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

At the end of the last reporting period (January 10, 1986), drilling operations for the SSSDP scientific well had been placed in "standby secured" mode while waiting for a cement plug to set and to allow Imperial County Irrigation District personnel time to clean the canal that provides makeup water to the rig. By the end of this reporting period, drilling had reached a depth of 9,450 ft and 31 cores had been taken from about 770 ft of the interval drilled (Table 1). The penetration of intrusive rock of diabase composition in the bottom 5 feet of the well was of particular significance. Figure 1 shows the lithology and degree of alteration indicated by the cuttings recovered from the SSSDP well.

During this 4th monitoring period, drilling and sampling operations progressed smoothly, but continued to be impeded by wellbore deviation and loss of circulation. Loss of circulation adversely affected coring operations.

DRILLING AND LOGGING ACTIVITIES

On January 11th, drilling resumed and the cement plug from 6,410 to 6,772 ft was drilled out. At a depth of 6,803 ft, a zone of total circulation loss was encountered and efforts to regain circulation were initiated. The well did not respond fully to treatment with lost circulation material (LCM) in that only partial circulation was regained to 6,850 ft, at which point all circulation was again lost. In an effort to correct the problem, two cement plugs and LCM pills were set from 6,850 to 5,749 ft. These were drilled-out on January 13th and 14th, and, again, a total loss of circulation was experienced at 6,880 ft. In an effort to obtain rock samples from the lost circulation zone, the decision was made to core. Core #20 was cut from 6,880 to 6,889 ft before the core barrel jammed. Core #20 consisted of 3.5 feet of predominantly laminated dark grey and light grey indurated mudstone with pyrite along bedding planes. No epidote or free quartz were noted. The absence of fractures in core #20 led to the presumption that the base of the zone of lost circulation was shallower than the interval cored.

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.
** TOTAL **			770.5	713.4	92.6	

* Difference reflects broken condition of core.

TABLE 1: SSSDP CORING SUMMARY

On January 15th and 16th, after setting another cement plug from 6,889 to 6,243 ft, drilling resumed, but was delayed by yet another zone of lost circulation extending from 6,970 to 7,100 ft (80-90 bbls/hr at 7,100 ft). Core #21 was then cut from a depth of 7,100 to 7,109 ft (78% recovery). It consisted predominantly of indurated mudstone with the secondary authigenic minerals chlorite, hematite and anhydrite.

On January 17th, drilling proceeded through claystone, siltstone and anhydrite to a depth of 7,300 ft. The core barrel was run into the well and the 22nd core was cut from 7,300 to 7,313 ft. It also consisted of indurated mudstone with the authigenic minerals chlorite, hematite and anhydrite. On the following day, drilling continued through a sequence of claystone and siltstone to a depth of 7,432 ft, where the average rate of fluid loss was 50 bbls/hr. Drilling then proceeded with bit #35 to 7,547 ft, where the average mud loss declined to 25 bbl/hr on January 19. Core

