0440 - BHT 312°F at 2528'

0700 - Replace wireline with new 5000' line while drilling ahead.

1240 - BHT is 320°F at 2557'.

2220 - At 2598' pull back 32 stands and grease rods due to torque and vibrations.

**28 Aug 93**

0100 - BHT is 315°F at 2608'.

0610- Bit gone at 2598'. POOH.

0930 - Bit on carbides on outside gage. Will run a new special series 7 bit with Geosets on outside gage and lower diamond concentration. This bit design from Longyear bit engineer should improve gage protection and matrix stripping. Also rig up 20 ft core barrel w/o top reamer shell.

1030- RIH while greasing with Husket grease loaded with Tork-ease.

1230- Back on bottom drilling.

**29 Aug 93**

Drilled ahead from 2690' to 2795'.

**30 Aug 93**

Drilled ahead from 2795' to 2930'.

2300 - Begin POOH with drillstring for flow tests.

**31 Aug 93**

0300 - RIH through 280' N-rod with temperature logging tool. Log to bottom indicates relatively constant temperature, decreasing slightly below approximately 900'.

0545 - Have been airlifting well, it starts flowing on its own (~25 gpm); will let it flow and heat at least until water cleans up.

0740 - Kill well to POOH with N-rods.

0820 - Pressurize wellhead to 100 psi.

0853 - Release pressure, well begins to flow through 2" James tube and stabilizes at about 60 gpm.

1022 - Throttle well back to about 45 gpm; since maximum flow rate is much less than that with 3" James tube, we will go back to the larger tube.

1147 - Pump cold water down well to kill it, POOH with logging tool, and pressurize wellhead. Change to 3" James tube.

1208 - Release pressure on wellhead, well begins to flow again at about 100 gpm.

1224 - James tube pressure transducer has calibration wires shorted, giving too high pressure.

1235 - Separate and dry calibration wires, pressure goes back to correct value.

1230 - Flow seems to be stabilizing at about 106 gpm.

1305 - James tube transducer shorted again; clip calibration wires.

1508 - Throttled back well flow; stabilizes at about 88 gpm, run downhole log.

1826 - Throttled back well; flow is about 71 gpm, begin PTS log at 1840.

2025 - Throttled back to 50 gpm; take downhole data at 808', but not a full survey.

2050 - Open well to full flow with PTS tool hanging at 808', let flow stabilize and shut-in at 2122.

### 1 Sept 93

0520 - Injection water line is pressured up from power plant; begin pumping into well to determine maximum flow rate. Line temperature is 213°F. Maximum flow rate is approximately 720 gpm, limited by pump (even with lower temperature water.) Logging tool (PTS) is not working and apparently has not been since before shut-in last night. Speculated cause of failure is high internal temperature, but tool cannot be easily or quickly repaired. Since there is no back-up tool, and since there is no meaningful test we can do without downhole instrumentation, injection tests are canceled. Will resume drilling at 2930'

0700 - RIH, grease rods, wash to bottom, and circulate hole.

1210 - Resume drilling at 2930' with same bit used on previous interval.

2210 - Drilling ahead at 2990'. Deviation survey = 1-1/4°.

### 2-5 Sept 93

Drilled from 3000' to 3470' with generally good rates of penetration (~ 10 ft/hr). Downhole vibration problems have mostly ceased. Formation has few major open fractures except for vuggy/fractured zone at 3208' which has fracture apertures ~1/2". Bit changes at 3072' and 3430'.

Have also spent these days examining and plotting data from three series of flow tests. In general, surface data (wellhead pressure and temperature, flash tank exit temperature, James tube pressure, magmeter flow rate, and weir box flow rate) appear good, although James tube pressure fluctuates enough to cause difficulty in deciding which value to use for flow rate calculations.

Downhole data shows considerable variation. Two different tools were used in the three tests, possibly with different transducers in the same tool for the second and third series of tests. Temperature and pressure apparently drift with time, with temperature changing as much as 10°F over 10-12 hours. Pressure during post-production shut-in tests also shows odd behavior - rising, then falling, then rising and falling again. Will attempt to resolve these anomalies before further testing.

1600 - Have POOH for bit change and rigged up SNL logging truck for temperature log. Frayed outer braid on wireline packs a rat's-nest into the cable guide at ~2600'. Clear tangled wire, POOH with logging tool. Bad spot in wireline is too far from end to allow cutting off the

frayed part and still reach bottom of hole at 4000'. Wire can be dressed to reduce the possibility of snagging, but we don't want to risk getting a downhole tangle, especially if logging through the packers.

### 6 Sept 93

0800 - Drilling ahead at 3510'. Deviation survey shows 1/4°.

### 7 Sept 93

0800 - Drilling ahead at 3650'. Some downhole torque, about to pull out of hole to grease rods and inspect bit.

1200 - Changing bit; bit in since 3450' still has ~60% life, but new one may finish hole.

1300- Set down on something at 268 ft while RIH with new bit. Could not work through. POOH and inspect bit. It shows sign of riding on junk on outside gage. Bit is over gage, 3.925" rather than 3.895". PU new bit and RIH. It also set down at 268' but wrenched through. Rig down for 2 hours for hydraulic repair.

1730- Back on bottom; drilling ahead at 3650' with low torque.

### 8 Sept 93

0700- Drilling ahead at 3730'.

2200 - Rate of penetration at 3799' has fallen drastically, to about 1 ft/hr. POOH for bit change; bit is not badly worn, but matrix is not stripping. Core is much harder; previous core showed hardness = 5-6 on scratch test, current core shows hardness = 7-8

### 9 Sept 93

0230 - RIH with temperature tool for log.

0530 - Log shows that bottom-hole temperature is less than 300°F. RIH with new bit (series 10).

1730 - Drilling ahead at 3860'.

### 10 Sept 93

1200 - Have drilled to 4000'. Far West has tentatively decided not to drill deeper at this time. The principal decision is on what the test program should now be. Lengthy discussion has produced the following procedure: 1) run in hole with SNL temperature tool through drill pipe with bit at 3500' (hoping that the bit will act as a quasi-packer) and let tool sit at bottom to see if it warms up; 2) log out of hole, attach SNL pressure-temperature tool to bottom of temp tool and do comparison log; 3) trip out of hole and start well flow for production test, use commercial logging company for PTS surveys while flowing and shut-in; 4) kill well and do full-hole injection with PTS; 5) based on results of injection, consider packer tests.

1830 - Temperature tool is at bottom; temperature is 147.8°C (298°F).

### 11 Sept 93

0630 - Tool has been hanging at 3990' for 12 hours, temperature is 146.35°C (295.4°F) Log up hole, temperatures do not vary much between logs until above production zone at 815'. Begin pulling out of hole with drill rod so that we can air-lift hole and start flow.

1300 - Did not need to air-lift, just pressurized wellhead. After third pressure, well flow started. Can probably start well without air-lift now because cooler drilling fluid goes into the formation at a deeper zone than at earlier tests and the top of the hole stays hotter.

1500 - RIH with SNL temperature tool for flowing log.

1600 - Tool hangs up on something at ~2700', try to come out of hole. Cable or tool stuck at 1700'. Kill well, allow it to cool, and remove top of lubricator. Wireline is badly tangled inside and so cannot pull through top pack-off (i.e., knot formed at about 1000' depth when line went slack because of set-down.) Untangle wireline (knot area is seriously frayed) and pull the rest of the way out of the hole.

1930 - Release pressure on wellhead, flow begins. Cut off cable head, spool out wireline to bad spot, and cut to re-head. PT tool has bad temperature transducer (RTD). Waiting for loggers; continue to flow well.

2315 - James tube pressure goes down almost 1 psi when crew uses steam-cleaning line off of flow tee.

### 12 Sept 93

0515 - Loggers arrive, begin rigging up. Well flow rate and James tube pressure are down slightly.

0930 - After several problems with logging truck, go in hole with PTS tool for production log. Tool hits same obstruction that stopped SNL log yesterday. Pull up to 805' and shut in well.

1500 - POOH with PTS tool. RIH with drillpipe, feel no obstruction at 2700'.

1830 - Drill pipe hanging at 2720', RIH with SNL temperature tool and PT memory tool. Tools hang up at 3200', cannot get deeper. POOH, memory tool has no data.

2330 - Plan to RIH with rest of drill pipe, core about 1' (capturing any cave that has fallen into the wellbore), POOH with drill pipe, and try another temperature log.

### 13 Sept 93

0600- Rigging up for temperature log with SNL tool; memory tool not working (batteries).

- 0830 - Tool goes to bottom of hole with no interference; will hang at bottom for 1/2 hour and POOH.
- 1000 - Logging company rigging up for static PTS log; will pull up into lubricator afterward and start injection with new pump, supposedly capable of 100 psi/2000 gpm.
- 1240 - Begin taking data for injection test; PTS tool is out of lubricator, cooling
- 1248 - Injection starts; pump can only deliver ~900 gpm. Pressure at pump is 150 psi (60 psi line pressure from power plant), but only 60 psi at wellhead. This implies 90 psi pressure loss in supply line from pump to wellhead, which seems high.
- 1445 - Begin PTS log, flow has stabilized at ~920 gpm/58 psi wellhead pressure. Log to bottom and back up.
- 1745 - Injection ends.
- 1800 - Pick up packer. Will set it at 1060' and take temperature recovery logs. RIH with packer on H-rod.
- 2130 - Packer is set but we cannot retrieve standing valve. Wireline overshot is either not engaging valve stem, or is releasing it. Examine overshot and call packer manufacturer; overshot appears to be right.

