5. WIRELINE REENTRY TEST ON DEEP SEA DRILLING PROJECT LEG 88[1]

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ABSTRACT

This chapter describes a test of a wireline reentry system designed to emplace packages into holes on the seafloor without the use of drill pipe. In this initial test, no reentry was attempted, but a passive sled with an acoustic beacon was lowered to 3000 m below the surface and its tracking capability was monitored. The test is different from other bottom-package experiments because the drill ship was able to remain stationary within a 100-m radius during the experiment. The results are thus applicable to a "hovering" rather than a "towing" mode. The conclusions are (1) the bottom package remained within 100 m of the ship's position; (2) bottom-package motion lags the ship's motion by 10 to 15 min., and (3) controlling the bottom-package position to within 3.0 m (the accuracy required for reentry) was not possible by maneuvering the ship alone. It appears necessary to have propulsion on the bottom package.

INTRODUCTION

For the past decade, the *Glomar Challenger* has routinely reentered boreholes on the deep ocean floor with drill pipe. This innovation permitted multiple-bit holes, which in turn led to deeper penetration into oceanic sediments and crust. Concomitant with this technological progress was a growing scientific interest in borehole geophysical and geochemical measurements. Not surprisingly, the question arose of "wireline reentry": can instrument packages be emplaced into boreholes in the ocean floor with standard cables from conventional research vessels?

Such a capability would expedite considerably the *in situ* science of the drilling program. (1) Routine well logging would be more cost effective because it would not be necessary to hire specialized personnel and equipment for long periods of time when they were not needed. In the past, logging programs would take only 2 or 3 days on a 60-day leg. (2) Special downhole measurements legs could be scheduled with little regard for the logistical difficulties of the drill ship. Again, in the past, scientists have waited for the drill ship for up to two months in order to carry out a 12-hr. experiment, and co-ordinating with other programs on the drill ship was frequently awkward. (3) Downhole measurements programs could be planned after holes had already been drilled and hole conditions known. A number of experiments have been canceled after considerable planning and expense because drilling was unsuccessful. (4) Long-term installations of borehole instruments could be emplaced and maintained. Boreholes would no longer be just artifacts of a sampling procedure; they would become "observatories." (5) In addition, large-diameter packages (up to 8 in.), which would not normally fit in the drill pipe, could be emplaced.

To test the feasibility of wireline reentry, the Deep Sea Drilling Project initiated a pilot project based on their traditional acoustic reentry system. A frame containing navigation gear (a tracking beacon and side-scanning sonar) would be suspended on the end of conventional logging cable (Fig. 1). The equipment was built and the system was tested on DSDP Leg 88.

Unfortunately, the scanning sonar device used to locate the reentry cone on the seafloor did not function properly. However, we did test the tracking of the sled relative to the *Glomar Challenger* to determine how well the sled could be maneuvered by simply towing it with the *Glomar Challenger*. This chapter presents a description and the results of the test.

OBJECTIVES

The objectives of this test in order of importance were to (1) determine the response of the tool and cable to motion of the ship; (2) use the EDO reentry tool, which had been modified to include a north marker, to locate the tool relative to the ocean floor; (3) determine the importance of tool spin; (4) locate the drill cone; and (5) actually reenter the cone with the reentry tool.

When it became clear that we could not attempt the desired reentry because of tool malfunction, our objectives were reduced to determining how well the passive tool could be towed to a location under the ship and to testing the feasibility of locating the tool with the onboard transponders and computing facilities.

OPERATIONS

The wireline reentry test took place immediately after the loss of Hole 581B and prior to Hurricane Gordon.

[1] Duennebier, F. K., Stephen, R., Gettrust, J. F., et al., *Init. Repts. DSDP*, 88: Washington (U.S. Govt. Printing Office).

