GL00540

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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INTRODUCTION

The drilling phase of the Salton Sea Scientific Drilling Program (SSSDP) officially ended on March 17, when a total well depth of 10,564 ft was reached (fig. 1). The flow testing and sampling phase ended on April 1, when the well was shut-in for the 6-month standby period. During the drilling phase, more than 725 ft of core were recovered from a total cored interval of more than 800 ft; two production zones were flow-tested; surface and downhole fluid and gas samples were collected from the flow tests; and geophysical logs were obtained from over 80 percent of the downhole interval. The maximum bottom-hole temperature has been estimated to be in excess of 350°C (662°F), even though thermal equilibrium is not expected to be established for several months.

Early data derived from the drilling and engineering program indicate that: (1) the deep hydrothermal convection system extends downward at least to 10,564 ft; (2) the "roots" of the hydrothermal convection system were neither fully penetrated nor thoroughly examined; and (3) the diabasic intrusive rocks that were penetrated and sampled by coring near the bottom of the well may represent the "frozen" equivalent of the heat source for this "magma-driven" convection system.

Geologic units penetrated during the drilling phase consisted primarily of a sequence of young fluvial and lacustrine sedimentary rocks and evaporites. Some of these units have undergone extensive fracturing and hydrothermal alteration, and in the lower part of the well, were often described from cuttings and core as "hornfels," indicative of regional metamorphism.

Results of testing the deeper flow zone (below the 7-inch liner at 10,136 ft) are inconclusive. It has been suggested that flow from a lost circulation zone encountered near 8,600 ft may have adversely affected the test results.

DRILLING AND LOGGING ACTIVITIES

At the beginning of this reporting period (February 11), the scientific well had been drilled to a depth of 9,450 ft and a "pill" composed of lost circulation material (LCM) and cement had been placed at the bottom of the well. Circulation was lost again the following day while reaming from 9,420 to 9,450 ft and milling with junk-sub to 9,453 ft to recover buttons broken from roller cone bit #51. Placing of an LCM pill failed to regain circulation, and the well began flowing as well as taking fluid. Finally, a cement plug was set to seal off the loss zones. After cementing, the blowout preventer was closed and the well pressured to 200 psi. The cement failed to hold and fluids continued to be lost. Circulation was regained after pumping stabilizing material into the formation, and the well was reamed to a depth of 9,453 ft.

As a result of having penetrated igneous intrusive rock near this depth, an attempt to recover core samples was initiated (Table 1). The coring assembly was tripped-in (running pipe or tools into the well) and Core # 32 was taken from the interval 9,453 to 9,458 ft with mud losses of 30 to 80 Bbls/hr. This core consisted of 2.3 ft (46 percent recovery) of fractured diabasic rock with minor secondary pyrite and epidote. Coring continued on February 13 from 9,458 to 9,473 ft (Core # 33), after an LCM pill had been placed to control fluid loss. The 5-feet of core

