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Use of Vibratory Coring Samplers for Sediment Surveys

by

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and

S. Jeffress Williams

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The vibratory coring apparatus was developed about 30 years ago by Soviet engineers to increase existing capabilities to penetrate and recover cohesionless soil samples. In 1963, the original Soviet design was used by personnel at Alpine Geophysical Associates, Inc., to fabricate a system to recover 20-foot-long (6 meters) cores for use in CERC's sand inventory program, later known as the Inner Continental Shelf Sediment and Structure (ICONS) program. The core apparatus has since been improved to recover up to 40-foot-long (12 meters)

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continuous cores in water depths to -60 feet (-18 meters), and is now widely used in oceanographic work. The CERC experience consists of more than 1,600 cores collected in 15 surveys along the Atlantic, gulf, and Pacific coasts, as well as Lakes Michigan and Erie. This experience in obtaining, handling, and sampling cores for sedimentological analysis is presented to aid others in conducting geologic and engineering studies using the vibracore.

PREFACE

This report provides information on the development and use of the pneumatic vibratory coring apparatus and on the analyses of cores used by the Coastal Engineering Research Center (CERC) during the past 18 years to assess offshore sand and gravel resources and to study the geologic character of U.S. coastal areas. The work was carried out under the coastal processes program of CERC.

This is the second of three reports which describe procedures for conducting offshore sand resources surveys to locate potential sources of sand for beach restoration and nourishment. The first report (Prins, 1980) discussed preliminary procedures for establishing a sand resources survey program. The third report will cover the use of seismic reflection data in sand resources surveys.

The report was prepared by Edward P. Meisburger and S. Jeffress Williams, Research Geologists, under the general supervision of Dr. C.H. Everts, Chief, Engineering Geology Branch, Engineering Development Division.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

USE OF VIBRATORY CORING SAMPLERS FOR SEDIMENT SURVEYS

by
Edward P. Meisburger and S. Jeffress Williams

I. INTRODUCTION

In the early studies of geological oceanography the use of a grab-type sediment sampler was the only method of retrieving physical samples from the surface of the seabed. Although this method is relatively inexpensive and still adequate for obtaining small quantities needed to map surface sediment distributions, the sampler yields highly disturbed samples and has limited penetration on cohesionless sediments.

The need to determine vertical changes in seabed sediments led to the use of coring devices to retrieve continuous and relatively undisturbed samples. In deep ocean areas where muddy sediments predominate, free-fall gravity corers proved quite effective. However, in nearshore and Continental Shelf environments where dense clay and sandy soils are often abundant, the use of terrestrial borehole equipment mounted on anchored floating platforms was (until the early 1960's) the only means of obtaining core data from these sediments. Because offshore borehole methods are extremely expensive and are usually dependent on mild sea conditions, coring equipment that can rest on the seabed and operate remotely from a survey platform was developed. An interesting study on the development of recent coring equipment is presented in Tirey (1972)[1].

II. SUBMERSIBLE VIBRATORY CORER

Soviet scientists and engineers in the early 1950's were apparently the first to demonstrate that vibratory or oscillatory hammer equipment greatly increased rates and depths of core-barrel penetration as well as core recovery. They experimented with vibracorers having core barrels of different dimensions, and with variable frequencies and amplitudes of the vibrating device. Based on this initial work, personnel at the U.S. Naval Ordnance Laboratory subsequently built a prototype vibracore which was successfully tested off the Florida coast. It was designed to collect cores of cohesionless material up to 4 feet (1.2 meters) long.

