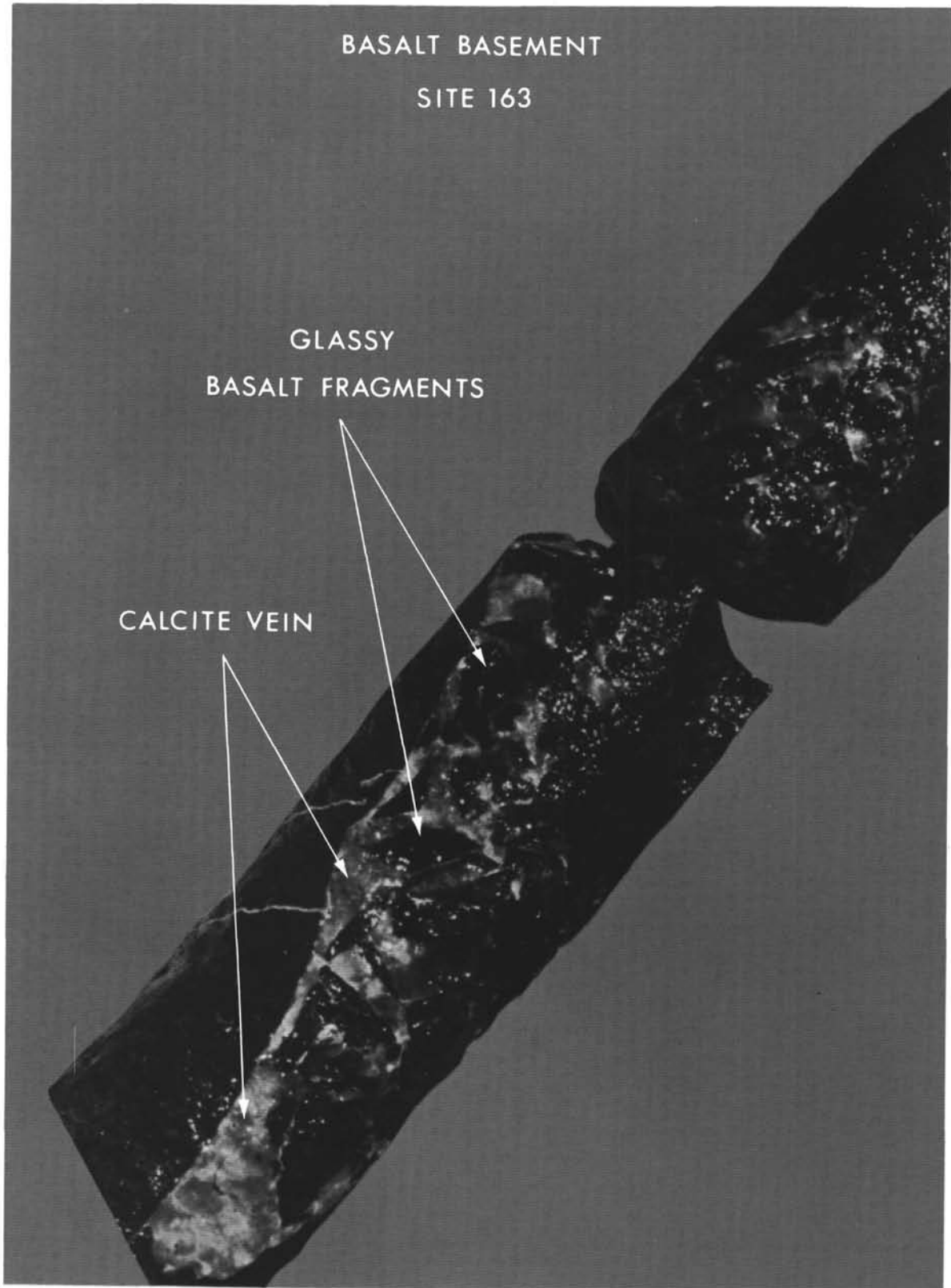


BASALT BASEMENT

SITE 163

GLASSY  
BASALT FRAGMENTS

CALCITE VEIN



Greenish gray calcite vein containing angular fragments of glassy basalt. Most of the fragments are quite fresh. This vein is about 10 meters below the sediment-basalt contact and lies between the 5th and 6th of seven cooling units cored at Site 163. 163-29-1 (120-143 cm)

