OCEAN DRILLING PROGRAM

LEG 132 ENGINEERING PROSPECTUS

WESTERN AND CENTRAL PACIFIC

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INTRODUCTION

Leg 132 (Engineering Leg II) is the second of a series of cruises designed to support the development and operational refinement of hardware and techniques that will be required to meet the ODP scientific mandate of the future. Since the technical complexity of high-priority scientific problems continues to grow, so too does the demand for dedicated ship time. Although ODP/TAMU continues to emphasize thorough shore-based testing of developmental equipment, these tests cannot adequately model the offshore marine environment in which the tools are to be operated. Dedicated engineering legs are therefore invaluable to successful attainment of the required technology.

LEG 124E ENGINEERING TEST RESULTS

During the first dedicated engineering leg (Leg 124E) the concept of deploying a mining-type diamond coring system (DCS) from a floating vessel was demonstrated to be feasible. State-of-the-art "high-tech" sensor technology, coupled with a microprocessor unit, was used to drive an active secondary heave compensation system. The system was designed to maintain extremely accurate control of weight ($\pm$ 500 lb) on a narrow-kerf, high-speed, diamond core bit. The DCS heave compensation system was demonstrated to be effective in maintaining accurate weight-on-bit control even under extreme weather conditions. A 3-1/2-in. outer diameter (OD) tubing string, with Hydril series 500 wedge-lock threaded connections, was used as a work string inside the ODP API 5-1/2-in. drill pipe. The tubing string performed well, with no failures or detectable wear occurring while rotating the string at 60 to 120 revolutions per minute (RPM). Skidding back and storing the fully assembled diamond coring system platform from well center when not in operation proved to be effective. Though space was limited, it was possible to trip drill pipe conventionally using the iron roughneck (make-up/break-out unit) while the DCS platform was positioned to the starboard side of the rig floor. Though limited coring operations were performed, the viability and utility of deploying a diamond coring system from a floating vessel was clearly demonstrated both technically and operationally.

Drilling a pilot hole with the ODP 5-1/2-in. drill string, then deploying the diamond coring system through the drill string with the large bit remaining on bottom in open hole, was accomplished with marginal success. Due to limited overhead clearance in the derrick, the large roller cone bit had to be drilled to a precise depth to provide the proper spacing for the top-drive/heave-compensator traveling assembly. In the event the drill pipe became stuck off bottom while tripping in the 3-1/2-in. tubing work string or while rigging up the DCS platform, it would be necessary to free the stuck pipe before continuing with the diamond coring operation. Deployment of the DCS tubing through the 11-5/8-in. extended core barrel (XCB) bit positioned 15-20 ft. off bottom could have resulted in the tubing buckling in the open hole below the bit. It is also probable that if the rotating tubing were to buckle, it would make contact with the 11-5/8-in. XCB roller cones.

Having to maintain the ability to move the bit on and off bottom during deployment and during the DCS core bit run required good hole stability. Lack of good hole stability hampered deployment and testing of the DCS throughout Leg 124E. A total of 16-1/2 days was allocated to testing the DCS. Of that time, 51% was spent in transit to prospective sites and drilling/coring seven holes ranging in depth from 6 to 361 meters below seafloor (mbsf). Larger diameter holes were drilled in an effort to establish a borehole penetration near basement that would be stable enough for DCS deployment. For the DCS to be used effectively as a scientific coring system, a means to provide upper hole stability (in sediments as well as in fractured rock) must be devised.

Though only 5% of the allotted time on Leg 124E was spent actually coring with the DCS, five cores were successfully cut. The core material was clay and silty clay. DCS core bits run were designed specifically for coring basalt, but the clay cores demonstrated that soft formations also can be cut effectively. One core in particular (Core 124E-773B-4M) was deemed by shipboard scientists to be of excellent quality for a sediment core, having little drilling disturbance. Only 7% of the time was spent in tripping tubing. The remaining 36% of the time was spent in rigging and handling the DCS platform on the rig floor and in the derrick.

Though the objective to core in basement (basalt) was not accomplished during Leg 124E, a significant amount of operational and technical information was obtained. The DCS was deployed in weather and heave conditions that in many instances exceeded original design parameters. The handling and operational characteristics of the core-drill platform are now well defined. As a result of the DCS testing on Leg 124E, modifications to the DCS platform, top drive, secondary heave compensator, and coring equipment are being made that will allow the system to be streamlined and made operationally more efficient for Leg 132 operations.

LEG 132 ENGINEERING LEG OBJECTIVES

Leg 132 is scheduled to depart Pusan, Korea, on 7 June 1990 and arrive in Guam on 5 August 1990. As indicated above, engineering goals will remain a priority throughout the leg. However, several important scientific objectives may also be investigated (described in the following text). The leg will be 59.0 days long and will conduct coring operations in three distinct areas of the western and central Pacific Ocean (Fig. 1). Three sites (ENG-5, ENG-6, and ENG-7) will be occupied (Tables 1 and 2). Each site has been selected to maximize the value and efficiency of the engineering test objectives while at the same time providing an opportunity to obtain valuable scientific information in the selected areas.

Primary engineering goals for Leg 132 include evaluating the DCS system in problematic geologic environments, and testing new techniques for spudding and controlling unstable formations. As such, the test plan for Leg 132 is focused on the ability to spud a hole on bare rock, stabilize fractured or unstable formations, and deploy the DCS for coring operations in crystalline rock, interbedded chalk/chert formations, and in shallow-water carbonate formations prevalent on atolls and guyots. At this time, DCS technology holds the most promise for successfully achieving future scientific objectives in these environments. In addition, it is anticipated that the coring system will be tested at higher speeds (200-500 RPM) and be deployed to deeper operating depths (2700-3000 m) than during Leg 124E.

Primary engineering goals during Leg 132 include the following:

1. Evaluating the overall performance and efficiency of the Phase II (4500-m capability) DCS in water depths ranging from 1000 to 3000 m (Appendix I). The DCS is to be evaluated in three distinctive geological environments, including (1) bare and/or fractured crystalline rock, (2) interbedded chalk/chert sequences, and (3) atoll/guyot shallow-water carbonate formations.
2. Deploying and testing the new "mini" hard-rock guide base (HRB) designed for more efficient and economical spudding on bare and/or fractured rock.
3. Deploying and testing a modified reentry cone designed for compatibility with the DCS mini-riser tensioning system.
4. Evaluating techniques and hardware for establishing and maintaining upper hole stability to allow successful deployment of the DCS for operational scientific coring operations in unstable formations.
5. Evaluating the HRB or reentry cone/API drill string tensioning system for possible future use as a drill-string mini-riser.

Specific engineering and operational objectives for Leg 132 include the following:

Mini Hard Rock Guide Base/Upper Hole Stabilization

1. Test gimbal concept for greater rotational freedom of reentry cone.
2. Evaluate use of weighted cement (with steel punchings) for ballast.
3. Evaluate use of ODP API drill pipe as a mini-riser in deeper water and at higher RPM then was attempted on Leg 124E. Note: There is no plan to include return circulation to the rig floor at this time.
4. Install and evaluate performance of a new tapered stress joint above the breakaway mechanical tensioning device.
5. Evaluate use of a mechanical tensioning tool to hold tension on guide base.
6. Test a modified 16-in. casing hanger designed to accept a mechanical tensioning tool and landing seat for a modified back-off sub.
7. Evaluate drill-in/back-off release mechanism allowing use of the bottom-hole assembly (BHA) for spudding in bare fractured rock and for upper hole stabilization.
8. Evaluate adaption of mini-riser tensioning system to standard reentry cone design.

Diamond Coring System Phase II 4500 Meter Capability

1. Continue evaluation of DCS in offshore environment.
2. Operate and evaluate an upgraded and modified version of the HQ-3 core barrel system.

3. Test redesigned heavy duty, self winding, wireline winch for core barrel retrieval.
4. Operate and evaluate upgraded dual cylinder secondary heave compensation system with simplified computer network.
5. Evaluate use of safer, operationally improved, DCS platform.
6. Operate and evaluate new electric top drive system with higher load and higher torque capability.
7. Deploy and evaluate high strength tubing (DCS core string) in a production mode and locate nodal vibration points at varied RPM and string lengths.
8. Evaluate new umbilical design for DCS platform.
9. Evaluate new upgraded DCS mud pump system.
10. Evaluate performance of new hybrid drill-in bit for drilling BHA into fractured basalt.

LEG 132 DRILL SITES

Site ENG-5 (31°03'N, 139°53'E, water depth 1750 m) is located east of Kyushu and south of Yokohama, Japan, in the Bonin backarc basin. This site will be occupied for approximately 20.8 days while evaluating the "mini" HRB, bare rock spudding/hole stabilizing techniques, and performance of the improved Phase II (4500-m) DCS in fractured crystalline rock.

Site ENG-6 (32°19.6'N, 157°50.8'E, water depth 2625 m) is located ~912 nmi east of ENG-5 on the Shatsky Rise. Approximately 13.8 days will be spent at this site deploying a modified re-entry cone/casing system and coring with the DCS through interbedded chalk/chert sequences. If the new version of the Navi-Drill core barrel (NCB) is available and given sufficient time, the NCB may be deployed and evaluated in an adjacent XCB hole at this site.

The third site, ENG-7 (27°18.8'N, 151°53.15'E, water depth 1360 m), is located southwest of the Shatsky Rise on M.I.T. Guyot. A back-reef site is proposed, and two other sites, one a reef site and one a lagoonal site, have been identified as alternates. A total of 11.9 operational days is scheduled for this site, during which another "mini" HRB system will be set. Coring operations with the DCS through reefal limestone formations will be conducted. Again, pending hardware and time availability, the NCB coring system may be deployed and evaluated in an adjacent borehole.

LEG 132 ENGINEERING AND DRILLING OPERATIONS TEST PLAN

Test Plan for Site ENG-5 (Figures 2, 3, and 4)

Upon arrival in the vicinity of ENG-5 (Bonin backarc) an optimum "bare rock" site location will be selected during an underwater television survey. A pilot hole (Hole A) will be spudded and drilled using a conventional 9-1/2-in. positive displacement mud motor (PDM). Drilling this hole will establish the degree of formation stability and will determine the number of drill collars that can be conservatively drilled in at the primary HRB location (Hole B). Hole A will also provide information necessary for proper location of the back-off sub in the drilling BHA. Hole A will be drilled with a standard tricone drill bit, so there will be no provision for recovering core.

After completing a drill pipe round trip, the new "mini" HRB will be deployed and landed on the seafloor. Another pipe trip will be made to make up the drilling BHA and back-off sub. That assembly will reenter the HRB and be drilled with the PDM to the appropriate depth. After landing and latching the lower portion of the BHA in the HRB, it will then be released using a back-off sub. The released collars will provide the casing required for deploying and coring ahead with the DCS system. A round trip will then be made to remove the PDM and deploy the mini-riser tensioning joint. Once the API drill string has reengaged the HRB assembly, then the DCS coring system will be deployed. The plan is to core at least 150 m beyond the emplaced BHA in the fractured, bare crystalline rock environment.

<u>Test Plan for Site ENG-6</u> (Figures 5, 6, and 7)

Evaluation of the DCS at ENG-6 (Shatsky Rise) will differ from the bare rock deployment at ENG-5 in that there will be soft sediment overlying chert/chalk horizons at ~125 mbsf. At this site a conventional pilot hole (jet-in test) will be conducted (Hole A) prior to deploying a modified re-entry cone with attached 16-inch conductor pipe (Hole B). Modification of the standard ODP reentry cone will allow attaching the API drill string (5-in. and/or 5-1/2-in. pipe) and tensioning as was done with the mini HRB at ENG-5. Once the reentry cone and casing have been installed, a round trip will be made to make up the drilling BHA and back-off sub. That assembly will then be deployed as described for ENG-5. The plan for the hole is to core a minimum of 150 m beyond the emplaced BHA into an interbedded chert/chalk formation.

<u>Test Plan for Site ENG-7</u> (Figures 2, 3, and 4)

At site ENG-7 (M.I.T. Guyot) DCS operations will be conducted on an atoll containing shallow-water reefal limestone formations. Upon arrival in the vicinity of ENG-7, an optimum "bare rock" site location will be selected during a limited underwater television survey. A pilot hole (Hole A) will be spudded and drilled using a conventional 9-1/2-in. positive displacement mud motor (PDM). Drilling the hole will establish the degree of formation stability and will determine the number of drill collars that can be conservatively drilled in at the primary HRB location (Hole B). Hole A will also provide information necessary for proper location of the back-off sub in the drilling BHA. Hole A will be drilled with a standard tricone drill bit, so there will be no provision for recovering core.

After completing a round trip, the second "mini" HRB of the leg will be deployed and landed at the sea floor. Another round trip will be made to make up the drilling BHA and back-off sub. That assembly will reenter the HRB and be drilled with the PDM to the appropriate depth. After landing and latching the lower portion of the BHA in the HRB, it will then be released using a back-off sub. The released collars will provide the casing required for deploying and coring ahead with the DCS system. The plan is to core at least 150 m beyond the emplaced BHA into the shallow-water reefal limestone formations.

As stated above, the primary objective for Leg 132 is to evaluate the DCS in three distinctively different geological environments. It is critical that an adequate amount of time be spent establishing the hole and stabilizing the formation so that the DCS can be tested properly in a coring mode without fighting upper hole stability problems as encountered during the DCS concept evaluation on Leg 124E.

SCIENTIFIC OBJECTIVES OF LEG 132

The scientific objectives of Leg 132 are closely related to the development and successful use of the DCS. The DCS is designed to improve both coring and recovery of rock. Leg 132 will test the DCS in three environments. A successful test in each should provide materials of sufficient coherence and continuity to understand detailed relationships of lithology, stratigraphy, and diagenesis or alteration.

Although we plan to core only a nominal 150 m at each site, the results will have a considerable bearing on plans for drilling in similar environments elsewhere. The three environments are (1) fractured, uncemented pillow basalts in axial, hydrothermally active regions of spreading ridges, (2) Mesozoic sequences of layered chert-porcellanite and chalk with alternating hard and soft characteristics, and (3) reef-lagoonal deposits with contrasting coarse (loose) and fine-grained (firm) characteristics atop a Cretaceous guyot in the western Pacific. Previous experience with conventional rotary coring procedures is that although coring can proceed in the chert/chalk and reef/lagoonal facies, recovery is typically too poor, particularly in the soft or coarse intervals, to provide either biostratigraphic control or sufficient material for the study of pore fluids and the mechanisms of diagenesis. Critical intervals, which we have reason to believe should exist based on exposures of comparable age on land (e.g., black shales rich in organic carbon), have apparently been missed in several of the chert/chalk sequences cored in the Pacific to date.

In pillow basalts at young ridges, coring results have been even worse. The drilling literature concerned with this is replete with accounts of torn-up core bits, blown-off bottom hole assemblies, low recovery (or no recovery), and endlessly foiled attempts to drill holes more than a few tens of meters deep. Coring such basalts has long been a major concern of scientists interested in crustal drilling, and was an important motivation in the development of the DCS. The results of drilling on Leg 132 will determine the feasibility of two drilling legs planned for the East Pacific Rise in 1992-3.

In terms of the immediate drilling targets of Leg 132, scientific objectives can be summarized very simply. More is better, specifically more recovery. In the basalts we anticipate recovering at ENG-5, in the Sumisu Rift near the Bonin arc (Fig. 1), we should be able to observe complete or nearly complete cross sections of pillowed lava and possible lava flows in the 150-m section. The glassy margins, fracture distributions, and networks of vein minerals formed within a short period of time following eruptions should be intact. We will be able to observe these features close up in a vertical section (including pillow interiors), which cannot be done even using a submersible, and have the entire section available for sampling and detailed analytical study. A special feature of the rocks is that they will be drilled at a center of spreading and will record processes chiefly associated with heir extrusion and short existence on the seafloor. The DCS should be able to core the rocks in a way that will retain some of the more fragile but most important evidence for these processes, in the form of vein minerals, gas bubbles trapped in glass, and the like.

