6. OPERATIONS[1]

Shipboard Scientific Party[2]

PRE-LEG PREPARATIONS

A considerable operations and engineering effort and investment was required for Leg 158 because of unknown drilling conditions, the potential for acidic water (pH < 3), H_2S release, and temperature extremes, from ambient bottom-water temperatures (2°–3°C) at the surface of the mound to bottom-hole temperatures exceeding 400°C. Extensive cement testing was done at Halliburton Laboratories in Tulsa, OK, on experimental high-temperature retarders. Rock Bit Industries in Fort Worth, TX, performed extensive materials testing to extend roller cone bit seal and lubricant operating temperatures to prolong bit life. Two reentry cones, two hard-rock bases (HRB), and two CORKs were built, and rental hole openers, underreamers, and mud motors were obtained. High-temperature casing hanger seals were developed to prevent annular flow behind the casing, a 16-in. HRB centralizer was developed to permit centralized coring, the first HRB CORK was developed, and a tapered drill collar was developed to reduce drill-collar failures when spudding in hard rock. Ocean Drilling Program (ODP) personnel took an H_2S safety training course, additional gas masks and detectors were ordered, and the shipboard detectors were serviced.

PORT CALL IN LAS PALMAS

Leg 158 began with the first line ashore at Quaya La Luz Naciamiento in Las Palmas, Gran Canaria, at 0630 hr on 23 September 1994. The shipboard clocks were retarded 1 hr on 25 September to match the daylight savings time change on Gran Canaria. Shipboard time remained the same throughout the leg and was equal to Greenwich Mean Time (GMT) + 0 hr or College Station (CST) + 5 hr. The Shipboard Measurements Panel visited the drill ship. Departure was delayed for 2 days because most of the sea-freight shipment did not arrive until 1400 hr on 28 September. The last line was on board at 0800 hr on 29 September, and the *JOIDES Resolution* departed for the Trans-Atlantic Geotraverse (TAG) active hydrothermal mound.

LAS PALMAS TO TAG SITE 957

The 1614-nmi sea voyage from Las Palmas to Prospectus Site TAG-2 required 135 hr at an average speed of 11.96 kt. The weather was fair and clear, with air temperatures of 19° to 24°C, a following 1-kt current, 1- to 2-ft seas, and a quartering 10- to 14-kt wind. The H_2S detectors and monitoring system were tested, the science party received H_2S safety training, and H_2S contingency plans were reviewed. A reentry cone was bolted together in the moonpool.

ARRIVAL AT THE TAG ACTIVE MOUND AND CAMERA SURVEY

The *JOIDES Resolution* arrived at the global positioning system (GPS) coordinates of the TAG site beacon at 26°08.164′N, 44°49.461′W, at 2230 hr on 4 October. The pre-positioned beacon was commanded on but did not respond. Another beacon was deployed at 2336 hr on 4 October at 26°08.164′N, 44°49.408′W. The beacon landed about 280 m east of the mound; therefore, we surmise that the beacon was dropped on a bad GPS fix.

The ship moved in dynamic positioning (DP) mode 80 m south and 400 m west to 26°08.140′N, 44°49.525′W. A backup beacon was dropped at 0153 hr on 5 October. The beacon landed 81 m southeast of the drop point and about 100 m south of the mound. In preparation for a camera survey and attempts to piston core the surface of the mound, the drill string was lowered with an advanced hydraulic piston corer (APC) bit and an extended core barrel (XCB) assembly. While still south of the mound to avoid contamination, a wiper pig was pumped down the drill string to remove interior rust.

The vibration insulated television (VIT) frame was run with the television (TV), sonar, VIT beacon, and a marker float on a 3 m tether that could be deployed by activating the VIT beacon release. At 1014 hr on 5 October, as the final stands of pipe were being lowered, the ship proceeded north from the backup beacon drop point and encountered the edge of the mound after about 100 m. The survey proceeded with a series of north-south transects over the eastern half of the mound so as to locate the Kremlin area and select a site for the first hole. At the eastern edge of the mound, Marker A, which had been deployed by submersible in 1993 and been precisely located during a seafloor survey in June/July 1994, was clearly identified. It proved to be a useful reference point for the remainder of the survey. A series of additional north-south lines augmented by some east-west transects resulted in the verification of the bounds of the upper and lower platforms, and the location of the Black Smoker Complex, the depression to the east of them, and the active white smokers in the Kremlin area. At 2045 hr on 5 October, the VIT-deployed marker float "7C" was deployed at 26°08.217′N, 44°49.569′W in 3651 m water depth next to an area of active white smokers. Immediately after, a bottom-water sample was obtained from this location using the water sampling temperature probe (WSTP).

PENETRATION/JET-IN TESTS NEAR PROPOSED SITE TAG-2

The bit was positioned 10 m west of ODP Marker 7C in the Kremlin area, and at 0030 hr on 6 October a penetration/jet-in test was performed. The mound surface was at 3639 mbsl. The bit penetrated 0.75 m with 5,000–10,000 lb weight-on-bit (WOB) without circulation. The bit was jetted-in an additional 0.5 m in 10 min circulating drilling water at 200 gallons per minute (gpm); however, the bit could not be washed below 1.25 mbsf with 300 gpm. The XCB was retrieved with no recovery.

[1]Humphris, S.E., Herzig, P.M., Miller, D.J., et al., 1996. *Proc. ODP, Init. Repts.*, 158: College Station, TX (Ocean Drilling Program).

[2]Shipboard Scientific Party is as given in the list of participants in the contents.

The ship was moved 5 m west of ODP Marker 7C, and a second penetration/jet-in test was performed. The mound surface was at 3640 mbsl. The bit penetrated 0.5 m in 15 min with 5,000–10,000 lb WOB without circulation; however, the bit could not be washed below 0.5 mbsf with 500 gpm. The XCB was circulated clear.

HOLE 957A

The ship was moved 2 m northwest of ODP Marker 7C. Hole 957A was spudded at 0400 hr on 6 October at 26°08.196′N, 44°49.552′W. The mound surface was at 3641.9 mbsl. A punch core was taken with the XCB, and it penetrated 2.0 mbsf with 5,000 to 10,000 lb WOB; however, the bit could not be washed below 2.0 mbsf without rotation while circulating at up to 200 gpm. Cores 158-957A-1X to 3X were taken with the XCB from 3653.2 to 3668.2 mbsl (0–15.0 mbsf) (Table 1). The operating parameters were as follows: 5,000–10,000 lb WOB, 20–30 rotations per minute (rpm), and 120 gpm. The formation was resistant to penetration between 2 and 5 mbsf, but from 5 to 15 mbsf was soft (cored 10 m in 20 min). The rotary stalled at 10 mbsf with 30,000 lb overpull. A 10 barrel (bbl) bentonite mud pill was pumped to help clear the drill cuttings from the borehole.