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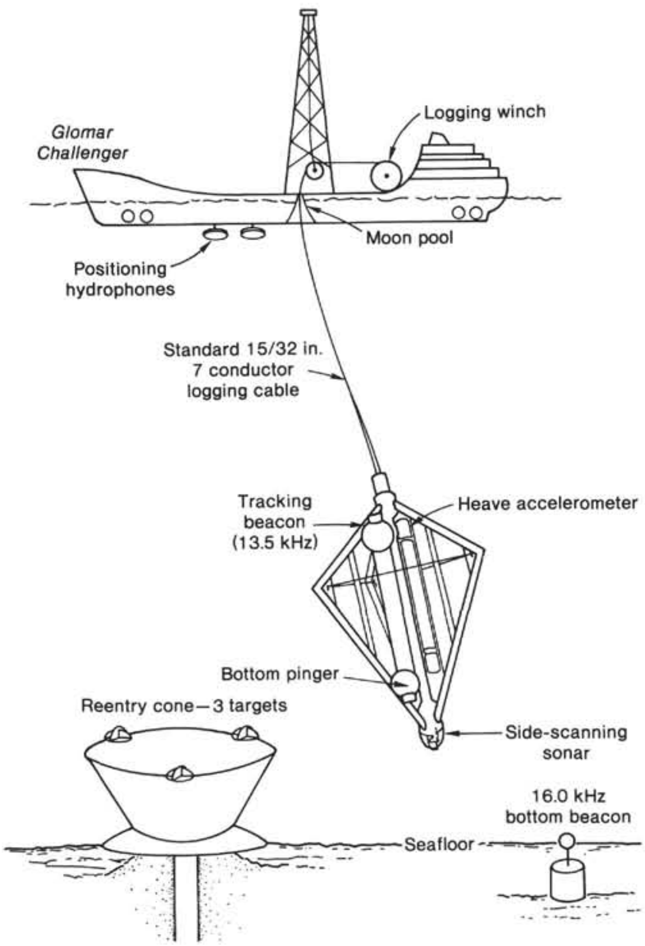

Figure 1. Schematic diagram of the DSDP wireline reentry system. During the Leg 88 test, only the tracking beacon on the reentry sled was operational.

The assembly of the wireline reentry tool commenced at 1415 (local time) on 5 September. The logging cable was keel-hauled and tests of the reentry unit were made on deck at 1845. It was apparent at this time that the north-seeking capability of the tool had failed. The tool, however, was lowered to 3000 m to check its tracking capability with the ship's dynamic positioning computer. The tests were carried out between 2005 and 2230 and the gear was back on board at 0100, 6 September. Total time for the tests was 10 hr. 45 min.

NAVIGATION

In a wireline reentry operation it is convenient to continuously monitor the locations of two items, the reentry tool and the drill ship, relative to the reentry cone or seafloor. Since there was only one acoustic navigation device on the *Glomar Challenger*, we alternately located the ship and the tool.

Under normal operations a reference beacon is anchored to the seafloor. Acoustic signals from this beacon are received on an array of hydrophones on the ship, and the time delays of these arrivals are used to locate the ship relative to the beacon. The propulsion of the ship can be controlled automatically to maintain the ship at a fixed position relative to the seafloor beacon.

In our experiment a second beacon, similar to the seafloor beacon but at a different frequency, was attached to the wireline reentry tool. Navigation alternated between two modes. In the first mode the *Glomar Challenger* was located relative to the seafloor (a 16-kHz beacon), and in the second mode the reentry device (a 13.5-kHz beacon) was located relative to the *Glomar Challenger*.

For each location measurement two types of position data were available. The most basic were the raw X, Y positions of the transponders (13.5 or 16 kHz) relative to the ship. These data were available on every update (approx. 6 s) but were uncorrected for ship's yaw, pitch, and roll. No smoothing was applied to the data by the computer. The second type of data was the output of a low-pass filter with corrections for yaw, pitch, and roll. Although we felt that the corrections were important, the low-pass filter amounted to a 3–5 min. average and we needed more frequent and accurate positions than this. Thus, we used the raw data (which were not corrected for ship's motion) for the experiment. The Global Marine electronics technician generated a readout of these values at approximately 6.0-s intervals. We averaged the values ourselves, and a 1-min. interval was determined empirically to give consistent and meaningful results.

In summary, approximately every 6 s we would receive a "ping" from either the 13.5- or 16.0-kHz transponders. The time delays of the "ping" at the positioning hydrophones were used to generate the X,Y coordinates of the transponder relative to the ship. We recorded these values for 1–5-min. intervals on each beacon, and took 1-min. averages to reduce scatter caused by ship motion.

TESTING SCENARIO

In order to check the effect of currents on the tool, we decided initially to hold the ship as close as possible over the cone while lowering the tool to 3000 m. (We had originally planned to carry out similar tests at 1000-m intervals all the way to the bottom but had insufficient time.) We would then check the tool position. Because the computer could locate only one transponder at a time, the ship's position was unknown while the tool was being located. While positioning equipment was monitoring the tool, there was no way to locate the ship relative to the seafloor beacon. Through trial and error we found that the ship could drift about 200 ft. (61 m) in 3 min. and we tried to limit positioning windows to 3 min.

The second phase of the experiment, to move the ship a known distance and to see how the tool and cable would follow this movement, could not be carried out because of unexpected instrumental difficulties.