The location targeted for ENG-5 is at or near an axial volcanic high not covered by turbidites from the nearby arc. Submersible observations (Taylor, Brown, et al., in press) establish that the terrain is primarily pillow basalts only thinly dusted by sediment. Site selection will be based on a pre-drilling television survey to find the best location for a bare-rock guide base.

At ENG-6, we plan to drill a bedded chert-chalk sequence of Aptian-Albian age beneath an unconformable cap of largely eroded Paleogene-Neogene chalks and oozes ~125 m thick exposed on a flank of Shatsky Rise (Fig. 1). Previous drilling on DSDP Legs 6, 32, and 86 (Fischer, Heezen, et al., 1971; Larson, Moberly, et al., 1975; Heath, Burckle, et al., 1985) recovered primarily broken chert/porcellanite fragments in materials of this age from Shatsky Rise. The sedimentary rocks are of interest because they were deposited in moderate depths. Thus, they presumably preserve both siliceous and calcareous microfossil assemblages that were not all preserved in deeper waters at these times. Moreover, coring elsewhere in the Pacific together with observations in Franciscan exposures in California (Sliter, 1989) suggest that the intervals of high silica productivity recorded by the cherts was associated with or punctuated by intervals of anoxia, which may have been widespread at certain levels in the water column during the Cretaceous. Although scattered organic-rich sediments deposited at these times have been recovered by drilling in the Pacific, understanding them requires the precise multifaunal biostratigraphic control that only nearly continuous recovery can provide.

Additionally, continuous recovery through 150 m of bedded chert and chalk will provide the first information on the lithological characteristics of such rocks under *in situ* conditions in the Pacific. It will be possible to address the general problem of formation of chert from calcareous-siliceous biogenic components, as well as the significance of residual pore fluids residing in the more porous chalks, left following the diagenesis.

Finally, at ENG-7, we plan to core both eroded reefal and lagoonal facies atop M.I.T. Guyot in the western Pacific (Fig. 1). Guyots with their flat summits were first described as simple wave-beveled volcanic islands that subsided below sea level (Hess, 1946). Expeditions in 1951, 1970, and 1988, however, showed that many guyots are capped with calcareous reefs of generally mid-Cretaceous age (Hamilton, 1956; Matthews et al., 1974; Heezen et al., 1973; Winterer et al., 1989). The latest expedition established that a number of guyots are actually drowned and submerged atolls with thick reefs enclosing well-stratified lagoonal sediments. Multi-beam high-resolution bathymetric surveys revealed a characteristic summit geomorphology of a well-defined reef perimeter enclosing an interior with complex relief, but in general indicating partial removal of uppermost lagoonal sediments by processes of karsting and wave erosion during periods of emergence of the summits in the Cretaceous.

The specific location of ENG-7 is just within the lagoonal facies in a shallow depression immediately behind a reef segment. The coring will provide the first coherent recovery of a lagoonal sequence atop a guyot, but the placement of the site will also allow recovery of coarser reefal material cast into the back reef by the action of waves and storms. Site location here will depend primarily upon results of a pre-drilling television survey required for placing a bare-rock guide base. The surface of the guyot is encrusted with ferromanganese oxides and phosphatized Cretaceous limestone, constituting a hard ground that will not allow washing in of casing conductor pipe with a conventional reentry cone.

The rocks cored below the hardground will provide detailed information on the lithological constitution of a central Pacific Cretaceous atoll, the community of organisms that dwelled there, and probably the mechanism and timing of reef extinction. Evidence for an interval of emergence and karst development may be evident from the diagenetic history of the rocks and the light-isotope compositions of their authigenic carbonate minerals.

A number of the cores collected in the course of the Leg 132 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 are scheduled after they are stored in the ODP repository. An understanding of the scientific importance of changes that occur in these cores during storage is vital to core analysis in general.

REFERENCES

Fischer, A. G., Heezen, B. C., et al., 1971. *Init. Repts. DSDP,* 6: Washington (U.S. Govt. Printing Office).

Hamilton, E. L., 1956. Sunken islands of the mid-Pacific mountains. *Geol. Soc. Amer. Mem.,* 64.

Heath, G. R., Burckle, L., et al., 1985. *Init. Repts. DSDP,* 86: Washington (U.S. Govt. Printing Office).

Heezen, B. C., Matthews, J. L., Catalano, R., Natland, J., Coogan, A., Tharp, M., and Rawson, M., 1973. Western Pacific guyots. *In* Heezen, B. D., MacGregor, I. D., et al., *Init. Repts. DSDP,* 20: Washington (U. S. Govt. Printing Office), 653-723.

Hess, H. H., 1946. Drowned ancient islands of the Pacific basin. *Amer. J. Sci.,* 244:772-791.

Larson, R., Moberly, R., et al., 1975. *Init. Repts. DSDP,* 32: Washington (U.S. Govt. Printing Office).

Matthews, J. L., Heezen, B. C., Catalano, R., Coogan, A., Tharp, M., Natland, J., and Rawson, M., 1974. Cretaceous drowning of reefs on mid-Pacific and Japanese guyots. *Science,* 184:462-464.

Sliter, W., 1989. Aptian anoxia in the Pacific basin. *Geology,* 17:909-912.

Smith, J. R., Taylor, B., Malahoff, A., and Petersen, L., in press. Submersible and deep-tow camera studies of submarine volcanic terrains in the Sumisu Rift, Izu-Bonin Arc. *Earth Planet. Sci. Lett.*

Taylor, B., Brown, G., Fryer, P., Gill, J., Hochstaedter, F., et al., in press. *Alvin*-SeaBeam studies of the Sumisu Rift, Izu-Bonin area. *Earth Planet. Sci. Lett.*

Taylor, B., Moore, G., Klaus, A., Systrom, M., Cooper, P., and MacKay, M., in press. Multichannel seismic survey of the central Izu-Bonin Arc. *In* Taylor, B., Fujioka, K., et al., *Init. Repts., Proc. ODP,* 126.

Winterer, E. L., Natland, J. H., Van Waasbergen, R., McNutt, M., and Sager, W., 1989. NW Pacific Cretaceous guyots: morphology, stratigraphy, and latitudinal histories. *EOS, Trans. Amer. Geophys. Un.,* 70:468.

TABLE 1

LEG 132 ENGINEERING TEST PROGRAM

Site	Latitude (N)	Longitude (E)	Water Depth (m)	Drilling Depth (mbsf)	Drilling Time (days)	Logging Time (days)	Total Time (days)
			BONIN BACKARC				
ENG-5	31°03'	139°53'	1750	1900	20.8	0	20.8
			SHATSKY RISE				
ENG-6	32°19.6'	157°50.78'	2625	2875	13.8	0	13.8
ENG-6A	32°19.0'	157°50.75'	2625				
			M.I.T. GUYOT				
ENG-7	27°18.80'	151°53.15'	1360	1510	11.9	0	11.9
ENG-7A	27°18.35'	151°53.15'	1340				
ENG-7B	27°19.45'	151°53.05'	1360				

TABLE 2

SITE OCCUPATION SCHEDULE

SITE	LOCATION (days)	TRANSIT TIME[a] (days)	OPERATIONS	DATE
In Port, Pusan, 2-6 June 1990				
Depart Pusan				7 June 1990
		3.1[b]		
ENG-5	31°03'N, 139°53'E		20.8	
		3.8		
ENG-6	32°19.60'N, 157°50.78'E		13.8	
		1.8		
ENG-7 (Revised Proposal 203E)	27°18.80'N, 151°53.15'E		11.9	
		3.8[c]		
Arrive Guam				5 August 1990
		—	—	
	SUBTOTAL	12.5	46.5	
	TOTAL		59.0	

[a] Calculated at a transit speed of 10.0 kt.

[b] Transit through Odate shoal passage and Osumi Kaiko.

[c] Transit time to "Alph Hotel" (unmarked approach point 2 mile west entrance to Arpa Harbour).

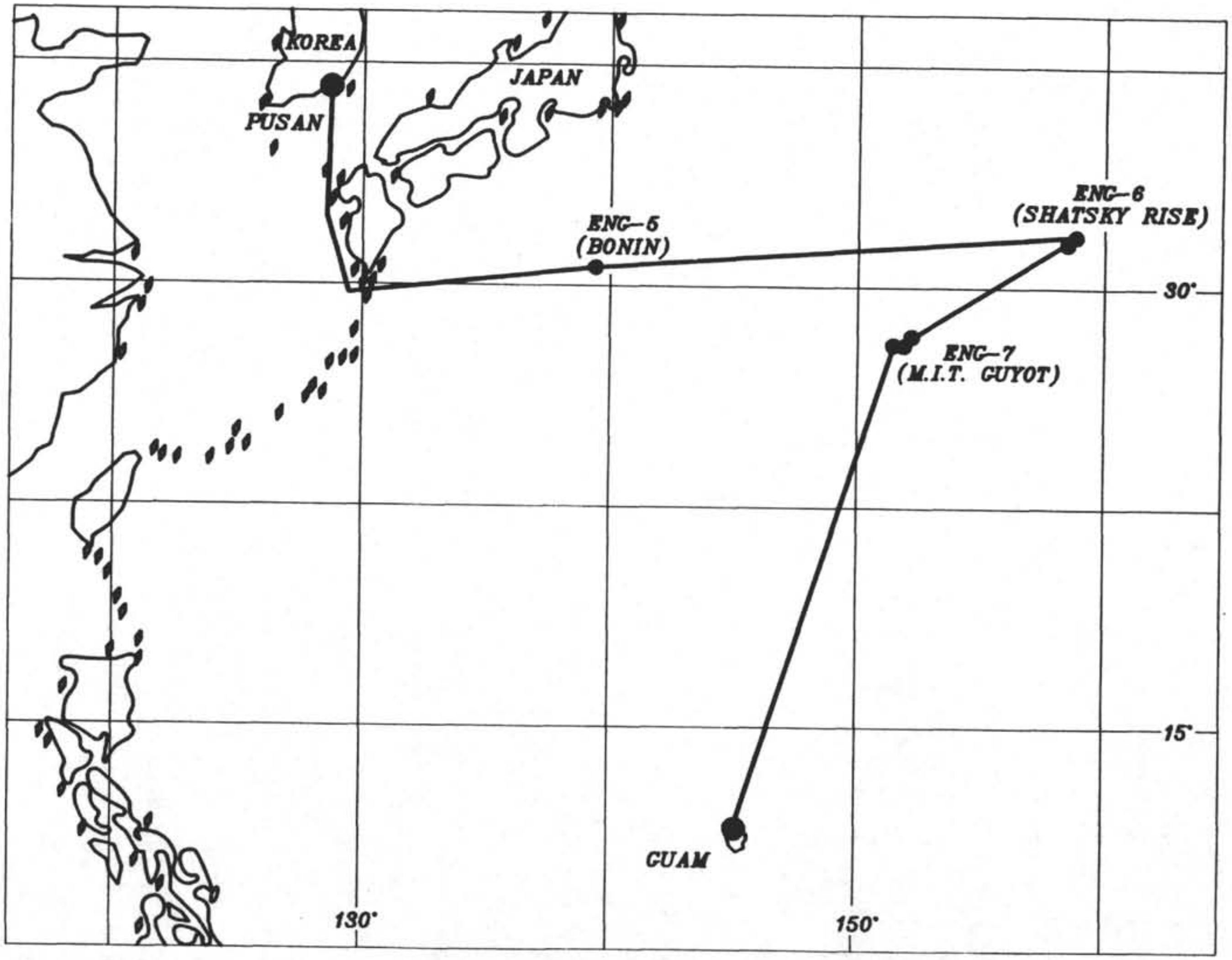


Figure 1.
Locations of sites proposed for drilling on ODP Leg 132

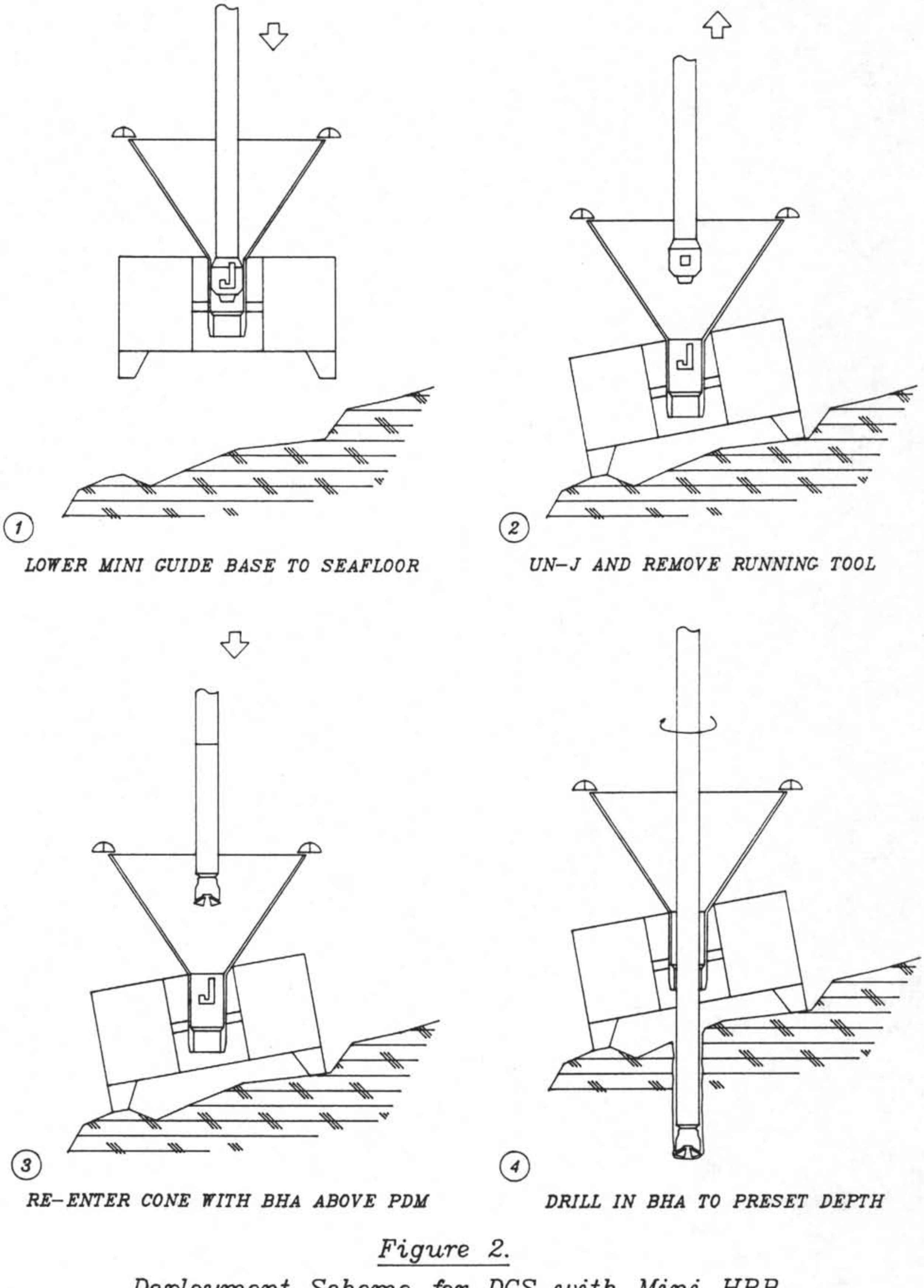


Figure 2.