After Core 158-957A-3X at 3668.2 mbsl (15.0 mbsf), an APC core was attempted in an effort to recover some of the soft material; however, only a few grains of pyrite were recovered and the bit did not advance. In light of the poor recovery from Hole 957A, particularly from the upper part of the mound, an APC core barrel was run to obtain a surface sample. The VIT frame was run back down, and, while pulling out of Hole 957A, Marker E was identified about 10 m east of Marker 7C. Marker E had been deployed from *Alvin* in 1993 in a flat area close to the white smokers that exhibited the highest measured fluid temperatures in the Kremlin area. The bit was positioned about 1 m from the white smokers at a depth of 3640 mbsl. The APC core barrel did not penetrate the mound. Trapped pressure stroked out the APC core barrel downslope, which pushed the bottom hole assembly (BHA) aside and bent the barrel. The bit cleared the rotary table at 0000 hr on 6 October. There was no APC recovery or penetration, and therefore there is no hole designation.

HOLE 957B—RUNNING THE HRB

The original operations plan called for running a reentry cone; however, the penetration/jet-in tests indicated that 0.5 to 2.0 m of sulfide sediment covered a hard, massive sulfide layer. The water depth estimated from the drill-pipe measurements indicated local slopes as high as 10° to 20° in the Kremlin area. Inasmuch as reentry cones are not designed to be used on slopes, the decision was made to attempt to set an HRB. The HRB assembly was completed, and it was run in on the following BHA at 0700 hr on 7 October: reentry/logging bit, 9⅞-in. stabilizer, Dril-Quip CADA tool, one stand of drill collars, crossover, and two stands of 5½-in. drill collars.

The HRB was set down twice in the Kremlin white smoker area, but the "bull's eye" slope monitor mounted on the HRB indicated that the HRB was tilted in excess of 20°. The HRB was set down a third time on top of what appeared to be white smoker chimneys, with a tilt of about 15°. The running tool was torqued to 3,000 ft-lb, where it spun into the release position; however, it would not release. Additional torque was applied, but the running tool still failed to release. With the intention of moving the base to a more level site, the running tool was reengaged requiring 12,000 ft-lb of torque. The HRB was repositioned on a nearly level part of the mound; however, the tool would not release even with 25,000 ft-lb of torque at various tensions. Rather than risk a string shot release and dropping the HRB, the base was pulled back to the surface, clearing the moonpool at 2315 hr on 7 October. A torque of 40,000 ft-lb was required to break out the 16-in. running tool. No damage was noted to the running tool except that the torque ring had slipped; therefore, the running tool was rerun with the HRB at 0200 hr on 8 October.

The VIT frame was run and Markers E and 7C were located. In addition, ODP Marker 5, which had been deployed by the submersible *Shinkai* in August 1994, was identified and was located about 12 m south of Marker E. At 1000 hr on 8 October, the HRB was positioned between these two markers and set without problems on an 8° slope in 3643.4 mbsl water depth. The running tool was pulled, and a rotary core barrel (RCB) BHA was run. Hole 957B was spudded at 0230 hr on 9 October at 26°08.193′N, 44°49.546′W. Cores 158-957B-1R to 4R were taken with the RCB from 3643.4 to 3673.0 mbsl (0–29.6 mbsf) (Table 1). High torque and 4 m of hole fill were noted at 29.6 mbsf after the connection, and the hole could not be cleaned out in 2 hr of washing with two 20-barrel, high-viscosity bentonite mud sweeps. The core barrel was recovered with 0.01 m recovery, which was archived as Core 158-957B-5B (bit sample) from 0 to 29.6 mbsf. Because Core 158-957B-4R (19.9–29.6 mbsf) recovered relatively fresh basalt, the Shipboard Scientific Party concluded that the area of interest for a deep hole (the stockwork zone) was unlikely to be encountered below fresh basalt; therefore, the bit was pulled out of the HRB at 1630 hr on 9 October, and Hole 957B was abandoned.

MOVING THE HRB

The VIT frame was lowered and a camera survey was started at 1630 hr on 9 October on the upper platform in a flat area between the Black Smoker Complex and a depression to the east (prospectus TAG-1 area). This area was selected so as to recover a thicker sulfide section as well as to be closer to the center of the hydrothermal mound, thereby increasing the likelihood of intersecting the stockwork. Several penetration tests with the 9⅞-in. RCB bit identified an area of 0.5 m penetration with 10,000 lb WOB east-southeast of the main Black Smoker Complex. A marker ("7D") was deployed with the VIT at 26°08.225′N, 44°49.565′W, in 3640 m water depth. The RCB bit with centering bushing was pulled out, and an HRB running tool assembly was run as follows: 16-in. running tool, 17½-in. stabilizer, and reentry/logging bit. The ship was positioned on the beacon/VIT offset coordinates, and the HRB was reentered at 0730 hr on 10 October. The HRB had muddy water in the cone, but no recognizable flow in or out of the hole. The HRB was engaged easily, picked up, and moved to the prospectus TAG-1 area. The HRB was set down three times; however, in each instance, it appeared to be tilted in excess of 20° and was picked up. The HRB was finally set down about 10–20 m east-southeast of the main Black Smoker Complex. The HRB was tilted about 8°, and the water depth was 3648 m. The HRB was released easily and checked, and the area immediately around it was surveyed. This indicated that the HRB was located about 8–10 m south of Marker 7D. The running tool was on deck at 1630 hr 10 October.

Hole 957C

To enhance recovery potential, the subs required for the motor driven core barrel (MDCB) apparatus were included in the normal APC/XCB BHA. The MDCB was spaced out and function tested, and the BHA was run with an 11 7/16-in. bit. A short TV survey in the immediate vicinity of the HRB suggested that there was a weak flow of black smoke coming through the reentry cone and out from under the base. The HRB appeared to be over a fissure that was emitting black smoke. After completion of the TV survey, a bottom-water sample was taken up current from the HRB with the WSTP.

The HRB was reentered, and Hole 957C was spudded at 1000 hr on 11 October in 3636.6 m water depth at 26°08.226′N, 44°49.555′W. The HRB tilt appeared to have increased to about 12°.

Table 1. Coring summary for Holes 957A through 957Q.

