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10. SITE 870[1]

Shipboard Scientific Party[2]

HOLE 870A

Date occupied: 16 May 1992

Date departed: 16 May 1992

Time on hole: 10 hr 45 min

Position: 11°20.829′N, 162°15.788′E

Bottom felt (rig floor, m; drill-pipe measurement): 49.8

Distance between rig floor and sea level (m): 11.17

Water depth (drill-pipe measurement from sea level, m): 38.6

Total depth (rig floor, m): 50.0

Penetration (m): 0.2

Number of cores (including cores with no recovery): 1

Total length of cored section (m): 0.20

Total core recovered (m): 0.19

Core recovery (%): 95.0

Oldest sediment cored:
Depth (mbsf): 0.2
Nature: Bioclastic sand and gravel
Age: Holocene
Measured velocity(km/s): Not measured

HOLE 870B

Date occupied: 16 May 1992

Date departed: 16 May 1992

Time on hole: 6 hr 45 min

Position: 11°20.833′N, 162°15.775′E

Bottom felt (rig floor, m; drill-pipe measurement): 48.7

Distance between rig floor and sea level (m): 11.17

Water depth (drill-pipe measurement from sea level, m): 37.5

Total depth (rig floor, m): 80.0

Penetration (m): 31.3

Number of cores (including cores with no recovery): 3

Total length of cored section (m): 31.3

Total core recovered (m): 0.41

Core recovery (%): 1.3

Oldest sediment cored:
Depth (mbsf): 31.3
Nature: Coral debris
Age: Holocene
Measured velocity(km/s): Not measured

Principal results: Site 870 (proposed Site Ane-1) was drilled at 11°20.83′N, 162°15.78′E, in the lagoon of Anewetak Atoll in the Marshall Islands. The main purpose for drilling at this site was to test the shallow-water station-keeping and drilling capabilities of the *JOIDES Resolution*. Because this was an engineering test, scientific goals were considered secondary; nevertheless, the Shipboard Scientific Party hoped that core could be retrieved from the upper 100 mbsf of this modern atoll to provide contrast and comparison with Cretaceous shallow-water carbonates drilled at other Leg 143 sites.

Station-keeping and positioning tests provided valuable insights about handling the drill ship in shallow water having variable currents. The taut-wire system was able to hold the ship on position for a period of hours, although an abrupt change in current speed and direction caused an unacceptable excursion at one point. Changing the ship's heading by small angles caused insignificant pipe-angle deflections, but heading changes of 45° created deflections of 5° to 7°. A modified deep-water beacon was tried as a back-up position reference, but it saturated the hydrophones. In addition, the taut-wire tugger-winch was damaged by stress on the taut-wire arm at high wire angles. Overall, the positioning tests were successful and indicated areas where improvements could be made.

Drilling at Site 870 produced little core material. Two holes were drilled, Hole 870A, which consists of one incompletely extended APC core, and Hole 870B, which consists of three XCB cores. Hole conditions were unstable, probably owing to loose sand, and eventually caused drilling to be terminated. In all, 0.6 m of material was recovered from 31.5 m of coring. Most of the recovered material consists of hard coral fragments.

BACKGROUND AND SCIENTIFIC OBJECTIVES

Site 870 (proposed Site Ane-1) was drilled at 11°20.83′N, 162°15.78′E at the south edge of the lagoon in Anewetak Atoll, in the Marshall Islands. (Note: this position was determined by averaging several dozen GPS satellite fixes. Radar fixes to the islands gave a position of 11°21.1′N, 162°16.5′E, a difference of 0.8 nmi, suggesting that island map coordinates are inaccurate). The purpose of drilling at this site was to test the shallow-water drilling and positioning capabilities of the *JOIDES Resolution* because proposed scientific problems and future ODP legs stand to benefit from the development of this capability. Drilling mainly consisted of an engineering test; scientific goals were secondary. Nevertheless, we hoped that test coring might produce samples of scientific value.

