1. INTRODUCTION AND EXPLANATORY NOTES

The Shipboard Scientific Party[1]

INTRODUCTION

The *Glomar Challenger* sailed on Leg 46 from San Juan, Puerto Rico, on Wednesday morning, 28 January 1976. Legs 45 and 46 were to be the first cruise of IPOD (International Program of Ocean Drilling) to drill a very deep multiple re-entry hole near the Mid-Atlantic Ridge axis. This hole was to be the first of a longitudinal Atlantic transect planned by the JOIDES Ocean Crust Panel.

Table 1 shows drill holes that have penetrated more than 20 meters into the basement since the initiation of the drilling project. Legs 34 and 37 were pre-IPOD cruises designed to test the feasibility of drilling into the oceanic basaltic layer. Leg 34 was not able to drill a deep hole, and shipboard scientists then felt that breccia was common in young ocean crust and that basalt drilling would be difficult in such areas. Leg 37 was relatively successful with five holes penetrating more than 100 meters of basalt.

The IPOD holes were expected to be more successful than previous ones for several reasons. The re-entry cone had been redesigned for increased strength, a heave compensator which had been malfunctioning for several years was thought to be improved, and the sonar re-entry tool was redesigned.

In addition, all deep holes on Leg 46 were to be completely logged (services donated by Schlumberger), heat flow was to be measured downhole, and integrated velocity to be determined by a downhole hydrophone and surface airgun. The *Challenger* on this leg was to have a major program with the R/V *Knorr* of the Woods Hole Oceanographic Institution. For an oblique seismic experiment the *Knorr* was to fire explosive charges which were to be recorded on special downhole wall-lock geophones. The *Knorr* was also to take bottom photographs of the re-entry cones to study their possible damage and the post drilling sediment distribution around them. All of the non-drilling programs were completed, except those related to the *Knorr*. The cruise was terminated before the *Knorr* arrived because of a structural failure on the derrick.

TABLE 1
Glomar Challenger **Holes Penetrating More Than 20 Meters of Basalt**

Leg	Hole	Penetration (m)	Estimated Age (m.y.)
24	235	29	60
24	236	22	60
24	238	80	30
26	254	46	15
26	257	64	110
27	259	38	110
27	261	48	140
30	286	57	45
31	292	76	40
33	317	34	120
34	319	59	15
37	332A	230	3.5
37	332B	589	3.5
37	333A	300	3.5
37	334	100	10
37	335	100	20
38	336	31	60
45	395	90	7
45	395A	580	7
45	396	96	10
46	396B	256	10

After extensive site surveys at Sites 5 and 6 to the west and east of the Mid-Atlantic Ridge, the Ocean Crust Panel recommended that Legs 45/46 give primary emphasis to drilling at Site 6 because of simpler structures there. Leg 45 had intended to drill a one-bit hole at Site 5, then proceed to Site 6 for the deep hole attempt. After drilling the one-bit hole, Leg 45 scientists decided to make the deep hole attempt there and proceeded to drill Hole 395A to a depth of 580 meters sub-basement. The hole was terminated at that depth because of bad drilling conditions. In attempting to do a post-drilling hydrophone velocity log, a steel tool was inadvertently dropped in the hole, further complicating the planned continuation of drilling there. Enroute to its main drill location at Site 6, the *Challenger* dropped a fresh beacon at Hole 395A in case she should be able to return to that hole for downhole logging.

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Geophysical Setting

According to the theories of sea floor spreading and plate tectonics, the North American and African continents separated about 180 m.y. ago. The South American continent separated from Africa more recently, about 100 m.y. ago. It is generally believed that the Caribbean Island Arc was formed as a splinter between North and South American plates probably about the time of the North American initial rift.

There have not been extensive marine geophysical surveys to the east of the Caribbean Arc near the Mid-Atlantic Ridge so the configuration of the "Caribbean splinter" is not known near the Ridge axis. The area of Sites 5 and 6 at about 23°N lie just to the north of where such a splinter might be (Figure 1). The ridge crest area had been initially studied by van Andel and Bowin (1968), and shown to be reasonably typical section of the Mid-Atlantic Ridge. Pre-drilling surveys of Site 5 were made by Hussong (unpublished report) in March and April 1975, of Site 6 by Purdy (unpublished report) in September and October 1975, and of Site 6 by the Akademik *Kurchatov* earlier in the year.

From the Purdy survey of Site 6, two sediment ponds suitable from drilling were located (Figure 2). These had a minimum of 100 meters of sediments required for spudding in and were centrally located in a magnetized block as determined from analysis of magnetic anomalies. Site 6 also showed a linearity of topography and magnetic anomalies. The larger sediment pond at 23°59′N was the one recommended for drilling and a one-bit hole was drilled there on Leg 45 (Figure 3).

Structure of Sediment Pond

The Site 6 sediment pond at about 23°N is about 5 miles long, with its axis oriented essentially north-south following the trend of the topography. The *Atlantis II* made six crossings of this pond during the Purdy survey when sediment thicknesses were determined. The *Challenger* made seven additional crossings of the northern portion of the pond in approaching its drill sites and leaving them (Figure 4).

All of the sediment thickness profiles were made with a towed airgun source and towed hydrophone array; accordingly, the horizontal spatial resolution of features is poor. It is clear, however, that the pond has an irregular edge and several deep sediment depths of approximately 250 meters. All of the pond lies within the magnetized block associated with magnetic anomaly number 5, although the paleontological age (mid-Miocene) is older than anomaly 5.

A preliminary analysis of sonobuoy refraction data from the pre-drilling survey showed the following basement thicknesses and velocities with the uppermost listed first.

Layer Thickness	Layer Velocity
0.4 km	3.5 km/sec
1.5 km	4.7 km/sec
4.0 km	6.9 km/sec
moho	8.0 km/sec

While these values will doubtlessly be revised with further study, it seemed likely that the uppermost layer probably could be penetrated by drilling.

