Harding, B. W., Storms, M. A., et al., 1990
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18. SITE 777[1]

Shipboard Engineering and Scientific Parties[2]

HOLE 777A

Date occupied: 7 February 1989

Date departed: 8 February 1989

Time on hole: 1 day, 7 hr, 54 min

Position: 17°42.20′N, 148°41.80′E

Bottom felt (rig floor; m, drill-pipe measurement): 5810.5

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

Water depth (drill-pipe measurement from sea level, m): 5800.0

Total depth (rig floor, m): 5860.0

Penetration (m): 49.5

Number of cores: 6

Total length of cored section (m): 48.5

Total core recovered (m): 14.69

Core recovery (%): 30.29

Oldest sediment cored:
Depth sub-bottom (m): 49.5
Nature: red brown clay, claystone, and cherty claystone/porcellanite
Earliest age: Campanian(?)
Measured velocity (km/s): 2.32

HOLE 777B

Date occupied: 8 February 1989

Date departed: 9 February 1989

Time on hole: 15 hr, 42 min

Position: 17°42.20′N, 148°41.80′E

Bottom felt rig floor; m, drill-pipe measurement): 5810.5

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

Water depth (drill-pipe measurement from sea level, m): 5800.0

Total depth (rig floor, m): 5849.6

Penetration (m): 39.1

Number of cores: 5

Total length of cored section (m): 37.2

Total core recovered (m): 38.41

Core recovery (%): 103.23

Oldest sediment cored:
Depth sub-bottom (m): 39.1
Nature: red brown to light brown clay and cherty claystone/porcellanite
Earliest age: Campanian(?)
Measured velocity (km/s): 2.98

HOLE 777C

Date occupied: 9 February 1989

Date departed: 9 February 1989

Time on hole: 7 hr, 42 min

Position: 17°42.20′N, 148°41.80′E

Bottom felt (rig floor; m, drill-pipe measurement): 5810.5

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

Water depth (drill-pipe measurement from sea level, m): 5800.0

Total depth (rig floor, m): 5857.9

Penetration (m): 47.4

Number of cores: 1

Total length of cored section (m): 4.0

Total core recovered (m): 0.84

Core recovery (%): 21

Oldest sediment cored:
Depth sub-bottom (m): 47.4
Nature: cherty claystone/porcellanite; some oxidized volcaniclastic conglomerates
Earliest age: Campanian(?)
Measured velocity (km/s): 3.66

HOLE 777D

Date occupied: 9 February 1989

Date departed: 11 February 1989

Time on hole: 1 day, 16 hr, 36 min

Position: 17°42.20′N, 148°41.80′E

Bottom felt (rig floor; m, drill-pipe measurement): 5810.5

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

Water depth (drill-pipe measurement from sea level, m): 5800.0

Total depth (rig floor, m): 5870.3

Penetration (m): 59.8

Number of cores: 4

Total length of cored section (m): 9.2

Total core recovered (m): 2.36

Core recovery (%): 15.76

Oldest sediment cored:
Depth sub-bottom (m): 59.8
Nature: cherty claystone/porcellanite and chert fragments
Earliest age: Campanian(?)
Measured velocity (km/s): 4.695

HOLE 777E

Date occupied: 11 February 1989

Date departed: 13 February 1989

Time on hole: 2 days, 1 hr, 6 min

[1] Harding, B. W., Storms, M. A., et al., 1990. *Proc. ODP, Init. Repts.*, 124E: College Station, TX (Ocean Drilling Program).

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

Position: 17°41.80′N, 148°41.00′E

Bottom felt (rig floor; m, drill-pipe measurement): 5817.0

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

Water depth (drill-pipe measurement from sea level, m): 5806.5

Total depth (rig floor, m): 5878.5

Penetration (m): 61.5

Number of cores: 2

Total length of cored section (m): 10.5

Total core recovered (m): 0.62

Core recovery (%): 5.9

Oldest sediment cored:
Depth sub-bottom (m): 51.50
Nature: dark brown chert and cherty claystone/porcellanite
Earliest age: Campanian(?)

HOLE 777F

Date occupied: 13 February 1989

Date departed: 13 February 1989

Time on hole: 14 hr, 48 min

Position: 17°41.80′N, 148°41.00′E

Bottom felt (rig floor; m, drill-pipe measurement): 5817.0

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

Water depth (drill-pipe measurement from sea level, m): 5806.5

Total depth (rig floor, m): 5819.5

Penetration (m): 2.5

Number of cores: 1

Total length of cored section (m): 2.5

Total core recovered (m): 2.46

Core recovery (%): 98.4

Oldest sediment cored:
Depth sub-bottom (m): 2.5
Nature: chert and cherty claystone/porcellanite
Earliest age: Campanian(?)

Principal results: Site 777, located in the East Mariana Basin just east of the Mariana Trench, was chosen to coincide with previously drilled DSDP Site 452. This site is known to have an extensive chert layer needed to test the deep sonar source (DSS). The DSS was designed to carry out a localized survey of a sub-bottom surface such as the top of a chert zone.

Engineering tests and procedures were the main objectives at this site. In addition to testing the DSS, techniques for drilling and recovering chert were explored using the navidrill coring system.

The DSS was lowered on a vibration-isolated television (VIT) frame to a depth just above the ocean floor, but after several minutes the "pinger" ceased to work and was retrieved. The data records received, while limited, were of good quality.

Six holes were drilled. Hole 777A was drilled to a total depth (TD) of 49.5 mbsf. The hole was cored with the advanced hydraulic piston corer (APC) for one core and then cored with the extended core barrel (XCB) from Core 124E-777A-2X through -6X, the last core. The drill pipe began sticking, and therefore the hole was abandoned. Hole 777B, 25 m southwest of Hole 777A, was APC-cored for Cores 124E-777B-1H through -4H and then was cored with the navidrill core barrel (NCB) for Core 124E-777B-5N to a TD of 39.1 mbsf. Owing to hole degradation, Hole 777B was abandoned. Hole 777C, 25 m northeast of Hole 777B, was washed for one core and then navidrilled for one core to a TD of 47.4 mbsf. This hole was cleared, and the ship was offset to the northeast for Hole 777D. The first core of Hole 777D was washed, and Cores 124E-777D-2N through -4N were navidrilled to a TD of 59.8 mbsf. After trouble developed with the navidrill this hole was abandoned.

A DSS survey again was attempted but the pinger malfunctioned and drilling was continued. Hole 777E was drilled to a depth of 51 mbsf and then XCB-cored for one core and navidrilled for one core to a TD of 61.5 mbsf. Hole 777F was APC-cored adjacent to the previous hole to confirm the water depth.

These operations demonstrated that the XCB and NCB techniques as they presently exist are not capable of efficient drilling and recovery of core in formations dominated by chert and porcellanite. The XCB cutting shoe is not sufficiently robust to withstand quick abrasion in these formations, and when penetration is achieved, XCB recovery is no better than with standard rotary drilling (RCB). NCB recovery occasionally is more encouraging, but the cores cut at this site are usually jammed in the core catcher after only a small amount of recovery. No soft sediment was recovered below the uppermost layer of chert/procellanite in any of these holes, although some fine-grained chert was recovered that had been pulverized by the drilling process.

The cores were described and curated for the geriatric core study.

One lithostratigraphic interval containing three units was identified. Unit I comprises biosiliceous ooze and clay subunits overlying a nonfossiliferous clay subunit. Unit II, a mottled buff and brown clay, showed a marked change in appearance and physical character. Unit III, a well-lithified mudstone and chert layer, was highly disturbed by the drilling process; the cobble-sized fragments exhibited laminations similar to those of Unit II.

BACKGROUND AND OBJECTIVES

Engineering Objectives

The engineering objectives of Site 777 were multifaceted and open to a great deal of flexibility depending upon the nature of the chert-interbed lithology found or implied by the results of the deep sonar source (DSS) survey as well as the results of the initial coring attempts. The anticipated engineering operations and equipment to be used and evaluated included:

1. Latest generation of the extended core barrel (XCB).
2. Navidrill core barrel (NCB).
3. Coring interbedded chert/sediment to optimize core recovery.
4. Attempting to "spud" a core hole in sediment with chert layers near the surface (with as little as 20–30 m of sediment over the first chert layer).
5. Sonic core monitor.
6. Dipstick tool.

The goals were to test both hardware and operational procedures. The XCB was made ready for Leg 124E in its latest design iteration after having been revamped since field testing during Leg 121. It was intended that the Leg 124E version would get enough downhole time to verify that the system was operational and a significant improvement over previous versions. It was the same in concept as its operational predecessor (-101C version) but provided more flow to the cutting shoe, better control over extension and flow parameters, a greater and more economical variety of cutting shoes, and significant improvements in the strength of several areas of known mechanical weakness, especially the threaded core-barrel connections. All of these problem areas had served to limit the usefulness and range of acceptable lithologies for XCB deployments in the past.

Operational plans for the XCB-124E included intentionally repeated cores in parallel holes through troublesome chert intervals to observe the effects on core recovery of changing coring parameters (weight on bit, rpm, cutting-shoe type, and flow rate). At the same time, wear and breakdown of the XCB coring equipment when the chert became uncoreable would be diagnostic for future engineering and science planning.

The NCB was ready for more sea trials after its first successful deployment during Leg 121. We desired to give the tool as much downhole time as possible both for "wringing out" the basic design and concept as well as for testing its effectiveness as a coring device specifically in chert interbeds. Among the improvements made to the system since Leg 121 were new titanium flex shafts in the mud motors, improved torque-reaction segments, and two all-new mud-motor designs devised by Eastman-Christensen. Both of the new motors were designed to be capable of producing more torque and slightly higher speeds than the best motors previously available in their size range. The motors were fabricated to virtually the same length as previous motors used with the NCB; thus no adjustment to bottom-hole assembly (BHA) was required. Special motor-adaptor crossover subs were made on board the ship to allow the motors to be assembled into the NCB standard assembly. The new motor adaptors ordered from Eastman-Christensen with the new motors did not arrive.

Scientific Objectives

Site 777 lies in the East Mariana Basin just east of the Mariana Trench in about 5800 m of water (Figs. 1 and 2). Lineated magnetic anomalies have been identified as the M24 sequence of approximately the Oxfordian Stage of the Late Jurassic Epoch, so the basement age was expected to be approximately 150 Ma. Site 777 is within a few nautical miles of DSDP Site 452, where 27 m of brown pelagic clay was cored, overlying a chert-bearing zone of Late Cretaceous age. Only two cores were taken at Site 452 in the cherty material before the hole was terminated at 46.5 mbsf. However, it is suspected that the geology of DSDP Site 452 is similar to many other holes that have been drilled in the western Pacific (for instance, DSDP Site 307; Fig. 3), where the cherty material is first interbedded with pelagic clays; this sequence grades down to clays and carbonates, and eventually overlies earliest Cretaceous volcanic basement. Site 777 thus serves as an engineering-test analogue for the drilling and recovery of soft sediments interbedded with chert that exist over an area of the western Pacific equivalent to 60% of the continental United States.

Several major scientific objectives have been proposed for ODP drilling and coring in various areas and geologic environments of the western Pacific. These objectives generally can be grouped into three major subjects: the paleoceanography and paleontology of the Middle to Late Jurassic open ocean, calibration of the magnetic-reversal time scale during the Middle to Late Jurassic, and the seismic stratigraphy of the deep western Pacific basins as influenced by Cretaceous volcanic sequences.

The paleoceanography and paleontology of the Middle to Late Jurassic open ocean is essentially unknown. The only marine environments that have been sampled from this time span are from the just-opening, proto-Atlantic Ocean and the Tethyan Ocean between Europe and Africa. Both these environments comprise restricted circulation systems that are not representative of the major world ocean that covered 70% of the Earth at that time. All that remains of that ocean exists today in the far western Pacific.

The magnetic-reversal time scale has been calibrated back to latest Jurassic time at about M25 of the magnetic reversal pattern. Additional reversals have been identified back to M37 in the East Mariana and Pigafetta basins, whose ages are unknown but presumably range back into the Middle Jurassic. That time has been identified as one of rapid polarity transitions and short polarity intervals, mainly from stratigraphic sequences in Spain and Italy. Attempts to correlate the reversal sequences derived from continental and marine data have proved unsuccessful to date and require time-scale calibration of the oldest marine magnetic-lineation sequences.

The seismic stratigraphy of the western Pacific is difficult to interpret because it contains cherty material and a large amount of volcaniclastic debris, both of middle to Late Cretaceous age. These sediments are highly reflective at seismic-source wavelengths and have been termed the "reverberant layer" or the "opaque layer" in previous studies. They contain a partial record of one of the largest off-ridge volcanic outpourings in geologic history, which originally was termed the Darwin Rise. Their interpretation is critical to our understanding of this enormous mantle overturn and energy release.

Besides these Mesozoic scientific objectives, Site 777 also was the location of one of the two prime sites targeted for drilling and coring on a high-priority proposal for the study of geochemical reference sections. The primary goal of this program is to obtain information on the geochemistry of material being supplied into the western Pacific subduction zones. The geochemistry of erupted lavas of the Bonin and Mariana arcs contain first-order differences that must be accounted for by differences in the geochemical input or in the subduction and remelting processes. In order to isolate the source of this variation, a deep basement-penetration site has been targeted on the Pacific plate just east of each of these island arcs. Site 777 is the location of the Mariana Arc site that is planned for 100 m of basement penetration on an upcoming ODP leg. In addition to the primary goal as a geochemical reference section, this site can be used for studies of eolian sediment transport, paleomagnetic-pole locations for the latest Jurassic Pacific plate, and strain measurements on the portion of the Pacific plate about to be subducted.

The three primary objectives for studies of Mesozoic geology, as well as the primary objective of the geochemical reference section, all require the ability to core through Cretaceous chert zones to Jurassic volcanic basement while recovering a substantial and representative sample of the interbedded soft clays and chalks. These soft sediments contain the datable fossil record of the area as well as the isotopic record of paleoceanographic conditions during the Jurassic and the geochemical input to the subduction zones. Although the ability to drill through the cherty formations was achieved early in DSDP operations, primarily through the use of unslotted bumper subs and roller-cone bits with sealed journal bearings, the soft-sediment recovery problem has remained unresolved.

Site 777 was aimed at attacking the chert drilling and recovery problem in two independent ways. First, a 3.5-kHz sound source was to have been lowered down the outside of the drill pipe on the camera frame (VIT) to approximately 50 m above the seafloor. From this position, the *Resolution* was to have been moved at 0.5–1.0 kt in a gridlike pattern in order to conduct a detailed, near-bottom seismic reflection survey of the upper surface of the chert zone.

Besides a purely scientific investigation of the physical stratigraphy of the chert zone, this survey also was to locate the thickest section of overlying pelagic clays to optimize BHA spudding in the subsequent drilling and coring tests. These tests were to consist of multiple coring attempts in short holes located close (approximately 100 m) to each other and having nearly identical geological sections. Drilling hardware and drilling parameters were to be varied individually at each of these holes and the cored results compared to determine the optimum drilling-hardware/drilling-parameter configurations for subsequent scientific-drilling attempts. These drilling and coring tests are described more fully in the next section on engineering operations.