In 1964, as a result of the extensive beach erosion caused by the Great East Coast Storm of 1962 along the mid-Atlantic region, the Coastal Engineering Research Center's (CERC) predecessor, the Beach Erosion Board (BEB), initiated the Sand Inventory Program. The objective of the program was to conduct geologic surveys of inner shelf areas off eroding coasts to locate, describe, and quantify sand and gravel deposits suitable for extraction and placement on eroded beaches. To satisfy the need to obtain cores up to 13 feet (4 meters) long, personnel at Alpine Geophysical Associates, Inc., Norwood, New Jersey, developed and built the pneumatic Alpine Vibracore in 1963 based on the original Soviet design. The original BEB-CERC contract surveys used the high-resolution

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[1]TIREY, G.B., "Recent Trends in Underwater Soil Sampling Methods," *Underwater Soil Sampling, Testing, and Construction Control*, Special Technical Publication 501, American Society For Testing Materials, Philadelphia, Pa., 1972, pp. 42-54.

seismic reflection equipment and the vibracorer to successfully identify sand resources; the surveys have continued to the present time under an expanded program, the Inner Continental Shelf Sediment and Structure (ICONS) program. ICONS survey results from many areas along the U.S. seacoasts and Lakes Michigan and Erie are available in numerous CERC publications. Prins (1980)[2] provides a brief discussion on methods and requirements for conducting such surveys.

The original Alpine Vibracore has been modified to obtain 20-foot-long (6 meters) cores in sand; subsequently, 40-foot-long (12 meters) continuous cores have been obtained. This coring apparatus is now available from several private firms and research groups in the United States and other countries, and is the most efficient method for obtaining long cores in unconsolidated sediments. A 20-foot vibracorer is available from the U.S. Army Engineer District, Mobile, on a cost reimbursable basis, for use by the Corps.

1. Vibracore Components.

The primary components of the vibratory corer are shown in Figures 1 and 2 and are listed in the Table. The central mast consists of an aluminum H-beam (several feet longer than the core barrel used), which acts as a guide and support for the vibrator head and core barrel during the coring process. The H-beam is supported in a vertical position on the seabed by four legs. One of the legs is hinged so that the coring frame can be placed on its side on the deck of the platform for ease of loading the core barrel and removing the core liner after the coring operation. When the core apparatus is hoisted off the deck for deployment at a core site, the articulated leg locks into proper position for placement in the bottom. The actual sampler consists of a pneumatic impacting piston vibrator head fixed on top of a standard 4-inch steel pipe which is loaded with a clear plastic liner to contain the sediment sample. To aid in core penetration and recovery of the sediment after pullout, a steel cutterhead is threaded to the end, and a metal core catcher with thin curved "fingers" is attached to reduce loss of muddy sediments.

After the coring frame is resting on the bottom, the vibrator head and barrel are driven through a hole in the baseplate. When coring is complete the barrel is pulled back into the frame along the H-beam before lifting the frame to allow for straight pullouts which minimize the chance of bending the core barrels.

The pneumatic vibrator is powered by a compressor 250 cubic feet (7.08 cubic meters) per minute at 120 pounds per square inch onboard the coring platform; three intake and exhaust hoses provide the connection.

A complete description of the vibratory cores is provided by Tirey (1972)[3].

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[2]PRINS, D.A., "Data Collection Methods for Sand Inventory-Type Surveys," CETA 80-4, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1980.

[3]TIREY, G.B., op. cit., p. 7.