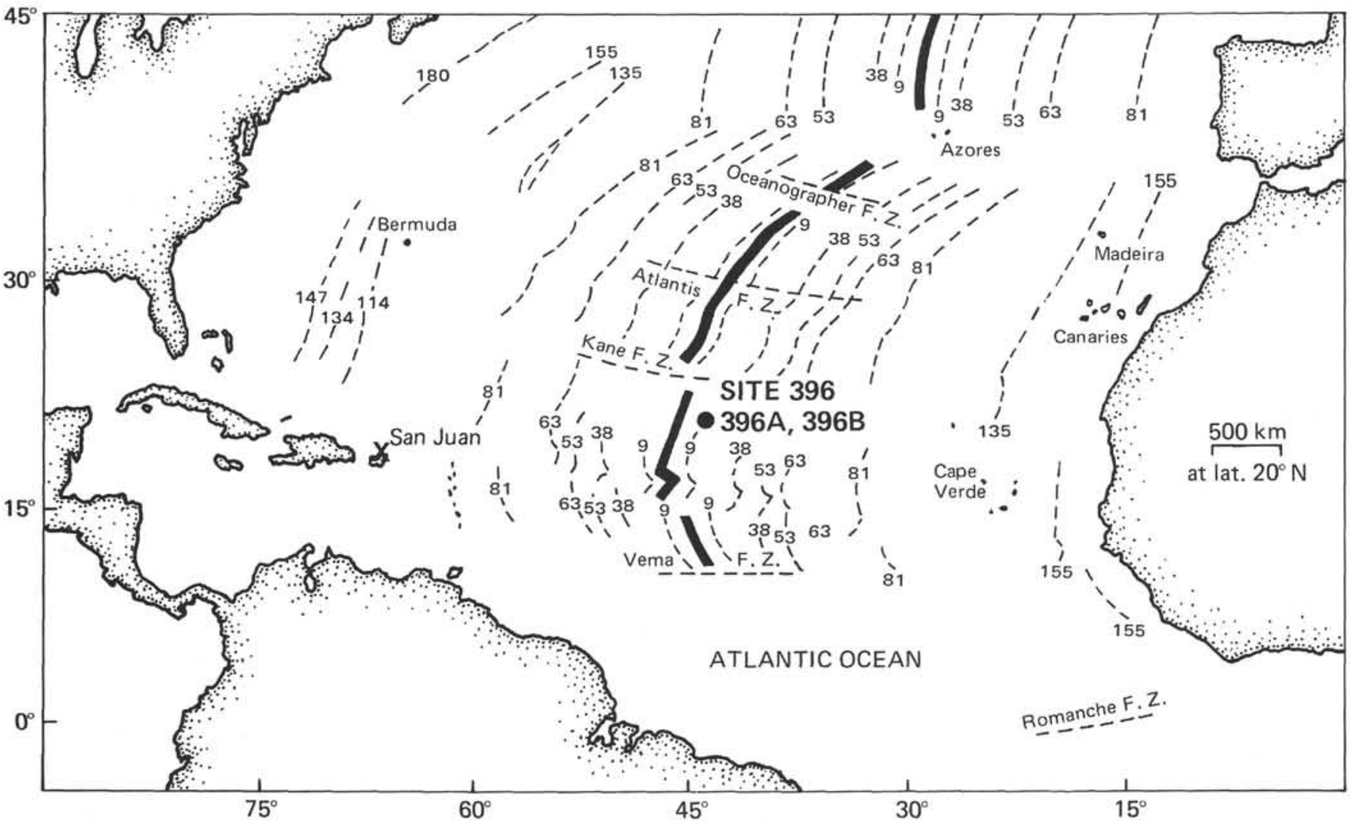

Figure 1. *Leg 46 Site Map.*

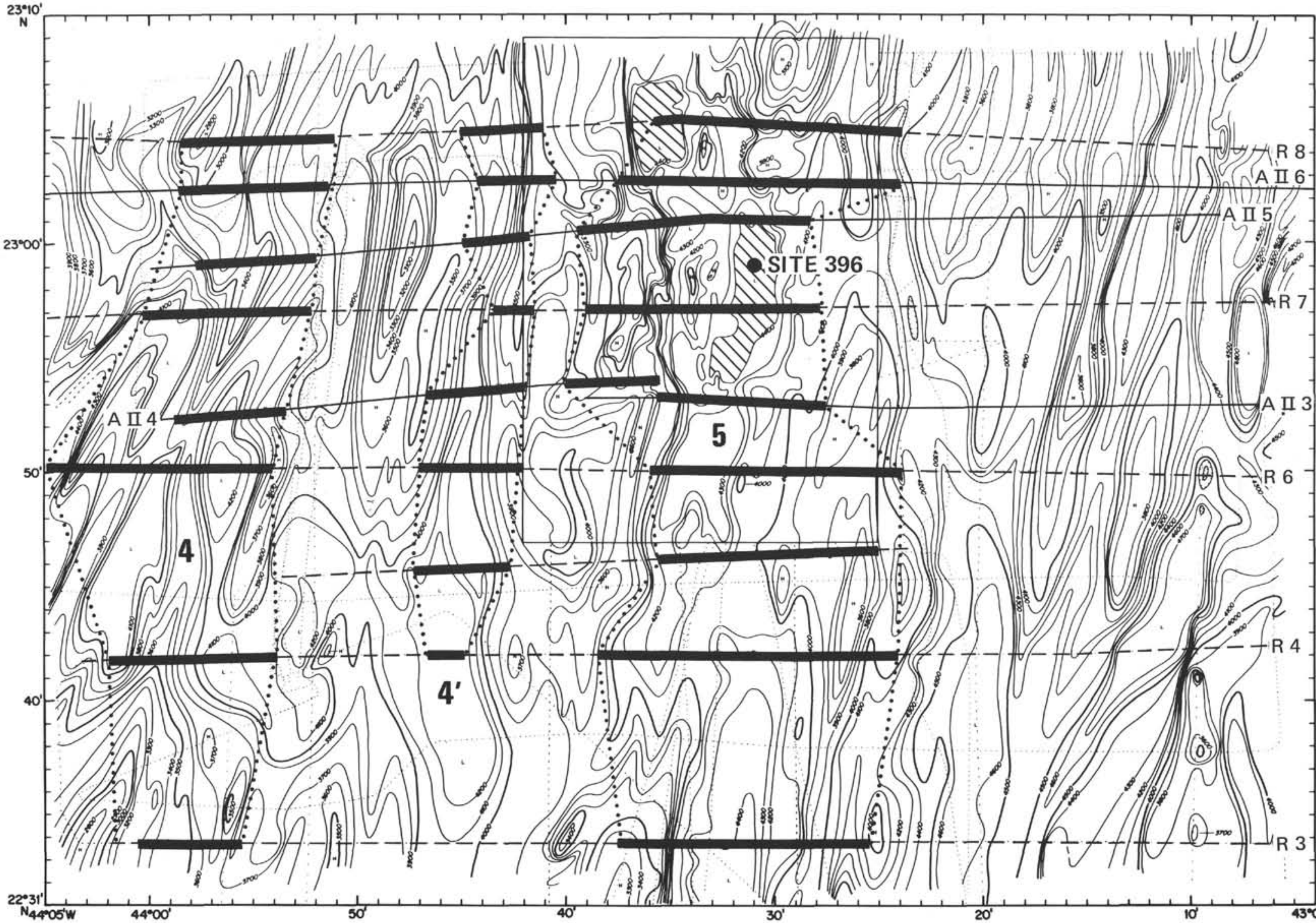

Figure 2. *Local topography and magnetic source bodies beneath tracks (H. Schouten, personal comm.), Site 396 .*

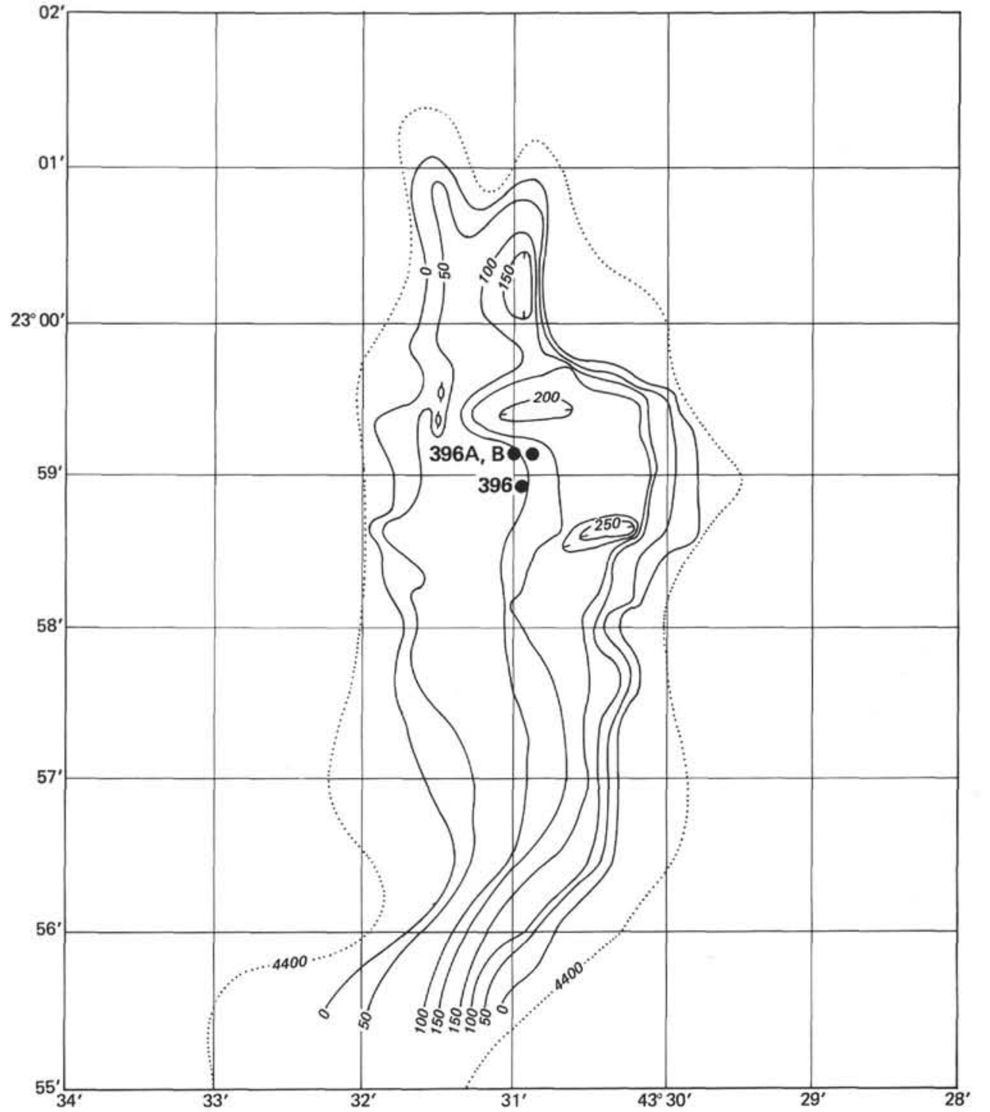

Figure 3. *Isopach map showing location of Holes 396 (Leg 45), 396A, and 396B. Dotted line is 4400-meter depth contour.*

Shipboard Procedures

Inasmuch as Leg 46 was one of the first IPOD hard rock cruises, it may be of some interest to note briefly the shipboard procedures that were found most convenient to use.

Petrologists were organized into three core lab watches of eight hours each. Two or three petrologists were assigned to each watch, with one designated as a watch leader. Watch leaders were rotated on a daily basis and the watch times rotated on an approximately weekly basis or sometimes when bits were changed. One other scientist was assigned to Physical Properties, one to Heat Flow, one to Logging, one to Magnetics, and one to Chemistry. These scientists were not part of the core lab watch but were available at all hours if required.