OPERATIONS

Introduction

At 2130 hr on 6 February, the *Resolution* slowed and deployed the water guns for surveying into the immediate area of

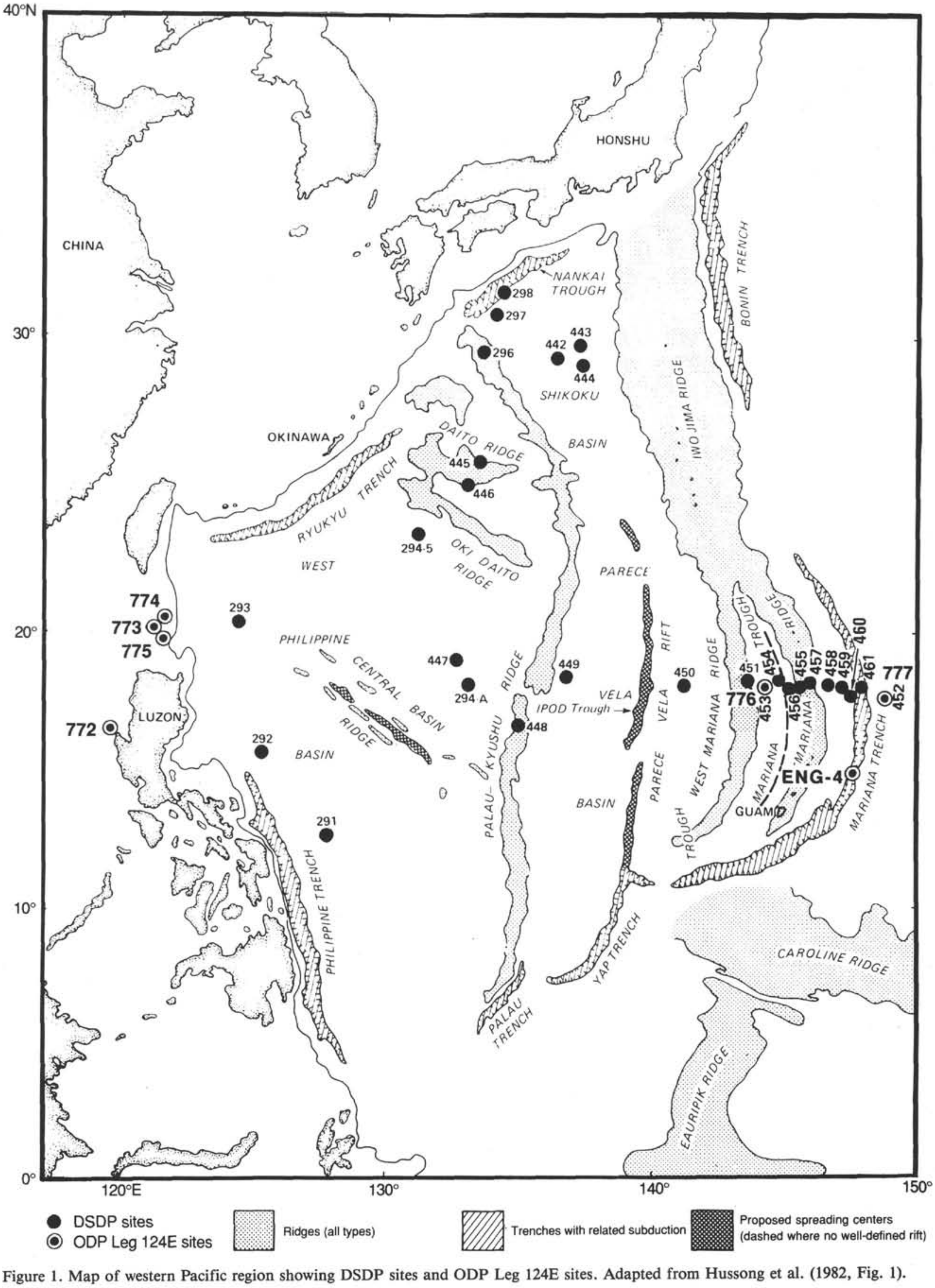


Figure 1. Map of western Pacific region showing DSDP sites and ODP Leg 124E sites. Adapted from Hussong et al. (1982, Fig. 1).

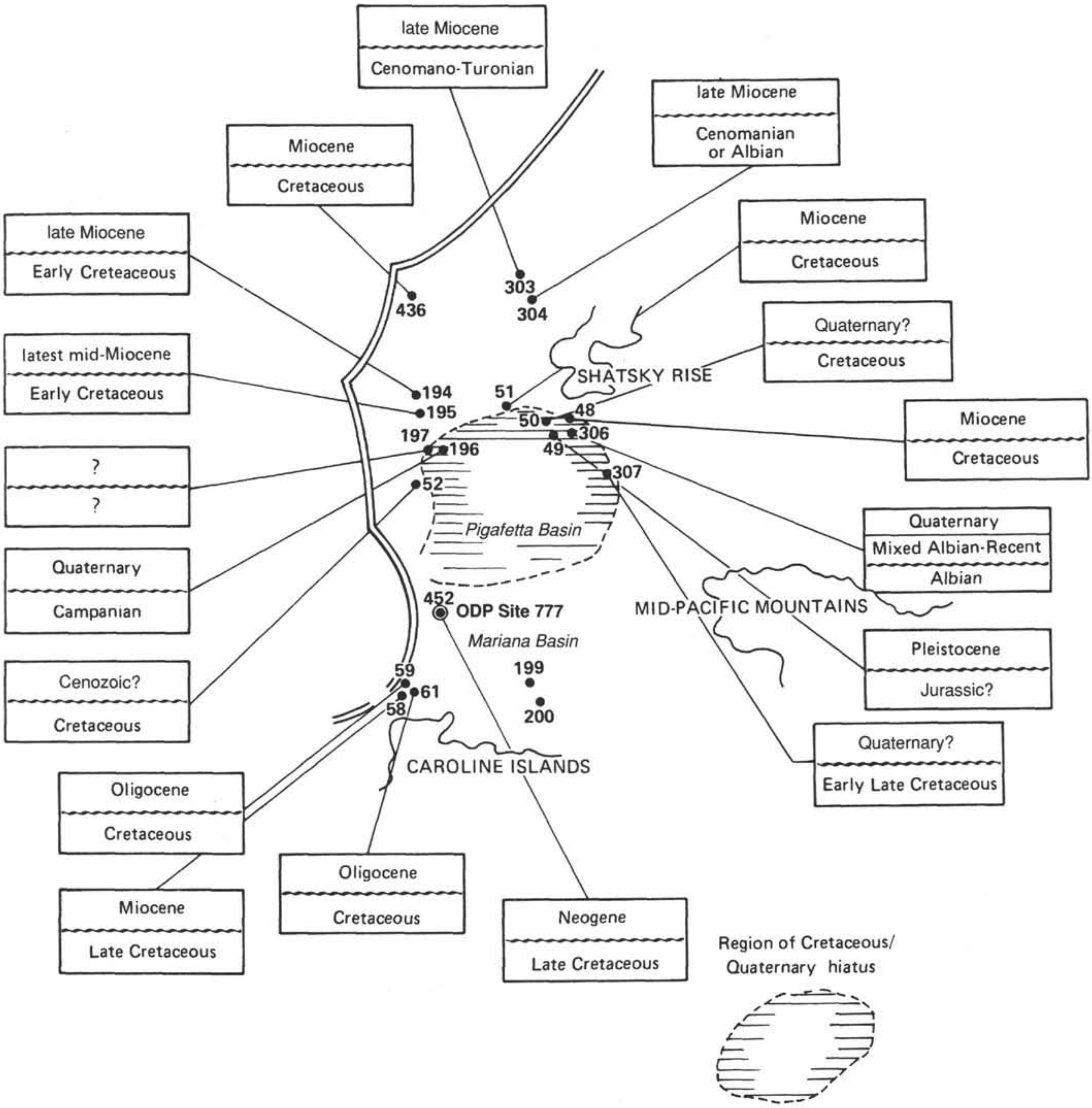


Figure 2. Stratigraphic relationship of DSDP drill sites in the northwestern Pacific. Site 777 is slightly east-northeast of Site 452. From Shipboard Scientific Party (1982, Site 452, Fig. 6).

the ENG-3 site (Site 777 and DSDP Site 452) in order to see if the present survey could be tied to that done by the *Conrad* in 1981. (All times given are Universal Time Coordinated or UTC.) A 17.0-kHz releasable Datasonics beacon was dropped at 0608 hr on 7 February, and the site reoccupied by the vessel immediately (Fig. 1). The BHA was made up at 0710 hr after the thrusters and hydrophones had been lowered and secured.

A 3.5-kHz deep sonar source (DSS) bottom "pinger" had been attached to the VIT camera frame in order to run a bottom survey to see if the expected layers of chert barely drilled into in Hole 452 could be more accurately imaged and displayed on a flat-bed recorder. The VIT frame was installed on the drill pipe once 4138 m of pipe had been run. The corrected precision depth recorder (PDR) reading for the site had been established at 5812.4 m, and the drill pipe was run to 5771.71 m or approximately 1.5 stands off bottom. The VIT frame was left half a stand above the bit, and the survey was begun at 2010 hr on 7 February. After only several minutes, the DSS quit pinging and

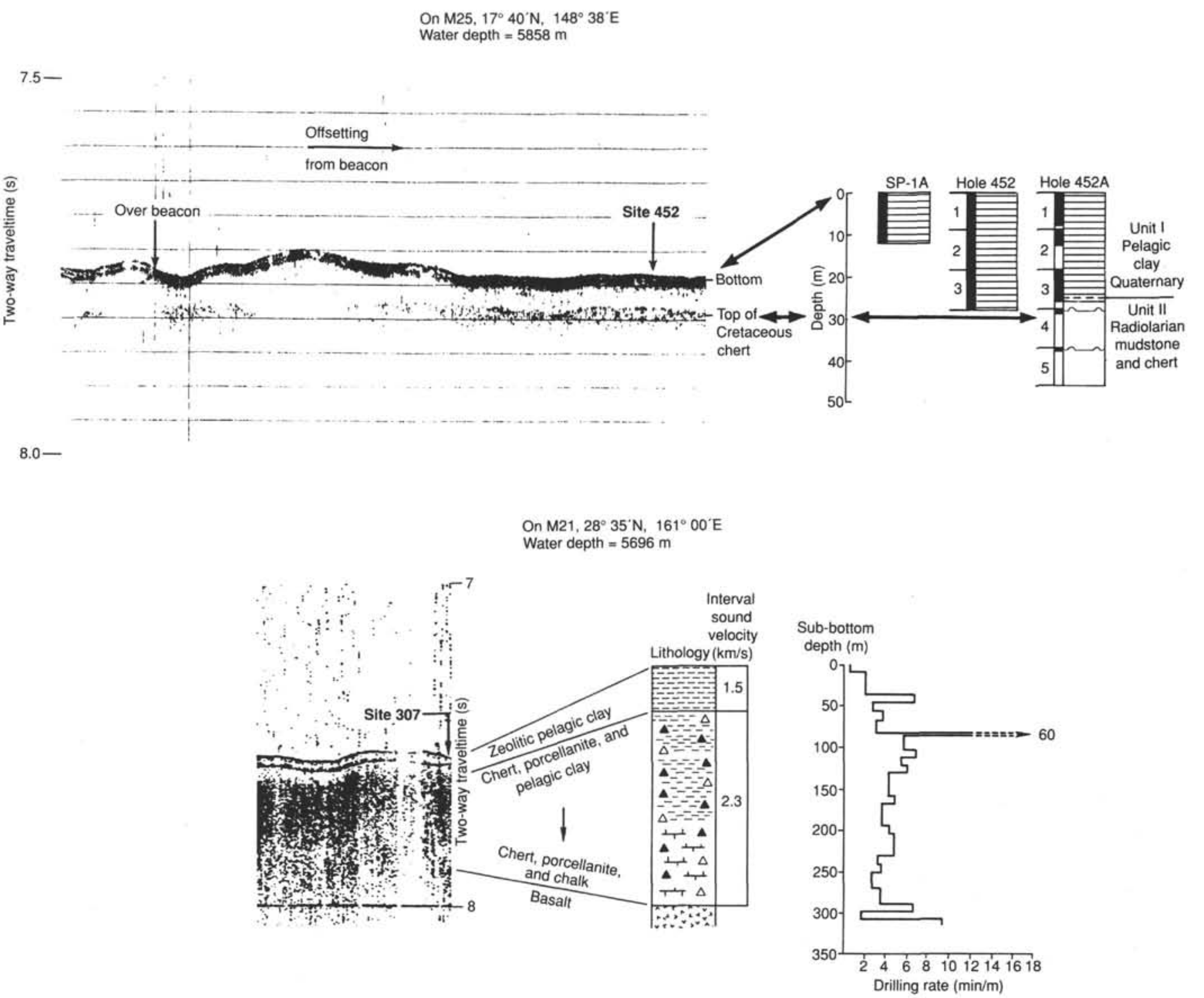


Figure 3. Comparison of stratigraphic/age relationships at DSDP Sites 307 and 452 in the northwestern Pacific. Site 777 is slightly east-northeast of Site 452. From Shipboard Scientific Party (1982, Site 452, Figs. 3, 5; 1975, Site 307, Fig. 4).

needed to be pulled to the surface for repair. After recovery of the VIT and a check of the DSS, it was discovered that a transistor on one of the electronics boards had failed.

Hole 777A

After the VIT was out of the water, the upper guidehorn was reinstalled. The drill string was spaced out, and all was made ready to shoot the first APC core and establish the mud-line depth. Because of a misrun with the GS tool, the pin in the APC failed, allowing the APC to fall. A full core barrel was found upon retrieval; thus the mud line was not determined. Since the thickness of the overlying sediment was not yet known, a switch to the XCB system was made for the second coring run, to be safe. Coring with the XCB continued from 10.5 mbsf to a TD of 49.5 mbsf for Cores 124E-777A-2X through -6X. A 30-bbl high-viscosity mud sweep was pumped, and upon pulling the sixth core we found that 110,000 lb overpull was required to move the drill pipe. Once the pipe was free, the driller immediately pulled out in doubles with the top drive. Having to sever the pipe on two previous occasions made us all wary.

Hole 777B

After pulling clear of the seafloor and retrieving Core 124E-777A-6X, the ship was offset 25 m to the southwest (away from the beacon), and preparations were made to spud Hole 777B. We decided to take four APC cores, based on the lithology seen in the first four cores of Hole 777A. The first four APC cores of Hole 777B obtained 103.3% recovery, as the hole reached 5848.9 mbrf. The first navidrill run then was made, because the hardness of the formation into which the XCB had drilled in Hole 777A had completely effaced two diamond-impregnated cutting shoes. The first NCB run (Core 124E-777B-5N) took 3.25 hr to cut, and the hole was advanced 1.3 m below the barrel. No apparent end of stroke was evident from the strip-chart recorder that had monitored pressure vs. time for the entire run. Upon retrieval of the core, it was quickly discovered that the surface-set cutting shoe that was run had been ground down severely, and that not only the bit crown was gone but also 1.5 in. of the body of the cutting shoe. Since there was now junk in Hole 777B, the pipe was pulled clear of the mud line, and the ship once again offset.

Hole 777C

Hole 777C was drilled 25 m back northeast toward the beacon. We were quite cognizant that we had been operating approximately 3500 ft away from the beacon in 5810.5 m of water and therefore were on the edge of the beacon's cone of good signal. Hole 777C was spudded at 0602 hr on 9 February and washed from the mud line to 5849.28 mbrf. After we retrieved the center bit and pumped a 10-bbl sweep of high-viscosity mud, the first NCB core was cut. Four hours was required to cut this core, from 5853.87 to 5857.87 mbrf. Upon retrieval of the core barrel and motor, we discovered that a diamond-impregnated cutting shoe had been completely destroyed. By this time it was not clear to ODP's engineers whether or not there was a problem with the metallurgy of the cutting shoes or if perhaps the NCB was running with too much weight on bit (WOB). The sizes of the jets in the flow divider had been increased prior to the last NCB run, but now the engineers were really puzzled. The drill pipe was again pulled clear of the mud line, and the ship offset again to the northeast, or closer to the beacon. The recovery in both Holes 777B and 777C was 0.72 and 0.84 m respectively, and in both cases the cores were jammed in the barrel. Also, the NCB strip-chart recorder showed no clear indication of when the jamming might have occurred in the run. Since the NCB run in Hole 777C had revealed a 4.0-m stroke, it was decided to make another run with a slightly different impregnated cutting shoe, and also to vary the drilling parameters of the NCB run slightly.

Hole 777D

Hole 777D was washed to a depth of 5865.6 mbrf, and the hole swept with 10 bbl of high-viscosity mud. The first NCB run was started at 1830 hr on 9 February and took 4 hr to drill from 50.6 to 51.7 mbsf. This core, Core 124E-777D-2N, recovered 0.27 m of porcellanite/chert, and although the core was once again jammed in the core catcher, the cutting shoe had come back worn but in one piece. In an attempt to continue the learning curves both for the NCB and chert drilling, another NCB run was deployed. Core 124E-777D-3N, from 51.7 to 55.8 mbsf, was drilled in only 30 min, and a definite end-of-stroke indication was seen on the recorder. While there was more encouragement about the way the NCB had operated, upon breaking out the barrel only 0.60 m of core was recovered from the 4.1-m advancement of the hole. The formation was definitely getting harder, and the ODP engineers thought that the learning experience was invaluable. Core 124E-777D-4N was dropped down the drill pipe at 0300 hr on 10 February, and again the core took less than 1 hr to achieve full stroke. During an attempt to retrieve the NCB, the RS overshot sheared. Once the wireline was out of the hole, a set of wireline hydraulic jars was made up and run in the hole (RIH) in an attempt to jar the core barrel loose. After 2.5 hr of jarring and working the navidrill without success, the only thing left to do was to drop the Kinley wireline cutter, retrieve the sand line, and pull out of the hole (POOH) with the drill pipe to free the navidrill. The sand line had been cut and retrieved by 1315 on 10 February, and the driller then doubled out of the hole with the top drive until clear of the mud line.

Since the DSS pinger had now been fixed, and another bottom survey with the 3.5-kHz sonar source had been planned, it was decided to run the VIT prior to pulling the drill pipe. Knobby joints were installed in the drill string to cross the guidehorn, and the VIT was installed and run to bottom. The survey was to center on Hole 777D, since previously at 0210 hr on 11 February a second beacon had been dropped owing to a total signal loss from the first beacon. A maximum of 12 hr was to be devoted to the pinger survey for insight into the nature of the chert layers. Once again, shortly after reaching the seafloor with the VIT and pinger, the package developed problems and the VIT frame had to be pulled and troubleshot. Later analysis of the problems with the pinger revealed that an "FET" transistor was malfunctioning and could not be repaired. After the VIT frame was pulled, and the upper guidehorn and rotary-floor equipment reinstalled, the drill-string trip for the NCB was begun. At 0530 hr, the BHA was at the drill floor and being broken down and stood back. Slowly and carefully, different sub breaks were made and components of the navidrill disassembled until, finally, at 0800 hr, the connection at the double-window latch sub revealed that the Belleville springs in the navidrill had become wedged through the window, not allowing the NCB to come free.