Deployment Scheme for DCS with Mini HRB

(Bonin Backarc and M.I.T. Guyot)

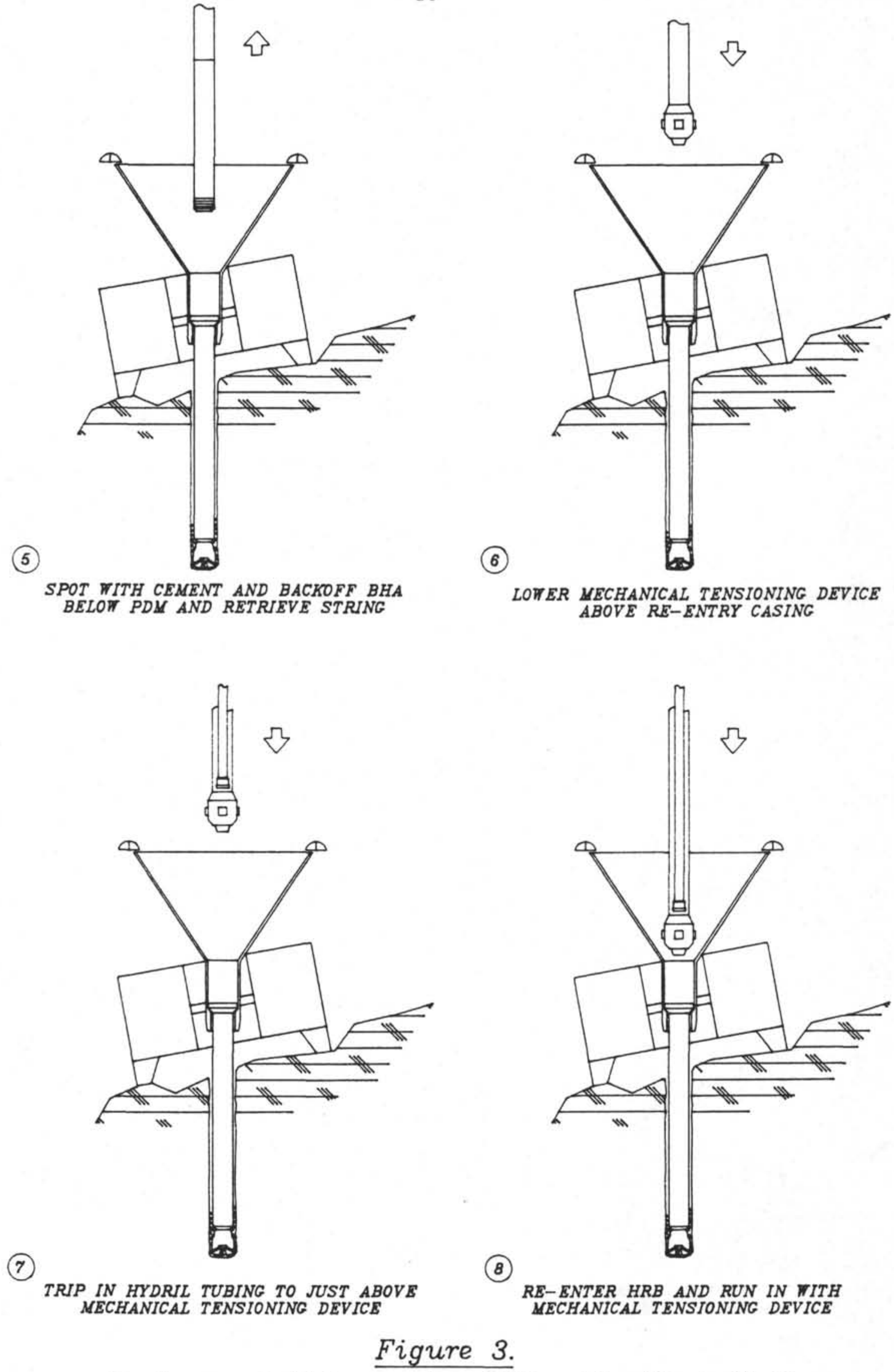


Figure 3.
Deployment Scheme for DCS with Mini HRB
(Bonin Backarc and M.I.T. Guyot)

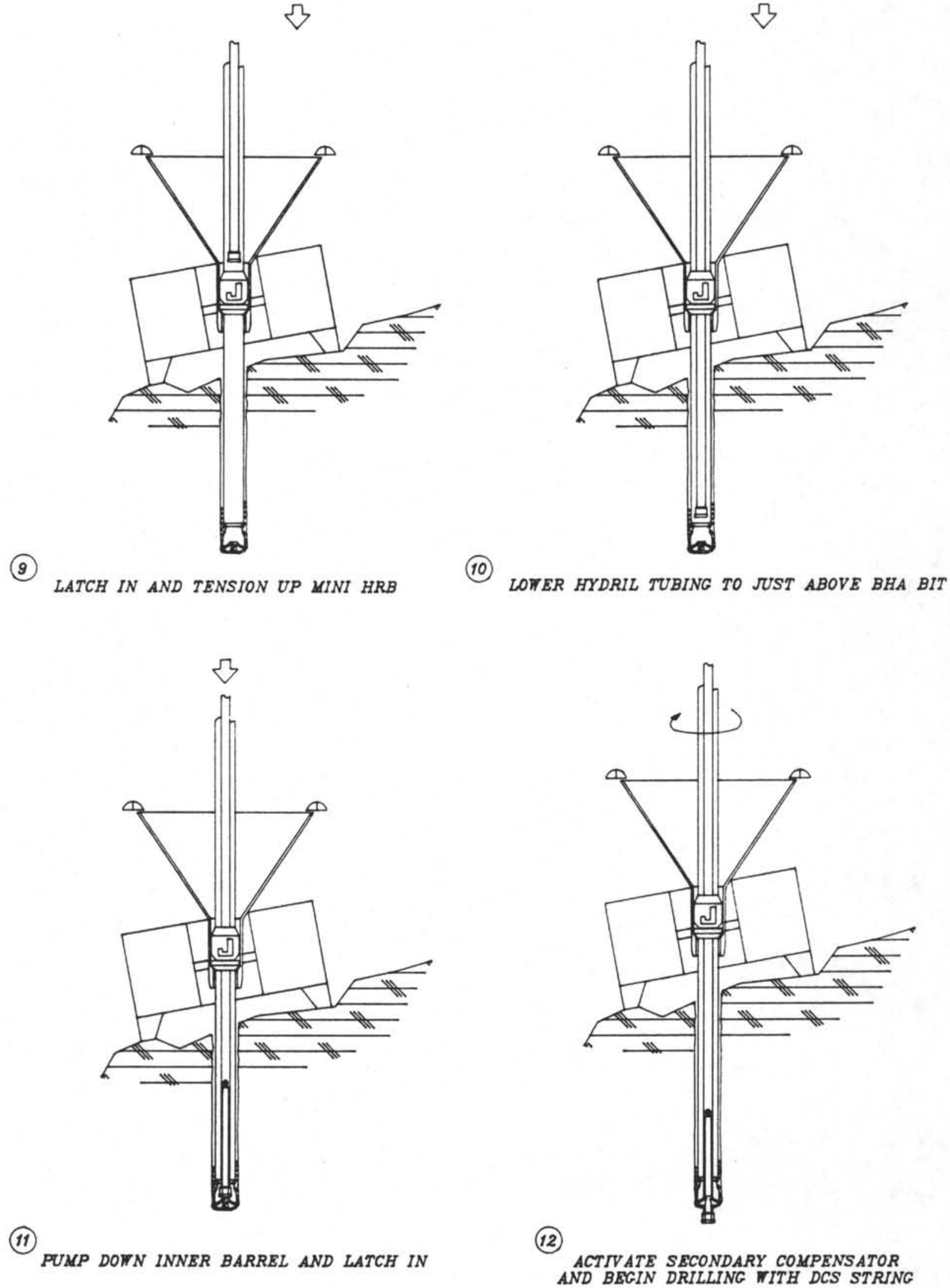


Figure 4.

Deployment Scheme for DCS with Mini HRB

(Bonin Backarc and M.I.T. Guyot)

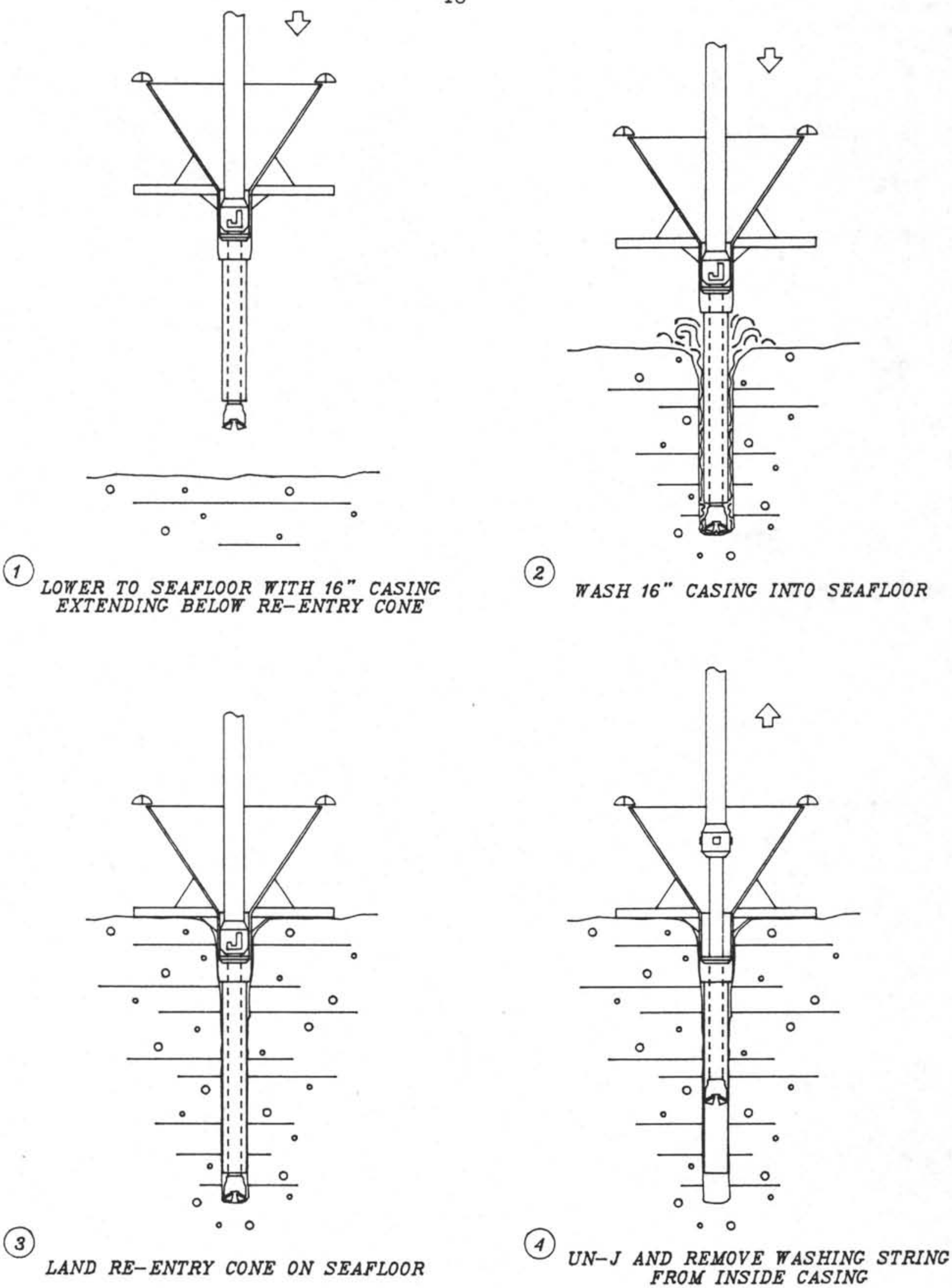


Figure 5.

Deployment Scheme for DCS with Re-Entry Cone

(Shatsky Rise)

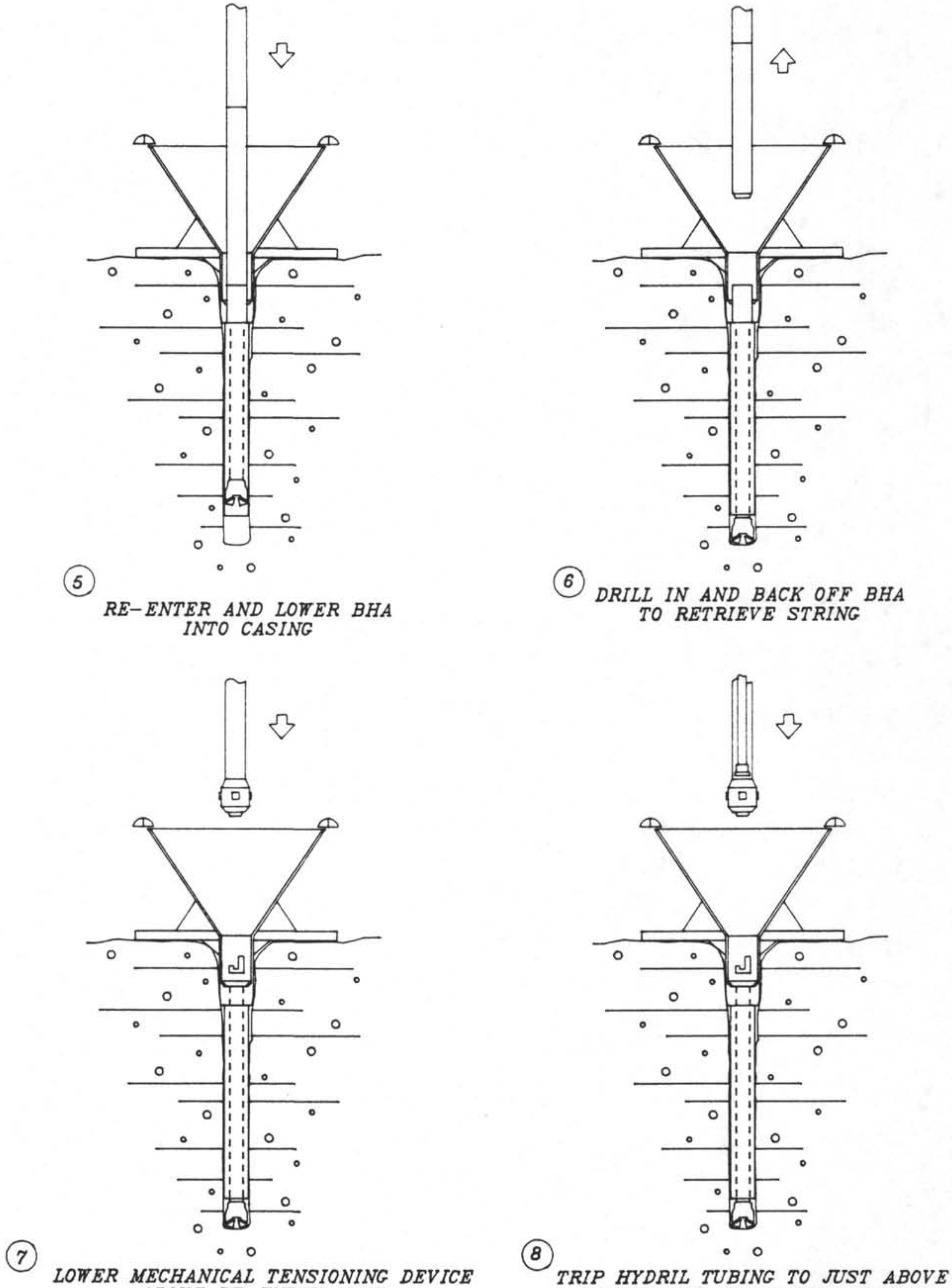


Figure 6.