It was the function of the core lab watch to meet the core when it came on deck, identify bottom of pieces, reconstruct broken pieces, place styrofoam spacer for missing segments, split the core into archive and working halves, and oversee labeling and marking each piece. We tried to get one 4-inch-long split piece per section to keep in sea water. We placed it in clean fresh sea surface water (or sometimes deionized water) within an hour after arrival on deck.

The watch leader chose minicores that would be used for both magnetics and chemistry analyses and for physical properties. The procedures are shown in Figure 5. The minicores were 1.0 inch in diameter and had their axis at right angle to the core axis (vertical). Since magnetics determinations could be made twice as fast as XRF measurements, the magnetics were done first and approximately every second minicore was powdered for XRF measurement. The magnetic sections that were not powdered were returned to the working half of the core. Additionally, the core lab watch would identify samples for thin-sectioning and detailed photography, and would complete the visual core descriptions. Physical property measurements included sonic velocity (using the Hamilton Frame) and measurements of wet bulk density and porosity.

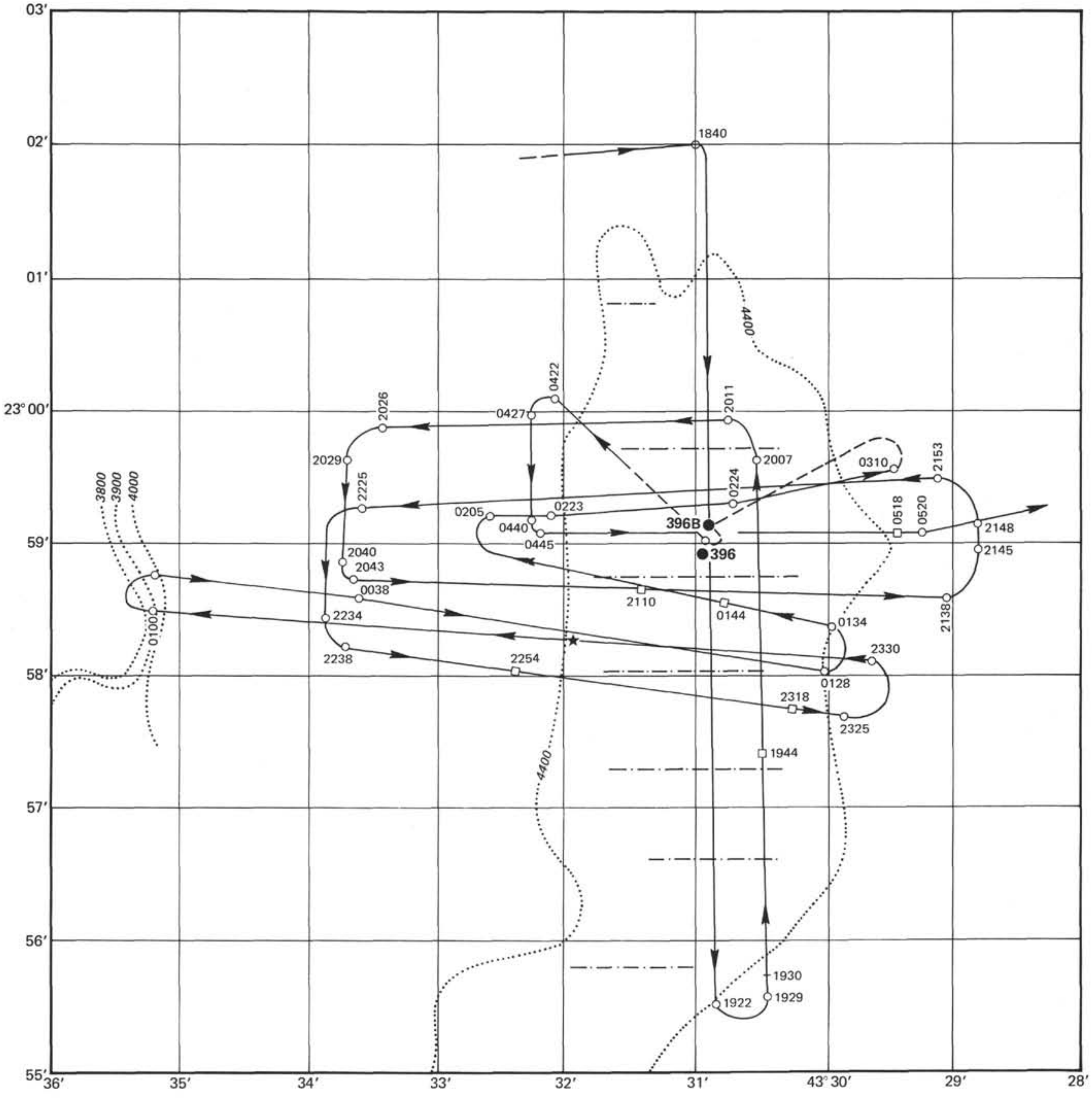

Figure 4. Glomar Challenger *tracks of the Site 396 sediment pond.*

Leg 46 drilled two holes (396A and 396B) in a sediment pond about 150 km east of the Mid-Atlantic Ridge at 22°59.14'N, 43°30.90'W. Leg 45 had previously drilled Hole 396 to about 100 meters into basement in the sediment pond. Hole 396A was a mudline test with only 0.64 meters recovered from the two cores taken at the top of the sediment column. Hole 396B was a multiple re-entry hole which penetrated 150.5 meters of sediment and 205 meters into basaltic basement.

The top 122 meters of sediment were washed to set the casing for the re-entry cone, and there were no cores taken in this interval. Cores 1, 2, and 3 recovered marly-nannofossil ooze and foraminiferal nannofossil ooze. Core 4 had 7 cm of unmetamorphosed marly-nannofossil ooze just above basement, which gives a date of middle Miocene (Bukry, 1978).

