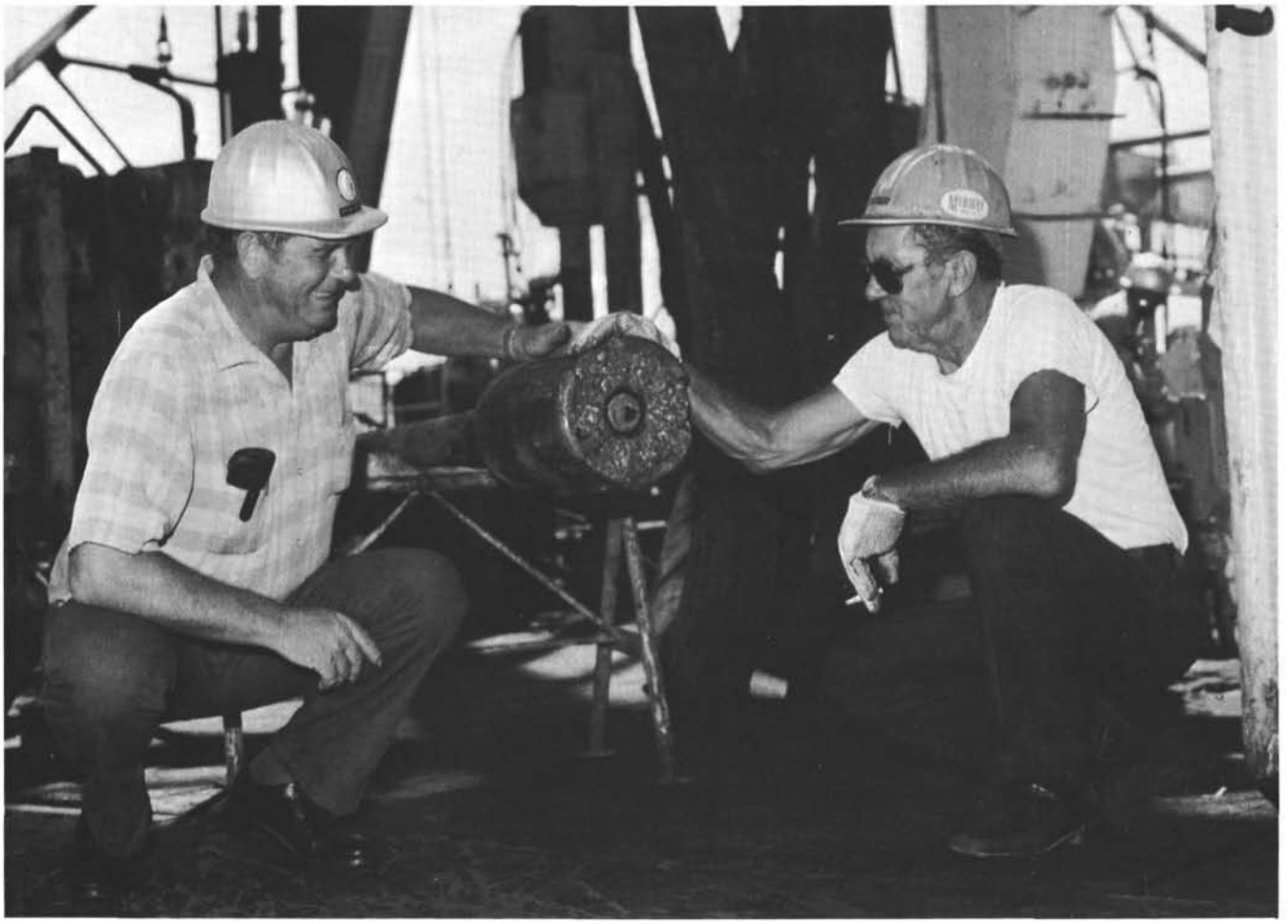

Otis Winton, Drilling Superintendent, and Arkie Slayton, Downhole Specialist, inspecting a modified clover-leaf junk grinder after it was used by Slayton to grind up a bit cone lost 953 meters below the sea floor at Site 462. Triangular inserts covered with tungsten carbide have been added to the original grinder to form a flat, upward-concave surface suitable for continuous grinding.