Deployment Scheme for DCS with Re-Entry Cone
(Shatsky Rise)

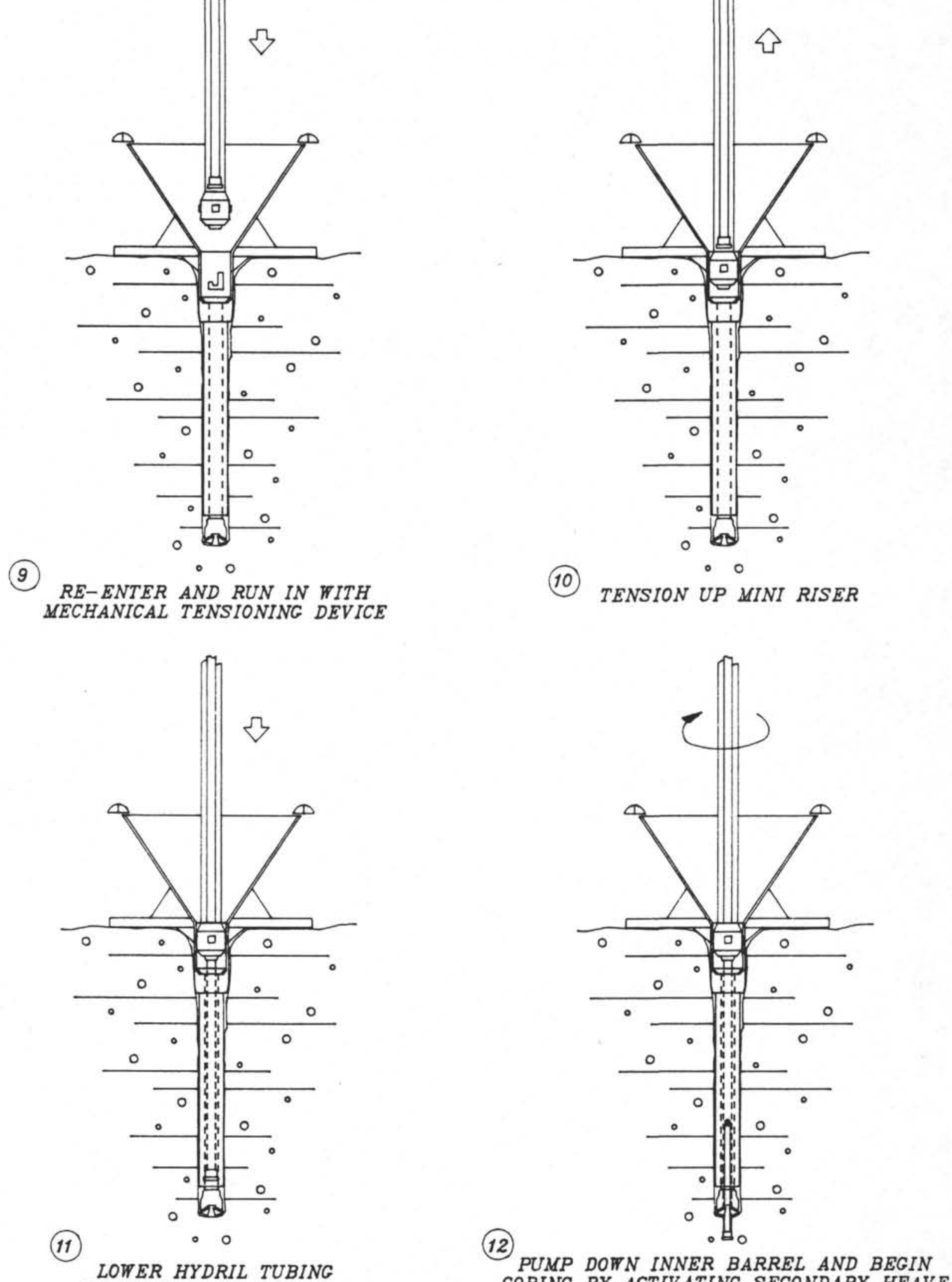


Figure 7.

Deployment Scheme for DCS with Re-Entry Cone
(Shatsky Rise)

Site Number: ENG-5 (Bonin backarc)

Position: 31°03'N, 139°53'E

Jurisdiction: Japan

Sediment Thickness: None (bare rock)

Priority: 1

Water Depth: 1750 m

Proposed Drilling Program: (Prospectus Figures 2, 3, and 4)

Hole A: Pilot hole (drilled only) to evaluate the formation drilling conditions and determine the amount of BHA/drill collars to be emplanted for the Diamond Coring System (DCS) test hole "B".

Hole B: Prototype testing of the new "mini" Hard Rock Guide Base (HRB) system, drill-in BHA/back-off sub bare rock spudding system, and the Phase II DCS. After deployment of the mini HRB and emplacement of the required drill collars the DCS will be evaluated for use in coring up to 150 m of fractured basalt.

Seismic Record: Saddle on *Fred Moore* multichannel line FM3507-8 (II-8) at approximately shotpoint 2250; close to *Kana Keoki* 84 single-channel line G at 0825.

Other Background Data: Site is located at junction of *Alvin* dive 1890 and Bottom Camera Tow 01 (see photogeology map; Smith et al., 1989; see also SeaBeam bathymetric map: Taylor, et al., pers. comm., 1989).

Engineering Objectives:

(1) Deploy and test the new "mini" HRB.
(2) Test new bare rock spudding techniques.
(3) Evaluate the Phase II 4500 m DCS.

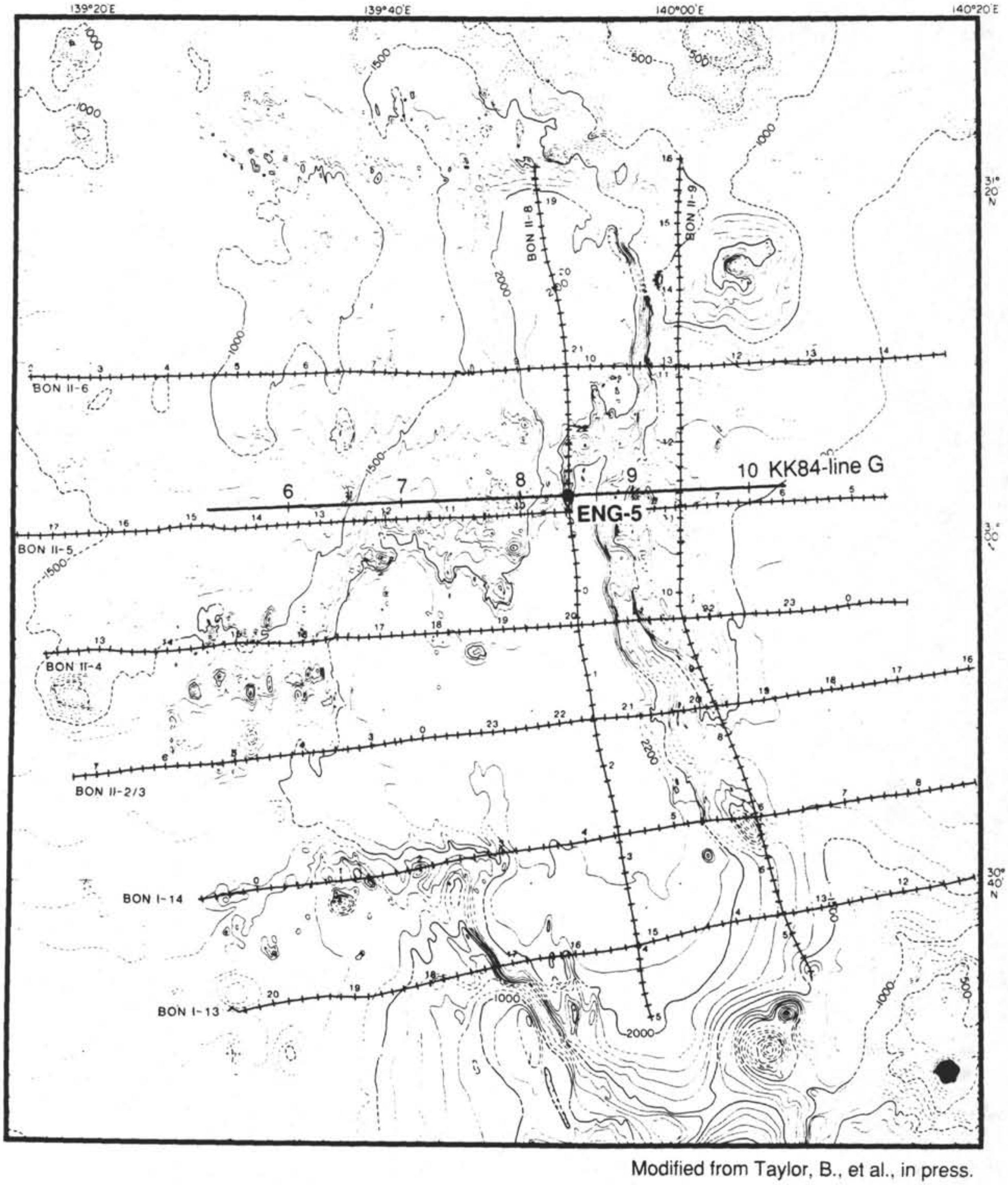
All three objectives are geared towards developing the capability to satisfy future zero age crust and sedimented ridge scientific coring requirements.

Secondary Science Objectives: Lithologic characteristics of well-recovered pillow basalts. Basalt chemical stratigraphy, mineralogy, compositions of vein minerals and alteration zones in very young basalts.

