OCEAN DRILLING PROGRAM

LEG 124E ENGINEERING PROSPECTUS

PHILIPPINE SEA

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INTRODUCTION

The engineering technology requirements of the JOIDES science community have grown immensely over the past few years. The complexity of the tasks facing the ODP Engineering and Drilling Operations group is greater than ever before. To achieve the desired result -- the accomplishment of heretofore unattainable scientific goals -- requires a high level of cooperation between ODP and JOIDES. Key factors in the cooperative effort are improved communications between development engineers and JOIDES panels, more advanced planning (3- to 4-year plans) including better definition of technical requirements and science goals, more thorough shore- and sea-based test programs, and, finally, adequate funding levels for critical development projects and equipment.

To conduct the necessary sea-based tests, the concept of a dedicated engineering leg has been discussed for many years both within the Ocean Drilling Program and its predecessor, the Deep Sea Drilling Project. The opportunity to utilize JOIDES Resolution for testing developmental tools and evaluating new operational techniques, independent of science objectives, is indeed timely. Such things as vessel motion (operational handling and deployment considerations), marine corrosive atmosphere (rust and corrosion effects on mechanical actuation and hydraulic sealing), and ambient downhole conditions of temperature and pressure are rarely modeled effectively in a shore-based test. Proper testing at sea is critical to development of any efficient and reliable operational system.

Leg 124E, the first ODP cruise dedicated to engineering, is an important step in improving ODP sea-trials' test programs. It is hoped that the concept of dedicated ship time for engineering testing will continue as a pivotal element in future planning, and will help ensure successful hardware development. As such, the complex scientific requirements of the future can likewise be confidently planned for and achieved.

Major engineering objectives of Leg 124E include the following:

1. Shallow-water concept evaluation of the new Diamond Coring System (DCS) (Appendix A);
2. Continued operational evaluation of the developmental Navi-Drill Core Barrel (NCB) (Appendix B);
3. Prototype testing of the Pressure Core Sampler (PCS) (Phase I) (Appendix C);
4. Comparison performance testing, in parallel holes, of the newly redesigned Extended Core Barrel (XCB) (Appendix D);
5. Performance evaluation of ODP's most advanced coring systems (NCB, new XCB, etc.) in deep-water chert sequences;
6. Testing and evaluation of Lamont/BRG logging technology; and
7. Evaluation of deep-water operating capabilities of JOIDES Resolution, including drill-pipe hoisting system, drill-string design, coring/core retrieval systems, positioning beacons, etc.

OBJECTIVES OF PROPOSED SITES

Leg 124E is scheduled to depart Manila on 9 January 1989 and arrive in Guam on 13 February 1989. The leg will be 35 days in duration and will complete a transit across the Philippine Sea (Fig. 1). A minimum of three sites (ENG-1, ENG-2, and ENG-3) will be drilled, with a fourth site (ENG-4) scheduled if time permits (Tables 1 and 2). Each site has been selected to meet the required geologic and oceanographic conditions for the planned engineering and logging tests, while making optimum use of ship's time.

Site ENG-1 (20°12.20'N, 121°38.6'E, water depth 1650 m) is located just north of the Philippine Islands, south of Taiwan, in the Luzon Strait near the Batan Islands (Fig. 2). The site will be occupied for approximately 15.5 days while testing the Diamond Coring System (DCS), Pressure Core Sampler (PCS), Navi-Drill Core Barrel (NCB), and the latest version of the Extended Core Barrel (XCB).

Site ENG-2 (17°54.42'N, 143°40.95'E, water depth 4703 m) is approximately 1257 nautical miles due east of ENG-1 (at the location of DSDP Site 453). A total of 1.5 days will be spent drilling a hole dedicated to testing Lamont/BRG developmental logging tools. Five days will then be spent deploying and testing those tools.

Site ENG-3 (17°40.17'N, 148°37.75'E, water depth 5872 m) lies northeast of Guam near the location of DSDP Site 452, where difficult drilling conditions in an abundance of deep-water chert with very limited sediment cover (20-50 m) prevented achieving DSDP science objectives. Approximately 2.3 days will be spent attempting to core at this site using ODP's latest technology (i.e., NCB, new XCB, etc.)

Site ENG-4 (15°N, 147°30'E, water depth 8250 m) is a priority 2 site, that will be drilled only if time is available. The site is located in the Mariana Trench, where the intention is to spend as much as 1.5 days evaluating the deep-water operating capabilities of the JOIDES Resolution. Of primary interest is functioning of the vessel's hoisting equipment (i.e., draw works and coring winch) and dynamic positioning system (i.e., deep-water beacon performance). A drill-pipe bending stress test, such as that conducted on ODP Leg 117, is also planned to obtain additional bending stress data. A deep-water test of the sonar reentry system, TV winch/coaxial cable, and logging line will use any remaining time.

ODP ENGINEERING AND DRILLING OPERATIONS TEST PLAN

Most of the available time is to be devoted to engineering tests at the first site (ENG-1; Figs. 1 and 2). The first hole drilled at this site ("A" hole) will be an XCB (possible reentry pilot) hole to basement. After locating and spudding the mud line with the APC system, the new XCB will be used to core through the volcaniclastic material anticipated, to basement. One or two runs with the prototype Pressure Core Sampler (PCS) will be made depending on formation conditions and tool performance. Upon reaching basement (possibly earlier if conditions warrant),the Navi-Drill Core Barrel will be deployed for several cores. The "drill ahead by adding drill rod" method will be evaluated both for technical feasibility and time optimization. The objective is to drill at least 30 m into basement.

The results of the first test hole (Hole "A") will determine if a reentry cone and 11 3/4-in. surface casing run to basement is necessary for the Diamond Coring System (DCS) test, or whether the DCS can be deployed through a slightly modified bottom-hole assembly (BHA) drilled down to basement.

The DCS test (in Hole "B") will consist of continuously coring 100-200 m into indurated rock and/or basement lithologies. The soft overlying sediments and volcaniclastic material will not be cored using this system. The intention is to calculate the usefulness of a high-speed (400-600 rpm), low-bit-weight (4,000-12,000 lb), narrow-kerf diamond coring system through 5-1/2-in. drill pipe to successfully core from a floating vessel. Of primary importance is the evaluation of the DCS secondary heave compensation system's ability to control the DCS weight on bit (WOB) to a maximum ±1,000-lb load fluctuation. After completion of the DCS test, all related contract personnel (i.e., Tonto Drilling, Westech Gear, etc.) and hardware accompanying the cruise will be returned to Manila via an oilfield supply boat and/or helicopter.

A third hole (Hole "C") may be continuously cored at ENG-1 after the DCS test. This hole, a duplicate of the first hole, will allow comparison with the XCB system. Coring a second hole in the same formation will permit varying XCB design options/operational parameters and evaluating the resulting coring system performance. One or two additional runs with the PCS are considered, depending on tool status and formation conditions. Note that the time to drill this "C" hole will be available only if a reentry cone and surface casing string are unnecessary on the "B" hole or if the DCS evaluation testing progresses significantly faster than anticipated.

The NCB will again be drilled into basement to continue gathering information on operating parameters, refining deployment/handling techniques, and learning more about the interpretation of rig operating data. Refinement of the NCB into an effective, reliable, and efficient coring system will require many hours of shipboard operation. Reaming the "rat-hole" with the main 11-7/16-in. XCB bit will likely be evaluated in this second round of testing.

After completing coring operations at ENG-1, the vessel will travel 1250 nautical miles (nmi) (approximately 4.8 days) nearly due east to ENG-2. A dedicated 9-7/8-in. hole will be drilled at that site approximately 200 m into basement for the purpose of evaluating Lamont/BRG developmental logging tools. There will be no coring operations at this site since it is at previously cored DSDP Site 453. An evaluation is scheduled also of the Sidewall Entry Sub (SES) as a potential method of cooling downhole logging tools with circulating drill fluid while conducting logging operations. That technique is being evaluated for use in future high-temperature logging situations. Details of the test plan for Site ENG-2 can be found in the following section, "Lamont/BRG Logging Test Plan".

Site ENG-3 lies approximately 283 nmi east of ENG-2, at the location of DSDP Site 452. Here an attempt will be made to find as thick a sediment section as possible. DSDP attempts to core at this site were unrewarding due to the occurrence of massive chert close to the mud line (within 20-50 mbsf). The XCB (if sufficient sediment cover is found) and/or NCB holes drilled at this site will attempt to recover samples of this deep-water chert accumulation. It is anticipated that several holes will be spudded at the site.

Site ENG-4 lies south of ENG-3, in the general direction of the island of Guam. This site is located within the Mariana Trench, and will be drilled only if time remains after completing the objectives at the higher priority sites. It is anticipated that several shallow holes, with either the APC/XCB or RCB coring system, will be attempted. The primary objective is to confirm the capability and readiness of JOIDES Resolution to perform routine coring operations in deep (8250+ m) water. The ship's hoisting (draw works and coring winch) and positioning (deep-water beacons) will be evaluated as well as the standard ODP coring systems, sonar reentry system, TV winch/coaxial cable, and seven-conductor electric logging line. Although the ship has been designed for operations in over 9150 m (30,000 ft) of water, the longest ODP drill string deployed to date has been less than 5500 m (18,000 ft.). With test operations conducted at ENG-4, ODP plans to confirm a deep-water capability before such a leg is planned into the science schedule.

LAMONT/BRG LOGGING TEST PLAN

At site ENG-2, a new hole will be drilled at the location of DSDP Hole 453. Approximately 450 m of mud, silt, and volcaniclastic material overlies basement at this site (Shipboard Scientific Party, 1981). Total basement penetration of 200 m is planned through metagabbroic breccia, metabasalt, and serpentinite. Heat flow of 2.4 m cal/cm^2 s at this site should produce a bottom-hole temperature in excess of 50°C.

GEOCHEMICAL LOGGING TOOL CONFIGURATIONS

Engineering tests planned in the hole will begin with several experiments with the geochemical logging tool suites. Future western Pacific (WPAC) logging plans require the combination of several very complex nuclear logging measurements into one tool string. The combination of (1) natural spectral gamma ray, (2) aluminum activation, and (3) gamma ray spectroscopy tools with (4) lithodensity has produced cross-activation problems in two previous deployments (ODP Legs 111 and 116). Experimental configurations of the lithodensity with the seismic stratigraphy, phaser induction, and natural gamma spectroscopy tools will also be tested to see which combination produces the most reliable, accurate, and rapid logging results.

The variable lithologies of the basement and sediments at this site should produce sharp geochemical contrasts that will be ideal to evaluate of the best configuration for future Schlumberger tool combinations. Repeatability and signal-to-noise ratio of repeat intervals from several different tool combinations will be tested also.

We plan 24 hr of logging, first with the AMS/NGT/AACT/GST/H-LDT, then with the AMS/NGT/LSS/DIT-E/H-LDT combinations. The H-LDT is the new Schlumberger hydraulically excentered, high-temperature lithodensity tool to be used for the first time during these tests. A thorough tool check will also be performed at this time.

WIRELINE PACKER TESTS

Initial sea-trial testing of the TAM International Wireline Packer will occupy 48 hr. Setting and inflating the balloon packers, successful deflation, repeated trips into the bottom-hole assembly, fluid drawdown, sample chamber sensitivity, sample bottle filling, sample integrity, pressure and temperature monitoring capabilities, and filtration system will be tested in repeated lowerings into the borehole. Packer and gechemical tests will be conducted simultaneously. This will allow breaking down the tools and evaluating the packer's performance to proceed on deck while the geochemical tool is downhole, and vice-versa. Recovering fluid samples from basement, hard lithified sediment, and soft unconsolidated sediment will also be attempted.

FORMATION MICROSCANNER DEPLOYMENT

First sea trials of the new miniaturized version of the Schlumberger formation microscanner (FMS) will be carried out for 12 hr. Repeated opening and closing of the dipmeter pads, telemetry of the borehole images, reentry into the bottom-hole assembly, and effects of ship's heave on data quality will be evaluated.

WIRELINE HEAVE COMPENSATION TESTS

Testing of the Wireline Heave Compensator (WHC) will be conducted by first logging with the WHC on, then off. When the seas are calm, the WHC has been shown to produce "artificial ship heave" by overcompensating for the vertical acceleration of the ship. Twelve hours of experimentation with various driving functions of the WHC will be conducted with accelerometers of the formation microscanner (FMS) used to monitor behavior of the logging tool (with dipmeter pads closed). An attempt will be made to evaluate driving of the WHC with the downhole acceleration from the FMS tool.

SIDEWALL ENTRY SUB HOT HOLE EVALUATION

The Sidewall Entry Sub (SES) will be added to the drill string and the Auxiliary Measurement Sonde (AMS) lowered into open hole beneath the pipe to monitor temperature. The drill pipe and logging cable will then be pulled at the same speed while pumping at various circulation rates. The change in temperature of the logging tool will be measured and compared against predictions from theoretical studies of the cooling effect of such a circulate-while-logging technique. The effect of halted circulation during pipe trips, while joints are disconnected, will also be observed. Methods of streamlining assembly and disassembly of the SES will also be investigated during these tests.

BOREHOLE TELEVIEWER/MAGNETOMETER TOOL

The Borehole Televiewer/Susceptibility/Magnetometer/Gyro tool combination will be tested pending availability of those tools and if all other borehole tests have been completed. This tool combination will save three different lowerings of speciality logging tools, but transmission of data from the three tools together is complex, and mechanical modifications are extensive. Consequently, this test has a lower priority than all others.

SCIENTIFIC OBJECTIVES OF LEG 124E

The scientific objectives of Leg 124E are of secondary priority relative to the engineering development and logging tool tests described above, though some of them are related to the primary objectives. The scientific objectives include:

1. Where cores are collected at Sites ENG-1, ENG-3, and ENG-4, the nature, age, degree of drilling disturbance, and physical properties characteristics of the recovered material will be documented. This will add to our geologic understanding of the regions drilled by complementing the results from DSDP Legs 59 and 60. It will also provide valuable information for interpreting the effects of varying coring systems and drilling parameters.

2. Where logs are collected at Site ENG-2, the logging data will serve to augment previous coring results at Site 453 (DSDP Leg 60). Core recovery at Site 453 averaged 39%.

3. A number of the cores collected in the course of the engineering tests will be dedicated to a geriatric core study. This study will systematically monitor changes in faunal assemblages, chemistry, and physical properties over an indefinite period of time, beginning with initial core recovery aboard ship. Repeated subsampling and measurements of the dedicated cores is scheduled after they are stored in the ODP repository. An understanding of the scientific importance of the changes which occur in these cores during storage is vital to core analysis in general.

To fulfill these scientific objectives, the staff of Leg 124E will include a number of shipboard scientists and curatorial personnel. The scientists will analyze the recovered core material and logs, and write up the results for post-cruise publication; the curatorial personnel will be responsible for planning and implementing the geriatric core study.