#### 14 Sept 93

- 0030 - Decide to POOH; release packer by turning drill pipe.
- 0130 - Packer has crossover to N-rod thread (because we first ran it on N) then N-to-H. N-to-H crossover ID is too small to pass the overshot.
- 0400 - Get new crossover; RIH again with packer and set at 1060'.
- 0500 - Retrieve standing valve with overshot.
- 0752 - RIH with loggers' PTS tool (really a PT tool; spinner removed to get through packer. Log down and up.
- 1230 - Repeat PT log through packer. Temperatures below packer are identical with first log. Rig up to pump cold water through packer.
- 1614 - Start injecting cold water at ~460 gpm/90 psi wellhead pressure. Log to bottom and back to 2150'. Flow stabilizes at 440 gpm.
- 1735 - Stop injection, log pressure/temperature at 2150'.
- 1900 - POOH with logging tool; POOH with packer. Will pick up second packer, RIH to 2450', and set packer.

2330 - Inflate packer, but it doesn't hold pressure. Try to re-inflate, with no success.

### 15 Sept 93

0030 - Begin POOH with packer; will RIH with other packer.

0430 - New packer set, holds pressure, rig up for static log through packer to TD.

0628 - Begin static log through packer; temperature below packer has hardly changed since previous logs.

1230 - Second static log through packer; temperatures below packer have not changed since previous static log. Rig up to inject through packer.

1344 - Start injecting through packer with big pump; flow rate is approximately 280 gpm with a wellhead pressure of 110 psi. This compares with injection through the packer at 1060', when flow was 450 gpm at 90 psi wellhead pressure. It appears that, although some of the difference could be caused by friction loss in the longer pipe, the formation must be considerably less permeable below 2500'. Try to do traverse downhole, but logging tool cannot get below 2700'. It first appears that this could be flow related, but we later find that the tool will not pass this zone even after flow is shut-in.

1600 - POOH with drill pipe and packer. Rig up for flow test, run primarily to test SNL memory tool at production shut-in.

2000 - Release pressure on wellhead, flow begins.

2115 - Lower PT memory tool to 800'; will leave it there for 5 hours.

### 16 Sept 93

0230 - Retrieve memory tool; it has successfully taken data. Make wiper trip to bottom with drill pipe, driller can feel obstruction at 2700' where logging tool stopped. Begin POOH with drill pipe, laying down 10' rods. Will release rig when pipe is laid down.

## **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, Far West Capital, and other interested researchers. The reports were compiled primarily by the Sandia on-site project leaders, with valuable input from Desert Drilling Fluids and Longyear field engineers, as well as personnel from the UNLV Division of Earth Sciences.

DAILY DRILLING REPORT - 07/21/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 1 | Depth today - 2' | Hole advance last 24 hr - 2' | Core recovered - n/a

BITS -- Now drilling 12-1/4" hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - ft/hr  
Bit number | Type | Depth in, KB | Depth out, KB | Footage | Hours  
1 12-1/4" tri-cone 10' 12' 2 2

Drilling fluid - air

Flow rate - gal/min | Pressure - psi | Returns temp - °F |

Wt - lb/gal | Vis - sec | PV - cP | YP - lb/100ft<sup>2</sup> | pH -

Lost circulation -

Lithology of today's core : n/a

Summary of events last 24 hours:

Completed rigging up and spudded 12-1/4" hole approximately 3' for mud riser. Cemented in 9-5/8" casing, WOC, and welded riser to 8' above ground for returns and flow line.

Report by: John Finger

DAILY DRILLING REPORT - 07/22/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 2 | Depth today - 121' | Hole advance last 24 hr - 119' | Core recovered - 115'  
Last casing - 9-5/8" riser @ 3'

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BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'			

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Drilling fluid - water, bentonite, polymer

Flow rate - 30 gal/min | Pressure - psi | Returns temp - 90°F |

Wt - 8.5 lb/gal | Vis - 33 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation - generally minor, up to 20%

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Lithology of today's core : not yet logged

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Summary of events last 24 hours:

Picked up HQ core string and drilled approximately 119'. Top 25-30 feet were very hard, but softer rock below that, including significant amounts of clayey, highly altered volcanics.

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Report by: John Finger

DAILY DRILLING REPORT - 07/23/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 3 | Depth today - 176' | Hole advance last 24 hr - 55' | Core recovered - 55'  
Last casing - 9-5/8" riser @ 3'

BITS -- Now reaming 8.5" hole | Rotary speed - rpm; WOB - lb; Rate of Penetration - ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12

Drilling fluid - water, bentonite, polymer

Flow rate - 70 gal/min | Pressure - psi | Returns temp - 90°F |

Wt - 8.5 lb/gal | Vis - 33 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation -

Lithology of today's core : not yet logged

Summary of events last 24 hours:

Finished coring HQ to 172' at approximately 1200 yesterday. Picked up 8-1/2" roller-cone bit to ream HQ hole. Reaming very slow at first because of hard surface formation and little weight on bit, but picked up at deeper part of hole. Drilled approximately 4' deeper with roller bit than cored so that top of casing would have the correct height for cementing. Made wiper trip and circulated hole in preparation for running 7" casing.

Report by: John Finger

**DAILY DRILLING REPORT - 07/2493**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 4 | Depth today - 176' | Hole advance last 24 hr - 0' | Core recovered - n/a  
Last casing - 7", 20 lb/ft @ 175'

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

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12

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Drilling fluid - water, bentonite, polymer

Flow rate - xx gal/min | Pressure - psi | Returns temp - xx°F |

Wt - 8.5 lb/gal | Vis - 33 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation -

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Lithology of today's core : n/a

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Summary of events last 24 hours:

Ran 4 joints 7"/20lb casing, with float shoe at bottom and float collar at top of first joint. Cemented with 49 cu. ft. of Portland cement with friction reducer and 35% silica flour. Full cement returns to surface, displaced cement with water. Cement away at 1530, WOC until 0400 and begin welding wellhead. Begin nipping up BOP at 0730.

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Report by: John Finger

**DAILY DRILLING REPORT - 07/25/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 5 | Depth today - 212' | Hole advance last 24 hr - 36' | Core recovered - 36'  
Last casing - 7", 20 lb/ft @ 175'

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**BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)			

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Drilling fluid - water, bentonite, polymer

Flow rate - 40 gal/min | Pressure - psi | Returns temp - 100°F |

Wt - 8.5 lb/gal | Vis - 33 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation - intermittent

---

Lithology of today's core : Not yet logged

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Summary of events last 24 hours:

Finish nipping up BOP, tested accumulators, and rams. Blind and pipe rams each held 500 psi for 15 minutes. Minor leak around kill line nipple welded. Tests witnessed and approved by Dick Whiting, Nevada Department of Minerals. Picked up 5-1/2" core rods and 6-1/4" bit, RIH and tagged top of cement at 110'. Drilled through casing shoe at 2230, coring ahead since then.

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Report by: John Finger

**DAILY DRILLING REPORT - 07/26/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 6 | Depth today - 295' | Hole advance last 24 hr - 83' | Core recovered - 83'  
Last casing - 7", 20 lb/ft @ 175'

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BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'			

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Drilling fluid - water, bentonite, polymer, MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 130°F |

Wt - 8.6 lb/gal | Vis - 36 sec | PV - 12 cP | YP - 6 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation - intermittent

---

Lithology of today's core : Not yet logged

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Summary of events last 24 hours:

Continue coring 6-1/4" hole x 4" core. Entered top of granodiorite at approximately 225'. This formation is fairly hard but drills reasonably well at 5 to 6 ft/hr. Lost circulation varies from total to none, but has mostly been less than 25%. Lost some time last night when wireline broke, apparently because the core tube snagged on a protrusion inside one of the rods. Tripped rods and laid down bad one.

---

Report by: John Finger

**DAILY DRILLING REPORT - 07/27/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 7 | Depth today - 415' | Hole advance last 24 hr - 120' | Core recovered - 120'  
 Last casing - 7", 20 lb/ft @ 175'

BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'			

Drilling fluid - water, bentonite, polymer, MagmaFiber and paper LCM  
 Flow rate - 25 gal/min | Pressure - psi | Returns temp - 160°F |  
 Wt - 8.6 lb/gal | Vis - 31 sec | PV - 7 cP | YP - 1 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - slight, hole is probably making fluid

**Lithology of core to date:**

- surf- 43' Siliceous sinter, siliceous cemented, laminated fractured breccia
- 43 - 45' Hydrothermally altered, clay rich, punky, siliceous breccia
- 45 - 48' Non - clay
- 48 - 56' Black matrix, siliceous breccia, hydrothermally altered in places
- 56 - 61' Plucked clasts, black-gray breccia
- 61 - 73' Clay-rich, green, gray-green to black layers
- 73 - 91' Becomes granular, intercalated with clay and altered volcanic rock
- 91 - 106' Heavily altered soft clay
- 106 - 112' Pale green, highly altered volcanic rock, clay, remnant phenocrysts apparent
- 112 - 114' Less clayey, still altered
- 114 - 120' Visible 1 cm pyrite crystals, very competent, no clay
- 120 - 125' Pale green epidote altered lahar with 1 cm pyrite and quartz lining veins
- 125 - 140' Darker green, less alteration, 1 cm pyrite crystals and stibnite needles on fractures
- 140 - 152' Vugs, partially filled with SiO<sub>2</sub>, appear, no pyrite or stibnite
- 152 - 163' 1 mm pyrite crystals, brecciated volcanics with red mineral filling veins and fractures
- 163 - 167' Rapidly becomes clayey & non-competent, clay is matrix, phenocrysts altered, olive-drab to pale green
- 167 - 170' Vuggy, hydrothermally altered, rounded clasts, 1 mm pyrite and SiO<sub>2</sub> in veins, also red mineral vein fillings
- 170 - 173' Not cored
- 173 - 187' Altered volcanics, fine grained, light gray, volcanic lahar, SiO<sub>2</sub> vein filling, vuggy, trending to less vuggy with no mineralization
- 187 - 194' 1 cm wide red vein along fracture, vertical to sub-horizontal
- 194 - 196' Red veins disappear, 1 mm pyrite returns
- 196 - 206' Increasingly clay-rich with pyrite, fine-grained
- 206 - 216' Clay
- 216 - 220' Altered volcanic breccia or dry clay with pyrite mineralization
- 220 - 223' Larger breccia clasts, vuggy, SiO<sub>2</sub> filled fractures, light gray to pale green
- 223 - 225' Pale purple, light green volcanic breccia, no clay, very minor mineralization

**Summary of events last 24 hours:**

Continue coring 6-1/4" hole x 4" core. Continued drilling granodiorite since yesterday with almost complete core recovery. Returns temperature increasing to a peak ~ 165°F. Hole is probably producing some fluid into the flow stream - viscosity is down, chlorides are up, and flow instrumentation shows excess returns fairly regularly.

