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SALTON SEA SCIENTIFIC DRILLING PROGRAM

Report of the Fourth Quarter

FY 1986

January 1987

U.S. DEPARTMENT OF ENERGY
Office of Renewable Energy Technologies
Geothermal Technology Division

SALTON SEA SCIENTIFIC DRILLING PROGRAM

Eighth Quarterly Progress Report:
Report of the Fourth Quarter
(July through September)
FY 1986

JANUARY 1987

U.S. Department of Energy
Office of Renewable Energy Technologies
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Table 2: (continued)

Key Considerations		Remarks
Barriers to Obtaining More Core	o	See "Barriers to Going Deeper," above.
	o	Improved stability of the coring assembly and drill string.
	o	Improved core barrels and core catchers to reduce jamming and increase recovery. When the formation begins spalling and discing from thermal shock and changes in geostatic pressure, conventional equipment is ill-adapted.
	o	Ultimately, trip times for coring become prohibitively expensive. The need to make frequent stops, in and out, to cool the well contributes to major increases in trip time. When a lost circulation condition exists, where drilling-fluid weighting can not be relied upon for well control, the problem can become critical.
Barriers to Obtaining Geophysical Logs and Fluid Samples	o	Construction and packaging materials, especially seals, are temperature limited.
	o	Failure-potential of wireline increases with time of exposure to temperature and corrosivity.
	o	Signal conducting cables are subject to temperature limits of about 300°C.

SSSDP Principal Investigators meeting - September 28, 1986

The principal investigators of the SSSDP met prior to the Geothermal Resources Council annual meeting in Palm Springs, California. Presentations at the Principal Investigators meeting were given by personnel funded by the participating agencies. A list of presenters is given in Table 3. The purpose of the meeting was to inform one another about progress and plans for analysis of samples and data collected during the SSSDP. According to protocol, letter reports on progress were to be circulated among principal investigators within 6-months of drilling completion. The informal progress reports were not to be published, but were aimed at fostering an awareness of research activities among investigators.

In response to a questionnaire distributed by Wilf Elders, most investigators opted for formal presentation of results at a National meeting in the Spring of 1987. In addition, most preferred that the conference proceedings be a special issue of a professional/scientific journal.

EXECUTIVE SUMMARY

The Salton Sea Scientific Drilling Program (SSSDP) has been documented in a series of quarterly reports. This eighth reporting period, from July 1 through September 30, 1986, began following diagnostic testing of the damaged wellbore. Emphasis during this reporting period was placed upon repairing wellbore damage and assessing options for continuation of the SSSDP.

Partial repair of the parted 7-inch liner in the scientific well was completed August 25, 1986. Nine joints of liner with cracked collars were removed, the fallen section was milled clear to 8,000 ft, and 10-ft of 5 1/2-inch liner connected to 802 ft of new 7-inch liner was placed in the well. Consequently, planned temperature and pressure gradient measurements (at least to 6521 ft) could be resumed. Further remedial options are being considered in order to allow performance of a long-term (30-day) flow test and continued scientific experimentation in the well. Industry's experience with collar cracking and liner failure was surveyed in order to determine the probable cause of the failure and reduce the possibility of reoccurrence.

Scientific data analysis and reporting continued during this quarter. Three geophysical studies have been initiated by the USGS. Results are expected to be available in the near-term. These investigations are: 1) a study and comparison of USGS and commercial logs, 2) a study of seismic velocity and geothermal alteration in the SSSDP well and 3) a study of transport properties of SSSDP cores. The number of SSSDP publications continues to grow and the first public report of scientific results from the SSSDP is planned for the spring of 1987.

Acquisition of uncontaminated brine samples under in-situ conditions was considered an important part of the scientific and technical objectives of the

CONTENTS

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TABLES

FIGURES

SSSDP. The three downhole sampling devices used are discussed in the body of this report.

A workshop was held on September 17 to discuss technological barriers to deep continental scientific drilling in thermal regimes. Required improvements in drilling and coring, logging techniques, and instrumentation, in view of the SSSDP experience, were discussed at the workshop.

INTRODUCTION

The Salton Sea Scientific Drilling Program (SSSDP), first major enterprise of the much broader Continental Scientific Drilling Program (CSDP), is a jointly sponsored effort of the U.S. Department of Energy, the U.S. Geological Survey and the National Science Foundation, with Bechtel National, Inc. as the prime contractor. The SSSDP scientific well site is located on the southeast shore of the Salton Sea in Southern California. The project was undertaken with the intent of penetrating the "roots" of a known hydrothermal system, evaluating the energy potential of deep geothermal zones, characterizing the hydrothermal fluids, obtaining a better understanding of ore genesis, and heat and mass transfer processes in such systems. Moreover, a publicity-available, complete data-set from a deep geothermal well would be obtained, and new instruments and testing procedures would emerge from the project.