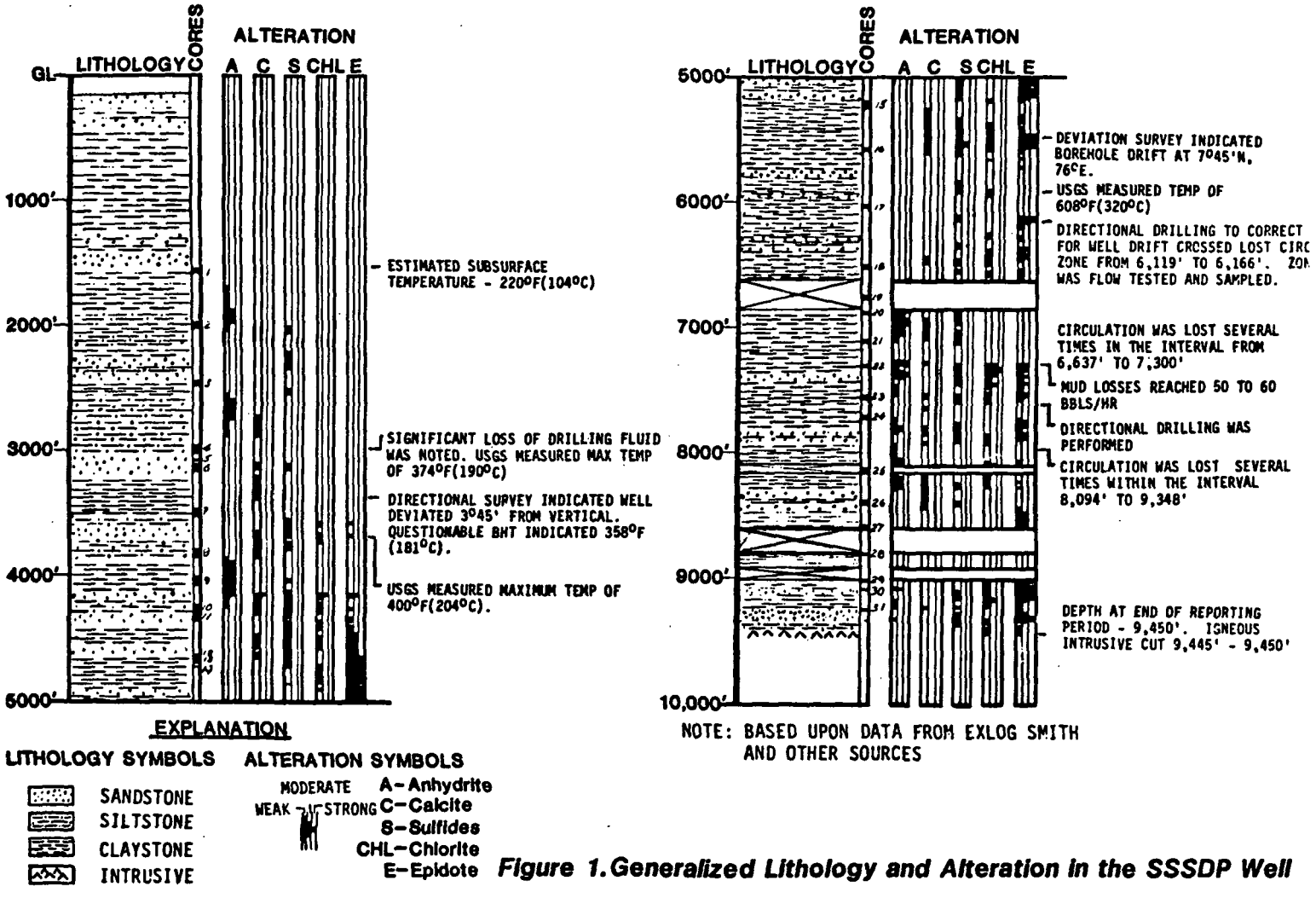

Figure 1. Generalized Lithology and Alteration in the SSSDP Well

#23 was cut from the 7,547 to 7,577 ft depth interval. Recovered core was 28.5 feet of primarily medium grey, indurated mudstone with a single narrow bed of epidotized siltstone.

On the 20th of January, drilling progressed through a fine-grained clastic sequence to a depth of 7,704 ft. A directional survey at 7,654 ft indicated that wellbore deviation had increased from 4 degrees 45 minutes to more than 6 degrees to the southeast. Core #24 was then cut and recovered from the 7,704 to 7,734 ft depth interval (100% recovery). It was a moderately indurated mudstone with anhydrite porphyroblasts. After core recovery, efforts to correct wellbore deviation by turbo-drilling were undertaken on January 21. By January 23, the well had been deepened to 7,935 ft with only slight mud losses of 5 to 20 bbls/hr. Well depth was then increased by conventional drilling and reaming to 7,972 ft.

Turbo-drilling was reinitiated and continued through January 25th to a depth of 8,070 ft, where the rock composition was predominantly claystone with minor sandstone and siltstone. As a result of directional drilling from January 21st through January 25th, the angle of wellbore deviation was changed to about 4 degrees to the southwest.

On January 26th, conventional drilling resumed, but was soon hindered again by loss of circulation and wellbore drift. Mud losses had become insignificant until circulation was again lost near the depth of 8,094 ft. Rock composition immediately above the zone of lost circulation was mainly claystone with minor siltstone. The interval 8,094 to 8,126 ft was drilled without returns and with the "shale shaker" off. Placement of another lost circulation pill was required. The well was flowing during and after the trip at 8,126 ft. At this point, the CO_2 gas content of the drilling fluid was reported to have increased from 300 ppm (background) to 64,000 ppm. Methane was detected at a level of 375 ppm. This rapid, short-duration increase in gas content could indicate penetration of a reservoir with fluids of higher gas volume. On the other hand, loss of circulation could explain, at least in part, the increased gas content. As a result of these observations, procedures for sampling influxes of gas were established.