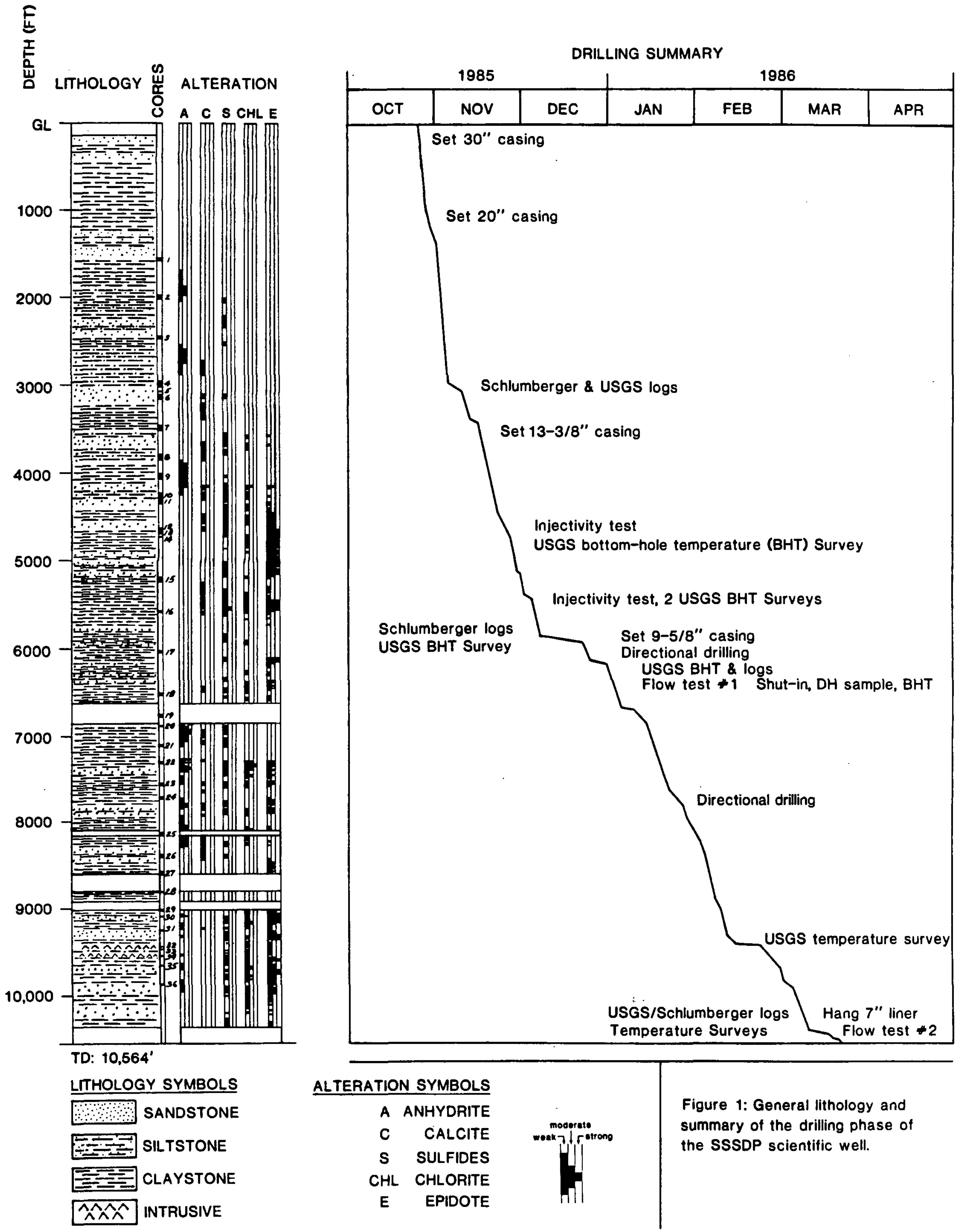


Figure 1: General lithology and summary of the drilling phase of the SSSDP scientific well.