Initiated on October 23, 1985, drilling of the scientific well officially ended at a depth of 10,564 ft on March 17, 1986. During and shortly after the drilling phase, two short-duration flow testing and fluid sampling sessions were performed in addition to several periods of geophysical logging. While running a wireline temperature survey, during the shut-in period following completion of the well, an obstruction was encountered in the wellbore at about 6,380 ft, indicating that the 7-inch liner had parted or collapsed. The main concerns during this reporting period were reactivation of the well, resumption of planned experiments, and assessment of the extent to which further scientific studies could be carried out within the available budget. Obtaining equilibrium wellbore temperature and pressure profiles, and performing a long-term flow test of a deep isolated reservoir were activities considered necessary to complete the original program objectives.

condition of the fallen 7-inch liner. Test results suggested that the liner had parted at the bottom (pin-end) of the ninth joint. Following the DOE/SAN July 15 directive to Bechtel to proceed with remedial work at the Salton Sea well, mobilization of the Cleveland drilling rig commenced August 7. Repairs included removal of about 380 ft of damaged liner and a polished-bore receptacle (PBR), completion of a tapered milling tool run to 8,005 ft and installation of 812 ft of new 7-inch liner. With the preliminary repairs completed, instrument access to about 8,000 ft was reestablished for continuation of temperature and pressure gradient measurements by USGS. Further remedial options are being reviewed for technical, scientific and financial feasibility.

Restoring wellbore integrity in order to perform a long-term flow test and recover high-quality, deep reservoir fluids continues to be a high priority for DOE, and is supported by both the Science Coordinating Committee (SCC) and the Continental Scientific Drilling Review Group (CSDRG). Kennecotts' cooperation is required prior to conducting further field operations.

FY 1986 funding for Bechtel contract activities within the Salton Sea Scientific Drilling Program (SSSDP) was increased this quarter by $290,000 from $930,000 to $1,220,000 (totals include $75,000 provided by the other participating agencies). This supplemental funding was provided for diagnosing wellbore damage and initiating repair. The first remedial repairs were completed on August 25. In addition, $105,000 was provided to the USGS in FY 1986 for conducting studies of the heat and pore fluid transport properties of rock cores recovered from the scientific well, and acoustic characterization of fractures and hydrothermal alteration in the geothermal reservoir. Funding in the amount of $50,000 was provided to Sandia National Laboratory earlier in the fiscal year for fabrication of the electronic memory, downhole temperature

Results of the scientific experiments conducted in this unique environment have contributed, and will continue to contribute, to a better understanding of Earth's thermal processes. With continuation of the SSSDP, more specific studies of magma systems, the genesis of hydrothermal ore deposits, contact metamorphism, techniques of reservoir characterization, estimates of the recoverable resource and behavior of high-temperature, high-salinity brine can be implemented. Also, performance of high-temperature materials can be evaluated and downhole instrumentation further improved.

The SSSDP was cited on July 24, 1986 as evidence of the scientific benefit of a National continental scientific drilling program. Reference occurred in a hearing before the Senate subcommittee on Natural Resources and Production, Committee on Energy and Natural Resources, that was held concerning the Continental Scientific Drilling and Exploration Act (S. 1026). At these hearings, Donald K. Stevens, Associate Director for Basic Energy Sciences, cited the SSSDP as being "fully successful in meeting its targets for depth and recovery of samples for research." Dr. Wilfred A. Elders, geology professor at the University of California, further stated "the SSSDP epitomizes the reasons why we need to organize a national program of continental scientific drilling on a secure footing with long-term planning and funding." In addition, Carel Otte, President of Unocal Geothermal Division, supported drilling ultra-deep, high--temperature wells in order to uncover and develop the geothermal energy supplies and hydrocarbon resources of the future.