Core no.	Date (1994)	Time (UTC)	Depth (mbsf)	Length cored (m)	Length recovered (m)	Recovery (%)
158-957A-						
1X	6 Oct	0730	0.0–5.0	5.0	0.05	1.0
2X	6 Oct	0930	5.0–10.0	5.0	0.01	0.2
3X	6 Oct	1130	10.0–15.0	5.0	0.19	3.8
Coring totals				15.0	0.25	1.7
158-957B-						
1R	9 Oct	0510	0.0–9.9	9.9	1.17	11.8
2R	9 Oct	0700	9.9–14.9	5.0	0.00	0.0
3R	9 Oct	0900	14.9–19.9	5.0	0.06	1.2
4R	9 Oct	1045	19.9–29.6	9.7	0.39	4.0
5B	9 Oct	1430	29.6–29.6	0.0	0.04	400.0
Coring totals				29.6	1.66	5.6
158-957C-						
1X	11 Oct	1115	0.0–5.5	5.5	0.00	0.0
2X	11 Oct	1315	5.5–10.5	5.0	0.00	0.0
3N	11 Oct	1530	10.5–15.0	4.5	0.00	0.0
4W	11 Oct	1915	10.5–15.0	4.5	0.12	(wash core)
5N	11 Oct	2230	15.0–19.5	4.5	0.50	11.1
6W	12 Oct	0045	15.0–19.5	4.5	0.02	(wash core)
7N	12 Oct	0300	19.5–24.0	4.5	3.60	80.0
8W	12 Oct	0415	19.5–24.0	4.5	0.05	(wash core)
9X	12 Oct	0915	24.0–28.7	4.7	0.06	1.3
10N	12 Oct	1300	28.7–30.7	2.0	0.15	7.5
11N	12 Oct	1745	30.7–35.2	4.5	4.07	90.4
12N	13 Oct	0445	35.2–37.2	2.0	3.20	160.0
13N	13 Oct	1045	37.2–40.2	3.0	1.69	56.3
14N	13 Oct	1400	40.2–42.2	2.0	1.55	77.5
15N	13 Oct	1730	42.2–46.2	4.0	4.27	107.0
16N	13 Oct	2100	46.2–49.2	3.0	2.60	86.6
Coring totals				49.2	21.69	44.1
Washing totals				13.5	0.19	
Combined totals				62.7	21.88	
158-957E-						
			*****Drilled from 0.0 to 31.5 mbsf*****			
1R	20 Oct	0530	31.5–37.0	5.5	0.20	3.6
2R	20 Oct	0715	37.0–41.7	4.7	0.30	6.4
3R	23 Oct	0300	41.7–49.0	7.3	0.10	1.4
4R	23 Oct	0500	49.0–58.6	9.6	0.16	1.7
5R	23 Oct	0710	58.6–63.3	4.7	0.30	6.4
6R	24 Oct	1545	63.3–68.3	5.0	0.25	5.0
7R	24 Oct	1800	68.3–72.8	4.5	0.27	6.0
8R	24 Oct	2015	72.8–77.8	5.0	0.16	3.2
9R	24 Oct	2300	77.8–82.1	4.3	0.20	4.7
10R	25 Oct	0130	82.1–87.1	5.0	0.12	2.4
11R	25 Oct	0400	87.1–91.8	4.7	0.25	5.3
12R	25 Oct	0540	91.8–96.8	5.0	0.27	5.4
13R	25 Oct	1000	96.8–101.5	4.7	0.00	0.0
14R	25 Oct	1430	101.5–106.5	5.0	0.35	7.0
15R	25 Oct	1630	106.5–111.1	4.6	0.32	7.0
16R	25 Oct	1830	111.1–116.1	5.0	0.16	3.2
17R	25 Oct	2000	116.1–120.7	4.6	0.40	8.7
18R	26 Oct	0115	120.7–125.7	5.0	0.22	4.4
Coring totals				94.2	4.03	4.3
Drilling total				31.5		
Total				125.7		
158-957F-						
			*****Drilled from 0.0 to 1.0 mbsf*****			
1N	21 Oct	0100	1.0–5.5	4.5	0.80	17.8
2N	21 Oct	0530	5.5–10.0	4.5	0.15	3.3
Coring totals				9.0	0.95	10.5
Drilling total				1.0		
Total				10.0		
158-957G-						
			*****Drilled from 0.0 to 12.0 mbsf*****			
1N	21 Oct	1200	12.0–16.5	4.5	0.23	5.1
2N	21 Oct	1630	16.52–1.0	4.5	0.09	2.0
3N	21 Oct	2330	21.0–25.0	4.0	0.80	20.0
Coring totals				13.0	1.12	8.6
Drilling total				12.0		
Total				25.0		
158-957H-						
			*****Drilled from 0.0 to 8.7 mbsf*****			
1N	28 Oct	1540	8.7–13.2	4.5	0.61	13.5
2N	28 Oct	2000	13.2–17.7	4.5	0.23	5.1
3N	28 Oct	2330	17.7–22.2	4.5	0.81	18.0
4N	29 Oct	0315	22.2–26.7	4.5	0.00	0.0
5N	29 Oct	1005	26.7–31.2	4.5	1.59	35.3
6N	29 Oct	1330	31.2–35.7	4.5	0.39	8.7
7N	29 Oct	1725	35.7–40.2	4.5	0.10	2.2
8N	29 Oct	2115	40.2–44.7	4.5	1.14	25.3
9X	30 Oct	1010	44.7–54.5	9.8	0.14	1.4
Coring totals				45.8	5.01	10.9
Drilling total				8.7		
Total				54.5		
158-957I-						
			*****Drilled from 0.0 to 9.0 mbsf*****			
1N	30 Oct	2315	9.0–13.5	4.5	0.77	17.1
Coring totals				4.5	0.77	17.1
Drilling total				9.0		
Total				13.5		
158-957J-						
1X	1 Nov	0200	0.0–9.0	9.0	0.08	0.9
Coring totals				9.0	0.08	0.9
158-957K-						
1X	1 Nov	0900	0.0–10.0	10.0	0.28	2.8
2N	1 Nov	1315	10.0–14.5	4.5	0.40	8.9
3X	1 Nov	2000	14.5–20.0	5.5	0.31	5.6
Coring totals				20.0	0.99	5.0
158-957M-						
1R	8 Nov	1900	0.0–9.3	9.3	0.85	9.1
2R	8 Nov	2045	9.3–14.3	5.0	0.59	11.8
3R	9 Nov	0200	14.3–19.3	5.0	1.15	23.0
4R	9 Nov	0430	19.3–24.3	5.0	0.48	9.6
5R	9 Nov	0810	24.3–29.3	5.0	0.73	14.6
6R	9 Nov	1115	29.3–34.3	5.0	0.32	6.4
7R	9 Nov	1445	34.3–38.3	4.0	0.24	6.0
8R	9 Nov	1900	38.3–42.3	4.0	0.30	7.5
9R	9 Nov	2100	42.3–46.2	3.9	1.04	26.6
10R	10 Nov	0100	46.2–51.2	5.0	1.25	25.0
Coring totals				51.2	6.95	13.6
158-957N-			***No Recovery***			
158-957O-						
1R	13 Nov	1830	0.0–7.9	7.9	0.00	0.0
2R	13 Nov	2015	7.9–10.9	3.0	0.43	14.3
3R	13 Nov	2200	10.9–15.9	5.0	0.20	4.0
4R	13 Nov	0030	15.9–20.5	4.6	0.64	13.9
Coring totals				20.5	1.27	6.2
158-957P-						
1R	14 Nov	1240	00.0–7.9	7.9	0.47	5.9
2R	14 Nov	1445	7.9–11.9	4.0	0.12	3.0
3R	14 Nov	1630	11.9–16.9	5.0	0.08	1.6
4R	14 Nov	1830	16.9–21.5	4.6	0.08	1.7
5R	14 Nov	2015	21.5–26.5	5.0	0.13	2.6
6R	14 Nov	2230	26.5–30.1	3.6	0.18	5.0
7R	15 Nov	0100	30.1–35.1	5.0	0.05	1.0
8R	15 Nov	0400	35.1–40.1	5.0	0.06	1.2
9R	15 Nov	0710	40.1–45.1	5.0	0.17	3.4
10R	15 Nov	0920	45.1–50.1	5.0	0.17	3.4
11R	15 Nov	1130	50.1–54.4	4.3	0.38	8.8
12R	15 Nov	1430	54.4–59.4	5.0	2.69	53.8
13W	15 Nov	1730	—	0	2.5	(wash core)
Coring totals				59.4	4.6	7.7
Washing totals				—	2.5	
Combined totals				59.4	7.1	12.0
158-957Q-						
1R	16 Nov	0200	0.0–9.5	9.5	5.8	61.1
2R	16 Nov	0545	9.5–14.5	14.5	0.11	2.2
Coring totals				14.5	5.91	40.8