TABLE 1: SSSDP CORING SUMMARY

CORE #	INTERVAL START (FT)	CORED END (FT)	TOTAL CORED (FT)	CORE RECOVERED (FT)	(%)	GENERAL DESCRIPTION
1	1553.0	1577.0	24.0	24.6*	100.0	Mudstone: indurated.
2	1983.0	2013.0	30.0	29.2	97.3	Conglomerate: indurated granular, minor mudstone and siltstone, with calcite veins, galena, sphalerite, and chalcopyrite.
3	2447.0	2477.0	30.0	30.0	100.0	Mudstone and siltstone: indurated, with minor sandstone, some calcite veining
4	2970.0	3030.0	60.0	59.6	99.3	Sandstone and claystone: fractured, with epidote and chlorite, and contains sulfide-bearing veins with well crystallized chalcopyrite, and traces of hematite.
5	3080.0	3087.0	7.0	7.0	100.0	Rock recovered with junk.
6	3107.0	3167.0	60.0	55.0	91.7	Sandstone: laminated, containing pyrite and calcite veins, epidote, and chlorite.
7	3470.0	3505.0	35.0	34.0	97.1	Claystone: minor calcite veins and traces of disseminated pyrite.
8	3790.0	3850.0	60.0	57.0	95.0	Mudstone: indurated, some granular conglomerate, sandstone and siltstone, scarce veining.
9	4007.0	4067.0	60.0	60.0	100.0	Mudstone: indurated, some granular conglomerate, sandstone, and siltstone, scarce veining.
10	4241.0	4301.0	60.0	60.0	100.0	Mudstone: indurated, granular conglomerate, sandstone and siltstone, anhydrite porphyroblasts, lower part contains calcite, epidote, and sulfide veinlets.
11	4301.0	4334.0	33.0	33.0	100.0	Sandstone: with calcite, epidote and sulfide-bearing veins.
12	4643.0	4676.0	33.0	33.0	100.0	Sandstone and siltstone: abundant epidote with specular hematite in veins, extensively fractured.
13	4676.0	4682.0	6.0	3.5	58.3	Sandstone and siltstone: contains much epidote, 1 cm veins of specular hematite, and large chalcopyrite crystals.
14	4718.0	4718.5	0.5	0.5	100.0	Mudstone: epidotized (rock recovered with junk).
15	5188.0	5218.0	30.0	30.0	100.0	Mudstone: black, aphanitic, indurated, with pyrite.
16	5574.0	5591.0	17.0	17.5*	100.0	Mudstone: indurated, with brecciated fractures, abundant epidote and hematite, and traces of sulfides.
17	6026.0	6044.0	18.0	18.0	100.0	Mudstone: some epidote, with quartz veins and traces of pyrite.
18	6506.0	6517.0	11.0	11.0	100.0	Claystone: grayish, with minor epidote.
19	6758.0	6771.0	13.0	8.0	61.5	Sandstone and siltstone: grayish-green.
20	6880.0	6889.0	9.0	3.5	38.9	Mudstone: indurated, laminated dark grey to light grey.
21	7100.0	7109.0	9.0	7.0	77.7	Mudstone: indurated, with minor amounts of siltstone; authigenic minerals include chlorite, hematite, and anhydrite.
22	7300.0	7313.0	13.0	11.5	88.5	Mudstone: indurated, with minor amounts of siltstone; authigenic minerals include chlorite, hematite, and anhydrite.
23	7547.0	7577.0	30.0	28.5	95.0	Mudstone: medium grey, indurated, with a single narrow bed of epidotized siltstone.
24	7704.0	7734.0	30.0	30.0	100.0	Mudstone: moderately indurated, containing anhydrite porphyroblasts.
25	8133.0	8161.0	28.0	28.0	100.0	Siltstone: dark, with minor sandstone, contains mica and epidote along fractures.
26	8395.0	8402.0	7.0	7.0	100.0	Mudstone: black, containing chalcopyrite.
27	8585.0	8604.0	19.0	12.0	63.2	Sandstone: grey, with abundant epidote along inclined bedding.
28	8800.0	8807.0	7.0	4.0	57.1	Mudstone: primarily hornfelsic, minor quartzitic sandstones with greenschist facies alteration minerals.
29	9004.0	9027.0	23.0	4.5	19.6	Mudstone: primarily hornfelsic, minor quartzitic sandstones with greenschist facies alteration minerals.
30	9095.0	9098.0	3.0	3.0	100.0	Shale: with interbedded fine grained sandstone, numerous fractures lined with epidote, chlorite, pyrite, and pyrrhotite.
31	9248.0	9253.0	5.0	3.5	70.0	Mudstone: hornfelsic, with minor quartzose sandstone exhibiting greenschist alteration.
32	9453.0	9458.0	5.0	2.3	46.0	Mafic intrusive: fairly fresh, fine-grained diabasic texture, containing minor pyrite, epidote and quartz inclusions.
33	9458.0	9473.0	15.0	5.0	33.0	Mafic intrusive: aphanitic, containing brecciated contact with hornfelsic, epidote-rich mudstone.
34	9473.0	9477.0	4.0	2.0	50.0	Mudstone: hornfelsic.
35	9694.0	9698.0	4.0	3.5	88.0	Quartzite: epidote-rich.
36	9907.0	9912.0	5.0	.8	13.0	Hornfels: fractured, black, silicified and cherty.
** TOTAL **			803.5	727.0	90.5	

* Difference reflects broken condition of core.

recovered from this interval was obtained while pumping water downhole at 300 gallons per minute (gpm) without returns. Recovered core revealed that the diamond core bit (heavily damaged by insufficient lubrication) had penetrated the brecciated contact between the aphanitic, mafic, intrusive rock and an epidote-rich mudstone described as hornfelsic.

Most of February 14 was spent inspecting the bottom-hole assembly (BHA) and drill pipe, and replacing bad sections. This action was prompted by the discovery the previous day of a cracked pin on a joint of drill pipe, 10 stands above the "heavy-weight" drill pipe. Pipe failure could have resulted in a costly fishing job. (NOTE: a "pin" is the male section of a tool joint; and a "stand" is the number of joints of connected drill pipe that can stand vertically in the derrick--usually 3 joints.)

Late on February 14, the well started flowing after having pumped in 350 barrels of water with only 20 barrels returned. Early on the 15th, the flow was killed (stopped) and reaming operations were conducted to remove fill from 9,315 ft to the previous total depth of 9,473 ft. During this operation, returns declined from 20 percent to 0. The USGS then ran a continuous temperature log that revealed several cooled zones interpreted as representing the zones of fluid loss. A downhole flow meter (spinner) tool, also run for detection of fluid loss, malfunctioned due to excess LCM in the drilling mud. The well was flowing during logging operations, and afterwards when the BHA was tripped-out (removed from the well) and changed. The flow was killed by conditioning the mud with additives, holding the weight at less than 9 pounds per gallon (ppg), and attempting to build to maximum volume.

After killing well flow, results from the temperature survey were used on February 16 as the basis for setting cement plugs at three depths (7,400, 8,500 and 9,200 ft) to regain circulation. After waiting 6-hours for the cement to set, normal drilling operations still could not be resumed until cement had been cleaned from the BHA and drill pipe which had become plugged.

