Bound for more than two years of drilling, Legs 54 through 70, the *Challenger* departs the California coast.
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 LIX
covering Leg 59 of the cruises of the Drilling Vessel Glomar Challenger
Naha, Okinawa to Apra, Guam
February–March 1978

PARTICIPATING SCIENTISTS
Loren Kroenke, Robert Scott,
Kathy Balshaw, Simon Brassell, Pierre Chotin,
Mary E. Heiman, Teruaki Ishii, Barbara H. Keating,
Erlend Martini, David P. Mattey, Kelvin Rodolfo, Renzo Sartori,
Fritz Theyer, John L. Usher, and Guram Zakariadze

STAFF SCIENCE REPRESENTATIVE
John L. Usher

EDITOR
Susan Orlofsky

Prepared for the
NATIONAL SCIENCE FOUNDATION
National Ocean Sediment Coring Program
Under Contract C-482
By the
UNIVERSITY OF CALIFORNIA
Scripps Institution of Oceanography
Prime Contractor for the Project
This material is based upon research supported by the National Science Foundation under Contract No. C-482.

Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

It is recommended that reference to whole or part of this volume be made in one of the following forms, as appropriate:


Effective Publication Dates of DSDP Initial Reports

According to the International Code of Zoological Nomenclature, the date of publication of a work and of a contained name or statement affecting nomenclature is the date on which the publication was mailed to subscribers, placed on sale, or, when the whole edition is distributed free of charge, mailed to institutions and individuals to whom free copies are distributed. The mailing date, not the printed date, is the correct one.

Mailing dates of the more recent Initial Reports of the Deep Sea Drilling Project are as follows:

Volume 47 — Part 1, September, 1979
Part 2, November, 1979
Volume 48 — August, 1979
Volume 49 — March, 1979
Volume 50 — June, 1980
Volume 51, 52, 53 — Part 1, January, 1980
Part 2, February, 1980
Volume 58 — August, 1980

Printed January 1981

Library of Congress Catalog Number 74—603338

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402
Foreword

For the three and one-half years between 1872 and 1876, the H.M.S. CHALLENGER—after which D/V GLOMAR CHALLENGER is named—undertook the world’s first major oceanographic expedition. It is fitting that our century should have its counterpart to that famous ship a century ago whose voyages helped establish oceanography as a science. It is equally fitting that GLOMAR CHALLENGER should be plying the same waters one century later seeking answers to new questions concerning the history of our planet and the life it supports. The fundamental advancement of our knowledge of the earth will lead to enhanced capabilities to understand its processes and to use 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 is conducted under the auspices of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). The JOIDES consortium has convened advisory panels for that purpose, consisting of a large number of distinguished scientists from the academic institutions, government agencies, and private industry of many countries. Altogether, the Project has involved the active interest and participation of many of the world’s best scientists and technologists.

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, and Mediterranean Sea, and Antarctic waters, 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.

From these concepts came major interpretations of the results of the drilling as they bear on patterns of sedimentation and physical and chemical characteristics of the ancient oceans.

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 36 months of drilling, allowing GLOMAR CHALLENGER to continue operations throughout the oceans of the world in exploring the deep ocean floors for a period presently extending one full decade. Scientific interest will involve major effort in drilling deeply into the oceanic crustal igneous rocks to study the processes and mechanisms leading to the formation of the oceanic crust.

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 importance of the work of the Deep Sea Drilling Project and D/V GLOMAR CHALLENGER is internationally recognized. In response to this recognition, a number of nations are providing partial support. Effective January 1974, the USSR and the Federal Republic of Germany entered into agreements with the United States for participation and support. Similar arrangements were agreed to by Japan in July 1975, the United Kingdom in September 1975, and France in January 1976.

All people, in their lives, activities, and industry, should benefit greatly from the Project—from the technological advances that are being made and through the information being obtained on natural resources.

Richard C. Atkinson
Director

Washington, D.C.
October 1976
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 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. xix) 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

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

Bundesanstalt für Geowissenschaften und Rohstoffe,
Federal Republic of Germany

University of California at San Diego,
Scripps Institution of Oceanography

Centre National pour l'Exploitation des Océans,
Paris

Columbia University, Lamont-Doherty Geological
Observatory

University of Hawaii, Hawaii Institute of
Geophysics

University of Miami, Rosenstiel School of
Marine and Atmospheric Science

Natural Environment Research Council,
London

Oregon State University, School of
Oceanography

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.