Report by: John Finger

**DAILY DRILLING REPORT - 07/28/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 8 | Depth today - 495' | Hole advance last 24 hr - 80' | Core recovered - 80'  
 Last casing - 7", 20 lb/ft @ 175'

BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	

Drilling fluid - water, bentonite, polymer, MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 145°F |

Wt - 8.6 lb/gal | Vis - 35 sec | PV - 13 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 7.5

Lost circulation - slight

**Lithology of core logged since yesterday:**

- 225 - 226' 2 cm quartz-filled veins, vuggy, minor mineralization, fresh looking
- 226 - 230' Brecciated gradational contact between volcanic and granodiorite, pale green to gray medium-grained volcanic adjacent to pinkish-red medium-grained granodiorite, 2 cm near-vertical quartz veins are 90% filled, no recent hydrothermal alteration
- 230 - 414' Below 230' formation remains granodiorite, with the following features at the given depth
  - 233' Pinkish-gray equigranular, medium-grained ; 2-3 cm filled quartz veins:
  - 235' 1 cm filled quartz veins, minor fractures @ 30° to vertical filled with red mineral
  - 240' Decreasing quartz and red veins
  - 244' Massive 2-3 cm quartz veins
  - 254' Increasing irregularly spaced 1 mm fractures with quartz @ 70° from vertical
  - 260' Veins @ 45° from vertical
  - 272' Massive 1 cm quartz veins
  - 275' 1 mm quartz veins
  - 282' Intersecting fracture sets, near vertical and 45°, vugs or dissolution cavities near intersection
  - 293' 1-2 mm filled veins with minor quartz
  - 303' Veins, red, black, and quartz
  - 306' Massive quartz veins @ 45°
  - 309' No quartz veins this interval
  - 313' Minor fractures with erosion in fractures, some quartz filling
  - 316' Fractures at 30° to vertical, 1 large quartz-filled with red mineral zoning
  - 321' Less pink, now medium gray-green
  - 327' Vertical to sub-vertical green veins
  - 331' 1 mm near-vertical veins with green mineralization
  - 355' Occasional fractures, possibly open, with quartz filling
  - 369' Spiderweb veining, dark color, occasional open fractures at 45°
  - 383' Noticeable 5 cm xenolith
  - 385' Natural fractures at 20° to vertical with associated chlorite mineralization
  - 390' Quartz veining at 45°
  - 394' Spiderweb veins continue, no quartz veining
  - 396' 1-2 cm multi-generational quartz vein at 45°
  - 399' Extensive fracture with pyrite-sulfide mineralization (1' interval)
  - 406' Natural fracture (1')

**Summary of events last 24 hours:**

Continue coring 6-1/4" hole x 4" core. Continued drilling granodiorite since yesterday with almost complete core recovery. Bit change at 462'. [ Report by: John Finger ]

DAILY DRILLING REPORT - 07/29/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 9 | Depth today - 510' | Hole advance last 24 hr - 15' | Core recovered - 15'  
Last casing - 7", 20 lb/ft @ 175'

BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'			

Drilling fluid - water, bentonite, polymer; MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |

Wt - 8.6 lb/gal | Vis - 33 sec | PV - 8 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 12 (cement returns)

Lost circulation - mostly

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 414' to 506' is all granodiorite, generally with spiderweb veining, 1mm to 1cm calcite-filled fractures, most fractures at about 45°, some red and green mineralization. Unusual features as described below -

424' More frequent 5 mm calcite filled fractures at 45° on 1' to 1.5' spacing

434' No major fractures, breaks have minor reaction to HCl, disseminated sulfite mineralization

438'- 440' Slightly pale green, slight hydrothermal alteration, epidote-chlorite alteration of phenocrysts, significant spiderweb veining, 45° fracture with 1 mm calcite veins

447' Near vertical 1mm calcite fracture with some hydrothermal alteration, 5cm xenolith in fracture

453' Begin disseminated pyrite throughout

467' Slightly more altered granodiorite, 45° veins with green mineral filling

480'- 490' Massive (> 10cm) calcite vein, 30° to near vertical, epidote rim, granodiorite relatively unaltered

495'- 498' Core has rougher, sticky surface, clayey, zone ends at 45° fracture

505' Return of 10cm calcite vein described above

Summary of events last 24 hours:

Continued coring 6-1/4" hole x 4" core. Complete loss of returns at approx 0915 (~500'). Lost 25-30 gpm for about 3 hours and then a combination of lost circulation materials sealed fracture. Drilled ahead until about 1400 and lost returns again. Repeated attempts to plug fracture with LCM were futile. Recovered core shows a massive (>3") calcite-filled fracture. Rigged up to mix cement; pumped 10 sacks cement through open-ended H-rod at the fracture and led it with a slug of cottonseed hulls. WOC until 0200, it appeared firm, filled up hole with fluid and it retained the fluid. Tagged cement (~480') with drillpipe, POOH with H-rod, RIH with 5-1/2" and resume drilling 6-1/4" hole. Target is to reach approximately 520', which will allow running televiwer past fracture and will give enough hole to set casing at 500' (required to drill to 5000').

Report by: John Finger

**DAILY DRILLING REPORT - 07/30/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 10 | Depth today - 525' | Hole advance last 24 hr - 15' | Core recovered - 15'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 6-1/4" hole | Rotary speed - 300 rpm; WOB - 3Klb; Rate of Penetration - 5-6 ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	

Drilling fluid - water, bentonite, polymer, MagmaFiber and paper LCM  
 Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |  
 Wt - 8.5 lb/gal | Vis - 35 sec | PV - 9 cP | YP - 1 lb/100ft<sup>2</sup> | pH - 9.0  
 Lost circulation - minor

Lithology of core logged since yesterday: [Summary - detailed log available]  
 Core from 510' to 525' is still granodiorite, containing the end of the same massive calcite vein described yesterday.

Summary of events last 24 hours:

Continued coring 6-1/4" hole x 4" core. Reached target of 525'. Ran temperature log through drill pipe and bit; laid down 5-1/2" drill pipe. Ran another temperature log in open hole; latter log was much more erratic, partially because of pumping across the riser, which caused the hole to take some fluid. Maximum temperature in second log was 132° C at bottom. RIH with H-rod and circulate to cool and clean hole; rig up for televiewer run. Televiewer successful; showed numerous fractures mostly dipping southwest, although some were in the opposite orientation. Riggged up and ran casing, pumped 125 cu ft (100% excess) cement and did not get returns, although the water lead did appear to return (cement probably got back near surface but fell away.) Will do temperature log to try and locate top of cement.

Report by: John Finger

**DAILY DRILLING REPORT - 07/31/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 11 | Depth today - 525' | Hole advance last 24 hr - 0' | Core recovered - 0'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	

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Drilling fluid - n/a

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Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 510' to 525' is still granodiorite, containing the end of the massive calcite vein described earlier.

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Summary of events last 24 hours:

Repeated temperature logs while pumping "cold" (75<sup>o</sup>) water into the annulus between the 4-1/2" casing indicate that the top of cement is between 220' and 230'. Called wireline company to perforate casing; nipped up BOP while waiting, performed required pressure test on BOP. Perforated casing from 220' to 230'.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/01/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 12 | Depth today - 525' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

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

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	

Drilling fluid - water, bentonite, polymer; MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |

Wt - 8.5 lb/gal | Vis - 36 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 12 (drilling cement)

Lost circulation - none (drilling in casing)

Lithology of core logged since yesterday: [Summary - detailed log available]

No new core

Summary of events last 24 hours:

After perforating tools are clear of hole, rig up to pump cement. One stand drill pipe in BOP pipe rams has a tee on top; one leg to Halliburton pumper, one leg to rig pump. Pump cement until we get good returns at surface (~85 cu ft) and shut in cement line. Pump 70 gal mud with rig pump (calculated volume to displace cement out of drill pipe and halfway to perforations) Shut in mud line. Keep filling annulus from top as cement falls back, but very little is required (< 10 gal). WOC 12 hours and core into top of cement with HQ core tools; cements is hard. Core past perforations and test to 100 psi at wellhead. Perforations do not leak. Drilling cement toward shoe.

Report by: John Finger

**DAILY DRILLING REPORT - 08/02/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 13 | Depth today - 637' | Hole advance last 24 hr - 112' | Core recovered - 112'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)			

---

Drilling fluid - water, bentonite, polymer; MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |

Wt - 8.5 lb/gal | Vis - 36 sec | PV - 10 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 12 (drilling cement)

Lost circulation - none (drilling in casing)

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Lithology of core logged since yesterday: [Summary - detailed log available]

Not yet logged

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Summary of events last 24 hours:

Drilled cement out of casing; good contact between cement and formation below shoe. Drilled ahead in granodiorite. Lost returns at 0330 (~637') but fracture was relatively minor. Getting 50%+ returns with LCM, decided fracture is not big enough to flow test. Continue drilling.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/03/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 14 | Depth today - 783' | Hole advance last 24 hr - 146' | Core recovered - 146'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS --** Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'			

---

Drilling fluid - water, bentonite, polymer; MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |

Wt - 8.5 lb/gal | Vis - 42 sec | PV - 15 cP | YP - 10 lb/100ft<sup>2</sup> | pH - 8.0

Lost circulation - varying from 50% to total

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Lithology of core logged since yesterday: [Summary - detailed log available]

Not yet logged

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Summary of events last 24 hours:

Have been drilling the same type of granodiorite seen since 225', although the core has contained many fractures, mostly calcite-filled. Fluid returns have disappeared completely at times, but at least partial returns have been regained with lost circulation material. Since previous drilling here indicates that losses will be total and irretrievable when we hit a major, productive fracture, we have not interpreted the fluid losses so far as signalling a potential flow/injection test.