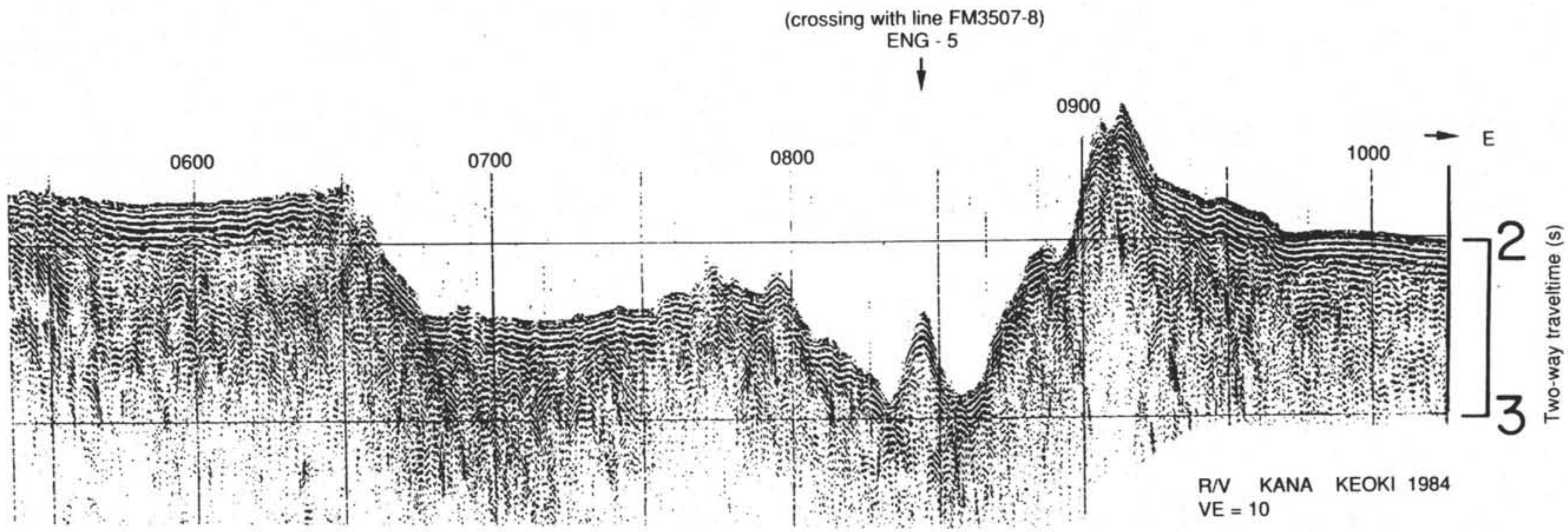
Logging: None

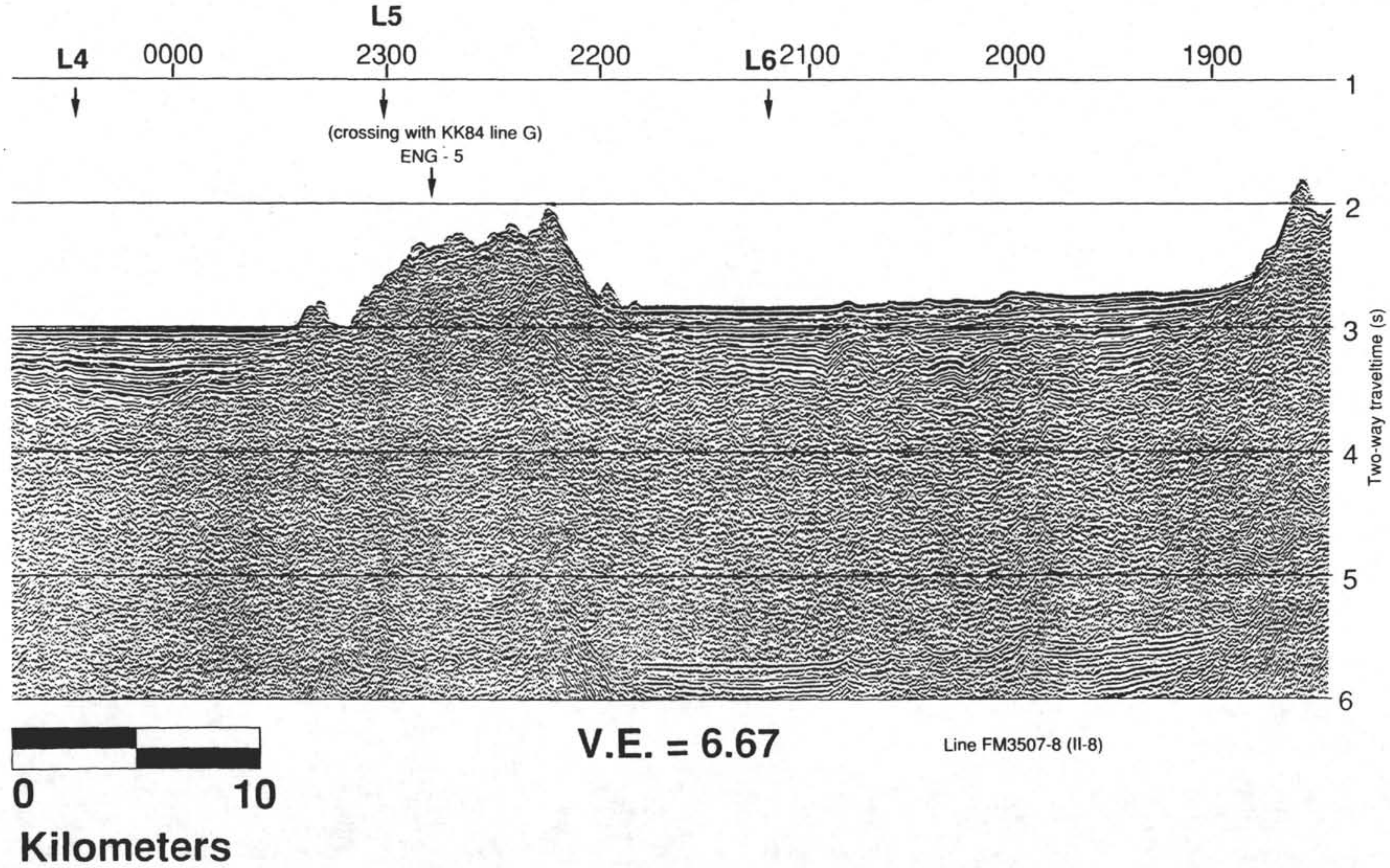
Sediment Type: None

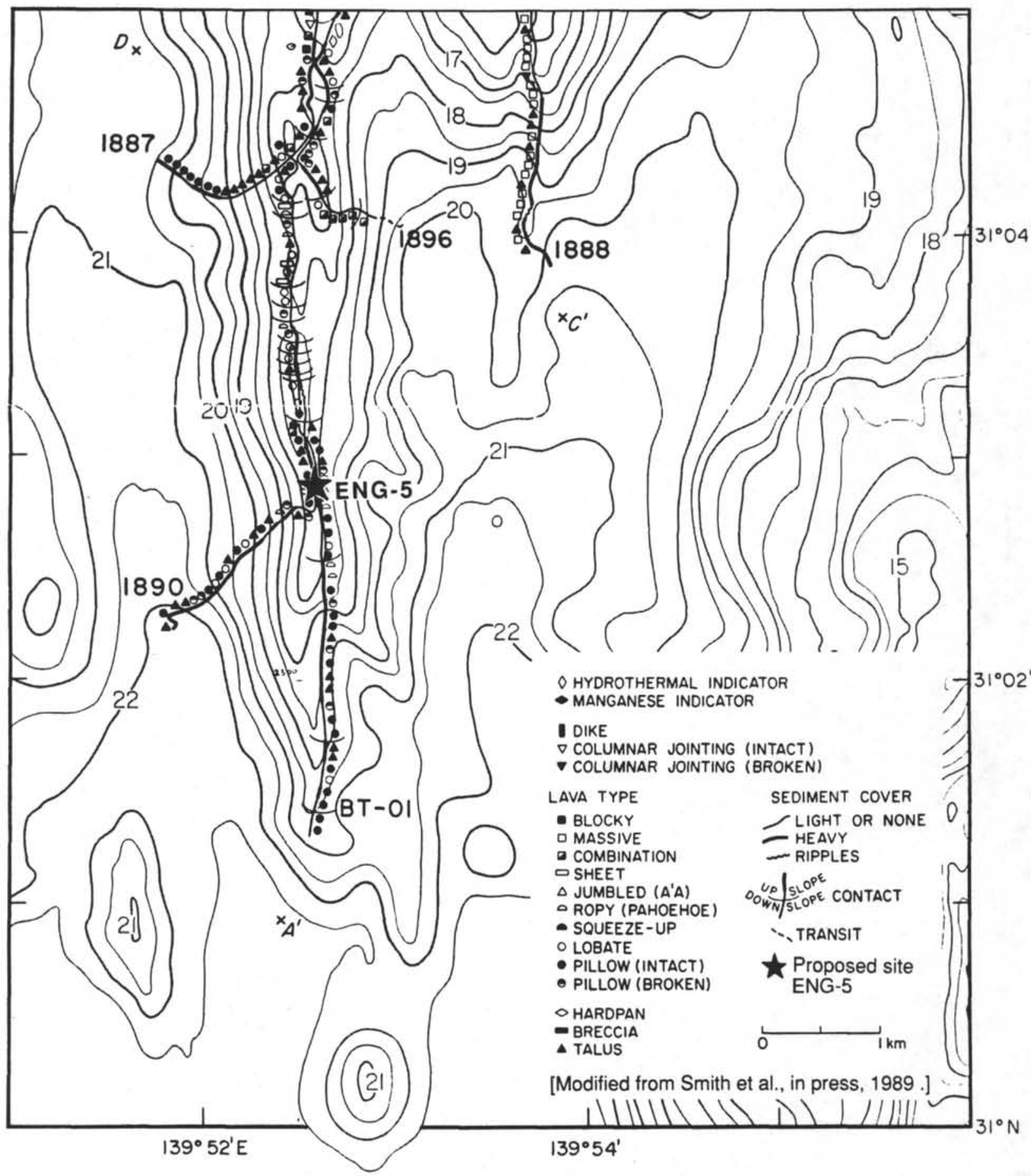
Basement Type: Zero-age pillow basalts.



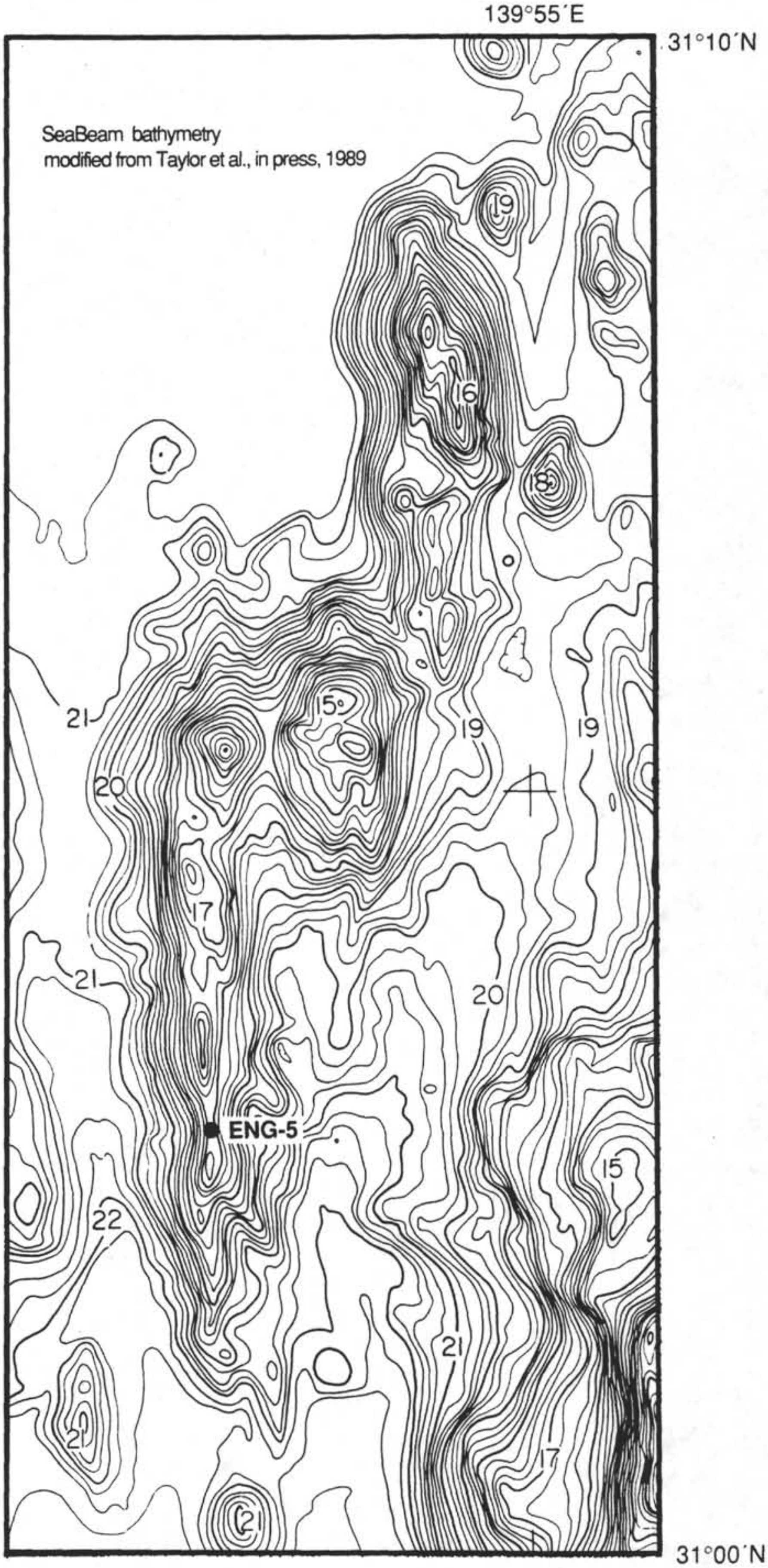
Modified from Taylor, B., et al., in press.


(crossing with line FM3507-8)
ENG - 5
0600
0700
0800
0900
1000
E
2
3
Two-way traveltime (s)
R/V KANA KEOKI 1984
VE = 10


L5
L4
0000
2300
2200
L6
2100
2000
1900
1
(crossing with KK84 line G)
ENG - 5
2
3
4
5
6
Two-way traveltime (s)
0
10
Kilometers
V.E. = 6.67
Line FM3507-8 (II-8)



Dx
1887
1896
1888
1890
ENG-5
BT-01
×C'
×A'
17
18
19
20
21
22
15
31°04'
31°02'
31°N
139° 52'E
139°54'
◊ HYDROTHERMAL INDICATOR
MANGANESE INDICATOR
DIKE
COLUMNAR JOINTING (INTACT)
COLUMNAR JOINTING (BROKEN)
LAVA TYPE
BLOCKY
MASSIVE
COMBINATION
SHEET
JUMBLED (A'A)
ROPY (PAHOEHOE)
SQUEEZE-UP
LOBATE
PILLOW (INTACT)
PILLOW (BROKEN)
HARDPAN
BRECCIA
TALUS
SEDIMENT COVER
LIGHT OR NONE
HEAVY
RIPPLES
UP SLOPE
DOWN SLOPE
CONTACT
TRANSIT
Proposed site ENG-5
0
1 km
[Modified from Smith et al., in press, 1989 .]


139°55′E
31°10′N
SeaBeam bathymetry
modified from Taylor et al., in press, 1989
19
16
18
15
19
19
21
20
17
21
20
ENG-5
15
22
21
21
17
21
31°00′N

Site Number: ENG-6 (Shatsky Rise)

Position: 32°19.6'N, 157°50.78'E

Jurisdiction: International

Sediment Thickness (above chert): 125 m

Priority: 1

Water Depth: 2625 m

Proposed Drilling Program: (Prospectus Figures 5, 6, and 7)

Hole A: Pilot hole (jet-in test) to determine the amount of casing to be washed-in with the modified re-entry cone.

Hole B: Prototype testing of the modified re-entry cone adapted for use with the DCS/API drill string tensioning system. After deployment of the re-entry cone and emplacement of a surface casing string and/or drill collars, the DCS will be evaluated for coring up to 150 m of interbedded chalk/chert sequences.

Seismic Record: *Kana Keoki* 77-03-17 Leg 5, 1816Z.

Engineering Objectives:

(1) Deploy and test a new (modified) reentry cone designed for compatibility with DCS coring and spudding techniques.

(2) Continue evaluating the drill-in BHA/back-off sub concept for upper hole stabilization.

(3) Continue evaluating the Phase II 4500 m DCS.

All objectives are geared towards developing the capability to satisfy future interbedded hard/soft scientific coring requirements.

Secondary Science Objectives:

(1) Obtain sufficient core material to study the paleontology, chemistry, and sedimentology of strata deposited during specific time intervals characterized by the accumulation of organic-carbon-rich sediments.

(2) Define the paleodepth of these strata to test the theory of an expanded oxygen-minimum zone and the development of upwelling conditions.

(3) Further our understanding of the paleoceanographic conditions that contributed to the deposition of organic-carbon-rich sediments in the ancient Pacific Ocean.

Logging: None

Sediment Type: ~125 m of nannofossil chalk and interbedded nodular chert overlying interbedded nannofossil chalk and bedded or nodular chert.

Site Number: ENG-6A (Alternate Shatsky Rise site)

Position: 32°19'N, 157°50.75'E

Jurisdiction: International

Sediment Thickness (above chert): 150 m

Priority: 2

Water Depth: 2625 m

Proposed Drilling Program: (Prospectus Figures 5, 6, and 7)

Alternate to the primary ENG-6 site. This site is to be drilled only if the primary Shatsky Rise site is prematurely abandoned or proves to be unsuitable for achieving the primary engineering objectives.

Hole A: Pilot hole (jet-in test) to determine the amount of casing to be washed-in with the modified reentry cone.

Hole B: Prototype testing of the modified reentry cone adapted for use with the DCS/API drill string tensioning system. After deployment of the reentry cone and emplacement of a surface casing string and/or drill collars, the DCS will be evaluated for coring up to 150 m of interbedded chalk/chert sequences.

Seismic Record: *Kana Keoki* 77-03-17 Leg 5, 1812Z.

Engineering Objectives:

(1) Deploy and test a new (modified) reentry cone designed for compatibility with DCS coring and spudding techniques.

(2) Continue evaluating the drill-in BHA/back-off sub concept for upper hole stabilization.

(3) Continue evaluating the Phase II 4500 m DCS.

All objectives are geared towards developing the capability to satisfy future interbedded hard/soft scientific coring requirements.

Secondary Science Objectives:

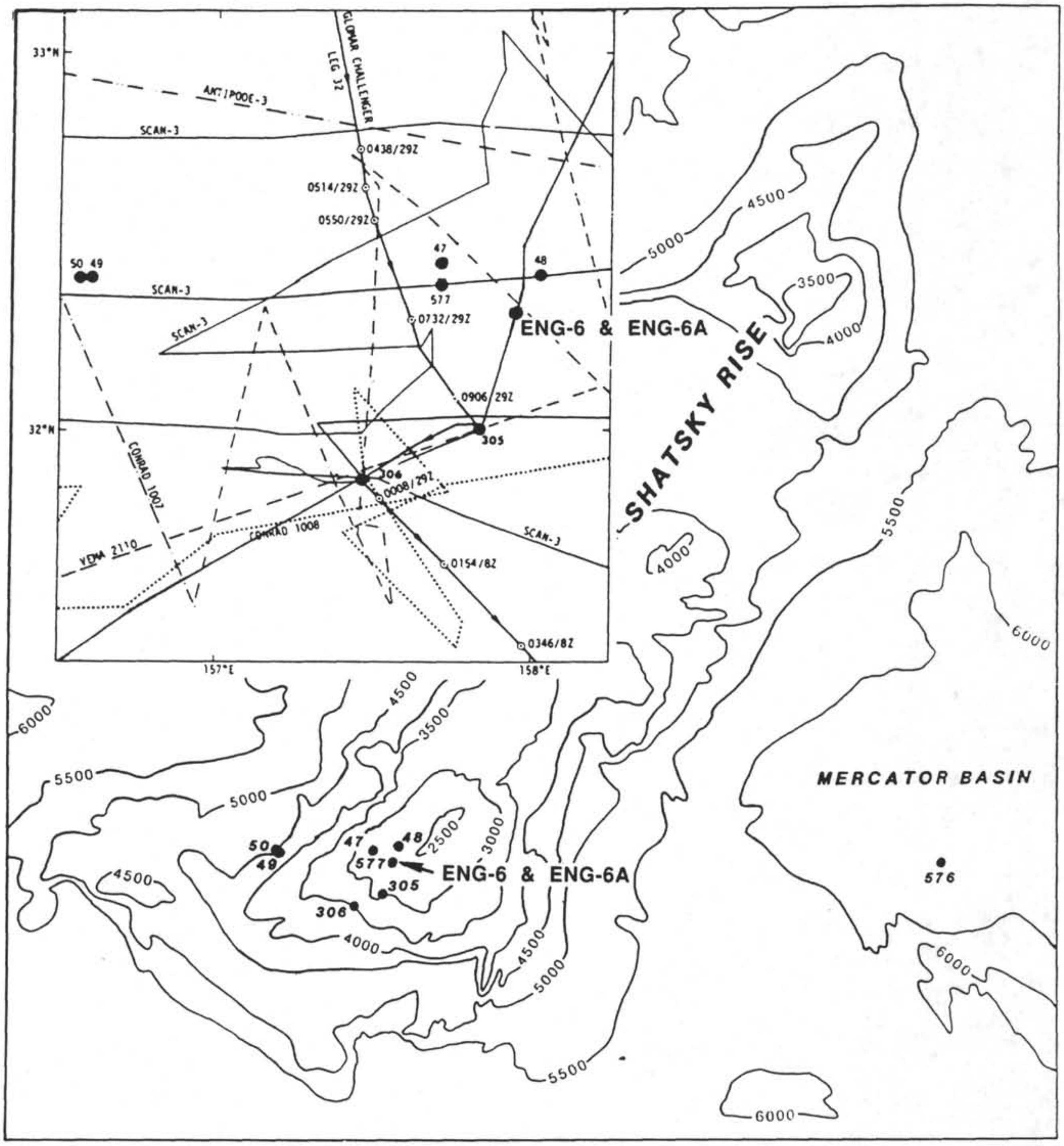
(1) Obtain sufficient core material to study the paleontology, chemistry, and sedimentology of strata deposited during specific time intervals characterized by the accumulation of organic-carbon-rich sediments.