Anewetak lagoon was chosen as a test site because it has been extensively surveyed as a result of nuclear bomb tests, thus its geology and topography are well known. This lagoon was also near Leg 143 sites, so that transit times to and from the site were short. Although an area near seismic control lines was chosen for the drill site, the actual location was determined by water depth and safety factors. Lest a failure in the positioning system occur, the Captain was concerned that the ship be in an area devoid of shoals. A spot near the south pass of the atoll (Fig. 1), in water 38.6 m deep, was chosen for the drill site.

Geologic Background

Anewetak Atoll consists of a Cenozoic reef-carbonate platform resting upon a basaltic foundation having an ^{40}Ar–^{39}Ar whole-rock date of 76 ± 1 Ma (Lincoln et al., in press). The carbonate platform

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

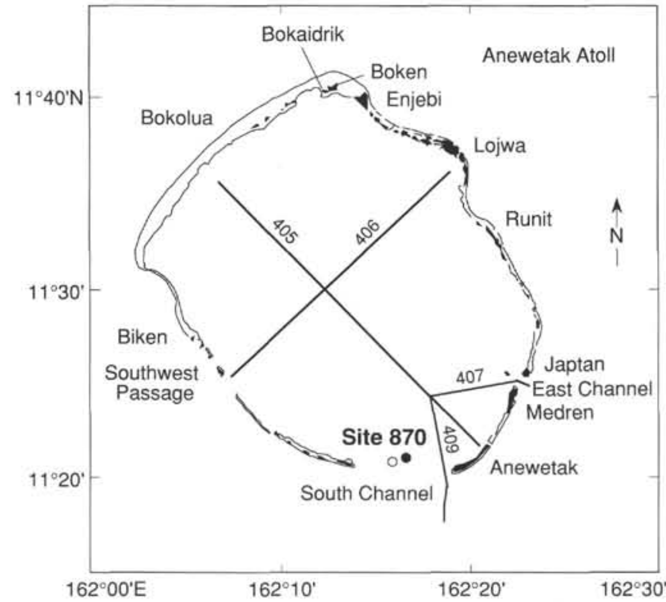

Figure 1. Location map of Anewetak Atoll, showing locations of USGS seismic Lines 405, 406, 407, and 409 (Grow et al., 1986). Filled circle shows location of Site 870. Note: Site 870 has been plotted in its correct configuration relative to the islands, as determined by radar fixes and triangulation. GPS location, plotted on map as open circle, has been offset from actual position relative to islands, probably indicating inaccuracy of the map coordinate system.

has been drilled extensively to reveal Eocene-age shallow-water carbonates above basement (Schlanger et al., 1963). Much work has been done on the shallower part of the carbonate section, which shows a series of solution unconformities caused by atoll-wide emergence events tied to variations in relative sea level (Henry et al., 1986; Ludwig et al., 1988; Quinn and Matthews, 1990; Wardlaw and Quinn, 1991). In the upper 371 m of the atoll, nine major disconformities have been recognized, six of which are within the Pliocene–Pleistocene (Wardlaw and Henry, 1986).

Drilling Objectives

Two test holes were planned at Site 870, one 100-m hole to test the APC/XCB coring system and a 50-m hole to try the RCB system. The shallower hole would have penetrated into the middle-Pleistocene and the deeper one, into the upper Pliocene (Wardlaw and Quinn, 1991). Scientific drilling goals were (1) to sample young lagoonal facies sediments for comparison with Cretaceous sediments from similar settings drilled during Leg 143 and (2) to examine isotopic, age, and diagenetic trends for comparison with world-wide sea-level curves. Our engineering objective was to test the station-keeping ability of the drill ship in shallow water, at different headings relative to wind, waves, and currents. In addition, holes were to be drilled to test drilling and coring capabilities in very shallow water.

OPERATIONS

Transit to Site 870

After logging operations were finished at Site 869, the drill string was pulled from the hole and secured on deck at approximately 0700 UTC, 15 May. We began steaming to Anewetak Atoll, 136 nmi (252 km) to the west, profiling with the magnetometer, 200-in.^{3} water gun, seismic streamer, and 3.5- and 12-kHz echo-sounders. The magnetometer and seismic gear were operated until the ship was about 8 nmi (15 km) from the atoll. The transit took approximately 15 hr, and we arrived at the east passage at 2200 UTC, 15 May.