Turbo-drilling was again performed on January 27th, as the interval 8,126 to 8,133 ft was drilled. The well began flowing again and LCM pills were pumped until conditions were stable.

Core #25 was taken on January 28 from the interval 8,133 to 8,161 ft. It consisted mostly of a dark siltstone, and, to a lesser extent, sandstone containing micaceous fractures and significant chlorite.

Lost circulation continued to be a problem during directional drilling and coring. Circulation was regained on the 29th of January after having set three LCM and cement plugs, the last from 8,128 to 8,161 ft. Drilling resumed and a depth of 8,395 ft was reached on January 30th. Directional surveying, at 8,342 ft, showed orientation of the wellbore to be 4°15' to the southwest.

On January 31st, the core barrel became jammed at 8,402 ft, while attempting the 26th core. Some 7.0 ft of core was recovered from the interval 8,395 to 8,402 ft (100% recovery). The core was composed primarily of black mudstone and reportedly contained chalcopyrite. Drilling resumed that same day through a sequence of claystone, siltstone and sandstone, but continued to be plagued by loss of circulation to a depth of 8,585 ft.

With no returns and the well attempting to flow, the core barrel was "run in" the hole early on February 1 for the 27th attempt. Coring proceeded to 8,604 ft, where the barrel became jammed once again. The core recovered was 63 percent of the total interval cored and consisted predominantly of grey sandstone with abundant epidote and secondary quartz.

On February 3rd, conventional drilling proceeded, essentially "blind" (with no returns), to a depth of 8,800 ft, after having made five attempts to regain circulation. The lost circulation pill placed at this depth resulted in recovery of circulation. The core barrel was then "run in" and core #28 was taken from the interval 8,800 to 8,807 ft, with 57 percent recovery. The core consisted primarily of hornfelsic mudstone.

On February 4th, conventional drilling resumed and a depth of 9,004 ft was reached.

Core #29 was taken from 9,004 to 9,027 ft, with poor recovery. Again, the interval cored consisted primarily of hornfelsic mudstone. The poor recovery appeared to be attributable to the loss of circulation from 8,911 to 9,027 ft in that optimum wellbore conditions could not be maintained.

A combination of cement and LCM was placed and allowed to set on February 6th, after which drilling resumed to 9,070 ft with a 50% loss of returns. After another treatment with LCM, drilling continued to the next coring point. Late on February 6th, core #30 was cut from 9,095 to 9,098 ft, where the barrel became jammed. The coring rate was 2.5 ft/hr with mud losses of 70 bbl/hr. The core consisted primarily of interbedded shale and fine grained sandstone with abundant fractures filled with epidote, chlorite, and sulfide minerals.

Circulation was not immediately regained after having spotted LCM and cement pills at 9,098 ft on February 7th, but was eventually regained on February 8th. Drilling then continued to 9,248 ft. While attempting to take the 31st core with mud losses of 50 bbl/hr, the drill pipe became stuck, but was freed after addition of diesel oil to the drilling fluid. The core barrel jammed after only 5-ft of coring, and the well attempted to flow twice during core recovery (400 barrels of fluid were gained and increased temperature was noted). This core, taken on February 9th from 9,248 to 9,253 ft, consisted mainly of hornfelsic mudstone with minor quartzose sandstone and exhibited greenschist facies alteration.

While circulating to cool the well and control flow, CO_2 in the drilling fluid reached a maximum of 72,000 ppm. After the core was taken, drilling resumed with bit #51 and a depth of 9,450 ft was reached on February 10th.

At the end of this reporting period, a pill was being mixed and spotted to control well flow. Most significantly, however, 5-ft of intrusive igneous rock had been penetrated. It was described as a diabase, medium grey, hard, fine grained, predominantly feldspar and pyroxine or amphibole, with traces of very fine grained pyrite or magnetite, and chlorite.

RESULTS OF FLOW TEST ACTIVITIES

Preliminary results of the first flow test, performed in late December, were made available during this reporting period. The total dissolved solids content of the brine was 24.5 weight percent before flashing. The "preflash" gas content was 0.17 weight percent and consisted of 99.6% CO_2. As a result of the liquid-gas composition of the brine, the fluid had a lower heat capacity than a weight-equivalent of sodium chloride brine.