OPERATING INSTITUTION:

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

DEEP SEA DRILLING PROJECT

Dr. W. A. Nierenberg
Principal Investigator

Dr. M. N. A. Peterson
Project Manager

Mr. Frank C. MacTernan
Principal Engineer and
Deputy Project Manager

Dr. Yves Lancelot
Chief Scientist

Dr. Matthew H. Salisbury
Associate Chief Scientist for
Science Operations

Dr. John L. Usher
Associate Chief Scientist for
Science Services

Dr. William R. Riedel
Curator

Mr. Valdemar Larson
Project Development Engineer

Mr. Barry Robson
Operations Manager

Mr. William T. Soderstrom
Finance Administrator

Mr. Robert Olivas
Logistics Officer

Mr. Robert S. Bower
Contracts Officer

Ms. Sue Strain
Personnel Officer
Participants aboard
GLOMAR CHALLENGER for Leg Fifty-Nine

Dr. Loren Kroenke
Co-Chief Scientist
Hawaii Institute of Geophysics
University of Hawaii at Manoa
Honolulu, Hawaii 96822

Dr. Robert Scott
Co-Chief Scientist
Department of Geology
Texas A&M University
College Station, Texas 77843

Ms. Kathy Balshaw
Sedimentologist
Department of Geology
Rice University
Houston, Texas 77001

Mr. Simon Brassell
Organic Geochemist
School of Chemistry
University of Bristol
Bristol BS8 1TS
United Kingdom

Dr. Pierre Chotin
Physical Properties Specialist
Laboratoire de Structurale Géologie
Pierre et Marie Curie Université
4, place Jussieu
75230 Paris Cedex 05
France

Ms. Mary E. Heiman
Paleontologist (foraminifers)
Stratigraphy Laboratory
Mobil Oil Company
P.O. Box 900
Dallas, Texas 75221

Dr. Teruaki Ishii
Igneous Petrologist
Ocean Research Institute
University of Tokyo
Nakano, Tokyo 164
Japan

Dr. Barbara H. Keating
Paleomagnetist
Hawaii Institute of Geophysics
University of Hawaii at Manoa
Honolulu, Hawaii 96822

Professor Dr. Erland Martini
Paleontologist (nannofossils)
Geologisch-Paläontologisches Institut
Johann-Wolfgang-Goethe-Universität
D-6000 Frankfurri am Main
Federal Republic of Germany

Dr. David P. Mattey
Igneous Petrologist
Department of Geology
Bedford College
University of London
Regents Park
London NW1 4NS
United Kingdom

Dr. Kelvin Rodolfo
Sedimentologist
Laboratorio di Geologia Marina
Consiglio Nazionale delle Richerche
Zamboni 65
40127 Bologna
Italy

Dr. Renzo Sartori
Sedimentologist
Department of Geological Sciences
University of Illinois
P.O. Box 4348
Chicago, Illinois 60680

Dr. Fritz Theyer
Paleontologist (radiolarians)
Hawaii Institute of Geophysics
University of Hawaii at Manoa
Honolulu, Hawaii 96822

Dr. John L. Usher
Sedimentologist and Shipboard Science Representative
Deep Sea Drilling Project, A-031
Scripps Institution of Oceanography
La Jolla, California 92039

Dr. Guram S. Zakariadze
Igneous Petrologist
Janelidze Institute of Geology
Academy of Science of Georgian S.S.R.
Tbilisi
U.S.S.R.
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Glen Foss</td>
<td>Cruise Operations Manager</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. Melvin Fields</td>
<td>Weatherman</td>
<td>NOAA—National Weather Service</td>
<td>439 West York Street, Norfolk, Virginia 23510</td>
</tr>
<tr>
<td>Captain Joseph A. Clarke</td>
<td>Captain of the Drilling Vessel</td>
<td>Global Marine, Inc.</td>
<td>Los Angeles, California 90017</td>
</tr>
<tr>
<td>Mr. James Ruddell</td>
<td>Drilling Superintendent</td>
<td>Global Marine, Inc.</td>
<td>Los Angeles, California 90017</td>
</tr>
<tr>
<td>Mr. Michael Lehman</td>
<td>Laboratory Officer</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Ms. Kathleen O’Neill</td>
<td>Curatorial Representative</td>
<td>Lamont-Doherty Geological Observatory</td>
<td>Palisades, New York 10964</td>
</tr>
<tr>
<td>Mr. John Rutherford</td>
<td>Chemist</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. Robert Bongard</td>
<td>Electronics Technician</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. Burnette Hamlin</td>
<td>Marine Technician</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. William Jurel</td>
<td>Marine Technician</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. James Prescott</td>
<td>Marine Technician</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Mr. William Brennan</td>
<td>Photographer</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
<tr>
<td>Ms. Cindy Deen</td>
<td>Yeoperson</td>
<td>Deep Sea Drilling Project, A-031</td>
<td>Scripps Institution of Oceanography, La Jolla, California 92093</td>
</tr>
</tbody>
</table>