# Initial Reports of the Deep Sea Drilling Project

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A Project Planned by and Carried Out With the Advice of the  
JOINT OCEANOGRAPHIC INSTITUTIONS FOR DEEP EARTH SAMPLING (JOIDES)

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## Volume XVI

covering Leg 16 of the cruises of the Drilling Vessel *Glomar Challenger*  
San Cristobal, Panama to Honolulu, Hawaii  
February-March 1971

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### PARTICIPATING SCIENTISTS

Tjeerd H. van Andel, G. Ross Heath, Richard H. Bennett,  
J. David Bukry, Santiago Charleston, David S. Cronan,  
Menno G. Dinkelman, Ansis G. Kaneps, Kelvin S. Rodolfo,  
Robert S. Yeats

EDITOR, Ansis G. Kaneps

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By the  
UNIVERSITY OF CALIFORNIA  
Scripps Institution of Oceanography  
Prime Contractor for the Project

*References to this Volume*

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# Foreword

The year 1972 marks the 100th anniversary of H.M.S. CHALLENGER—after which D/V GLOMAR CHALLENGER is named. It is fitting that our century should have its counterpart to the famous ship of the 19th century, which helped establish oceanography as a science through her voyages. It is equally fitting that GLOMAR CHALLENGER should be plying the same waters one century later seeking answers to new problems concerning the history of our planet and of life on it. The fundamental advancement of our knowledge of the earth will lead to enhanced capabilities to understand its processes and to exploit its natural resources intelligently.

The Deep Sea Drilling Project is being undertaken within the context of the National Science Foundation's Ocean Sediment Coring Program. The Foundation is funding the project by means of a contract with the University of California, and the Scripps Institution of Oceanography is responsible for its management. The University has, in turn, subcontracted with Global Marine Incorporated for the services of the drilling ship, GLOMAR CHALLENGER. Scientific planning, both of the detailed itinerary and of the preliminary analyses leading to these Initial Reports, has been conducted under the auspices of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). The JOIDES consortium has convened several panels for that purpose, consisting of a large number of distinguished scientists from academic institutions, government agencies, and private industry. Altogether, the project has involved the active interest and participation of many of the Nation's best scientists and technologists. Leading scientists from abroad have participated and their countries have made contributions to the project.

The first ocean coring operations for the Deep Sea Drilling Project began on August 11, 1968. During the ensuing 18 months of drilling operations in the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Caribbean Sea, the scientific objectives that had been set forth were successfully accomplished. Primarily, the age of the ocean basins and their processes of

development were determined. Emphasis was placed on broad reconnaissance and on testing the involvement of the mid-oceanic rise systems in the development of the ocean basins.

As a result of the success of the Deep Sea Drilling Project, the National Science Foundation extended its contract with the University of California to encompass an additional 30 months of drilling, allowing GLOMAR CHALLENGER to continue operations throughout the oceans of the world in exploring the deep ocean floors. This extension includes a broad geographic range of operations in the Atlantic, Pacific, and Indian Oceans, and the Mediterranean, Caribbean, Bering, and Red Seas. The ultimate goal is a fundamental advancement of our knowledge of the earth.

These reports contain the results of initial studies of the recovered core material and the associated geophysical information. The contribution to knowledge has been exceedingly large and future studies of the core material over many years will contribute much more. The National Science Board in its 1971 report, "Environmental Science—Challenge for the Seventies," stressed the importance of the work of the GLOMAR CHALLENGER:

Special mention should be made of the development of new types of deep sea drilling techniques and their use on the unique, prototype vessel, GLOMAR CHALLENGER. This facility has brought to light in only a few years information that has literally revolutionized man's understanding of the physical processes occurring in the earth's crust.

Moreover, industry should benefit greatly from the project—from the technological advances that are being made and through the information being obtained on natural resources.



H. Guyford Stever

Washington, D. C.  
June 1972

## Preface

Recognizing the need in the oceanographic community for scientific planning of a program to obtain deep sedimentary cores from the ocean bottoms, four of the major oceanographic institutions that had strong interests and programs in the fields of marine geology and geophysics, formed in May 1964, the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). This group, Lamont-Doherty Geological Observatory; Rosenstiel School of Marine and Atmospheric Science, University of Miami; the Scripps Institution of Oceanography, University of California at San Diego; and the Woods Hole Oceanographic Institution, expressed an interest in undertaking scientific planning and guidance of the sedimentary drilling program. It was the purpose of this group to foster programs to investigate the sediments and rocks beneath the deep oceans by drilling and coring. The membership of this original group was later enlarged in 1968 when the University of Washington became a member.