Cores 158-957C-1X to 2X were taken with the XCB from 3636.6 to 3647.1 mbsl (0–10.5 mbsf) (Table 1). Recovery was low, and fine sulfide grit was noted in the 8 and 10 finger core catchers.

The MDCB core barrel was dropped, and Core 158-957C-3N was taken from 3647.1 to 3651.6 m (10.5–15.0 mbsf). Fine sulfide grit was again found in the 8 and 10 finger core catcher. In an attempt to improve recovery, a piloted diamond impregnated MDCB bit was fitted to the MDCB. In the interim, an XCB was run as a wash barrel to clean out 4 m of fill on bottom. The process of coring with the MDCB, followed by reaming an 11 7/16-in. hole with the XCB bit, proved to gain little in the way of recovery, so the hole was circulated and conditioned with mud sweeps to ensure good contact between the

diamond bit and the bottom of the borehole. MDCB Core 158-957C-7N (3656.1–3660.6 mbsl, 19.5–24.0 mbsf) was advanced 4.5 m and recovered 3.60 of massive sulfide and anhydrite. The hole was reamed and an MDCB barrel was dropped, but the tool never seated and the piston stuck; therefore, there was no advance and no recovery. Core 158-957C-9X was taken with the XCB from 3660.6 to 3665.3 mbsl (24.0–28.7 mbsf), with 4.7 m cored but little recovery as a result of a jammed core catcher. The hole was again reamed and conditioned, and MDCB Core 158-957C-10N was taken from 3665.3 to 3667.3 mbsl (28.7–30.7 mbsf), with 2.0 m of advancement. Once again, however, recovery was limited because of a jammed core catcher. A borehole water sample was then collected at 3665.2 mbsl (28.6 mbsf) with the WSTP, and a borehole water temperature of 15°C was recorded. The hole was reamed from 28.7 to 30.7 mbsf. MDCB Core 158-957C-11N was taken from 3667.3 to 3671.8 mbsl (30.7–35.2 mbsf). Advancement was 4.5 m with 4.07 m of recovery.

At this point, the hole was regarded to be deep enough to set a casing string, so coring was ended in anticipation of opening the hole and setting the casing. The bit was pulled up to 3.5 mbsf, and preparations were made to take a seafloor APC (to attempt recovery of the material not sampled in the upper part of Hole 957C) and pull out for casing. The HRB appeared to have shifted during the coring operation and was resting at an angle of about 18°–20°. This increased tilt meant that the locking gimbal/funnel assembly of the HRB was now likely 8°–10° off perpendicular to the seafloor. There was, however, no obvious bending or damage to the BHA or centering bushing, and hole conditions were good; therefore, the decision was made to continue coring rather than pull the drill string from the HRB, which might have caused the base to topple. Following the procedure that had resulted in the greatest degree of recovery in previous cores, MDCB Cores 158-957C-12N to 16N were taken from 3671.8 to 3685.8 mbsl (35.2–49.2 mbsf), with greater than 95% recovery. A hole deviation survey run after Core 158-957C-11N indicated that the hole was drilled with a 6¾° deviation. Overall recovery was calculated by bit advancement based on the apparent stroke (wear on a paint mark) on the MDCB kelly. Between each MDCB, an XCB equipped with a center bit was run to condition the bottom of the hole for coring with the piloted diamond impregnated bits used for most of the MDCB cores. Repairs were made to the upper section of the MDCB after Core 158-957C-12N. After retrieving Core 158-957C-16N, the XCB with a center bit stuck in the hole and the bit plugged. Attempts to retrieve the stuck wash barrel were unsuccessful, and the bit was pulled to the HRB throat to determine if the HRB could be reentered. The VIT was run and the HRB appeared to have shifted again, to an angle in excess of 20°. We attempted to reenter the HRB, to see if reentry was even possible, but the HRB tipped up on edge. The BHA was then picked up to allow the HRB to set back down. While attempting to position the drill ship to improve the cone angle for reentry, the bit slid to the edge of the cone and the HRB either fell over or collapsed into the substrate. The HRB appeared to be lying on its side about 2 m from Hole 957C. The pipe was tripped, terminating Hole 957C; although the BHA was relatively undamaged, the center bit would not retract through the MDCB because of a connection that had been swollen by overtorque. The bit cleared the rotary table at 1245 hr on 14 October. The bit shirt tail was badly worn, which caused the seals to fail and, in turn, three of four cones locked up.

Hole 957D

The repeated failure of the HRB forced reconsideration of a means to run a casing string with a reentry cone and casing hanger system for the CORK. The engineers suggested using a drill-ahead casing system, run above an underreamer to advance the casing. A reentry cone was attached to the casing/CORK hanger system. To improve chances for success in running casing, 27.97 m (two joints) of 13⅜-in. casing was run on a 16-in. casing hanger and latched into the transition pipe (reentry cone). A 12¼-in. three-cone drill bit, a 17½-in. underreamer, a mud motor, and two 8¼-in. drill collars (31.36 m) were run inside the 13⅜-in. casing on the 16-in. running tool.

The ship was positioned on beacon offset coordinates twice before a suitable water depth was located at 3637.0 mbsl. Hole 957D was spudded at 0730 hr on 15 October. The casing was drilled ahead from 3637.0 to 3666.5 mbsl (0–29.5 mbsf) in 3.5 hr. Repeated attempts to release the running tool from the casing were not successful. The ship was moved off the mound as a precaution in the event that the casing might be inadvertently dropped and the assembly pulled. The reentry cone was in the moonpool at 2230 hr on 15 October. An initial attempt to release the running tool in the reentry cone was not successful because the casing hanger was rotating on the snap ring in the transition pipe. The snap ring was released, and the running tool was pulled to the rotary where a second release attempt was unsuccessful. The running tool was finally released in the rotary after the top was removed and it was cleaned internally. The bottom o-rings evidently had failed in the running tool, allowing fine sulfide sand to enter the tool and prevent releasing.