Hole 777E

The five-cone XCB bit had only 4.5 rotating hr on it from the first four XCB and NCB holes and was graded 1/3/In, so the same bit was rerun. All the BHA connections were checked upon RIH, and the trip was started at 1000 hr on 11 February. Even with 2.25 hr of rig repair during the trip to bottom, Hole 777E was spudded at 2240 hr and drilled to 51 mbsf. An XCB coring run was next made from 51 to 60.5 mbsf, and 0.41 m of loose hole fill of chert pieces was recovered. The first NCB was dropped at 0245 hr on 12 February and drilled on for only a few minutes before it was discovered that the navidrill did not unlatch and drill. At 0515 hr, while the navidrill was being pulled out of the hole, the sand line parted approximately 1150 m above the rope socket. After we retrieved the sand line at the surface, an in-the-pipe fishing spear was deployed in the hope of snagging the wireline securely enough to pull the wire and NCB out of the hole. Two hours was spent attempting to work the spear past the top of the wire and pull-up to see if the weight indicator showed a weight gain that indicated that the NCB had been caught. At 0730 hr, the fishing attempts had not been successful, and it was decided to POOH with the spear and add a D/P rabbit on top of the spear in order to mash down on the top of the wire to create a snarl with the spear to catch the wireline. When the sand line arrived at the surface, it was discovered that the shear pin in the GS overshot had somehow sheared and that now the spear was in the hole. On the first run back in the pipe with the renewed overshot, the spear was engaged, and after half an hour the NCB and the wire caught and slowly started POOH. The pulling speed coming out with the NCB was held to 30 m/min because it was not known how securely the catch had been made. The spear and NCB arrived at the surface at 1200 hr, and indeed the entire NCB assembly and wireline had been retrieved. The spear was laid down, and the wireline was T-barred out of the hole until enough was on the deck to go over the crown and long-splice onto the forward coring winch drum to pull the entire NCB out. Since the NCB had not unlatched, the barrel had never drilled the formation and was empty. The hole was washed and reamed from 5839 to 5870.97 mbrf, and at 1730 hr Core 124E-777E-2N was dropped.

Hole 777F

In order to confirm the exact water depth at Hole 777E, it was decided to shoot one piston core before recovering the drill string. Hole 777F was shot at 0635 hr on 13 February, and as the wireline was spooled, a line compound was applied to the wire as a preservative. Core 124E-777F-1H was on deck at 0925 hr and recovered 2.46 m of soft brown ooze and mud. The water depth was therefore established at 5817.0 mbrf.

After setting back the top-drive, the drill-string trip was begun. The trip out of the hole was interrupted by two minor separate rig-repair items. The bit reached the drill floor at 2030 hr, and the vessel was under way at that time on 13 February.

Transit to ENG-4 Site

Since the drum of cement that had been poured had not set up enough to drill upon recovery of the drill string, the transit to the ENG-4 site was begun at 2030 hr on 13 February. The first beacon dropped at the site was a recoverable model, and although it could be commanded to turn "on/off," the beacon was not recovered. At 2315, the *Resolution* reduced speed to investigate a problem with one of the six propulsion motors on the starboard shaft. After 1.75 hr of working on the motor coupling, the chief engineer decided to remove the motor from service and to continue with the voyage. The starboard shaft had only five motors driving it, but because of the good weather with little sea or wind, there was little difference in transit speed. Including the downtime because of the propulsion motor, the transit took 18 hr to arrive at the ENG-4 site, with an average speed of 11.4 kt.

ENG-4 Site

Approximately 1 hr was involved in surveying along a course of 160° after crossing the original ENG-4 location at a speed of 5 kt in order to locate a suitable water depth and bottom profile in which to drop the deep-water beacon. Upon slowing to the 5-kt speed, the bottom signal began to come in clearly, and at 1530 hr on 14 February the beacon was launched. The ship was stopped immediately and backed to the spot of the drop. We had estimated that the newly designed deep-water beacon could take as much as 2 hr to fall to the seafloor in this part of the Mariana Trench. During that time the thrusters and hydrophones were lowered, and at the same time on the rig floor the ODP engineers were setting up a test of the NCB's unlatching for drilling a barrel of cement. From 1730 until 2130 hr a positioning test over the beacon was performed by biasing the thrusters against one another. The biasing created artificial noise, since the weather was so mild, and simulated noisier conditions that might be expected to prevail. The result of the test was that at 30% of maximum thruster output, the automatic positioning had to be taken over by joystick control and dead reckoning. The ship's position could be maintained in those cases if the vessel were turned into the wind and seas. The power/water ratio for deep water with the 220-dB beacon and 8176.4 m (26,819 ft) of water was about the same as for the current-style 214-dB beacons used for water depths of less than 20,000 ft. The UDI electrical supervisor also practiced manual control of the dynamic-positioning system in case the Honeywell computer should be lost. The beacon deployed was releasable, but after 1.25 hr of commanding the beacon, we could only turn it on and off, and the release mechanism again was a failure.

The test as a whole was definitely worth doing and was considered a success because of two reasons: (1) the beacons rated to 20,000 ft that ODP currently uses perform marginally at times in water depths beyond 18,000 ft when the weather is rough, and (2) when the day arrives when ODP must really drill in 24,000–27,000 ft of water, then at least one beacon manufacturer has demonstrated capability in building a true deep-water beacon. The only thing that remains unknown is how the beacon will hold up over a 10–12-day hole, as trip time alone from that depth is considerable.

Transit to Guam

The *Resolution* was under way from the ENG-4 site at 2248 hr on 14 February under full power. The trip into Guam was 190 nmi and was anticipated to take 19 hr of transit time. The weather en route to Guam was nearly smooth with virtually no vessel motion, which allowed the final clean-up and painting of the ship to proceed rapidly. One of the navidrill motors had been stored in the "mousehole" on the rig floor since the end of Site 777. When its landing sub was lifted to conduct final flow tests on this motor, it was discovered that the navidrill motor had backed off from its threaded connection to the landing-sub joint and carried away into the Mariana Trench. The agent in Guam had been alerted to the vessel's arrival at the pilot station at 1900 hr on 15 February 1989. The pilot boarded the vessel at 1917 hr, and the first line was passed over to the dock at 2000 hr (0600 hr on 16 February local time), ending Leg 124E.

SITE GEOPHYSICS

Site 777 lies a few kilometers northeast of DSDP Site 452 in about 5800 m of water (Fig. 4). It is positioned very close to *Conrad* 2006 multichannel line 49, which trends east-west across the survey area and was part of the geophysical site survey for Site 452 (Fig. 5). The *Conrad* multichannel seismic (MCS) line and the associated 3.5-kHz record (Fig. 6) both show clear and essentially continuous reflections from the upper surface of the chert zone at 30–50 mbsf. Whereas both sets of reflection data show an essentially continuous chert zone, the 3.5-kHz record indicates that the upper surface of that zone is not flat but contains undulations, and tails of reflection hyperbolas trail down from the surface at numerous places. The 3.5-kHz record also shows most clearly the variable thickness of the sediment overburden above the chert zone.

The multichannel seismic reflection record shows a relatively transparent interval about 100 ms thick lying directly below the chert zone at its closest point of approach (CPA) to Site 777, which may indicate a chert-free interval or may simply be an artifact of the large reflectivity of the chert zone. Beneath this relatively transparent layer are numerous subparallel reflections that have been termed collectively the "reverberant layer" or the "opaque layer" in previous studies. They may indicate more

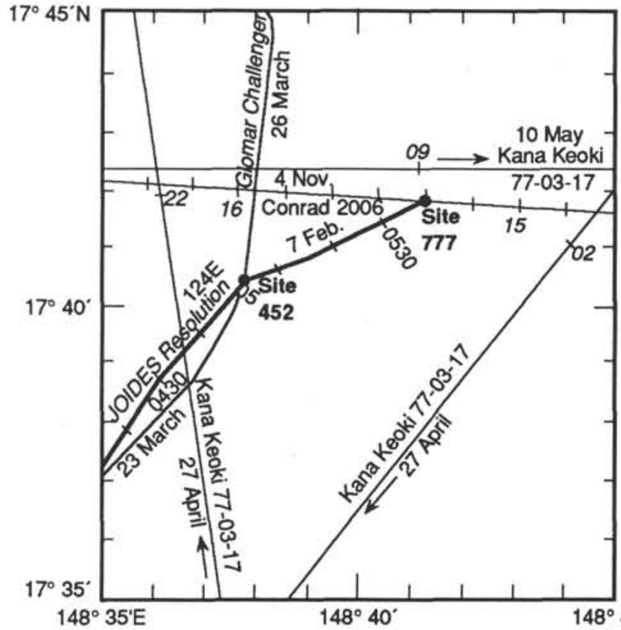


Figure 4. Map showing location of DSDP Site 452 and Site 777 in the East Mariana Basin just east of the Mariana Trench. *Conrad* 2006 seismic data are displayed in Figures 5 and 6. *JOIDES Resolution* seismic data are displayed in Figures 7 through 9.

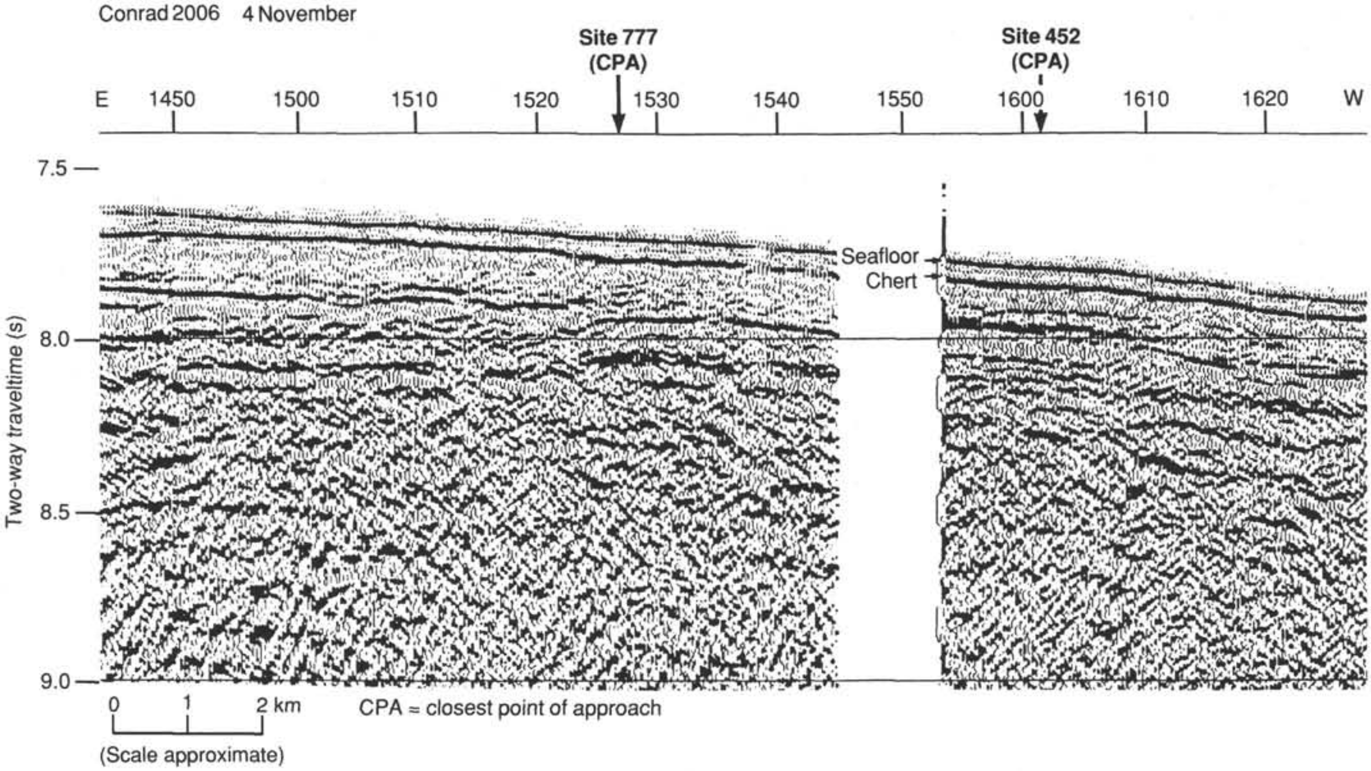


Figure 5. *Conrad* 2006 MCS profile crossing the area in the vicinity of DSDP Site 452 and Site 777. MCS data were collected with two 466-in.^{3} air guns as the sound source. The MCS data display is a 24-channel stack with a normal moveout correction and time-varied gain. The bandpass frequency is 6–40 kHz. The chert zone sampled at both sites shows as a continuous sub-bottom reflection at about 30–50 ms.

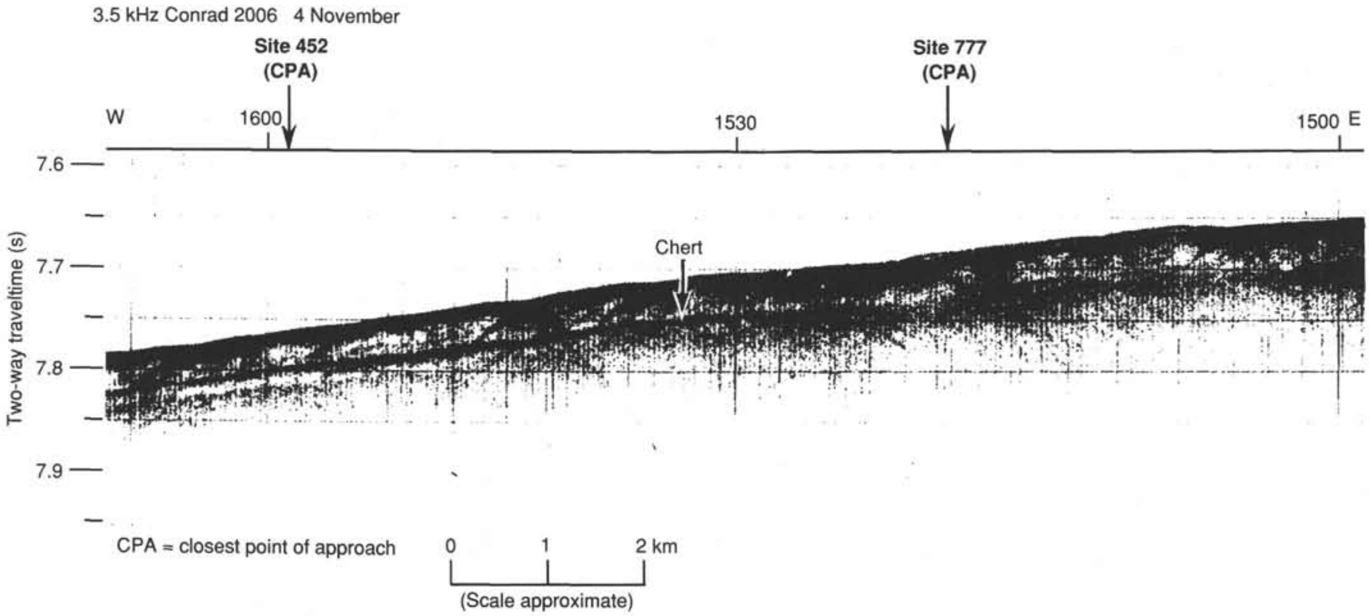


Figure 6. *Conrad* 2006 3.5-kHz echo-sounder profile crossing the area in the vicinity of DSDP Site 452 and Site 777. The chert zone sampled at both sites shows as a nearly continuous but undulating horizon at about 30–50 ms. Note that east and west are reversed relative to Figure 5.

chert zones or volcaniclastic sediments from the middle Cretaceous volcanic event, which are both prevalent over a broad area of the western Pacific. It is also possible that they represent solid basalt flows and sills from the middle Cretaceous volcanic event similar to the material recovered from DSDP Site 461 in the Nauru Basin just west of the Marshall Island chain.

The Site 777 area has been surveyed with numerous total-intensity magnetic-field profiles. The magnetic-anomaly structure is definitely lineated in a northeast-southwest direction, and these anomalies have been tentatively correlated with the M24 polarity sequence of the magnetic-reversal time scale. Such a correlation predicts a basement age of about the Oxfordian Stage of the Late Jurassic, or a radiometric age of about 150 Ma. This correlation is hampered by numerous seamounts in the surrounding area that disrupt the lineated magnetic-anomaly pattern; however, it is part of a larger correlation of the entire M23 to

M37 sequence that extends from the Mariana Trench to about the center of the East Mariana Basin. Drilling to volcanic basement at Site 777 during the upcoming ODP leg dedicated to geochemical reference sections should be a conclusive test of this magnetic-anomaly correlation.