Through discussions sponsored by the JOIDES organization, with support from the National Science Foundation the Lamont-Doherty Geological Observatory operated a drilling program with Dr. J. Lamar Worzel as Principal Investigator. This successful drilling effort early in the summer of 1965, on the Blake Plateau region off Jacksonville, Florida, used the drilling vessel, *Caldrill I*.

With this success in hand, planning began for a more extensive deep sea effort. This resulted in the award of a contract by the National Science Foundation to the University of California for an eighteen-month drilling program in the Atlantic and Pacific Oceans, termed the Deep Sea Drilling Project. Operations at sea began in August 1968.

The goal of the Deep Sea Drilling Project is to gather scientific information that will help determine the age and processes of development of the ocean basins. The primary strategy is to drill deep holes into the ocean floor, relying largely on technology developed by the petroleum industry.

Through the efforts of these five principal organizations and of the panel members which were drawn from a large cross section of leading earth scientists and associates, a scientific program was developed.

Cores recovered from deep beneath the ocean floor will provide reference material for a multitude of future studies in fields such as biostratigraphy, physical stratigraphy, and paleomagnetism, that will afford a new scope for studies of the physical and chemical aspects of sediment provenance, transportation, deposition, and diagenesis. In-hole measurements, as feasible, should provide petrophysical data to permit inference of lithology of intervals from which no cores were recovered.

A report, describing the core materials and information obtained both at sea and in laboratories on shore, is published as soon as possible after the completion of each cruise. These reports are a cooperative effort of the scientists participating in the cruise and are intended primarily to be a compilation of results which, it is hoped, will be the starting point for many future new and exciting research programs. Preliminary interpretations of the data and observations taken at sea, are also included.

Core materials and data collected on the cruise will be made available to qualified scientists through the Curator of the Deep Sea Drilling Project, following a Sample Distribution

Policy (p. xvii) approved by the National Science Foundation.

The advent of *Glomar Challenger*, with its deep-water drilling ability, is exceedingly timely. It has come when geophysical investigation of the oceans has matured through 20 to 30 years of vigorous growth to the point where we have some knowledge about much of the formerly unknown oceanic areas of our planet. About one million miles of traverses had been made which tell us much about the global pattern of gravity, magnetic and thermal anomalies, and about the composition, thickness and stratification of the sedimentary cover of the deep-sea and continental margin. The coverage with such data has enabled the site selection panels to pick choice locations for drilling. The knowledge gained from each hole can be extended into the surrounding area. Detailed geophysical surveys were made for most of the selected locations prior to drilling.

The earth sciences have recently matured from an empirical status to one in which substantial theories and hypotheses about major tectonic processes are flourishing. Theories about the origin of magnetic fields and magnetic reversals, about ocean floor spreading and continental drift, and about the thermal history of our planet, have led to specific predictions that could be tested best by an enlightened program of sampling of deep-sea and continental margin sediments and underlying rocks.

The members of JOIDES and the scientists from all interested organizations who have served on the various advisory panels are proud to have been of service to the Nation and believe that the information and core materials that have been obtained will be of value to students of earth sciences and all humanity for many years to come.

# Deep Sea Drilling Project

## **MEMBER ORGANIZATIONS OF THE JOINT OCEANOGRAPHIC INSTITUTIONS FOR DEEP EARTH SAMPLING (JOIDES):**

Lamont-Doherty Geological Observatory, Columbia  
University

Rosenstiel School of Marine and Atmospheric Sci-  
ence, University of Miami.