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TABLE 1

LEG 124E ENGINEERING TEST PROGRAM - PHILIPPINE SEA

SITE	LATITUDE (N)	LONGITUDE (E)	WATER DEPTH (m)	DRILLING DEPTH (mbsf)	DRILLING TIME (days)	LOGGING TIME (days)	TOTAL TIME (days)
PRIORITY 1 SITES							
ENG-1	20°12.20'	121°38.6'	1650	350-450	15.5	0	15.5
ENG-2 (DSDP SITE 453)	17°54.42'	143°40.95'	4703	655	[a]1.5	5.0	6.5
ENG-3 (DSDP HOLE 452A)	17°40.17'	148°37.75'	5872	????	2.3	0	2.3
PRIORITY 2 SITE							
ENG-4	15°	147°30'	8250	30-50	[b]1.5	0	1.5

[a] Dedicated hole for Lamont/Borehole Research Group test program.

[b] This site is lower in priority and will be drilled only if time remains after all test objectives at Sites ENG 1-3 have been satisfied.

TABLE 2

SITE OCCUPATION SCHEDULE

SITE	LOCATION	TRANSIT[a] TIME (days)	OPERATIONS (days)	DATE
In port, Manila 4-8 Jan 1989				
Depart Manila				9 Jan 1989
		1.8		
ENG-1	20°12.20'N 121°38.6'E		15.5	
		4.8		
ENG-2 (DSDP SITE 453)	17°54.42'N 143°40.95'E		6.5	
		1.1		
ENG-3 (DSDP SITE 452)	17°40.17'N 148°37.75'E		2.3	
		0.7		
ENG-4	15°N 147°30'E		1.5	
		0.8		
Arrive Guam				13 Feb 1989
	SUBTOTAL	9.2	25.8	
	TOTAL		35.0	

[a] Calculated at a transit speed of 11.0 kt.

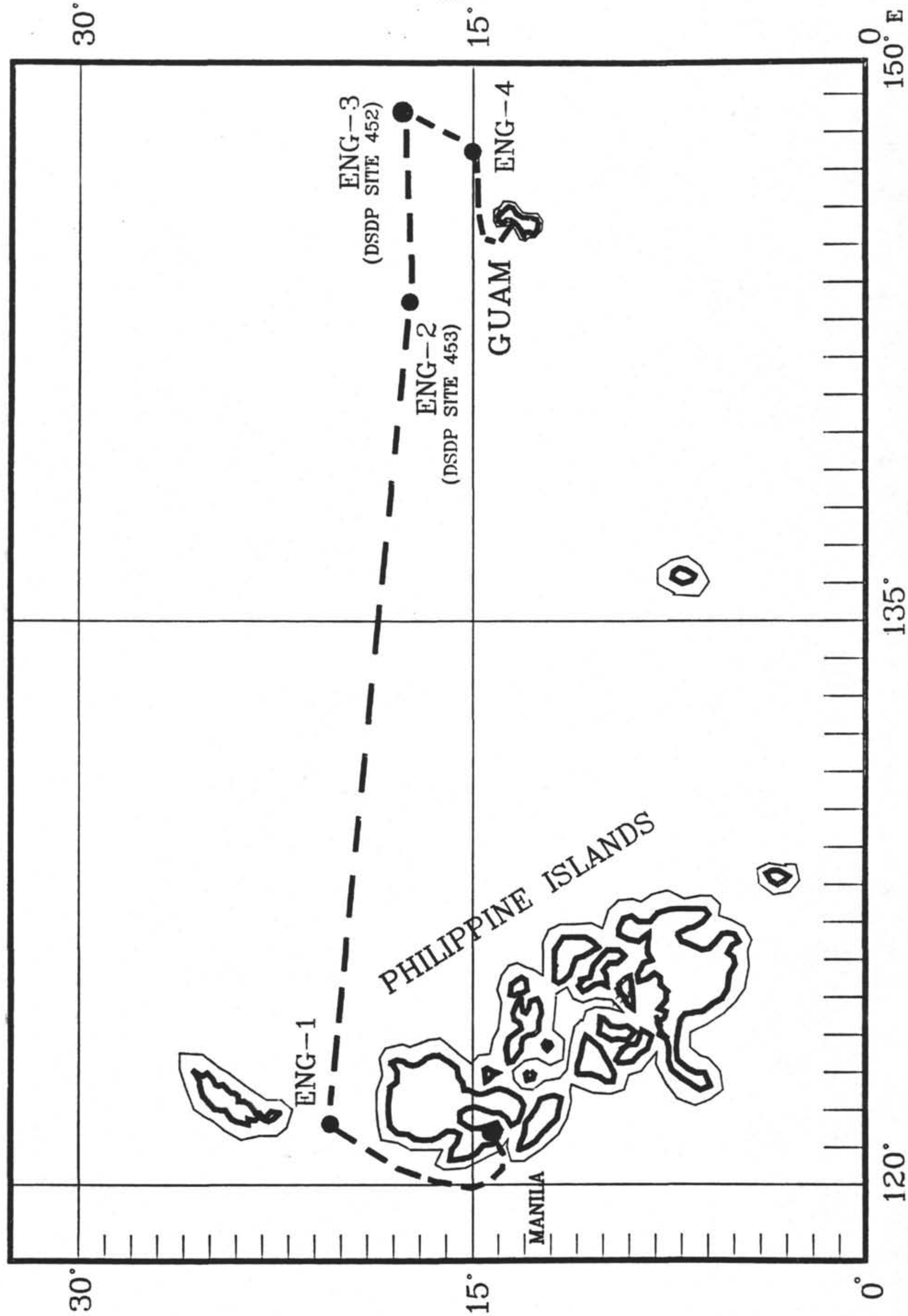


Figure 1. Locations of Sites proposed for drilling on ODP Leg 124E.

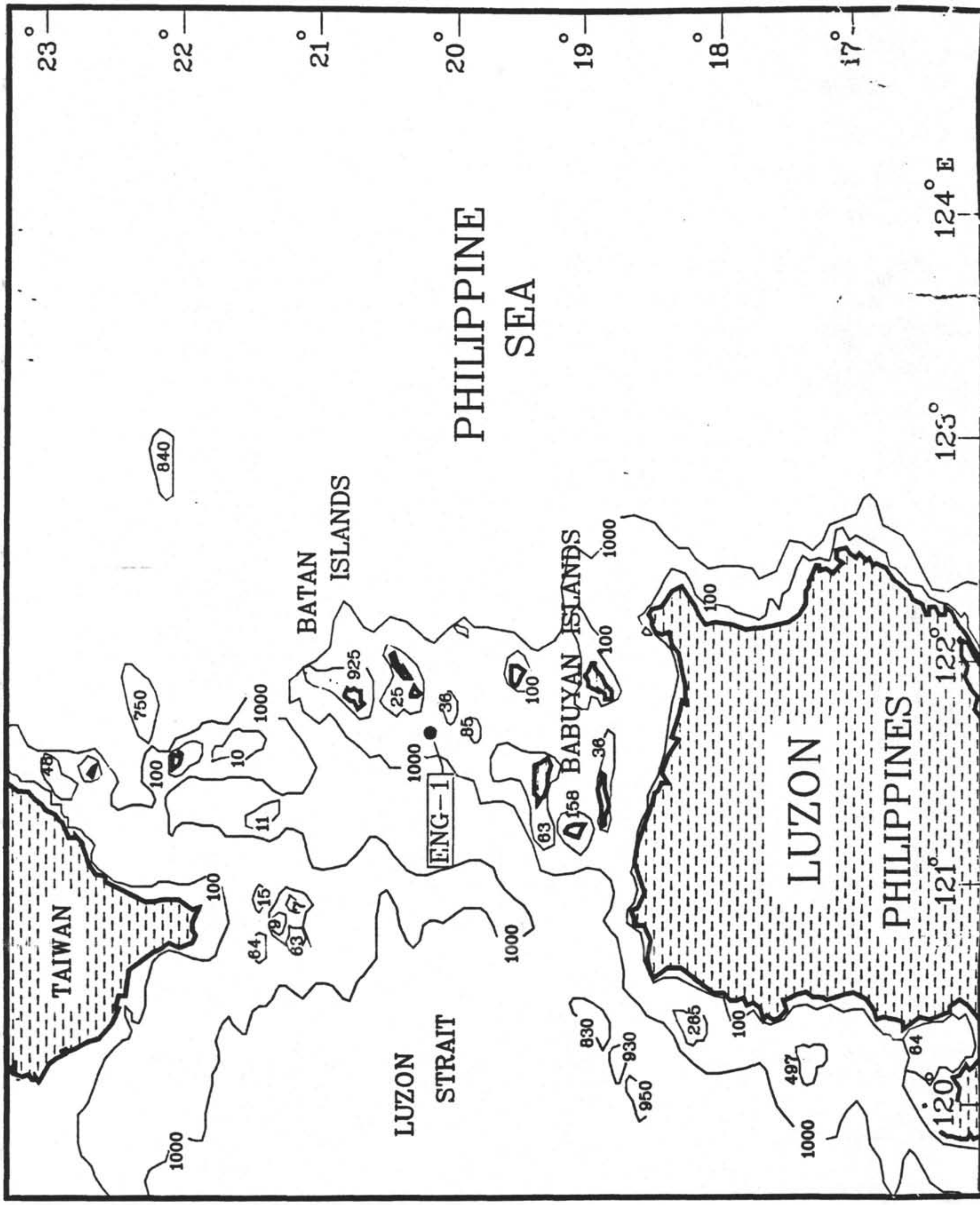


Figure 2. Location of ODP Site ENG-1.

<u>SITE NUMBER:</u> ENG-1

<u>POSITION:</u> 20°12.2'N, 121°38.6'E <u>JURISDICTION:</u> Philippines

<u>SEDIMENT THICKNESS:</u> 250 m <u>PRIORITY:</u> 1

<u>WATER DEPTH:</u> 1650 m

<u>PROPOSED DRILLING PROGRAM:</u>

Hole A: This hole will be the pilot hole that determines whether a reentry cone and casing will be needed for the Diamond Coring System (DCS) test on hole "B." In addition to a "wash-in" test, the following engineering tests will be conducted in this hole:

1. Test Pressure Core Sampler (PCS) in the upper pelagic sedimentary sequence. Phase I - downhole tool only. Estimate one or two runs with the PCS in the upper 50-100 m.
2. Test the new Extended Core Barrel (XCB) coring system in the volcaniclastic sedimentary sequence overlying basement. Continuous core with the XCB from the mud line. Possibly attempt one or two cores into basement with the XCB.
3. Test the Navi-Drill Core Barrel (NCB) in the volcaniclastic sequence (depending on XCB performance) and/or basement. Core ahead of the main XCB bit with the NCB by adding drill rod. A basement penetration of 30-50 m is desired.

Hole B: Prototype test of the Diamond Coring System (DCS). Set reentry cone. Run and cement 11 3/4" casing to basement. Deploy DCS system and core 100-200 m into basement.

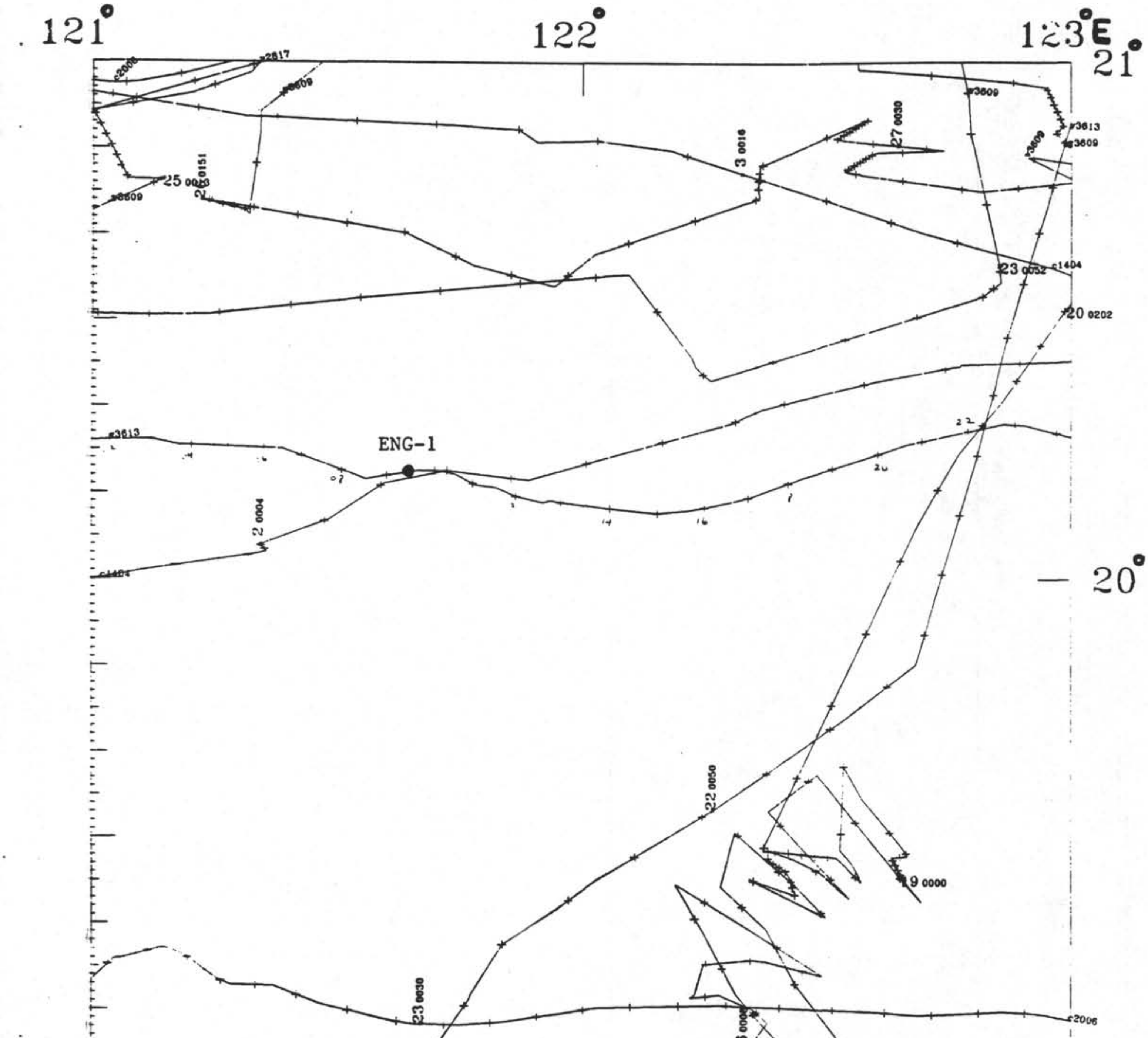
Hole C: Continuously core sequence with the XCB a second time. Change operating parameters and/or cutting shoes from hole "A" to evaluate the effect on coring system performance. Deploy the PCS for one or two additional runs in the upper 50-100 m of pelagic sediment. Deploy the NCB for 30-50 m of basement penetration in the core-ahead-then-ream deployment mode. May not be drilled if reentry cone/casing is required on "B" hole.