Deviation survey at 528' gives inclination = 1°.

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Report by: John Finger

DAILY DRILLING REPORT - 08/04/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 15 | Depth today - 835' | Hole advance last 24 hr - 52' | Core recovered - 49'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'			

Drilling fluid - n/a

Lithology of core logged since yesterday: [Summary - detailed log available]

Formation from 521' to 653' is still the granodiorite previously described, will the following features:

- 522'-582' Background of spiderweb fractures; typically 1mm fractures, mostly calcite-filled, at 70 to 90° from horizontal
- 582'-583' More hydrothermally altered; gougeable with knife blade
- 583'-652' Mostly same as above 582'; fractures generally at lower angle (45°-60°); transition to lighter colored granodiorite at 609'; occasional 3-5cm xenoliths.

Summary of events last 24 hours:

Continued drilling the same type of granodiorite seen since 225', with lost circulation varying from 50 to 90%. Major drilling break at 816'; lowered bit 2+ feet without rotating. Fluid level in hole fell below 300', although it later returned to the previous level of 100-150'. Drilled ahead without returns to 835', POOH with drill pipe and began rigging up flow equipment. Did temperature log while rigging up. After all connections completed, pressurized wellhead to 100 psi with air compressor (to force upper, colder fluid deeper into the hole), left it for an hour and released pressure. Well did not flow. Did another temperature log and found that the hole had heated up about 40°F since previous log. Pressurized hole again and decided to leave it for ~ 8 hours (until 0630.) Released pressure at 0630; well still did not flow. Tried 8 cycles of pressure/quick release; still no flow. Going to get higher-pressure compressor and rigging for air-lift. If well will still not flow, will go to injection test. Waiting on logging company.

Report by: John Finger

**DAILY DRILLING REPORT - 08/05/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 16 | Depth today - 968' | Hole advance last 24 hr - 133' | Core recovered - 133'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'			

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Drilling fluid - water, bentonite, polymer; MagmaFiber and paper LCM

Flow rate - 25 gal/min | Pressure - psi | Returns temp - 155°F |

Wt - 8.5 lb/gal | Vis - xx sec | PV - xx cP | YP - xx lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since major fracture at 816'

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Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 642' to 788' is weakly to moderately altered, light green-gray to whitish granodiorite with many calcite-filled fractures, mostly at 45-60° from horizontal. It also has the following features:

657' Dog-tooth calcite fills fractures

680' Filled fractures are prevalent and pervasive below this depth.

708' Open 2-3cm fracture

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Summary of events last 24 hours:

Trying larger air compressor still did not start well flowing. Apparent lack of permeability and/or fluid indicated that an injection test would not be worthwhile. Reconfigured wellhead so that we can drill through the flow tee; resumed drilling at 1215. Drilled through approximately 80' (868'-948') of steeply dipping, highly mineralized fractures which do not fit closely when reassembled (i.e., there should be significant apertures downhole.) Rigging up to run temperature log; air compressor is on site to try an air-lift for starting flow.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/06/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 17 | Depth today - 968' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'			

Drilling fluid - n/a

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 792' to 828' is weakly altered, light green-gray to whitish granodiorite with mica, many calcite-filled fractures, mostly at 60-70° from horizontal. It also has the following features:

797' 1cm open fracture

815'-823' 5.3' core lost in this interval, major drilling break indicates at least 2' void, calcite coating with chloride rim at borders of fracture, multiple generations of deposition.

Summary of events last 24 hours:

Temperature log shows high temperature (>160°C) in fractured interval from 868' to 948', indicating high permeability in that interval. Will try air-lifting from about 250' (inside casing). Compressor is rated at 100 psi, 100 scfm. Air lift is producing about 4-5 gpm, outflow temperature rises from about 135°F to 180°F, but the small annulus between the H-rod and wellbore will probably prevent flow even if temperature gets near boiling. Pull rods and pressurize wellhead. Left wellhead at 100 psi for 30 min, released pressure, well did not flow. Ran back in with N-rod (2-3/4" OD) and air lift again, hoping that the larger annulus will allow lifting more water. Rig for temperature log through N-rod before air-lift. Temperature log shows temperatures below about 150' almost identical to yesterday's last log. Begin air lift with 100 psi compressor. Temperature in flow line reaches about 199°, flow rate ~ 25-28 gpm. Add larger compressor (200 psi, 300 scfm) into line - compressors in parallel. Temperature drops to 190°F and flow rates becomes very erratic, from 12 to 28 gpm. Speculation is that both compressors are blowing too much air past the water. Will take small compressor out of the circuit. When both compressors are turned off, well begins to flow on its own. Outflow temperature goes to 203°F (boiling at this altitude) and flow rate remains erratic at 10 - 30 gpm, probably because of the drill pipe in the hole. Let the well flow to clean up the fluid (get rid of drilling mud, etc) and shut in. POOH with N-rods and pressurize wellhead to 150 psi with compressor. Release wellhead pressure at 2008 hours and well flows. Beginning flow rate is approximately 60 gpm (liquid), but builds to 100+ gpm over the course of the next hour. Rig up to run wireline temperature, pressure, spinner (TPS) logs. Spinner log shows most production from major fracture at 815'. Choke flow in steps by closing wellhead valve; flow rate and wellhead temperature go down, wellhead pressure goes up. Shut in well for ~7-8 hours to watch for pressure build. Good data set from flow test; rigging up to do downhole water samples, followed by injection test.

Report by: John Finger

**DAILY DRILLING REPORT - 08/07/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 18 | Depth today - 1035' | Hole advance last 24 hr - 67' | Core recovered - 64'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'			

Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 6 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 7.5

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Formation from 834' to 966' is still the granodiorite previously described, with many fractures in the zone from 868' to 947', especially the following:

868' Open 2-3cm fracture at 70°

888' Open 1cm vertical fracture, with dog-tooth spar

912' Open 5cm fracture/void at 45°

Summary of events last 24 hours:

Opened well to conclude production shut-in test from previous night. Wellhead pressure had relaxed to zero as upper hole cooled. POOH with PTS logging tool and used LBL fluid sampler to get water sample from below the production zone (this will tell whether the produced water and that below it are chemically the same.) RIH with Sandia temperature log. Rigged up for injection test. Injection will be hot (~195°F) water from power plant injection line, step-wise injection at four flow rates (maximum first, then step down and back up), then shut in. Inject at increasing flow rate (low wellhead pressure up to 350 gpm causing injection line to flash; inlet temperature ~ 220°F) up to 650 gpm. Line blows off injection pump; consensus is that it will take at least two days to rebuild for high temperature, so go with cold water injection now. Do step-rate injection with cold water, and shut in well. Leave shut in for 1-1/2 hours, log out of hole, and resume drilling.

Report by: John Finger

**DAILY DRILLING REPORT - 08/08/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 19 | Depth today - 1149' | Hole advance last 24 hr - 114' | Core recovered - 112'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673'	148	
8	HQ impreg	673'	1149'	476	

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Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 7.0

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

None today

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Summary of events last 24 hours:

Have continued drilling ahead with no particular problems. Formation below 815' is very similar to that below 1015'; large (~2 ft) void followed by open, high-angle fractures. This implies that the zone at 1015' could be a large production zone, as was the one at 815', but flow from the upper zone may suppress any production from below.

Flow from first test was unexpectedly high. Previous theoretical work indicated that the maximum total flow expected from the corehole (compared to the companion production well) was ~90 gpm, but the corehole actually flowed over 100 gpm, liquid phase. This could indicate several phenomena, which we hope to resolve with further tests.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/09/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 20 | Depth today - 1288' | Hole advance last 24 hr - 139' | Core recovered - 139'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'	1149	476	
9	HQ impreg	1149"			

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Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 33 sec | PV - 5 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 7.0

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

None today

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Summary of events last 24 hours:

Have continued drilling ahead with no particular problems. We have tentatively scheduled another set of tests for tomorrow - production in the daytime, injection at night (to get cooler water from the power plant) and packer isolation tests the following day.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/10/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 21 | Depth today - 1478' | Hole advance last 24 hr - 190' | Core recovered - 189'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'	1149	476	
9	HQ impreg	1149"			

Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 33 sec | PV - 5 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 7.0

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Granodiorite from 966' to 1137' is similar to that previously described, with the following features:

- 988' Open, quartz-lined 1-2cm fracture at 70°
- 1011' Open, 2-3cm fracture at 75°, dog-tooth spar in vugs
- 1015' Lost ~ 2.7' core in major void/fracture, quartz rubble in core tube apparently belongs in this void
- 1032'-1047' Significant 1-2cm open fractures throughout this interval
- 1111' 3-4cm vug becomes vertical 1-2cm open fracture

Summary of events last 24 hours:

Have continued drilling ahead with good rate of penetration (up to 10 ft/hr). Production test scheduled for this afternoon; waiting on logging tools, will drill until they arrive.