With the well again flowing, the interval 9,360 to 9,473 ft was re-reamed on February 17. On the morning of the 18th, a coring attempt was begun, only to be aborted 12-hours later when circulation could not be established at 9,400 ft. The coring assembly was tripped-out of the well and the USGS attempted to run another temperature survey to locate the zone(s) of fluid loss. However, the tool would go no deeper than 6,124 ft and was removed early on February 19.

From about noon on February 19 until the morning of the 21st, more than a half-dozen cementing and recementing operations were performed at various depths between 6,292 and 9,230 ft. These efforts to cement were temporarily hampered by sticking of the drill stem at 9,230 ft. Cleaning-out of the cement plugs then began and continued until noon on February 22. After clean-out, the coring assembly was picked-up and tripped into the well. The pipe then became differentially stuck at about 9,440 ft. It was freed in 4-hours using approximately 3,000 gallons of diesel and additives. Fill was cleaned from 9,440 to 9,473 ft and Core #34 was cut from the interval 9,473 to 9,477 ft. However, damage to the core bit while cleaning fill and jamming of the core barrel resulted in recovery of only 2-feet of hornfelsic mudstone on February 23.

After normal drilling operations resumed on February 23 with bit # 54, another igneous intrusive was penetrated between about 9,505 and 9,517 ft. A subsequent attempt to core the intrusive was terminated when the drill stem became stuck at a depth of 9,458 ft. It was freed in 10-hours and reaming of the "tight" zone from 9,458 to 9,488 ft was then performed. Normal drilling operations resumed late on February 25 and, after reaming, continued through the intrusive (9,517 to about 9,530 ft) into a sedimentary sequence (claystone, siltstone and sandstone). A depth of 9,694 ft was reached on February 26. Mud losses experienced were on the order of 15 Bbls/hr.

Core #35 was cut on February 28 from the interval 9,694 to 9,698 ft and 3.5 ft of epidote-rich quartzite was recovered. The well began flowing after the core barrel was tripped-out, requiring the placement of a 10-ppg slug to kill the flow. After reaming, drilling continued to 9,907 ft on March 1, with mud losses of

5 to 20 Bbls/hr.

Using a smaller (7 5/8-inch) coring bit designed for medium-hard formations, Core #36 was cut from the interval 9,907 to 9,912 ft. After rotating on bottom for approximately 8 1/2 hours, only 0.8 ft of core was recovered (13 percent recovery). This core consisted of fractured, black, silicified, cherty hornfels. Upon retrieval, it was discovered that the bit had been badly damaged during coring.

On March 4, drilling continued with mud losses of 15 Bbls/hr to 10,061 ft. (NOTE: The original target depth of 10,000 ft was passed late on March 3.) The rocks consisted mostly of hard, silicified, medium to dark grey-green claystone with decreasing secondary mineralization. Traces of disseminated pyrite and rare epidote veins were noted. Drilling was suspended at 3:30 p.m. for 5-hours in order to repair the blowout preventer.

By March 5, the well had been deepened to 10,212 ft. Lithology consisted of dark grey to green claystone, siltstone, and white and yellow-green sandstone containing epidote, traces of disseminated pyrite and rare, white, fibrous tremolite. While reaming-out the hole, the drill pipe became stuck near 10,170 ft and 5,000 gallons of diesel were pumped down the well in an effort to dislodge the pipe. The drill pipe was freed at 10:30 a.m. on March 6. The well began flowing when the pipe was freed and the drilling mud was badly contaminated by the influx of highly saline formation water that produced a sharp increase (50°F) in flow-line temperature. The drilling mud was treated for contamination and circulated for 2 1/2 hours to kill the flow.

By 6:00 a.m. on March 7, the well had been deepened to 10,350 ft. On the trip-out from 10,350 ft, with the well flowing, CO_2 in the mud increased sharply to 128,000 ppm. The formations penetrated consisted predominantly of dark grey-green to grey-brown claystone and light grey-brown siltstone with trace epidote veining and disseminated pyrite. An attempt to survey wellbore deviation on the morning of March 7 using a "multishot" was unsuccessful because high temperature destroyed the film within the device.

Low penetration rates were experienced as drilling proceeded below 10,350 ft through hornfelsic rocks. On March 8, just as a decision was made to trip-out of the well due to the low rate of penetration, the drilling rate increased from 6 ft/hr to 11 ft/hr. Below 10,450 ft, increasing fluid losses were experienced with increasing depth (200 Bbls/hr at 10,460 ft); all circulation was lost at 10,475 ft.