The locations of the ship and tool, based on 1-min. averages, are summarized in Table 1. Figures 2 and 3 display the resulting positions of the ship and tool relative to the beacon. Ship's positions were linearly interpolated between measurements, and the ship locations corresponding to tool locations are indicated by circles.

Table 1. Wireline reentry test at 3000 m (9843 ft.)

Time (local)	Ship-Beacon Relative		Ship-Tool Relative		Beacon-Tool Relative	
5/9/82	X	Y	X	Y	X	Y
Part I						
2027	−56.4 ± 21.4	31.2 ± 11.2				
2028	*−103.2*	*66.1*	−47.7 ± 6.5	40.2 ± 4.8	55.5	−25.8
2030	−196.8 ± 14.2	135.8 ± 23.5				
2100:44	88.4 ± 28.6	−30.2 ± 17.8				
2102:14	*116.1*	*−87.3*	20.6 ± 9.9	−301.8 ± 14.7	−97.4	−209.8
2103:42	143.8 ± 14.2	−144.3 ± 20.0				
2105:11	*175.8*	*−157.1*	58.8 ± 20.5	−341.2 ± 16.2	−117.0	−184.1
2106:30	207.7 ± 13	−169.8 ± 13				
2108:00	*208.5*	*−198.4*	100.0 ± 34.7	−324.4 ± 42.0	−180.5	−126.0
2119:30	37.8 ± 15.4	21.6 ± 19				
2121:18	*−19*	*+59*	−268.5 ± 26.5	−186.9 ± 19	−249.5	−127.9
2122:18	*−76.6*	*+96*	−308 ± 11	−208 ± 14	−231.4	−112.0
2123:18	*−134*	*+133*	−338 ± 13.9	−176 ± 20.4	−204	43
2124:47	−199.1 ± 20.9	170 ± 20.5				
2130:33	−59.7 ± 33.1	144.0 ± 31.4				
2132:23	*34.1*	*133*	17.4 ± 32.7	190 ± 9	17.3	57.0
2132:23	*129*	*122*	96.1 ± 52	4.6 ± 22	32.9	−117.4
2134:23	*223.6*	*111*	194.4 ± 25.3	16.4 ± 10.8	−29.2	−94.6
2135:52	317.6 ± 22	100.4 ± 25.2				
Part II						
2152:51	52.6 ± 24.6	15.4 ± 25				
2154:33	*−31.9*	*+41.7*	−69 ± 23	66.7 ± 23	−37	25
2155:33	*116.4*	*+68.1*	−162.0 ± 39.6	100.4 ± 13	−46	32
2156:33	*200.8*	*+94.4*	−237.1 ± 22	99.9 ± 22	−36	6
2157:58	−285.3 ± 26.4	120.7 ± 16.0				
2209:00	235.1 ± 34.3	−1.0 ± 29.9				
2210:40	*−150.9*	*−18.9*	34.0 ± 56.1	−204.1 ± 14.1	185	−185
2211:40	*−66.7*	*−26.7*	194.7 ± 54.4	−201.3 ± 11.2	216	−174
2212:40	*+17.6*	*−34.6*	288.7 ± 22.4	−140.7 ± 23.2	271	−106
2214:10	101.8 ± 46.7	−42.4 ± 23.4				
2222:16	450.4 ± 49.9	18.7 ± 35.6				
2224:02	*296*	*−21*	462.3 ± 27.3	−6.0 ± 17.2	166	15
2225:05	*141.5*	*−60.7*	343.5 ± 33.3	−40.8 ± 25.4	20.2	20
2226:08	*−13*	*−100.5*	203.4 ± 54.2	−81.7 ± 23.8	216.5	18.8
2227:11	*−167.4*	*−140.2*	59.8 ± 63.8	−111.5 ± 31.6	227.2	28.7
2228:45	*−321.9*	*−179.9*	−211.5 ± 81.9	−178.5 ± 12.2	110.4	1.4
2230:36	−476.3 ± 32.8	−219.6 ± 13.7				

Note: Ship's heading = 165°, all distances in feet. Italicized numbers indicate interpolation.

Over a 3-min. period the tool movement appears to be independent of the ship's movement. However, over a 10–15-min. period the tool appears to be influenced by the ship. Tool positions are adjacent to ship's positions taken 10–15 min. earlier.

The effect of any current in this area seems to be negligible at a resolution of 300 ft. (92.3 m). It is conceivable that simply lowering the tool below the ship will bring it within 500 ft. (154 m) of the cone. Since 500 ft. (154 m) is the range of the EDO reentry tool, a transponder on the sled may not be necessary.