Scripps Institution of Oceanography, University of  
California

University of Washington

Woods Hole Oceanographic Institution

## **OPERATING INSTITUTION:**

Scripps Institution of Oceanography  
University of California at San Diego  
La Jolla, California  
W. A. Nierenberg, Director

## **DEEP SEA DRILLING PROJECT**

Principal Investigator and  
Project Manager  
M. N. A. Peterson

Project Chief Scientist  
N. T. Edgar

## Participants Aboard

### GLOMAR CHALLENGER for Leg Sixteen:

Dr. Tjeerd H. van Andel  
Co-Chief Scientist  
*Dept. of Oceanography  
Oregon State University  
Corvallis, Oregon*

Dr. G. Ross Heath  
Co-Chief Scientist  
*Dept. of Oceanography  
Oregon State University  
Corvallis, Oregon*

Mr. Richard H. Bennett  
Sedimentologist  
*NOAA-Atlantic Oceanographic  
and Meteorological Laboratories  
Miami, Florida*

Dr. J. David Bukry  
Paleontologist  
*La Jolla Marine Geology  
Laboratory  
United States Geological Survey  
La Jolla, California*

Dr. Santiago Charleston  
Sedimentologist  
*Instituto Mexicano del Petroleo  
Mexico 14 D. F., Mexico*

Dr. David S. Cronan  
Sedimentologist  
*Dept. of Geology  
University of Ottawa  
Ottawa, Canada*

Mr. Menno G. Dinkelman  
Paleontologist  
*Dept. of Oceanography  
Oregon State University  
Corvallis, Oregon*

Mr. Orrin Russie  
Photographer  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Jim Pine  
Chemist  
*Scripps Institution of Oceanography  
La Jolla, California*

Miss Marilee Henry  
Yeoman  
*Scripps Institution of Oceanography  
La Jolla, California*

Mrs. Ann M. Strathern  
Paleontological Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Robert Olivas  
Marine Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Jack Minter  
Marine Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Donald Cameron  
Marine Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Victor Sotelo  
Marine Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Mr. Jim Natland  
Marine Technician  
*Scripps Institution of Oceanography  
La Jolla, California*

Dr. Ansis G. Kaneps  
Paleontologist  
*Deep Sea Drilling Project  
Scripps Institution of Oceanography  
La Jolla, California*

Dr. Kelvin S. Rodolfo  
Sedimentologist  
*Dept. of Geological Sciences  
University of Illinois  
Chicago, Illinois*

Dr. Robert S. Yeats  
Sedimentologist  
*Dept. of Geology  
Ohio University  
Athens, Ohio*



Mr. Dell Redding  
Cruise Operations Manager  
*Phillips Petroleum Company*  
*Anchorage, Alaska*

Mr. Charles Green \*  
Meteorologist  
*NOAA*  
*Washington, D. C.*

Captain Loyd E. Dill  
Master,  
D/V GLOMAR CHALLENGER  
*Global Marine, Inc.*  
*Los Angeles, California*

Mr. Cotton Guess  
Drilling Superintendent  
*Global Marine, Inc.*  
*Los Angeles, California*

Mr. Michael Lehman  
Laboratory Officer  
*Scripps Institution of Oceanography*  
*La Jolla, California*

Mr. Lloyd Russill  
Electronics Technician  
*Scripps Institution of Oceanography*  
*La Jolla, California*

\* deceased

## Senior Project Personnel

Dr. Melvin N. A. Peterson  
Principal Investigator and  
Project Manager

Mr. Frank C. MacTernan  
Deputy Project Manager

Dr. N. Terence Edgar  
Chief Scientist

Mr. Valdemar Larson  
Operations Manager

Mr. Stanley T. Serocki  
Project Development Engineer

Dr. Thomas A. Davies  
Co-ordinating Staff Geologist

Mr. William R. Riedel  
Curator

Dr. Peter R. Supko  
Chief Scientific Editor

Mr. Oscar Weser  
Senior Staff Scientist

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*Lamont-Doherty Geological Observatory*
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*Lamont-Doherty Geological Observatory*

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*Scripps Institution of Oceanography*

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*Scripps Institution of Oceanography*

Dr. Tsunemasa Saito  
*Lamont-Doherty Geological Observatory*

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*National Oceanic and Atmospheric Administration*

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*University of South Carolina*

Dr. Adrian F. Richards  
*Lehigh University*

**Advisory Panel on Well Logging**

Dr. A. E. Worthington  
*Chevron Oil Field Research Company*

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*Humble Oil and Refining Company*

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*Pan American Petroleum Corporation*

Dr. George V. Keller  
*Colorado School of Mines*

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*Gulf Research and Development Company*