Site 870

Station-keeping Tests

Because the primary purpose of drilling at Site 870 was to test the shallow-water station-keeping ability of the *JOIDES Resolution*, no specific site in the lagoon was targeted for drilling. Bathymetric charts indicated that the south side of the lagoon was shallowest and has the fewest coral heads, so that area was chosen for the drill site. The ship sailed slowly through the lagoon until a suitably shallow spot was found that had a sufficiently large radius of clear water surrounding the ship to provide a reasonable margin of safety. The location chosen for Site 870 is about 1 km inside the South Pass, approximately midway between Anewetak and the island bordering the west side of the pass (see Fig. 1) in water 38 m deep.

As the ship slowed to begin positioning, the #1 ASK (dynamic positioning) computer failed, and the one remaining back-up was pressed into service. Thrusters were lowered at 2330 UTC, dynamic positioning assumed control, and the ship was turned into the wind on a heading of 090°. The taut-wire position sensor was lowered with a 2-drum anchor (2000 lb) at 2355 UTC. The ship was stabilized on the taut-wire by 0158 UTC, 16 May, as ASK gains were adjusted. The ASK system was found capable of holding location to 3% of the water depth along the fore/aft axis and 4% along the athwartship axis. During this phase of the test, the current averaged about 0.5 kt, but was highly variable in strength and direction, presumably owing to the site location near the South Pass.

A shallow-water beacon having a low-power, wide-angle signal was considered as a back-up for the taut-wire system because the ship could temporarily position on the beacon should problems arise with the taut-wire system. A shallow-water beacon was not aboard the ship, so a Datasonics 354b beacon (18.0 kHz, with S/N of 750) was modified with a 12-V battery to give a 195-dB signal. It was dropped at 0158 UTC near the taut-wire. The signal proved too strong and saturated the hydrophones, so the beacon was retrieved at 0300 UTC.

Testing resumed on ASK performance until 0530 UTC, when a test was run to examine the effect of turning the ship around the taut-wire sensor, as if positioning for changes in current and wind direction. This test was important because the taut-wire system measures line angle using a linear angle proportioner (i.e., not using a trigonometric calculation), so wire-angles in excess of about 20° will have a significant error in angular measurement. A length of 5.5-in. transition pipe was run to the sea bed at 49.8 mbrf (38.5 mbsl), and a heading-change test was conducted while the ship turned 70° to starboard and 45° to port. A 2° pipe-deflection was noted at 30° of the turn and a 5° to 7° deflection was noted at 45° in both directions. Nevertheless, the test demonstrated the ship's ability to change headings using the taut-wire system. Because of excessive torque at high wire angles, the small air-tugger winch on the taut-wire arm broke, showing the need for bracing (these were removed between Legs 101 and 103).

Coring

An APC/XCB bit and bit sub (SBDC) and three drill collars were run, and Hole 870A was spudded at 0830 UTC, 16 May (Table 1). APC Core 143-870A-1H was taken from 0 to 0.2 mbsf, where 0.19 m of coral, carbonate sand, and shell fragments was recovered. The core did not stroke completely and penetration was negligible, so APC coring was terminated. The core was tested for radiation with a Geiger counter and found to be clean.

The ship was moved 5 m north, and Hole 870B was spudded at 1030 UTC with the XCB coring system. Core 143-870B-1X was taken from 0 to 12.4 mbsf with 0.1 m of hard, vuggy coral recovered. At 1245 UTC, the ASK system lost its heading and a yellow caution light was lit (denoting an offset of 10% of water depth). The bit was pulled out of the hole as a precaution. Evidently, the excursion was caused by an abrupt change in current direction and strength around

Table 1. Coring summary for Holes 870A and 870B.