Site 777 was targeted at a location on the *Conrad* 2006 line where basement is not disturbed, and the pelagic clay layer above the chert zone appears to be somewhat thicker than at DSDP Site 452 (Figs. 4, 5, and 6). The approach to Site 777 was from the southwest via DSDP Site 452 in an attempt to identify the chert zone cored at DSDP Site 452 and to correlate it to the Site 777 location with our hull-mounted 3.5-kHz echo-sounder. Although ship speed was reduced to about 6.2 kt while crossing DSDP Site 452 and during the transit to Site 777, the chert zone was not apparent on our echo-sounder until our final approach to Site 777 (Fig. 7). The seismic reflection profile (Fig. 8) made during this approach with our two 80-in.^{3} water guns does not image the chert zone in any definitive way owing to the small amount of pelagic-clay overburden, but it does provide a reasonably good picture of what is presumed to be volcanic basement. At Site 777, basement occurs at about 300 ms sub-bottom, indicating a total sediment thickness of approximately 300 m.

In order to study the physical stratigraphy of the upper chert zone and to locate the thickest layer of pelagic clay overburden for spudding the drill string, a near-bottom reflection-profiling survey was planned prior to the drilling and coring program at Site 777. This consisted of lowering a 3.5-kHz deep sonar source (DSS) or pinger down the outside of the drill string on the deep-sea camera (VIT) frame to within about 100 m above the seafloor and 40 m above the bottom of the drill pipe. The pinger is a DSS-350 device supplied by Datasonics, Inc. It is battery powered and has a 2000-W output pulse that can be transmitted in various pulse lengths from 0.3 to 4.0 ms at repetition rates from 1 to 10 pulses/s. The signal is both sent from and received at the pinger near the seafloor and can be displayed in real time in the underway-geophysics lab on a linescan recorder and recorded on magnetic tape. It has a battery life of 100–250 hr before the pinger must be retrieved and the batteries replaced.

During our first 3.5-kHz-pinger lowering, bottom reflections were picked up about 400 m above the seafloor, and the instrument provided a detailed image of the seismic stratigraphy down to the level of the chert zone (Fig. 9) when it was positioned about 100 m above the seafloor. This record shows the chert zone at 45 ms, or about 35–40 mbsf. It is overlain by a much more indistinct zone at 27 ms, or about 20–25 mbsf. No reflections were recorded below the chert zone, and it was not feasible to lower the pinger closer to the seafloor owing to outgoing ping reverberation in the first 100 ms (75 m) of the record. Almost coincidentally with initiating a 2-km^2 grid survey with the near-bottom pinger, the instrument failed because of a failed transistor in the near-bottom package. It was decided to initiate the

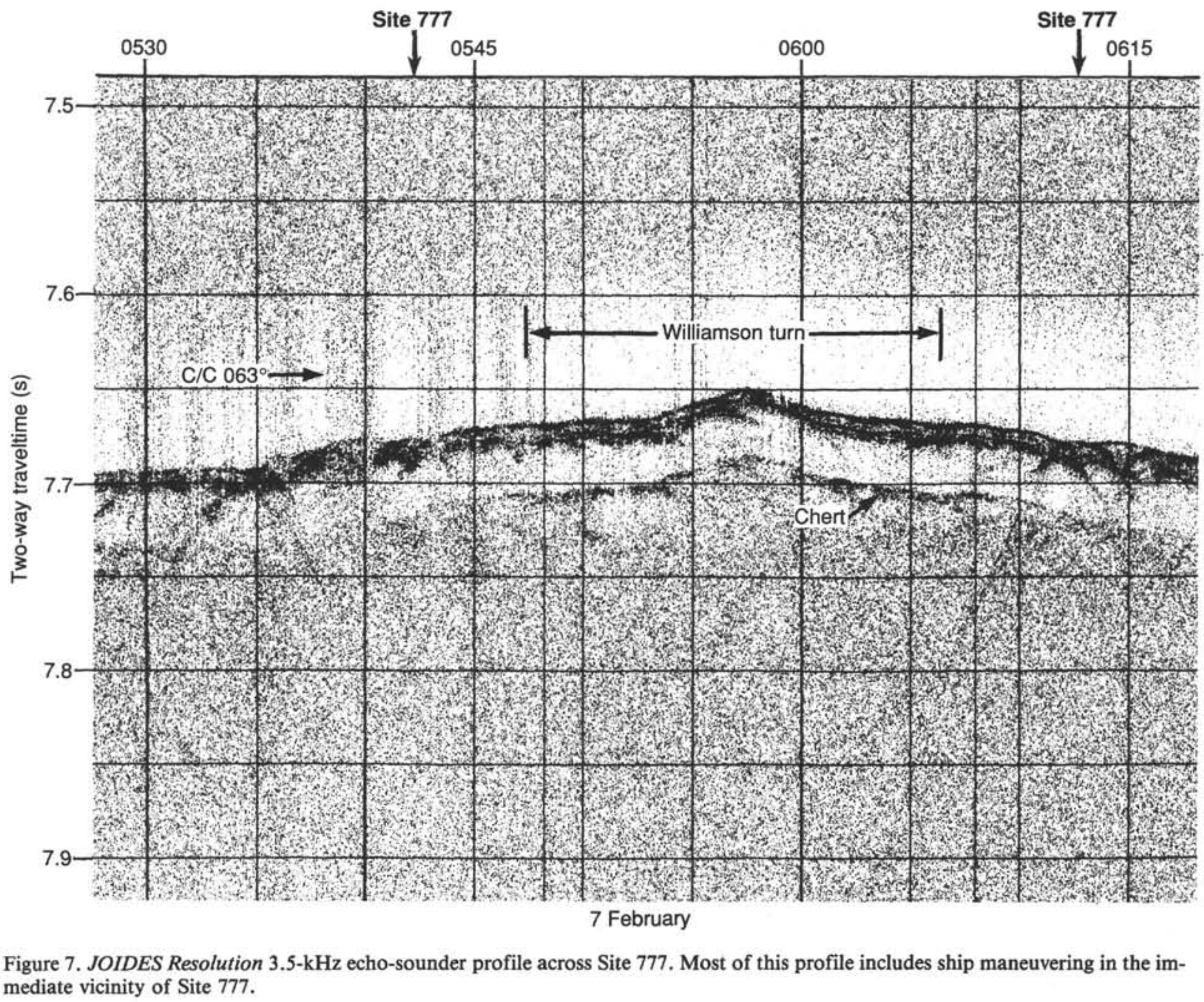


Figure 7. *JOIDES Resolution* 3.5-kHz echo-sounder profile across Site 777. Most of this profile includes ship maneuvering in the immediate vicinity of Site 777.

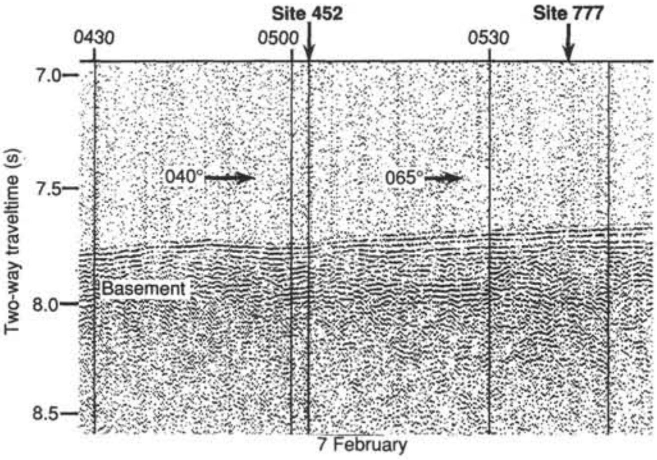


Figure 8. *JOIDES Resolution* water-gun seismic reflection profile across DSDP Site 452 and Site 777.

coring program at this location while the pinger was retrieved and repaired and to delay the grid survey until later in the Site 777 program.

After an interval for coring, the near-bottom pinger survey was restarted. The pinger failed again at the near-bottom instrument package, this time because of a faulty component that could not be replaced from shipboard supplies, so the attempts at a pinger survey were terminated. Because this is almost certainly a useful technique for understanding the details of near-surface stratigraphy in locating future drill sites, a brief operational description of the survey technique is included here for future users.

The ship is moved at 0.5–1.0 kt in a gridlike pattern with the thrusters and main propulsion in dynamic-positioning mode in order to conduct a detailed seismic reflection survey of the area immediately surrounding the location of interest. The horizontal dimensions of this survey are limited by the maximum receiving range for the seafloor beacon, which in turn is a percentage of the water depth. For a water depth of 5800 m at this location, the maximum horizontal beacon range is about 3000 ft or 1000 m, so the maximum size of a survey grid is about 2 km. Because the pinger is located near the bottom of a long drill string, the pinger is positioned relative to a beacon on the seafloor with another beacon mounted next to it on the VIT. The position of both of these instruments relative to the hull of the drillship can be continuously determined, and the vector sum of these two positions closes a vector triangle and determines the position of the beacon on the drill pipe relative to the beacon on the seafloor. In addition to providing positioning of the actual pinger location relative to the fixed beacon on the seafloor, this exercise also provides information on horizontal drill-pipe motion and bending with a long pipe string.

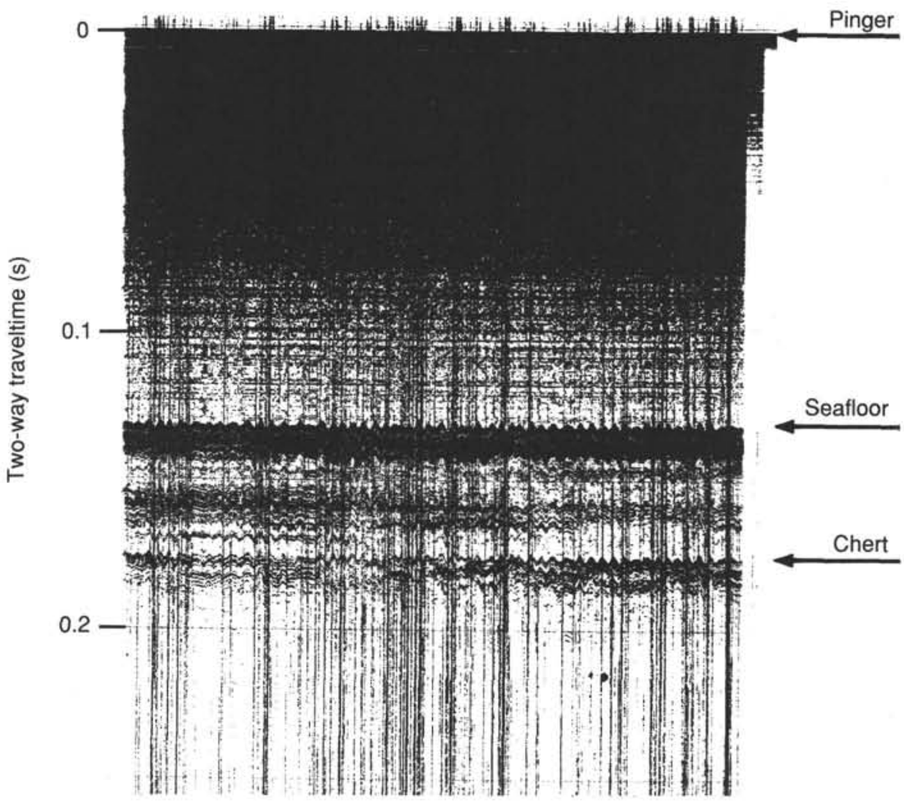


Figure 9. *JOIDES Resolution* near-bottom 3.5-kHz pinger record at Site 777. The ship was horizontally stationary during the extent of this record. The "sawtooth" pattern superimposed on each reflecting horizon shows the amount of vertical motion of the uncompensated camera frame owing to vessel heave.

LITHOSTRATIGRAPHY

Introduction

Six holes were drilled at Site 777, and a total of 56.3 m of sediment was recovered. Only the first five holes, for a total of 53.84 m, were studied. The sedimentary sequence drilled is predominantly hemipelagic clay, chert, and cherty claystone and/or porcellanite. In the absence of paleontological age dating, the sediments recovered have been divided into three lithostratigraphic units, using physical attributes derived from visual core descriptions and smear slides (Fig. 10).

Lithostratigraphic Unit I is a predominantly structureless hemipelagic clay with a biosiliceous component and can be subdivided into two subunits. Subunit IA shows a decreasing biosiliceous component with depth. Subunit IB is a hemipelagic clay sequence, which is mostly barren of biosiliceous fossils. Unit II differs in visual and physical properties from Unit I by having a lighter color and having numerous very thinly bedded layers. Unit III is the harder unit and is composed predominantly of chert and cherty claystones.

Sediments of Site 777 have been slightly to heavily disturbed by the drilling process. Soupy sediments occur in the tops and less commonly in the bottoms of some soft-sediment cores. Drilling breccia is not uncommon in the harder sediment cores. The boundaries of some units and subunits are approximated, owing to low core recovery and variable drilling disturbances.

Table 1 summarizes the coring at Site 777. Table 2 gives the results of interstitial-water analyses of sediments from Holes 777A and 777B.

Unit I

Unit I (Cores 124E-777A-1H through -3X and 124E-777B-1H through -4H) starts with a biosiliceous layer (Subunit IA) on top of a generally monotonous brown hemipelagic clay (Subunit

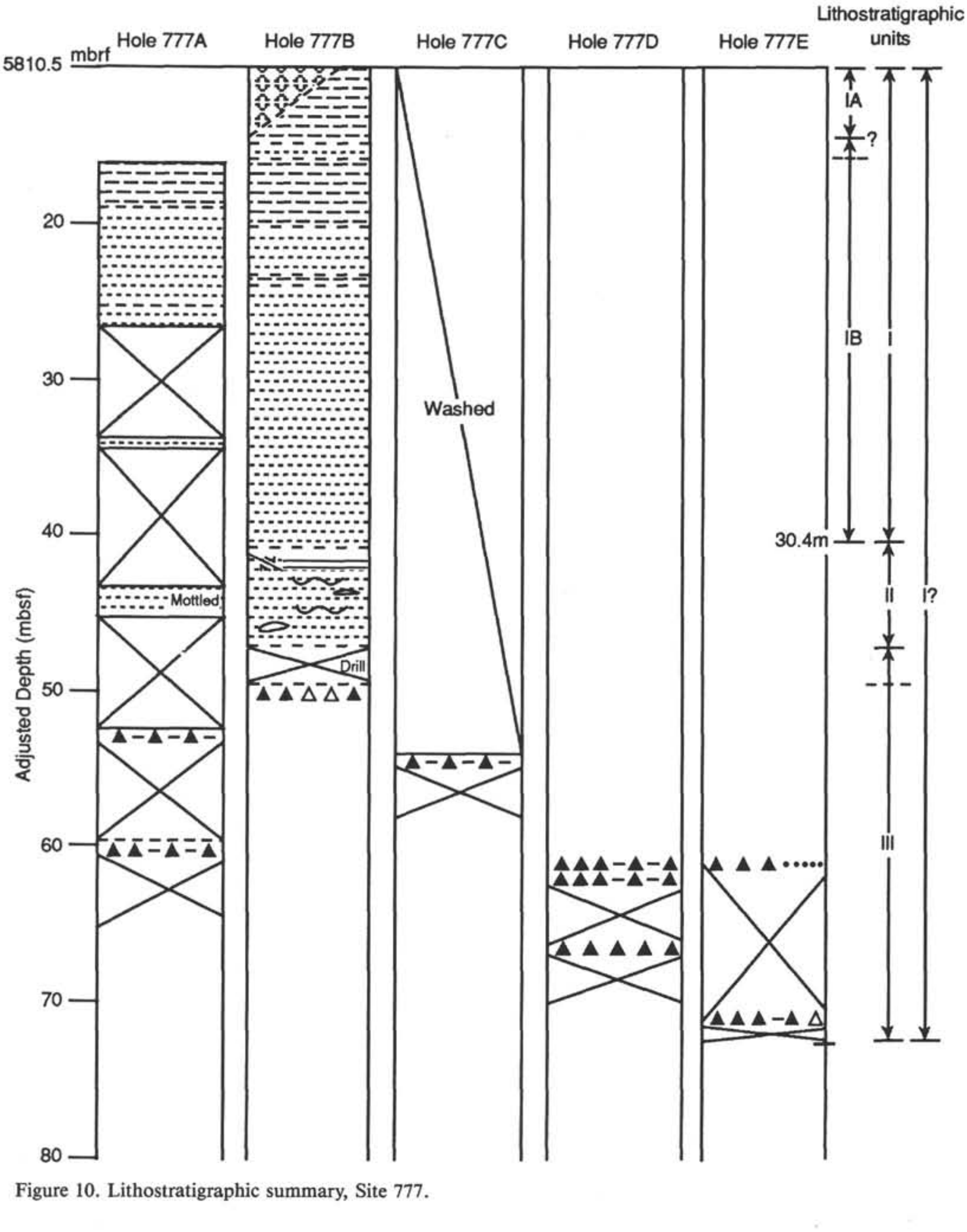


Figure 10. Lithostratigraphic summary, Site 777.