On March 8 and 9, a temperature log was obtained over a 5-hour period using the USGS wireline logging unit (Table 2). A bottom-hole temperature of 287°C (532°F) was measured 60 ft off-bottom, about 8-hours after the last circulation. After temperature logging, a caliper tool was run on March 9. It failed to open, however, because the high downhole temperature burned-out the motor.

Eighty-six bags of #20 silica sand were

TABLE 2: SUMMARY OF USGS LOGGING

DATE	LOG	INTERVAL (ft)
MAR 8-9	Temperature	0 - 10,500
MAR 12	Temperature	tool hangs at 8,600
MAR 12-13	Televiewer	6,000 - 6,600
MAR 13-14	Acoustic Waveform	6,000 - 7,000
MAR 27	Temperature	0 - 10,220
MAR 29-30	Gamma Ray	5,690 - 10,000
MAR 29-30	Neutron	5,770 - 10,200
MAR 31-APR 1	Temperature	0 - 10,200

then mixed and pumped into the bottom of the well in an unsuccessful attempt to regain circulation. LCM pills were subsequently placed at 10,350 and 10,425 ft. After waiting for the pills to set and building mud volume, a dual induction log was attempted by Schlumberger on the afternoon of March 10. However, "bridging" in the well at 8,819 ft prevented logging below this depth. This was fortuitous in that deeper logging would probably have burned-out the tool.

Much of the evening of March 10 was spent circulating to condition the mud and reaming in order to return to bottom. The well attempted to flow while tripping-in and a bridge from 6,850 to 6,950 ft required reaming. At 10:00 p.m., a depth of 10,331 ft was reached. Circulation was maintained at this depth for 5 hours to condition the hole because the well, again, was trying to flow.

Since fluid loss could not be controlled, it was decided to cement the bottom of the hole prior to installing the 7-inch liner. On March 11, the drill pipe was tripped-out, the bit removed and the pipe tripped-in, open-ended. An LCM/cement plug was then set from 10,414 to 10,114 ft. (NOTE: The drilling budget was expended on March 11 and an additional $135,000 in funding was obtained from the sponsoring agencies in order to properly complete the well prior to flow testing.) The cement failed to seal-off the zone of lost circulation, and a second cement plug was placed within the same interval.

After tripping-out to 9,885 ft and waiting for the cement to set, the drill pipe was then tripped-in to try to circulate at the top of the cement plug. Circulation was prevented by cement-plugged pipe. The drill pipe was pulled (wet) from the well on the morning of March 12. It was discovered that about 43 joints (1,300 ft) of the 5-inch drill pipe had become plugged with cement.

While cement was being removed from the drill pipe on March 12, the USGS attempted another period of logging using the temperature probe, caliper tool and acoustic borehole televiewer. The temperature and caliper tools could not be lowered below 8,700 ft due to a "bridge" in the well. The maximum temperature after 9-hours was 225°C (437°F).

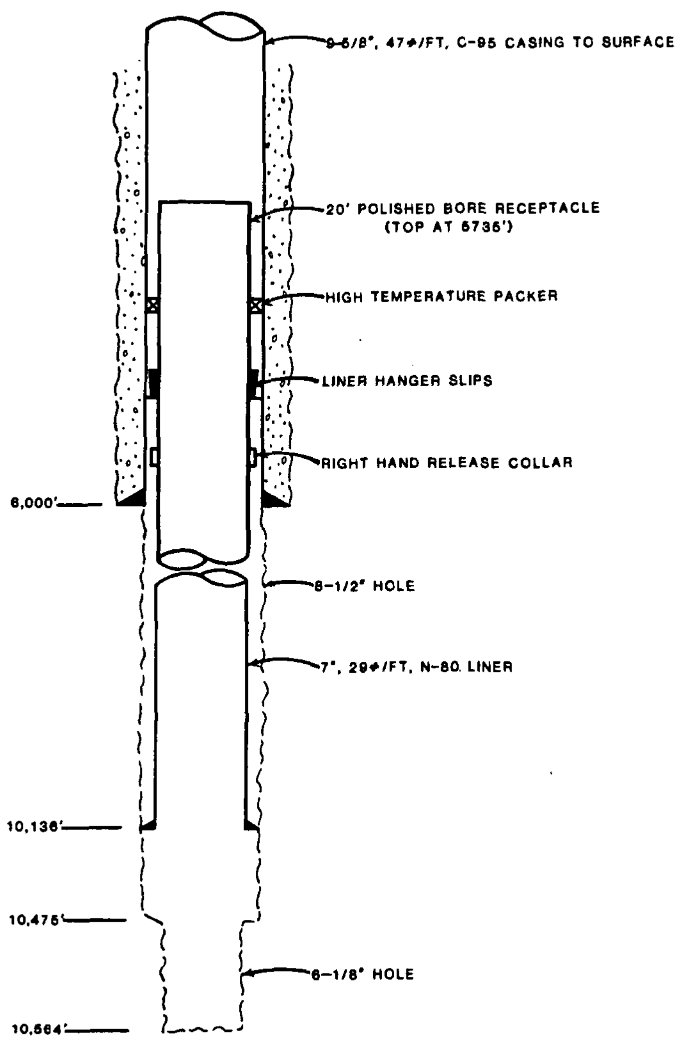
Acoustic televiewer logging was next attempted, but was restricted to the uppermost lost circulation zone that extended from the base (shoe) of the 9 5/8-inch casing (6,000 ft) to about 6,600 ft. This restriction was necessary because wellbore heat had increased, since the well could not be entered sooner than 7-hours after the last circulation, and because the televiewers' performance deteriorates at high temperature. Even within this relatively shallow interval, tool response indicated that elevated temperature was affecting performance, although temperature within the dewared electronics section was still relatively low. Overall, tool response within the lower part of the casing was good and reasonable signal levels were attained in the open-hole interval below 6,300 ft.