Report by: John Finger

**DAILY DRILLING REPORT - 08/11/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 22 | Depth today - 1510' | Hole advance last 24 hr - 32' | Core recovered - 32'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr**

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'	1149	476	
9	HQ impreg	1149"			

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Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 33 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 9.0

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

Granodiorite from 1118' to 1288' is similar to that previously described, with the following features:

1118'-1123' Lost 1.6' core in this interval of mixed rock with multiple shear zone

1152'-1157' 1-2 cm open fractures in this zone

1180' Highly altered rubble zone

1256'-1262' Zone of complex 1-2cm vuggy, open "see-through" fractures, some with dog-tooth spar

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Summary of events last 24 hours:

Continued drilling ahead to 1510' while waiting for logging tools to arrive and rig up. After tools are on site, begin air-lifting fluid out of core hole to stimulate it to flow. Flow begins and stabilizes, slightly lower rate than first test (95 gpm max vs 103 gpm). Perform temperature-pressure-spinner surveys up and down hole while flowing, then shut-in wellbore with TPS tool hanging at 808' to collect pressure build-up data. Appear to have good data set for production test. Rigging up for injection test.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/12/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 23 | Depth today - 1563 | Hole advance last 24 hr - 53' | Core recovered - 53'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673'	148	
8	HQ impreg	673'	1149'	476	
9	HQ impreg	1149"	1510'	361	

Drilling fluid - water, bentonite, polymer;  
 Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 33 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 9.5  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 Granodiorite from 1271' to 1488' is similar to that previously described, with the following features:  
 1283'-1323' This zone has at least one 1cm or larger fracture, at 15-75°, in each 10' interval  
 1346'-1364' 1-2 cm open fractures, at 75-80°, in this zone  
 1399'-1414' Highly altered shear zone, with some open fractures  
 1449'-1460' More altered/shear zone, with series of 1cm open fractures

Summary of events last 24 hours:

Begin injection test with hot (195°) water from power plant; recorded data for one flow rate, hose on injection pump fails. Rig down pump and begin replacing hoses with pipe. Rig up to run packer; will pack off zone at 690', separating producing interval at 815' from interval at ~640' which appears to take all the injected water. RIH with packer on N-rod, which will allow injection down annulus as well as through pipe, and set at 690'. Pressurize packer to sit it, and begin logging down pipe, through packer, and into open hole while pumping hot water into the annulus. Temperature data is anomalous, appearing isothermal across packer, so we conclude test and start to pull out of the hole. Packer requires no force to move it (i.e., it is deflated). Lay down packer and disassemble it; O-ring has failed. Will refurbish both packers with different O-rings. Resume drilling ahead at 1510'.

Report by: John Finger

DAILY DRILLING REPORT - 08/13/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 24 | Depth today - 1670' | Hole advance last 24 hr - 107' | Core recovered - 107'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673'	148	
8	HQ impreg	673'	1149'	476	
9	HQ impreg	1149'	1510'	361	
10	HQ test bit	1510'	1568'	58	
11	HQ surf set	1568'	1600'	32	
12	HQ impreg	1600'			

Drilling fluid - water, bentonite, polymer;

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 33 sec | PV - 4 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.5

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

None logged

Summary of events last 24 hours:

Have been drilling ahead for the last 24 hours with no problems, although overall progress has been reduced by two bit changes to try different kinds of bits. We are now drilling with the same type of bit (#7 impregnated) that has previously given satisfactory performance. Both packers have been completely refurbished with new Viton O-rings; apparent cause of previous failure was improper rings. Tentative plan is to drill ahead throughout the weekend and resume injection and packer tests on Monday.

Report by: John Finger

**DAILY DRILLING REPORT - 08/14/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 25 | Depth today - 1709' | Hole advance last 24 hr - 39' | Core recovered - 39'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673	148	
8	HQ impreg	673'	1149	476	
9	HQ impreg	1149'	1510'	361	
10	HQ test bit	1510'	1568'	58	
11	HQ surf set	1568'	1600'	32	
12	HQ impreg	1600'	1702'	102	
13	HQ test bit	1702'	1709'	7	
14	HQ surf set	1709'			

Drilling fluid - water, bentonite, polymer, soda ash

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 31 sec | PV - 2 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

None logged today

Summary of events last 24 hours:

Have been drilling ahead for the last 24 hours with low overall penetration because of severe bit wear. Formation has not changed significantly, but there is considerable vibration in the drill string. This vibration, which is usually destructive to bits, could be caused by lost circulation combined with water inflow to the wellbore; this would eliminate the lubricating effect of the drilling fluid and cause intermittent torque in the upper part of the hole. We will try slugging the fluid with LCM to improve the mud column in the annulus; we have also been pumping a separate drilling fluid stream down the annulus while drilling.

Report by: John Finger

**DAILY DRILLING REPORT - 08/15/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 26 | Depth today - 1828' | Hole advance last 24 hr - 119' | Core recovered - 119'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

BITS -- Now drilling 3.89" hole | Rotary speed - rpm; WOB - Klb; Rate of Penetration - 5-6 ft/hr

Bit number	Type	Depth in, KB	Depth out, KB	Footage	Hours
1	12-1/4" tri-cone	10'	12'	2	2
2	HQ impreg	12'	172'	160	16
3	8-1/2" tri-cone	12'	176'	164	12
4	6-1/4" impreg	110' (cement)	225'	115	
5	6-1/4" impreg	225'	462'	237	
6	6-1/4" impreg	462'	525'	63	
7	HQ impreg	525' (rock)	673'	148	
8	HQ impreg	673'	1149'	476	
9	HQ impreg	1149'	1510'	361	
10	HQ test bit	1510'	1568'	58	
11	HQ surf set	1568'	1600'	32	
12	HQ impreg	1600'	1702'	102	
13	HQ test bit	1702'	1709'	7	
14	HQ surf set	1709'	1754'	45	
15	HQ test bit	1754'			

Drilling fluid - water, bentonite, polymer; soda ash

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 1467' to 1745' is generally the same granodiorite previously described, with the following features:

1530'-1546' Heavily altered granodiorite, clayey in spots, mechanically sheared, with at least one 2cm fracture

1607'-1613' Altered zone as above

1625'-1638' Intrusion (probably a dike) of fine-grained basalt, contact at 75° from horizontal

1638'-1642' Contact area below basalt is heavily altered granodiorite as above

Summary of events last 24 hours:

Have been drilling ahead for the last 24 hours with somewhat better penetration and bit performance. Have laid down 20' core barrel and gone back to 10' barrel. It is not clear why this should make a difference in bit wear, but drilling has improved since the change. Still pumping drilling fluid down the annulus. Slightly lower penetration rate in the basalt intrusion described above.

Ran televiewer in one of the smaller (3") core holes in this field while pumping cooling water down around the tool; it produced a good picture with reliable performance at 110°C, becoming erratic as temperature approached 130°C. This opens the possibility of logging smaller holes in this and other locations, thereby providing better definition of reservoir characteristics.

Report by: John Finger

**DAILY DRILLING REPORT - 08/16/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 27 | Depth today - 1908' | Hole advance last 24 hr - 80' | Core recovered - 80'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

---

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673	148
8	HQ impreg	673'	1149	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'		

---

Drilling fluid - water, bentonite, polymer; soda ash

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

None logged today

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**Summary of events last 24 hours:**

Have been drilling ahead for the last 24 hours. Still experiencing some drillstring vibration, both high and low in the hole. Low rotary speeds (~ 100 rpm) have reduced vibration, but also penetration. Will continue trying combinations of rod lubricant and LCM.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/17/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 28 | Depth today - 2008' | Hole advance last 24 hr - 100' | Core recovered - 100'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673	148
8	HQ impreg	673'	1149	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'		

Drilling fluid - water, bentonite, polymer; soda ash  
 Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 Core from 1745' to 1819', with the following features, is generally the same granodiorite as that previously described:

1768'-1770' Moderately to heavily altered zone, with significant mechanical shear, open fractures at 60-90°

Summary of events last 24 hours:

Have been drilling ahead for the last 24 hours. Rate of penetration is reasonably good, with 100' since yesterday. Bit wear is also better, with 170'+ on bit now in the hole. Current schedule is to drill through Wednesday night and begin rigging up for next series of production and injection tests at ~ 0400 Thursday. This will allow air-lifting to warm up the well before logging service company gets here. Will do production tests on Thursday, shut-in Thursday night, and injection tests on Friday. We will inject into both the open hole, at stepped injection rates, and into zones above and below a packer.

Deviation survey at 2000' = 1°.

Report by: John Finger

**DAILY DRILLING REPORT - 08/18/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 29 | Depth today - 2077' | Hole advance last 24 hr - 69' | Core recovered - 68'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673'	148
8	HQ impreg	673'	1149'	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'	2077'	240

---

Drilling fluid - water, bentonite, polymer; soda ash

Flow rate - 25 gal/min | Pressure - psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

No log today

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**Summary of events last 24 hours:**

Drilled ahead until approximately 2100 yesterday. POOH for bit change; when back on bottom with new bit, drill string experienced heavy torque loads, enough to stall rotation. Drill rods either twisted off or were unscrewed by torque release; string is parted approximately 140' off bottom. Driller sent wireline overshot down to retrieve core tube; overshot could not get back through pipe break, so pulled wireline out of overshot, leaving about 20' of wire in the hole. Overshot is now either on top of stuck pipe or has fallen back into it. Running back in hole to tag top of fish and determine overshot location.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/19/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 30 | Depth today - 2077' | Hole advance last 24 hr - 0' | Core recovered - 0'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

---

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673'	148
8	HQ impreg	673'	1149'	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'	2077'	240

---

Drilling fluid - water, bentonite, polymer; soda ash

Flow rate - xx gal/min | Pressure - psi | Returns temp - n/a

Wt - xxx lb/gal | Vis - xx sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 1819' to 2015' is generally the same granodiorite previously described. There are fewer open fractures, none more than 3-5mm, and only one short (1980'-1985') zone of heavy alteration and mechanical shear.

---

Summary of events last 24 hours:

Have continued fishing for the last 24 hours. Used an inside swage to catch the inside of stuck pipe; pulled up approximately 10,000 lb but pipe would not release. Suspect the fish is stuck at the bit. Went in the top of the drill pipe with an outside swage and tried to pick up the broken wireline, along with the overshot and possibly the inner core barrel. Retrieved wire and upper part of overshot; remainder of fish is still in hole. Will continue fishing to determine how much we can retrieve, then decide whether to sidetrack or mill up remainder.