Hole 957E

The 16-in. running tool was cleaned and rebuilt. The bottom seals were tested, and the top was sealed with aqualube. There was negligible wear on the bit or underreamer, and the cones turned freely. The bolt holes in the transition pipe were closed, holes were cut in the reentry cone base, and holes in the cone base were patched to reduce flow back through the hanger and to prevent sulfide sand from contaminating the unlatching mechanism. The same BHA and casing system as described above were then run back to the seafloor. The ship was positioned three times on beacon offset coordinates (positioning beacon to ship and ship to VIT beacon) before a suitable water depth was located at 3637.1 mbsl. An attempt to drill ahead with the 13⅜-in. casing resulted in high pump pressures, which indicated that the motor was stalling. When the bit was picked up off bottom to free the motor, back torque apparently caused the running tool to release. An attempt to drill down a 12¼-in. hole using low circulation (to allow the underreamer arms to close so the running tool could be reset) failed. The motor stalled again, and the reentry cone was picked up off bottom with the pump on (the casing weight appeared to be supported on the underreamer arms). The ship was moved off the mound, again as a precaution against the accidental release of the casing string, and the assembly was tripped. The assembly was set on the moonpool doors at 0430 hr on 17 October.

The reentry cone and casing were riding on the underreamer arms; therefore, the reentry cone was set on the moonpool doors and the underreamer was lowered, which allowed the arms to close. The bit cleared the rotary at 0530 hr on 17 October. No damage was noted to the tools or casing; however, the mud motor and underreamer were changed out as a precaution. The running tool was rerun with a new underreamer, new mud motor, and the same bit. The reentry cone transition pipe was modified with two angle-iron spikes on the side and four bars on the bottom (like a castle nut) to bite into the seafloor and stop rotation.

The ship was moved back over the mound and positioned on beacon offset coordinates. Hole 957E was spudded at 1800 hr on 17 October in 3634.5 m water depth. Hard layers from 0 to 8 mbsf and from 12 to 18 mbsf reduced the rate of penetration (ROP) from 3.2 to 2 m/hr, and drilling was much slower than in Hole 957D (8–12 m/hr). The new underreamer had mill tooth cones (instead of tungsten carbide insert cones), but inspection after tripping the pipe demonstrated that the cones had only moderate wear, which does not explain the slow ROP. The 13⅜-in. casing was drilled ahead with the 17½-in. underreamer and the 12¼-in. bit to 3665.8 mbsl. The 13⅜-in. casing shoe

was at 3663.6 mbsl (29.1 mbsf). We attempted to release the reentry cone, and the 16-in. running tool rotated but did not come free. Inspection of the running tool after returning it to the ship indicated that it was in a bind in the hanger. The pipe and casing then became stuck and could not be freed, even with 50,000 lb of overpull. The mud motor was restarted, and the reentry cone began rotating, which indicated that the casing was being carried on the open underreamer arms. The casing was worked back to 3663 mbsl with the underreamer arms open. The hole was reamed back to 3665.8 mbsl, and circulation was reduced to close the underreamer arms and to drill ahead with the 12¼-in. bit. The running tool then popped out of the reentry cone throat, the underreaming BHA was free, the reentry cone and the 13⅜-in. casing were set, and the underreaming BHA was pulled. The underreamer and bit had some shirt-tail wear, but they were both reusable.

The hole was cleaned out with a 12¼-in. bit to total depth, and it was cemented with 18 sacks of 16.0 ppg Class "G" cement with 50% silica flour. The 10-m-high plug of cement was set from 1 m below the casing shoe. After circulating the hanger area to set the cement, a 4 hr TV survey was conducted while waiting for the cement to harden. This was used to fix the location of Hole 957E, relative to the known positions of the markers placed on the seafloor by submersible vehicles and later surveyed in using a towed imaging system. The ship was moved first to Marker A (on the eastern side of the mound) and then to Marker E (in the Kremlin area); at each location, a time series of *x*-*y* coordinates relative to Hole 957E were taken and averaged. During the survey, ODP Marker 5 was also observed and its location 10–15 m south of Marker E was verified.

After the camera survey, Hole 957E was reentered and the bit stopped at a depth of 3657.0 mbsl (6.6 m above the casing shoe). Two meters of soft cement, 5 m of hard cement, and an additional 0.2 m of new hole were drilled to 3666.0 mbsl (31.5 mbsf) to prepare for RCB coring.

An RCB BHA was run with a 9-polycrystalline diamond compact (PDC) bit in an effort to increase RCB recovery. Cores 158-957E-1R to 2R were cut from 3666.0 to 3676.2 mbsl (31.5–41.7 mbsf) (Table 1). After making a connection, the pipe stuck while circulating a 30 bbl high viscosity mud sweep. The pipe was worked at up to 120,000 lb overpull, and the rotary was stalled. The pipe came free in 15 min, but the PDC coring was discontinued on account of the poor recovery and the stuck pipe problem with a near-gauge PDC bit. The bit cleared the rotary at 1445 hr on 20 October. Good core recovery in the mound had been achieved only with the MDCB, but a critical upper 0–20 mbsf section had been missed at both TAG-2 (Holes 957A and 957B) and TAG-1 (Holes 957C, 957D, and 957E). After making a pipe trip, the Shipboard Scientific Party decided to run in the MDCB to core the upper section of the mound in both areas before deepening Hole 957E.

Hole 957F

An APC/XCB/MDCB BHA was run, and Hole 957F was spudded at 2345 hr on 20 October in 3637.1 m water depth. The hole is between Holes 957E and 957C (about 4 m from both). The bit penetrated from 3637.1 to 3638.1 mbsl (0–1.0 mbsf), when it was set down to take the first MDCB core. MDCB Cores 158-957F-1N to 2N were taken from 3638.1 to 3647.1 mbsl (1.0–10.0 mbsf) (Table 1). The core barrel stuck, and the bit was pulled clear of the seafloor at 0500 hr on 21 October. The MDCB came free, but the barrel was bent and required repairs.

Hole 957G

As Hole 957F sampled only the upper 10 m, another hole was required to complete the upper section. Hole 957G was spudded at 0715 hr on 21 October about 2 m north of Hole 957C (HRB) and 2 m south of Hole 957F. The bit was drilled in from 3634.4 to 3646.4 mbsl (0–12.0 mbsf). MDCB Cores 158-957G-1N to 3N were taken from 3646.4 to 3659.9 mbsl (12.0–25.5 mbsf) (Table 1). The hole was again reamed with a center bit between MDCB cores to provide a clean bottom for the diamond impregnated bit. After Core 158-957G-2N, the seals on the locking piston assembly were replaced and pyrite was washed out of the thruster barrel. The pipe stuck at 3655.4 mbsl (21 mbsf) after Core 158-957G-3N. Despite 260,000 lb of overpull being applied to the pipe, we were unable to pull it free. The rotary stalled with 700 amps (17,000 ft-lb of torque). Two 30 bbl, high-viscosity mud sweeps were circulated, which reduced the circulating pressure. The BHA jars could not be used because nearly the entire BHA was above seafloor and unsupported. The pipe was pulled up to a point that a joint could be removed and the MDCB retrieved. The pipe was finally worked free at 0015 hr on 22 October. The seafloor was cleared at 0030 hr, and the bit cleared the rotary at 0700 hr. The MDCB was tested and would not fully stroke, so it was repaired.