The 2225L positions in Figure 3 display a curious phenomenon. The sequence of locations of ship and tool are numbered. For about 4 min. the tool moved relatively little (approx. 50 ft., 15.4 m) while the ship drifted 600 ft. (184.6 m). However, in the fifth minute it made a large (100 ft., 30.8 m) jump parallel to the ship's motion but in the opposite direction. This could be explained by a catenary forming in the wire as shown in Figure 4. Alternatively, it may be that the tool at the end of the 2225L track was just feeling the drift of the ship between 2210L and 2225L. The two explanations cannot be resolved from the data.

The standard deviations corresponding to the averaged locations are about 25 to 30 ft. (7.7–9.2 m). Thus, most of the indicated drifts are significant.

CONCLUSIONS

1. At least to a depth of 3000 m the tool remains within 300 ft. (92.3 m) of the ship, almost directly below.

2. Tool motions generally lag ship's motions with a 10–15-min. delay time. This magnitude of delay is about a factor of two longer than that of the pipe itself. Observed tool motions (about 50 ft./min., 0.26 m/s) are generally slower than ship's motions (about 90 ft/min., 0.46 m/s) during this test. These values are expected to change with water depth and tool configuration.

3. Although it is possible to keep the tool within a 300-ft. (92.3 m) radius by maneuvering the ship, controlling the tool to within 10 ft. (3.0 m) of a fixed point was not possible because of the poor knowledge of ship and tool locations and the difficulty in holding the ship stationary. Even with dynamic positioning, the ship's location varies plus or minus 18.4 m both longitudinally and transversely.

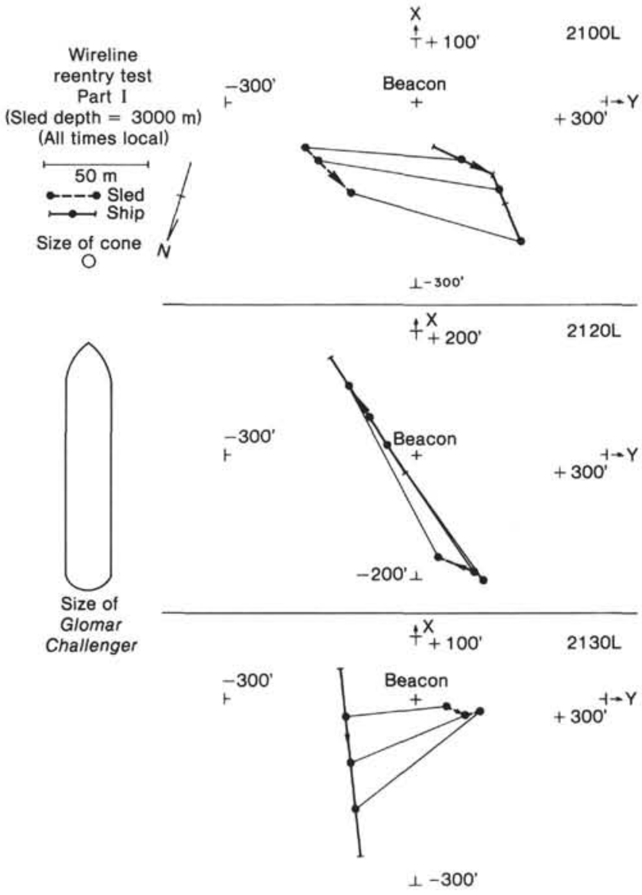

Figure 2. Locations of the reentry sled and the *Glomar Challenger* relative to the seafloor beacon in three intervals around 2100, 2120, and 2130 local time. The sled seems to follow the ship with a delay of about 15–20 min. For example, at 2120 the sled is at the same position that the ship was at 2100.