**Deep Sea Drilling Project Publication Staff**

- **Publications Manager**
  - Marianna Lee

- **Editors**
  - Susan Orlofsky
  - Robert Powell
  - James Shambach
  - Larry N. Stout

- **Production Manager**
  - Raymond F. Silk

- **Production Assistants**
  - Elaine M. Bruer
  - Madeleine A. Mahnken

- **Production Coordinators**
  - Mary A. Young
  - Janice E. Bowman

- **Art-Photo Supervisor**
  - Virginia L. Roman

- **Illustrators**
  - Myrta Anagnostopoulos
  - Tommy F. Hilliard (this volume)
  - Elizabeth R. Peters (this volume)
  - Kathleen Sanderson
  - Alice N. Thompson
JOIDES Advisory
Groups

Executive Committee
Dr. Maurice Rattray, Jr.
University of Washington
Professor Dr. F. Bender
Bundesanstalt für Geowissenschaften und Rohstoffe
Dr. John V. Byrne
Oregon State University
Dr. William W. Hay
Rosenstiel School of Marine and Atmospheric Science
Dr. Charles E. Heiby
Hawaii Institute of Geophysics
Sir Peter Kent, F. R. S.
Natural Environment Research Council
Dr. John A. Knauss
University of Rhode Island
Monsieur Yves La Prairie
C.N.E.X.O.
Dr. Ryuzo Marumo
University of Tokyo
Dr. William A. Nierenberg
Scripps Institution of Oceanography
Dr. Worth D. Nowlin, Jr.
Texas A&M University
Dr. M. N. A. Peterson (ex-officio)
Scripps Institution of Oceanography
Academician A. V. Sidorenko
Academy of Sciences of the U.S.S.R.
Dr. John Steele
Woods Hole Oceanographic Institution
Dr. Manik Talwani
Lamont-Doherty Geological Observatory

Planning Committee
Dr. Joe S. Creager
University of Washington
Dr. Helmut Beiersdorf
Bundesanstalt für Geowissenschaften und Rohstoffe
Dr. William R. Bryant
Texas A&M University
Dr. J. Dymond
Oregon State University
Dr. C. G. A. Harrison
Rosenstiel School of Marine and Atmospheric Science
Dr. Dennis E. Hayes
Lamont-Doherty Geological Observatory
Dr. James R. Heitzler
Woods Hole Oceanographic Institution

Dr. Anthony S. Laughton
Institute of Oceanographic Sciences
Dr. Xavier LePichon
C.N.E.X.O.
Dr. Ralph Moberly
Hawaii Institute of Geophysics
Dr. David G. Moore (ex-officio)
Scripps Institution of Oceanography
Dr. T. C. Moore, Jr.
University of Rhode Island
Dr. Noriyuki Nasu
University of Tokyo
Dr. L. Nikitin
Academy of Sciences of the U.S.S.R.
Dr. William Riedel (ex-officio)
Scripps Institution of Oceanography
Dr. E. L. Winterer
Scripps Institution of Oceanography