EXPLANATORY NOTES

Obtaining DSDP Samples

Persons wishing to obtain samples are directed to the DSDP-NSF sample distribution policy. Sample requests must be submitted on standard DSDP request forms which may be obtained from:

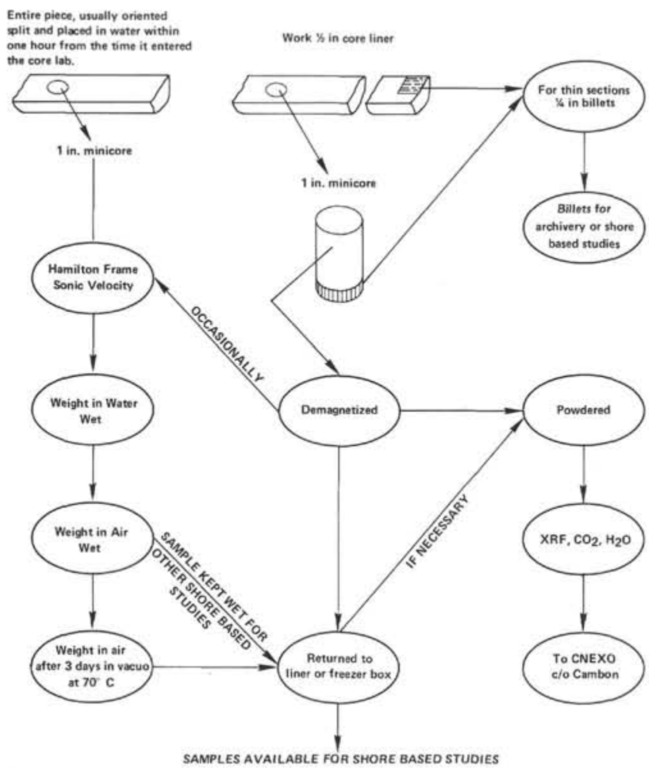

Figure 5. *Flow diagram for sample processing on Leg 46.*

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The following material is intended as an aid in understanding:

1) Terminology, labeling, and numbering conventions used by the Deep Sea Drilling Project.

2) Sedimentary, igneous, and metamorphic classifications used on Leg 46.

3) Presentation of the lithologic and paleontologic data on the core forms which make up much of this publication.

Numbering of Sites, Holes, Cores, Samples

Drill site numbers run consecutively from the first site drilled by *Glomar Challenger* in 1968; each site number is unique. Sites are drilled in site survey areas, designated by a mnemonic letter code and a number. On Leg 46, Atlantic Transect Area AT-6 was drilled. The first (or only) hole drilled at a site takes the site number. Additional holes at the same site are further distinguished by a letter suffix. The first hole has only the site number; the second has the site number with suffix A; the third has the site number with suffix B; and so forth. It is important, for sampling purposes, to distinguish the holes drilled at a site, since recovered sediments or rocks usually do not come from equivalent positions in the stratigraphic column at different holes.

Cores are numbered sequentially from the top down. In the ideal case, each core consists of 9.3 meters of sediment or rock in a plastic liner 6.6 cm in diameter. In addition, a short (ideally, 20-cm) sample is obtained from the core catcher (a multifingered device at the bottom of the core barrel which prevents cored materials from sliding out during core-barrel recovery). During Leg 46, the core-catcher sample was split, described, and placed at the bottom of the material recovered in the core barrel, taking care to maintain its proper vertical orientation. This sample represents the lowest sample recovered in a particular cored interval.

The cored interval is the interval in meters below the sea floor measured from the point at which coring for a particular core was started, to the point at which it was terminated. This interval is generally about 9.5 meters (nominal length of a core barrel) but may be shorter or longer if conditions dictate.

When a core is brought aboard the *Glomar Challenger*, it is labeled and the plastic liner and core cut into 1.5-meter sections. A full, 9.5-meter core consists of seven sections, numbered 1 to 7 from the top down. Generally, something less than 9.5 meters is recovered. In this case, the sections are still numbered starting with 1 at the top, but the number of sections is the number of 1.5-meter intervals needed to accommodate the length of core recovered. If a core contains a length of material less than the length of the cored interval, the recovered material is measured from the top of the recovered material, with the top of Section 1 equal to the top of the cored interval. Figure 6 illustrates the possible core configurations and the section labeling procedure. For

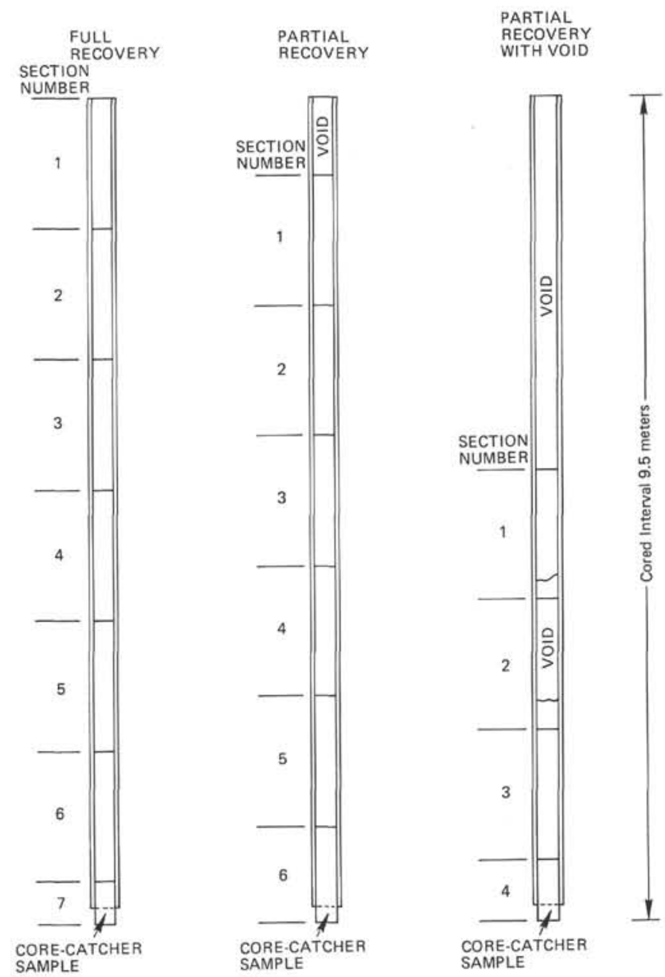

Figure 6. *Labeling of sections for various kinds of recovery.*

basalts, the voids in the core are closed and styrofoam spacers put between pieces which cannot be fit together (see section on "Basement Description").