Initial Reports of the Deep Sea Drilling Project

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

VOLUME LXI

covering Leg 61 of the cruises of the Drilling Vessel *Glomar Challenger*
Apra, Guam to Majuro Atoll, Marshall Islands
May–July 1978

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Foreword

Between 1872 and 1876, the H.M.S. CHALLENGER undertook the world's first major oceanographic expedition. That expedition greatly expanded man's knowledge of the world's oceans and revolutionized his ideas about this planet earth. A century later, over the course of the past decade, another vessel, also named CHALLENGER, has continued to expand man's knowledge of the world ocean, and has revolutionized his concepts of how the seafloor and continents were formed and continue to change. The D/V GLOMAR CHALLENGER is plying the same waters as its historic counterpart, seeking answers to new questions concerning the history of our planet and the life it supports. The continued advancement of knowledge about the fundamental processes and dynamics of the earth will lead to a greater understanding of our planet and more intelligent use of its resources.

Since 1968, the Deep Sea Drilling Project has been supported by the National Science Foundation, primarily through a contract with the University of California which, in turn, subcontracts to Global Marine Incorporated for the services of the drillship D/V GLOMAR CHALLENGER. Scripps Institution of Oceanography is responsible for management of the University contract.

Through contracts with Joint Oceanographic Institutions, Inc. (JOI, Inc.), the National Science Foundation supports the scientific advisory structure for the project and funds some pre-drilling site surveys. Scientific planning is conducted under the auspices of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). The JOIDES advisory group consists of over 250 members who make up 24 committees, panels or working groups. The members are distinguished scientists from academic institutions, government agencies and private industry in many countries.

In 1975, the International Phase of Ocean Drilling (IPOD) began. IPOD member nations, USSR, Federal Republic of Germany, Japan, United Kingdom and France, provide partial support of the project. Each member nation takes an active role in the scientific planning of the project through organization membership in JOIDES. Scientists from these countries also participate in the field work aboard the D/V

GLOMAR CHALLENGER and post-cruise scientific studies.

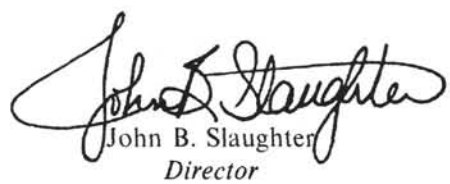
The first ocean coring operations for the Deep Sea Drilling Project began on August 11, 1968. During the ensuing years of drilling operations in the Atlantic, Pacific and Indian Oceans, the Gulf of Mexico, Caribbean Sea, Mediterranean Sea, and Antarctic waters, the scientific objectives that had been proposed were successfully accomplished. Primarily, the age of the ocean basins and their processes of development were determined. The validity of the hypothesis of sea floor spreading was firmly demonstrated and its dynamics studied. Emphasis was placed on broad reconnaissance and testing the involvement of mid-oceanic ridge systems in the development of the ocean basin. Later legs of the CHALLENGER's voyages concentrated on the nature of the oceanic crust, the sedimentary history of the passive ocean margins, sediment dynamics along active ocean margins and other areas of interest. The accumulated results of this project have led to major new interpretations of the pattern of sedimentation and the physical and chemical characteristics of the ancient oceans.

As a result of the continued success of the Deep Sea Drilling Project, the National Science Foundation has presently extended the project through fiscal year 1982. The latest contract extends the period of exploration of the deep ocean floors of the world by GLOMAR CHALLENGER to a total of over 14 years.