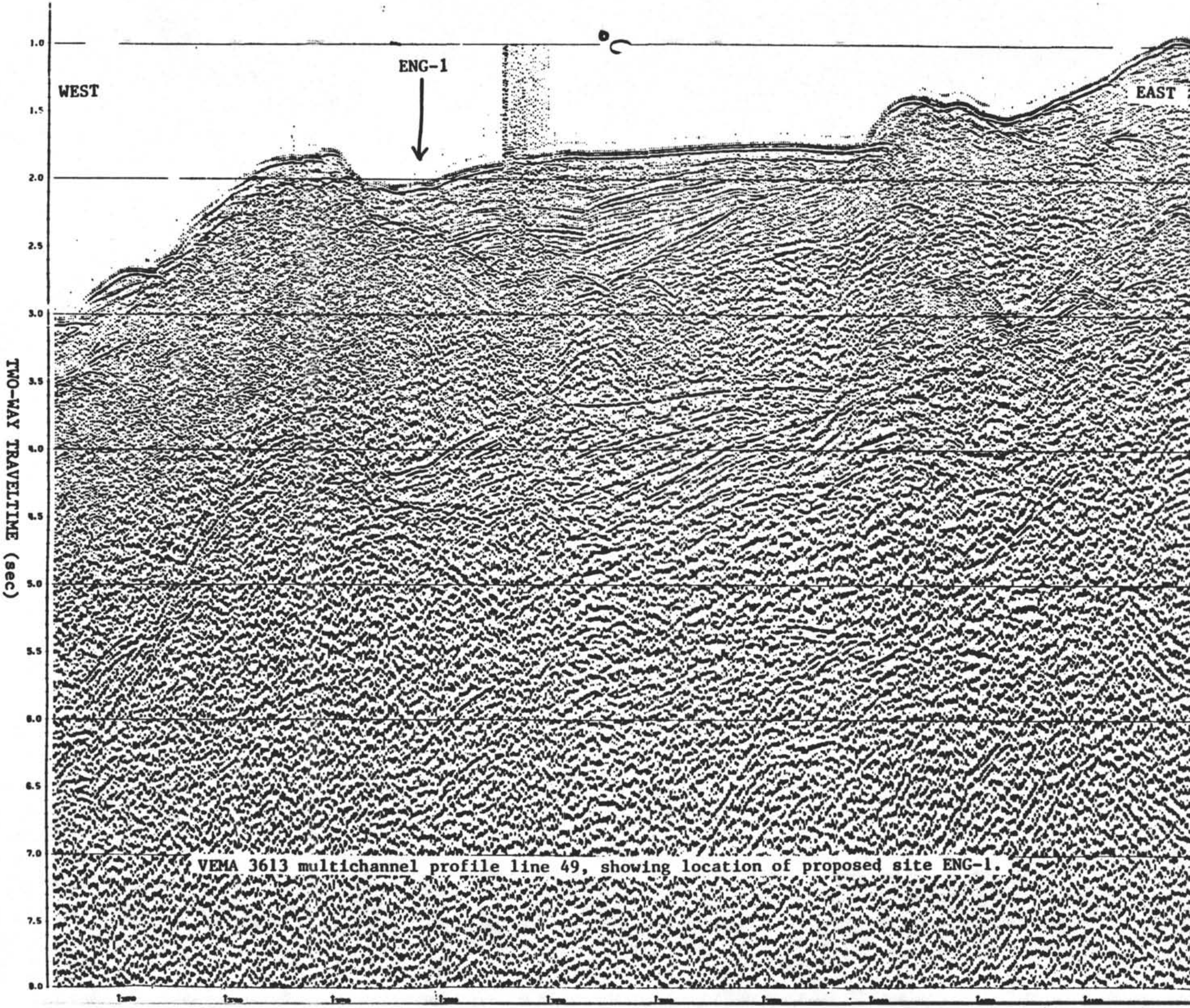
<u>SEISMIC RECORD:</u> VEMA 3613 multichannel seismic profile (line 49, CDP 3770; 19 July 1980, shotpoint 0930 UTC).

<u>OBJECTIVES:</u> Test Prototype Diamond Coring System, New Extended Core Barrel, Navi-Drill Core Barrel, and Pressure Core Sampler.

<u>LOGGING:</u> None

<u>SEDIMENT TYPE:</u> Volcaniclastic material interbedded with pelagic mud and silt overlying basement.


121°
122°
123°E
21°
20°
19°N
ENG-1
25
3 0016
27 0030
23 0032
20 0202
22 0050
2 0004
19 0000
23 0030
c1404
c2006
c3613



VEMA 3613 multichannel profile line 49, showing location of proposed site ENG-1.

SITE NUMBER: ENG-2 (DSDP Site 453)

POSITION: 17°54.42'N, 143°40.95'E

JURISDICTION: North Mariana Islands (U.S. Commonwealth)

SEDIMENT THICKNESS: 455 m

PRIORITY: 1

WATER DEPTH: 4703 m

PROPOSED DRILLING PROGRAM:

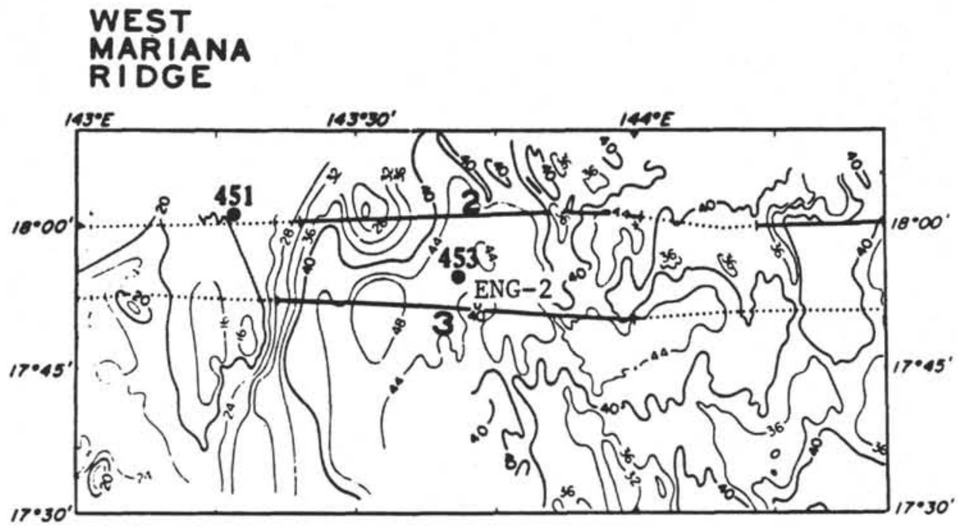
Hole A: Dedicated hole drilled for Lamont/BRG logging tests. Hole to be drilled approximately 200 m into basement. Testing to include: Wireline Packer, Combined Geochemical/Lithodensity Nuclear Tool, Sidewall Entry Sub Hot Hole Logging System, Wireline Heave Compensator, FMS Slimhole Dipmeter deployment, and possible deployment of a Combined Borehole Televiewer/ Susceptibility/Three Component Magnetometer.

SEISMIC RECORD: *Glomar Challenger* profile collected during pre-site survey for DSDP Site 453 on Leg 60 (28 March 1978, 0240 UTC and 0325 UTC). Multichannel seismic profiles 2 and 3 collected on *Robert Conrad* cruise 20-06 (See also DSDP Leg 60).

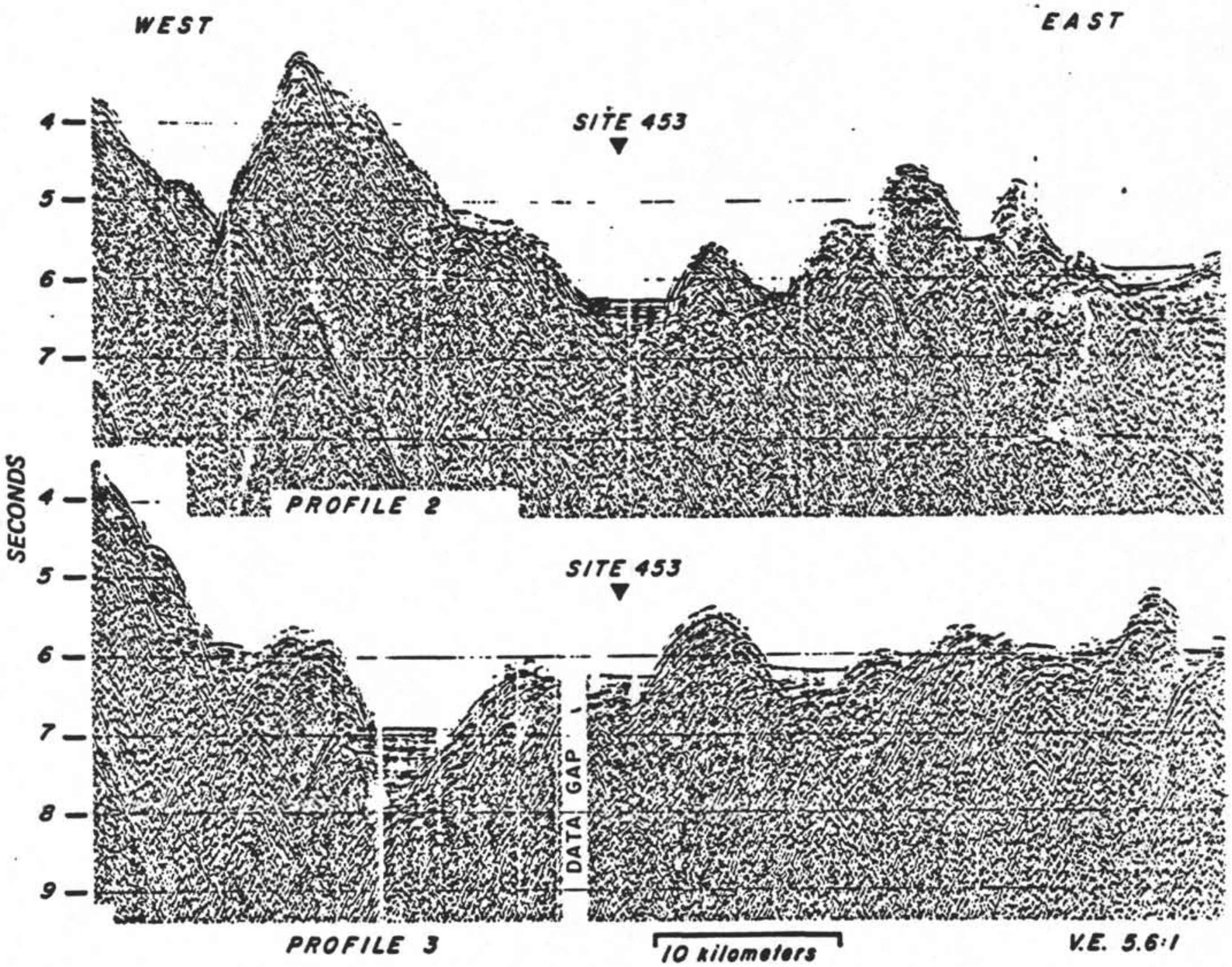
OBJECTIVES: Evaluate all the above-mentioned logging tools (see proposed logging tools test plan) for use on standard ODP legs including evaluation of the SES as a possible means of cooling the borehole to acceptable limits for hot hole operations.

LOGGING: Defined above.

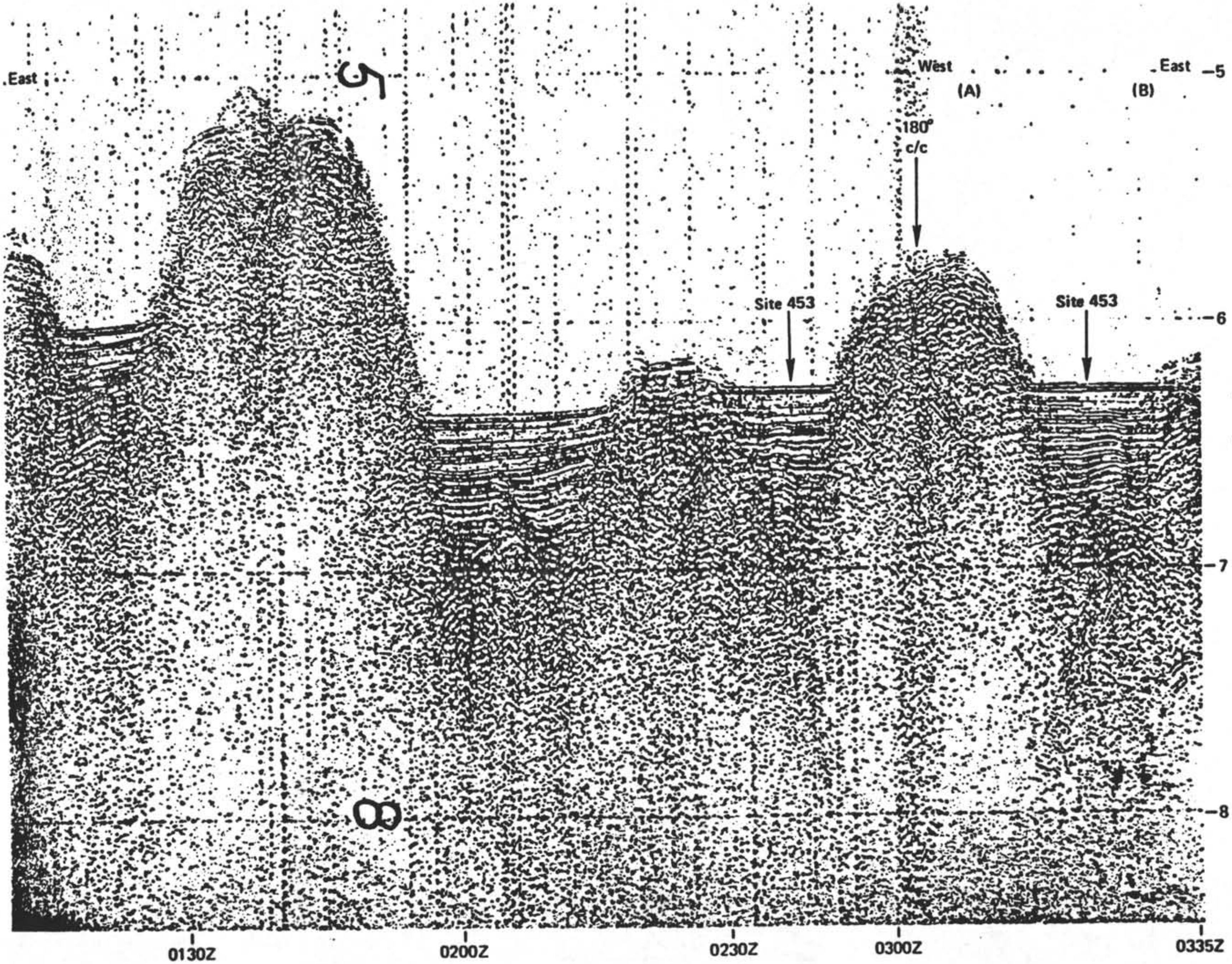
SEDIMENT TYPE: Pleistocene-Pliocene volcaniclastic mud, silt, and sand, overlying igneous and metamorphosed polymict breccias.