(2) Define the paleodepth of these strata to test the theory of an expanded oxygen-minimum zone and the development of upwelling conditions.

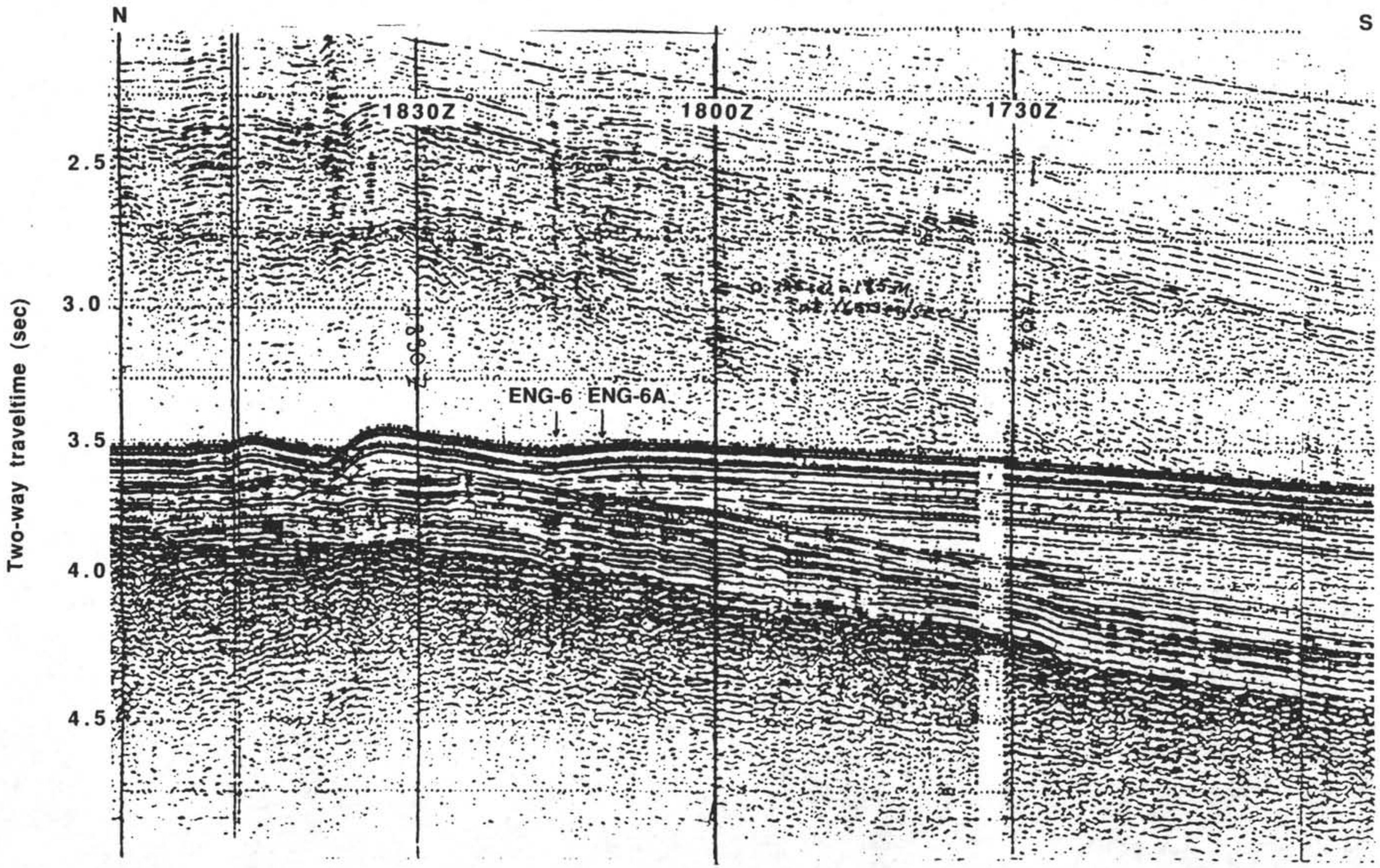
(3) Further understanding of the paleoceanographic conditions that contributed to the deposition of organic-carbon-rich sediments in the ancient Pacific Ocean.

Logging: None

Sediment Type: ~150 m of nannofossil chalk and interbedded nodular chert overlying interbedded nannofossil chalk and bedded or nodular chert.



Bathymetric chart of Shatsky Rise showing DSDP sites drilled to date and proposed sites ENG-6 & ENG6A. Inset shows tracks of seismic lines.


N
S
1830Z
1800Z
1730Z
ENG-6
ENG-6A
2.5
3.0
3.5
4.0
4.5
Two-way traveltime (sec)

Site Number: ENG-7 (M.I.T. Guyot, Backreef site)

Position: 27°18.80'N, 151°53.15'E

Jurisdiction: International

Sediment Thickness: 750 m (0.5 s @ 3 km/sec)

Priority: 1

Water Depth: 1360 m

Proposed Drilling Program: (Prospectus Figures 2, 3, and 4)

Hole A: Pilot hole (drilled only) to evaluate the formation drilling conditions and determine the amount of BHA/drill collars to be emplanted for the Diamond Coring System (DCS) test hole "B".

Hole B: Continued prototype testing of the new "mini" Hard Rock Guide Base (HRB) system, drill-in BHA/back-off sub bare rock spudding system, and the Phase II DCS. After deployment of the mini HRB and emplacement of the required drill collars the DCS will be evaluated for use in coring up to 150 m of shallow-water carbonate and reefal limestone formations.

Seismic Record: *R/V Thomas Washington,* Roundabout Leg 10, 1052Z, 18 Nov 88. Site shown on accompanying Sea Beam map.

Engineering Objectives:

(1) Second deployment and test of the new "mini" HRB.

(2) Continue evaluation of the new bare rock spudding techniques.

All objectives are geared toward developing the capability to satisfy future atoll/guyot scientific coring requirements.

Secondary Science Objectives:

(1) Characterize and date shallow-water (lagoonal) limestones.

(2) Characterize dissolution/diagenetic effects.

(3) Characterize extent of surface phosphatization.

Logging: None

Sediment Type: Backreef facies. Surface ~1 m: manganese crust and phosphatized limestone. Below 1 mbsf: lagoonal facies limestone, interbedded with transported reefal limestone.

Site Number: ENG-7A (M.I.T. Guyot, Reef Site)

Position: 27°18.35'N, 151°53.15'E

Jurisdiction: International

Sediment Thickness: 750 m

Priority: 2

Water Depth: 1340 m

Proposed Drilling Program: (Prospectus Figures 2, 3, and 4)

Alternate to the primary ENG-7 site. This site is to be drilled only if the primary M.I.T. Guyot site is abandoned prematurely or proves to be unsuitable for achieving the primary engineering objectives.

Hole A: Pilot hole (drilled only) to evaluate the formation drilling conditions and determine the amount of BHA/drill collars to be emplanted for the Diamond Coring System (DCS) test hole "B".

Hole B: Continued prototype testing of the new "mini" Hard Rock Guide Base (HRB) system, drill-in BHA/back-off sub bare rock spudding system, and the Phase II DCS. After deployment of the mini HRB and emplacement of the required drill collars the DCS will be evaluated for use in coring up to 150 m of shallow-water carbonate and reefal limestone formations.

Seismic Record: *R/V Thomas Washington,* Roundabout Leg 10, 1055Z, 18 Nov 88. Site shown on accompanying Sea Beam map.

Engineering Objectives:

(1) Second deployment and test of the new "mini" HRB.

(2) Continue evaluation of the new bare rock spudding techniques.

All objectives are geared toward developing the capability to satisfy future atoll/guyot scientific coring requirements.

Secondary Science Objectives:

(1) Characterize and date reefal limestones.

(2) Characterize dissolution/diagenetic effects.

(3) Characterize extent of surface phosphatization.

Logging: None

Sediment Type: Reefal facies. Surface ~1 m: manganese crust and phosphatized limestone. Below 1 mbsf: reefal facies limestone.

Site Number: ENG-7B (M.I.T. Guyot, Lagoonal Site)

Position: 27°19.45'N, 151°53.05'E

Jurisdiction: International

Sediment Thickness: ~750 m

Priority: 2

Water Depth: 1360 m

Proposed Drilling Program:

Alternate to the primary ENG-7 site. This site is to be drilled only if the primary M.I.T. Guyot site is abandoned prematurely or proves to be unsuitable for achieving the primary engineering objectives.

Hole A: Pilot hole (drilled only) to evaluate the formation drilling conditions and determine the amount of BHA/drill collars to be emplanted for the Diamond Coring System (DCS) test hole "B".

Hole B: Continued prototype testing of the new "mini" Hard Rock Guide Base (HRB) system, drill-in BHA/back-off sub bare rock spudding system, and the Phase II DCS. After deployment of the mini HRB and emplacement of the required drill collars the DCS will be evaluated for use in coring up to 150 m of shallow-water carbonate and reefal limestone formations.

Seismic Record: *R/V Thomas Washington,* Roundabout Leg 10, 1047Z, 18 Nov 88, and 2022Z, 18 Nov 88.

Engineering Objectives:

(1) Second deployment and test of the new "mini" HRB.
(2) Continue evaluation of the new bare rock spudding techniques.

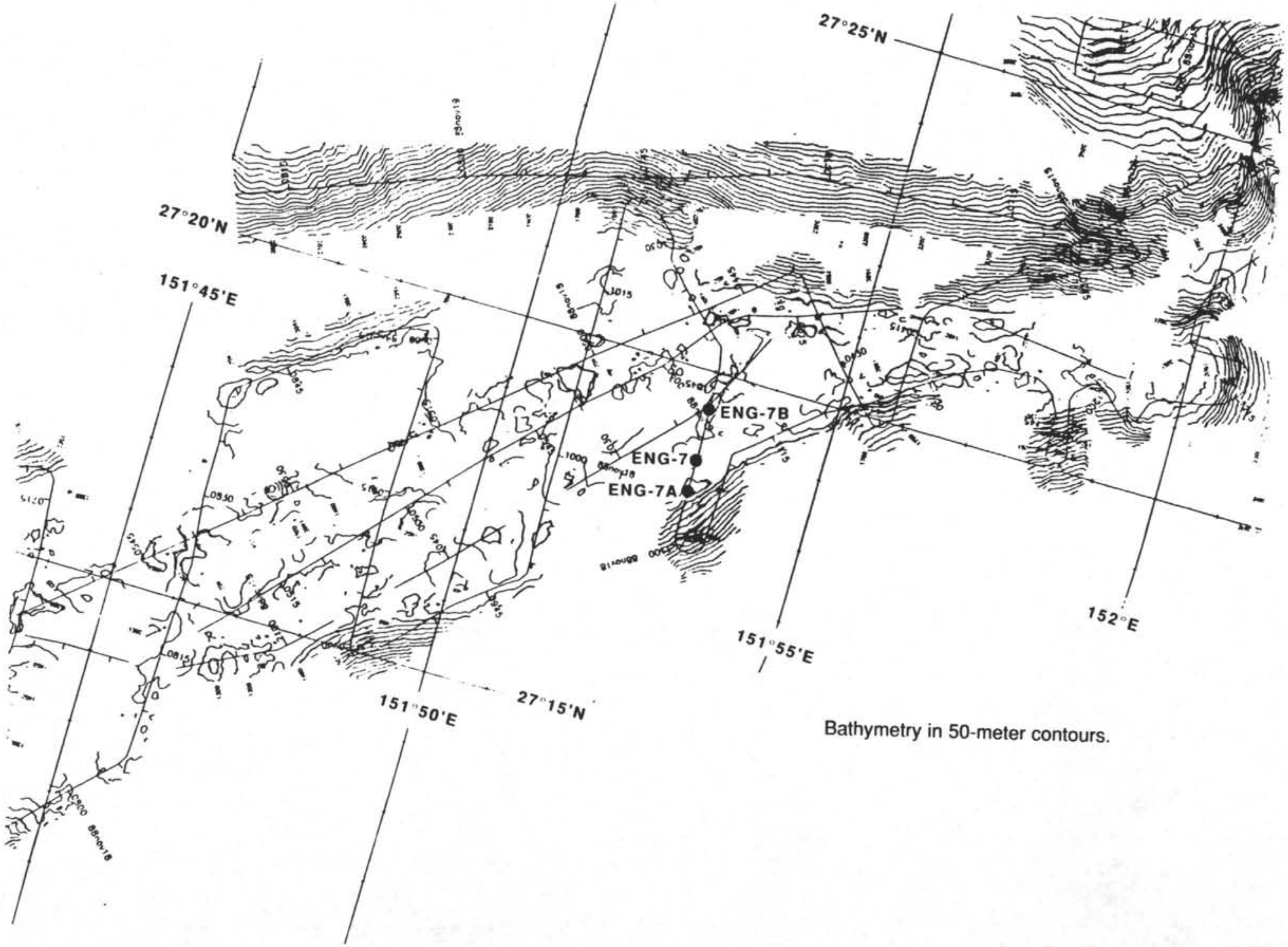
All objectives are geared towards developing the capability to satisfy future atoll/guyot scientific coring requirements.

Secondary Science Objectives:

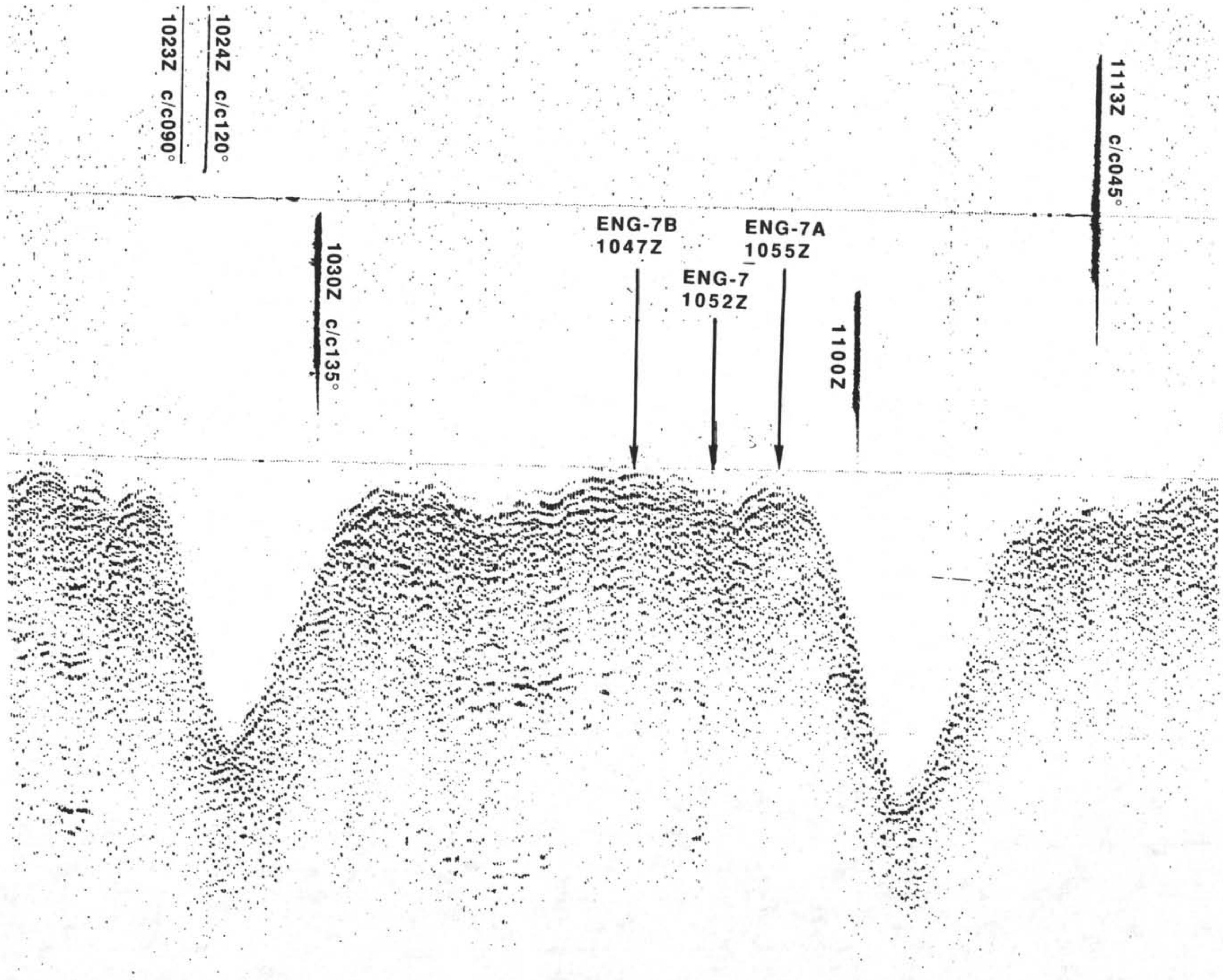
(1) Characterize and date lagoonal limestones.
(2) Characterize dissolution/diagenetic effects.
(3) Characterize extent of surface phosphatization.