Table 1. Coring summary for Site 777.

Core no.	Date (Feb. 1989)	Time (UTC)	Interval cored (mbsf)	Length cored (m)	Length recovered (m)	Recovery (%)
124E-777A-						
1H	8	0450	1.0–10.5	9.5	10.06	105.9
2X	8	0605	10.5–18.5	8.0	1.09	13.6
3X	8	0720	18.5–28.1	9.6	0.98	10.2
4X	8	0845	28.1–37.5	9.4	2.49	26.5
5X	8	1100	37.5–44.5	7.0	0.05	0.7
6X	8	1530	44.5–49.5	5.0	0.02	0.4
124E-777B-						
1H	8	1750	0–8.0	8.0	8.05	100.0
2H	8	1910	8.0–17.5	9.5	9.75	102.0
3H	8	2120	17.5–27.0	9.5	9.95	105.0
4H	8	2325	27.0–36.5	9.5	9.94	104.0
5N	9	0530	38.4–39.1	0.72	0.72	100.0
124E-777C-						
1W	9	0900	0–43.4	43.4	0	(Wash core)
2N	9	1230	43.4–47.4	4.0	0.84	21.0
124E-777D-						
1W	9	1820	0–50.6	50.6	0.99	(Wash core)
2N	9	2200	50.6–51.7	1.1	0.27	24.5
3N	10	0210	51.7–55.8	4.1	0.60	14.6
4N	11	1000	55.8–59.8	4.0	0.50	12.5
124E-777E-						
1X	11	0240	51.0–60.5	9.5	0.41	4.3
2N	13	0045	60.5–61.5	1.0	0.21	21.0
124E-777F-						
1H	13	0925	0–2.5	2.5	2.46	98.4
		Coring totals		98.92	55.31	55.9
		Washing totals		94.0	0.99	
		Combined totals		192.92	56.30	

IB). The base of Unit I is seen as its transition from a red brown (5YR 3/3) sediment to the mottled light brown (7.5YR 6/6) sequence in Unit II. This can be observed in Cores 124E-777B-1H to 124E-777B-4H.

Subunit IA (Core 124E-777B-1H; 0–3.5 mbsf; thickness, 3.5 m) is a brown (7.5YR 3/4), siliceous, fossil-rich clay interval. This layer is very soft to soupy. The fossil content decreases with depth, and the base of the subunit is marked by the disappearance of the biosiliceous sediment in the hemipelagic clay.

Subunit IB (Cores 124E-777A-1H through 124E-777A-3X, 80 cm; 1.0–19.3 mbsf; thickness, 18.3 m; and Cores 124E-777B-1H through -4H; 3.5–30.4 mbsf; thickness, 30.4 m) is a predominantly brown (7.5YR 3/4) hemipelagic clay. It is soft, silty in the upper part (Cores 124E-777B-1H to -2H), and generally massive and structureless except for some very dark brown (7.5YR 3/0 to 10YR 3/2) clay and claystones that appear as scattered patches or isolated lenses. Micronodules of manganese are commonly found within the interval, and pebble-sized manganese nodules appear at the base. A very thin, fine- to medium-grained clean sand lens in Core 124E-777B-1H contains grains of zeolite, manganese, glass, plagioclase, siltstone, and silica-cemented aggregates. Sediment disturbance by drilling ranges from slight to heavy; soupy sediments are present in tops and bottoms of cores from Hole 777A. A marked color change from brown (7.5YR 3/4) to red brown (5YR 3/2) is evident in Core 124E-777B-3H. The base of the unit is marked by the transition in color from red brown to light brown and by a convoluted surface, which may indicate bioturbation, in Core 124E-777B-4H.

Unit II

Unit II is wholly represented in the lower part of Core 124E-777B-4H, 30.4–36.5 mbsf; thickness, 6.1 m) as a light brown (7.5YR 6/6) clay interlayered with dark brown (7.5YR 3/2) clay and pinkish brown (7.5YR 7/6 and 5YR 6/4) clay. In Core 124E-777A-4X the unit is seen as a red brown (5Y 5/3) clay mottled by a light brown (5YR 8/4) clay. Unit II exhibits complex bedding ranging from planar laminar to wedge planar to lenticular and wavy structures. Micronodules of manganese are common in the unit, and some possible bioturbation marks are also evident. Heavy drilling disturbance is seen in the last section of Core 124E-777B-4H, as sediment apparently was sucked into the core barrel (man-made artifact).

Unit III

Unit III, the chert and cherty claystone unit, is present in all five holes. The unit is first seen in Core 124E-777B-5N at an estimated depth of 37 mbsf. The top of the unit can only be approximated, as a 1.9-m interval was drilled and not cored. The low recovery as well precludes an accurate estimate of thickness. Recovery was typically gravel, pebbles, and cobbles of chert and cherty claystone. It is difficult to distinguish the chert from the cherty claystone, as the difference is in the degree of silicification. Both have the predominantly brown (7.5YR 4/4) to red brown (5YR 3/2) colors; they are banded (interlayered) with buff (10YR 7/6) porcellanite and pink brown (5YR 6/6) layers. Bedding structures are very complex and difficult to examine, owing to the small size of most samples.

In general, porcellanite normally occurs as continuous bands in planar-laminar to wavy to convoluted fashion. The pink brown layers are commonly discontinuous lenses, wedge planar to lenticular. Softer sediments ranging from porcellanites to claystones are seen still attached to the ends of some chert and cherty claystone pieces. Unsilicified sediments, which are softer, should be expected to be present in this unit; presumably they have been washed away.

PALEOMAGNETISM

Paleomagnetic measurements were made on a total of five cores from Site 777: Core 124E-777A-1H and Cores 124E-777B-1H through -4H. The archive half of each of these cores was measured on the ODP cryogenic magnetometer using a measuring interval of 2 cm. Although a 2-cm sampling interval is "overkill" in terms of the resolution of the instrument, the low sedimentation rate expected at this site made maximum resolution, perhaps using a future deconvolution technique, essential. The design of the instrument and current software provide a resolving power, without deconvolution, of 10–15 cm, depending upon the axis. Thus it should be understood that the interpretation of the data from the continuous core must be understood in terms of this inherent averaging built into the instrument.

A core end, or a sharp boundary between two polarity intervals, produces a response that is not the actual magnetism of the material being measured but instead is a product of the instrument response with the magnetization of the sample. Thus, even an abrupt boundary produces a "transition-like" response, and an interval of opposite polarity whose thickness is less than 20 cm yields a response that has no true opposite polarity values. Nevertheless, a polarity zone as thin as a few centimeters has a pronounced response, and its presence can be detected even though its true properties cannot be identified.

Each of the five cores was measured for natural remanent magnetization (NRM) and was again measured after demagnetization at 2, 5, and 9 mT. Most of the material was quite unstable and had a large drilling and present field overprint. The stepwise demagnetization removed much of this overprint, but the cores were by no means free of secondary magnetization after demagnetization. Nevertheless, the polarity can be resolved for almost all of the cores, and some intervals yield consistently clean directions.

Table 2. Interstitial-water analyses, Site 777.

Core, section, interval (cm)	Depth (mbsf)	Vol. (mL)	pH	Alkalinity (mM)	Salinity (g/kg)	Chlorinity (mM)	SO_4 (mM)	SiO_2 (μM)	Mg (mM)	Ca (mM)	Mg/Ca
124E-777A-											
1H-1, 140–150	2.40	—	7.47	2.83	35.5						
1H-1, 140–150	2.40	—	7.77	3.21	36.0	560	28.6	252	41.0	10.33	4.0
1H-1, 140–150	2.40	—	7.46	2.34	36.8	589	35.2	220	42.6	10.68	4.0
1H-1, 140–150	2.40	—	7.62	3.12	35.5	554	30.6	256	43.8	10.30	4.3
1H-1, 140–150	2.40	—	7.65	2.32	37.0	583	34.0	216	43.6	10.69	4.1
1H-1, 140–150	2.40	—	7.55	2.33	37.0	—	—	—	—	—	—
1H-2, 140–150	3.90	—	7.58	2.53	36.0	554	29.2	222	42.2	10.41	4.1
1H-2, 140–150	3.90	—	7.43	3.06	34.5	554	31.7	222	41.0	10.53	3.9
1H-2, 140–150	3.90	—	7.33	2.80	36.0	—	—	—	—	—	—
1H-4, 140–150	6.90	—	7.76	3.09	35.5	554	31.5	190	41.7	10.52	4.0
1H-4, 140–150	6.90	—	7.31	2.88	35.5	—	—	—	—	—	—
1H-4, 140–150	6.90	—	7.35	3.03	36.0	556	33.0	192	40.4	10.60	3.8
1H-5, 140–150	8.40	—	7.64	3.09	35.5	552	33.0	188	41.9	10.67	3.9
1H-5, 140–150	8.40	—	7.46	3.06	35.5	550	30.7	192	41.1	10.93	3.8
1H-5, 140–150	8.40	—	7.40	2.56	36.0	—	—	—	—	—	—
1H-6, 140–150	9.90	—	7.56	3.06	35.5	554	31.5	180	41.3	10.59	3.9
1H-6, 140–150	9.90	—	7.46	3.09	35.5	559	33.3	182	41.1	10.69	3.8
1H-6, 140–150	9.90	—	7.43	2.85	35.5	—	—	—	—	—	—
124E-777B-											
1H-1, 140–150	1.40	45	7.56	2.33	36.5	548	29.3	455	41.2	10.08	4.1
1H-1, 140–150	1.40	—	7.39	2.85	35.0	—	—	—	—	—	—
1H-1, 140–150	1.40	—	7.25	2.48	36.0	—	—	—	—	—	—
1H-1, 140–150	1.40	—	7.68	2.50	35.5	—	—	—	—	—	—
1H-1, 140–150	1.40	—	7.41	2.30	35.5	—	—	—	—	—	—
1H-1, 140–150	1.40	85	7.49	2.36	36.8	558	28.3	513	42.1	10.26	4.1
1H-2, 140–150	2.90	75	7.34	2.32	35.0	552	29.9	472	41.0	9.97	4.1
1H-2, 140–150	2.90	—	7.47	2.36	35.0	—	—	—	—	—	—
1H-2, 140–150	2.90	—	7.44	2.34	36.0	—	—	—	—	—	—
1H-4, 140–150	5.90	—	7.34	2.41	35.5	—	—	—	—	—	—
1H-4, 140–150	5.90	65	7.42	2.56	35.5	553	28.6	316	40.4	10.19	4.0
1H-4, 140–150	5.90	—	7.29	2.49	35.0	—	—	—	—	—	—
1H-5, 110–120	7.10	—	7.50	2.33	35.0	—	—	—	—	—	—
1H-5, 110–120	7.10	—	7.21	2.39	35.0	—	—	—	—	—	—
1H-5, 110–120	7.10	80	7.38	2.54	35.5	557	29.6	284	39.9	10.24	3.9
2H-4, 140–150	13.90	55	7.36	2.99	36.0	557	30.1	—	40.7	10.83	3.8
2H-4, 140–150	13.90	—	7.38	2.86	35.5	—	—	—	—	—	—
2H-4, 140–150	13.90	—	7.31	3.09	35.5	—	—	—	—	—	—
3H-4, 145–150	23.45	52	7.36	3.09	35.5	559	28.4	256	41.0	10.95	3.8
3H-4, 145–150	23.45	—	7.39	3.04	35.5	—	—	—	—	—	—
3H-4, 145–150	23.45	—	7.41	2.89	36.0	—	—	—	—	—	—

The stability of the magnetization was studied further on one 6-cm^3 sample taken from the working half of each segment of the first core of Hole 777A and the first two cores from Hole 777B. These specimens were measured for NRM and demagnetized with applied fields of 2, 5, 9, 12, and 15 mT. Higher applied fields were not used, since previous experiments indicated that a weak but significant anhysteretic remanent magnetization (ARM) began to be acquired at fields higher than 15 mT. Figure 11 shows a selection of these results. Samples 124E-777B-2H-5, 108 cm, and 124E-777B-2H-6, 108 cm, are examples of specimens that reach stable endpoints, while Samples 124E-777B-1H-5, 31 cm, and 124E-777A-1H-5, 60 cm, are examples of specimens that indicate a polarity but that do not reach a stable endpoint at the maximum applied field.

Figure 12 shows the magnetostratigraphy of Hole 777B. For the most part, the interpretation of the data is straightforward, at least through Core 124E-777B-3H. The upper 20 cm of Section 124E-777B-1H-1 was quite "soupy," and it is unlikely that a useful remanence could have been preserved. As can be seen from Figure 12, the upper 5.8 m exhibits normal polarity, with the exception of an interval between 70 and 90 cm, and a small anomaly at about 3.2 m. This normal-polarity interval, therefore, has been assigned to the Brunhes. It is interesting to note that the two "events" are at the proper stratigraphic positions to be the Blake episode and the Emperor event, respectively. Owing to resolution constraints of the record, however, little more can be noted about these "events."

The Brunhes/Matuyama boundary is at 5.8 m and the Matuyama interval continues to about 8 m and includes three short normal intervals, presumably the Jaramillo, Olduvai, and Reunion(?) events. In comparison to the overlying Brunhes and the underlying Gauss, the Matuyama seems to be very short and suggests that a small hiatus may be present in this interval.

Correlation of the observed anomalies with the standard magnetic time scale of Berggren (1985a, 1985b) continues to be relatively easy through Chron C5 (11 Ma), which is recognizable at 23 m. The correlation continues to be reasonable, although a bit strained, to a depth of 30 m, which may be equivalent to Chron C5E (19 Ma, middle early Miocene). Below this depth a reversal stratigraphy is still present but is very different in character to that above 30 m. This may be the result of a very slow sedimentation rate, one that is so slow that no individual polarity zone is identifiable but one in which the bias toward either normal or reversed is still recognizable owing to the averaging properties of the magnetometer. No discrete samples were taken in this interval, so this possibility cannot be totally discarded. If this possibility is correct, the base of the sampled section might be as old as middle Oligocene.

A more reasonable alternative is available, however. At the base of Section 124E-777B-4H-2, a marked change in color is

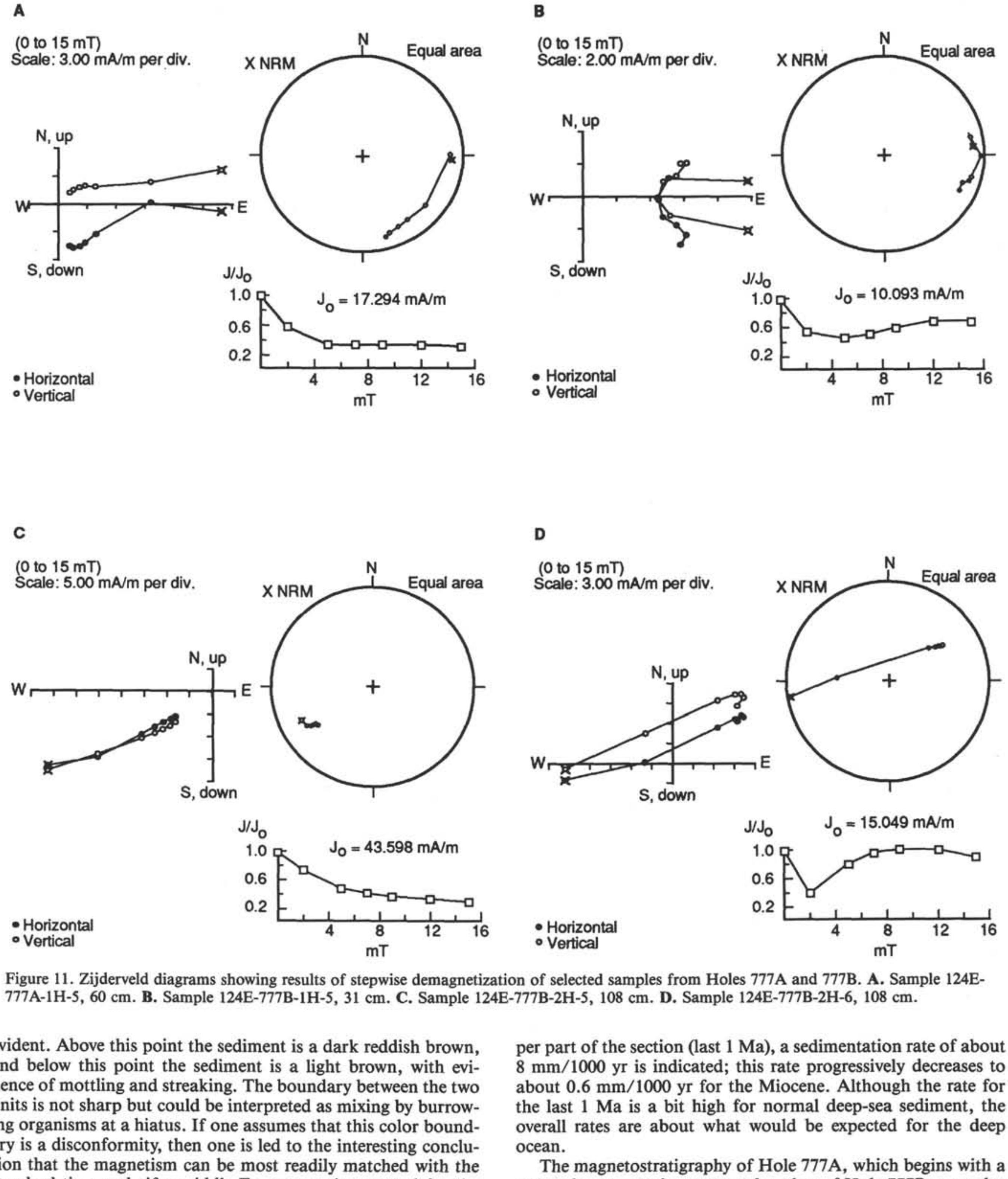


Figure 11. Zijderveld diagrams showing results of stepwise demagnetization of selected samples from Holes 777A and 777B. **A.** Sample 124E-777A-1H-5, 60 cm. **B.** Sample 124E-777B-1H-5, 31 cm. **C.** Sample 124E-777B-2H-5, 108 cm. **D.** Sample 124E-777B-2H-6, 108 cm.

evident. Above this point the sediment is a dark reddish brown, and below this point the sediment is a light brown, with evidence of mottling and streaking. The boundary between the two units is not sharp but could be interpreted as mixing by burrowing organisms at a hiatus. If one assumes that this color boundary is a disconformity, then one is led to the interesting conclusion that the magnetism can be most readily matched with the standard time scale if a middle Eocene age is assumed for the sediments below 30 mbsf. This would then suggest that we have sampled lower Miocene sediments disconformably overlying middle Eocene. Confirmation of this speculation must await examination of the sediments by a paleontologist.