Bathymetric map of West Mariana Ridge and Mariana Trough region, simplified from Hussong (1981) and Langseth and Mrozowski (1980). Contours in hundreds of meters. R/V Conrad 20-06 shiptrack is shown by dotted line. MCS profiles 2 and 3 are indicated by solid lines. DSDP Sites shown by numbered dots; proposed site ENG-2 is located at DSDP Site 453. [Modified from Mrozowski, Hayes, and Taylor, 1981, Fig. 1].



R/V Robert Conrad multichannel profiles 2 and 3, showing location of DSDP Site 453 (=location of proposed site ENG-2). From Mrozowski, Hayes, and Taylor, 1981, Fig. 3).



Portion of D/V Glomar Challenger profile collected during pre-site survey for Site 453 (=location of proposed site ENG-2), showing two crossings over site. (From Shipboard Scientific Party, 1981, Fig. 17).

SITE NUMBER: ENG-3 (DSDP Site 452)

POSITION: 17°40.17'N,148°37.75'E

JURISDICTION: Northern Mariana Islands (U.S. Commonwealth)

SEDIMENT THICKNESS:

PRIORITY: 1

WATER DEPTH: 5872 m

PROPOSED DRILLING PROGRAM:

Hole A: Spud mud line with XCB coring system and core upper pelagic sediment until chert is reached. If sufficient sediment exists to stabilize the BHA, then attempt to core chert intervals with new XCB system and advanced diamond cutting shoes. If lateral support is insufficient, then attempt chert coring with the NCB coring system.

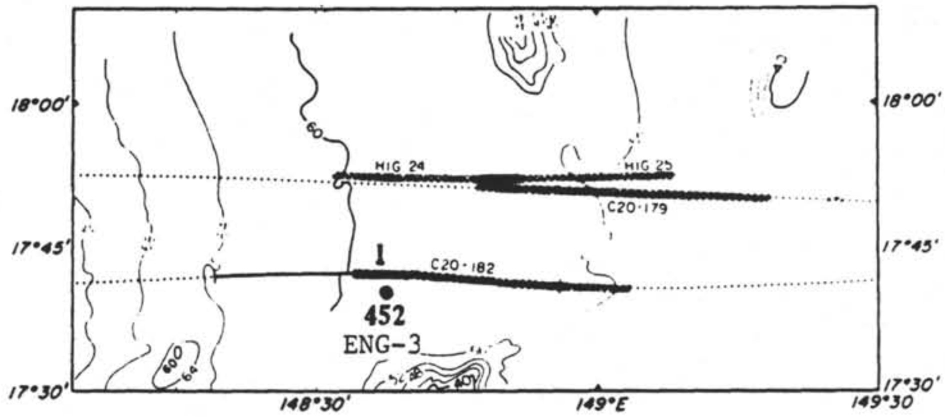
Hole B: Due to limited sediment cover overlying the chert at this location, several holes may be required during the test.

SEISMIC RECORD: Kana Keoki single-channel air-gun record (27 April 1977, 0800 UTC). Glomar Challenger records collected during pre-site survey for DSDP Site 452 on Leg 60. Multichannel seismic profile 1 collected on Robert Conrad cruise 20-06 (See DSDP Leg 60).

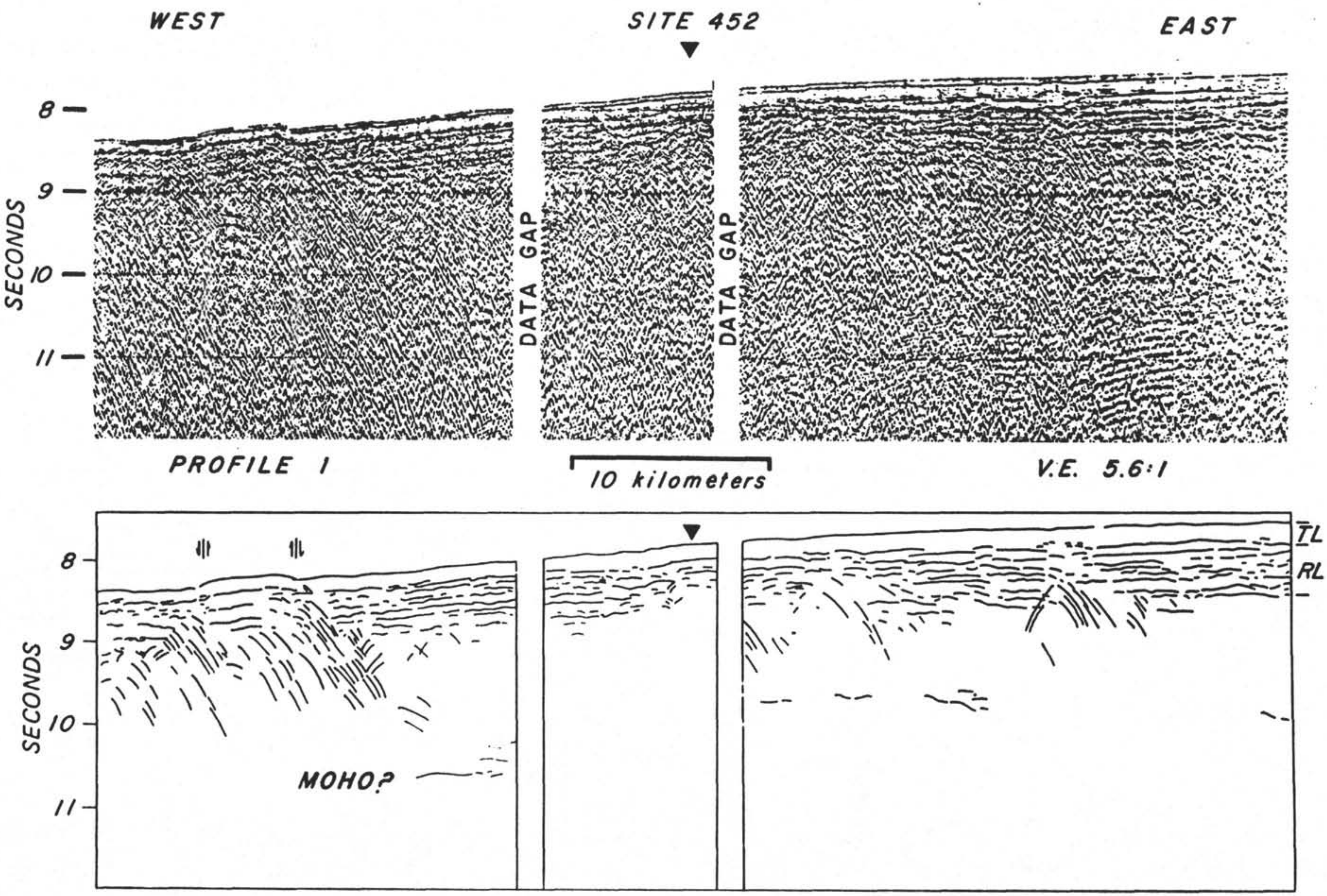
OBJECTIVES: Evaluate the ability of ODP coring systems (XCB and NCB) to effectively penetrate and core chert facies.

LOGGING: None

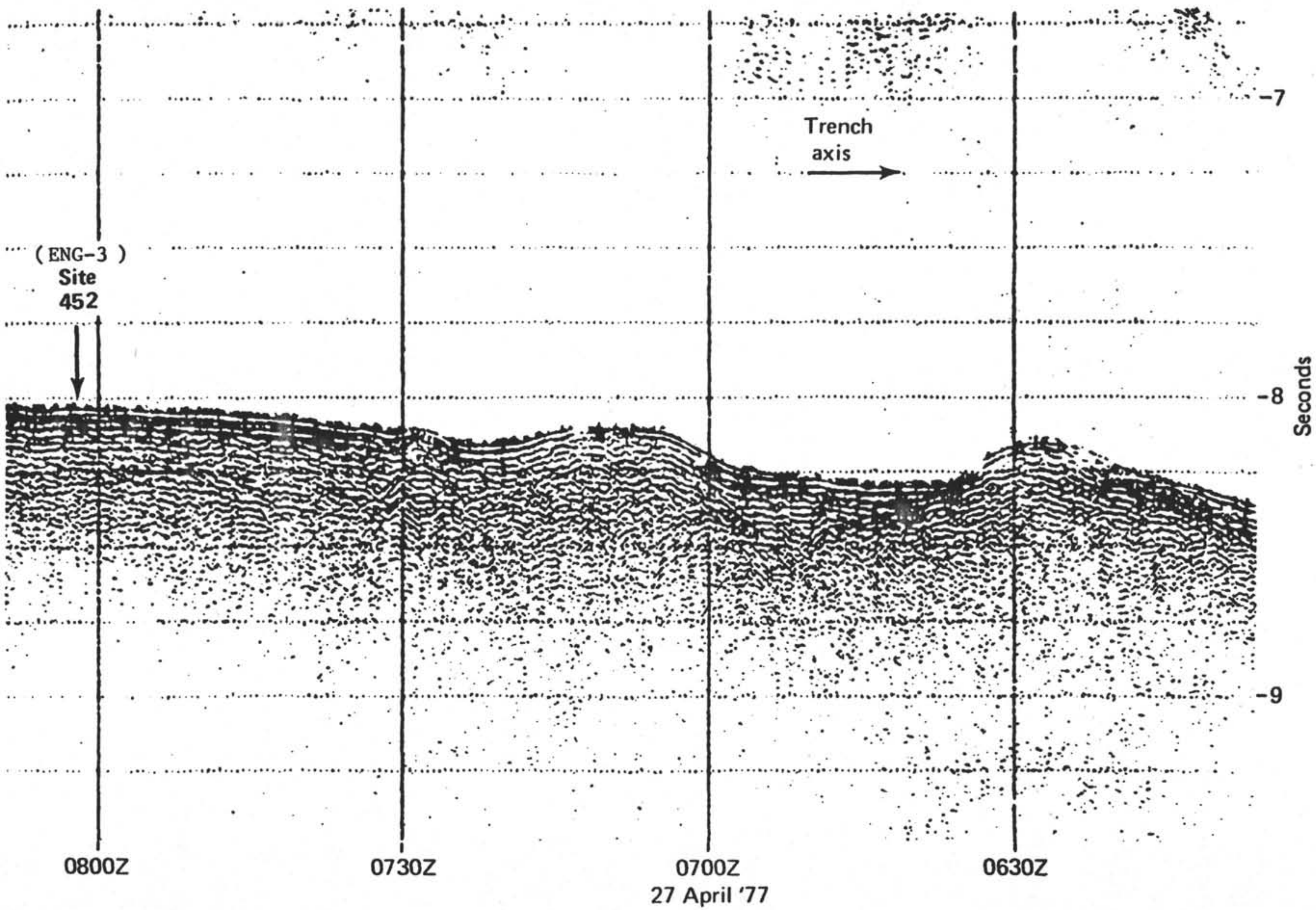
SEDIMENT TYPE: Pelagic sediments overlying chert.



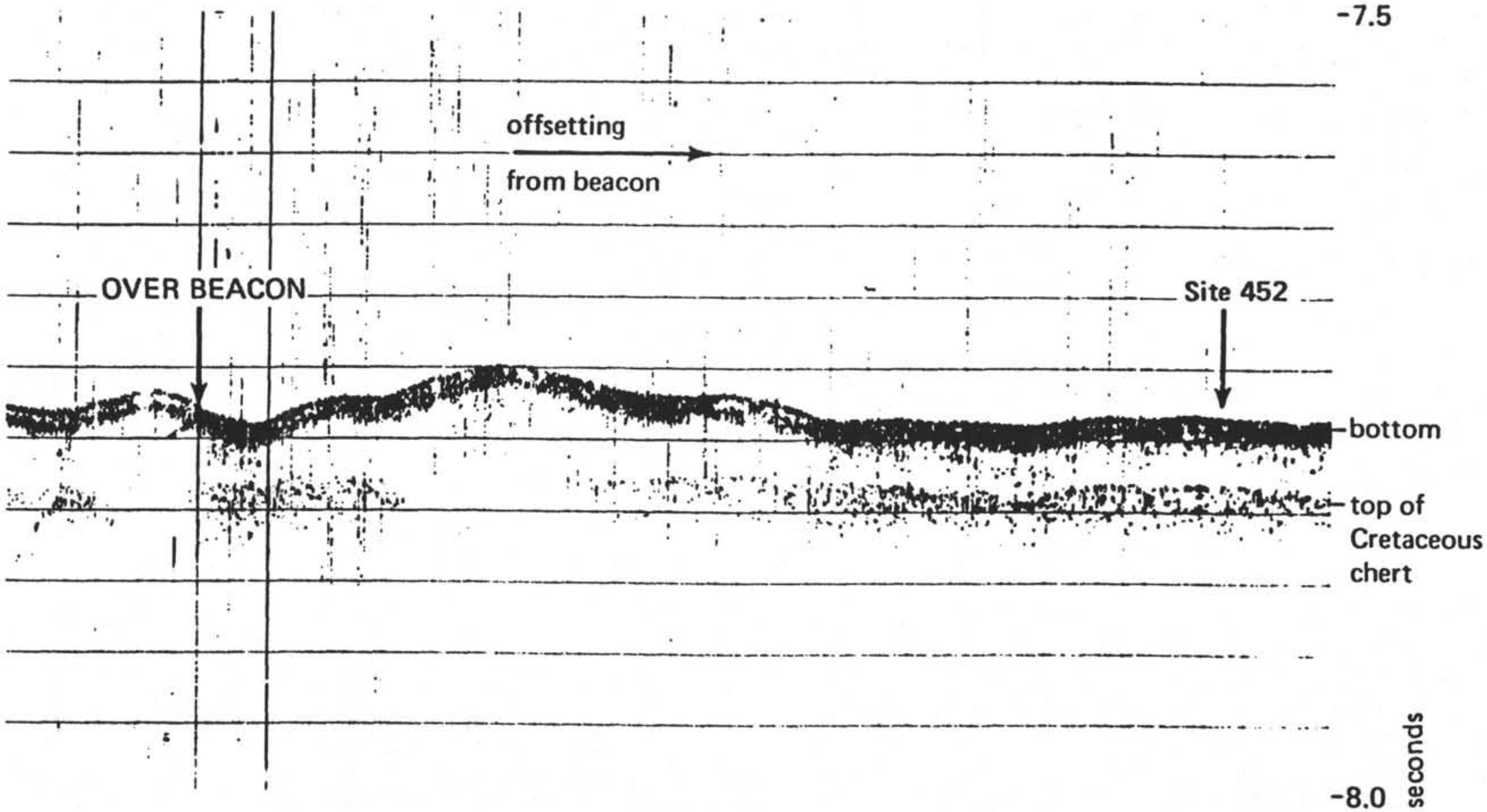
Bathymetric map of region east of Mariana Trench, simplified from Hussong (1981) and Langseth and Mrozowski (1980). Contours in hundreds of meters. Location of R/V Robert Conrad and R/V Kana Keoki seismic profiles are shown; Robert Conrad multichannel line 1 shown by solid line. Sonobuoys are shown by screened bars and DSDP Site 452 by solid circle. Proposed site ENG-3 is located at DSDP Site 452. [Modified from Mrozowski, Hayes, and Taylor, 1981, Fig. 1.]