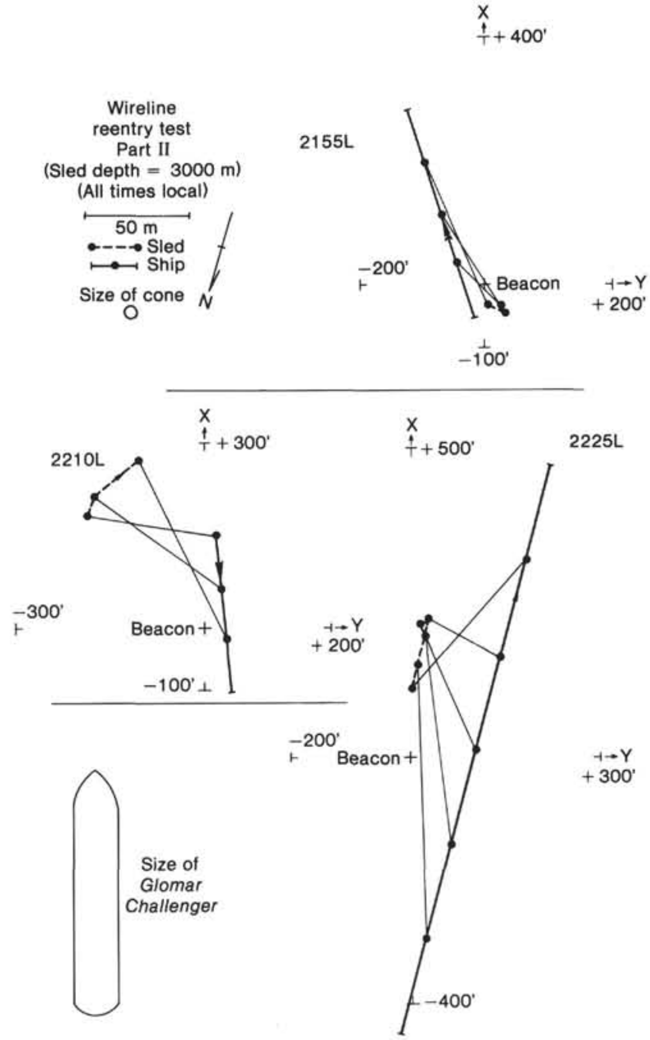

Figure 3. A diagram similar to Figure 2 for another set of times. The beacon locations correspond to the ship locations 15 min. earlier. On the 2225 run the individual 1-min. average locations are indicated sequentially. Although the ship is moving south, the sled moves north (see Fig. 4). The size of the *Glomar Challenger* and the size of the reentry cone are shown to scale.

RECOMMENDATIONS

1. It may be possible to do this test using only the modified EDO reentry tool (i.e., no beacon on the tool). The ship's positioning system would only be used to locate the ship.

2. If the ship's positioning system is to be used to locate the tool, it must have the ability to monitor two beacon locations at the same time, preferably with a display showing the location of both beacons.

3. A method for recording the data for this test should be devised that would allow detailed analysis of the results after completion. This is important if spin of the tool is important. Without quantitative data on how fast the tool spun and in response to what forces, it is very hard to design corrective modifications.

4. This test should take less than 18 hr. to complete, and it requires only that the ship be able to hold position. Thus, it can be conducted in marginal weather when the ship cannot run pipe.

5. It should be kept in mind that the primary purpose of the wireline reentry technique is to reenter holes from conventional oceanographic research vessels. Although initial testing of systems from the drilling vessel has advantages, tests from conventional research vessels should be encouraged as soon as possible. Because of the lag between ship and tool motions and the relatively poor resolution of the ship's position (even with dynamic positioning the ship moves up to 60 ft. [18.4 m] off location and the cone diameter is only 15 ft. [4.5 m]), propulsion on the tool itself should be seriously considered.

ACKNOWLEDGMENTS

This project was inspired and initiated by Swede Larson, former head of drilling operations at DSDP, and we regret that he was unable to see the project develop to this stage. We hope that future wireline reentry development will be a tribute to his memory.

Captain Clarke, the officers and crew of the *Glomar Challenger*, and the Global Marine and Scripps electronic technicians played an essential role in carrying out the experiment and we express our gratitude to them. Woods Hole Oceanographic Institution Contribution No. 5781.

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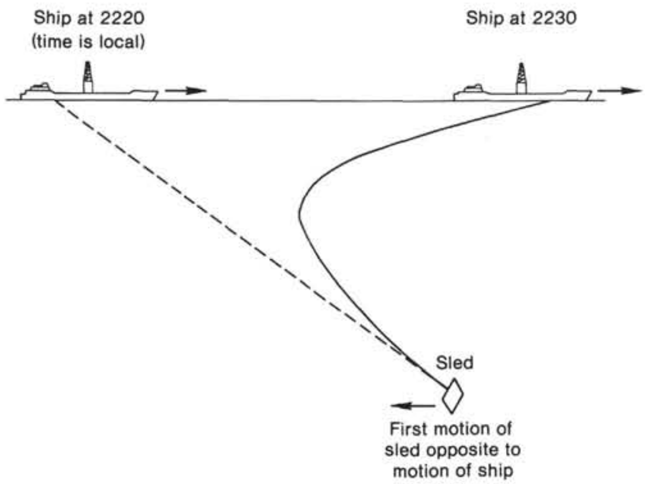

Figure 4. Given a ship-sled configuration shown by the dashed line at 2220, the catenary that forms as the ship moves south will move the sled in the opposite direction.