GL00543

# Salton Sea Scientific Drilling Program Monitor

A PERIODIC REPORT OF SSSDP EVENTS PREPARED BY THE U.S. DEPARTMENT OF ENERGY, IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY AND THE NATIONAL SCIENCE FOUNDATION.

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## IMPORTANCE OF THE SSSDP

The basic concept behind the Salton Sea Scientific Drilling Program (SSSDP) originated within the context of the Continental Scientific Drilling Program (CSDP). Specifically, one of the objectives of the CSDP was to increase the body of knowledge concerning "active hydrothermal systems related to young magmatic intrusions." Until the SSSDP, knowledge of the roots of hydrothermal systems had been based on inferences from:

* Geochemical laboratory studies
* Field studies of exhumed "fossil" systems
* Theoretical heat and fluid flow models
* Geophysical surveys
* Shallow and intermediate test drilling (2 to 4 km).

Geothermal wells have been drilled to depths greater than 4 km and to temperatures greater than 400°C, although most meaningful measurements are restricted to downhole environments having temperatures less than 250°C. Ideally, one would like to penetrate and investigate the entire hydrothermal-magma system, to magmatic temperatures deep within the Earth's crust. However, such an objective requires significant advances in drilling and instrumentation technology. Because of these restrictions, it is presently most realistic to focus on hydrothermal systems with temperatures less than 500°C at depths less than 7 km--the "roots" of hydrothermal systems. Direct measurement and sampling of this environment will provide important knowledge not obtainable in any other way.

The SSSDP is an integral part of the geothermal programs of the U.S. Department of Energy, Geothermal Technology Division (GTD), in as much as SSSDP results will be used to assist and direct other GTD programs. The SSSDP is important because it will offer the opportunity to verify existing theoretical models developed by other researchers on behalf of GTD. Verification will help scientists and engineers to better understand and predict the performance of similar hydrothermal systems in the western U.S., and worldwide. This could lead to more efficient geothermal energy extraction methods and, thus, more available energy.

## SSSDP DRILLING ACTIVITIES

Near the end of the last reporting period, Schlumberger ran a suite of commer-

cial geophysical logs, which are summarized below.

At the beginning of this reporting period, the U.S. Geological Survey (USGS) was finishing a first suite of research geophysical logs (see the table below). All logging instruments were used successfully with the exception of the Acoustic Borehole Televiewer, which would not perform (as expected) in the presence of heavy mud.

After completion of logging, the well was reamed to a depth of 3,030 ft, and drilling was resumed. Because the wellbore was much cooler than expected and the flow test facility was only 40% complete, the decision was made to continue drilling to 3,500 ft before setting 13-3/8 inch casing. At a depth of 3,078 ft, two roller cones broke away from the drill bit and lodged at

SUMMARY OF SCHLUMBERGER LOGS (11/5/85)

INTERVAL LOGGED: 1,032 ft to 3,000 ft
LOGGING PERIOD : 15-hour period beginning approximately 6:00 A.M.
LOG TYPES:
- o Dual Induction Log
- o Formation Compensated Density Log
- o Compensated Neutron Log
- o Gamma Ray Log
- o Sonic Log
- o 4-Arm Caliper Log*

* 3 runs, average borehole diameter - 19.5 inches

CHRONOLOGY OF USGS LOGS

| Log Type | Date | In Hole | Out of Hole |
|---|---|---|---|
| Resist temp. | 11-5 | 09:00 | 13:00 (before circulation) |
| Natural gamma | 11-5 | 21:00 | 23:00 (2-sec time const.) |
| Resist temp. | 11-6 | 04:00 | 10:00 (after circulation) |
| Caliper | 11-6 | 04:00 | 10:00 |
| Televiewer | 11-6 | 11:00 | 13:00 (no useful logs) |
| Resist temp. | 11-6 | 13:00 | 17:00 (many stationary readings) |
| Caliper | 11-6 | 13:00 | 17:00 |
| Acoustic DT | 11-6 | 18:00 | 21:00 (3-ft spacing) |
| Acoustic DT | 11-6 | 21:00 | 23:00 (2-ft spacing) |
| Waveform | 11-7 | 01:00 | 03:30 (2-microsec. sampling) |
| Resist temp. | 11-7 | 04:00 | 06:00 (stationary readings temp vs. time) |
| Natural gamma | 11-7 | 08:00 | 11:30 |
| Gamma spec. | 11-7 | 08:00 | 11:30 (spectrum at 5 depths) |
| Resist temp. | 11-7 | 12:30 | 14:30 (stationary readings at bottom) |

the bottom of the hole. At this point, fishing tools were used, including a magnetic tool that failed to recover the lost cones. A milling tool and junk basket were then successfully used to recover the cones, and, in the process, cut a wide shallow core, referred to as Core #5 (3,080 to 3,086 ft)

On November 10, drilling was resumed and the 6th core was taken within the interval from 3,107 to 3,167 ft, showing laminated sandstone containing pyrite and calcite. The 7th core was taken from the interval 3,470 to 3,505 ft, before the 60-ft core barrel became jammed. It was later determined that the well was deviated 3°45' from vertical. A suite of Schlumberger logs was run on November 13, as summarized below, followed by measurement of bottom-hole temperature (BHT) using bare Kuster tools. A questionable BHT measurement of 358°F (181°C) was obtained.

