Harding, B. W., Storms, M. A., et al., 1990
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# 17. SITE 776[1]

Shipboard Engineering and Scientific Parties[2]

## HOLE 776A

**Date occupied:** 1 February 1989

**Date departed:** 5 February 1989

**Time on hole:** 4 days, 7 hr, 12 min

**Position:** 17°54.40′N, 143°40.95′E

**Bottom felt (rig floor; m, drill-pipe measurement):** 4713.0

**Distance between rig floor and sea level (m):** 10.5

**Water depth (drill-pipe measurement from sea level, m):** 4702.5

**Total depth (rig floor, m):** 5245.85

**Penetration (m):** 532.45

**Number of cores:** 0

**Total length of cored section:** 0

**Total core recovered:** 0

**Principal results:** Site 776, previously identified as ENG-2 site, also coincides with DSDP Site 453, which was cored to a total depth (TD) of 455.5 mbsf. Core recovery from DSDP Hole 453 averaged 39%. The rocks near the bottom of the hole were identified as altered polymictic igneous breccias overlying intensely sheared gabbro cataclastites and were not considered to constitute "true" basement (Shipboard Scientific Party, 1982). The site is in the western part of the Mariana Trough (Fig. 1).

Site 776 was designed to combine engineering and scientific objectives by drilling a hole dedicated to testing a number of logging tools developed by the Borehole Research Group of Lamont-Doherty Geological Observatory (LDGO), Columbia University, logging operator for ODP. A major benefit to be derived from logging at this site was the provision of a representative suite of logs to supplement the DSDP cores. When Hole 453 was drilled in 1978, logging had been attempted but could not be achieved because of bent drill pipe.

Operations at Site 776 began inauspiciously when almost 2 days' time was lost because of severe weather on the way to the site, curtailing some of the planned logging runs and downhole experiments. As it turned out, Hole 776A was drilled to a TD of 532.45 mbsf, or an estimated penetration into "basement" rocks of about 100 m. Unfortunately, the hole fell in around the drill string, and the hole was lost, along with the bottom-hole assembly and part of the drill pipe. The bottom part of the pipe was shot off to free the remainder. Time constraints did not allow drilling an additional hole.

Although no logs could be run in Hole 776A, successful tests were conducted on several downhole tools in the severed drill pipe, which was hanging in open seawater.

## BACKGROUND AND OBJECTIVES

### Background

Former DSDP Site 453 was selected for the location of Site 776 on Leg 124E, where a borehole was to be drilled for dedicated wireline-logging tests. The hole drilled at this location on DSDP Leg 60 in 1978 provided useful information on the lithology and heat-flow characteristics of the site. The DSDP core hole penetrated 455.5 m of poorly consolidated sedimentary materials consisting of Pleistocene-Pliocene muds, silts, and sands of mainly volcanic origin (Shipboard Scientific Party, 1982). The DSDP hole also sampled 150 m of basement rocks. The cores indicated that the upper 85 m of basement consists of breccia containing fragments of diabase, basalt, and large clasts of gabbro cemented in a matrix of quartz, carbonate, pyrite, iron oxides and hydroxides, and chlorite. Core recovery in this upper section ranged from 20% to 60% and averaged about 40%. Below this zone, in the interval 85–114 m into basement, core recovery dropped to less than 5% in the softer, more chloritic polymictic breccia, which contained no gabbro clasts. Below this interval the drill encountered sheared serpentinite and mafic gabbro, where core recovery increased to about 20% on one run near the bottom of the hole. Drilling was discontinued when the bit failed 150 m into basement. No wireline logs were run in the DSDP hole because the drill pipe was bent just above the seafloor, preventing entry of logging probes into the hole.

Since cores were obtained at the site when it was drilled on DSDP Leg 60, it was considered unnecessary to core another hole on Leg 124E. Instead, it was planned to drill a rotary hole 200 m into basement as efficiently as possible to maximize the time available for wireline-logging tests and to provide a stable hole for the tests. The bottom-hole temperature of the Site 776 hole was predicted to be at least 50°C, which was considered hot enough to challenge pumping techniques for cooling the hole and wireline tools. Cooling techniques will be required on future legs in the Pacific where very hot holes are to be expected.