R/V <u>Robert</u> <u>Conrad</u> multichannel profile 1, with seismic interpretation, showing location of DSDP Site 452 (=location of proposed site ENG-3). From Mrozowski, Hayes, and Taylor, 1981, Fig. 2.



R/V Kana Keoki airgun record, showing location of DSDP Site 452 (=location of proposed site ENG-3). From Shipboard Scientific Party, 1981.



Portion of the D/V Glomar Challenger 3.5-kHz record over Site 452 (=location of proposed site ENG-3), showing near-surface sub-bottom reflectors. The lower of these corresponds to a profound Cretaceous/Neogene disconformity. From Shipboard Scientific Party, 1981).

SITE NUMBER: ENG-4

POSITION: 15°N, 147°30'N

JURISDICTION: Northern Mariana Islands (U.S. Commonwealth)

SEDIMENT THICKNESS: 30-50 m

PRIORITY: 2

WATER DEPTH: 8250 m

PROPOSED DRILLING PROGRAM:

Hole A: Position ship in ultra-deep water using new higher db-output beacons from several vendors. Trip long drill string and identify potential operational problems. Conduct deep-water bending stress test (weather dependent) by deploying "strain-gauged" joints of 5" drill pipe at maximum depth possible and then causing the ship to list 5°. Complete trip with 5-1/2" drill pipe and core with the RCB coring system to identify potential problems with the core barrel retrieval (sandline) system.

Time permitting, deploy the Colmech underwater television system, Mesotech sonar, TV winch/coaxial cable, and seven-conductor electric logging line to their maximum operating depths (Note: This test will most likely be conducted last, after tripping out of the hole).

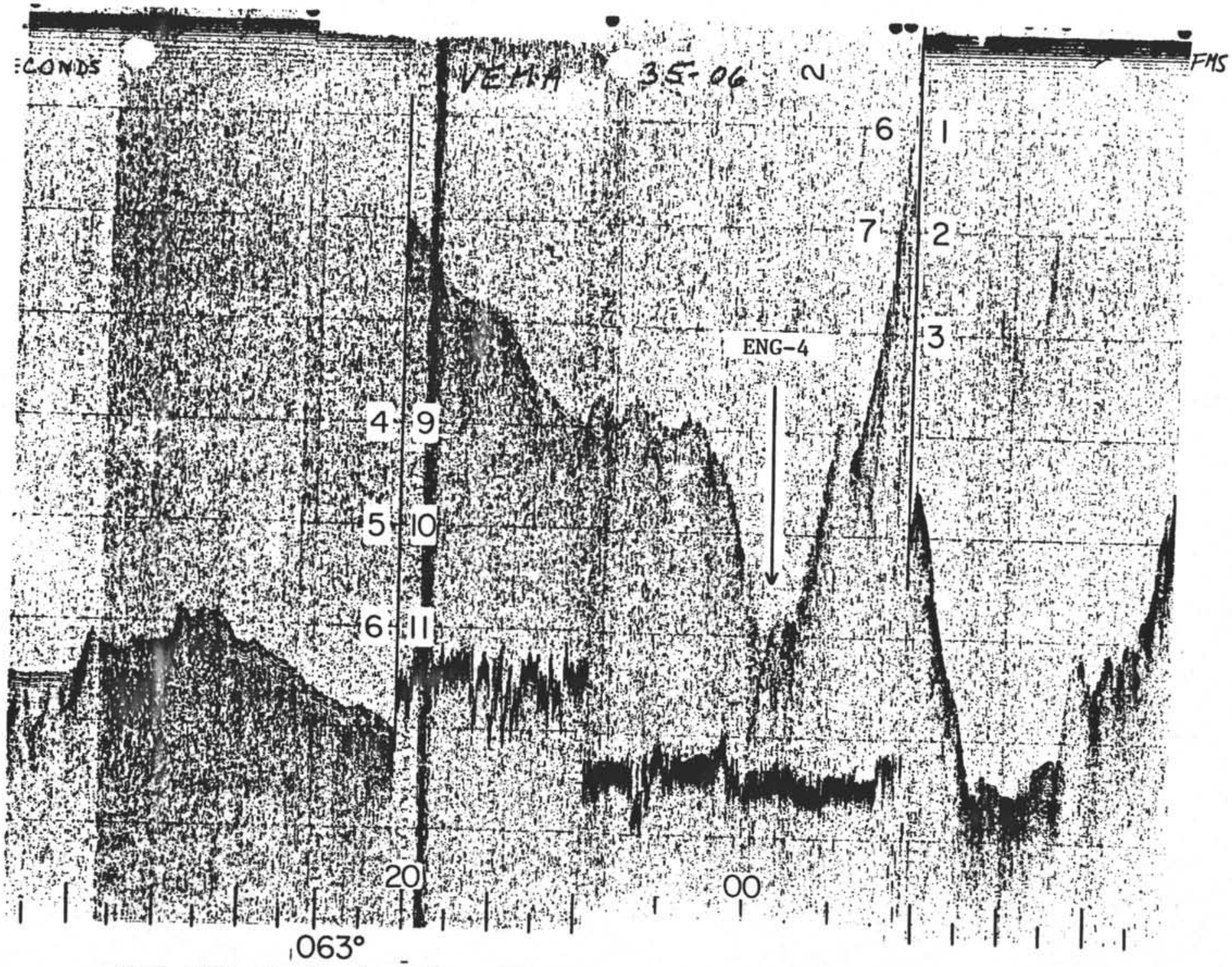
Hole B: Due to limited sediment cover at this location, several holes may be required during the test.

SEISMIC RECORD: VEMA 3506 single-channel profile (7 July, 0000 UTC).

OBJECTIVES: Evaluate the ability of the JOIDES Resolution to conduct deep-water coring operations.

LOGGING: None

SEDIMENT TYPE: Pelagic sediments.



VEMA 3506 single-channel profile showing location of proposed site ENG-4 at 7 July/0000 UTC.

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OCEAN DRILLING PROGRAM LEG 124E
ENGINEERING LEG

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TOTAL ODP STAFFING: 51

FOOTNOTES:

(a) Fierback, Sheppard, and Millheim, aboard for Site ENG-1 only.

(b) Second Schlumberger logger, Anderson, Potter, and Mills aboard for Sites ENG-2, ENG-3, and ENG-4 only.

(c) Anderson may be replaced by Jim Scott, USGS (Retired).

APPENDICES

PROTOTYPE DOWNHOLE TOOL DESCRIPTIONS

I. Diamond Coring System (DCS)

* System description
* DCS schematic drawing (Diagram DCS-A)
* Platform Configuration drawing (Diagram DCS-B)

II. Navi-Drill Core Barrel (NCB)

* System description
* NCB schematic drawing (Diagrams NCB-A and NCB-B)
* NCB advancement options (Diagrams NCB-C and NCB-D)

III. Pressure Core Sampler (PCS)

* System description
* PCS schematic drawing (Diagram PCS-A)

IV. **Latest Extended Core Barrel (XCB**

* **System description**
* XCB schematic comparison drawing (Diagram XCB-A)

DIAMOND CORING SYSTEM
SYSTEM DESCRIPTION

A scaled-down version of the Diamond Coring System (DCS), under development for use in coring and drilling fractured rock on the East Pacific Rise, is being designed and fabricated for deployment on the Engineering Leg (124E). The purpose of the test is to evaluate the potential and validate the use of a top-drive diamond coring system from a floating vessel.

The scaled-down system will be designed to operate in combined water and sediment depths up to 2000 m. Drilling/coring depth, with drill rod in open hole, will be 100-200 m. Some of the DCS components (top drive, core drill platform, drill rod string) will be rated for use in 4000 m of water.

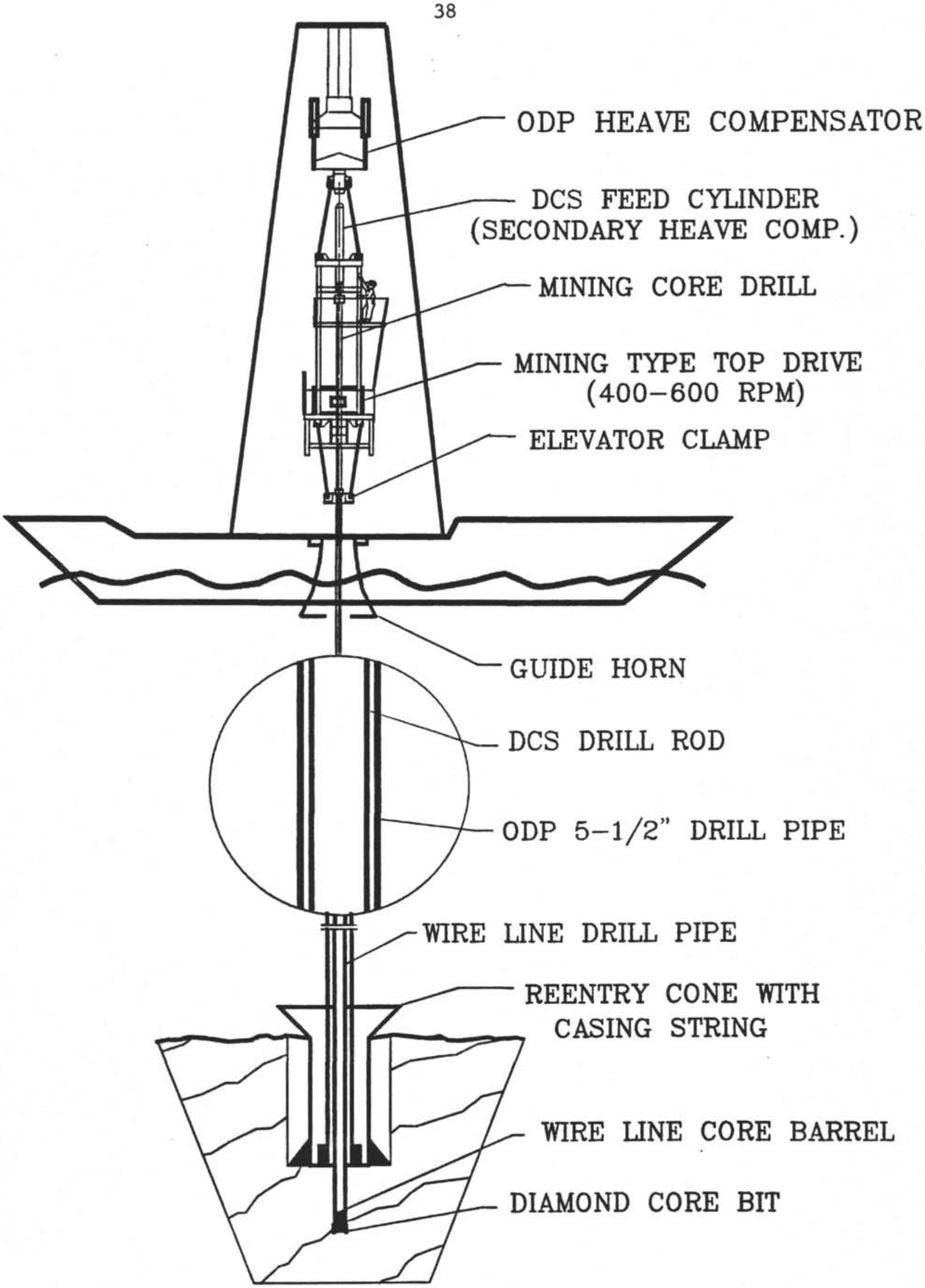
The diamond coring system involves running a small diameter 3.868" O.D. (3-1/2" pipe body X 2.942" I.D.) drill rod string inside 5-1/2" ODP drill pipe to the seafloor (see Diagram DCS-A). A high-speed diamond coring bit (nominal 4" O.D. X 2.4" I.D.) will be run with a core barrel assembly on the drill rod string. The drill rod string will be rotated from the surface with a hydraulically driven top-drive unit. The top drive will rotate the drill rod string at 400-600 RPM with approximately 1500 ft/lb of torque available. Typically, 4000-12,000 lb of weight will be run on the diamond core bits. Both natural diamond and impregnated bits will be utilized as dictated by formation conditions.

A secondary heave compensator will be required for maintaining precise control of weight on bit (WOB) for the thin-kerf diamond core bits. The secondary compensation system will be designed to remove the high load fluctuations resulting from the mechanical inefficiencies of the primary 400-ton drill pipe compensator. This will allow the diamond core bit drilling weight to be controlled to within approximately 1000 lb.

All of the diamond coring operations and drilling functions will be controlled from a manned core drill platform, suspended in the derrick (see diagram DCS-B). From the driller's console on the core drill platform, the driller will control the top drive, secondary heave compensator, wire line, and make-up/break-out of the drill rod joints. Upon tripping the diamond core bit to bottom, the driller will activate the secondary heave compensator/automatic feed system. At that point, the diamond core bit will automatically feed to bottom and the desired bit weight will be established for the coring run. All of the automatic heave compensator controls will have manual overides controlled by the driller as required. Upon completing a coring run, the bit will be retracted off bottom and the core barrel retrieved. An empty core barrel will then be dropped (free-fall deployed) down the drill rod string and coring resumed.