PROGRAM PLAN & ACTIVITIES

Current Program

At the end of the last reporting period (April through June, 1986), diagnostic tests were performed in order to ascertain the position and

Date (August)	Major Action	Description
7,8	Activated Site	Installed water lines and utilities, and assured that equipment was on-site.
9,10	Activated Rig	Killed well, nippled-up, installed and tested the Blow-out Prevention Equipment (BOPE).
11,12	Picked-up drill collars and drill pipe	Cooled well and spotted lost circulation material(LCM) pill. Ran in hole (RIH) and tagged fish at 5782. RIH with spear.
13	Speared and recovered fish	Pulled out of hole (POH), fish became stuck in expansion spool, set cement plug at 450 ft.
14	Retrieved 4-joints of 7-inch liner, liner-hanger and polished bore receptacle (PBR)	Rigged-down rotary table & rig floor, nippled-down BOPE, including master valve and expansion spool. Nippled-up BOPE, and rigged-up floor and rotary table. Ran 8 1/2-inch bit to drill cement plug.
15	Retrieved 5-joints of 7-inch liner	Tagged top of liner at 6301 ft. POH, picked-up spear and RIH. POH with fish. RIH, tagged lower section of liner at 6519 ft.
16	Ran tapered mill (6 1/8-inch diameter)	RIH with tapered milling tool and worked to 8005 ft.
17	Ran pilot mill (8 1/8-inch diameter)	POH, layed down tapered mill. Picked-up and ran pilot mill on top of collar 6519 to 6521 ft. POH, all blades broken off bit. Ran sawtooth mill.
18	Ran 18-joints of 7-inch liner with 10-ft stinger	Worked over at 6519 ft and POH. Ran 802 ft of 7-inch liner with 10-ft of 5 1/2-inch tubing. Stabbed into lower 7-inch liner section.
19	Layed down drill pipe and collars	Set retrievable bridge plug at 260 ft. Nippled-down BOPE, master valve and expansion spool. Replaced expansion spool seal assembly. Reassembled wellhead.
20, 21, 22	Deactivated Rig	Retrieved bridge plug and deactivated both rig & site.

Table 1: Chronology of Remedial Work Completed August 1986.

and pressure measuring device. Total DOE Geothermal Technology Division SSSDP funding for the fiscal year was $1,300,000, 88 percent of which was for drilling and engineering operations.

Drilling & Engineering Program

Remedial Well Work

A set of diagnostic tools, including minimum I.D. caliper, continuous temperature probe, casing collar locator and casing inspection tool, were run on June 25 and 26, 1986 to assess the mechanical condition of the 7-inch liner that had parted and fallen into the well. Based on these logging results, it was determined that the liner had parted at the bottom (pin-end) of the ninth joint, possibly from the combined effects of high salinity, high temperature and mechanical stresses. In August, preliminary repairs were completed. A chronology of events is detailed in Table 1. The first spear run into the hole stopped at 4,365 ft, but worked successfully when the solid stop-ring on top of the jar assembly was replaced with a lugged stop that was 1/4-inch smaller in diameter. At first, only 4 joints of 7-inch liner, the liner-hanger and the PBR were retrieved. However, the slips on the liner-hanger hung-up in the wellhead, in the enlarged part of the expansion spool, and damaged the seal assembly. A cement plug was required at approximately 450 ft to maintain wellbore control while dismantling the rotary table, rig floor and wellhead, removing the junk, then reassembling these components.

The cement plug was drilled out and the second spear run latched onto the next 5 joints of 7-inch liner on August 15th. All 5 joints were recovered with the pin-end of the bottom joint (9th) showing indentations resulting from