A new dimension of scientific discovery has been added to the project, the detailed study of paleoenvironment. With the introduction of the hydraulic piston corer in 1979; virtually undisturbed cores of the soft sediment layers can now be obtained. This technological advance, together with the new pressure core barrel, has greatly enhanced the ability of the project to study ancient ocean climates as recorded by the micro flora and fauna preserved in the sedimentary layers.

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. Future studies of the core material over many years will contribute much more.

People of our planet, in their daily living and work activities will benefit directly and/or indirectly from this research. Benefits are derived from the technological advances in drilling, coring, position-keeping and other areas as well as through the information being obtained about natural resources and their origins. As with the original H.M.S. CHALLENGER oceanographic expedition, this second CHALLENGER expedition will have profound effects of scientific understanding for many years to come.



John B. Slaughter
Director

Washington, D.C.
June 1981

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 Institututions 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 the original group was later enlarged, in 1968 when the University of Washington became a member and again in 1975 when University of Hawaii Institute of Geophysics, the Oregon State University School of Oceanography, the University of Rhode Island Graduate School of Oceanography, and Texas A&M University Department of Oceanography became members. In accordance with international agreements, institutions of participating nations became members of JOIDES. Thus, during 1974 to 1976, the Bundesanstalt für Geowissenschaften und Rohstoffe of the Federal Republic of Germany, the Centre National pour l'Exploitation des Océans of France, the National Environmental Research Council of the United Kingdom, the University of Tokyo of Japan, and the Academy of Sciences of the USSR became JOIDES members.

Through discussions sponsored by the JOIDES organization, with support from the National Science Foundation, Columbia University's Lamont-Doherty Geological Observatory operated a drilling program in the summer of 1965 on the Blake Plateau region off Jacksonville, Florida.

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 Scripps Institution of Oceanography, University of California at San Diego for an eighteen-month drilling program in the Atlantic and Pacific oceans, termed the Deep Sea Drilling Project (DSDP). Operations at sea began in August 1968, using the now-famous drilling vessel, the *Glomar Challenger*.

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 the principal organizations and of the panel members, who 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 provide reference material for a multitude of studies in fields such as biostratigraphy, physical stratigraphy, and paleomagnetism that afford a new scope for investigating the physical and chemical aspects of sediment provenance, transportation, deposition, and diagenesis. In-hole measurements, as feasible, 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 onshore, is published after the completion of each cruise. These reports are a cooperative effort of shipboard and shore-based scientists 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 each cruise will be made available to qualified scientists through the Curator of the Deep Sea Drilling Project, following a Sample Distribution Policy (p. xxi) approved by the National Science Foundation.

The advent of *Glomar Challenger*, with its deep-water drilling capability, 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 have been made which tell us much about the global pattern of gravity, magnetic and thermal anomalies, and about the composition, thickness, and stratigraphy 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.

In October 1975, the International Phase of Ocean Drilling (IPOD) began. This international interest, and the true participation of both the scientists and governments of a number of nations, are eloquent testimony to the importance of the work being done by the Deep Sea Drilling Project.

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

Deep Sea Drilling Project

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University of Rhode Island, Graduate School of Oceanography

Texas A&M University, Department of Oceanography

University of Tokyo, Ocean Research Institute

University of Washington, Department of Oceanography

U.S.S.R. Academy of Sciences

Woods Hole Oceanographic Institution

*Includes member organizations during time of the cruise.

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Deep Sea Drilling Project
SAMPLE DISTRIBUTION POLICY*

Distribution of Deep Sea Drilling samples for investigation will be undertaken in order to (1) provide supplementary data to support GLOMAR CHALLENGER scientists in achieving the scientific objectives of their particular cruise, and in addition to serve as a mechanism for contributions to the *Initial Reports;* (2) provide individual investigators with materials that are stored with samples for reference and comparison purposes.

The National Science Foundation has established a Sample Distribution Panel to advise on the distribution of core materials. 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 cores and their contents. Funding for the proposed research must be secured separately by the investigator. It cannot be provided through the Deep Sea Drilling Project.