Return to Hole 957E

An RCB BHA was run with a 9⅞-in. bit, and Hole 957E was reentered in 45 min at 2230 hr on 22 October. Coring parameters were as follows: 15,000 lb WOB at 30–70 rpm with 150 amps torque, circulating 180 gpm at 500 psi. The pipe stuck while retrieving Core 158-957E-5R (3693.1–3697.8 mbsl, 58.6–63.3 mbsf). The bit was at 3704 mbrf (58 mbsf), and 240,000 lb of overpull was applied to attempt to free the pipe. High viscosity mud sweeps were pumped, and the BHA jars were used for 9 hr to hit more than 200 blows at 150,000–180,000 lb on the BHA. Slow progress on freeing the pipe (0.5 m/hr), despite a total of 260 bbl of very high-viscosity mud sweeps, indicated that the pipe was severely stuck, and preparations were made to sever the BHA. While laying out excess drill pipe, the circulating pressure decreased, and the pipe came free. The pipe was pulled to inspect the jars and upper unsupported BHA. The seafloor was cleared at 2015 hr on 23 October. The inspection revealed no problems, and the jars were in excellent shape. A total of 30.75 hr was expended in the stuck pipe incident.

We decided to continue coring in spite of the hole problems, and Hole 957E was reentered at 0930 hr on 24 October. While retrieving Core 158-957E-13R (3731.3–3736.0 mbsl, 96.8–101.5 mbsf) at 0800 hr on 25 October, the pipe stuck with the bit 5 m off bottom, and the rotary stalled. Two sepiolite sweeps were pumped, rotation was restored, and the pipe was reamed upward to 3720.5 mbsl. A wiper trip was made to the casing shoe, and 1.5 m of fill was encountered on bottom.

Cores 158-957E-14R to 18R were taken from 3736.0 to 3760.2 mbsl (101.5–125.7 mbsf) (Table 1). The pipe stuck again at 0200 hr on 26 October with the bit at 3752 mbsl while dropping the next core barrel. The jars could not be set (evidently the pipe was stuck above the jars), the rotary corer was stalled, and circulation in the hole was impaired. Rotation was finally reestablished, and two 50 bbl, high-viscosity mud sweeps were circulated. The bit was pulled to 3741 mbsl with 240,000 lb of overpull, and a single joint of pipe was removed from the drill string. Despite nearly 24 hr of effort, the pipe could not be freed and we decided to sever the pipe at the bit. We hoped that releasing the bit might allow logging operations in this hole. After the severing charge was fired, however, the pipe did not come free, and a second severing charge was shot in the bottom joint of 5½-in. transition pipe at 3649 mbsl (within the casing). The severed pipe was on deck at 2145 hr on 27 October. A total of 43.75 hr of leg time was expended in this stuck pipe operation.

Hole 957H

A successful function test was performed on the MDCB in preparation for attempting to recover the upper part of the mound in the

Kremlin white smoker area, where Holes 957A and 957B are located. After a short survey during which Marker E and ODP Marker 5 were identified, Hole 957H was spudded at 0830 hr within a few meters of ODP Marker 7C, and about 8–10 m from Hole 957B. The bit did not penetrate when it contacted the seafloor at 3643.4 mbsl. An 11 7/16-in. hole was drilled with the APC/XCB/MDCB BHA from 3643.4 to 3652.0 mbsl (0–8.6 mbsf) with a center bit. After MDCB Core 158-957H-4N (3665.6–3670.1 mbsl, 22.2–26.7 mbsf) was retrieved with no recovery (Table 1), the polypack seals were changed in the MDCB, and it was dropped again. The MDCB failed to land properly in the BHA; therefore, it was retrieved. A missing shuttle valve was replaced, and the MDCB was rerun. A precautionary wiper trip was taken after Core 158-957H-6N (3674.6–3679.1 mbsl, 31.2–35.7 mbsf) as drilling conditions indicated excessive pressure on the drill string several times during the coring operation. Only 1 m of soft fill was present in the bottom of the hole. The MDCB core barrels were dropped twice, but attempts to core were unsuccessful because the drill string could not be worked to bottom. Mud sweeps were not effective in cleaning out the 3–4 m of soft fill that had accumulated in the bottom of the hole. Continuous pumping was required to keep the string relatively free, and it was not possible to core with the MDCB. Core 158-957H-9X was taken from 3688.1 to 3697.9 mbsl (44.7–54.5 mbsf) with poor recovery, and hole conditions were considered unsatisfactory for continued operation. Hole 957H was abandoned, and the bit cleared the seafloor at 1315 hr on 30 October. The VIT was run to determine the Hole 957H coordinates and to survey for a site in the prospectus TAG-4 area, on the west side of the Black Smoker Complex.

Hole 957I

Based on the *x*-*y* coordinate grid used to navigate around the mound, the ship was moved around the northern side of the Black Smoker Complex to the western side of the mound. The area was surveyed to locate a small, flat terrace at a depth of about 3645 m that would provide a suitable site for drilling. During the survey, the Japanese "Daibutu" data logger and mooring were observed, together with some of the heat-flow probes and cables distributed on this side of the mound. These had been emplaced on the seafloor during a cruise of the submersible *Shinkai* in August 1994.

The bit was set down in 3633 m water depth at 1520 hr on 30 October to spud Hole 957I. The site was on the western edge of the terrace on a slope in black smoker chimney rubble. An 11 7/16-in. hole was drilled from 3633 to 3642 mbsl (0–9.0 mbsf) in 2¾ hr. The formation was very hard and the hole appeared to be unstable. The standard operation of following an MDCB core with a center bit was employed; however, when the center bit was run to clean out the hole after Core 158-957I-1N (3642–3646.5 mbsl, 9.0–13.5 mbsf) (Table 1), the XCB shoe and extension sub were destroyed, and the center bit was worn from the very hard and abrasive formation. The hole could not be cleaned out with mud sweeps, and the drill string was pulled to examine the bit after only rotating 3 hr, ending Hole 957I. The bit exhibited extensive wear and the seals were exposed on all four cones.

Hole 957J

An 11 7/16-in. APC/XCB/MDCB bit was run, and the area northwest of the prospectus TAG-4 area was surveyed. Markers C and F (both put down by *Alvin* in 1993) were identified, and, at 2100 hr on 31 October, the seafloor was tagged at 3635.3 mbsl to spud Hole 957J between these two markers. A Force 8 storm had moved in with rain and wind to 35–43 kt (50 kt gusts), 8-ft seas, 12-ft swells, 3° of pitch and roll, and 2–3 m of heave. When the bit set down on the steep slope, it hit very hard and slid down and sideways before heave compensation reduced the pounding. It is possible that the main bit and XCB shoe were damaged in that incident. Core 158-957J-1X was taken from 3635.3 to 3644.3 mbsl (0–9.0 mbsf) (Table 1) with very poor recovery, which was composed of chert. The XCB shoe was destroyed, probably as a result of the cherty layer. The hole appeared to be collapsing, and the subsequent core barrel could not be retrieved. The hole could not be cleaned out, and Hole 957J was abandoned at 0030 hr on 1 November.