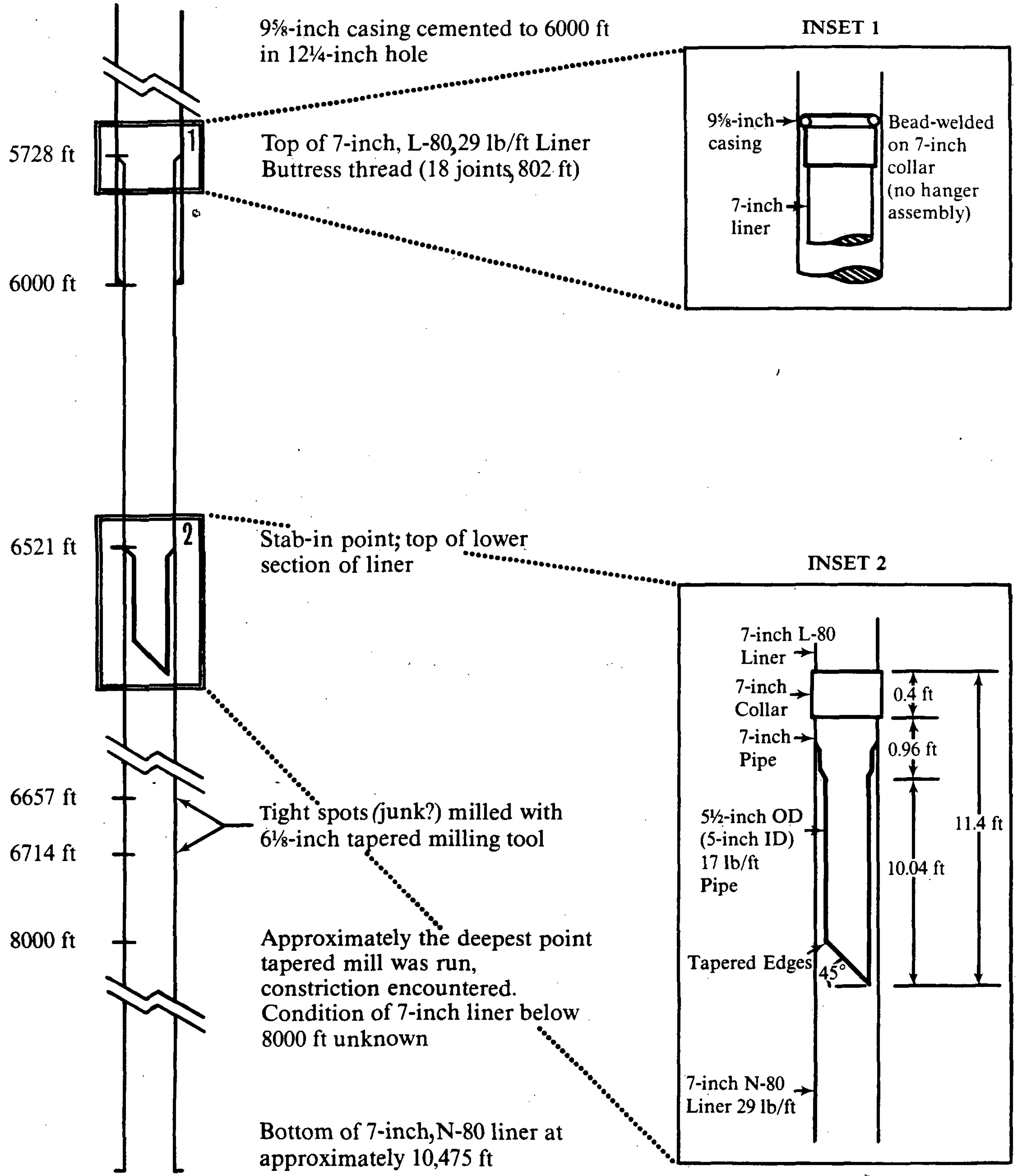

Figure 1: Schematic of Wellbore Construction after August 1986 Repairs

having fallen 330 ft or more. Thus, the PBR, liner-hanger and 9-joints of liner were removed.

The section of parted 7-inch liner was entered with a 6 1/8-inch tapered milling tool and milled clear to 8,005 ft, where, presumably, buckling made further milling inadvisable because of the risk of cutting through the liner. Tight spots were also milled at 6,657 ft and from 6,714 to 6,754 ft. On August 17, a custom pilot milling tool was run to mill-off the collar (top) of the 10th-joint of 7-inch liner at 6,519 ft in order to install a casing bowl connection. After milling two feet, it was found that all six cutting blades were broken from the tool. The condition of the top of the liner and the location of the broken blades were unknown. The collar could have either been milled smooth or "belled-out." Financial constraints prohibited waiting for a new tool, but allowed one run in the well with an 8 1/8-inch sawtooth milling tool. The collar had not been milled-off. Therefore, the casing bowl could not be installed. As an alternative, 10-ft of 5 1/2-inch pipe (stinger) connected to the bottom of 802 ft of 7-inch, L-80, 29 lb/ft, BT&C pipe was stabbed into the lower section of parted liner at 6,521 ft depth. This temporary repair section was installed without use of a hanger assembly or PBR. A Baker retrievable bridge plug was installed on August 19th to allow repair of the expansion spool seal assembly. It was removed on August 20th. Throughout the remedial work, it was necessary to inject and circulate drilling fluids to maintain control of the wellbore. On August 25, 1986, temporary repair operations were completed. It was anticipated that temperature and pressure gradient measurements, scheduled for October, could be run at least to 6,521 ft and possibly as deep as 8000 ft. A schematic diagram of the current wellbore construction is shown in Figure 1.