The Deep Sea Drilling Project's Curator is responsible for distributing the samples and controlling their quality, as well as preserving and conserving core material. He also is responsible for maintaining a record of all samples that have been distributed, shipboard and subsequent, indicating the recipient and the nature of the proposed investigation. This information is made available to all investigators of DSDP materials as well as to other interested researchers on request.

The distribution of samples is made directly from one of the two existing repositories, Lamont-Doherty Geological Observatory and Scripps Institution of Oceanography, by the Curator or his designated representative.

1. *Distribution of Samples for Research Leading to Contributions to Initial Reports*

Any investigator who wishes to contribute a paper to a given volume of the *Initial Reports* may write to the Chief Scientist, Deep Sea Drilling Project (A-031), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A., requesting samples from a forthcoming cruise. Requests for a specific cruise should be received by the Chief Scientist two months in advance of the departure of the cruise in order to allow time for the review and consideration of all requests and to establish a suitable shipboard sampling program. The request should include a statement of the nature of the study proposed, size and approximate number of samples required to complete the study, and any particular sampling technique or equipment that might be required. The requests will be reviewed by the Chief Scientist of the Project and the cruise co-chief scientists; approval will be given in accordance with the scientific requirements of the cruise as determined by the appropriate JOIDES advisory panel(s). If approved, the requested samples will be taken, either by the shipboard party if the workload permits or by the curatorial staff shortly following the return of the cores to the repository. Proposals must be of a scope to ensure that samples can be processed and a contribution completed in time for publication in the *Initial Reports*. Except for rare, specific instances involving ephemeral properties, sampling will not exceed one-quarter of the volume of core recovered, with no interval being depleted and one-half of all core being retained as an archive. Shipboard sampling shall not exceed approximately 100 igneous samples per investigator; in all cases co-chief scientists are requested to keep sampling to a minimum.

The co-chief scientists may elect to have special studies of selected core samples made by other investigators. In this event the names of these investigators and complete listings of all materials loaned or distributed must be forwarded, if possible prior to the cruise or as soon as possible following the cruise, to the Chief Scientist through the DSDP Staff Science Representative for that particular cruise. In such cases, all requirements of the Sample Distribution Policy shall also apply.

If a dispute arises or if a decision cannot be reached in the manner prescribed, the NSF Sample Distribution Panel will conduct the final arbitration.

Any publication of results other than in the *Initial Reports* within twelve (12) months of the completion of the cruise must be approved and authored by the whole shipboard party and, where appropriate, shore-based investigators. After twelve months, individual investigators may submit related papers for open publication provided they have submitted their contributions to the *Initial Reports*. A paper too late for inclusion in the *Initial Reports* for a specific cruise may not be published elsewhere until publication of that *Initial Reports* for which it was intended. Notice of submission to other journals and a copy of the article should be sent to the DSDP Staff Science Representative for that leg.

*Revised October 1976

2. *Distribution of Samples for Research Leading to Publication Other Than in Initial Reports*

A. Researchers intending to request samples for studies beyond the scope of the *Initial Reports* should first obtain sample request forms from the Curator, Deep Sea Drilling Project (A-031), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A. On the forms the researcher is requested to specify the quantities and intervals of the core required, make a clear statement of the proposed research, state time required to complete and submit results for publication, and specify the status of funding and the availability of equipment and space foreseen for the research.

In order to ensure that all requests for highly desirable but limited samples can be considered, approval of requests and distribution of samples will not be made prior to 2 months after publication of the Initial Core Descriptions (I.C.D.). ICD's are required to be published within 10 months following each cruise. The only exceptions to this policy will be for specific instances involving ephemeral properties. Requests for samples can be based on the Initial Core Descriptions, copies of which are on file at various institutions throughout the world. Copies of original core logs and data are kept on open file at DSDP and at the Repository at Lamont-Doherty Geological Observatory, Palisades, New York. Requests for samples from researchers in industrial laboratories will be handled in the same manner as those from academic organizations, with the sample obligation to publish results promptly.