Hole 957K

The VIT frame was lowered again, and the ship was moved back to the small terrace on the west side of the mound. Hole 957K was spudded in 20 m west of the Black Smoker Complex and about 10 m east of Hole 957I at 0415 hr on 1 November at a depth of 3632.3 mbsl. Core 158-957K-1X was taken from 3632.3 to 3642.3 mbsl (0–10.0 mbsf) with poor recovery (Table 1). The XCB shoe was destroyed, and the hole was unstable. The hole was cleaned out, and mud sweeps were circulated. MDCB Core 158-957K-2N was taken from 3642.3 to 3646.8 mbsl (10.0–14.5 mbsf), again with poor recovery. The MDCB barrel had some bit tooth marks, which indicated that the bit cones were beginning to fail. The hole was cleaned out four times, and high-viscosity mud sweeps were circulated. Despite this, 3 m of fill remained, and MDCB coring could not be continued. Core 158-957K-3X was taken from 3646.8 to 3652.3 mbsl (14.5–20.0 mbsf) with 0.31 m recovered. The XCB shoe was destroyed, and the sub had bit tooth drag marks, which suggested bit failure. The bit cleared the seafloor at 2245 hr on 1 November, and Hole 957K was abandoned. The bit cleared the rotary at 0900 hr on 2 November. The 11 7/16-in. bit had lost all four legs (welds failed) and had sustained severe wear on the body; the pads were worn completely off. The failure is attributed to the very hard chert and possible damage sustained when the bit pounded bottom as it spudded Hole 957J.

Hole 957L

The drilling experience to this point suggested that the only way to penetrate deeper into the stockwork zone to recover rocks and log the hole was to drill without coring through the upper, highly unstable part of the mound. The site chosen was close to Hole 957E, just east of the Black Smoker Complex. In this area, the gross stratigraphy of the mound was known based on samples recovered from Holes 957C, 957E, 957F, and 957G. A camera survey was conducted to determine beacon offset coordinates for a new site in this location. During the camera survey, a new reentry cone was moved to the moonpool, and one joint of 16-in. casing was run with a 13⅜-in. adapter, a 16-in. pup joint, and a 16-in. hanger. The 16-in. running tool was made up, and the casing was landed in the reentry cone. A mud motor, a 17½-in. underreamer, and a 14¾-in. drill bit were function tested and run inside the casing on the running tool. Straps were welded to the bit and underreamer to prevent the connections from breaking if the motor stalled. The running tool was torqued to 2000 ft-lb excess left-hand torque to counter the left-hand rotation of the mud motor.

Hole 957L was spudded at 0045 hr on 3 November, based on the beacon offset coordinates, which later proved to be located about 5 m from Hole 957C. The 16-in. casing was drilled in from 3634 to 3653.5 mbsl (0–19.5 mbsf). The top drive rotary was left unlocked, and the left-hand mud-motor torque rotated the casing at about 6 rpm counterclockwise. The reentry cone was landed on the seafloor at 3634 mbsl. Hole 957L is 5 m west-northwest and 10 m south of Hole 957E.

It took 4 hr to release the running tool, with repeated attempts necessitating as high as 25,000 ft-lb of torque. When the running tool

finally released, the cone and casing fell on the open underreamer arms. The hole beneath the casing was deepened to allow room to close the underreamer arms while operating the mud motor and bit. The bit and the underreamer assembly were pulled clear of the seafloor at 1015 hr. The bit cleared the rotary at 1645 hr and showed minor abrasion. The 16-in. running tool was jammed and damaged during the release operation.

A 9⅞-in. bit was run in an attempt to drill a hole to 100 m for logging. Drilling progress was slowed by continuous hole problems. High torque, overpull (to 70,000 lb), and pump pressure (to 2700 psi at 500 gpm) indicated that the hole was packing off. High-viscosity mud sweeps were circulated in an attempt to lift the cuttings out of the hole, but these attempts were largely unsuccessful in reducing the depth of fill. Ledges were contacted running in and pulling out of the hole even after repeated reaming. The water level in the pipe dropped significantly when the pipe connections were broken, indicating that the formation was drawing fluid and thwarting circulation to the surface. The hole was not open after reaming several times to bottom, and attempts to deepen the hole beyond 66.6 mbsf were abandoned in favor of setting casing. The bit cleared the seafloor at 0215 hr and cleared the rotary at 0715 hr on 5 November. The lower BHA, the underreamer body, and the drill bit all exhibited signs of excessive wear.

A 12¼-in. bit and a 17½-in. underreamer were run in an attempt to open the 9⅞-in. hole (with the rotary) in preparation for emplacement of the 13⅜-in. casing. Hole 957L was reentered at 1515 hr on 5 November. The hole was opened from 3650.4 to 3700 mbsl (16.4–66.0 mbsf); however, during hole cleaning and conditioning operations the pipe stuck at 3690 mbsl, the rotary stalled, and circulation was lost. After multiple attempts to flush the hole with high-viscosity mud, and after application of overpull as high as 160,000 lb, circulation was finally regained and the drill string was worked free. Unfortunately, as the drill string was lowered back through the casing, the bit bottomed out at 3664 mbsl (13.6 m below the casing shoe), indicating that the lower 36 m of the hole had collapsed or filled in. Attempts to wash-in the drill string without rotation and to ream the hole back to 60 mbsf were unsuccessful. The decision was made to pull the drill string and attempt to drill-in a casing in the hope that this would isolate the upper 50+ m of the hole and speed hole cleaning. The bit cleared the seafloor at 1100 hr on 6 November and cleared the rotary at 1630 hr. The underreamer and the bit both exhibited signs of severe body abrasion.

At this point, 54 m of 13⅜-in. casing was run into Hole 957L, preceded by a 17½-in. underreamer and pilot bit at 0700 hr on 7 November (the reentry cone was initially obscured by black smoke). The 13⅜-in. casing was run in to the bottom of the 16-in. casing (16 mbsf), where the mud motor stalled out repeatedly. After 1 hr, the 13⅜-in. casing began to advance and was washed in from 3650 to 3687.7 mbsl (16.0–53.7 mbsf) in 9¾ hr. The 13⅜-in. casing hanger was landed in the reentry cone three times before it latched successfully. Our view of the hanger assembly was obscured because of suspended particulate in the water column around the drill string, but the reentry cone appeared to be about half full of mud. The running tool was rotated 3½ turns to the right, but it did not come free. Several attempts to retrieve the tool by applying additional overpull of at least 60,000 lb simply caused the tool and casing to come back out of the hole, indicating that the tool had not released. In addition, high pump pressure implied that the bit was plugged and without circulation, so it was not possible to underream back to bottom to make an additional attempt to release the casing string. As it was also possible that the running tool might be jammed and inoperable, the drill string was pulled. The bit cleared the seafloor at 1900 hr on 7 November. The ship was moved off mound in case of accidental release of the casing string, and the casing was pulled. The bit cleared the rotary at 0330 hr on 8 November.