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Report by: John Finger

**DAILY DRILLING REPORT - 08/20/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 31 | Depth today - 2077' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673'	148
8	HQ impreg	673'	1149'	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'	2077'	240

Drilling fluid - water, bentonite, polymer, soda ash

Flow rate - xx gal/min | Pressure - psi | Returns temp - n/a

Wt - xxx lb/gal | Vis - xx sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

No core logged

**Summary of events last 24 hours:**

Have continued fishing for the last 24 hours. Made several more trips inside stuck pipe with an outside swage and tried to pick up the overshot release, overshot and the inner core barrel. Got over the release but could not work it free. Went in with cutter and severed pipe at 2050 ft. Picked up inside swage and retrieved 126 ft of drill pipe. Core barrel with 14 ft of drill pipe still in hole. RIH with outside swage again and worked overshot and inner core barrel could not pull free. At report time running in hole with fishing service company spear and jars to work stuck core barrel. Have located wedge and drill off tools for side track if needed.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/21/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 32 | Depth today - 2118' | Hole advance last 24 hr - 41' | Core recovered - 40'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673'	148
8	HQ impreg	673'	1149'	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'	2077'	240
17	HQ impreg	2077'	2077'	0
18	HQ impreg	2077'		

---

Drilling fluid - water, bentonite, polymer; soda ash

Flow rate - 20 gal/min | Pressure - 0 psi | Returns temp - n/a

Wt - n/a lb/gal | Vis - 37 sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since fracture at 815'

---

Lithology of core logged since yesterday: [Summary - detailed log available]

No core logged

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Summary of events last 24 hours:

Locked into fish with spear and jarred eight times before any movement. Jarred two more times and could pull up hole with 8,000 lb over string weight. Continued pulling for 120 ft. while weight slacked off then no over pull. POOH without fish. RIH with swage and tagged fish 120 ft off bottom. Pushed to bottom to tighten swage then POOH with fish. Recovered everything but overshot release. Bit is burned and missing two sections of matrix. Tube is severely sanded in. Upon investigation it looks as if the mica added to the drilling mud had exceptionally high sand content. This sanded in the tube reducing mud flow which burned the bit in. Ran temperature log then RIH with new bit and washed back to bottom. Back to coring by midnight. Not much fill in hole and release must be back in a crack. Recovered both missing bit segments on top of first core run. Coring ahead at report time with some vibration problems.

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Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/22/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 33 | Depth today - 2188' | Hole advance last 24 hr - 70' | Core recovered - 70'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg	110' (cement)	225'	115
5	6-1/4" impreg	225'	462'	237
6	6-1/4" impreg	462'	525'	63
7	HQ impreg	525' (rock)	673'	148
8	HQ impreg	673'	1149'	476
9	HQ impreg	1149'	1510'	361
10	HQ test bit	1510'	1568'	58
11	HQ surf set	1568'	1600'	32
12	HQ impreg	1600'	1702'	102
13	HQ test bit	1702'	1709'	7
14	HQ surf set	1709'	1754'	45
15	HQ test bit	1754'	1837'	83
16	HQ impreg	1837'	2077'	240
17	HQ impreg	2077'	2077'	0
18	HQ impreg	2077'	2168'	91
19	HQ impreg	2168'		

Drilling fluid - water, bentonite, polymer, soda ash

Flow rate - 20 gal/min | Pressure - 0 psi | Returns temp - n/a

Wt - n/a lb/gal | Vis - 37 sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 2015' to 2068' is generally the same granodiorite previously described. No open fractures greater than 5mm.

Summary of events last 24 hours:

Core ahead to 2168' then trip for bit change. Drilled through one heavily fractured zone and had to redrill cave from this zone. Stuck inner tube at report time, will have to trip to recover tube.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/23/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 34 | Depth today - 2238' | Hole advance last 24 hr - 50' | Core recovered - 50'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

---

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg-S2	110' (cement)	225'	115
5	6-1/4" impreg-S8	225'	462'	237
6	6-1/4" impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	361
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'		

---

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
Flow rate - 20 gal/min | Pressure - 0 psi | Returns temp - n/a  
Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 8.5  
Lost circulation - no returns since fracture at 815'--

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Lithology of core logged since yesterday: [Summary - detailed log available]  
No core logged.

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**Summary of events last 24 hours:**

Had two trips, one for a stuck inner tube caused by loose roll pin and the other for high water pressure and vibration. Greased rods on trip back in. Rotation speed up and torque down, drilling good.

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Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/24/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 35 | Depth today - 2298' | Hole advance last 24 hr - 60' | Core recovered - 60'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg-S2	110' (cement)	225'	115
5	6-1/4" impreg-S8	225'	462'	237
6	6-1/4" impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	361
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 20 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 8.5  
 Lost circulation - no returns since fracture at 815'--

Lithology of core logged since yesterday: [Summary - detailed log available]  
 2070.4 to 2186 logged. Heavily altered highly fractured zone from 2132.9 to 2144.7.

**Summary of events last 24 hours:**

Continued vibration problems. Trying to find backside lubricants that will withstand the temperature. Have had some success with rod grease but it doesn't stay long enough. Made three short and one full trip to condition hole. Rotation speed up and torque down after trips.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/25/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 36 | Depth today - 2388' | Hole advance last 24 hr - 90' | Core recovered - 90'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	6-1/4" impreg-S2	110' (cement)	225'	115
5	6-1/4" impreg-S8	225'	462'	237
6	6-1/4" impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	361
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'		

---

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
Flow rate - 20 gal/min | Pressure - 0 psi | Returns temp - n/a  
Wt - 8.4 lb/gal | Vis - 33 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 8.0  
Lost circulation - no returns since fracture at 815'--

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Lithology of core logged since yesterday: [Summary - detailed log available]  
No new core log report.

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**Summary of events last 24 hours:**

Cored ahead with no trips. Going a little slow but going good. No down hole vibrations since greasing all the drill rods with rod grease loaded with torkease. BHT 316 deg. F.

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Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/26/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 37 | Depth today - 2348' | Hole advance last 24 hr - 60' | Core recovered - 60'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	361
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437	11
20	HQ impreg-S7	2437		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 33 sec | PV - 3 cP | YP - 2 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'--

Lithology of core logged since yesterday: [Summary - detailed log available]

Core logged from 2182 to 2388'. Still mostly the same granodiorite previously described. Very few open fractures none over 3mm.

**Summary of events last 24 hours:**

Bit went at 2426'. POOH and RIH with series 9 bit. It would not cut so tripped out to try another series 7 bit. Greased rods on trip. BHT 318 deg F. at 2358' and 315 deg F at 2408'. Drilling ahead with at report time with no vibration problems.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/27/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 38 | Depth today - 2538' | Hole advance last 24 hr - 90' | Core recovered - 90'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	361
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'		

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 33 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 9.0  
 Lost circulation - no returns since fracture at 815'--

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No core logged.

**Summary of events last 24 hours:**

Drilling ahead last 24 hours. ROP a little slow but going OK. Bore hole deviation at 2500' is 2 deg. Replaced core retrieval wire line.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/28/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 39 | Depth today - 2624' | Hole advance last 24 hr - 86' | Core recovered - 86'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg-S7S	2624'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 33 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 9.0  
 Lost circulation - no returns since fracture at 815'--

Lithology of core logged since yesterday: [Summary - detailed log available]

Core log received from 2388 to 2538'. Mostly weak to unaltered granodiorite with no open fractures > 1mm logged.

**Summary of events last 24 hours:**

ROP slowing, having trouble stripping bit. Vibrations and torque back at 2598', pull back 32 stands and grease. ROP improves in more broken rock. Torque up and bit goes at 2624.8'. At time of report making up 20' core barrel with new special series 7 bit built with geosets for gage protection and lower diamond concentration. It is hoped this will allow the bit to strip better and hold gage longer. Last BHT at 2608' is 315 deg. F.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/29/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 40 | Depth today - 2720' | Hole advance last 24 hr - 96' | Core recovered - 96'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg-S7S	2624'		

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Drilling fluid - water, bentonite, polymer; soda ash, torkease

Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a

Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 9.0

Lost circulation - no returns since fracture at 815'--

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Lithology of core logged since yesterday: [Summary - detailed log available]

No core log received at report time.

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Summary of events last 24 hours:

Drilling ahead at report time with low torque and high RPM. The twenty foot core barrel is working good with one reamer shell on the bottom rather than with top and bottom shells used in the 1510' to 1754' interval.

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Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/30/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 41 | Depth today - 2850' | Hole advance last 24 hr - 130' | Core recovered - 130'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg-S7S	2624'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 9.0  
 Lost circulation - no returns since fracture at 815'--

Lithology of core logged since yesterday: [Summary - detailed log available]  
 Core logged from 2538' to 2611', no significant changes.

**Summary of events last 24 hours:**

Drilling ahead last 24 hours. BHT still 320 deg F. At report time pulling 2850 core.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 08/31/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 42 | Depth today - 2930' | Hole advance last 24 hr - 80' | Core recovered - 80'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg-S7S	2624'	2930'	306

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 17 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 3 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 9.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 None logged

**Summary of events last 24 hours:**

Drilling ahead until 2300h when began POOH to prepare for flow tests. RIH 280' with N-rod for air-lift. Started temperature log at 0300h. Started air compressor at 0545h, well began flowing on its own (~25 gpm) at 0615h. Killed well at 0740h to POOH with N-rods; will start flow test as soon as possible.

Report by: John FInger

**DAILY DRILLING REPORT - 09/01/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 43 | Depth today - 2930' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg-S7S	2624'	2930'	306

Drilling fluid - water, bentonite, polymer; soda ash, torkease

Flow rate - n/a gal/min | Pressure - 0 psi | Returns temp - n/a

Wt - xxx lb/gal | Vis - xx sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx

Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 2695' to 2834' is the same granodiorite previously described, with numerous fractured zones and some heavily altered intervals and slickensides.

**Summary of events last 24 hours:**

Began flow tests with 2" James tube on outflow line, but maximum flow rate was only about 60 gpm. Took data at 60 and 45 gpm, then shut in well and changed to 3" James tube. Took data at 106, 88, 71, and 50 gpm. Shut in well for 6-1/2 hours. Rigged up to begin hot-water injection test, but logging tool was malfunctioning. Tool apparently could not be quickly repaired, and no back-up tool was on hand, so remaining tests were cancelled. Will resume drilling.