Core no.	Date (May 1992)	Time (UTC)	Depth (mbsf)	Length cored (m)	Length recovered (m)	Recovery (%)
Hole 870A						
1H	16	0830	0.0–0.2	0.2	0.19	95.0
Coring totals				0.2	0.19	95.0
Hole 870B						
1X	16	1030	0.0–12.4	12.4	0.10	0.8
2X	16	1200	12.4–21.9	9.5	0.07	0.7
3X	16	1330	21.9–31.3	9.4	0.24	2.6
Coring totals				31.3	0.41	1.3

slack tide. The ship was quickly repositioned and Hole 870B was reentered by rolling the bit into the washout crater. Cores 143-870B-2X and -3X were taken from 12.4 to 21.3 mbsf with 0.31 m of hard coral fragments recovered. During the drilling of Hole 870B, coring parameters were 5,000 to 10,000 WOB, 40 to 45 rpm, 150 to 300 gpm, and torque of 125 to 150 A. Cores were checked for radiation; none was detected.

Hole 870B was extremely unstable and filled rapidly. It was impossible to clean the hole even momentarily with gel sweeps and high pump rates. The BHA was bumping bottom and jacking the pipe up in the slips when pipe connections were made. The drill pipe bent above the rotary and slapped the rotary when rotation was attempted. Furthermore, the hole tended to pack-off, causing the drill string to stick. Hole conditions were too unfavorable to continue, and the hole was terminated. The bit was pulled clear of the seafloor at 1615 UTC, and the drilling equipment was secured at 1730 UTC, ending Hole 870B operations. During drilling, the taut-wire positioning system kept the ship stable and on location.

As a result of the Anewetak lagoon test, we concluded the following:

1. The taut-wire system is adequate for positioning the ship in water depths of 30 m, with a current strength of up to 0.5 kt;
2. A shallow-water beacon should be tried as back-up position indicator for the taut-wire and should be mounted on a stand (to hold it vertical in currents); and
3. The taut-wire winch must be equipped with rigid braces.

Transit to Majuro Atoll

The ship cleared the South Passage of Anewetak at 1900 UTC, 16 May, to begin a two-day transit to Majuro Atoll, the port call that ended Leg 143. Because of time constraints associated with berth space, it was necessary to transit at high speed. Therefore, no seismic reflection profiling was conducted; however, magnetic and echo-sounder data were collected en route.

SITE GEOPHYSICS

Detailed multichannel seismic reflection studies have been made of the Anewetak Atoll lagoon by the U.S. Geological Survey (Grow et al., 1986). Four seismic lines from this study are shown in Figure 1. Lagoon-wide seismic reflections coincide with major disconformities that resulted from subaerial exposure (Robb et al., 1986; Grow et al., 1986). Seismic profiles near the drill site show a series of essentially flat-lying reflectors, prominent in the upper 1.0 s two-way traveltime (twtt), and fading with depth. Planned drilling at Site 870, with penetration of 100 mbsf or less, could reach only the uppermost reflector, at a depth of about 0.1 s twtt. This horizon marks the top of the Pleistocene (Robb et al., 1986; Grow et al., 1986).

LITHOSTRATIGRAPHY

Core 143-870A-1H consists of white, unconsolidated, bioclastic sand and gravel containing bivalve and gastropod debris (*Murex* and *Trochus*), together with massive and branching corals, benthic foraminifers (including *Homotrema*), plus *Halimeda* and other green algae. Rare black lithoclasts also are present. Core 143-870B-1X comprises yellow to very pale brown grainstone to boundstone. The skeletal components, some of which are encrusted by coralline algae, include bivalve, gastropod, coral, and algal debris. The rock is well cemented. Core 143-870B-2X is also a well-indurated grainstone, very pale brown in color, but in this case, composed dominantly of peloids, with bivalve, coralline algal, and bryozoan fragments. Core 143-870B-3X is represented by a drilling breccia that consists of a broken coral head of *Porites* and possibly *Acropora*, together with cemented burrows.

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* Abbreviations for names of organizations and publication titles in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

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NOTE: For all sites drilled, core-description forms ("barrel sheets") and core photographs have been reproduced on coated paper and can be found in Section 3, beginning on page 381.