Advisory Panel on Sedimentary Petrology
and Physical Properties
Dr. A. Richards
Lehigh University
Dr. R. Bennett
NOAA
Mr. R. E. Boyce (ex-officio)
Scripps Institution of Oceanography
Dr. William R. Bryant (ex-officio)
Texas A&M University
Dr. S. E. Calvert
Institute of Oceanographic Sciences
Dr. C. J. Clausen
Norges Geotekniske Institutt
Dr. J. Conolly
Era North America Inc.
Dr. John W. Handin
Texas A&M University
Dr. G. DeVries Klein
University of Illinois
Dr. Frédéric Mélières
Université Pierre et Marie Curie
Dr. G. Müller
Laboratorium für Sedimentforschung, Heidelberg
Dr. O. H. Pilkey
Duke University
Dr. P. O. Timofeev
Academy of Sciences of the U.S.S.R.
Advisory Panel on Organic Geochemistry
Dr. Keith Kvenvolden
U.S. Geological Survey
Dr. Earl W. Baker
Florida Atlantic University
Dr. Ellis E. Bray
Mobil Oil Company, Inc.
Dr. Geoffrey Eglinton (ex-officio)
University of Bristol
Dr. J. Gordon Erdman
Phillips Petroleum Company
Dr. Eric M. Galimov
Academy of Sciences of the U.S.S.R.
Dr. John M. Hunt
Woods Hole Oceanographic Institution
Dr. John W. Kendrick
Shell Development Company
Dr. Erwin Suess
Oregon State University
Dr. B. Tissot
Institut Français du Pétrole
Dr. Dietrich Welte
Lehrstuhl für Geologie, Geochemie, und Lagerstatten
des Erdöls und der Kohle
Mr. Oscar Weser (ex-officio)
Scripps Institution of Oceanography
Dr. E. L. Winterer (ex-officio)
Scripps Institution of Oceanography

Advisory Panel on Pollution Prevention
and Safety
Dr. Louis E. Garrison
U.S. Geological Survey
Dr. George Claypool
U.S. Geological Survey
Dr. Joe S. Creager (ex-officio)
University of Washington
Dr. Joseph R. Curray
Scripps Institution of Oceanography
Dr. H. Grant Goodell
University of Virginia
Dr. Arthur E. Green
Exxon Production Research Company
Dr. Brian T. R. Lewis (ex-officio)
University of Washington
Dr. A. Mayer-Gurr
Eichhaiderstrasse 79/3, Urach
Dr. G. A. Pommier
Compagnie Français des Pétroles
Dr. Maurice Rattray, Jr. (ex-officio)
University of Washington
Dr. E. Vekilov
Ministry of Geology, U.S.S.R.
Dr. Roland von Huene
U.S. Geological Survey
Mr. Oscar E. Weser
Scripps Institution of Oceanography

Advisory Panel on Information Handling
Dr. M. A. Rosenfeld
Woods Hole Oceanographic Institution
Dr. D. W. Appleman
Smithsonian Institution
Mr. J. G. Barr
Standard Oil Company of California
Dr. Joe S. Creager (ex-officio)
University of Washington
Dr. H. Glashoff
Bundesanstalt für Geowissenschaften und Rohstoffe
Dr. A. Loeblich, Jr.
University of California, Los Angeles
Dr. M. S. Loughridge
NOAA
Dr. J. Usher (ex-officio)
Scripps Institution of Oceanography
Dr. V. V. Zdorovenin
Academy of Sciences of the U.S.S.R.
Industrial Liaison Panel
Mr. W. A. Roberts
Phillips Petroleum Company
Mr. R. L. Adams
Continental Oil Company
Professor Vsevolod V. Fedynskiy
Ministry of Geology of the U.S.S.R.
Mr. Melvin J. Hill
Gulf Oil Corporation
Dr. Ing. Guenter Peterson
Deutsche Schachtbau und Tiefbohrgesellschaft mbH
Monsieur Gilbert Rutman
Société Nationale des Pétroles d’Aquitaine
Mr. G. Williams
United Kingdom Offshore Operators Association, Ltd.

Advisory Panel on Ocean Crust
Dr. J. R. Cann
University of East Anglia
Dr. J. L. Bischoff
U.S. Geological Survey
Dr. N. A. Bogdanov
Academy of Sciences of the U.S.S.R.
Dr. Paul J. Fox
State University of New York at Albany
Dr. Jean Francheteau
C.N.E.X.O.
Dr. J. M. Hall
Dalhousie University
Dr. C. G. A. Harrison (ex-officio)
Rosenstiel School of Marine and Atmospheric Science
Dr. James R. Heirtzler (ex-officio)
Woods Hole Oceanographic Institution
Dr. E. D. Jackson*
U.S. Geological Survey
Dr. Roger L. Larson
Lamont-Doherty Geological Observatory
Dr. James H. Natland (ex-officio)
Scripps Institution of Oceanography
Dr. John Orcutt
Scripps Institution of Oceanography
Dr. M. Ozima
University of Tokyo
Dr. H. U. Schmincke
Ruhr-Universität, Bochum
Dr. M. Treuil
Institut Physique du Globe