Logging: None

Sediment Type: Surface ~1 m: manganese crust and phosphatized limestone. Below 1 mbsf: lagoonal facies limestone.



Bathymetry in 50-meter contours.


1023Z c/c090°
1024Z c/c120°
1030Z c/c135°
ENG-7B
1047Z
ENG-7
1052Z
ENG-7A
1055Z
1100Z
1113Z c/c045°

APPENDIX
OCEAN DRILLING PROGRAM
DIAMOND CORING SYSTEM DESCRIPTION
PHASE II 4500 METERS
November 6, 1989

The Ocean Drilling Program is currently developing a Diamond Coring System (DCS) for deep-water applications. The system being developed will be able to both drill and core in sedimentary and crystalline rock formations in up to 4500 m of water. A prototype or scaled down version of the Diamond Coring System was tested during January 1989 near the Philippines in 1700 m of water. The purpose of the test was to evaluate the potential for use of a top driven high speed diamond coring system deployed from a floating vessel.

The Diamond Coring System proposed for Phase II (Fig. A1), involves running a small diameter tubing string inside ODP's 5- and 5-1/2-in. drill pipe. The actual drill rod consists of a high strength 3-1/2-in. tubing string with HYDRIL series 500, type 501, wedge lock threaded connections.

A high speed, thin kerf impregnated, diamond coring bit (3.96 in. OD X 2.20 in. ID) is attached to the outer core barrel assembly on the end of the tubing string. The core barrel under consideration for the DCS is a modified Longyear HQ-3 type core barrel. It has been specially developed for this application to allow deployment through the tubing string. This core barrel allows for 10.0 ft X 2.20 in. cores to be taken (5-ft cores are optional). The core will be retrieved in standard ODP acetate butyrate core liners. Split or whole steel liners are optional for high temperature applications.

The tubing string is driven with an open swivel electric top drive. It will operate with speeds varying between 60 and 540 RPM. This unit replaces the leased prototype hydraulic top drive used in the Phase I concept evaluation. The new electric version is capable of producing higher torque and has a larger load carrying capacity. The 800-hp top drive will have a maximum make and break torque of 11,000 ft-lb but will be limited to ~8300 ft-lb during coring operations. The open swivel concept allows for the core barrel to be retrieved without having to disconnect from the tubing string.

To successfully operate the DCS it is imperative that both weight on bit and mud flow be controlled in a precise manner. The first is accomplished by introduction of a secondary heave compensator. This secondary compensator removes the load fluctuations resulting from the mechanical inefficiencies of the primary 400-ton passive heave compensator. It is arranged in series beneath the larger compensator. This system is intended to provide control for weight on bit fluctuations of ±500-1000 lb and compensate for drill ship motion resulting in total heave of ±12 in. at the DCS platform. A schematic diagram of the secondary compensator is presented in Figure A2. The secondary compensator will be rated for 150,000 lb of working tubing string weight.

All of the diamond coring operations and drilling functions will be performed from a manned platform suspended in the drill ship's derrick. A driller's console will be situated on this platform to allow over all control of the DCS. This platform is picked up once the mini hard rock guide base (HRB) or reentry cone and the mini riser system (MRS) are installed with the tubing string situated inside. The platform is put into operation by tripping the remaining rods to just above the bottom of the borehole and activating the secondary heave compensator and automatic feed system. At this point the diamond core bit will be automatically fed to the bottom of the borehole and the desired bit weight established for the coring run. With the coring run completed, the bit is retracted off bottom and the inner core barrel retrieved via a wireline. Once the full inner barrel is removed, another empty barrel will be dropped and allowed to free-fall down the drill rod. Coring operations then resume once the inner barrel is landed and properly latched into the outer barrel.

The DCS platform used in Phase I will again be used for Phase II but with some modification. This platform is approximately 45 ft tall and weights 40,000 lb. The work area inside the platform is approximately 8 x 12 ft, which allows for two to three workers to comfortably move about during coring operations. The DCS platform is stored out of the way on the rig floor and rolled into position via a portable dolly/track system when required. Power to operate the console top drive and heave compensator is supplied by two electrical umbilicals from the rig floor.

The second most important consideration when coring with the DCS is controlled mud flow. This is accomplished by incorporating a mud pump with low volume flow but with a high pressure capability. The mud system will most likely be a small independent unit placed on the rig floor but with complete control from the drillers console mounted in the DCS platform. The mud pump will be accompanied with two 100-gal tanks also positioned on the rig floor. The pump system selected will ideally have a minimal or linear pump curve (i.e., no pulsation) allowing the driller to identify core blockage or other downhole problems thus optimizing core recovery.

In addition to the vessel mounted DCS hardware, several other pieces of hardware and concepts have been developed or refined to be used with this system. Specifically these include the Mini Hard Rock Guide Base, modified re-entry cone, use of the 5- and 5-1/2-in. drill pipe as a mini riser, mechanical attachment tensioning tool, tapered stress joint, mechanical attachment receptacle and multiple back-off devices. All of this equipment is necessary to deploy the DCS in up to 4500 m of water and conduct coring operations.

The DCS string requires outer stabilization in order to be deployed in deep water. To accomplish this task, the outer string must be held in tension, resulting in an over-pull on the HRB. To incorporate this concept into the seafloor hardware, a mechanical latching device (Fig. A3) was built that can be attached to the HRB and tensioned up after the guide base is situated on the seafloor. This male tensioning device requires a mating receptacle.

This concept of using a riser to support drilling operations is not new, but the small size and length that ODP will require makes this operation unique. An added complexity is the requirement that this equipment work not only with the new mini HRB (Fig. A4) but also with the existing ODP reentry cone (Fig. A5). Typical over-pull tension on either seafloor system will be ~40,000 lb.

An integral part of this seafloor latching system (SLS) is the flex joint. This specially designed 30-ft tapered drill collar situated on top the mechanical latching device reduces and/or removes any lateral motion that may be introduced by vessel offset during drilling operations. The whole mini riser concept required a thorough dynamic riser analysis before any of the equipment could be designed. This analysis proved critical for not only the design of the stress joint but also for the feasibility of performing deep-water DCS coring operations.

To deploy the Mini HRB, a mechanical back-off device that could be used to release the drill string also had to be developed. This device will allow ODP the flexibility to drill through hard fractured rock formations where hole instability problems prevented conventional casing strings from being set. The drill string itself serves as casing, isolating unstable formations in the upper portion of the hole and allowing the DCS to be deployed. This hole will be spudded through the HRB on bare rock with a mud motor placed above the bottom hole assembly. Once the BHA is drilled to a predetermined depth, the back-off sub beneath the mud motor will be activated, releasing the lower portion of the string (50-100 m). It is essential that a test hole be drilled prior to setting the HRB to ensure that some minimum attainable depth (back-off sub spacing) can be reached.

Specifications of DCS Components

I. Tubing String

Tubing OD	3.500 in.	Connection OD	3.868
Wall thickness	0.254 in.	Yield strength	130 KSI
Tubing ID	2.992 in.	Weight /ft	9.30 lb/ft.
Pin bore	2.942 in.	Connections: Hydril series 500 type 501	

II. Core Barrel

Type: Longyear modified HQ-3

Hole size	3.960 in.	Liner OD	2.343 in.
Core size	2.200 in.	Liner ID	2.243 in.
Outer Tube, OD	3.625 in.	Barrel length	5 & 10 ft.
Outer Tube, ID	3.063 in.	Landing shoulder width	0.100 in.
Inner Tube OD	2.625 in.	Landing shoulder impact area	0.871 in.
Inner Tube ID	2.375 in.		

III. Mini Hard Rock Guide Base

Length	120 in.
Width	120 in.
Height w/legs not dropped	67 in.
Height w/legs dropped	97 in.
Total height w/reentry cone attached	16.5 ft.
Diameter of reentry cone	10.8 ft.
Weight (in air) w/o ballast	26,000 lb.
Weight (in seawater) w/o ballast	21,000 lb.
Weight (in air) w/full cement ballast	79,000 lb.
Weight (in seawater) w/full cement ballast	45,000 lb.
Volume of tanks	448.4 ft^3
Volume of steel	53.25 ft^3

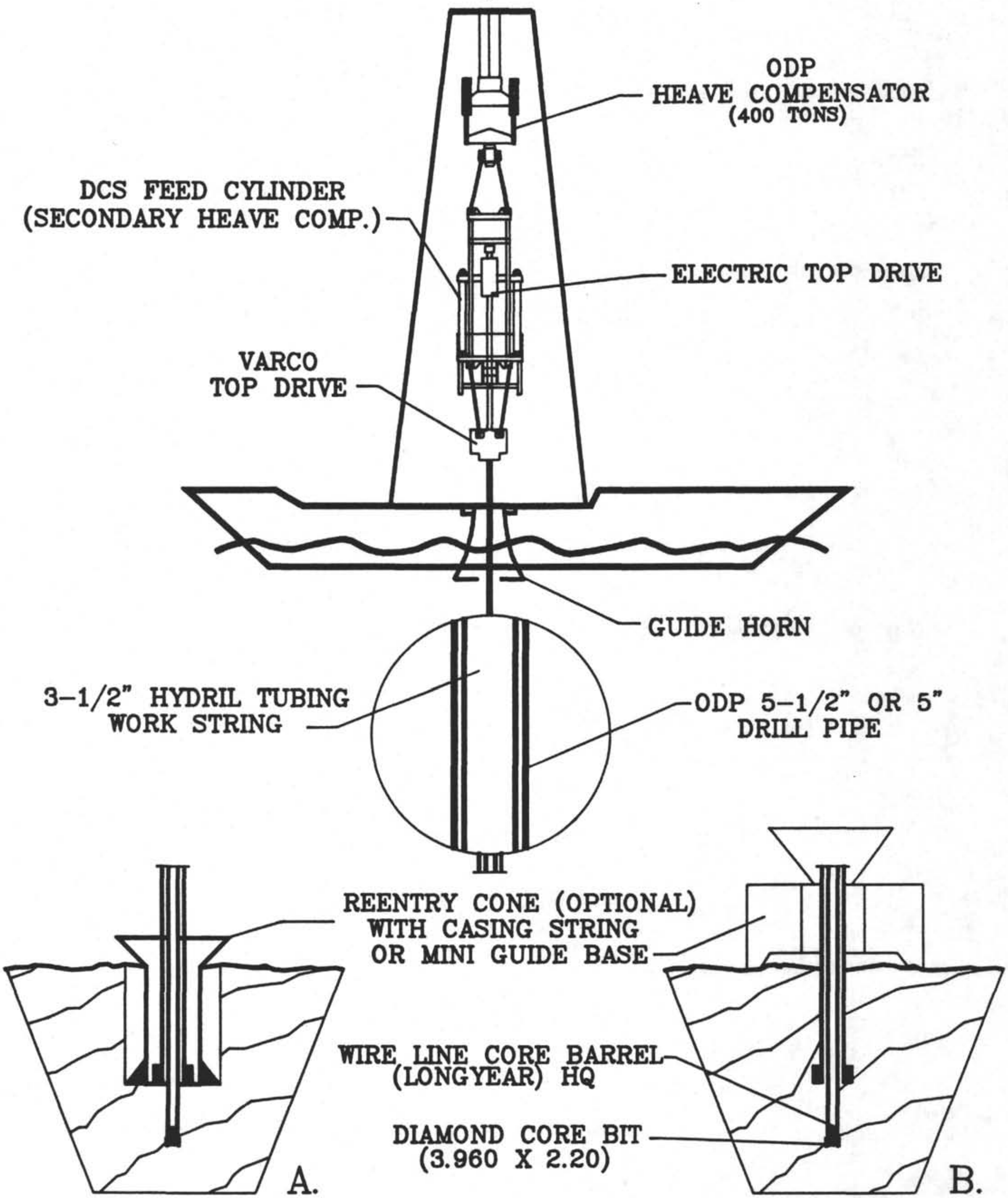
Weight of HRB with Concrete Ballast Supplemented with Steel Punchings

20% Vol. ballasted w/steel (in air)	112,144 lb.
30% Vol. ballasted w/steel (in air)	128,766 lb.
40% Vol. ballasted w/steel (in air)	145,386 lb.
50% Vol. ballasted w/steel (in air)	162,007 lb.
20% ballasted w/steel (in seawater)	81,780 lb.
30% ballasted w/steel (in seawater)	97,961 lb.
40% ballasted w/steel (in seawater)	114,130 lb.
50% ballasted w/steel (in seawater)	130,303 lb.

IV. Secondary Heave Compensator
Type: WESTECH Gear Corporation
Total working stroke... ± 12 in.
Total travel.. 16 ft.
Piston rods.. 5.25 in. OD
Maxing operating pressure.. 3000 psi
Maximum tripping pressure... 3500 psi
Load cell.. Metrox compression type
Dynamic test cylinder rods.. 3 in. OD
Test cylinder rod extension.. 48 in.
Power pack....................................... 200 HP, 1800 12 RPM, 60 HZ, 460 VOLT
Accumulator bank... 40 gal.
Oil reservoir.. 150 gal.