Scientific Experiments Program

Geophysical Data Analysis

The SSSDP scientific well was logged commercially and by the U.S. Geological Survey. A comparison by the USGS of their logs to the commercial logs has been completed. Most of the initial data analysis consisted of record clean-up, log correlation and depth adjustments. The USGS will publish a comprehensive open-file report, with the intention of providing a complete package of depth-correlated (where possible) geophysical log data, lithological logs (from cuttings), and drilling and engineering data. The report, although not approved, as anticipated, in time for the GRC meeting on September 28, was in the final stages of approval and release.

The USGS, in cooperation with MIT, is conducting a DOE/GTD-funded study of seismic velocity and geothermal alteration. Integration of acoustic well logs, acoustic full-waveform log data, core velocity analysis and VSP seismic data will both: 1) verify and identify the differences in core seismic velocities that produce velocity structure observed in acoustic logs and VSP data; and 2) investigate the relationship between geothermal alteration and seismic velocities. Initial study of acoustic logs and waveform records has been completed, yielding seismic velocity estimates for use in preparing synthetic seismograms. This study could provide a direct relationship between seismic velocities and state of alteration for SSSDP lithologies.

Another USGS study funded by DOE/GTD deals with transport properties of SSSDP cores. It involves laboratory measurement of thermal and hydraulic conductivity of SSSDP core samples. Controls for hydraulic and chemical systems have been completed, and electrical and thermal control systems are in progress.

The collars of the 9-joints of 7-inch casing that were removed showed evidence of severe to minimal cracking, minimal corrosion was noted on these joints. Two of the collars and the pin-end of the last joint (9th) of liner were cut-off and sent to Brookhaven National Laboratory for failure analysis. According to Brown Oil Tools, the liner-hanger used was not designed for removal, once set. Although all of the slips on the liner-hanger were recovered in the expansion spool, only part of the centralizers were recovered.

To reduce the possibility of cracks developing when the old liner is replaced, it was decided to consider changing from N-80 liner with LTC threads to L-80 with buttress threads. Various methods of further strengthening the liner in the severe dog-leg sections of the wellbore are also being considered. The selection of suitable replacement liner will be subject to results of metallurgical analysis of the failed collars by scientists at Brookhaven National Laboratory and their recommendations. These results are also expected to provide insight concerning the degree of difficulty and associated expense to be anticipated in removing the remainder of the N-80 liner.

Long-Term Flow Testing and Well Deepening Initiative

The Department of Energy is continuing with plans for a long-term (30-day) flow test and possible deepening of the Salton Sea scientific well. The San Francisco Operations Office of DOE has been directed to pursue this effort with officials of Kennecott Corporation. In order to conduct a long-term flow test, an injection well is required. Kennecott has plans to drill a commercial well near the SSSDP site that could serve as an injection well for a long-term flow test.

This commercial flow-through sampler is 4 cm in diameter and 2 m in length, and was designed by Leutert Instruments, Inc. to sample oil field petroleum and brine, downhole, at 150°C or less. The sampler has an adapter that can be used to extract associated gas, and is easily connected to the Los Alamos gas extraction system. The sampler valves are mechanically opened at the surface and can be closed at the desired depth either by use of a timer-clock or by jerking closed using a jawhead. A higher temperature (300°C) adaptation of this tool is being developed by LANL scientists.

Los Alamos Gas Extraction System

The gas-liquid ratio, as well as the gas and liquid compositions, is needed for reconstruction of in-situ formation fluid composition in the Salton Sea reservoir. A gas extraction line was designed and constructed by Los Alamos scientists to remove the gas for analysis and to measure the volume of gas collected by the downhole sampler.

Reporting of SSSDP Results

Documentation and dissemination of SSSDP results continued in accordance with protocol during this reporting period. General reports were scheduled to be presented orally at the Geothermal Resources Council (GRC) Annual meeting in Palm Springs, California on October 1, 1986 and were published in the Transactions volume. Informal progress reports were presented at the GRC meeting site in a closed meeting of principle investigators on September 28. Also in this reporting period, a draft report on downhole fluid sampling was completed by Los Alamos National Laboratory. The updated SSSDP bibliography follows:

(* = Status)

Aducci, A.J., Klick, D.W., and Wallace, R.H., Jr., 1986, Management of the Salton Sea Scientific Drilling Program: Geothermal Resources Council Transactions, v. 10, p. 445-448.

* Pub.

Description of Downhole Fluid Sampling Tools Used in SSSDP

Acquisition of unflashed and uncontaminated brine samples under in-situ conditions was considered to be an important part of the scientific and technical objectives of the SSSDP. A variety of downhole sampling devices were used with electrical signal-conducting cables, and a battery pack and non-conducting wireline to obtain in-situ fluid samples. A description of the tools follows.