Early on March 13, the drill stem was tripped-in to the top of the cement plug at 10,266 ft and an LCM pill was placed at that depth. However, circulation could not be re-established. LCM pills were then placed at depths of 8,000 and 10,200 ft.

The USGS logging unit was rigged up again on the evening of March 13, and an acoustic waveform log was obtained after repeated runs from 7,000 ft to the casing shoe at 6,000 ft. The tool response was good in casing, but deteriorated sharply in the open well. Therefore, logging was concentrated in the open-hole interval where signal response was considered adequate. This zone (6,000 to 7,000 ft) contained two production zones separated by competent rock that showed good acoustic response. The production zones and associated washouts were depicted on the logs by "dramatic" reductions in acoustic amplitudes. While running the waveform log, the well began flowing and 100 barrels of mud were "bullheaded" (without pipe in the well) to kill the flow. After the logging tool was removed and prior to tripping-in again with the drill stem, this technique was used twice more to kill well-flow.

Early on March 16, after having conditioned the mud to prevent flash-flowing and having set several LCM pills, some 102 joints of 7-inch, 29-lb/ft, N-80 LT&C casing were run into the well. This "liner" was hung from 5,735 to 10,136 ft using a liner hanger (fig. 2).

Figure 2.
WELL SCHEMATIC OF LOWER SECTION



On March 17, 3 1/2-inch drill stem with 6 1/8-inch bit was tripped-in to 10,136 ft and a series of thin cement stringers were drilled out to a depth of 10,475 ft, where circulation was lost. After placing an LCM pill at 10,136 ft and filling the annulus with 217 Bbls of water, drilling resumed without returns to a final total well depth of 10,564 ft (fig. 3). Six times, while tripping-out, the well began flowing at the surface, requiring conditioning of the mud to kill the flow.

FLOW TESTING AND EXPERIMENTATION

Activities for March 18 to 20 were focused on preparations for executing the revised flow testing and scientific experimentation schedule (Table 3). After removal of drilling equipment from the rig floor and the blowout preventer, the wellhead and test tree equipment were installed. Next, the orifice plates were installed in the flowline and the line was insulated. By 8:50 a.m. on March 20, when the 10-inch master valve was opened, wellhead pressure had increased to 270 psi. Pressure dropped initially, then increased as the well was allowed to flow for hydro-test of all lines, except the scientist's line of sampling spools. After the small blooie line (a pipe used to channel fluid discharge a suitable distance from the rig) was opened at 9:04 a.m., heavy steam flow occurred within about 5-minutes. At 9:21 a.m., flow was diverted to the main blooie line for discharge into the brine-holding pond. Discharge of solids was relatively insignificant. Therefore, flow was diverted at 11:15 a.m. from the blooie line through the James Tube, rock muffler and weir box into the brine pond. Rediversion to the blooie line was necessary after about 2 1/2-hours of flow in order to repair a leaking access door on the rock muffler and reinforce a steel plate in the weir box that was warped by high temperature brine flow. After switching flow back through the muffler, the scientist's sampling loop was opened at 3:45 p.m. However, fluid sampling was delayed while testing the sampling loop and changing (twice) the orifice plates, along with some gauges and valves. Maximum wellhead temperature and pressure recorded on March 20 were 243°C (470°F) and 448 psi, respectively. The well was flowed at rates of about 300,000 to 500,000 lbs/hr. The estimated flowing enthalpy on March 20 was approximately 480 to 520 BTU/lb with a steam fraction of 0.4.