Although there was no obvious damage to the running tool, it was completely packed with sulfide sand and jammed. The underreamer and pilot bit were both badly worn as well. Because no effective method existed to prevent sulfide grit from jamming the running tool if the 13⅜-in. casing was drilled-in again, the casing attempt was terminated, and Hole 957L was abandoned.

Hole 957M

In an attempt to obtain deeper penetration on the western side of the Black Smoker Complex (TAG-4), a 9⅞-in. RCB drilling assembly was built to overcome the difficult conditions experienced at the other TAG-4 holes. This drilling assembly included a mechanical bit release (MBR) that would be used in the event that penetration was sufficient to allow a logging program. Hole 957M was sited 5 m south of Hole 957K in 3636.2 m water depth, and drilling began at 1430 hr on 8 November. Cores 158-957M-1R to 10R were taken from 3636.2 to 3687.4 mbsl (0–51.2 mbsf) (Table 1). Even though coring proceeded cautiously and included several viscous mud sweeps, the drill string seized up at 19.3 and 29.3 mbsf. Poor hole conditions continued until Core 158-957M-10R. The next core barrel failed to engage because of cored material left in the bit and it was retrieved empty. A bit deplugger was dropped, but circulation pressure continued to be low. The drill string was then pulled, clearing the seafloor at 0530 hr on 10 November and the rotary at 1030 hr. The MBR had failed, leaving the bit, the bottom half of the MBR, the RCB core barrel, and the deplugger in the hole. In retrospect, the considerable amount of time spent reaming the hole may have resulted in metal loss and the ultimate failure of the MBR. In addition, the pipe was being worked at the time of failure, so the bit loss may have been initiated by a stuck pipe event.

Hole 957N

Given the extreme wear on drilling equipment in the TAG-4 area, and the lack of success drilling deeper than 125 m in the TAG-1 area, it was decided to attempt a deep penetration in the Kremlin (TAG-2) part of the mound. Because a section down to 50 m had already been recovered at Hole 957H, and given the hole stability problems already encountered in this upper section, the plan was to drill with the rotary coring system until a depth of 45 mbsf was reached, and then to begin coring and continue as deep as hole conditions would allow. After a short camera survey, the bit was set on the seafloor at 1745 hr on 10 November in 3636.1 m water depth. Hole 957N is 10 m west-northwest of Hole 957H. A 9⅞-in. hole was drilled from 3636.1 to 3678.3 mbsl (0–42.2 mbsf) with a wash barrel in place. Despite frequent hole conditioning, increasing torque finally stalled the rotary. The drill string was stuck at 40.0 mbsf, and it could not be freed after 8 hr of working the string.

Standard operating procedure in this type of situation necessitates severing the drill string at a weak point with an explosive charge. The Shipboard Scientific Party was very concerned that severing the drill string at the connection between the drill collars and the drill pipe (the weakest point in the BHA and about 20 m above the seafloor) would impair or prevent future submersible and deep-towed instrument operations in the Kremlin area. Consequently, two severing charges—first a single, and then a double—were fired in the thinnest wall of the bit assembly. Both of these shots failed to free the drill string despite continued efforts to work the string up and down. This indicated that the pipe was seized above the bit depth. Finally, when a third severing charge was shot with overpull and left-hand torque at the connection between drill collars just below the seafloor, the drill string parted and was retrieved.

Recovering the HRB

The Shipboard Scientific Party felt that leaving the upset HRB on the upper terrace of the mound would be detrimental to continued sci-

entific study of the TAG hydrothermal system (particularly submersible operations). Therefore, after consulting the shipboard ODP engineering staff, an attempt was made to recover it. The 16-in. running tool and a centralizer were run on the drill string, and the ship was positioned over the HRB at Hole 957C at 2100 hr on 12 November. The running tool engaged the HRB on the first attempt, and it was retrieved by 0300 hr on 13 November.

Hole 957O

Having completed a northwest to southeast transect across the mound, the Shipboard Scientific Party decided to use the few remaining days of operation to test the lateral heterogeneity of the mound and the depth to the stockwork by drilling holes on the northern (TAG-5 area) and, as time allowed, southern (TAG-3 area) flanks of the mound. Given the poor drilling conditions encountered during most of Leg 158, a standard RCB BHA was put together, and the ship was positioned over the location of Hole 957E, which was our best reference point. A brief camera survey was conducted moving north from this location, to an area that appeared to be relatively flat and clear of large boulders. Hole 957O was started at 1515 hr on 13 November on the north-central part of the TAG mound, about 30 m northeast of the Black Smoker Complex at 3636.1 mbsl. Cores 158-957O-1R to 4R were taken from 3636.1 to 3656.6 mbsl (0–20.5 mbsf) (Table 1). Hole conditions were no better in this area than they had been in other parts of the mound; therefore, after two stuck pipe incidents, the drill string was pulled above the seafloor and Hole 957O was abandoned.

Hole 957P

To attempt better recovery from the northern part of the mound, the VIT was run to the bottom, and a brief camera survey located a suitable site for Hole 957P. This location is approximately 20 m west-southwest of Hole 957O, north of the Black Smoker Complex. Hole 957P was spudded at 0915 hr on 14 November in a water depth of 3636.1 m. Cores 158-957P-1R to 12R were taken from 3636.1 to 3695.5 mbsl (0–59.4 mbsf) (Table 1). Coring operations were slowed by several hole conditioning and cleaning operations. After retrieving Core 158-957P-12R, a drill-pipe depth measurement indicated that the lower 25 m of the hole was filled with debris. Rather than spending the remaining few hours of operational time attempting to clean this hole, the decision was made to move to the southern flank of the mound (TAG-3 area) and resume coring. A wash barrel (Core 158-957P-13W) with more than 2.5 m of sulfide sand was retrieved and Hole 957P was abandoned.

Hole 957Q

With only 12 hr of drilling time remaining in the leg, the VIT was run down the drill string to allow for a brief camera survey of the southern part of the TAG hydrothermal mound. After crossing several areas of accumulated sulfide rubble, a reasonably flat and clear location on the lower terrace about 50 m south of the Black Smoker Complex was chosen for Hole 957Q. Cores 158-957Q-1R and 2R were taken from 3645.1 to 3659.6 mbsl (0–14.5 mbsf) (Table 1). After recovering Core 158-957Q-2R, fully 7 m of fill was encountered in the bottom of the hole, and the bit could not be advanced because the hole could not be cleaned. Hole 957Q was abandoned, ending drilling operations for Leg 158.

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