Sandia Battery Pack-Controller

Specifically designed to operate the Los Alamos downhole sampler for use in the SSSDP, the Sandia battery pack-controller was designed to operate for 4-hours at 400°C. A dewar (vacuum heat shield) houses a battery pack and electronics that are used to control the downhole motor in the Los Alamos sampler.

Los Alamos In-situ Sampler

The Los Alamos National Laboratory (LANL) fluid sampler was increased to 2-liter capacity and modified to operate on either the Sandia battery pack-controller or signal-conducting cable. Once the sampler reached the desired depth, a temperature hardened electric motor was actuated to open a valve to the pre-evacuated sample chamber that was designed to fill immediately.

Lawrence Berkeley In-Situ Sampler

The Lawrence Berkeley Sampler, originally built for the Gas Research Institute to be used in geopressured wells, was designed for 230°C temperatures and internal pressures up to 137.8 MPa greater than the external pressures. The sampler has a 1-liter chamber volume, a 5.7 cm diameter, a 3 m length and a 55 kg weight.

Leutert In-Situ Sampler

and Planetary Physics, University of California, Riverside, UCR/IGPP-86/2, v. 1, March, 33 p.

* Pub.

Los Alamos National Laboratory, 1986, Downhole Fluid Sampling at the SSSDP California State 2-14 Well Salton Sea, California; Goff, Fraser, Shevenell, Lisa, Grigsby, C.O., Dennis, Bert, White, A.F., Archuleta, Jake, and Cruz, Joe, eds.

* Draft - in Review

Mehegan, J.M., Herzig, C.T., and Sullivan, R.M., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Visual Core Descriptions: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/1, v. 1, March, 221 p.

* Pub.

Michels, D.E., 1986, SSSDP Fluid Composition at First Flow of State 2-14: Geothermal Resources Council Transactions, v. 10, p. 461-465.

* Pub.

Nicholson, R.W., 1986, Extensive Coring in Deep Hot Geothermal Wells: Geothermal Resources Council Transactions, v. 10, p. 467-471.

* Pub.

Paillet, F.L., Morin, R.H., Hodges, R.E., Robison, L.C., Priest, S.S., Sass, J.H., Hendricks, J.D., Kasamayer, P., Pawlowski, G., Duba, A., and Newark, R., 1986, Geophysical Logging Activity at the Salton Sea Scientific Drilling Project: Preliminary Report; Paillet, F.L., ed.: U.S. Geological Survey, Open-File Report 86-xxx, 113p.

* Draft - in Review

Sass, J.H., and Elders, W.A., 1986, Salton Sea Scientific Drilling Project: Scientific Program: Geothermal Resources Council Bulletin, v. 15, no. 9, p. 21-26.

* Pub.

Sass, J.H., and Elders, W.A., 1986, Salton Sea Scientific Drilling Project: Scientific Program: Geothermal Resources Council Transactions, v. 10, p. 473-478.

* Pub.

Sass, J.H., Priest, S.S., Robison, L.C., and Hendricks, J.D., 1986, Salton Sea Scientific Drilling Project On-site Science Management: U.S. Geological Survey Open-File Report 86-397, 24 p.

* Pub.

Andes, J., Jackson, J., Lilje, A., Sullivan, R., and Herzig, C.T., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Visual Core Descriptions; Herzig, C.T. and Mehegan, J.M., eds: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/1, v. 2, April, 93 p.

* Pub.

Carson, C.C., 1986, Development of Downhole Instruments for Use in the Salton Sea Scientific Drilling Project: Geothermal Resources Council Transactions, v. 10, p. 449-453.

* Pub.

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 28-30 December, 1985; for Bechtel National, Inc., San Francisco, California, June, 40 p.

* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Geologic Interpretation, Well State 2-14; for Bechtel National Inc., San Francisco, California, June, 158 p.

* Draft - in Review

GeothermEx, Inc., 1986, Salton Sea Scientific Drilling Program Flow Test of Well State 2-14, 20-21 March, 1986; for Bechtel National, Inc., San Francisco, California, June, 71 p.

* Draft - in Review

Goff, Sue, Mehegan, J.M., and Michels, D.E., 1986, Field Procedures Manual, Sample Handling, Salton Sea Scientific Drilling Project: Los Alamos National Laboratory, 34 p.

* Draft - in Review

Harper, C.A., and Rabb, D.T., 1986, The Salton Sea Scientific Drilling Project: Drilling Program Summary: Geothermal Resources Council Transactions, v. 10, p. 445-459.