B. (1) The DSDP Curator is authorized to distribute samples to 50 ml per meter of core. Requests for volumes of material in excess of this amount will be referred to the NSF Sample Distribution Panel for review and approval. Experience has shown that most investigations can be accomplished with samples 10 ml or smaller. All investigators are encouraged to be as judicious as possible with regard to sample size and, especially, frequency within any given core interval. The Curator will not automatically distribute any parts of the cores which appear to be in particularly high demand; requests for such parts will be referred to the Sample Distribution Panel for review. Requests for samples from thin layers or important stratigraphic boundaries will also require Panel review.

(2) If investigators wish to study certain properties which may deteriorate prior to the normal availability of the samples, they may request that the normal waiting period not apply. All such requests must be reviewed by the Curator and approved by the NSF Sample Distribution Panel.

C. 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 A). If a sample request is dependent, either wholly or in part, on proposed funding, the Curator is prepared to 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.

D. Investigators receiving samples are responsible for:

(1) publishing significant results; contributions shall not be submitted for publication prior to 12 months following the termination of the appropriate leg;

(2) acknowledging, in publications, that samples were supplied through the assistance of the U.S. National Science Foundation and others as appropriate;

(3) submitting five (5) copies (for distribution to the Curator's file, the DSDP repositories, the GLOMAR CHALLENGER's library, and the National Science Foundation) of all reprints of published results to the Curator, Deep Sea Drilling Project (A-031), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, U.S.A.;

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

E. Cores are made available at repositories for investigators to examine and to specify exact samples in such instances as may be necessary for the scientific purposes of the sampling, subject to the limitations of B (1 and 2) and D, above, with specific permission of the Curator or his delegate.

F. Shipboard-produced smear slides of sediments and thin sections of indurated sediments, igneous, and metamorphic rocks will be returned to the appropriate repository at the end of each cruise or at the publication of the *Initial Reports* for that cruise. These smear slides and thin sections will form a reference collection of the cores stored at each repository and may be viewed at the respective repositories as an aid in the selection of core samples.

3. *Reference Centers*

As a separate and special category, samples will be distributed for the purpose of establishing up to five reference centers where paleontologic materials will be available for reference and comparison purposes. The first of these reference centers has been approved at Basel, Switzerland.

Data Distribution Policy

Data gathered on board D/V *Glomar Challenger* and in DSDP shore laboratories are available to all researchers 12 months after the completion of each cruise. The files are part of a coordinated computer database, fully searchable and coordinated to other files. Data sets representing a variety of geologic environments can be arranged for researchers who may wish to manipulate the database directly.

Most data requests are filled free of charge, except if they are unusually large or complex and direct costs exceed $50.

When data are used for publication, the National Science Foundation must be acknowledged and DSDP provided with five reprints for inclusion in the DSDP index of publications and investigations. Requests for data should be submitted to:

Data Manager, Deep Sea Drilling Project
Scripps Institution of Oceanography (A-031)
University of California, San Diego
La Jolla, California 92093

Telephone: (714) 452-3526
Cable Address: SIOCEAN

I. The database includes files generally available both in digital form on magnetic tape and as microfilm copies of the original observation forms.

A. Geophysical data include underway bathymetry, magnetics, and sub-bottom profiles; bathymetry data exist both as 12-kHz and 3.5-kHz records. Underway data are processed by DSDP and the Geological Data Center at Scripps Institution of Oceanography (SIO). Seismic records are available in microfilm and photographic prints.