Advisory Panel on Ocean Margin (Active)
Dr. Roland von Huene
U.S. Geological Survey
Dr. Michael Audley-Charles
Royal School of Mines, London
Dr. René Blanchet
Université de Bretagne Occidentale
Dr. Creighton Burk
University of Texas, Austin
Dr. Joe S. Creager (ex-officio)
University of Washington
Dr. W. R. Dickinson
University of Arizona
Dr. D. M. Hussong
Hawaii Institute of Geophysics
Dr. Daniel Karig
Cornell University
Dr. Kazuo Kobayashi
University of Tokyo
Dr. I. P. Kosminskaya
Academy of Sciences of the U.S.S.R.
Dr. Keith Kvenvolden (ex-officio)
U.S. Geological Survey
Dr. David G. Moore (ex-officio)
Scripps Institution of Oceanography
Dr. James H. Natland (ex-officio)
Scripps Institution of Oceanography
Dr. H. W. Walther
Bundesanstalt für Geowissenschaften und Rohstoffe
Dr. A. Watts
Lamont-Doherty Geological Observatory

Advisory Panel on Ocean Margin (Passive)
Dr. Joseph A. Curray
Scripps Institution of Oceanography
Dr. Helmut Beiersdorf (ex-officio)
Bundesanstalt für Geowissenschaften und Rohstoffe
Professor Dr. D. Bernoulli
Geologisch-Palaontologisches Institut, Basel
Dr. William R. Bryant (ex-officio)
Texas A&M University
Mr. John I. Ewing
Lamont-Doherty Geological Observatory
Mr. John A. Grow
U.S. Geological Survey
Dr. K. Hinz
Bundesanstalt für Geowissenschaften und Rohstoffe
Dr. John M. Hunt (ex-officio)
Woods Hole Oceanographic Institution
Dr. H. Kagami
University of Tokyo