* Pub.

Herzig, C.T., and Mehegan, J.M., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Core Summaries: Institute of Geophysics and Planetary Physics, University of California, Riverside, UCR/IGPP-86/2, v. 2, April, 12 p.

* Pub.

Lilje, A., and Mehegan, J.M., 1986, Salton Sea Scientific Drilling Project, California State 2-14 Well, Coring Summaries: Institute of Geophysics

efforts to solve the problem caused by the parted liner, and the second by Wilfred A. Elders (UCR) on the options for additional scientific work. Funding for additional work at the well will be considered on an individual basis by each agency.

Planning for a conference on SSSDP results early in 1987 was also discussed. A symposium in conjuction with the spring meeting of the American Geophysical Union (AGU) or the American Association of Petroleum Geologists (AAPG) annual meeting was discussed, as was the merits of a combined reporting of scientific, and drilling and engineering research. Elders and Wallace were to continue to pursue this matter.

Initial distribution of samples to scientists by UCR was begun and permanent curation at the DOE/Grand Junction facility was set. Dr. Elders reported that his group was able to process the first batch of sample requests submitted in response to early August notices. The National Science Foundation has extended the UCR-SSSDP grant through December 31, 1986. Notices announcing the availability of core, cuttings and logs appeared in early August issues of, among others, EOS, Geotimes, Geothermal Resources Council Bulletin and the Geothermal Report. Elders reported that it was necessary to limit water sample distribution to a first-come, first-served basis, with present SSSDP investigators having precedence. Also, Dr. Elders was advised that the Scientific Experiments Committee should establish criteria for reviewing and selecting requests for well materials, and send these criteria to SCC for comment.

<u>Continental Scientific Drilling (CSD): Technology Barriers to Deep Drilling Studies in Thermal Regimes Workshop - September 17, 1986</u>

The major thrust of the workshop was to identify key barriers to, and set research priorities for, DOE supported continental scientific drilling into

Solbau, R., Weres, O., Hansen, L., and Dudak, B., 1986, Description of a High Temperature Downhole Fluid Sampler: Geothermal Resources Council Transactions, v. 10, p. 479-483.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 23 October - 6 November 1985, Report No. 1: Geothermal Resources Council Bulletin, v. 15, no. 2, p. 15.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 7 November - 6 December 1985, Report No. 2: Geothermal Resources Council Bulletin, v. 15, no. 2, p. 15-17.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 7 December 1985 - 10 January 1986, Report No. 3: Geothermal Resources Council Bulletin, v. 15, no. 4, p. 15-18.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 January - 10 February 1986, Report No. 4: Geothermal Resources Council Bulletin, v. 15, no. 6, p. 25-28.

* Pub.

U.S. Department of Energy, 1986, Salton Sea Scientific Drilling Program Monitor, 11 February - 1 April 1986, Report No. 5: Geothermal Resources Council Bulletin, v. 15, no. 8, p. 13-20.

* Pub.

Wolfenbarger, F.M., 1986, Battery Pack/Controller for High Temperature Applications: Geothermal Resources Council Transactions, v. 10, p. 485-489.

* Pub.

SIGNIFICANT MEETINGS

<u>SSSDP Science Coordinating Committee (SCC) Meeting - July 23, 1986</u>

The Committee heard two briefings concerning further work at the SSSDP well; the first by Ray Wallace (DOE/GTD) on the condition of the well and