### Objectives

The wireline-logging tests planned for Schlumberger and LDGO tools on Leg 124E included the following:

1. Tests of the new Schlumberger combination tool called the "quad-combo," which consists of a natural gamma spectral (NGT) and a high-temperature lithodensity (HLDT) module, a compensated neutron porosity (CNT-G) section, a sonic velocity and waveform (SDT) section, and a dual-induction resistivity (ILM, ILD) section also containing spherically focused (SFL) and self-potential (SP) units, known collectively as the DITE module. The objective of the Leg 124E tests was to determine whether or not the neutron and gamma sources and detectors, particularly the HLDT module, could be run in this new configuration without degrading the accuracy of the measurements because of mutual interference.

2. Tests of a new configuration of the Schlumberger "geochemical" tool, which includes natural gamma spectral (NGT), high-temperature lithodensity (HLDT), compensated neutron porosity (CNT-G), aluminum activation (AACT), and gamma-ray spectroscopy (GST) modules. The GST module uses a pulsed source of 14 MeV neutrons to activate elements in the formation, producing gamma rays with diagnostic energies that are spectrally analyzed downhole. A californium source provides low-energy neutrons for the compensated neutron (CNT-G) and aluminum activation (AACT) measurements. The tool also car-

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[2] Shipboard engineering and scientific parties are as given in the listing of participants preceding the contents.