Report by: John FInger

**DAILY DRILLING REPORT - 09/02/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 44 | Depth today - 3050' | Hole advance last 24 hr - 120' | Core recovered - 115' (core lifter  
 Last casing - 4-1/2", 11.5 lb/ft @ 524' spring broke, but core barrel is over the stick-up)

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'		

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - xxx lb/gal | Vis - xx sec | PV - x cP | YP - x lb/100ft<sup>2</sup> | pH - xxx  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 Core from 2835' to 2926' is the same granodiorite previously described, with numerous fractured zones, slickensides, and some heavily altered intervals.

Summary of events last 24 hours:

Ran back in hole with same bit used since 2624', washed to bottom. Almost no fill at bottom of hole, indicating that most fluid movement during flow tests was in upper part of hole. Drilling is going well, with ROP averaging 8.8 ft/hr. Formation appears somewhat softer; it is also fractured, which helps the bit to strip matrix. Maximum-reading thermometers on wireline show 325°F, about 10°F higher than previous readings. Deviation survey at 3000' is 1-1/4°.

Report by: John Finger

**DAILY DRILLING REPORT - 09/03/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 45 | Depth today - 3142' | Hole advance last 24 hr - 92' | Core recovered - 97' (stick-up from yesterday)  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 30 sec | PV - 2 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 2926' to 3038' is the same granodiorite previously described, with only a few zones of heavy alteration and no major open fractures.

Summary of events last 24 hours:

Have drilled ahead with generally good progress. Bit change at 3072'; now using another of the same bit type that drilled 448' in the previous interval.

Report by: John Finger

**DAILY DRILLING REPORT - 09/04/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 46 | Depth today - 3250' | Hole advance last 24 hr - 108 | Core recovered - 108  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 30 sec | PV - 2 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.5  
 Lost circulation - no returns since fracture at 815'

**Lithology of core logged since yesterday: [Summary - detailed log available]**

Core from 3038' to 3142' is the same granodiorite previously described, with a few strongly altered zones and one open 1cm fracture at 3044'.

**Summary of events last 24 hours:**

Drilling ahead with reasonably good rate of penetration and no bit change.

Report by: John Finger

**DAILY DRILLING REPORT - 09/05/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 47 | Depth today - 3410' | Hole advance last 24 hr - 160 | Core recovered - 152 (lost 8' core,  
 Last casing - 4-1/2", 11.5 lb/ft @ 524' probably ground up while drilling subsequent interval)

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'		

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

**Summary of events last 24 hours:**

Drilling ahead with good rates of penetration (~ 10 ft/hr) and no downhole vibration problems.

Report by: John Finger

**DAILY DRILLING REPORT - 09/06/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 48 | Depth today - 3510' | Hole advance last 24 hr - 100 | Core recovered - 100  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

**Summary of events last 24 hours:**

Drilled ahead with good rate of penetration (~ 10 ft/hr) to 3450'. POOH for bit change. Rigged up SNL logging truck for temperature log. RIH with temperature tool to ~2600' when frayed outer braid on wireline packed a rat's-nest into the cable guide. Cleared tangled wire, POOH with logging tool, but wireline is suspect for logging to bottom of hole. Current plan is to bring logging truck from Mammoth Lakes and do temperature log when corehole reaches 4000'; at that point Far West can decide whether to assume the expense of continuing the hole..

Report by: John Finger

**DAILY DRILLING REPORT - 09/07/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 49 | Depth today - 3640' | Hole advance last 24 hr - 130' | Core recovered - 130'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg	3450'		

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Drilling fluid - water, bentonite, polymer, soda ash, torkease  
Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0  
Lost circulation - no returns since fracture at 815'

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Lithology of core logged since yesterday: [Summary - detailed log available]  
No new logs today

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**Summary of events last 24 hours:**

Have drilled ahead with good rate of penetration (~ 10 ft/hr) since 3510'. Some downhole torque, pulling out of hole to grease rods and inspect bit.

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Report by: John Finger

**DAILY DRILLING REPORT - 09/08/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 50 | Depth today - 3730' | Hole advance last 24 hr - 90' | Core recovered - 90'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650"	200
24	HQ impreg S7S	3650'		

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

**Lithology of core logged since yesterday: [Summary - detailed log available]**

Logs received from 3142 to 3264'. Mostly the same granodiorite previously described with a extremely vuggy zone at 3210'.

**Summary of events last 24 hours:**

Drilling ahead at report time. POOH at 3650 ft to grease rods, bit about 40% wore but changed out anyway. Will rerun if needed to get to planned TD. Set down with new bit at 268' and could not work thru. POOH and checked bit, it is slightly over gage, 3.925". PU new bit and RIH. Had to wrench through tight spot at 268'. 15 hours drilling time, 7 hours tripping and 2 hours rig repair.

Report by: Ron Jacobson

**DAILY DRILLING REPORT - 09/09/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 51 | Depth today - 3810' | Hole advance last 24 hr - 80' | Core recovered - 78'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'		

Drilling fluid - water, bentonite, polymer; soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 4 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

Summary of events last 24 hours:

Drilling indicates that formation has gotten harder. Rate of penetration and bit life are down. POOH at 3810' for bit change; ran temperature log. Bottom-hole temperature is less than 300°F. Running back in hole with new bit at report time.

Report by: John Finger

**DAILY DRILLING REPORT - 09/10/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 52 | Depth today - 3960' | Hole advance last 24 hr - 150' | Core recovered - 150'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149'	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'		

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

**Summary of events last 24 hours:**

Have been drilling ahead since 1030 yesterday. Rate of penetration is good (8-9 ft/hr), minor torque. We are near the target of 4000', but there is still a question of whether to continue drilling. A major fracture zone near 3600' shows mineralization that does not usually occur below a temperature of 350°F, but temperature log to 3800' shows less than 300°F at that depth. After drilling either to 4000' or until the current bit is gone, we will attempt to resolve this by making additional temperature measurements while restricting the possible flow of cold water from above 3600'.

Report by: John Finger

**DAILY DRILLING REPORT - 09/13/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 55 | Depth today - 4001' | Hole advance last 24 hr - 1' | Core recovered - 1'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'	4001'	191

Drilling fluid - n/a

Lithology of core logged since yesterday: [Summary - detailed log available] No new logs today

**Summary of events last 24 hours:**

Ran logging company's PTS tool into flowing hole; got downhole data to 2700', then their tool sat down on the same obstruction that stopped SNL log on Saturday. This confirms that there is an actual bridge of some sort, not just a flow phenomenon that tangled the SNL wireline. Pulled PTS tool back to 805' (just above production zone) and shut well in for 5 hours. POOH with logging tool, RIH with drill pipe to 2800', felt no obstruction, but examination of core shows fractured zone where tool stopped. RIH with SNL temperature tool and pressure/temperature memory tool. Could not get past 3208' (core shows very large fracture there) and POOH. Memory tool has no data; temperature tool shows that upper part of hole has heated relative to the static log on Friday (as expected after 20+ hours of flow), but that the lower part has cooled. Run in hole with rest of drill pipe and core 1' to capture any cave that has fallen in the hole. POOH with drill pipe; at report time rigging for another attempt at SNL temperature log to bottom.

Report by: John Finger

**DAILY DRILLING REPORT - 09/11/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 53 | Depth today - 4000' | Hole advance last 24 hr - 40' | Core recovered - 40'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'	4000'	190

Drilling fluid - water, bentonite, polymer, soda ash, torkease  
 Flow rate - 18 gal/min | Pressure - 0 psi | Returns temp - n/a  
 Wt - 8.4 lb/gal | Vis - 32 sec | PV - 4 cP | YP - 3 lb/100ft<sup>2</sup> | pH - 8.0  
 Lost circulation - no returns since fracture at 815'

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

**Summary of events last 24 hours:**

Reached 4000' at 1200 yesterday. Pulled out of hole to 3500', with the idea that the bit will restrict intra-wellbore flow. Ran temperature log to 4000' and left tool hanging at 3990' for 12 hours. Bottom-hole temperature decreased by approximately 1.5°C. Logged back up; hole temperatures were slightly higher in some parts of the hole and lower in others. Pulling out of hole in preparation for flow test.

Report by: John Finger

**DAILY DRILLING REPORT - 09/12/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 54 | Depth today - 4000' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Now drilling 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'	4000'	190

Drilling fluid - n/a

Lithology of core logged since yesterday: [Summary - detailed log available] No new logs today

**Summary of events last 24 hours:**

Completed pulling out of hole with drill pipe. Pressurized wellhead, held for an hour, and released. Flow began. Ran in hole to 2700' with SNL temperature tool and tool sat down on an obstruction in the wellbore; wireline became tangled, and could not lower tool. Pulled out of hole to 1700' and wireline tangle stuck in lubricator. Killed well, let lubricator cool, and pulled out bad line (severely frayed at knot area.) Pulled temperature tool to surface, laid it down, spooled out wireline to bad spot, and cut it off. Will rehead wireline, giving enough length to reach bottom of hole. SNL pressure-temperature memory tool is not currently working because of a problem with the temperature transducer. Waited on logging company until 0530; at report time the depth counter on their truck is not working. Well has been flowing for approximately 20 hours; we have good surface data (flow rate, wellhead pressure and temperature, lip pressure) for that interval, but no useful downhole logs other than the flowing temperature log to 2700'.