DIAMOND CORING SYSTEM
TECHNICAL DATA

* HOLE SIZE:	NOMINAL 4.0 IN.
* CORE SIZE:	NOMINAL 2.4 IN. DIAMETER X 10.0 FT
* TOP DRIVE RPM:	400 - 600 RPM
* TOP DRIVE TORQUE:	1500 FT-LB
* DRILL ROD STRING:	HYDRIL SERIES 500 TUBING (MAXIMUM LENGTH 12,000 FT)
* ODP DRILL PIPE:	5-1/2 IN. S-140
* CONTINUOUS WIRELINE CORING CAPABILITY	
* DIAMOND WOB:	4,000 - 12,000 LB



DIAMOND CORING SYSTEM
-TOP DRIVE CONCEPT-

DIAGRAM DCS-A

DIAMOND CORING SYSTEM
PLATFORM CONFIGURATION

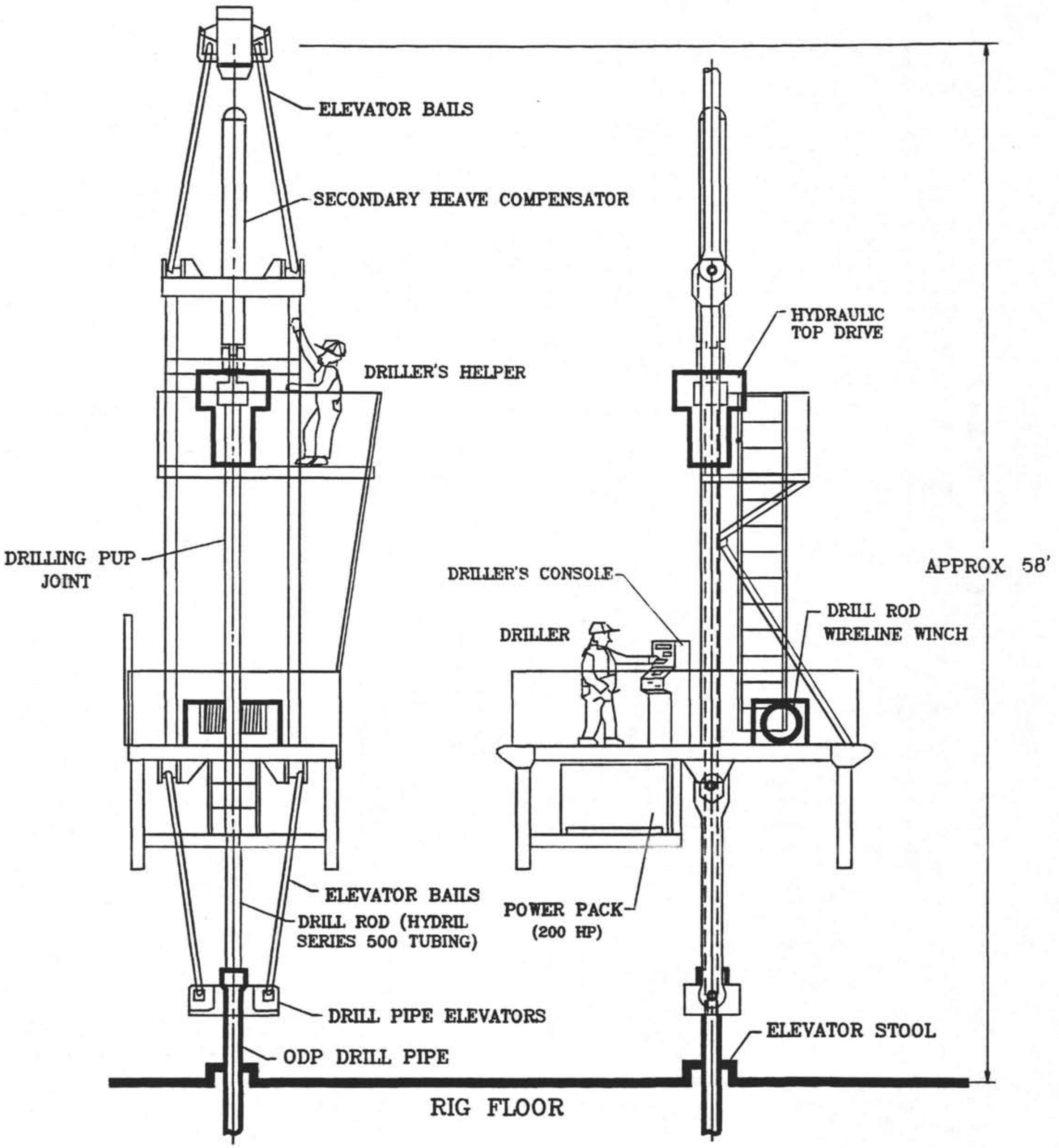


DIAGRAM DCS-B

NAVI-DRILL CORE BARREL (NCB) SYSTEM DESCRIPTION

GENERAL

The Navi-Drill Core Barrel (NCB) is a prototype 'hard-rock' coringsystem (Diagrams NCB-A and NCB-B) currently under development by the Ocean Drilling Program (ODP) and is designed for complete compatibility with the bottom-hole assembly used by the already operational Advanced Hydraulic Piston Corer (APC) and Extended Core Barrel (XCB) coring systems. The purpose of the NCB is threefold. First, to allow single-bit APC/XCB holes to be extended to greater depths and into more indurated formations, particularly fractured crystalline basement rocks. Second, to improve recovery in hard/soft interbedded formations such as soft chalks laced with chert stringers. Third, to evaluate using modern 'mining' technology to core hard fractured crystalline rock. This technology entails drilling/coring relatively small diameter holes with high RPM and light bit weights using narrow kerf diamond core bits. The mining industry has successfully used this technique to core deep into hard, highly fractured formations with virtually 100% recovery. To apply this technology to ODP's scientific coring operations requires a method of accurately controlling the weight on the small diamond core bit while coring from a floating vessel. The NCB is a first-generation attempt to apply mining concepts to offshore coring operations. If successful, it will lead to revolutionary systems for coring both massive and fractured crustal formations efficiently and with high recovery.

SYSTEM DESCRIPTION

The NCB is a wireline retrievable hard-rock coring system which can be deployed at any point in the coring operation. It is fully interchangeable with the hydraulic piston and extended core barrels allowing the coring system to be optimally used from the mud line down to and into indurated formations and/or basement rock. The NCB recovers a nominal 57-mm (2.25 in.) diameter core, 4-4.6 m (13.25-15.0 ft) long in a plastic polycarbonate liner. The NCB comprises four main components or subassemblies: a thruster unit for hydraulically applying weight on bit (WOB), a small 95-mm (3.75-in.) O.D. positive displacement mud motor for generating downhole rotation (torque), a nonrotating core barrel assembly for receiving the core, and a 95-mm (3.75-in.) O.D. narrow-kerf diamond core bit to cut the core. These subassemblies are described in more detail below.

THRUSTER UNIT

The thruster unit is the developmental part of the system. It comprises several components performing a wide variety of functions. The principle task of the thruster unit is to translate hydraulic force into mechanical weight on bit (WOB). The pressure drop created by circulation through a nozzle sub at the top of a hexagonal spline assembly results in a downward force (WOB) applied to the diamond bit. Removable nozzles allow optimization of the desired WOB at various flow rates. The reaction torque generated by mud-motor rotation is transferred through the spline assembly and torque segments to the main outer barrel assembly.

When the tool is free-fall deployed, the thruster unit dampens the landing impact thus reducing the stress and preventing mechanical failure. The tool may also be deployed using a wireline delivery system; however, this requires an additional wireline trip and results in a less efficient coring operation.

The thruster unit also effects a downhole seal causing all of the circulating fluid to be channeled through the mud-motor. In addition it maintains the stroking portion of the tool (hex male spline, core barrel, and diamond core bit) in a latched position until after the tool has landed and rotation is begun.

POSITIVE DISPLACEMENT MUD MOTOR

The NCB is powered by an Eastman Christensen (EC) positive displacement mud motor. Both Navi-Drill Mach I and Mach III motors can be used. The operating parameters for each motor are as follows:

	Mach I	Mach III
Pump Rate (gpm)	75-145	60-145
Bit Speed (rpm)	125-250	340-855
Maximum Torque (ft-lbf)	740	245

CORE BARREL ASSEMBLY

The core barrel assembly used with the NCB is a modified version of a standard Christensen Mining Products (CMP) HWD4 core barrel. It is attached to the mud motor with a modified (sealed) 3-lug quick disconnect to allow efficient handling in the same manner as the other ODP coring systems. The barrel contains a nonrotating inner tube which may be run with or without a polycarbonate liner. The core is retained by using either a standard core spring installed in an inner tube shoe (for hard formations) or a special spring loaded dog-type core catcher shoe (for soft formations). Installed between the inner tube and the shoe is an inner tube (breakoff) sub which allows for easy retrieval of the liner. There are two different lengths of breakoff subs provided for use depending on whether or not an anti-jam system is used. The CMP anti-jam system can be installed directly above the inner tube. When a core blockage occurs the inner tube raises, energizing the anti-jam system. The resultant 'jarring' action is designed to free the blockage and once again allow unrestricted core entry. When using the anti-jam system the core length is shortened by 0.6 m (1.75 ft). A flow divider sub is installed directly above the core barrel assembly. This sub allows the proper amount of circulating fluid to be directed to the diamond core bit (typically 10-15 gpm) while the remainder is diverted to the annulus for hole cleaning and cuttings removal. Removable nozzles allow the flow to be optimally balanced.

DIAMOND CORE BITS

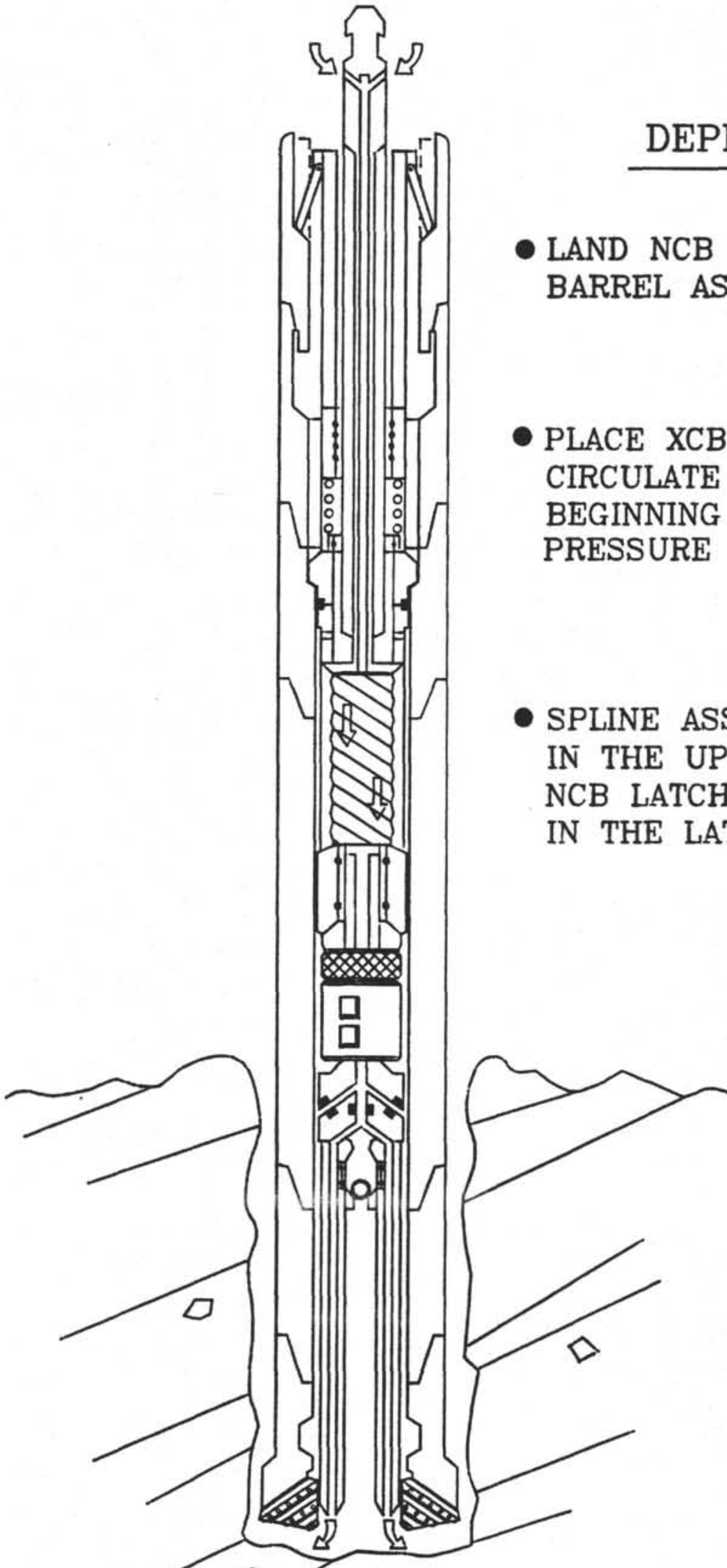
The NCB is designed to operate with three types of narrow-kerf diamond core bits. All bits have an O.D. of 95 mm (3.75 in.) and cut a 57-mm (2.25-in.) core. Both hard- and soft-matrix impregnated diamond bits are available as well as surface-set and geoset diamond bits. Appropriate bit selection is determined by the type of formation to be cored. A surface-set diamond reaming shell is installed directly behind the core bit to enhance stabilization and help maintain hole gage.

ADVANCEMENT OPTIONS

The NCB is designed to be advanced in one of two different ways. The first option (I) is to cut a 4.0-m core, recover the core, then ream down the pilot hole with the main XCB bit opening up the hole to full size (Diagram NCB-C). The second option (II) is to cut a 4.0-m core, recover the core, and add a 4.0-m drill rod section to the wireline tool just above the core barrel. A second core may then be cut ahead of the main bit (Diagram NCB-D) deepening the 3.75-in. pilot hole.

NAVI-DRILL CORE BARREL (NCB)

OPERATIONAL SEQUENCE



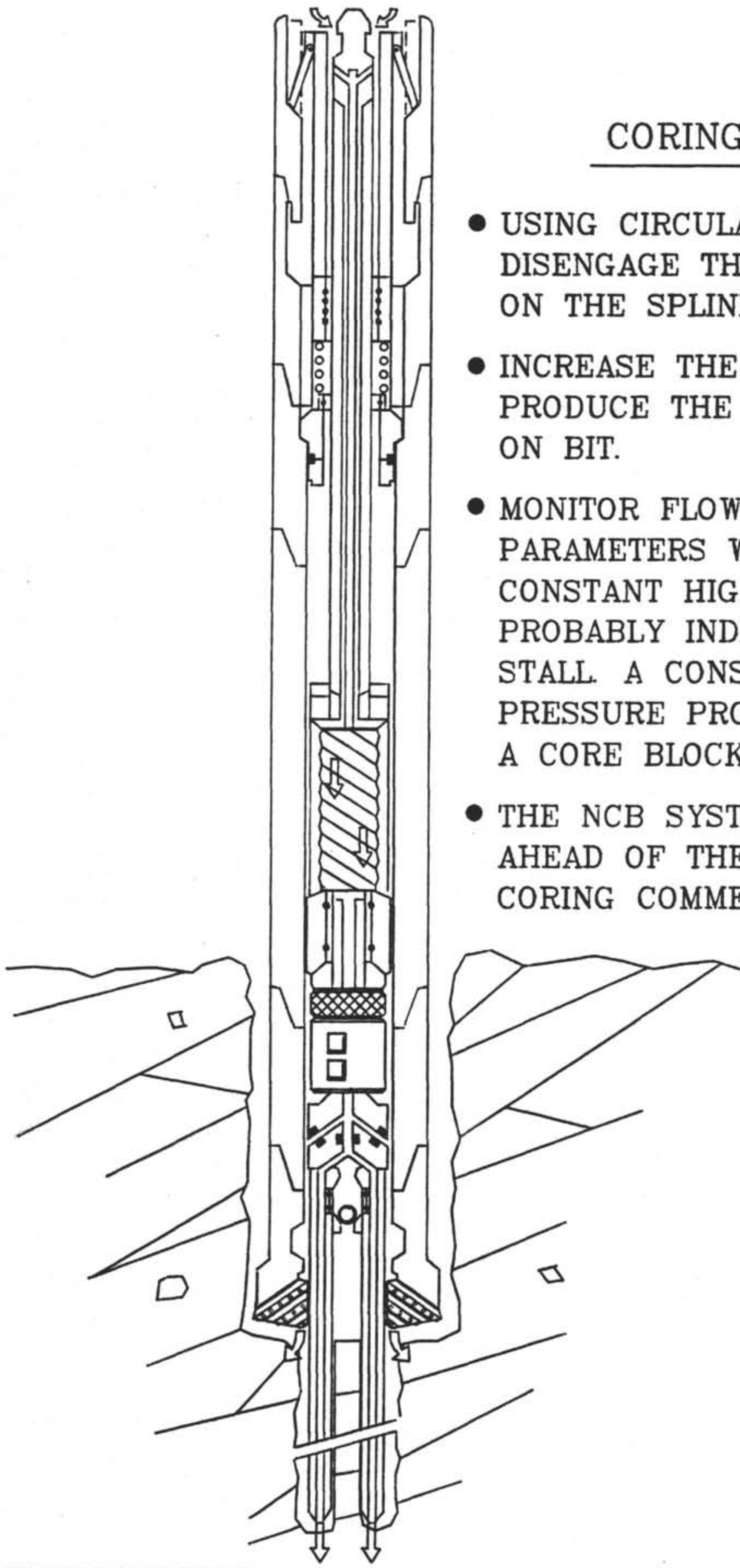
DEPLOYMENT

- LAND NCB IN OUTER CORE BARREL ASSEMBLY.
- PLACE XCB BIT ON BOTTOM AND CIRCULATE TO DETERMINE BEGINNING FLOW AND PRESSURE PARAMETERS.
- SPLINE ASSEMBLY IS LOCKED IN THE UP POSITION AND NCB LATCH DOGS ARE ENGAGED IN THE LATCH SUB.