Key Considerations	Remarks
1) Hierarchy of Problems	
Drilling	o Lost circulation and well control below 6,000 ft became expensive and hazardous. Eight to nine lost circulation zones were penetrated before reaching total depth: estimated cost impact was $640,000.
	o Bit life was generally poor because of: - the necessity to ream after coring, - accelerated bearing and button wear below 6,000 ft due to high temperatures and very hard formation, - drilling during lost circulation conditions, - inappropriate use of button bits with high-speed turbo-motors.
	o Directional drilling was unusually costly because of short turbo-motor life in the high-temperature, saline drilling environment.
Conventional Coring (730 ft recovered)	o Trip times to take spot cores added considerably to the project cost.
	o Reaming after coring (down to 6,000 ft) required an extra roundtrip and resulted in excessive bit wear and core loss.
	o Coring blind, i.e., during a lost circulation situation, resulted in accelerated bit wear due to overheating and abrasion, and in jamming of lost circulation material between the rotating and non-rotating parts of the coring assembly.
	o Instability and bouncing of the drill string and coring assembly led to poor coring and core recovery.
	o Very hot, very hard rock types, below about 8,000 ft, shatter when the formation pressure is removed from above and they are "chilled" by cooler drilling fluids during coring. Core barrel jamming and poor core recovery results.
Commercial Logging	o Virtually all commercial logging tools and wirelines are temperature-limited at about 350°F, with a few able to go to 500°F.
Scientific Logging	o Experimental high-temperature tools are difficult to calibrate, have questionable repeatability, and, especially for the more complex designs, are not fully reliable.
Sampling	o Problems in downhole fluid sampling occurred due to: - brine flashing upon entry into sample bottle of LANL-Sandia sampler - malfunction of battery system in LANL-Sandia sampler - seal failure in LANL-Sandia fluid sampler causing motor to flood and short circuit - lost circulation material clogging the bullnose in Leutert sampler - stopped clock preventing canister closing in Leutert Sampler - O-rings failing on sample bottle in Leutert sampler - failure of sample port to open in LANL-Sandia sampler. - loss of gas sample from LBL sampler.
2) Limits and Barriers	
Barriers to Going Deeper	o Difficulty in gaining and keeping control of multiple lost circulation zones in the deeper, hotter formations. Effective high-temperature lost circulation materials, cements, and techniques for their use is required.
	o Early failure of rotary bits, especially loss of buttons, bearing failure, and loss of gauge cutting capability.
	o Very slow cutting and early failure of diamond bits, resulting from poor cooling and poor removal of cuttings.
	o Slow cutting and early failure of PDC bits in hard formations.
	o High-temperature, efficient drill bits are needed.
	o Poor life of mud motors in high-temperature, saline environments. Thermal operating limits must be improved.

Table 2: Problems, Limits and Barriers Encountered in the Salton Sea Well

higher temperature environments. Workshop discussions are illustrated by the following priority listing of barriers or issues:

- Drilling and Coring:
  - long-life bits are needed to reduce cost and risk of hole damage
  - need control of lost drilling-fluid circulation to maintain cooling and hole stability
  - a systems approach should be used in reducing barriers
  - side-wall coring systems should be considered as a lower cost alternative to continuous coring
  - need temperature upgrade of bits, continuous (wireline) coring hardware, and bottom hole assemblies
- Logging and Instrumentation:
  - develop reliable logging tools and other instrumentation for 350°C to 400°C service
  - develop higher temperature cables and alternatives
  - develop tools for in-situ fluid chemistry and mineralogy determination
  - determine drilling parameters while drilling or coring
- Downhole Sampling Testing and Experimentation:
  - develop and deploy high-temperature vertical seismic profiling (VSP) tools
  - develop borehole packers for tests of in-situ rock and formation fluid properties, and stress state
  - develop sensors for extended downhole use to meet 400°C requirement

Identifying problems, limits and barriers encountered in the Salton Sea well is the first step to overcoming these difficulties in future high-temperature, deep drilling projects. Table 2 lists key problems, limits and barriers encountered in the Salton Sea well. Prior to further SSSDP scientific well operations, instrumentation and procedures should be reevaluated and improved.

NAME	ADDRESS	TITLE
*N. Valette-Silver	U. of Md.	Study of the 10Be isotope in the Salton Sea Geothermal Sys.
J. Mehegan	IGPP	Curation and distribution of samples from the Cal. State 2-14 well: SSSDP
M. Cho, L. Caruso	Stanford	Prograde phase relations in the SSSDP Borehole metasandstones, SSGF, Ca. *Fractures in the deep core samples from the SSSDP well*
M. McKibben	IGPP	Ore-forming processes in the SSGS
F. Paillet	USGS	Geophysical log analysis and core sample measurements on the SSSDP Project - progress and initial results
F. Goff, L. Shevenell, C. Grigsby, B. Dennis A. White	LANL	Downhole fluid sampling at the SSSDP Cal. State 2-14 well, Salton Sea, Cal.
A. Williams	IGPP	Oxygen isotope exchange in minerals during hydrothermal metamorphism: Salton Trough sediments
D. Hammond, T.-L. Ku J. Zukin	USC	Uranium and thorium series radionuclides in the SSSDP
W. Elders L. Cohen	IGPP	Magmatic and volcanic rocks in the Salton Trough
P. Kasameyer	LLNL	Downhole gravity measurements
D. Michels	D.M. Assoc.	Brine Chemistry from the two flow tests

* Did not attend

Table 3: Presentations for the SSSDP Principal Investigators Meeting