At 6:20 a.m. on March 21, flow was diverted from the bypass line through the sampling spools so that the scientists could obtain fluid samples. Geochemists and other scientists spent about 1/2-day collecting fluid and gas samples. To extend the sampling time, well flow was throttled to less than 300,000 lbs/hr for much of the day. For a brief period, however, the well was opened for maximum flow. The maximum flow rate achieved over a 1-hr period was about 700,000 lbs/ hr at a well-head pressure of 450 psig and temperature of 238°C (460°F). At this high rate, both the muffler and weir box were overflowing. Enthalpy was estimated to be 480 BTU/lb. The highest wellhead temperature recorded on the 21st was 252°C (486°F) with a pressure of 500 psi. Scale build-up in the flow-test facility was minimal compared to the first flow test.

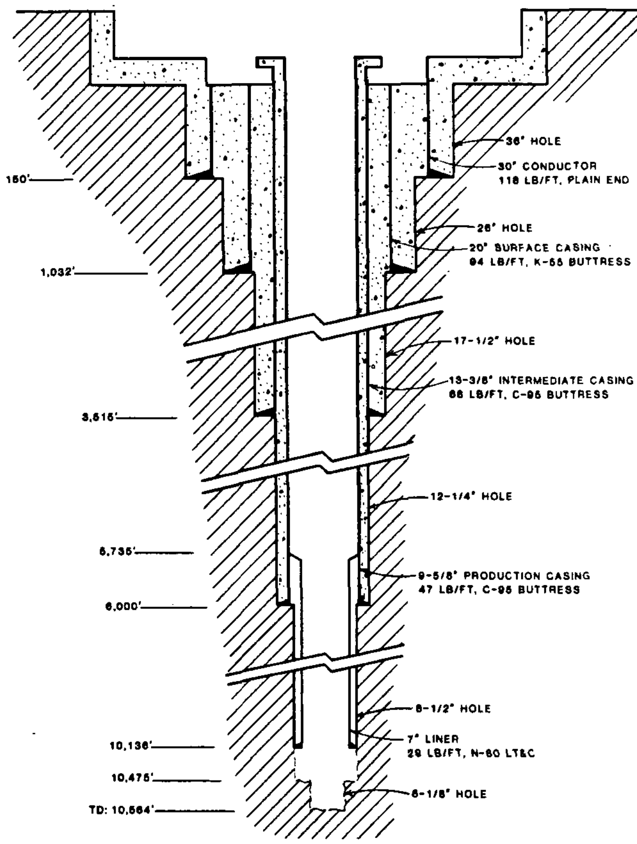
In order to more accurately determine downhole conditions, the USGS made several Kuster tool runs into the well during flow and after shut-in on March 21 and 22 using the Otis slickline. Shortly after mid-day on the 21st, dewared downhole flow (spinner) and pressure tools combined in tandem were first lowered into the well. When recovered, it was learned that particles in the flow stream had caused the spinner tool to malfunction, but that useful pressure readings had been obtained.

With Kuster temperature and pressure tools in the well to 10,000 ft, the well was shut-in at 10:00 p.m. on March 21. After about 38 hours of flow, the capacity of the brine-holding pond (1.1 million gallons) had been reached. The first temperature/pressure run was completed early on March 22, followed shortly thereafter by a second run. Although the temperature baseline on the first run was in error, both tools performed satisfactorily on the second run. A preliminary best estimate, based upon the "Kuster runs" indicated a temperature of 353°C (667°F) and a pressure (shut-in) of 4,287 psi at 10,400 ft.

On March 22 and 23, two attempts were made to obtain downhole fluid samples using the LANL/Sandia sampler in tandem with the undewared Kuster temperature tool. Both sampling attempts were unsuccessful due to failure of the metal seal between the battery pack and sampler unit in the hot, corrosive environment; this failure caused the motor to flood and short-out.

While off-site repairs were being made on the LANL/Sandia sampler, three additional sampling runs were made by Agnew and Sweet personnel using a commercial (Leutert) mechanically tripped sampler run on the Otis wireline. Although tripped successfully, none of these attempts recovered fluid. On the first sampling run, to 10,400 ft, the sampler failed when LCM clogged the sample port. The second run to 10,200 ft was unsuccessful because the downhole timer failed causing the fluid canister to remain closed. On the third run, "O" rings on the sample bottle failed.

Figure 3.
SSSDP WELL COMPLETION SCHEMATIC



A USGS experiment package involving synthetic fluid inclusions was deployed in the well late on March 23 for a scheduled test period of 24 hours. After the test period, however, the package was lost on retrieval when corrosion caused separation of the Otis wireline and the instrument dropped from near the wellhead to the bottom of the hole. A subsequent "fishing" attempt failed to retrieve the package.