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- Dr. Richard L. Hay  
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*Rosenstiel School of Marine and  
Atmospheric Science*
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*Scripps Institution of Oceanography*
- Dr. John C. Hathaway  
*Woods Hole Oceanographic Institution*
- Dr. Stanley McCaleb  
*Sun Oil Research Center*
- Dr. Robert W. Rex  
*University of California at Riverside*

**Advisory Panel on Paleomagnetism and Age Dating**

- Dr. Joseph D. Phillips  
*Woods Hole Oceanographic Institution*
- Dr. G. Brent Dalrymple  
*U.S. Geological Survey*

- Dr. Jack R. Dymond  
*Oregon State University*
- Dr. C. G. A. Harrison  
*Rosenstiel School of Marine and  
Atmospheric Science*
- Dr. Niel D. Opdyke  
*Lamont-Doherty Geological Observatory*

**Advisory Panel on Igneous and Metamorphic  
Petrography**

- Dr. Ian D. MacGregor  
*University of Texas at Dallas*
- Dr. Frederick A. Frey  
*Massachusetts Institute of Technology*
- Dr. Stanley R. Hart  
*Carnegie Institution of Washington*
- Dr. William G. Melson  
*Smithsonian Institution*
- Dr. A. Miyashiro  
*State University of New York at Albany*

# Deep Sea Drilling Project

## SAMPLE DISTRIBUTION POLICY\*

Distribution of Deep Sea Drilling samples will be undertaken in order to (1) provide supplementary data for inclusion in the appropriate Initial Report to support *Glomar Challenger* scientists in achieving the scientific objectives of their particular cruise, and (2) provide individual investigators with material to conduct detailed studies beyond the scope of the Initial Reports.

The National Science Foundation has established a Sample Distribution Panel to advise on distribution of core material. This panel is chosen in accordance with usual Foundation practices, in a manner that will assure advice in the various disciplines leading to a complete and adequate study of the core and related materials. Funding for the proposed research is handled separately by the investigator, not through the Deep Sea Drilling Project.

### *Distribution of samples for contributions to Initial Reports*

Any investigator who wishes to contribute a paper to a given volume of the Initial Reports may write to the Curator, Deep Sea Drilling Project, Scripps Institution of Oceanography, University of California, at San Diego, La Jolla, California 92037, requesting samples from a forthcoming cruise. The request should include the nature of the study, and type, size, number of samples, particular sampling techniques or equipment that might be required, and an estimate of the time required to complete the study. The requests will be reviewed by shipboard scientists, and, if they are deemed suitable and pertinent to the objectives of the leg, and shipboard workload permits, the requested samples will be taken during the cruise (provided, of course, material suitable to the investigation is obtained during the drilling). In case of multiple requests to perform the same investigation, selection of investigator will be made by the shipboard scientific party. Proposals should be of a scope appropriate to complete the sampling and study in time for publication in the Initial Reports. Studies deemed acceptable will be referred to the Curator who will, with the consent of the NSF Sample Distribution Panel, authorize distribution of the samples. The Sample Distribution Panel and the Deep Sea Drilling Project will strive to ensure that there is a reasonable degree of continuity in the investigations among the various cruises, that the studies are pertinent to goals of the cruise, and that they are consistent with the publication policy for the Initial Reports. Subject to these same provisions, the ship-

board scientific party may elect to have special studies of selected core samples of its recently completed cruise made by other investigators.

Investigations not completed in time for inclusion in the Initial Report may not be published in other journals until publication of the Initial Report for which it was intended, though it is expected that they will normally be published as an appendix in a later Initial Report volume.

### *Distribution of Samples for publication other than in Initial Reports*

1. Researchers intending to request samples for studies beyond the scope of the Initial Reports should first obtain a sample request form from the Curator, Deep Sea Drilling Project, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92037. Requests should specify the quantities and intervals of the core required, a statement of the proposed research, the possibility of returning residue to the Curator, the estimated time required to complete and publish the results, and the availability or need of funding and availability of equipment and space foreseen for the research.

In order to ensure that requests for highly desirable but limited samples can all be considered, approval of requests and distribution of samples will not be made prior to 12 months after date of completion of the cruise that collected the cores. Prior to the publication of an Initial Report, requests for samples from a cruise can be based on the preliminary shipboard core logs. Copies of these logs will be kept on open file at Scripps Institution of Oceanography and other designated institutions. The only exceptions to this policy will be for specific instances involving ephemeral properties.