On the basis of the magnetostratigraphy, a sediment-thickness vs. time diagram, or a sediment-accumulation rate, was constructed for Site 777 and is shown in Figure 13. For the upper part of the section (last 1 Ma), a sedimentation rate of about 8 mm/1000 yr is indicated; this rate progressively decreases to about 0.6 mm/1000 yr for the Miocene. Although the rate for the last 1 Ma is a bit high for normal deep-sea sediment, the overall rates are about what would be expected for the deep ocean.

The magnetostratigraphy of Hole 777A, which begins with a reversed zone, can be compared to that of Hole 777B to resolve a question that occurred during drilling. As stated elsewhere, Core 124E-777A-1H failed to recover the mud line, and thus there is some uncertainty as to what interval was cored. The magnetic correlation shown in Figure 12 assists in resolving this question and indicates that about 6 m of section was missed. This is consistent with the lithologic correlations discussed in the barrel sheets (at least 5 m offset).

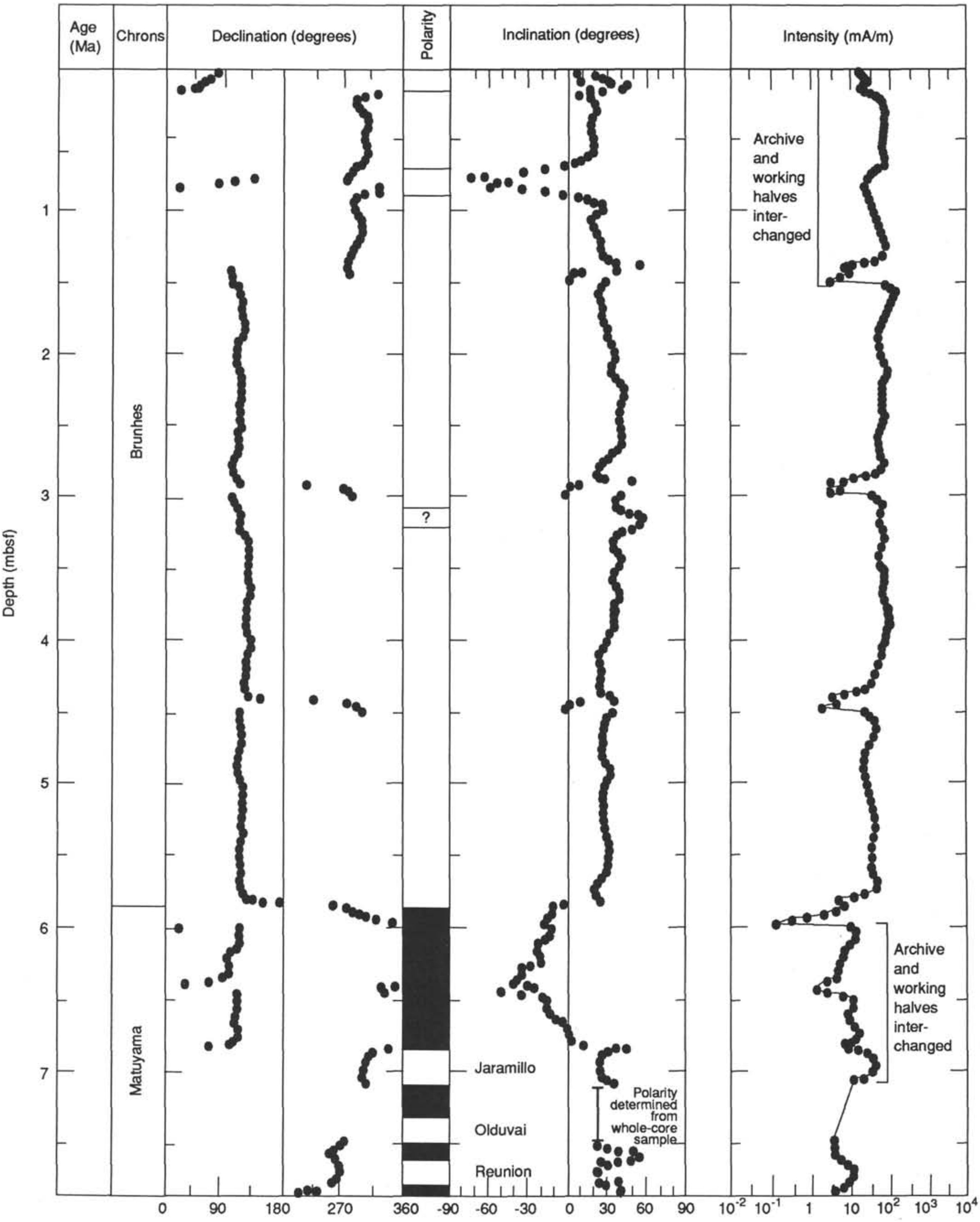
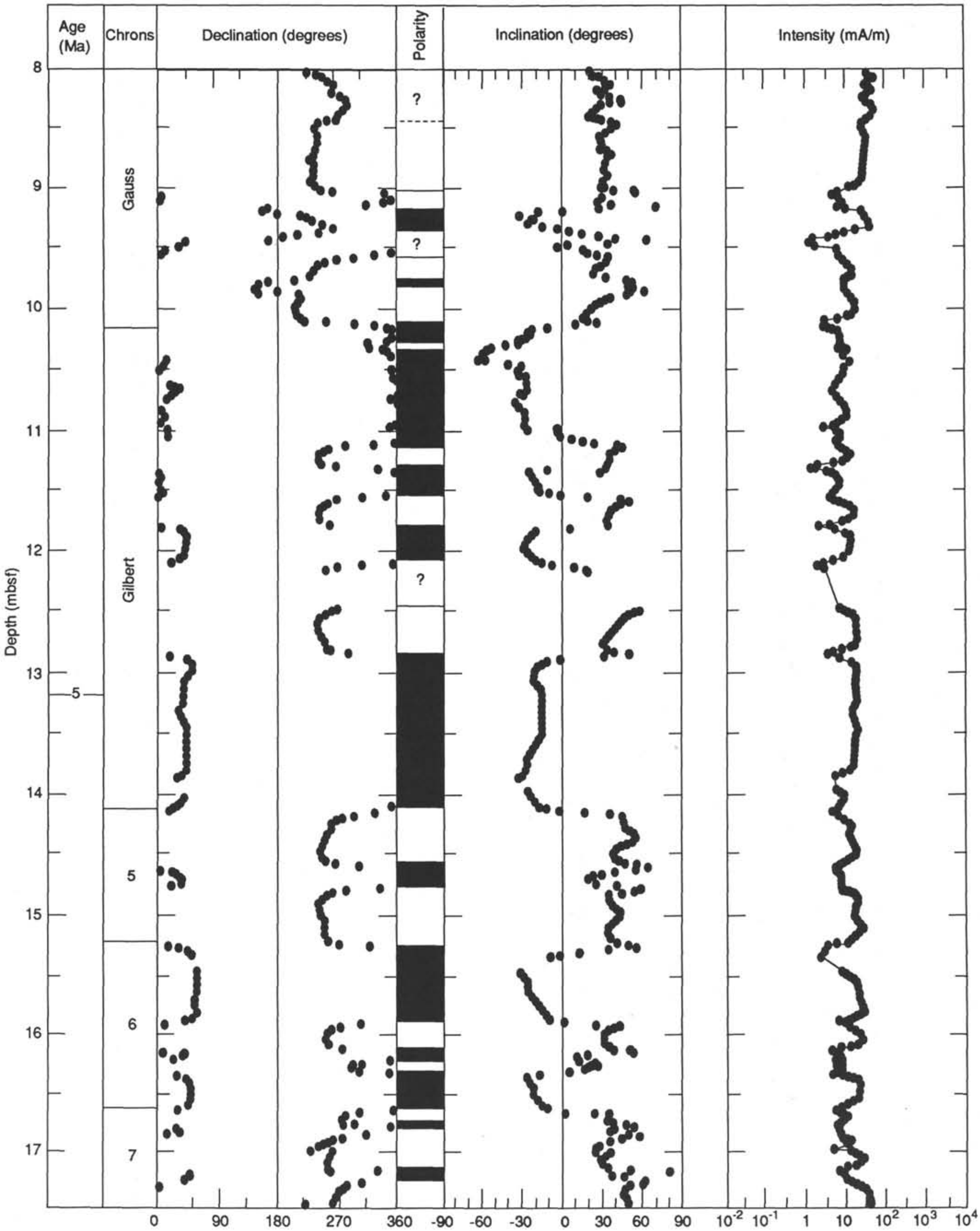


Figure 12. Magnetostratigraphy of sediments from Hole 777B. Reversed polarity indicated by solid black.



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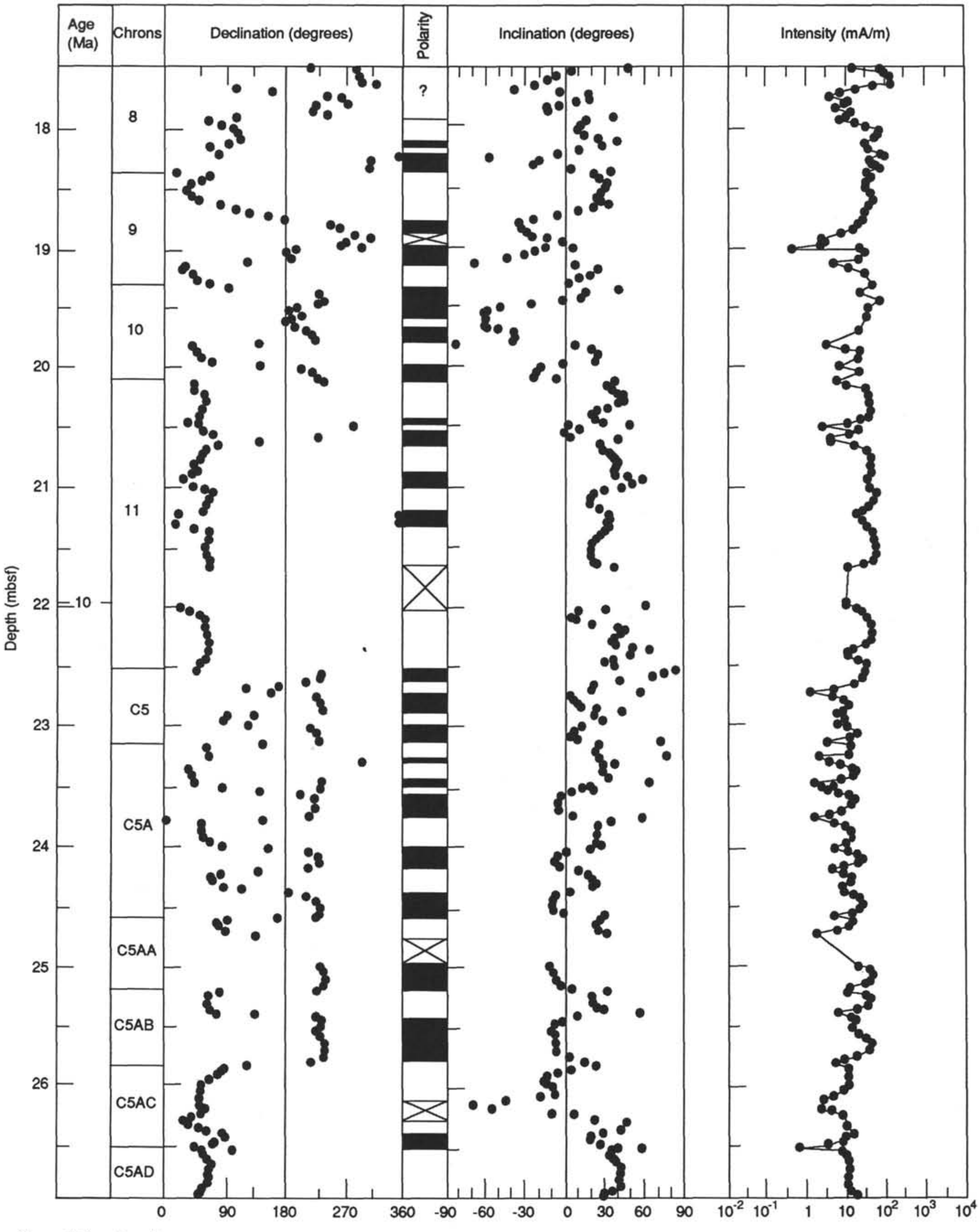

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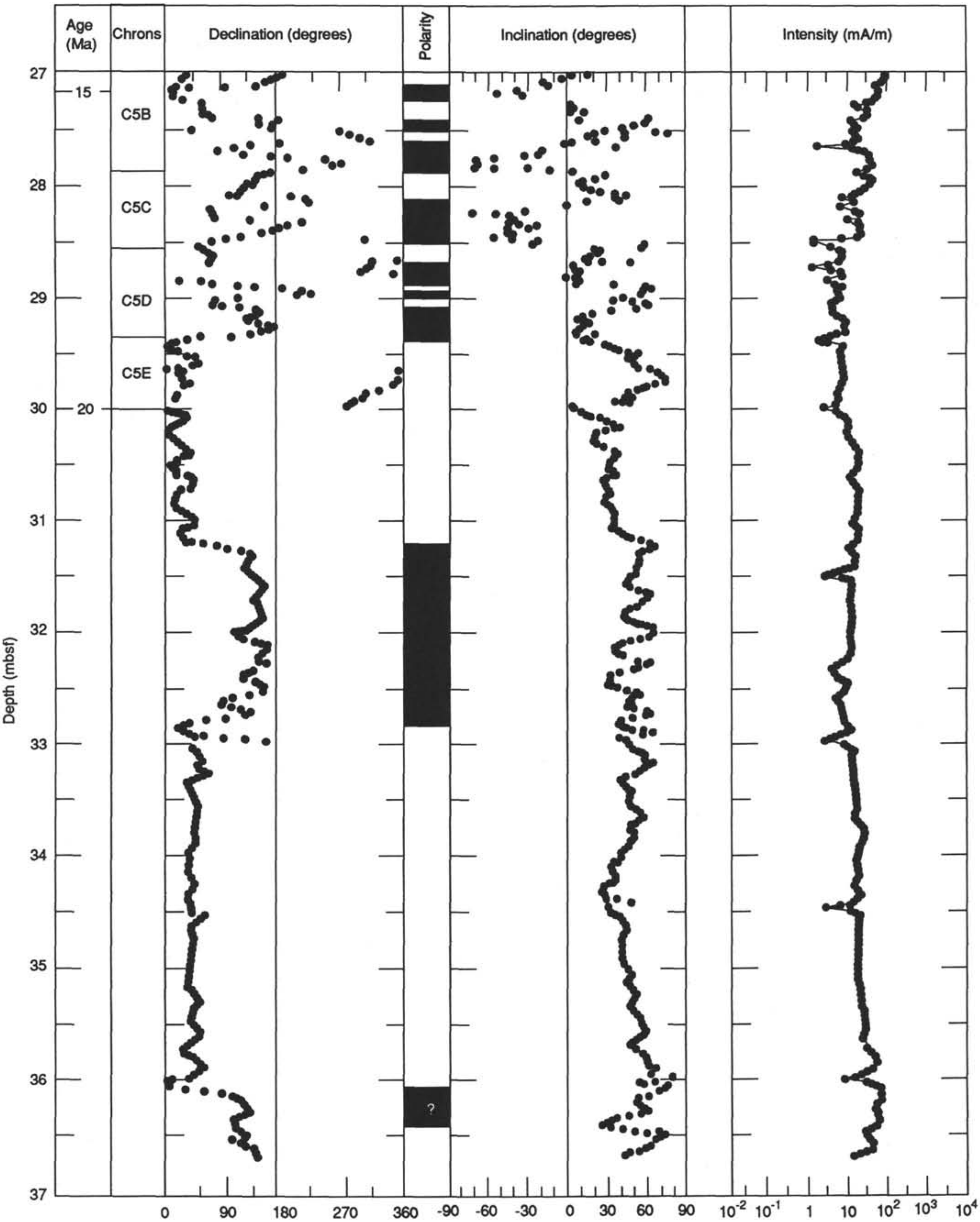