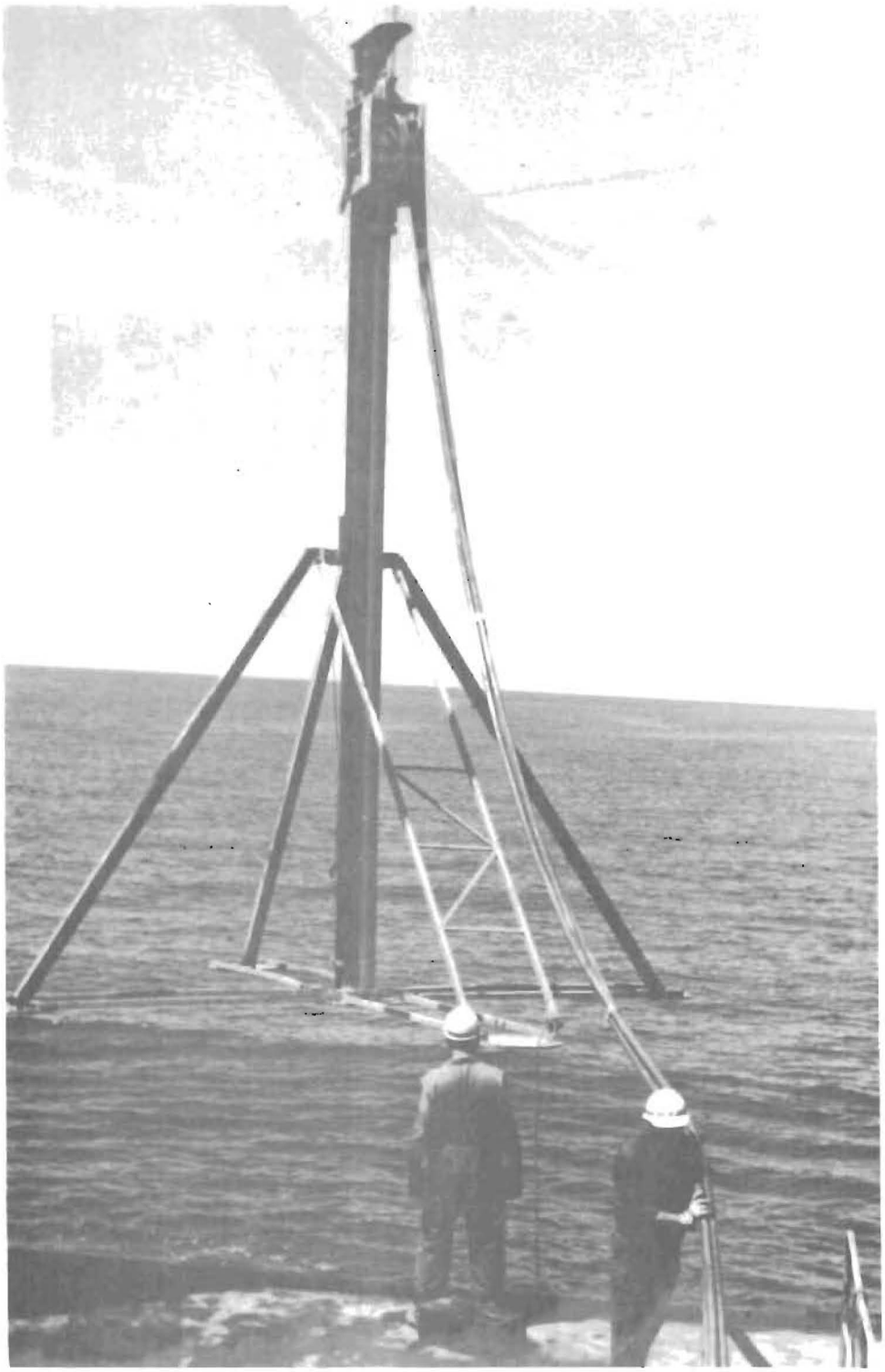

Figure 1. Vibratory core apparatus with a 20-foot-long barrel used in a geological survey off the Galveston, Texas, coast. The barrel is being lowered to the seabed from the platform.

Figure 2. Vibratory core rig with a 20-foot-long barrel used in a geological survey in Lake Erie. An articulated leg is used to allow the rig to be placed on the platform deck for insertion and removal of the core liner. Note recovered cores contained in the crib area in the foreground.

Table. Vibracore information summary.