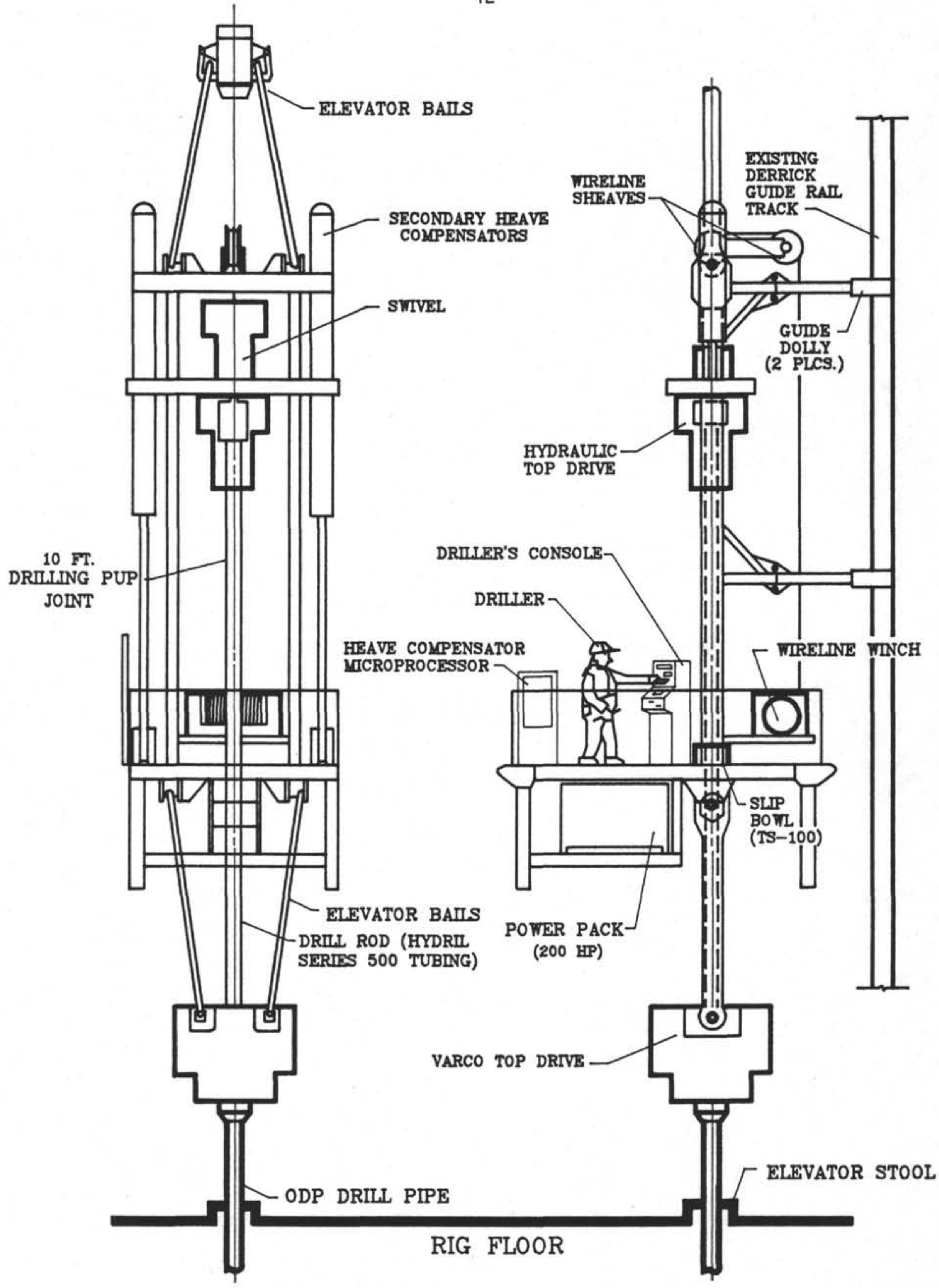
V. Electric Top Drive/Swivel
Type: PARTECH
Power rating.. 800 HP
Drilling coring torque.. 8300 ft. lb.
Maximum make and break torque... 11,000 ft. lb.
Air break... 12,000 ft. lb.
Maximum drilling speed... 540 RPM
Dead load rating of swivel.. 650 Tons
API bearing rating.. 425 Tons
Max operating pressure.. 5000 psi
Minimum fluid passage dia.. 4.125 in.

VI. Wire Line Winch
Drum size.......................................11 in. dia. X 49.91 in. length X 33.0 flange OD
Drum capacity..18,000 ft of 3/8 in. (7X19 cable)
Continuous line pull (bare drum).. 10,090 lbs at 5.5 rad
Continuous line pull (full drum).. 3,580 lbs at 15.5 rad
Intermittent line pull (bare drum).. 11,772 lb
Intermittent line pull (partial drum)...................................... 8,587 lbs at 15,000 ft
Intermittent line pull (full drum).. 4,177 lbs at 18,000 ft
Line speed (bare drum)... 600 ft/min
Motor RPM (bare drum).. 208 RPM
Motor RPM (full drum).. 74 RPM



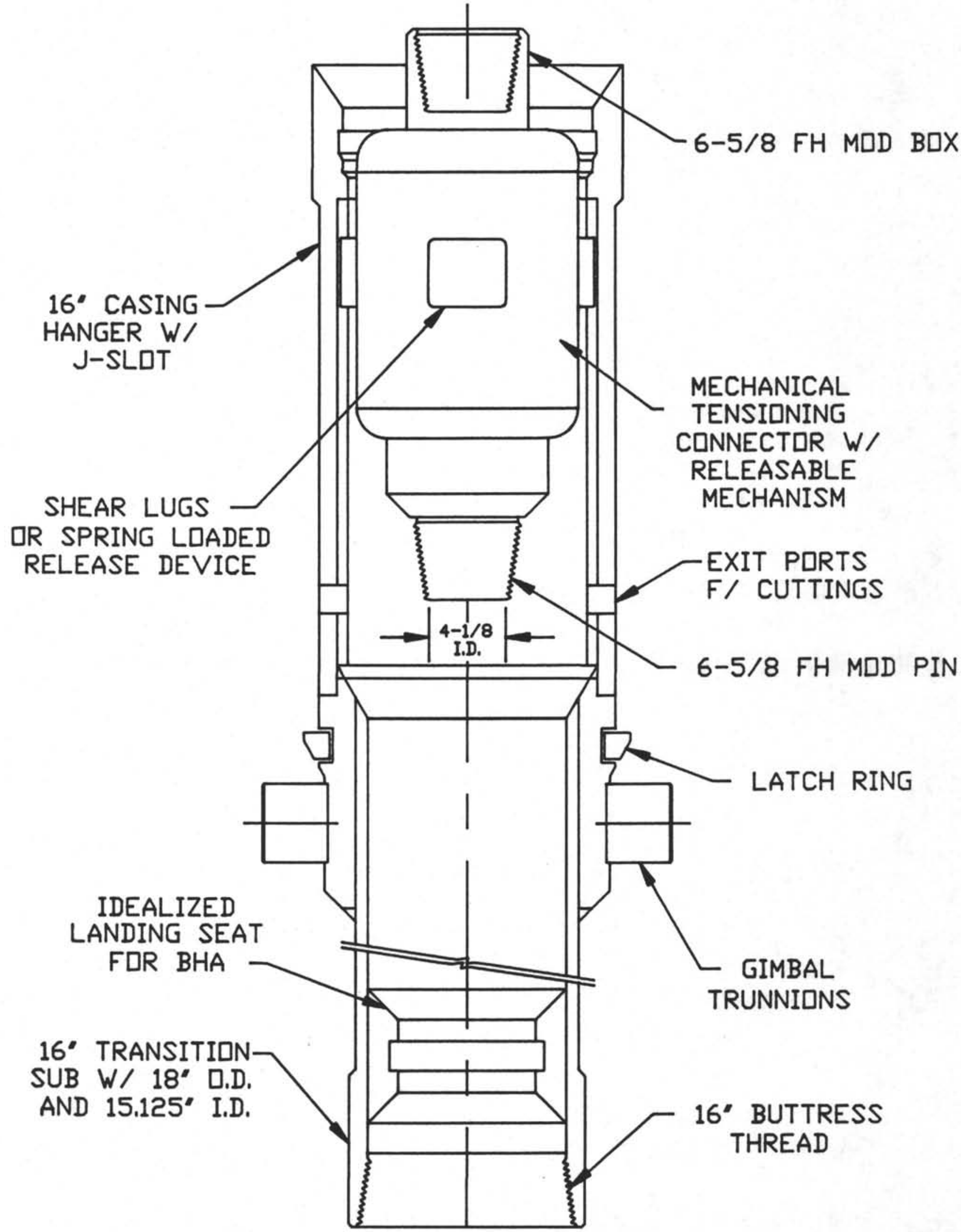
DIAMOND CORING SYSTEM
PHASE II – 4500 METER

Figure A1



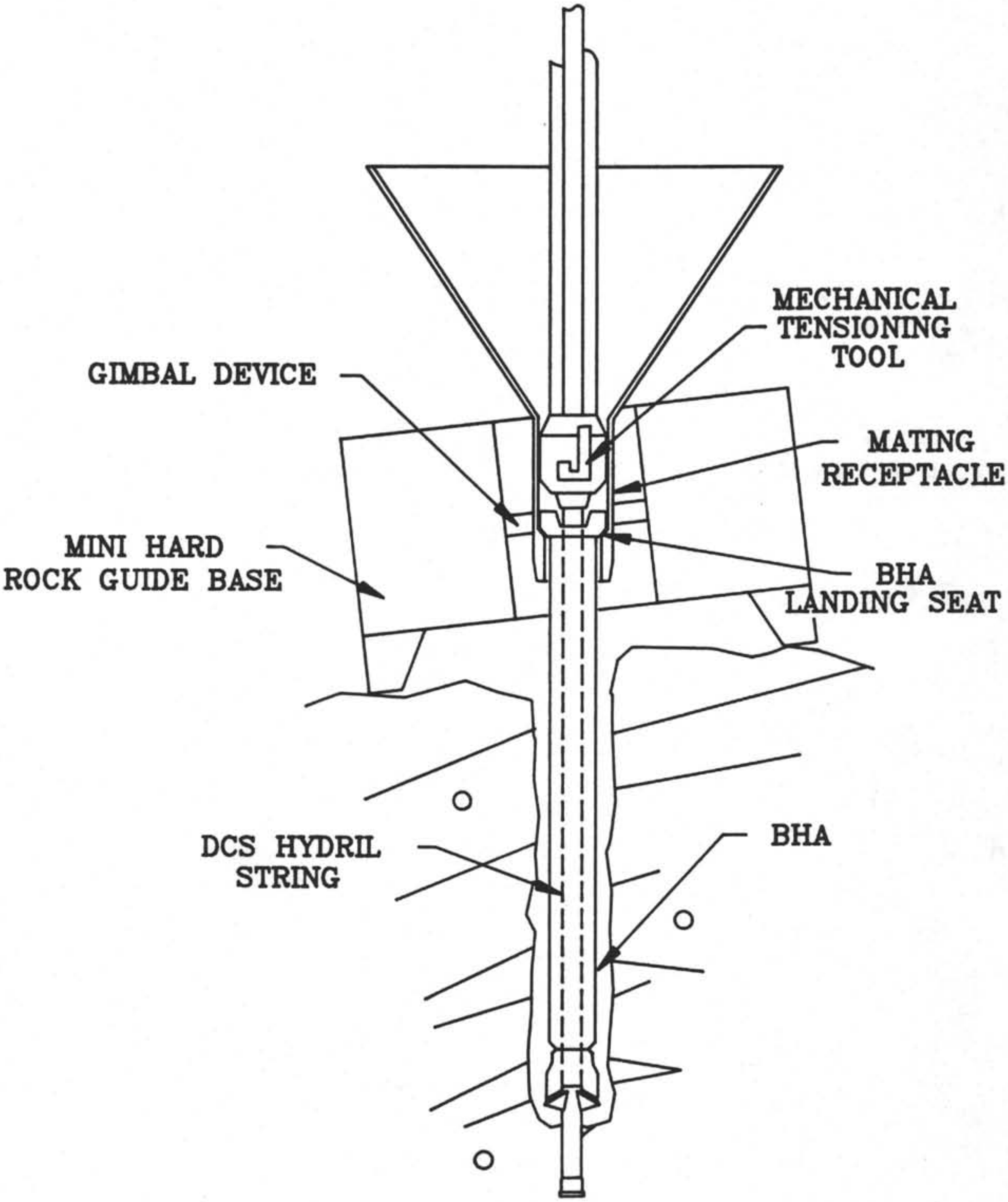
DIAMOND CORING SYSTEM
PLATFORM CONFIGURATION
PHASE II - 4500 METER DEPTH CAPACITY

Figure A2



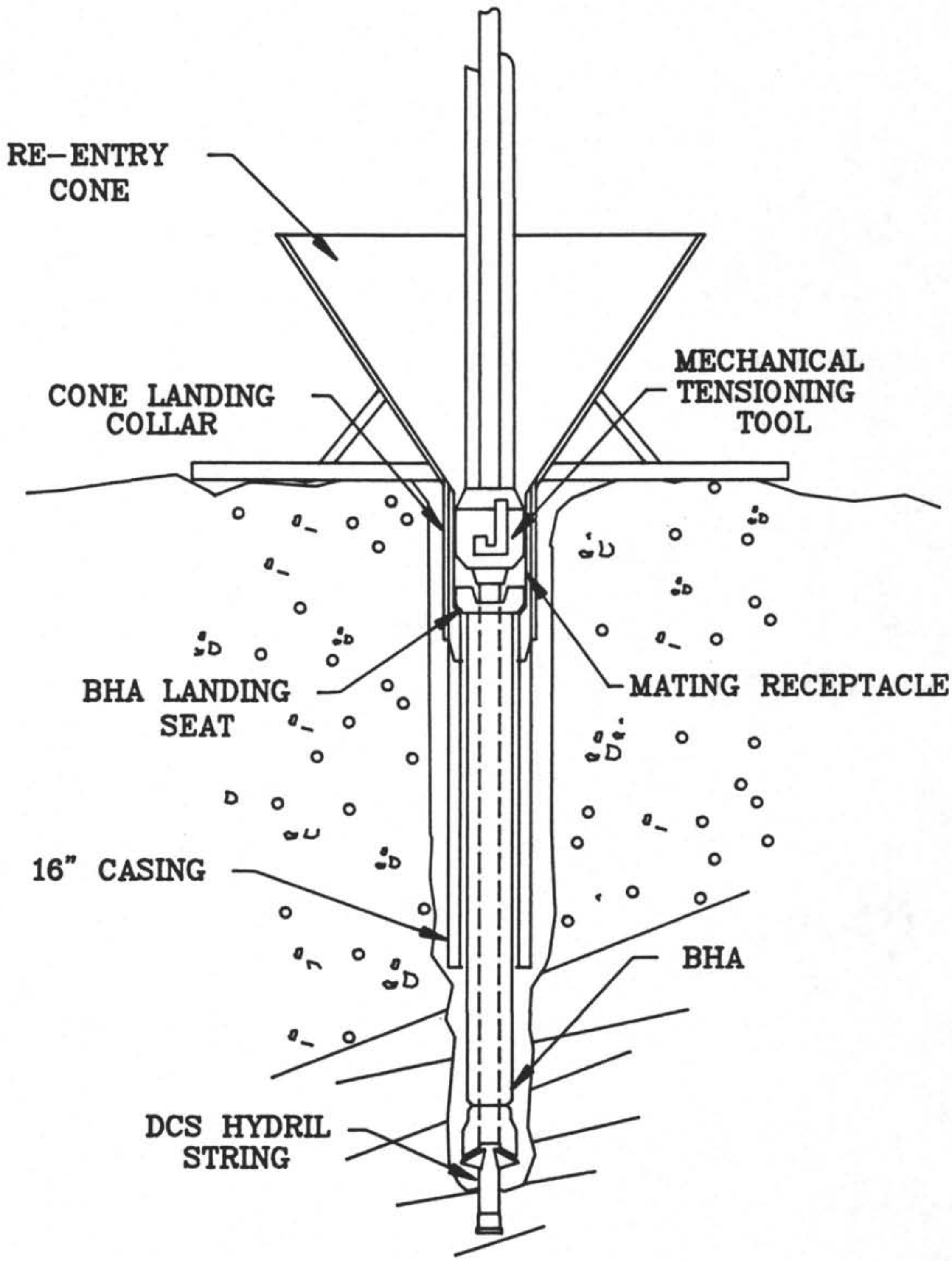
MECHANICAL TENSIONING CONNECTOR
WITH RECEPTACLE

Figure A3



WEIGHTED MINI GUIDE BASE FOR BARE ROCK OPERATIONS
USING BACKED OFF BHA FOR UPPER HOLE STABILIZATION

Figure A4



RE-ENTRY CONE WITH CASING
FOR SEDIMENT OVERLYING HARD ROCK
USING BACKED OFF BHA FOR UPPER HOLE STABILIZATION

Figure A5

SHIPBOARD PARTICIPANTS

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