Requests for samples from researchers in industrial laboratories will be handled in the same manner as those from academic organizations, and there will be the same obligation to publish results promptly. Requests from foreign scientists or organizations will also be considered.

2. The Deep Sea Drilling Project's Curator has the responsibility for distributing samples, controlling quality of samples, and preserving core material. He also has the responsibility for maintaining a record of requests for samples that have been

\*Revised June 1972.



processed and filled indicating the investigator and subjects to be studied. This record will be available to investigators.

The distribution of samples will be made directly from the two repositories at Lamont-Doherty Geological Observatory and Scripps Institution of Oceanography by the Curator or his designated representative.

3. (a) Samples up to 10 cc/meter of core length can be automatically distributed by the Curator, Deep Sea Drilling Project, or his authorized representative to any qualified investigator who requests them. The Curator will refrain from making automatic distribution of any parts of the cores which appear to be in particularly high demand, and any requests for these parts of the cores will be referred to the Sample Distribution Panel for review. Requests for samples from thin layers or important stratigraphic boundaries will generally require Panel review.

(b) All requests for samples in excess of 3(a) above will be referred to the Sample Distribution Panel.

(c) If, in the opinion of scientific investigators, certain properties they wish to study may deteriorate prior to the normal availability of the samples, such investigators may request that the normal waiting period not apply. All such requests must be approved by the Sample Distribution Panel.

4. Samples will not be provided prior to assurance that funding for sample studies either exists or is not needed. However, neither formal approval of sample requests nor distribution of samples will be made until the appropriate time (Item 1). If a sample request is dependent, either wholly or in part, on proposed funding, the Curator will provide to the organization to whom the funding proposal has been submitted any information on the availability (or potential availability) of samples that it may request.
5. Investigators receiving samples are responsible for:
  - i) promptly publishing significant results;
  - ii) acknowledging, in publications, that samples were supplied through the assistance of the National Science Foundation;
  - iii) submitting four (4) copies of all reprints of published results to the Curator, Deep Sea Drilling Project, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92037;

- iv) notifying the Curator of any work done on the samples that is additional to that stated in the original request for samples;

- v) returning, in good condition, the remainders of samples after termination of research, if requested by the Curator.

6. Cores will be made available at repositories for investigators to examine and specify exact samples in such instances as this may be necessary for the scientific purposes of the sampling, subject to the limitations of 3 (a), (b), (c), and 5, above, and with the specific permission of the Curator or his delegate.
7. Cores of igneous and metamorphic rocks will also remain at the repositories where they will be available for observation and description and where selected samples may be taken for thin-section preparation and other work.
8. The Deep Sea Drilling Project routinely processes by computer most of the quantitative data presented in the Initial Reports. Space limitations in the Initial Reports preclude the detailed presentation of all such data. However, copies of the computer readout are available for those who wish the data for further analysis or as an aid in selecting samples.

Magnetics, seismic reflection and bathymetric data collected underway by the *Glomar Challenger* will also be available for distribution twelve months after completion of the cruise.

Requests for these data may be made to:

Chief Scientific Editor  
Deep Sea Drilling Project  
Scripps Institution of Oceanography  
University of California at San Diego  
La Jolla, California 92037

A charge may be made to recover the expenses of responding to individual requests. Estimated charges can be furnished before the request is processed, if required.

9. This policy has the approval of the National Science Foundation and is designed to help ensure that the greatest possible scientific benefit is gained from the materials obtained, and that samples will be made widely available to interested geologists.

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This subject (and/or title) index is provided to assist readers in finding data that have been published in Volumes 1-14 of the Initial Reports.

The list is very general, compiled from the Table of Contents of each volume. Many chapters with very specific titles and subject contents are grouped under more general subjects. Volume 12 Site Report chapters have specific articles included; no effort was made to index them. Many chapters in Volume 13 consist of several major parts, some only slightly related to the chapter title. Because of this, duplication and cross-indexing were necessary in some cases.

The four number series used in this index designates volume, chapter (or parts of chapters in Volume 13), and page numbers. For example, the series 1-14-382-384 designates Volume 1, Chapter 14, pages 382-384. The letter A in the chapter space indicates that the chapter appears as an appendix in the volume. In Volume 13, parts of chapters are indicated as follows: Chapter 27 has five parts, so Part 5 of Chapter 27 is designated as 13-27.5.

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