Vibracore	Weight (lb)	Weight (kg)	Dimensions
Complete 40-ft system with spare parts for shipment	7,055	3,200	
Complete 40-ft coring apparatus	3,968	1,800	40-ft hgt, 20-ft wdth
Core-barrel pipe			o.d. 4.5 in
20 ft (lgth)	220	100	
40 ft (lgth)	441	200	
Core liner			o.d. 3.75 in, i.d. 3.5 in
20 ft (lgth)	24	11	
40 ft (lgth)	48	22	
Air compressor (requirement)			250 ft^3/min at 120 lb/in^2
Crane capacity (requirement)			10,000 kg (22,046 lb)
Crew size			(one skilled operator; two semiskilled helpers)

2. Coring Performance.

In the nearly 18 years that CERC has been using vibracorers for the ICONS program, more than 1,600 cores have been collected and analyzed. That experience has shown that penetration rates, depths, and sediment recovery can vary greatly depending on what coring equipment is used and, especially, on the physical nature of the sediment being cored. The easiest penetrations and best recoveries are made in soft, cohesive material such as lacustrine or estuarine sediments. Medium and coarse grain-sized sand and gravels also offer little resistance and recoveries are generally 75 to 100 percent; however, there is less success in coring firm and overconsolidated clays, glacial tills, and gravels with little or no sand. Some cores which have recovered shale bedrock and semiconsolidated Coastal Plain sediments are generally less than 0.6 to 0.7 foot (15 to 20 centimeters) in length and their hardness can blunt the edge on the cutterhead.

III. RECORDKEEPING AND CORE PROCESSING

1. Core Record.

The identity, location, water depth, and other pertinent information for each core should be maintained in a suitable, ruled looseleaf or bound record book aboard the coring vessel. A separate page is used for each core with the cores numbered in sequence from the start of the survey to the end. Entries for each core should include project name, core number, navigation fix location, date and time taken, water depth, vibration time, penetration depth, actual recovery, and a description of the sediment characteristics at the top and bottom of the core as well as any sediment that might be brought up on the core-rig legs. It is recommended that the logbook either be reproduced or a duplicate log maintained to avoid loss or damage to the original logbook because of the extreme importance of the logged information to future usability of the cores.

2. Core Handling and Marking.

After the coring apparatus is placed onboard the vessel, the core liner is removed and reference samples from top and bottom are bagged and labeled. Core recovery should then be measured and recorded. After the liner is cut into lengths for easier handling and the unfilled ends are removed, the ends are sealed with tightly fitting plastic caps and duct tape. The core is then carefully moved to a storage area to minimize postcoring disturbance.

To avoid errors in identifying cores, it is essential that the core liners be carefully labeled immediately after recovery. Each core label should contain an identifying serial number, with the bottom and top clearly marked, the date the core was taken, and the project area. If the core is sectioned into shorter lengths to facilitate handling and storage, each section should contain the above basic information plus section numbers or letters from the top to the bottom with arrows pointing to the top of each section. In addition to the essential information, the core liner should also have the core serial number and the top or bottom repeated on the end caps both as added security and to provide a means of identification when cores are stacked in core racks.

Several methods of marking cores have been used, including paint, grease pencil, engraving tools, soldering iron, and waterproof felt-tip markers. Paint and grease pencils do not generally provide permanent markings as they deteriorate during later handling and storage; engraving or soldering tools are satisfactory, but their use is time consuming and the marks are not always legible. However, these means are sometimes useful for supplementary markings which will remain if the primary marks are lost. The use of waterproof felt-tip markers is the fastest and most permanent way for primary marking of core liners. However, since all markers are not permanent or indelible, the selected marker should be tested for withstanding wetness and handling.

3. Core Sampling.

Sediment samples can be removed from a core either by drilling holes in the core container or by splitting the core lengthwise and removing samples from one of the halves. A power drill fitted with a 1.5- to 2-inch hole saw can be used to make holes in the liner. Samples can then be removed with a spoon and the hole closed by replacing the cutout disk and sealing with duct or plastic electrical tape. Since some core liners are opaque and clear plastic liners often become semiopaque due to abrasion and mud coatings, the spacing of the sample holes is generally arbitrary. To assure that samples are representative of the sequence of lithologies in the cores, spacing of about 1 foot (30 centimeters) is recommended.