In the core laboratory on the *Glomar Challenger*, after routine processing, the 1.5-meter sections of cored material and liner are split in half lengthwise. One half is designated the "archive" half, which is photographed; and the other is the "working" half, which is sampled by the shipboard scientists for further shipboard and shore-based analysis.

Samples taken from core sections are designated by the interval in centimeters from the top of the core section from which the sample was extracted; the sample size, in cm^3, is also given. Thus, a full sample designation would consist of the following information:

Leg (Optional)
Site
Hole
Core Number
Section Number
Interval in centimeters from top of section

Sample 396A-1-2, 122-124 cm ($10cm^3$) designates a $10cm^3$ sample taken from Section 2 of Core 1 from the second hole (A) drilled at Site 396. The depth below the sea floor for this sample would then be the depth to the top of the cored interval plus 3 meters for Sections 1 and 2, plus 122 cm (depth below the top of Section 3), or 3.2 meters. Note, however, that subsequent sample requests should refer to a specific interval with a core section (in cm) rather than depth in meters below the sea floor.

SEDIMENT DESCRIPTION CONVENTIONS

Core Disturbance

Sediment descriptions are given on sediment core description sheets. (Figure 7 is an example.) Conventions for descriptions are discussed below. The symbols used on Leg 46 are presented in Figure 8.

Unconsolidated sediments are often quite disturbed by the rotary drilling/coring technique, and there is a complete gradation of disturbance style with increasing sediment induration. An assessment of degree and style of drilling deformation is made on board ship for all cored material, and shown graphically on the core description sheets. The following symbols are used:

---- Slightly deformed; bedding contacts slightly bent.