DIAGRAM NCB-A

NAVI–DRILL CORE BARREL (NCB)

OPERATIONAL SEQUENCE



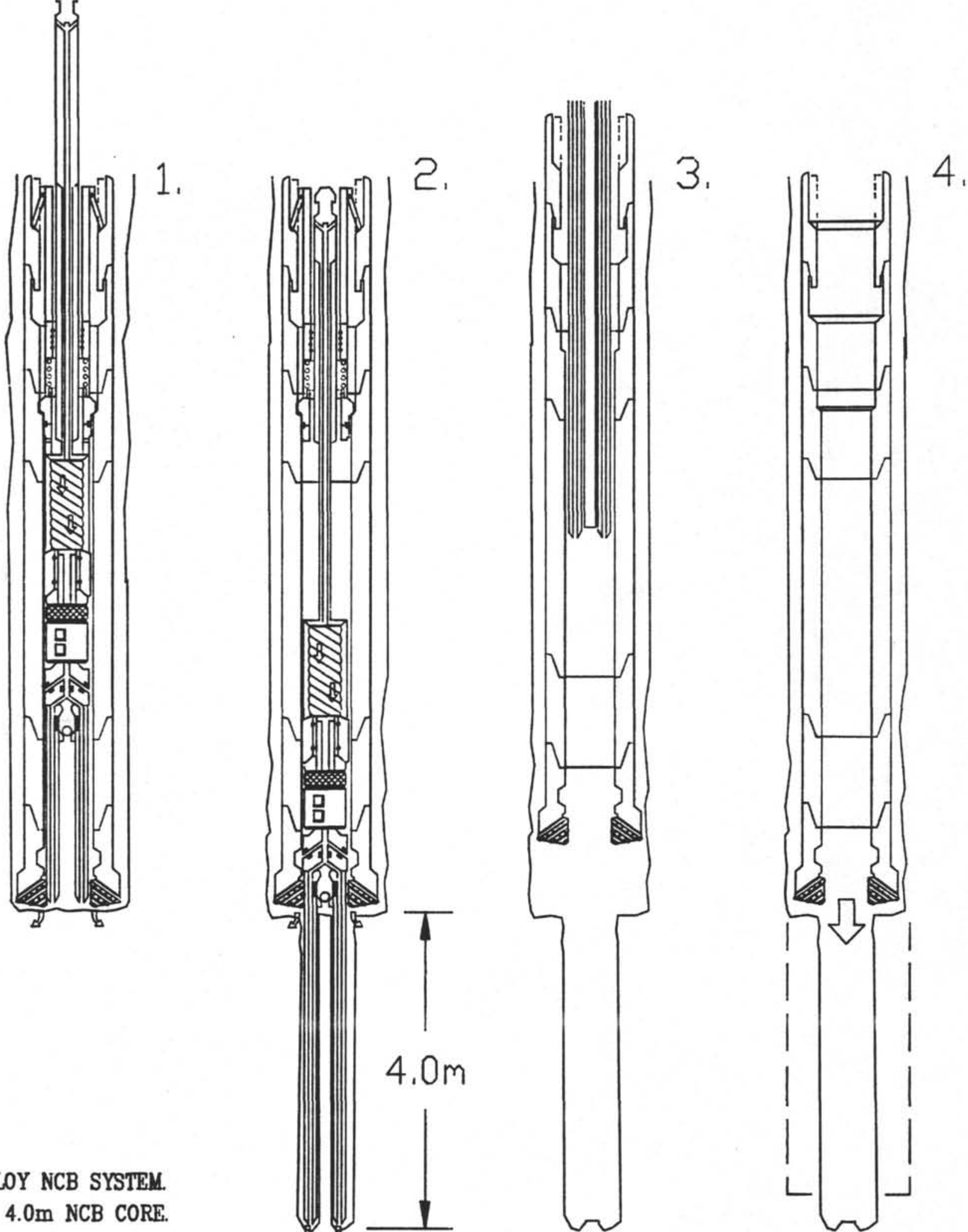
CORING AHEAD

- USING CIRCULATION PRESSURE DISENGAGE THE LOCKING BALLS ON THE SPLINE ASSEMBLY.
- INCREASE THE FLOW RATE TO PRODUCE THE DESIRED WEIGHT ON BIT.
- MONITOR FLOW AND PRESSURE PARAMETERS WHILE CORING. A CONSTANT HIGH PRESSURE PROBABLY INDICATES MOTOR STALL. A CONSTANT LOW PRESSURE PROBABLY INDICATES A CORE BLOCK.
- THE NCB SYSTEM PENETRATES AHEAD OF THE XCB BIT AS CORING COMMENCES.

DIAGRAM NCB–B

NAVI–DRILL CORE BARREL (NCB)

DEPLOYMENT OPTION I



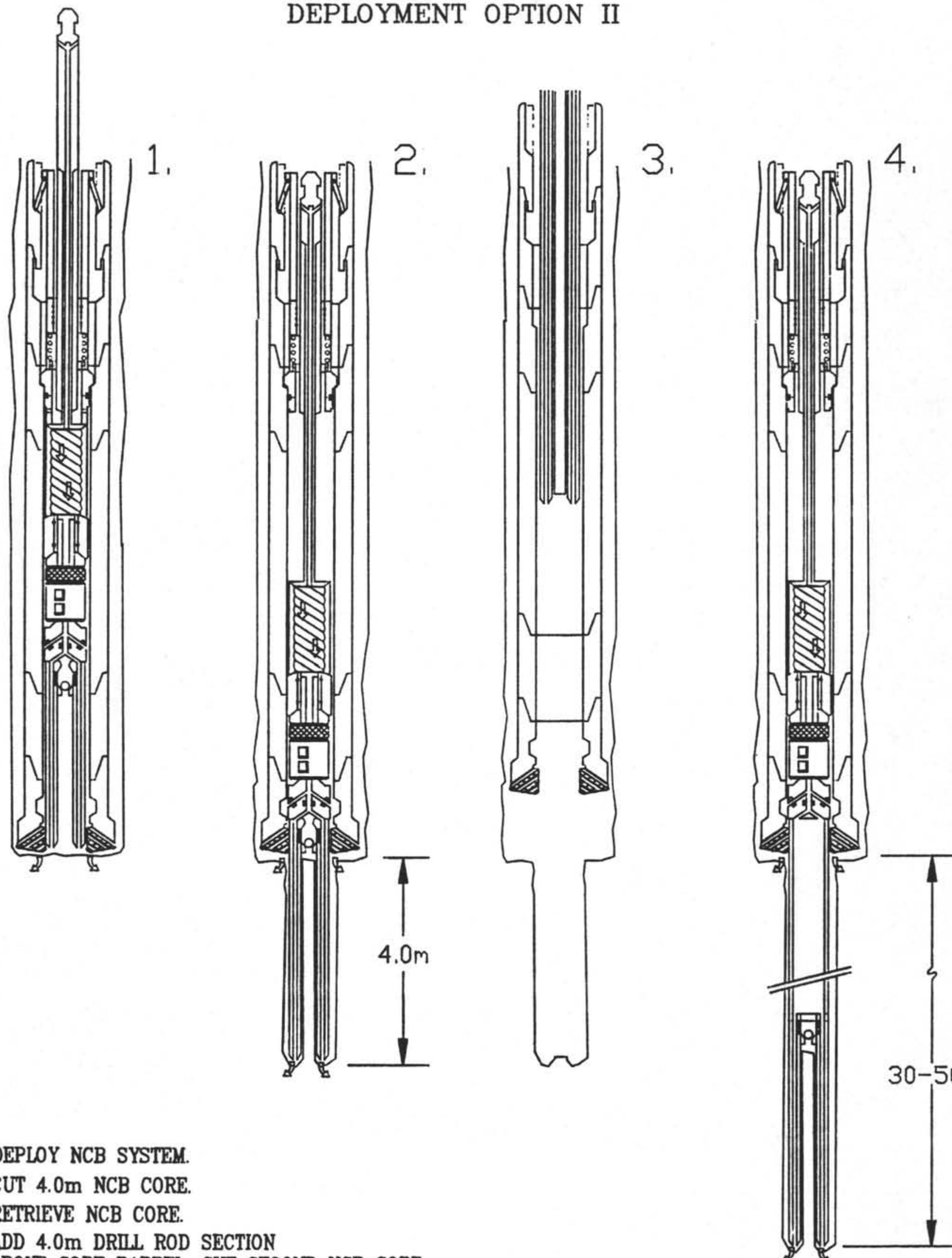
1. DEPLOY NCB SYSTEM.
2. CUT 4.0m NCB CORE.
3. RETRIEVE NCB CORE.
4. OPEN HOLE BY DRILLING DOWN WITH FULL SIZE CORE BIT.

REPEAT 1–4 UNTIL OBJECTIVE ACHIEVED.

DIAGRAM NCB–C

NAVI–DRILL CORE BARREL (NCB)

DEPLOYMENT OPTION II



1. DEPLOY NCB SYSTEM.
2. CUT 4.0m NCB CORE.
3. RETRIEVE NCB CORE.
4. ADD 4.0m DRILL ROD SECTION ABOVE CORE BARREL. CUT SECOND NCB CORE.

REPEAT 1–4 UNTIL OBJECTIVE ACHIEVED.

DIAGRAM NCB–D

PRESSURE CORE SAMPLER (PCS) SYSTEM DESCRIPTION

GENERAL

The Pressure Core Sampler (PCS) is a coring system capable of retrieving core samples at near in-situ pressures, under development by the Ocean Drilling Program. The PCS utilizes both current conventional oil-field pressure coring technology and technology developed by the Deep Sea Drilling Project. The PCS is completely compatible with the existing ODP bottom hole assembly (BHA) used for the Advanced Hydraulic Piston Corer (APC), Extended Core Barrel (XCB), and Navi-Drill Core Barrel (NCB). The purpose of the PCS is three fold. First, to be compatible with the APC-XCB-NCB BHA. Second, to retrieve a core sample while maintaining a near in-situ pressure as high as 689.7 atmospheres (10,000 psi) thus doubling the pressure capability of the earlier DSDP Pressure Core Barrel (PCB). And finally to retrieve a small core sample which can be transferred from the detachable sample chamber to a pressurized testing chamber while maintaining near insitu pressure. This could not be done with the PCB. The core sample is then available for direct scientific evaluation under near in-situ pressure and temperature conditions.

PCS SYSTEM DESCRIPTION

The PCS is a wireline retrievable, free-fall deployable, hydraulically actuated pressure coring system. When the PCS is deployed, it lands and latches into the BHA and is rotated with the BHA during coring operations. It is fully interchangeable with the APC and XCB coring systems,thus allowing a pressurized core sample to be taken from the mud line down to indurated formations and/or basement rock. The PCS recovers a nominal 42-mm (1.65-in.) diameter core sample, 0.86 m (34-in.) long at pressures as high as 689.7 atm (10,000 psi). The PCS comprises five main components or subassemblies: the latch, the actuator, the valve-accumulator, the ball valve, and the detachable sample chamber. Each of these subassemblies is described in detail below (see Diagram PCS-A).

PCS LATCH SUBASSEMBLY

The PCS Latch Subassembly is a modified XCB latch that serves four functions. First, the latch subassembly contains the landing point for the PCS when deployed. The latch subassembly has a 4.000-in. O.D. shoulder which can not pass the 3.82-in. I.D. throat of the Landing Saver Sub in the BHA, thus preventing the PCS from passing completely through the BHA. Second, by latching into the BHA the latch subassembly transmits torque from the BHA to the PCS allowing it to trim the core to proper size for entry into the sample chamber. Third, the latch subassembly holds a check ball used in the actuation of the ball valve subassembly. When the latch subassembly is engaged by the wireline and an upward force is applied, it automatically releases the check ball allowing the ball to fall into the actuation subassembly. Fourth, the latch subassembly diverts all flow through the PCS and provides a place for the wireline to automatically attach itself during retrieving operations. The latch subassembly is attached to the PCS by a three lug quick release allowing for efficient handling in the same manner as the other ODP coring systems.

PCS ACTUATOR SUBASSEMBLY

The PCS Actuator Subassembly serves two functions. First, it catches the check ball when released by the latch subassembly and by doing so stops all flow through the PCS until it strokes. Second, when pressure is applied to the PCS and the check ball has been released, the actuation subassembly unlatches and strokes through itself pulling the core tube containing the core sample through the ball valve into the sample chamber. As the core tube is pulled into the sample chamber the ball valve is closed and the upper end of the core tube is pulled into a seal receptacle thus sealing the sample chamber at both ends and trapping the core sample at hydrostatic pressure inside the PCS. When the actuation subassembly reaches the end of its stroke, it latches once again and opens a circulation path through the PCS.

PCS VALVE-ACCUMULATOR SUBASSEMBLY

The PCS Valve-Accumulator Subassembly contains a pressure maintaining mechanism, safety pressure relief mechanisms, a sampling port, temperature and pressure monitoring devices and the core tube. The pressure maintaining mechanism is a built-in accumulator that maintains the pressure inside the sample chamber as small volume changes occur during sealing and in the event of any minor seal leakage. The safety pressure relief mechanisms include an adjustable pressure relief valve set to automatically vent pressure above 689.7 atmospheres (10,000 psi). Should the pressure relief valve fail to release pressure a disk will rupture at 862.1 atm (12,500 psi) relieving all pressure from inside the PCS. An access port allows sampling of gases or fluids directly from the PCS sample chamber. A built-in thermistor and pressure transducer allow for connection of monitoring equipment to constantly monitor the temperature and pressure inside the PCS sample chamber. The sample tube is a nonrotating metal tube with integral core catchers to contain the core sample. During coring operations the core tube is extended through the ball valve subassembly into the cutting shoe. When the actuator subassembly is activated, the core tube is pulled through the ball valve into the sample chamber.