Splitting the cores along the longitudinal axis is the preferred means of processing the core as it allows direct observation of the vertical sedimentary sequence in the core as well as detailed logging of lithologies, sedimentary structures, bedding, and other important features. Samples removed from a split-core half that is logged in detail generally need not be as numerous, and st the same time may be more representative than "blind samples" taken through access holes in the liner where no logging is done.

A satisfactory technique of splitting cores for all types of core liners is described by Meisburger, Williams, and Prins (1980)[4], and is summarized in Appendix A. In practice, it is desirable that half of the split core be used for sampling and the other half be preserved as an archive. The archive half should be sealed in plastic sleeving and stored on core racks for future study or sampling. Careful handling is necessary because much of the strength of the liner is lost after splitting and the container easily twists or breaks if not adequately supported.

4. Core Logging.

The core log consists of a visual description of each sedimentary unit recovered in the core. Cores are generally logged on a form containing a vertical column on which the various sedimentary intervals are plotted with a description of each unit entered opposite the pertinent interval (Fig. 3). If possible, each core should be split for logging. If this is not feasible, then representative cores should be selected on the basis of sample data and

[4]MEISBURGER, E.P., WILLIAMS, S.J., and PRINS, D.A., "An Apparatus for Cutting Core Liners," *Journal of Sedimentary Petrology*, Vol. 50, No. 2, June 1980, pp. 641-642.