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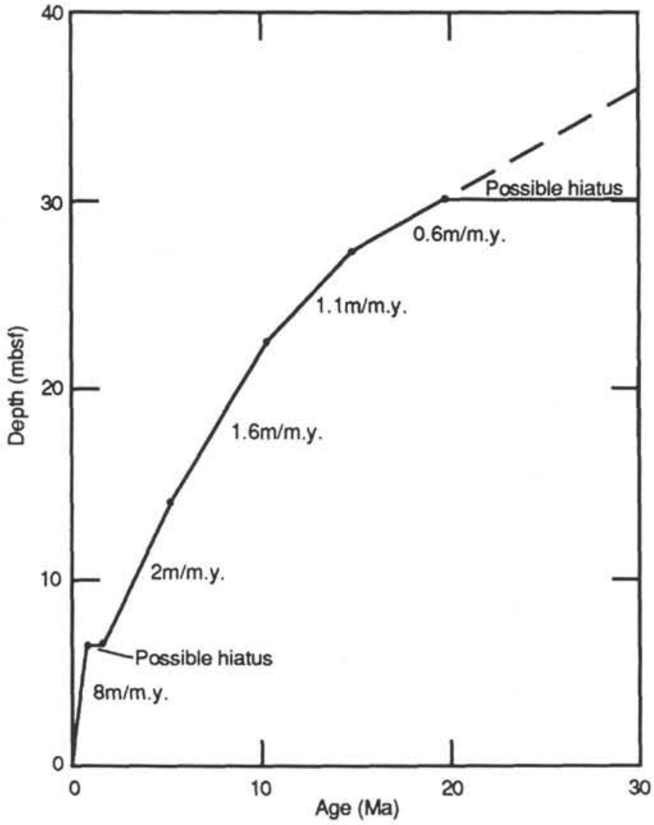

Figure 13. Depth vs. time diagram (sediment-accumulation rate) for Site 777.

PHYSICAL PROPERTIES

Introduction

The objectives of the physical-properties program at Site 777 were to help characterize the mass physical properties of the Northern Mariana Basin sediment (Units I and II) and to provide an important link between geophysical and engineering data and the geological realities of the materials that constitute the sedimentary section described by shipboard stratigraphers and sedimentologists.

The physical-properties program consisted of obtaining the following measurements: (1) index properties: gravimetric determinations of bulk density, porosity, water content, and grain density; (2) compressional-wave velocity: the speed of sound in the sediment; and (3) vane shear strength: a relative measure of the resistance of the sediment to loads and a measure of its cohesiveness.

Results

Index Properties

Two methods of determining the bulk densities and porosities of the sediment of lithostratigraphic Units I and II were used for Site 777. Bulk density, porosity, and water content were determined at discrete points within the cores by gravimetric determinations, in addition to the bulk density and porosity obtained from gamma-ray attenuation porosity evaluation (GRAPE) scanning of whole-round core sections. All core sections from Site 777 were logged on the GRAPE unit except those recovered by using the XCB. Bulk density and porosities were computed by assuming a grain density of 2.75 g/cm^3.

Index properties measured on samples are listed in Table 3. Profiles of bulk density, water content (dry basis), porosity, and void ratio are illustrated in Figures 14 through 17.

The bulk density of sediments at this site were of fairly uniform value except for those at the very tops and bottoms of the holes. The bulk density had an average value of 1.39 g/cm^3. The maximum value of bulk density was 1.64 g/cm^3 at the 3.59-mbsf level, and the minimum value was 1.27 g/cm^3 at 35 mbsf. It is interesting to note that this is just the opposite of what one would expect—the highest density at the bottom and the lowest at the top.

The grain density of the sediments of Site 777 averaged 2.72 g/cm^3. The maximum value was 3.01 g/cm^3, and the minimum was 2.41 g/cm^3.

The water content averaged 160%, with the maximum being 220% and the minimum 75% within Unit I of Hole 777B. The water content of these sediments is extremely high for a clayey material, particularly for the Miocene clay, which is assumed to be the age of Unit II.

The porosity of sediments in Hole 777B relative to depth is shown in Figure 16. Porosity has a similar profile to that of water content, and at this site has an average value of 82%. Porosity increases at a rate of 0.25%/m. The highest porosity was measured at 91.3% at 33.44 mbsf. The lowest porosity of Hole 777B was the cherty material at the 35.16-mbsf level in Unit III and measured 49.4% at 34.9 mbsf.

Void ratio correlates with water content, bulk density, and porosity and reflects similar environmental conditions. The average value of void ratio was 5.26 in Hole 777B. The maximum was 10.5, and the minimum 2.16. The high average value contrasts with that of such clayey sediments as those of the Gulf of Mexico, where within a section of similar thickness the void ratio averages 2.5, half the value of that in Hole 777B.

Compressional-Wave Velocity

Sonic velocities (V_p) in the sediment were measured by using two methods. A continuous measurement of V_p was made through the whole core using a *P*-wave logger (PWL) installed next to the GRAPE source and detector. The Hamilton Frame velocimeter was utilized for the laboratory determination of V_p for individual samples removed from the core, using procedures outlined by Boyce (1976). V_p was measured in only one direction, as the sediments at Site 777 were very homogeneous in the upper 20 m and acoustic anisotropy should be at a minimum. Figure 18 shows the V_p profile obtained by the Hamilton Frame velocimeter for Hole 777B sediments, and Table 3 lists the V_p determinations. The sediments recovered by the APC in Hole 777B (0 to 39.10 mbsf) have an average velocity of 1545 m/s. The highest velocities measured were at 35 mbsf. The mudstone at these levels had velocities of 2880 and 2976 m/s, and the cherts had velocities of 4850 m/s.

A profile of the impedance of the sediment from 0 to 31.3 mbsf is shown in Figure 18. The average impedance for the upper 31.3 m of sediment was 2079. The sediment at 3.59 mbsf had an impedance of approximately 2444.

Vane Shear Strength

The undrained shear strength of the sediment was measured by using the motorized miniature vane device. Its operation and calculations follow procedures outlined by Boyce (1976). The shear-strength determinations for Site 777 sediments are listed in Table 4 and are illustrated in profile in Figure 19. Shear strength increases at a moderate rate of 1.33 kPa/m. The average shear strength was 19.02 kPa. The highest strength, 34.5 kPa, was at the 7.80-mbsf level, an unusual event. Major fluctuations in strength occur at almost all levels within the section.

Table 3. Index properties, compressional-wave velocities, and acoustical impedance, Hole 777B sediments.

Core, section, interval (cm)	Depth (mbsf)	Bulk density (g/cm³)	Grain density (g/cm³)	Porosity (%)	Water content (%)	*P*-wave velocity (m/s)	Acoustic impedance (g/cm² · 10²/s)
124E-777B-							
1H-2, 90–94	2.40	1.43	2.80	82.5	145.2	1431.5	2047.0
1H-3, 59–63	3.59	1.64	2.72	68.4	74.6	1490.8	2444.9
1H-4, 53–57	5.03	1.31	2.75	86.9	210.0	1482.1	1941.6
1H-5, 52–56	6.52	1.34	2.78	86.0	192.8	1384.1	1854.7
1H-6, 31–36	7.81	1.54	2.92	77.3	105.7	1460.5	2249.2
2H-1, 44–48	8.44	1.35	2.84	85.3	183.1	1484.2	2003.7
2H-2, 44–48	9.94	1.36	2.91	86.5	188.7	1491.9	2029.0
2H-3, 44–47	11.44	1.39	2.81	86.3	175.7	1487.5	2067.6
2H-4, 69–73	13.19	1.32	2.68	86.4	203.0	1489.0	1965.5
2H-5, 44–48	14.44	1.38	2.84	86.1	177.9	1483.8	2047.6
2H-6, 44–48	15.94	1.33	2.58	86.3	199.6	1498.2	1992.6
2H-7, 44–48	17.44	1.33	2.89	83.7	179.6	1503.7	1999.9
3H-1, 26–30	17.76	1.33	3.01	85.9	194.2	1496.0	1987.7
3H-2, 44–48	19.44	1.32	2.41	86.2	200.6	1501.9	1982.5
3H-3, 44–48	20.94	1.35	2.68	85.1	182.7	1497.8	2022.0
3H-4, 44–48	22.44	1.30	2.52	87.3	220.2	1503.5	1954.5
3H-5, 44–48	23.94	1.41	2.61	81.7	146.3	1518.3	2140.8
3H-6, 44–48	25.44	1.37	2.56	82.6	162.5	1506.0	2063.2
3H-7, 44–48	26.94	1.38	2.74	84.1	166.5	1506.0	2078.3
4H-1, 44–48	27.44	1.37	2.55	83.5	168.0	1510.5	2069.4
4H-2, 44–48	28.94	1.38	2.71	83.3	163.5	1511.8	2086.3
4H-3, 44–48	30.44	1.52	2.80	76.7	107.0	1518.9	2308.7
4H-4, 44–48	31.94	1.49	2.71	74.8	106.4	1525.9	2273.6
4H-5, 44–48	33.44	1.49	2.66	91.3	168.6	1525.2	2272.5
4H-6, 44–48	34.94	1.27	2.57	49.4	66.3	1526.1	1938.1
4H-7, 4–8	36.04	1.46	2.83	75.5	112.5	1520.7	2220.2

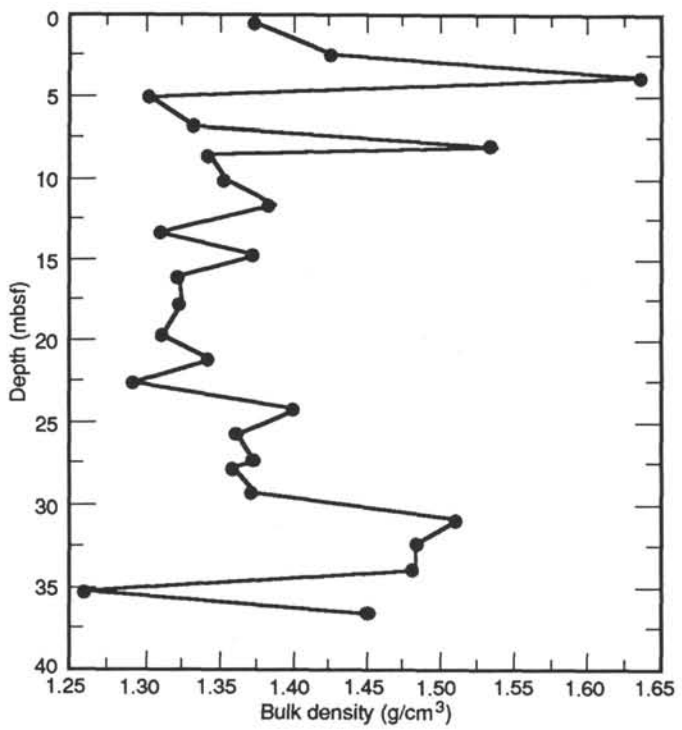

Figure 14. Bulk density vs. depth of samples for Hole 777B.

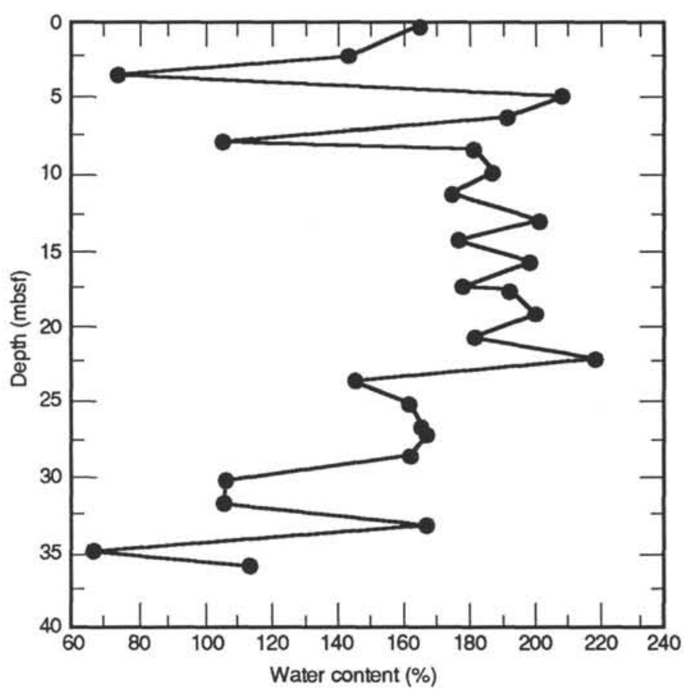

Figure 15. Water content vs. depth of samples for Hole 777B.

Discussion

The sediments at this site are most unusual in having very high water contents, porosities, and void ratios, and low shear strength and bulk densities. The porosity of the material does not change appreciably with depth. These characteristics are the result of the method of deposition and the diagenetic processes active in this environment. Most of the clayey sediments at this site are eolian in nature. They have been transported from the Asian continent by the planetary westerly wind flow. The rate of deposition at the site is estimated to be from 5 to 2.5 mm/1000 yr (see Fig. 13). This small rate of deposition and the eolian transport has supplied sediments at a low rate and in a nonfloc-

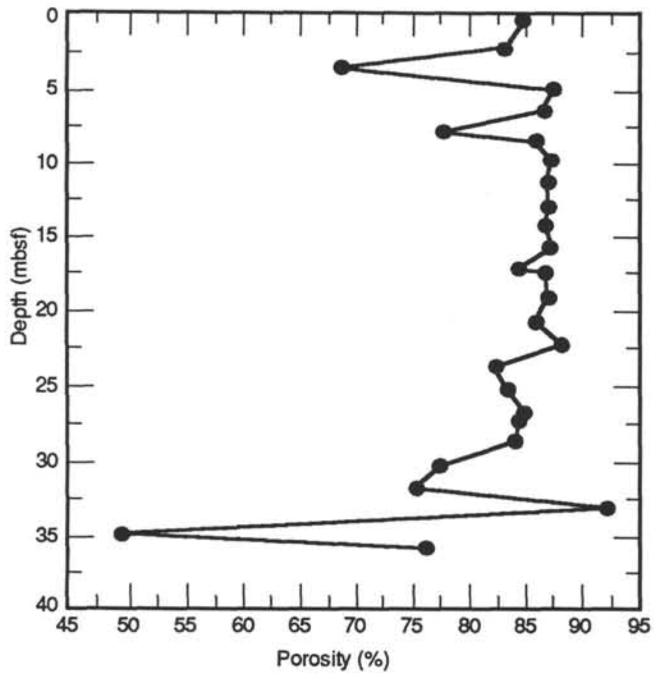

Figure 16. Porosity vs. depth of samples for Hole 777B.

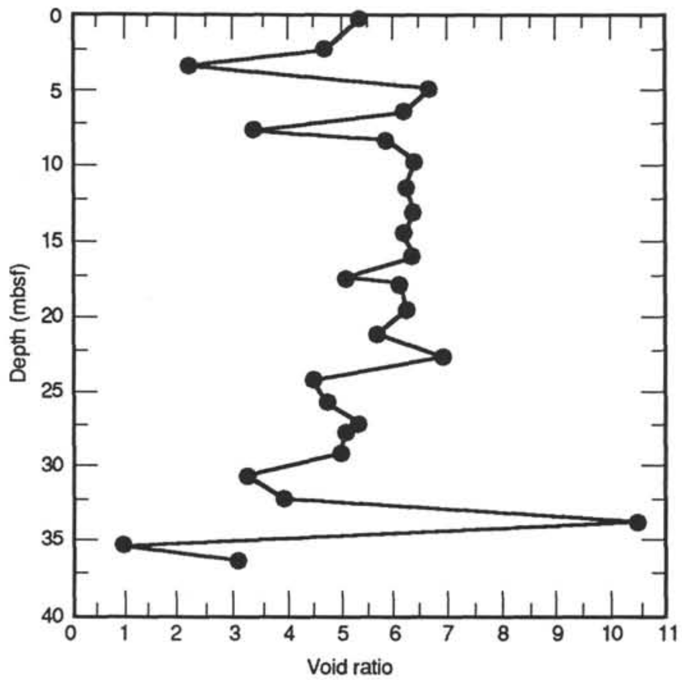

Figure 17. Void ratio vs. depth of samples for Hole 777B.

culated state. The individual particles deposited by the wind are most likely illite clays and fine quartz particles. The other sediment found at this site is most likely diagenetic. It is suggested that these high-porosity sediments are bound together by diagenetic smectite clay and various forms of silica, forming a microfabric that resists compaction and reduction in porosity from overburden stresses.