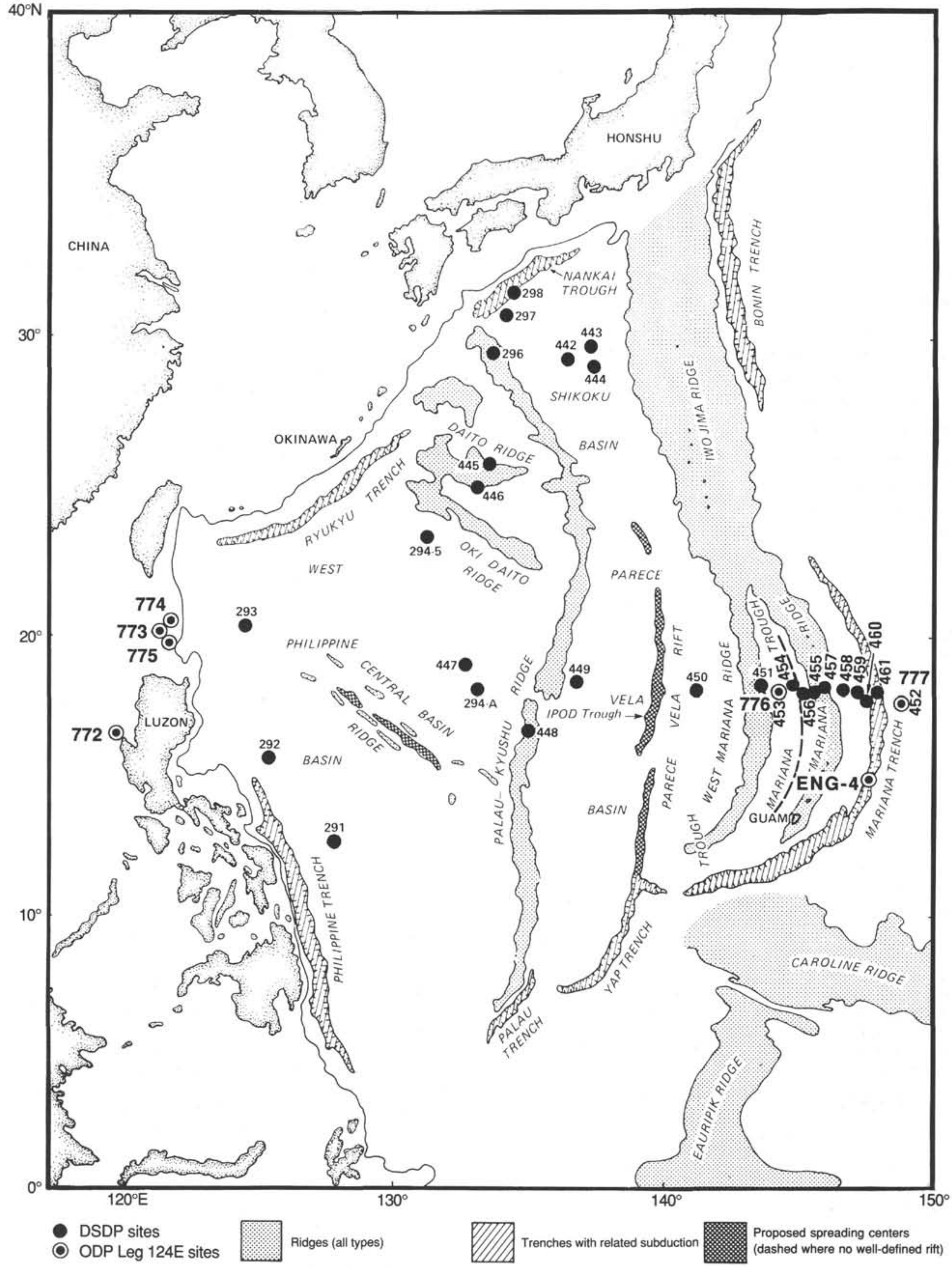


Figure 1. Map of western Pacific region showing DSDP sites and ODP Leg 124E sites. Adapted from Hussong et al. (1982, Fig. 1).

ries a GPIT cartridge for measuring vertical accelerations of the probe caused by ship's heave and winch-speed variations. The objective of the Leg 124E test was to determine whether this large assembly of nuclear-measurement devices could be run without interference with one another, particularly with regard to the HLDT module, which had not been run in this combination string before.

3. Tests of the redesigned TAM International wireline packer. Previous attempts to run this tool were unsuccessful because of downhole motor problems experienced in the land testing in late 1988.

4. Initial sea trials of the new miniaturized Schlumberger formation microscanner (FMS). This tool is a high-resolution dipmeter that produces an image based on electrical-resistivity variations around the borehole. The FMS tool was not available for testing on previous legs.

5. Calibration, reevaluation, and upgrading of the LDGO wireline heave compensator (WHC). On previous legs the WHC appeared to overcompensate for ship's heave in calm seas, introducing more motion at probe level with it turned on than turned off. The Leg 124E tests were designed to examine that problem and to correct it if possible.

6. Tests of techniques for cooling the borehole fluid near a logging tool by running the logging line through the sidewall-entry sub (SES) well above the bottom of the pipe string, then pumping seawater down the pipe after the tool has been lowered out the bottom of the pipe. Logging would then be accomplished by raising both pipe and logging tool while continuing to pump cold seawater out the bottom of the pipe. Pumping would be unavoidably interrupted when a stand of pipe is removed from the top of the string after the probe and the pipe have been raised the length of one stand. Leg 124E tests were planned to monitor probe temperature during these intervals as well as during logging to reveal problems and to evaluate the effectiveness of the technique.

7. Further tests of the LDGO magnetic tool (three-axis magnetometer and susceptibility combination) were planned, time permitting. Initial tests of this tool on Leg 118 indicated a problem with the susceptibility-measuring coil, causing the signal to be buried in noise. Leg 124E tests were planned to determine whether this problem had been corrected by installation of a new coil.

The sea trials of the wireline packer and the FMS were canceled prior to the beginning of Leg 124E because of problems in these systems that were revealed by land tests. Tests of the LDGO magnetic tool were also shelved because of time constraints resulting from delays in the transit from Site 775 to Site 776 because of high winds and rough seas.

## OPERATIONS

### Site 776

One day into the transit to Site 776 the weather into which the *Resolution* was heading began to pick up considerably. The *Resolution* was sailing almost due east on a course of 092°. The wind into which the ship was sailing was out of the east-northeast, and by 1 February the winds had increased from 12–15 to 35–40 kt, and seas from 7–9 to 12–14 ft, with swells of 18–20 ft. The vessel was taking water over the bow much of the time, and the motions averaged a 5°–6° roll and a 3°–4° pitch. At times the revolutions of the main shafts had to be decreased by 5–8 rpm because of the pitching motion. The rough weather not only took its toll on the crew, but it also severely limited the amount of outside welding and maintenance work that could be done. The maximum wind gusts recorded during the transit were 48 kt, with maximum sustained winds of 39 kt. For the total transit of 1345 nmi, the ship averaged 8.5 kt, but at times the speed was as low as 7.6 kt. The voyage from Site 775 to Site 776 consumed 1.8 days of extra time and ranks as one of the roughest transits that the *Resolution* had made during the first 4 years of ODP operations.