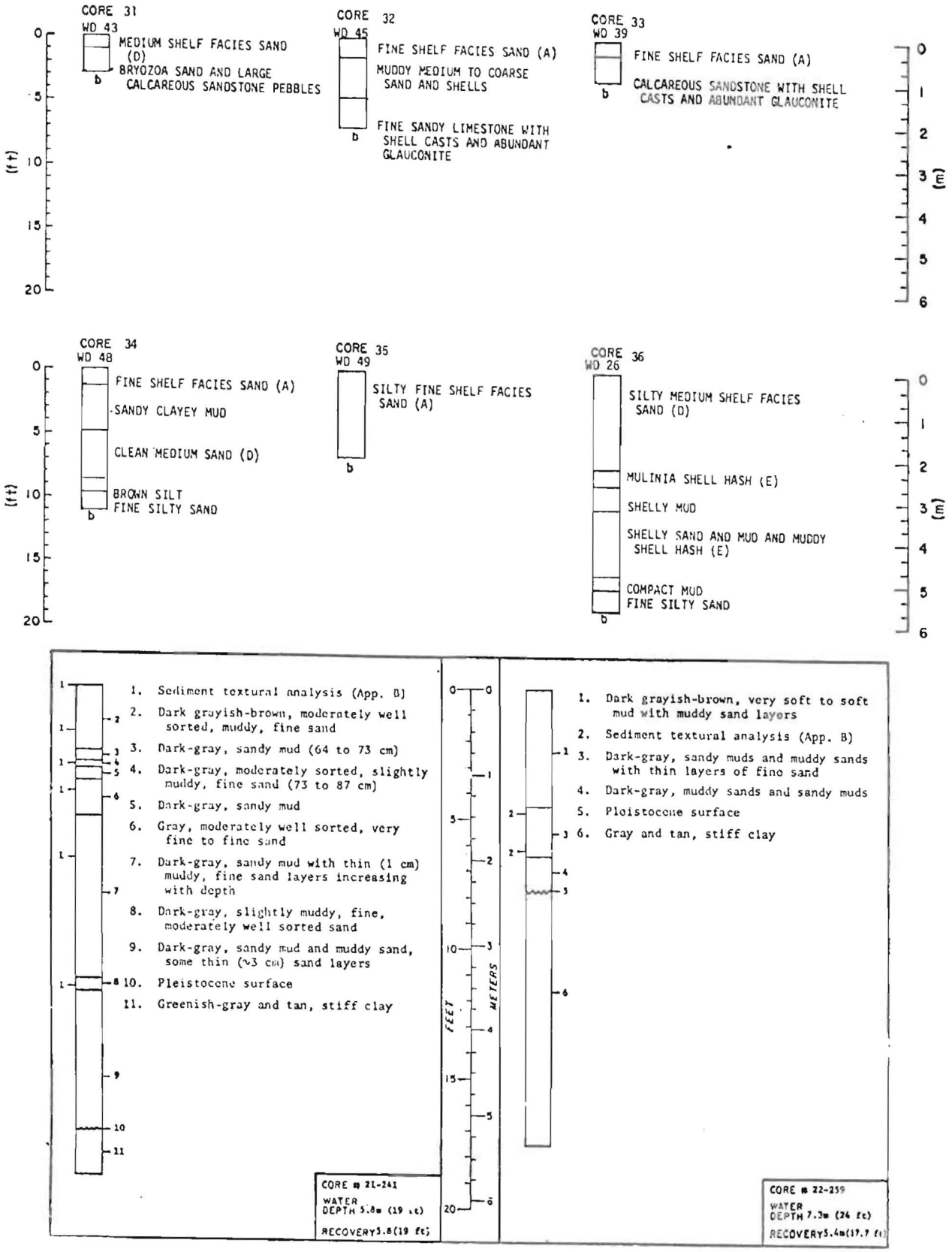

Figure 3. Examples of core logs used to describe the sedimentary sequence and lithology.

split for detailed logging. Log descriptions should include texture, color, organic matter, bedding features, and inclusions such as mollusk shells and rock fragments. If possible, samples of each interval should be dried and examined under a binocular microscope to determine the general composition of constituent particles, and these data should also be entered in the log. Such data are helpful in correlating lithologies between cores and in detecting breaks in the sedimentary sequence.

In addition to the descriptive core log, a carded log on which actual samples of the core intervals are glued in correct sequence is very useful. Such logs show subtle gradations of color and texture that cannot be adequately characterized by written descriptions and provide a convenient means of correlating a large number of cores. A brief description of this procedure is presented in Appendix B.

IV. SUMMARY

A pneumatic vibratory coring apparatus designed to recover 20-foot cores in cohesionless sediments on the seabed has been described. This basic system, improved to recover cores up to 40 feet long, has been used for nearly 18 years by CERC to conduct geological surveys of most U.S. Inner Continental Shelf areas and Lakes Michigan and Erie in order to assess offshore sand and gravel resources. This experience in using the vibracore as well as handling, sampling, and recording the recovered samples is presented to assist others in carrying out their own programs.

APPENDIX A

A DEVICE FOR CUTTING SEDIMENT CORE LINERS
(from an unpublished CERC Coastal Engineering Technical Note, TN-VI-1, Sept. 1979).

PROBLEM: Develop equipment and method for longitudinally cutting the core-barrel liner containing the coastal sediment core.

BACKGROUND: Most coring devices use plastic or thin-wall metal tubing as core-barrel liners. Coastal sediments collected during the drilling operations are contained within this liner which is removed, capped, identified, and stored. In order to make a detailed visual log of the core and to selectively sample the sediments it is necessary to split the core lengthwise into halves. An assembly for splitting core liners that has proven very satisfactory at the Coastal Engineering Research Center is described below.

DESCRIPTION OF EQUIPMENT: The core liner cutting assembly consists of two main components: (1) a metal table and trough assembly (Fig. A-1) for holding the core and (2) a high-speed router fitted with a guide arm. The lightweight table is constructed of aluminum plate with aluminum channels for bracing. The trough is made by mounting two steel angles on the table. One angle is fixed; the other is bolted to the table through slotted holes to permit width adjustment to various core liner diameters. The entire assembly can be set on sawhorses when used. The length of the table is determined by the length of the core liners to be split. As an example, the pneumatic vibratory coring device (Williams, Prins, and Meisburger, 1979)[5] used at Galveston, Texas, produced a 4-inch-diameter (10.1 centimeters) sediment core with a maximum length of 20 feet (6.1 meters).