On November 14, 13-3/8 inch casing was run into the well, hung to a depth of 3,515 ft., and cemented into place. Drilling then continued to 3,790 ft, where the USGS ran a temperature survey of the well, measuring a maximum temperature of 400°F (204°C) in 4 hours. Estimated equilibrium temperature at this depth was not greater than 437°F (225°C). The expected value was 500°F (260°C), based upon a nearby well--River Ranch No. 1. The 8th core was taken from 3,790 to 3,850 ft, with little or no frac-

SUMMARY OF SCHLUMBERGER LOGS (11/13/85)

INTERVAL LOGGED: 3,000 ft to 3,515 ft
LOGGING PERIOD: 14-hour period beginning approximately 10:00 A.M.

LOG TYPES:

- o Dual Induction Log
- o Formation Compensated Density Log
- o Compensated Neutron/Gamma Ray Log
- o Sonic and Gamma Ray Log
- o 4-Arm Caliper Log

turing and minimum alteration noted. Drilling and coring continued (see summary table below) to 4,678 ft, where the USGS ran another temperature survey, measuring a maximum temperature of 414°F (212°C) and climbing. Equilibrium temperature estimates ranged from 500-588°F (260-309°C). The lower than expected temperatures being encountered in the SSSDP well are supported by the observation that alteration minerals (epidote and chlorite), which were pervasive in Cores 4, 5, and 6, occurred only in trace amounts in Cores 8 through 11. Core #12 (4,643-4,676 ft), however, contained abundant epidote and specular hematite veins in extensively fractured sandstone and siltstone. Core #13 was similar, but contained large chalcopyrite crystals.

Based upon the fracturing and mineralogy observed in Cores 12 and 13 and the results of temperature surveys, it was decided to conduct a mini-injection test of the open-hole interval from approximately 3,515 to 4,686 ft. The test indicated that the permeability in this interval was too low to sustain flow, and drilling was resumed.

On November 26, four welded stabilizer blades broke off and were lost in the hole. Fishing operations resulted in the recovery of about 1 ft of epidotized mudstone (Core #14), but no junk from a depth of about 4,718 ft. Three mill bits were used in this operation. When drilling resumed at 4,722 ft on the 27th, penetration was slow and torque high. Hole deviation increased

CORING SUMMARY

| Core # | Cored interval (ft.) | Feet cored | Feet recovered | (%) Recovery |
|---|---|---|---|---|
| 1 | 1553-1577.6 | 24.6 | 24.6 | 100 |
| 2 | 1983-2012.2 | 29.2 | 29.2 | 100 |
| 3 | 2447-2477 | 30.0 | 30.0 | 100 |
| 4 | 2970-3030 | 60.0 | 59.6 | 99.3 |
| 5 | 3080-3086 (recovered with junk) | | 7.0* | |
| 6 | 3107-3167 | 60.0 | 55.0 | 95.0 |
| 7 | 3470-3505 | 35.0 | 34.0 | 97.1 |
| 8 | 3790-3850 | 60.0 | 57.0 | 95.0 |
| 9 | 4007-4067 | 60.0 | 60.0 | 100 |
| 10 | 4241-4301 | 60.0 | 58.6 | 97.7 |
| 11 | 4301-4334 | 33.0* | 36.0* | 100 |
| 12 | 4643-4676 | 33.0* | 37.0* | 100 |
| 13 | 4676-4686 | 10.0 | 2.0 | 20.0 |
| 14 | 4718-4719 (recovered with junk) | | 1.0 | |
| 15 | 5188-5218 | 30.0 | 30.0 | 100 |
| 16 | 5574-5591 | 17.0* | 17.5* | 100 |

* difference reflects broken condition of core

from 4°15'N, 13°E at 4,764 to 3°45'N, 45°E at 5,138.

On December 1st, Core #15 was cut from 5,188 to 5,218 ft, with 100% recovery of a black indurated mudstone exhibiting pyrite and minimum alteration. A "slip and dog" core catcher was used in this coring operation because of the poor recovery of Core #13.

Concern over wellbore deviation continued as directional surveys on December 2, at depths of 5,228 ft and 5,336 ft, showed an increase from 4°45'N, 58°E (83 ft E, 149 ft N) to 6°15'N, 73°E. An attempt at controlling deviation by decreasing weight-on-bit (and drilling rate to 4 ft/hr) was unsuccessful. This problem is to be corrected after the 9-5/8 inch casing is set and cemented.

At a depth of 5,422 ft, it was decided on December 3rd to perform a full-scale injection test of the 3,500 to 5,422 ft open-hole interval. Drilling mud was circulated out of the well and replaced by 1,000 barrels of 2% KCl solution. Fluid was externally pressured to 1,500 psi for a period of 45 minutes, and a pressure decline to 320 psi was noted. Additional pressure build-up fall-off tests yielded similar results. A temperature log was then run to detect possible "fluid-loss zones." No significant zones were found. The conclusion was reached that, within the 1,922 ft of open hole, there was insufficient permeability to sustain a flow test. Therefore, the intermediate flow test above 6,000 ft was cancelled and drilling was resumed on December 5.

After drilling from 5,422 to 5,424 ft on December 5, a drill-collar twisted off at 5,108 ft, but was recovered on the first attempt with an over-shot. Drilling resumed with a new bottom-hole assembly to a depth of 5,474 ft. At 9:30 p.m. on December 6, the 16th coring attempt was begun.