— — — Moderately deformed; bedding contacts have undergone extreme bowing.

~~~ Severely deformed; bedding completely disturbed, often showing symmetrical diapir-like structures, or water-saturated intervals that have lost all aspects of original bedding and sediment cohesiveness.

Smear Slides

The lithologic classification of sediments is based on visual estimates of texture and composition in smear slides made onboard ship. These estimates are of areal abundances on the slide and may differ somewhat from the more accurate laboratory analyses of grain size, carbonate content, and mineralogy. Experience has shown that distinctive minor components can be accurately estimated (±1 or 2%), but than an accuracy of ±10% for major constituents is rarely attained. Carbonate content is especially difficult to estimate in smear slides, as is the amount of clay present. The location of smear slides made are given on the core description sheets.

Sediment Induration

The determination of induration is highly subjective, but field geologists have successfully made similar distinctions for many years. The criteria of Moberly and Heath (1971) are used for calcareous deposits; subjective estimate or behavior in core cutting is used for others.

a) Calcareous sediments

Soft: Oozes have little strength and are readily deformed under the finger or the broad blade of a spatula.

Firm: Chalks are partly indurated oozes; they are friable limestones that are readily deformed under the fingernail or the edge of a spatula blade.

Hard: Cemented rocks are termed limestones.

b) The following criteria are used for other sediments:

If the material is soft enough that the core can be split with a wire cutter, the sediment name only is used (e.g.,silty clay; sand).

If the core must be cut on the band saw or diamond saw, the suffix "stone" is used (e.g., silty claystone; sandstone).

Sediment Classification

The sediment classification scheme used on Leg 46 is basically that devised by the JOIDES Panel on Sedimentary Petrology and Physical Properties and adopted for use by the JOIDES Planning Committee in March 1974, with minor modifications. The classification is outlined below. Only those portions pertinent to Leg 46 are listed. A compilation of symbols is given in Figure 8.

I. General rules for class limits and order of components in a sediment name.
   A. Sediment assumes the names of those components present only in quantities greater than 15 per cent.
   B. Where more than one component is present, the component in greatest abundance is listed farthest to the right, and other components are listed progressively to the left in order of decreasing abundance.
   C. The class limits are based on percentage intervals given below for various sediment types.

II. Pelagic Biogenic Calcareous Sediments
   >30% $CaCO_3$
   <30% terrigenous components
   <30% siliceous microfossils

   Principal components are nannofossils and foraminifers; qualifiers are used as follows:

Foram %	Name
<10	nannofossil ooze (chalk, limestone)
10-25	foraminiferal-nannofossil ooze
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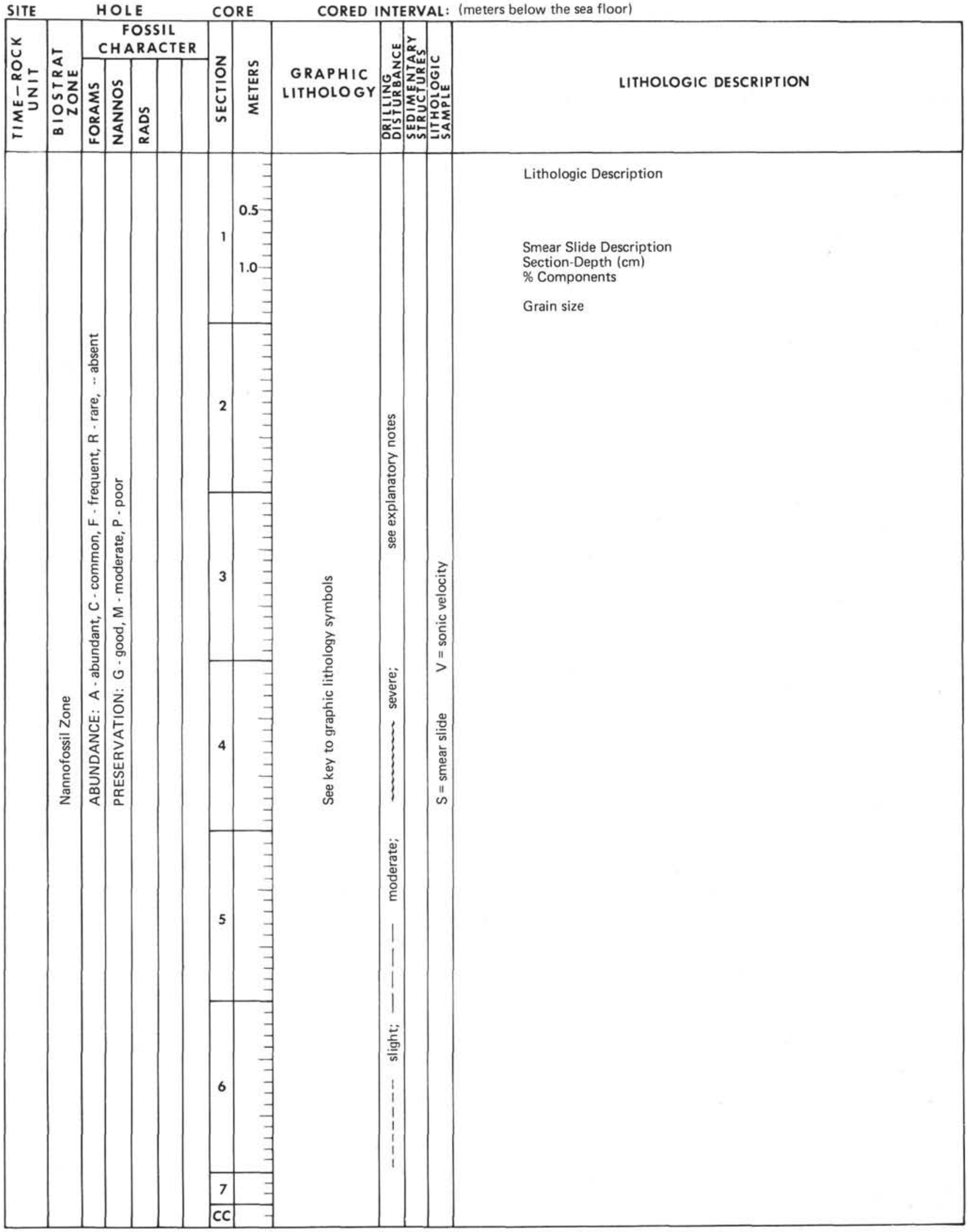

Figure 7. *Sample core form (sediment).*

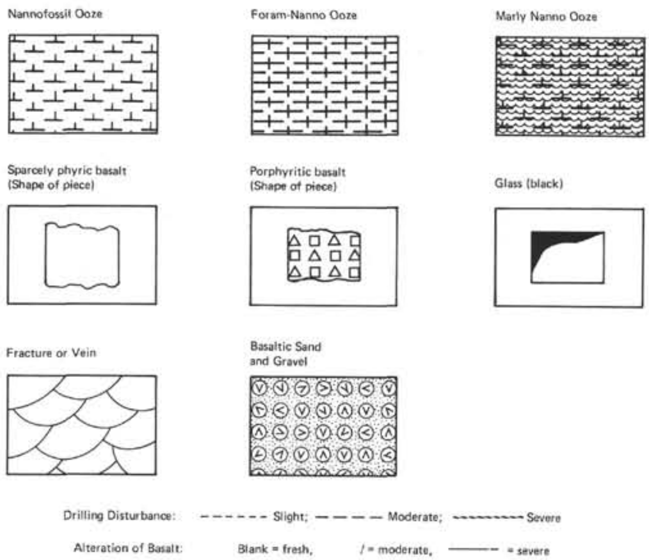

Figure 8. *Symbols used on core forms.*

25-50 nannofossil-foraminiferal ooze
>50 foraminiferal ooze

Calcareous sediment containing 10 to 30 per cent siliceous fossils carry the qualifier radiolarian, diatomaceous, or siliceous depending upon the identification.

III. Transitional Biogenic Calcareous Sediments
$>30\%$ $CaCO_3$
$>30\%$ terrigenous components or pelagic clay
$<30\%$ siliceous microfossils

If $CaCO_3$ = 30 to 60%: marly is used as a qualifier.
- soft: marly calcareous (or nannofossil, etc.) ooze
- firm: marly chalk (or marly nannofossil chalk, etc.)
- hard: marly limestone (or marly nannofossil limestone, etc.)