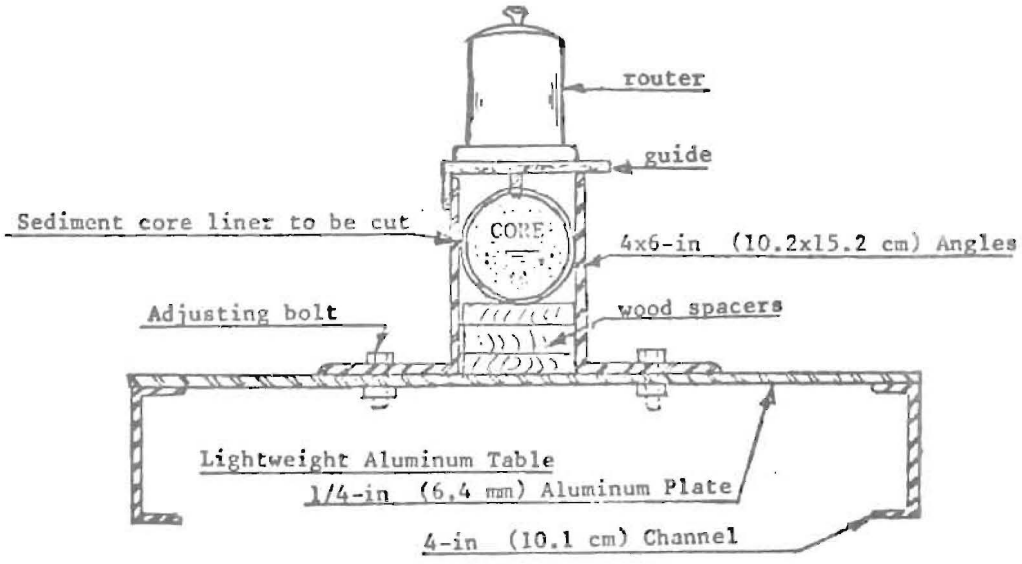

Figure A-1. End view of the core-splitting device.

[5]WILLIAMS, S.J., PRINS, D.A., and MEISBURGER, E.P., "Sediment Distribution Sand Resources, and Geologic Character of the Inner Continental Shelf Off Galveston County, Texas," MR 79-4, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., July 1979.

The router used is a commercial model equipped with a 5/16-inch-diameter (7.9 millimeters) carbide bit. The only modification necessary to the router is the addition of a metal guide bolted directly to the router baseplate (see Fig. A-1). It is important to use only carbide bits as ordinary steel bits are not adequate for cutting some liners and quickly become dull due to sediment abrasion. Circular saws previously were tried to cut the liners but they did not prove as good as a router.

METHODS: In use the core is placed in the trough and its elevation adjusted by inserting plywood spacers beneath the core so that the top of the liner is slightly below the top level of the trough sides. The router is then set on top of the trough angles and the bit adjusted to cut only the liner and not disturb the core. The guide is set so that the router will ride along one side of the trough, and keeping the bit on the centerline, the router is guided along the trough, making a longitudinal cut through the liner. The core is then rotated 180° and a second cut made. Once the liner is cut the core must be taped or held together when removed from the trough. The core is then moved to the table where a complete splitting of the sediment core is accomplished using a knife or wire.

APPENDIX B

SEDIMENT SAMPLE CARDING TO FACILITATE COMPARATIVE CORRELATION
(from an unpublished CERC Coastal Engineering Technical Note, TN-VI-2, Sept. 1979)

PROBLEM: Develop a technique for rapid visual analysis of a large number of sediment samples as a preliminary step in correlation.