Geotechnical Stratigraphy

The geotechnical stratigraphy (the process of delineating units and unit boundaries that have similar geotechnical and acoustic characteristics) of Site 777 is very simple, owing to the thin sediment layer (Units I and II) that covers the lithified mudstones and cherts of Unit III. Four geotechnical boundaries were identified by examination of the physical-properties data. These boundaries occur at 8, 23, 30, and 37 mbsf. The boundary at 23 mbsf is the prominent seismic horizon on the bottom-pinger

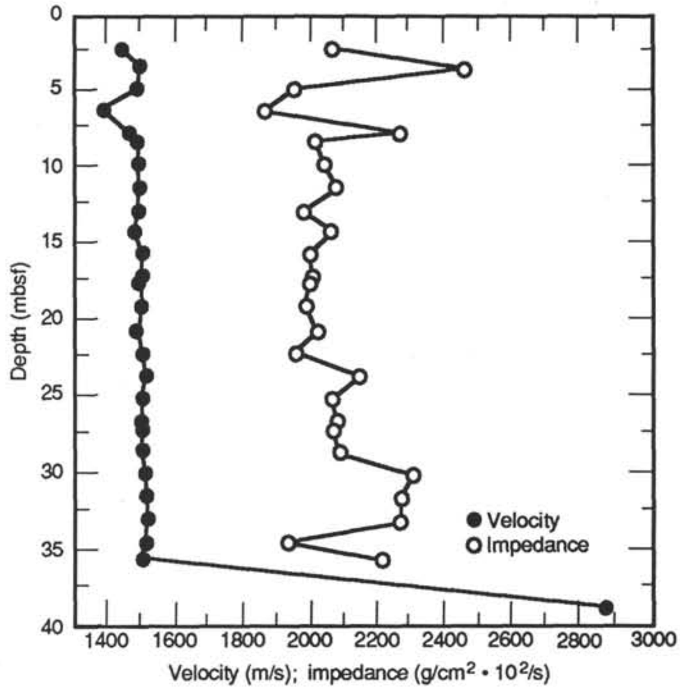

Figure 18. Compressional-wave velocity and acoustic impedance vs. depth of samples for Hole 777B.

Table 4. Undrained shear strength of Hole 777B sediments.

Core, section, interval (cm)	Depth (mbsf)	Shear strength (kPa)
124E-777B-		
1H-1, 75-76	0.75	3.0
1H-2, 87-88	2.37	5.1
1H-3, 50-51	3.50	9.1
1H-4, 52-53	5.02	11.4
1H-5, 51-52	6.51	11.4
1H-6, 10-11	7.60	25.5
1H-6, 30-31	7.80	34.5
2H-1, 50-51	8.50	13.8
2H-2, 50-51	10.00	17.5
2H-3, 50-51	11.50	13.8
2H-4, 75-76	13.25	17.5
2H-5, 50-51	14.50	20.4
2H-6, 50-51	16.00	19.7
2H-7, 50-51	17.50	13.1
3H-1, 50-51	18.00	13.1
3H-2, 50-51	19.50	14.6
3H-3, 50-51	21.00	18.9
3H-4, 50-51	22.50	18.2
3H-5, 50-51	24.00	21.1
3H-6, 50-51	25.50	27.7
3H-7, 50-51	27.00	14.6
4H-1, 50-51	27.50	24.0
4H-2, 50-51	29.00	24.8
4H-3, 50-51	30.50	24.0
4H-4, 50-51	32.00	29.8
4H-5, 50-51	33.50	30.6
4H-6, 50-51	35.00	24.0
4H-7, 50-51	36.50	31.3

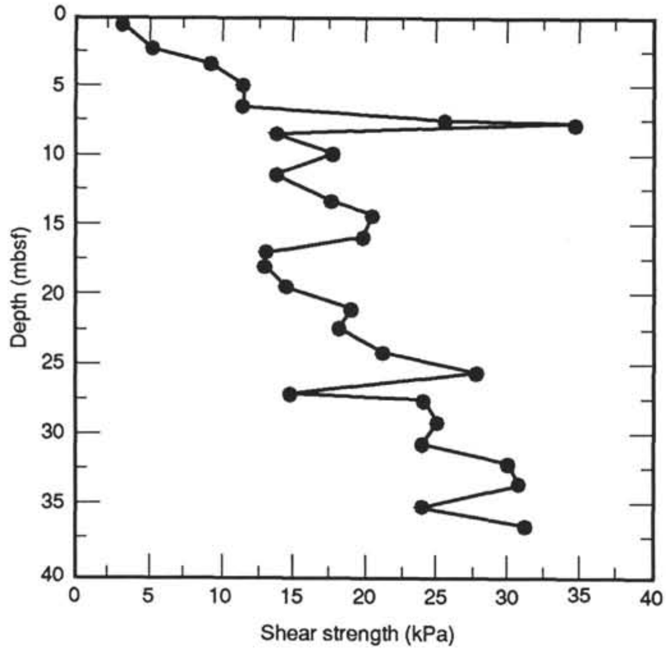

Figure 19. Undrained shear strength vs. depth of samples for Hole 777B.

high-resolution seismic profile at the mid-depth level (see Fig. 9). The 37-mbsf boundary corresponds to the cherty mudstone zone and chert layer at this site.

Summary and Conclusions

The siliciclastic sediments encountered in Units I and II at Site 777 presented most unusual geotechnical parameters. The sediment section is characterized by very high water content, porosity, and void ratios, and consists of eolian clays and quartz bound by diagenetic materials. Approximately 34 m of this sediment overlies a cherty mudstone and chert layer of low porosity and high velocity.

SUMMARY AND CONCLUSIONS

Engineering Summary

Extended Core Barrel (XCB)

The XCB-124E version of the XCB system was declared operational as a result of the trials on the leg and replaced the previous (-101C) version. Although the XCB is not suitable for chert or chert/sediment interbed coring, it is highly appropriate as a routine coring tool in many other lithologies commonly encountered in ODP operations. In testing in chert-dominated formations at Site 777 it was effectively given a severe trial. All previously identified areas of mechanical weakness were found to be improved over the previous design, as hoped. No mechanical failures occurred except for complete wear of the cutting shoes. In particular, the tendency toward catastrophic failure of the cutting-shoe box connection has been eliminated by new connections throughout the XCB with greatly improved torque strength. No evidence of any connection failures were observed, despite coring conditions that destroyed the best available diamond cutting shoes. The new-style cutting shoes also provided for enhanced cleanout capabilities when sediment managed to get in and clog the flow passages. There was not sufficient opportunity to evaluate how much of the clogging problem has been eliminated with the new, enlarged flow passages to the cutting shoes, but the results of the on-deck flow tests suggest that the problem will persist.

Navidrill Core Barrel (NCB)

Despite typical prototype-system problems with jammed sleeves and faulty mud motors and "Murphy's Law" (e.g., a shattered thruster spring and broken coring line), the NCB performed reasonably well. Two problems dominated the use of the NCB and accounted for the poor overall core recovery. The inability to stabilize the BHA in the shallow holes probably led to the fatigue failures of two diamond core bits and may well have contributed to the mysterious over-torqued connections. When the bit bodies fatigued and separated during a core run, the advance of the NCB in the formation was certainly terminated, and it cannot be said whether a good core would have been recovered. Core blocking in the core catchers and motor stalling, either or both of which dominated most of the "promising" NCB core runs, were both results of the interbedded chert conditions in the hole. Although all normal attempts were made to condition the holes between NCB core runs, it is almost certain that the bottom of the hole contained unremoved chips from the previous cored or drilled-down interval. This rubble surface was the first thing encountered by the NCB core bit when it unlatched and began the coring sequence. In typical mining diamond-coring operations the driller would start such a core run with very light weight on bit and controlled rpm until the bit was seated smoothly in fresh rock. The NCB is not capable of such delicacy and plunges ahead into a core jam or stall condition all too often.

Chert Interbed Coring in General

Site 777 had been chosen specifically for evaluation of the possibilities of achieving scientifically acceptable core recovery in interbedded chert/sediment lithologies. Although little to no soft sediment was recovered in any of the XCB or NCB cores, there was enough recovery to suggest that the chert was not massive rock but rather laced with either clay layers or, at the very least, prefractured. In either case the chert/porcellanite did not present itself as a stable hard-rock formation to be smoothly cut by the diamond coring bits of the XCB or NCB tools.

The attempts to core the chert beds with the XCB system were unsuccessful. A few pieces of chert were recovered with partially trimmed surfaces matching the cutting-shoe inner diameter, but the trimming operation was never completed because the chert layer apparently fractured before a full cylinder could be produced and "fed" into the core receptacle past the core catchers. This all-pervasive fracturing problem is thought to be caused by the excess energy caused by the proximity of the roller-cone bit and is endemic to the XCB system. In fact, this particular limiting characteristic of the XCB was one of the original factors that prompted development of the navidrill coring system. Although the cutting shoes, threaded connections, and latch assembly now used on the XCB (previous areas of mechanical vulnerability) all held up to the severe demands of chert-bed coring, the basic coring action of the XCB appears to be inadequate to core very hard/soft interbeds, owing to uncontrollable fracturing of the hard layers and washing of the soft material.

The NCB showed more promise than the XCB in chert-interbed coring but did not prove to be worthy of scientific commitment to a known chert-interbed locale unless certain improvements can be successfully made to the overall NCB system. The mud motors and bits used appeared to be capable of cutting core in the chert layers, as evidenced by well-trimmed pieces of chert/banded porcellanite in Cores 124E-777B-5N and 124E-777C-2N. These two cores were cut in the upper extremities of the chert zone and may have represented more readily coreable zones with less hard cuttings as fill between cores. When progress was made into what appeared to be more lithified zones deeper in the chert sequence, the NCB either stalled on the rubble, jammed the chunks in the core catcher, or both. The inherent characteristic of the NCB in its current configuration (as recognized long before Leg 124E) is to increase its downward force against the formation (weight on bit) as stall of the motor commences. This tendency causes almost certain stalling unless the bit can seat itself and get a smooth cutting action started. Even if equilibrium is achieved and coring of the chert layers proceeds smoothly, it can be interrupted and stalled by breaking through into a soft sediment layer and plunging ahead faster than the bit can trim the soft core. This, then, results in a core block and/or motor stall that cannot be corrected by any action taken on deck by the driller. The net result of these problems and tendencies is generally inefficient or ineffective coring in chert/sediment interbeds using the NCB. Significant design changes to the NCB system will be required to eliminate these problems.

Spudding into Hard Chert Zones under Minimal Sediment

Five holes were spudded and deepened into the chert layers at Site 777 without damage to the BHA, although this was considered a significant potential problem before the site was drilled. The improvements in heave compensation available with the *JOIDES Resolution* (as compared to the bumper subs used by the *Glomar Challenger*) make the spudding operation relatively routine (albeit slow), with as little as 38 m of extremely soft and unsupporting sediment over the hard chert/porcellanite layer.

Scientific Summary

Operations at Site 777 on Leg 124E demonstrate that XCB and NCB techniques as they presently exist are not capable of efficient drilling and core recovery in formations dominated by chert and porcellanite. The XCB cutting shoe is not sufficiently robust to withstand quick abrasion in those formations, and, when penetration is achieved, XCB recovery is no better than with rotary drilling (RCB). NCB recovery is occasionally more encouraging, but the cores at this site usually jammed off in the core catcher after only a small amount of recovery. The additional deployment time and maximum core length of 4 m make this technique very slow. In addition, the large amount of downpipe hardware and 4-m extension of the core barrel below the rotary bit at full stroke significantly increase the possibilities of mechanical malfunction and of a required pipe trip if the NCB cannot be retrieved with the wireline.

Leg 124E did not recover any original soft sediment below the uppermost chert/porcellanite zone in any of the Site 777 holes, although some fine-grained chert material was recovered that had been pulverized by the drilling process. Penetration rates varied after encountering the uppermost chert/porcellanite zone. This could be taken as evidence of interbedded hard and soft sedimentary layers or, alternatively, may indicate more or less drilling efficiency through solid chert/porcellanite, depending on the amount of chert rubble at the bottom of the hole at any given time. Because of this ambiguity in interpreting the drilling records, it is difficult to draw conclusions about the systems' capabilities to recover original soft sediment interbedded with cherts. Testing on land is badly needed to document the recovery capabilities of both of these systems in alternating hard and soft formations under ideal conditions. The Upper Cretaceous chert and chalk sequences of the South English or French Normandy coasts should be an excellent physical analogue of many deep-sea formations.

Scientific planning based on engineering developments yet to be achieved should always be a combination of optimistic thinking into the future tempered with the pragmatic realities of the present. Most of the goals for lithospheric drilling on the East Pacific Rise crest (the largest coherent ODP project ever approved by the JOIDES Planning Committee) can only be met with engineering technology that has yet to be developed and/or proved. Such optimistic plans are necessary goals for any significant technological progress and are equally as valid for scientific objectives in formations contaminated with chert as for bare-rock drilling on zero-aged crust. In the following discussion we shall assume, however, that the objectives must be obtained with *proved technology already in hand*, and shall develop an operational strategy to obtain those objectives.

Site 777 and a comparable site off the Bonin Trench are the two primary localities for obtaining geochemical reference sections for the western Pacific subduction-zone systems. Site 777 is also an excellent physical analogue for the highly rated Old Pacific drilling program, dedicated to obtaining the oldest remaining sedimentary and ocean-crustal samples of the Pacific Basin. The aspects of site-survey-location analysis that are most critical to the success of these drilling programs are careful study of existing 3.5-kHz and multichannel seismic records in an attempt to locate sites where "windows" might exist in the otherwise continuous chert/porcellanite zones. Failing discovery of such "windows," the 3.5-kHz profiles should reveal areas where the overlying pelagic clay layer is of maximum thickness for spudding with the BHA.

Operations at Site 777 demonstrate that in good weather conditions a pelagic clay overburden of 35–40 m could be sufficient to stabilize a short BHA, although a thicker section would be preferable. They also demonstrate that the chert/porcellanite zone will present both recovery and hole-stability problems. The only existing and proved ODP technology that potentially will deal with these stability problems, especially if 100–200 m of basement penetration is required, is to deploy a multiple reentry cone and to case through the unstable zone. This strategy was successful at Site 765 on Leg 123, where a geochemical reference section hole was drilled and cored 271 m into the Mesozoic basement of the Argo Abyssal Plain. Water depths and basement ages are nearly identical in both areas, so the main differences are that at Site 777 there is more chert/porcellanite to create hole-stability problems but less total sedimentary formation to case. The Leg 123 hole required 934 m of casing set 5 m into basement, whereas inspection of the seismic reflection records in the vicinity of Site 777 suggests a total sedimentary thickness of 300 m.

For the geochemical reference section sites off the Mariana Arc and possibly the Bonin Arc, we recommend a strategy essentially identical to that used at Site 765 on Leg 123. That consists of drilling and coring a "pilot" hole to basement with conventional RCB techniques to test the chert distribution at deeper levels than were reached at Site 777, locate the exact basement depth, and recover as much sedimentary material as possible. Then we recommend setting a conventional reentry cone, drilling to basement with an oversized tri-cone bit, and hanging and cementing 300 m of casing into basement to eliminate instability problems in the sedimentary section. The hole then can be cored to the desired basement depth with RCB techniques that usually provide good basement recovery in Mesozoic basalts.

The Old Pacific sites in the Pigafetta Basin could be attacked with a modification of that strategy, because deep penetration into basement is not as important, and there is a correspondingly greater interest in the Mesozoic sedimentary section. The site(s) should first be RCB drilled and cored to the basement surface for the same reasons as the geochemical reference section sites.

Inspection of the seismic records and the vertical/horizontal tectonic history of both areas suggest that the dominant chert zones are the ones first encountered at shallow levels and that the percentage of chert decreases downsection in the older material that was deposited prior to the equatorial crossings of these sites. Thus the main instability problems should be confined to the upper parts of the sedimentary sections and should allow a shorter casing program for the Old Pacific sites. After the pilot hole has been drilled to locate the unstable horizons, a reentry cone could be set and an oversized tri-cone bit used to redrill a casing hole to a level that will case off the main zone of instability, but not all the way to basement. We currently estimate that this would require about 150 m of casing at the Pigafetta Basin sites, leaving 150–400 m of Mesozoic sediments below the bottom of the casing.

The strategy for optimum recovery of the "target" section would consist of XCB or RCB coring of the Mesozoic sedimentary sequence to basement and then carrying the hole as deeply as possible into basement with RCB coring. Because the unstable chert zones would be cased off at that point, pumping rates could be reduced and recovery percentages increased over the pilot hole, even if RCB coring were deemed necessary.

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NOTE: All core description forms ("barrel sheets") and core photographs have been printed on coated paper and bound as Section 3, near the back of the book, beginning on page 139.