B. Physical property data obtained on board *Glomar Challenger* include:
   - Analytical water content, porosity, and density
   - Density and porosity by Gamma Ray Attenuation Porosity Evaluator (GRAPE)
   - Acoustic velocity by Hamilton Frame Method
   - Thermal conductivity
   - Heat flow (*in situ*)
   - Natural gamma radiation (discontinued after Leg 19)
   - Well logs

C. Sediment data obtained on board ship and from core samples in DSDP shore laboratories include:
   - Core photographs
   - Visual core descriptions
   - Smear slide descriptions
   - X-ray diffraction
   - X-ray fluorescence
   - Total carbon, organic carbon, and carbonate determinations
   - Grain-size determinations (sand, silt, clay)
   - Interstitial water chemistry
   - Gas chromatography

D. Igneous rock data include:
   - Core photographs
   - Visual core descriptions
   - Rock chemistry
   - Paleomagnetics
   - Thin-section descriptions

E. Paleontologic data include fossil names, abundance, preservation, and age of sample and are available, for selected sites, for Tertiary and Mesozoic taxa. Range charts can be generated from the database, using the line printer. A glossary of fossil names is available on microfiche or magnetic tape.

F. Ancillary files include:
   Site positions
   Sub-bottom depths of cores
   Master Guide File (a searchable core data summary file)

II. Additional publications, aids to research, are periodically updated and distributed to libraries. Single copies, at no charge, are distributed on microfiche at 48X magnification, except for the Data Datas (C, opposite), which are at 24X. They include:

A. Guides to DSDP Core Materials, a series of printed summaries containing maxima, minima, and typical values for selected observations. Guides are available for each of the major ocean basins and for Phases I, II, and III of the drilling program. The source data summary file is also available.

B. Index to Initial Reports and Subsequent Publications and Investigations is a comprehensive key word index to chapters of the *Initial Reports* and to papers and investigations in progress which cite DSDP samples or data. The Index and its annotated bibliography serve to inform researchers of other investigators working on similar projects. Each paper is assigned key words for field of study, material, geographic area, and geologic age. A complete citation, including the assigned key words, is printed in the bibliography. Key words are permuted to form a comprehensive cross-index to the author reference list.

C. Data Data, a series of informal memoranda providing a quick reference to accessible data, is available on microfiche. Also available is a site position map to assist researchers in large-area studies. (Site positions are plotted on a bathymetry map compiled by the SIO Geologic Data Center.)

D. Data Retrieval and Application Computer Programs to perform data management and retrieval functions and a set of programs designed to provide special graphic displays of data are available; they may be of limited use because of differences in computer hardware. All current programs are written in ALGOL for a Burroughs 7800 computer system. Software inquiries may be addressed to the Data Manager.

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ACKNOWLEDGMENTS

Leg 61 was originally planned to drill a single hole in the Nauru Basin, in order to sample Jurassic sediments on 148-m.y.-old crust generated at a fast-spreading ridge crest. What appeared to be a straightforward leg turned out to be a very complex one, because of surprising geologic findings. Instead of going from Guam to Site 462 to Majuro in 45 days, the cruise went from Guam to Site 462 to Majuro for a crew and partial scientist exchange to Site 462 to Majuro; the cruise lasted 59 days.

For coping with surprises, lost drill cones, and extensions, we wish to thank the crew of the *Glomar Challenger*, the engineers and drillers of Global Marine, and the DSDP technicians group, so ably led by G. Bode. To Captains Joseph Clarke and Loyd Dill, who accomplished a record 15 re-entries, we owe a debt of thanks. To Mr. Arkie Slayton of the Midway Fishing Tool Company, we owe special thanks for milling up a lost cone and thereby saving the hole. At the Majuro port call we had to leave behind for two weeks most of the Leg 62 crew who could not take part in the extension; for their patience in waiting on Majuro we have only praise. They are E. Vincent, A. Boersma, R. Schmidt, C. Adelseck, W. Dean, V. Koporulin, C. Sancetta, and A. Schaaf. Finally, to Mary Young, Janice Bowman, and Nancy Durham of the DSDP Production Department, we extend thanks for their expertise and patience in the publication of the *Initial Reports*.