On March 25, the LANL/Sandia downhole fluid sampler was deployed three more times. The third attempt resulted in no sample being recovered. On the fourth attempt, the sampler was successful in obtaining about 1.5 liters of brine and 0.5 liter of gas from a depth of 10,200 ft. A fifth attempt at fluid sampling was also unsuccessful because the sample bottle failed to open. On the same day, from the

TABLE 3: REVISED FLOW TEST AND DOWNHOLE SCIENCE SCHEDULE

Date	Time	Activity	Hours	Cum. Days
3/20	0800	Kickoff/Cleanup	12	
	2000	Sampling/Logging	48	2.5
3/22	2000	Post-flow temp/pressure buildup	24	3.5
3/23	2000	Leutert/Agnew & Sweet Fluid Sampler	6	
3/24	0200	Lawrence Berkeley Labs Fluid Sampler	6	4
	0800	LANL/Sandia Fluid Sampler	18	4.75
3/25	0200	Bethke/Fluid Inclusion	24	5.75
3/26	0200	Reinject Brine/Inject canal water	36	7.25
3/27	1400	VSP/LBL	36	8.75
3/29	0200	Inject/USGS Nuclear Logs	24	9.75
3/30	0200	Inject/Casing Caliper	6	10
	0800	Inject/Downhole Gravity	36	11.5
3/31	1000	Demobilize Rig		
4/07	0900	Temperature Log		
4/21	0900	Temperature Log		

same depth, a "flow-through" sampler deployed by scientists from Lawrence Berkeley Laboratory, on the USGS single conductor cable, was successful in obtaining about 1.0 liter of unpressurized fluid.

The first period of reinjection of produced brine collected in the brine pond began following downhole sampling on March 25, and was completed at 7:00 a.m. on March 27. A temperature log using a platinum resistance thermometer on the MP35N seven-conductor cable was run by the USGS immediately following reinjection. This log revealed a temperature of 193°C (379°F) at a depth of 5,740 ft (near the hanger for the 7" liner). Below this point, temperature declined steadily with depth, to a minimum of 147°C (297°F) at 8,600 ft (the location of a major lost circulation zone). From this point downward, temperature increased to 190°C (374°F) near the base of the liner (10,136 ft), and then rose rapidly to 278°C (532°F) at 10,220 ft. The logging run was ended at that depth in order to remain within the 300°C (572°F) limit of the logging cable and temperature tool.

Scientists later speculated that the temperature minimum, noted near the previously encountered lost circulation zone at about 8,600 ft, probably resulted from the cool, reinjected brine moving up the annulus between the liner and the wellbore and then outward into the formation opposite the fluid-loss zone.

Using this hypothesis and reflecting on the flow test, it was suggested that during at least the first 12 hours of flow, production was from the zone below the base of the liner (i.e., below 10,136 ft). After flow was throttled back, production probably came from several fluid-loss zones behind the liner. Cited as evidence was the copious production of brown foam containing diesel fuel that had been used on several occasions during drilling operations as a lubricant, and the large amount of lost circulation material being discharged to the brine pond on the second day.

Intermittent injection of "fresh" water to cool the well for scientific experimentation began on March 27. The first period of cooling allowed scientists from Lawrence Berkeley Laboratory to perform a vertical seismic profiling (VSP) experiment in the well. The experiment went smoothly as the instrument was run in on the USGS 7-conductor wireline, while radio communication was maintained between the hoist operator and the recording vans. When the experiment was completed at 8:00 a.m. on March 29, two good data sets had been obtained; first the vibrator "source" had been located on the drill pad and then approximately 1/2 mile to the east on McDonald Road.

On March 29 and 30, gamma ray and neutron logs were run by USGS from the top of the 7-inch cased hole to just outside the bottom. Both logs were good. Also on March 30, a Dia-Log casing caliper log was run from 5,700 ft to the surface with good results. Next, researchers from Lawrence Livermore National Laboratory, with Edcon /Schlumberger support, began an experiment involving downhole gravity measurements within the 9 5/8-inch cased part of the well. Cool, fresh water was periodically injected during the experiment in order to protect delicate instrumentation from the hot, corrosive geothermal brine.

At the conclusion of the LLNL downhole gravity experiment on March 31, and completion of reinjection of fluids produced during the flow test, the USGS ran another continuous temperature log from the surface to 10,200 ft. At 2:30 a.m. on April 1, logging operations were completed, and the SSSDP scientific well was shut-in for the final time, marking the beginning of the standby period.

Preliminary analyses of fluid samples taken during flow-testing suggest that brines from the deeper zone(s) contain 7 to 10 percent less chloride than those produced from the first flow test. Although this would indicate that the fluids were produced from separate hydrothermal convection systems, there was evidence of brine stream contamination at the time of shut-in.