BACKGROUND: Use of descriptive logs for comparative visual analysis of sediment from cores and borings is rarely as satisfactory as firsthand study of the actual material. This is true because subtle visual properties which cannot be fully described are often important in showing relationships. Where large numbers of samples are being analyzed, comparison of the sediments in their original containers is cumbersome and requires considerable space for layout. In addition the analyst, being unable to scan more than a few samples at a time, is less efficient in perceiving relationships. A useful expedient for making preliminary comparative analysis of a large number of samples is to glue small representative subsamples on illustration board cards.

The use of carded samples cannot, of course, eliminate the need for more complete work with the whole sample and for more sophisticated forms of analysis. It has been found, however, that carded samples are very useful during preliminary analysis and correlation, and in providing the basis for selection of representative samples for more detailed study.

PROCEDURE: The card stock used for the sample cards is white illustration board readily available from commercial art and drafting supply companies. Almost any size card can be used, depending upon the number of samples per core or boring. A 4- by 8-inch card is satisfactory for the usual number of samples per core.

Subsamples are mounted in stratigraphic order down the left side of the card in the following manner: A small quantity of all-purpose white glue is placed on the card in the appropriate position along the left side and spread over an area approximately 1 inch in diameter and having a thickness of approximately 0.5 millimeter. A small representative quantity of each sample is then placed evenly over the glue area. Upon drying the glue forms a relatively transparent matrix cementing the grains together. Each sample in turn is thus mounted down the left side of the card. After drying, the card should be lightly tapped on edge to remove excess loose material. As samples are mounted, information such as core designation, location, and sample interval can be entered on the right side of the card (see sample card in Fig. B-1). Small shells, pebbles and possible artifacts, if included in a sample, can also be mounted if the glue layer is made somewhat thicker than for the more normal sand-size material. Occurrence of large shell valves, pebbles, or peats in the core can be noted on the right side of the card at the corresponding sample interval.

Filled core sample cards are stored in boxes constructed of 1/4-inch plywood and 1-inch pine board. Slots 1/2-inch deep are made on one side of the pine board at 1/2-inch intervals using a cutoff saw. The pine material is used for the sides of the box with the slotted sides facing inward. The cards can then be easily slipped into slots, numbered, and stored according to core number sequence.

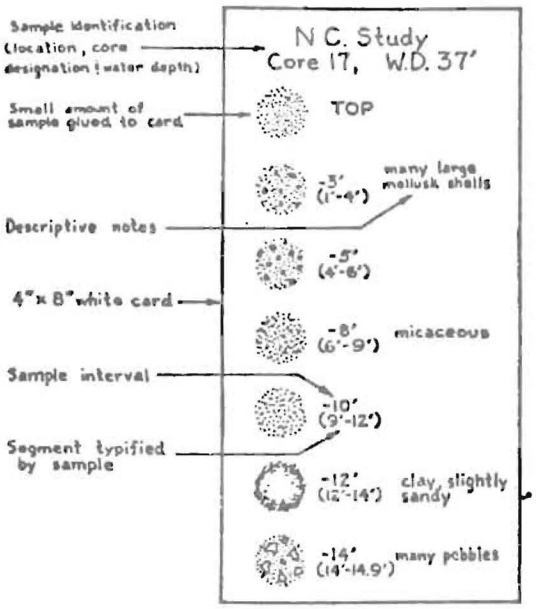

Figure B-1. Sample card.

DISCUSSION: The storage boxes of carded core samples can be kept in work offices, and large numbers of cards can be laid out on a desk or table for study. Continued restudy can be made with a minimum of effort. Also, the cards readily fit under a standard light binocular microscope for detailed examination and estimation of mean grain size or abundance of certain grain types or organisms. Duplicate core cards can be easily sent through the mail to a colleague for collateral study and the cards can be photographed for inclusion in analysis reports.

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