If $CaCO_3$ $>60\%$:
- soft: calcareous (or nannofossil, etc.) ooze
- firm: chalk (or nannofossil chalk, etc.)
- hard: limestone (or nannofossil limestone, etc.)

NOTE: Sediments containing 10 to 30 per cent $CaCO_3$ fall in other classes where they are denoted with the adjective "calcareous," "nannofossil," etc.

BASEMENT DESCRIPTION

Core Forms

Initial Core Description forms for igneous and metamorphic rocks are not the same as those used for sediments. The sediment barrel sheets are substantially those published in previous *Initial Reports*. Igneous rock representation on barrel sheets, however, is too compressed to provide adequate information about the rocks sampling. Consequently, Visual Core Descriptions forms, modified from those used onboard ship, are used here for more complete graphic representation. Each of these forms covers one 1.5-meter section. All shipboard chemical and physical property data, as well as summary hand-specimen and thin-section descriptions are presented for each section.

All basalts on Leg 46 were split by means of a rock saw into archive and working halves. The latter was described and sampled onboard ship. In a typical basalt description form (Figure 9), the left box is a visual representation of the working half using the symbols of Figure 8. Two closely spaced horizontal lines in this column indicate the location of styrofoam spacers taped between basalt pieces inside the liner. Each piece is numbered sequentially from the top of each section, beginning with the number 1. Pieces are labeled on the rounded, not the sawed surface. Pieces which could be fit together before splitting are given the same number, but individually are lettered consecutively as 1A, 1B, 1C, etc. Spacers were placed between pieces with different numbers, but not between those with different letters and the same number. In general, addition of spacers represents a drilling gap (no recovery). All pieces which are cylindrical and longer than the liner diameter have orientation arrows pointing up, both on the archive and working halves. Special procedures were adopted to ensure that orientation was preserved through every step of the sawing and labeling process. All orientable pieces are indicated by upward-pointing arrows to the right of the graphic representation on the description forms. Since the pieces were rotated during drilling, it is not possible to sample for declination studies.

Samples were taken for various measurements onboard ship. The type of measurement and appoximate location are indicated in the column headed "Shipboard Studies" using the following notation:

C = X-ray fluorescene and CHN chemical analysis
M = magnetics measurement
V = sonic velocity measurements
T = thin section
D = density measurements
P = porosity measurements.

The state of alteration (see Figure 8 for symbols) is shown in the column labeled "Alteration."

On Leg 46, some pieces were stored permanently in distilled water. These are labeled with a "W" in the "Special Storage" column.

Igneous and Metamorphic Rock Classification

All the igneous rocks recovered on Leg 46 are basalts. Their classification is based primarily on mineralogy of minerals visible in hand specimens, and secondarily on texture. Thin-section work in general added no new information to the hand-specimen classification.

Basalts were termed sparsely phyric or porphyritic, depending on the proportion of phenocrysts visible with binocular microscope (~12×). Sparsely phyric basalts are those with less than about 1 to 2 per cent phenocrysts. Porphyritic basalts contain more than 10 per cent phenocrysts. No basalts of intermediate phenocryst content were recovered.

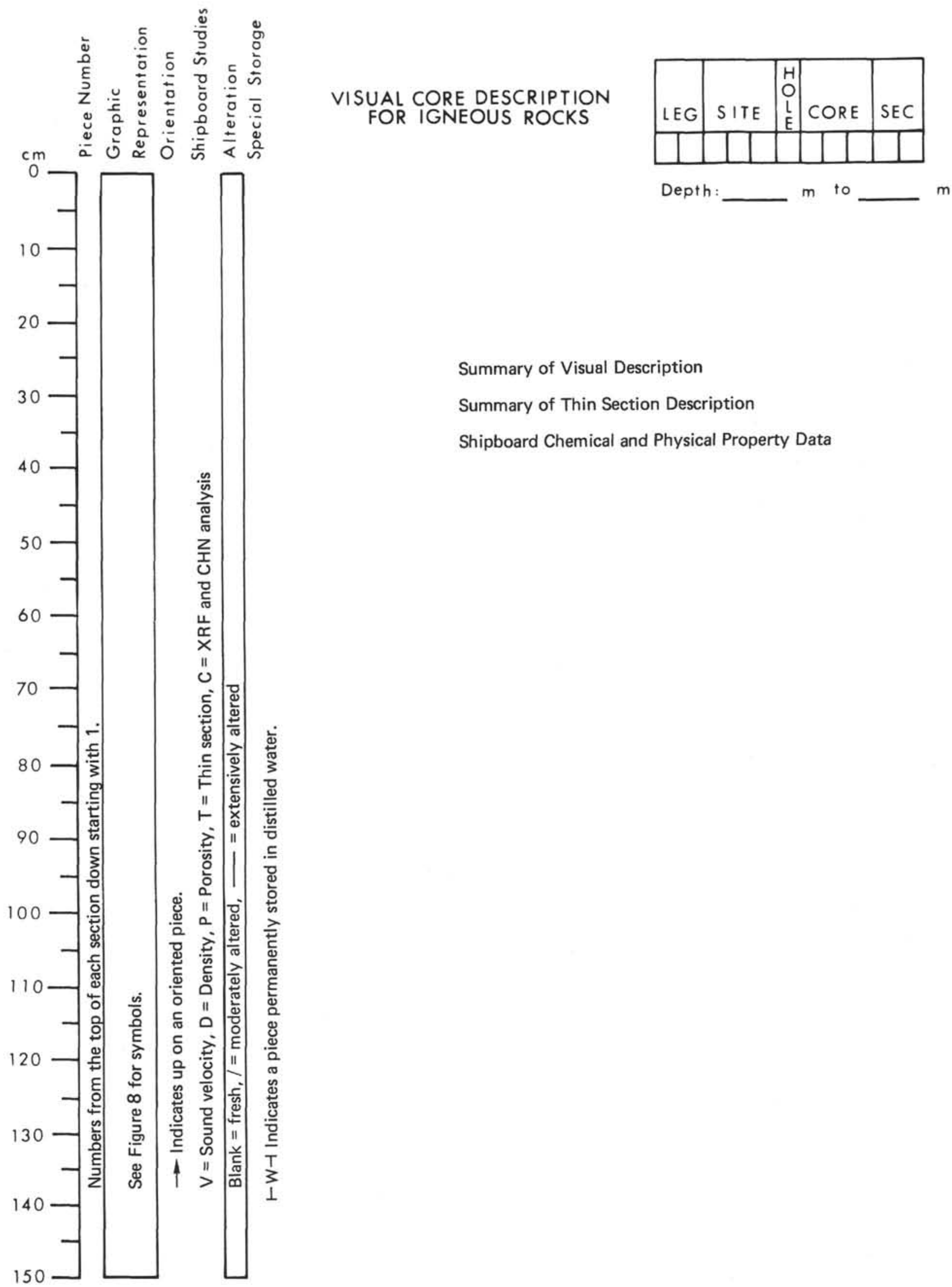

Figure 9. *Sample core form (basement).*

No petrochemical or normative classification schemes are used on the core forms.

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