The *Resolution* arrived at Site 776 at 1845 hr on 31 January and headed directly for former DSDP Site 453 (also ENG-2 site) at a location of 17°54.40′N and 143°40.95′E (all times given are Universal Time Coordinated or UTC). Upon our arrival, the global positioning system (GPS) was receiving only two satellite transmissions, and so being certain of our exact location was somewhat doubtful. The 12.0-kHz transducer mounted in the sonar dome was receiving a good record, and the east and west canyon walls of the locality were clearly evident. Site 776 lay on a flat expanse between the canyon walls. Even with fair GPS, it was decided to drop the first beacon and begin to run drill pipe and wait for better GPS information, since the pipe trip to bottom would be 10 hr. The weather was still rough upon our arrival at the site, and it was not possible to begin to move drill collars onto the casing hatch and measure them in preparation for picking them up to the drill floor. A releasable Datasonics beacon was chosen, which was dropped at 2250 hr, after the thrusters and hydrophones had been lowered.

Operations at Site 776 were dedicated to running borehole logs and conducting downhole experiments. A total of 5 days of logging had originally been allocated, but that time had to be cut by 1.9 days because of the longer transit time and after a reassessment of the actual time that would be required to drill the hole to 605 mbsf. No coring had been planned, as DSDP coring at the site had reached a TD of 605 mbsf in igneous breccias with an average recovery of 39%, and, moreover, because of the time constraint.

The bottom-hole assembly (BHA) was made up to a tri-cone drill bit. The BHA consisted of fourteen 8.25-in. drill collars and one 7.25-in. drill collar, and also included a bumper sub just under the top stand of drill collars. The total BHA length was 203.08 m, including two stands of 5.5-in. drill pipe. The precision depth recorder (PDR) reading from the underway-geophysics lab was 4713.4 m, corrected. At 0030 hr on 1 February, the GPS was improving, and it was determined that the first beacon was 1.7 nmi from the coordinates of DSDP Site 453. A second releasable beacon was dropped at 0330 hr, and the final position was occupied.

Prior to spudding Hole 776A, a detailed drilling plan had been worked out after looking at the drilling results of the *Glomar Challenger* at Site 453 and the lithology described in the DSDP volume for Leg 60. The results prepared by the DSDP drilling superintendent indicated that the sediment overlying basement would conceivably drill as fast as we wanted it to. Also, the coring results of Hole 453 showed that penetration rates in the basement slowed to an average of 4.5 m/hr through sections of possible talus of igneous rocks, breccias, and deeper metamorphic rocks. The description of basement rock definitely was not very encouraging in terms of both drilling rate and hole stability.

The ODP plan was to control-drill the upper sediment section, making sure to clean the hole of drill cuttings so as not to allow them to load up in the annulus. The fact that, even after drilling the hole, the drill string would be left stationary for at least 3 days was a major disconcerting operating factor. The drilling record of Site 453 indicated hole bridging and caving over time. The drilling curve for the sediment was plotted at 50 m/hr for drilling, and, at the same time, cleaning the hole. The basement part of the curve had a penetration slope of 5 m/hr. Reasons for our optimistic thought of outdrilling the *Challenger* were (1) not having to core, and (2) having better drilling equipment—i.e., heave compensator, top drive, and mud pumps.

### *Hole 776A*

Hole 776A was spudded at 0850 hr on 1 February, and the hole was drilled to 5011.44 mbrf in the first 6.75 hr for an average rate of penetration (ROP) of 44 m/hr. Ten barrels of high-viscosity mud was pumped on every connection for hole cleaning. At 5011.44 mbrf a short trip was made up to 4863.68 mbrf, with no fill encountered when back on bottom, and a maximum drag in and out of 10,000 lb. Another 6.75 hr was required to drill ahead to 5146.96 mbrf. A hard spot was hit at 5145.5 mbrf (432 mbsf), and it was thought that basement at Site 776 was 23 m higher than at DSDP Site 453. At the 5145.5-mbrf depth, 45 bbl of 80-viscosity sweep mud was circulated. Following another short trip back to 4863.68 mbrf to check for hole swelling, 19 m of fill was found upon returning to bottom. The next 15.5 hr of drilling in apparent basement yielded an average ROP of 4.8 m/hr to a depth of 5221.48 mbrf. At 1900 hr on 2 February a short trip back to 400 mbsf was made, and a ledge was encountered at 412 mbsf. Upon running back in, tight hole was found from 5183 to 5220 mbrf. The 37-m interval was reamed back through, and two 40-bbl pills of mud were spotted in the hole. Drilling continued to 5224.4 mbrf, and on the next connection another tight spot had to be worked back through from 5218 to 5224.4 mbrf. A total of 8.75 hr was required to drill ahead from 5224.4 to 5245.85 mbrf, or an average ROP of 2.45 m/hr. The depth at that point was 532.45 mbsf (TD), with apparent penetration into basement of 100.35 m. Since further penetration into basement would have been extremely slow, the ODP operations superintendent decided to terminate drilling and proceed with logging of the hole. The LDGO representative also agreed that 100.35 m of basement would be the minimum amount that would be acceptable, and, in the face of the reduced time for logging, that drilling should be terminated. Another convincing factor was that 30 min had been required to get unstuck just above bottom during drilling with the last single joint, which reached the 5245.85-mbrf depth.