Report by: John Finger

**DAILY DRILLING REPORT - 09/14/93**  
**STEAMBOAT HILLS EXPLORATORY SLIMHOLE**  
 Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

Days since spud - 56 | Depth today - 4001' | Hole advance last 24 hr - 0' | Core recovered - 0'  
 Last casing - 4-1/2", 11.5 lb/ft @ 524'

**BITS -- Completed 3.89" hole**

Bit number	Type	Depth in, KB	Depth out, KB	Footage
1	12-1/4" tri-cone	10'	12'	2
2	HQ impreg-S2	12'	172'	160
3	8-1/2" tri-cone	12'	176'	164
4	BSF impreg-S2	110' (cement)	225'	115
5	BSF impreg-S8	225'	462'	237
6	BSF impreg-S8	462'	525'	63
2RR	HQ impreg-S2	525' (rock)	673'	148
7	HQ impreg-S7	673'	1149	476
8	HQ impreg-S8	1149'	1510'	61
9	HQ impreg-S5	1510'	1568'	58
10	HQ surf set	1568'	1600'	32
11	HQ impreg-S7	1600'	1702'	102
12	HQ impreg-S5	1702'	1709'	7
13	HQ surf set	1709'	1754'	45
14	HQ impreg-S5	1754'	1837'	83
15	HQ impreg-S7	1837'	2077'	240
16	HQ impreg-S7	2077'	2077'	0
17	HQ impreg-S7	2077'	2168'	91
18	HQ impreg-S8	2168'	2426'	258
19	HQ impreg-S9	2426'	2437'	11
20	HQ impreg-S7	2437'	2624'	187
21	HQ impreg S7S	2624'	3072'	448
22	HQ impreg S7S	3072'	3450'	378
23	HQ impreg S7S	3450'	3650'	200
24	HQ impreg S7S	3650'	3810'	160
25	HQ impreg S10	3810'	4001'	191

Drilling fluid - n/a

Lithology of core logged since yesterday: [Summary - detailed log available]  
 No new logs today

**Summary of events last 24 hours:**

Completed SNL temperature log to bottom with no obstruction. Rigged up for injection into slimhole. Injected ~940 gpm with 60 psi wellhead pressure, while taking downhole PTS data and surface measurements. Rigged up to RIH with packer to 1060'. Objective of packer test is to seal off wellbore below it from flow out of upper fractures and observe effect on temperature, then pump into zone below packer and compare permeability of that interval with complete wellbore. Packer sets and holds pressure, but we cannot retrieve the standing valve that seals the packer for inflation. Release packer pressure by rotating it, then POOH. Crossover between packer and drill pipe is too small at ID to pass standing valve overshot. Replace crossover sub and RIH with new packer. It sets successfully; rigging up for static log through packer.

Report by: John Finger

DAILY DRILLING REPORT - 09/15/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE  
Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 57 | Depth today - 4001' | Hole advance last 24 hr - 0' | Core recovered - 0'  
Last casing - 4-1/2", 11.5 lb/ft @ 524'

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**BITS -- Completed 3.89" hole**

Used: 1 ea 12-1/4" tricone; 1 ea 8-1/2" tricone; 3 ea 6-1/4" impregnated core bits; 2 ea HQ surface set bits; and 18 HQ impregnated bits. Bit life averaged over 250' for the last six HQ bits, with an overall average of just under 200' for the HQ impregnated bits.

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Drilling fluid - n/a

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Lithology of core logged since yesterday: [Summary - detailed log available]

No new logs today

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Summary of events last 24 hours:

Ran pressure/temperature log through packer to TD. Waited 4 hours and repeated; temperatures below packer were identical, with slight wellbore heating above it. Rigged up to pump cold water through packer and did PT log through packer to TD; temperatures below ~2100' changed imperceptibly, with large wellbore cooling above that. POOH with packer and RIH to 2450' with new packer, planning to repeat the previous test. Cannot get packer to hold pressure. POOH with that packer, lay it down, pick up other packer which has been refurbished from previous test, RIH and set it at 2450'. RIH with PT tool (had to remove spinner because it's too big to pass through packer valve seat) for static log.

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Report by: John Finger

DAILY DRILLING REPORT - 09/16/93  
STEAMBOAT HILLS EXPLORATORY SLIMHOLE

Time of report - 0800

Well number - SNLG 87-29 | Location - SE 1/4, SE 1/4, Section 29, T18N, R20E, Washoe County, NV

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Days since spud - 58 | Total depth - 4001'

Last casing - 4-1/2", 11.5 lb/ft @ 524'

---

**BITS -- Completed 3.89" hole**

Used: 1 ea 12-1/4" tricone; 1 ea 8-1/2" tricone; 3 ea 6-1/4" impregnated core bits; 2 ea HQ surface set bits; and 18 HQ impregnated bits. Bit life averaged over 250' for the last six HQ bits, with an overall average of just under 200' for the HQ impregnated bits.

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Drilling fluid - n/a

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Lithology of core logged since yesterday: [Summary - detailed log available]

Core from 3210' to 4000' continued in the same granodiorite previously described. There are many strongly to intensely altered zones interlayered with unaltered rock. Vugs range up to 10cm, with most fractures continuing to be near vertical (75-90°). Numerous fractures and vugs below 3500' contain barite, usually indicative of temperatures over 350°F, but the formation is not now that hot.

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Summary of events last 24 hours:

Ran second static pressure/temperature log through packer at 2690' to TD (6 hours after first static log.) Temperature below packer had not changed from previous log. Rigged up to inject through packer. Injection rate was 260 gpm at 110 psi wellhead pressure, compared to 450 gpm/90 psi with packer set at 1060'. Part of this difference is due to additional friction loss in the longer pipe and different fluid temperatures at injection, but it appears that permeability in the lower part of the hole is considerably less than that above. Attempted to run PT survey below packer, but logging tool could not get below 2700' because of apparent bridge. POOH with logging tool and drillpipe. Pressurized wellhead and released to start flow for production test. Flowed well for 2 hours and RIH with Sandia PT memory tool. Continued flow for 1/2 hour and then shut in for 4-1/2 hours. POOH with memory tool; it had successfully taken data which can be compared with shut-in data from commercial loggers. RIH to TD with drillpipe for wiper trip and encountered obstruction at 2700', where logging tool was stopped. POOH in 10' joints, laying down pipe. Will release rig within next 24 hours.

This is the final Daily Drilling Report from the Steamboat Hills Exploratory Slimhole.

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Report by: John Finger/Ron Jacobson

## DISTRIBUTION

David N. Anderson  
Geothermal Resources Council  
PO Box 1350  
Davis, CA 95617

Jim Combs  
Geo Hills Associates  
27790 Edgerton Road  
Los Altos Hills, CA 94022

Greg Taylor  
Christensen Boyles Corporation  
PO Box 30777  
Salt Lake City, UT 84130

Alan Melchior  
Far West Capital  
921 Executive Park Drive, Suite B  
Salt Lake City, UT 84117

Eric Call  
SB Geo  
PO Box 18087  
Reno, NV 89511

Dave Harvey  
PO Box 10263  
Reno, NV 89510

Colin Goranson  
1498 Aqua Vista Road  
Richmond, CA 94805

Jim Lovekin  
California Energy Co.  
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Ridgecrest, CA 93555

Marc Steffen  
Cal-Pine Corporation  
1160 North Dutton, Suite 200  
Santa Rosa, CA 95401

Walter Haenggi  
Magma Power Company  
551 West Main Street, Suite 1  
Brawley, CA 92227

Bureau of Land Management (2)  
Attn: Michael Ferguson  
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787 N. Main, Suite P  
Bishop, CA 93514

R. C. Edmiston  
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835 Piner Road, Suite A  
Santa Rosa, CA 95403

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ARCO Oil and Gas Co.  
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Sue Goff  
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Halliburton Services  
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Barry Harding  
Ocean Drilling Program  
Texas A&M University  
1000 Discovery Drive  
College Station, TX 77840

George Cooper  
Dept. of Materials Science &  
Mineral Engineering  
University of California  
Berkeley, CA 94720

Helene Knowlton  
Smith International  
16740 Hardy Street  
Houston, TX 77205

Frank Monastero  
US Navy - Geothermal Office  
China Lake, CA 93555

John Mastor (4)  
Longyear Company  
PO Box 1000  
Dayton, NV 89403

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126 Countrywood Lane  
Encinitas CA 92024

Daniel Lyster  
Mono County Energy Mgmt.  
HCR 79, PO Box 221  
Mammoth Lakes, CA 93546

Desert Drilling Fluids (4)  
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3316 Girard Blvd NE  
Albuquerque NM 87107

Nic Nickels  
Eastman Christensen  
3636 Airway Drive  
Santa Rosa, CA 95403

Steve Pye  
Unocal Geothermal  
PO Box 7600  
Los Angeles, CA 90017

John Sass  
USGS  
2255 North Gemini Drive  
Flagstaff, AZ 86001

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Tonto Drilling Services (2)  
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Berkeley, CA 94720

US Department of Energy (3)  
Geothermal Division  
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1000 Independence Ave. SW  
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Susan Hodgeson  
Division of Oil and Gas  
20th Floor, MS-20  
801 K Street  
Sacramento, CA 95814-3530

Elizabeth Johnson  
Div. of Oil and Gas - Geothermal  
20th Floor, MS-21  
801 K Street  
Sacramento, CA 95814-3530

Warren Bollmeier  
PICHTR  
2800 Woodlawn Dr, Suite 180  
Honolulu, HI 96822

Dick Benoit  
Oxbow Power Services, Inc  
200 South Virginia St, Suite 450  
Reno, NV 89501

George Darr  
Geothermal Program Manager  
Bonneville Power Administration  
PO Box 3621  
Portland, OR 97208-3621

Mohinder Gulati  
UNOCAL Geothermal  
PO Box 7600, Room M-36  
Los Angeles, CA 90051

Thomas C. Hinrichs  
Magma Power Company  
11770 Bernardo Plaza Ct, Suite 366  
San Diego, CA 92128

S. K. Garg  
S-Cubed  
PO Box 1620  
La Jolla, CA 92038-1620

Cal Strobel  
Unocal Geothermal  
PO Box 6854  
Santa Rosa, CA 95403-1774

Tsvi Meidav  
Trans-Pacific Geothermal Corp.  
1901 Harrison St, Suite 1590  
Oakland, CA 94612

Joel Renner  
Manager, Renewable Energy Programs  
Idaho Nat'l Engineering Lab.  
PO Box 1625  
Idaho Falls, ID 83415

Richard Thomas  
Geothermal Officer  
Calif. Div of Oil & Gas  
1416 Ninth St, Room 1310  
Sacramento, CA 95814

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