PCS BALL VALVE SUBASSEMBLY

The PCS Ball Valve Subassembly is the sealing mechanism on the bottom of the PCS sample chamber. It also is the connection point for the PCS Cutting Shoe used to trim the core sample to size. During deployment and coring operations the ball valve is open with the core tube extended through it into the cutting shoe. When the actuation subassembly is activated and the core tube has been pulled through the ball, the ball is rotated into closed position, sealing the lower end of the sample chamber. The ball valve subassembly also provides a means for connecting the sample chamber to a pressurized testing chamber. This is done by removing the cutting shoe and using the threaded end to connect to the test chamber. The ball valve subassembly also incorporates the pressure-containing body of the sample chamber and the seal receptacle used to seal the upper end of the sample chamber.

PCS DETACHABLE SAMPLE CHAMBER

The PCS Detachable Sample Chamber is made up of the ball valve and valve-accumulator subassemblies. It is 92.2 mm (3.75 in.) in diameter, 1.5 m (5 ft) long and attached to the PCS by quick-release connections that allow the pressurized sample chamber to be removed from the rest of the PCS for easier handling. Since the valve-accumulator subassembly is an integral part of the detachable sample chamber, the pressure and temperature can be continuously monitored. Also, gas and fluid samples can be taken directly from the sample chamber.

PCS CUTTING SHOES

The PCS uses a specially designed pilot-type cutting shoe. The available cutting shoe cutting structures for the PCS are both hard- and soft-matrix impregnated diamonds, surface-set diamonds, geoset diamonds, as well as standard hard facing.

PCS OPERATION

The PCS is free-fall deployable and therefore is dropped down the drill pipe and landed in the BHA. The PCS is rotated by the top drive via the latch and drill string BHA. During coring operations the rig pumps maintain flow down the drill string to keep the hole open and to cool/lubricate the PCS cutting shoe. Once the core has been cut the rig pumps are secured, the wireline is attached to the PCS and an upward strain is applied to the PCS latch to release the check ball. The wireline is then slacked off and the rig pumps are restarted slowly, letting the pressure build to move the actuator and stroke the sample chamber closed. When circulation is once again established the sample chamber has been closed and the PCS is retrieved like any other wireline core barrel. Once on deck the detachable sample chamber is removed from the PCS, placed in a portable temperature-controlling bath/safety shroud where temperature and pressure monitoring equipment is attached. The sample chamber can then be safely moved from the rig floor for scientific evaluation.

PRESSURE CORE SAMPLER (PCS)
OPERATING SCHEMATIC

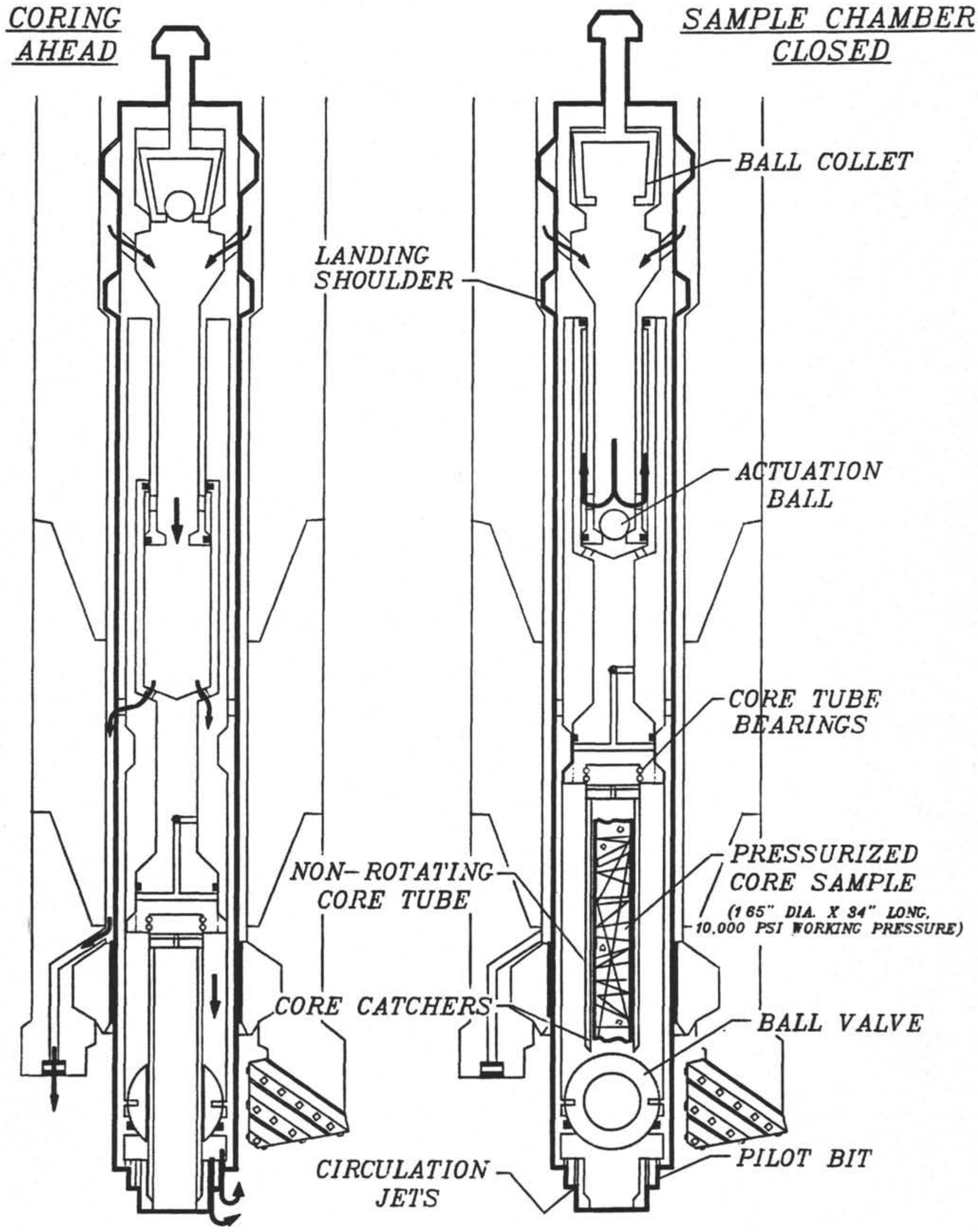


DIAGRAM PCS-A

LATEST VERSION OF THE EXTENDED CORE BARREL CORING SYSTEM (XCB-121)

The Extended Core Barrel coring system has become a workhorse tool for ODP dating back to its first fully successful use during Leg 90 of DSDP. It has been continually improved since, with its last major modification occurring at the outset of ODP field operations. That version, XCB-101C, has proven to be reliable but not without weaknesses and shortcomings identified over thousands of individualdeployments in a wide variety of lithologies. After a rash of unexpected downhole mechanical failures during Leg 113 it was apparent that a number of areas needed improvement.

XCB-121

The most recent version of the XCB was designed and given sea trials on Leg 121. Three primary areas of improvement were included in the -121 version:

1. Enhancements in the flow to the cutting shoe,
2. Improved cutting shoes, and
3. Mechanical (strength) upgrades.

FLOW ENHANCEMENTS

The main difference between the Extended Core Barrel concept and any other rotary coring system is a cutting structure that is part of the core barrel itself, extending ahead of the main roller cone bit to trim the core to its final diameter and protect it from the flow of pumped seawater or mud around the main bit. This extended cutting shoe must have its own flow for removing cuttings, cleaning sticky material off its cutting surfaces, and cooling. The flow must be controlled so that there is neither too much flow causing core washing and disturbance, nor too little flow resulting in clogging of the cutting structure, overheating, or jamming of the core. Providing correctly proportioned flow to the cutting shoe has always been the single most difficult design problem in XCB development. The XCB-121 version takes a more sophisticated approach to getting a portion of the overall flow in the drill pipe to take the path to the cutting shoe fluid ports. A positive XCB bit seal is incorporated to replace experimental versions tested in recent months. A new arrangement of cutting shoe adaptor components allow independently variable extension/retraction, flow quantity to the cutting shoe, and type of cutting structure for any given single core barrel deployment. In previous versions of the XCB, several of these parameters were not separable.

Vented fluid above the core inside the liner is removed via a vent system in the XCB-121 using a venturi assembly attached to the male quick-release and thus is removed from the female quick-release each time the XCB is broken down on deck to remove a core. This helps eliminate the possibility of a clogged venturi orifice being undetected and causing excess disturbance and possible loss of core in a later core run.

IMPROVED CUTTING SHOES

A long sawtooth steel cutting shoe with carbide hardfacing on the cutting surfaces has evolved as the standard for XCB use in sedimentary sequences. When chert, very hard sedimentary rocks, or basalt is encountered the steel teeth tend to wear very rapidly (often being completely destroyed in one core run). In addition, more serious failures have occurred, including torsional failures of the threaded connections at and near the cutting shoes resulting in core barrels being stuck in the BHA and requiring pipe round trips to correct. These overtorque problems are related to using cutting structures inappropriate for a given hard lithology. Experience with XCB applications of conventional diamond cutting shoes used by the mining industry has been largely unsatisfactory because of significant differences between weights-on-bit, rpm, and shock loads encountered with the XCB vs standard mining systems.

The goal of the new cutting shoes developed for XCB-121 was to reduce the wear when coring hard materials and eliminate mechanical failures in and around the cutting shoes caused by overloads. Both goals were sought by developing several varieties of short sawtooth cutting shoes with cutting structures produced by diamond-impregnated powder metallurgy techniques. These shoes are effectively hybrids of diamond coring technology and past XCB experience.

MECHANICAL UPGRADES

To overcome recurring instances of downhole mechanical failures associated with attempts to core with the XCB in more indurated materials a number of different components were either deleted or redesigned for greater strength. In particular, all threaded connections subject to drilling torque were either strengthened by increasing the minimum cross-sections, where feasible, or changed to a new design connection which was both slimmer in cross-section and 2-3 times stronger in torsion. Other weak points in the assembly were redesigned for greater strength (Diagram XCB-A).

LEG 121 SEA TRIAL RESULTS

Deployments on Leg 121 demonstrated that improvements to the overall performance and reliability of the XCB system were about 70% effective. The mechanical upgrades were almost completely effective, although some portions of the design will be changed prior to Leg 124E to minimize possibilities of quality control problems in fabrication and one particular type of fatigue failure experienced with the 121 prototype hardware.

The cutting shoe modifications proved to be enhancements and demonstrated that the concept of matching cutting shoe designs and materials to different formation properties can increase the range of the XCB. That is, the point of XCB refusal can be deepened for a given lithological sequence leading to more opportunities where APC/XCB/NCB coring can reach the scientific depth objective without requiring round trips to deploy the RCB system. In addition, XCB mechanical failures downhole caused in the past by overextending the use of the XCB could be reduced from actual equipment failures requiring unplanned round trips to mere inability to get adequate penetration.

Although changes to the overall flow system were the greatest single area of modification to the previous version of the XCB the results on Leg 121 were not markedly better than comparison deployments with the older system. The new version of the venturi vent system was nearly ideal but the flow around the cutting shoe continued to be inadequate to prevent clogging and core jamming in sticky sediments.

For Leg 124E, all these areas of improvement to the XCB will be further modified (as time allows between now and the shipping deadlines for Leg 124E) so that the XCB testing to be done during Leg 124E will be both general performance evaluation and testing of the latest design modifications.

EXTENDED CORE BARREL (XCB) COMPARISON

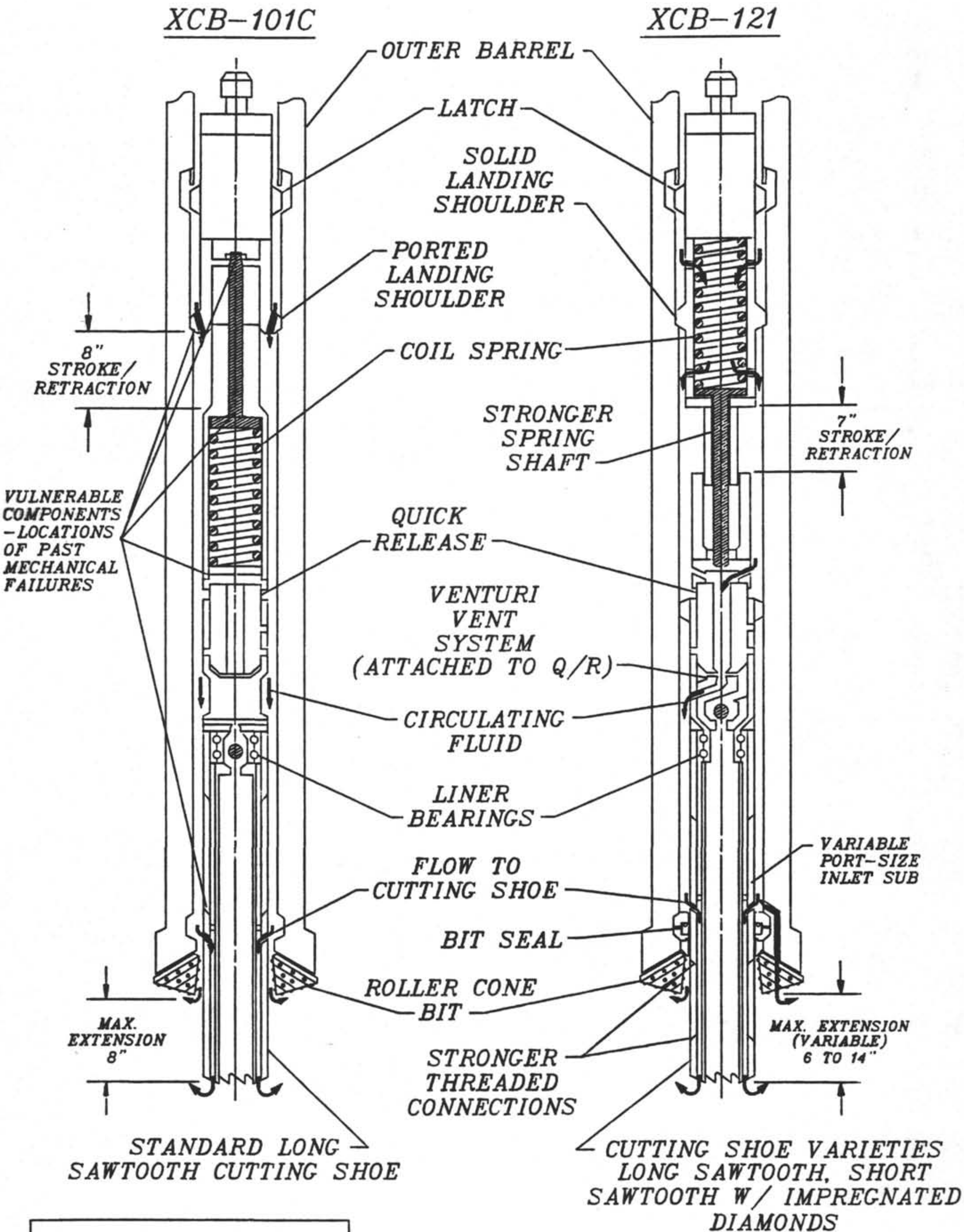


DIAGRAM XCB-A