Just after displacing the hole with 11.0 ppg mud for logging, the drill pipe became stuck at what was thought to be 5233-mbrf depth. As though stuck pipe were not enough of a problem, at 1200 hr on 3 February the beacon signal was becoming considerably weaker, and the dynamic-positioning operator advised that another beacon needed to be dropped. The stuck pipe was pulled and worked from 1300 hr until 2230 hr, with a maximum overpull of 130,000 lb available for use. At 1515 hr the shifting tool was dropped in order to drop the bit to see if the pipe was perhaps only stuck at the bit. While none of the ODP or Underseas Drilling, Inc. (UDI) personnel were hopeful that was the case, it had to be tried. When excessive backflow of the pipe was observed at the rig floor, it was certain that the bit had been released and the pipe was still stuck. The high risk of drilling through 400+ m of loose and unstable sediments had once again taken its toll.

The first severing charge was assembled and run in the pipe at 2230 hr, and the charge detonated at 0110 hr on 4 February. The charge was placed in the second joint of 5.5-in. drill pipe above the 7.25-in. drill collar. The ideal place to have exploded the charge would have been in the bumper sub, but the sub was closed. Tension of 100,000 lb of overpull was held in the pipe while the shot was made, and, while we received positive indication of detonation, the pipe did not come free. While the second severing charge was being rigged up, the drill pipe was worked during the time that the logging line was withdrawn. The spot picked by the ODP operations superintendent for shooting the second charge was 17 m higher than the point at which hole problems were experienced while drilling DSDP Hole 453 at 160 mbsf.

The first shot fired had been an 84-pellet shot, which is designed to produce enough energy to sever an 8.25-in. drill collar. The next try, in the 5.0-in. drill pipe, was a 31-pellet charge. With 160,000 lb of tension held on the pipe, the drill pipe came free almost immediately.

Previous conversations with the LDGO representatives about the amount of usable hole left had helped to make our decision to pull the pipe clear of the seafloor an easy one. The logging experiments had been aimed at the basement objective, and, since that was not now possible, the LDGO representatives said that logging through the pipe hanging in the water column was as good as anything the upper hole could provide, so the pipe was pulled clear of the seafloor at 0930 hr and left hanging 319 m above the seafloor.

Logging began at 1000 hr, and the "quad-combo" tool was run in the pipe at 1030 hr to a TD of 600 mbrf. Because of an apparent malfunction of the sonic module, the tool was out of the pipe at 1215 hr. A second run of the same tool was made from 1310 until 1515 hr, and the problem was traced to air in the upper 600 m of pipe.

The next logging run was with the geochemical tool (also used for wireline heave-compensator tests) and took from 1730 until 2315 hr. During this period, one of the UDI roughnecks fell off the drill-collar rack while hammering up a lift nubbin and suffered a severely sprained and dislocated ankle and foot. Since we were only another day at most from pulling the pipe and moving on to the ENG-3 site (DSDP Site 452; ODP Site 777), it was decided to rig down from logging and to attempt to evacuate the injured man to the island of Saipan for proper treatment so no permanent damage to the foot would be sustained. The detour to rendezvous with a boat operating out of Saipan was arranged by a call to the ship's agent in Guam.

## LOGGING RESULTS

Loss of the hole at Site 776 made it impossible to run most of the logging experiments scheduled for Leg 124E, and we were left with a minimal program of testing inside the 4700 m or so of drill pipe that was left above the seafloor after shooting off and pulling out of the hole. This completely eliminated the cooling-by-pumping tests and limited the testing of the "quad-combo" and geochemical tools to checking the new configurations for downhole hardware compatibility and data-acquisition problems. The presence of the pipe invalidated the electrical-resistivity measurements made by the DITE module, and the fact that the pipe was surrounded by seawater instead of formation limited the validity of the nuclear measurements of the GST, CNT-G, AACT, and NGT modules, making these tests inconclusive with regard to tool performance in an open hole.

The qualitative tests of the quad-combo tool indicated that all measurements were reasonable, considering that they were made inside drill pipe, except for those made by the sonic module. Although the transmitters and receivers appeared to be working, the digitized waveforms were weak and very low in frequency, and the reciprocal velocity, which should have been 57 $\mu$s per foot in the pipe, was not picked properly by the data-acquisition system. After the in-the-pipe tests were completed, we tested the sonic module alone, separated from the other sections of the quad-combo, and to our surprise we found that it was working perfectly. A "post-mortem" of the sequence of events prior to the logging tests in the pipe revealed that the upper 600 m or so of pipe was filled with air, not water, during the tests, and that the apparent failure of the sonic module was due to the lack of fluid to conduct the compressional wave from the sonic transmitters to the wall of the pipe and back to the receivers on the tool.

We believe that air filled the upper section of pipe as a result of the following circumstances. Before the hole caved and the drillers attempted to free the stuck pipe, a slug of heavy mud (11 lb/gal) was pumped down the pipe. After the pipe was shot off, it was pulled up and opened for logging. Opening the pipe allowed the slug of heavy mud to sink, pulling air in behind it, and lowering the fluid level to perhaps 1300 mbrf initially. After some of the mud ran out the bottom of the pipe, the fluid level returned to an equilibrium level of 600 mbrf as indicated by the wireline heave-compensator tests. All of the tests of the quad-combo and geochemical tool were made above 600 mbrf in the pipe without our realizing that air had filled this interval at the time.

Tests of the new geochemical-tool configuration indicated that all modules were reporting qualitatively valid data, and that the new acquisition software was operating successfully. However, because the measurements were made in pipe, the results were not quantitatively significant in terms of tool performance in an open hole.

The only logging experiment that was not significantly degraded by the presence of pipe and lack of open hole was the wireline heave-compensator test. We used the geochemical tool with the GPIT module near the top of the string to measure and record downhole accelerations of the tool at various depths from 90 to 2000 mbrf. Seas were low to moderate, causing ship's heave to range from 1 to 3 m, with maximum accelerations of about 1 G $\pm$ 0.7 m/s$^2$ measured with an accelerometer located amidships in the hull. Downhole vertical accelerations measured by the GPIT (with the heave compensator turned off) ranged from 9.1 to 10.5 m/s$^2$. In addition to the acceleration measurements, we were able to correlate the downhole acceleration with the surface wireline-tension measurements, which should make further study of phase, optimum logging speed, and vertical resolution possible. Prior to the tests in the pipe, we were successful in curing problems of erratic behavior and overcompensation by the wireline heave-compensating system, problems that were noted on previous legs.

## SUMMARY AND CONCLUSIONS

Drilling and logging at Site 776 were plagued with problems, as they were on DSDP Leg 60, at Site 453, the same site (Shipboard Scientific Party, 1982). Loss of the hole made it impossible to obtain logging data from the two new Schlumberger combination tools—the quad-combo and the geochemical tool with its high-temperature lithodensity module. It was only possible to make minimal tests of the qualitative performance of the new hardware and software in the drill pipe after the pipe was shot off and pulled up above the seafloor. These tests indicated that the new configurations worked successfully without any apparent interference between the nuclear modules. Hole cooling-by-pumping tests were not possible lacking a hole in hot rock.

The wireline heave-compensator tests were made successfully in the pipe from 90 to 2000 mbrf, and these measurements probably were just about as useful as measurements in an open hole would have been. Data obtained included heave-induced acceleration of the ship measured by an accelerometer in the hull, acceleration of the Schlumberger geochemical tool measured by the GPIT module near the top of the tool, and line tension measured at the logging winch. Results will be analyzed to determine optimum settings of the wireline heave compensator and optimum logging speeds.

### REFERENCES

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**Ms 124E-117**