*Deceased
Dr. L. Montadert  
*Institut Français du Pétrole*

Dr. David G. Moore (ex-officio)  
*Scripps Institution of Oceanography*

Dr. D. G. Roberts  
*Institute of Oceanographic Sciences*

Professor Dr. E. Seibold  
*Universität Kiel*

Dr. Robert E. Sheridan  
*University of Delaware*

Dr. S. Snelson  
*Shell Development Company*

Dr. J. Thiede  
*Universitetet Oslo*

Dr. P. R. Vail  
*Exxon Production Research Company*

Dr. S. Zverev  
*Academy of Sciences of the U.S.S.R.*

**Advisory Panel on Ocean Paleoenvironment**

Dr. Yves Lancelot  
*C.N.E.X.O.*

Dr. Wolfgang Berger  
*Scripps Institution of Oceanography*

Dr. G. Eglinton (ex-officio)  
*University of Bristol*

Dr. Kenneth Hsü  
*Eidg. Technische Hochschule, Zurich*

Dr. James C. Ingle  
*Stanford University*

Dr. Hugh C. Jenkyns  
*University of Oxford*

Dr. A. P. Lisitzin  
*Academy of Sciences of the U.S.S.R.*

Dr. T. C. Moore, Jr.  
*University of Rhode Island*

Dr. I. O. Murdmaa  
*Academy of Sciences of the U.S.S.R.*

Dr. Michael Sarnthein  
*Universität Kiel*

Dr. N. Shackleton  
*University of Cambridge*

Mr. W. V. Sliter  
*U.S. Geological Survey*

Dr. Y. Takayanagi  
*Tohoku University*

Dr. H. Thierstein  
*Scripps Institution of Oceanography*

Dr. J. Usher (ex-officio)  
*Scripps Institution of Oceanography*

Dr. E. L. Winterer (ex-officio)  
*Scripps Institution of Oceanography*

**Advisory Panel on Site Surveying**

Dr. Brian T. R. Lewis  
*University of Washington*

Dr. A. Beresnev  
*Institute of Physics of the Earth*

Dr. Elizabeth T. Bunce  
*Woods Hole Oceanographic Institution*

Dr. LeRoy M. Dorman  
*Scripps Institution of Oceanography*

Dr. Edgar S. Driver  
*Gulf Science and Technology Company*

Dr. Davis A. Fahlquist  
*Texas A&M University*

Dr. Dennis E. Hayes (ex-officio)  
*Lamont-Doherty Geological Observatory*

Dr. Donald M. Hussong  
*Hawaii Institute of Geophysics*

Dr. Ralph Moberly (ex-officio)  
*Hawaii Institute of Geophysics*

Dr. Shozaburo Nagumo  
*University of Tokyo*

Dr. Vince Renard  
*Centre Océanologique de Bretagne*

Dr. Roland Schlich  
*Observatoire Géophysique du Parc St.-Maur*

Dr. Gunter Stober  
*Deutsche Erdölversorgungsgesellschaft mbH, Essen*

Dr. Roland von Huene  
*U.S. Geological Survey*

Dr. Joel Watkins  
*University of Texas, Austin*

Dr. S. White (ex-officio)  
*Scripps Institution of Oceanography*

**Stratigraphic Correlations Panel**

Dr. R. H. Benson  
*Smithsonian Institution*

Dr. W. A. Berggren  
*Woods Hole Oceanographic Institution*

Professor Dr. H. M. Bolli  
*Eidg. Technische Hochschule, Zürich*

Dr. D. Bukry  
*U.S. Geological Survey*

Dr. P. Čepek  
*Bundesanstalt für Geowissenschaften und Rohstoffe*

Dr. R. G. Douglas  
*University of Southern California*

Dr. Stefan Gartner  
*Texas A&M University*

Dr. S. R. Hammond  
*Hawaii Institute of Geophysics*
Dr. C. G. A. Harrison (ex-officio)
Rosenstiel School of Marine and Atmospheric Sciences

Dr. N. Hughes
Sedgwick Museum, Cambridge

Dr. V. Krasheninnikov
Academy of Sciences of the U.S.S.R.

Dr. W. R. Riedel
Scripps Institution of Oceanography

Dr. J. B. Saunders
Naturhistorisches Museum, Basel

Dr. J. L. Usher (ex-officio)
Scripps Institution of Oceanography

Downhole Measurements Panel

Dr. R. Hyndman
Victoria Geophysical Observatory

Dr. Heinz Beckmann
Technische Universität Clausthal

Dr. N. Christensen
University of Washington

Dr. James R. Heirtzler (ex-officio)
Woods Hole Oceanographic Institution

Dr. A. H. Jageler
Amoco Production Research Company

Dr. Yuri Neprochnov
Academy of Sciences of the U.S.S.R.

Dr. A. Richards
Lehigh University

Dr. O. Serra
ELF-ERAP

Mr. J. R. Severns
McCulloh Oil Corporation
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 xix
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.
## CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACKNOWLEDGMENTS</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>PART I: INTRODUCTION, SITE REPORTS...</strong></td>
<td>3</td>
</tr>
<tr>
<td>1. INTRODUCTION: SCIENTIFIC OBJECTIVES AND EXPLANATORY NOTES, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>5</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
<tr>
<td>2. SITE 447: EAST SIDE OF THE WEST PHILIPPINE BASIN</td>
<td>21</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
<tr>
<td>3. SITE 448: PALAU-KYUSHU RIDGE</td>
<td>111</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
<tr>
<td>4. SITE 449: WEST SIDE OF THE PARECE VELA BASIN</td>
<td>321</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
<tr>
<td>5. SITE 450: EAST SIDE OF THE PARECE VELA BASIN</td>
<td>355</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
<tr>
<td>6. SITE 451: EAST EDGE OF THE WEST MARIANA RIDGE</td>
<td>405</td>
</tr>
<tr>
<td>Shipboard Scientific Party</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PART II: GEOPHYSICS AND TECTONICS, PALEONTOLOGY, SEDIMENTOLOGY, GEOCHEMISTRY AND PETROLOGY</strong></td>
<td>485</td>
</tr>
<tr>
<td><strong>SECTION A: GEOPHYSICS AND TECTONICS</strong></td>
<td>515</td>
</tr>
<tr>
<td>7. GEOPHYSICAL SURVEYS FOR LEG 59 SITES, DEEP SEA DRILLING PROJECT</td>
<td>487</td>
</tr>
<tr>
<td>Marcus G. Langseth and Cary L. Mrozowski</td>
<td></td>
</tr>
<tr>
<td>8. STRUCTURAL ANALYSIS OF SELECTED LEG 59 CORES, DEEP SEA DRILLING PROJECT</td>
<td>503</td>
</tr>
<tr>
<td>M. Friedman and M. A. White</td>
<td></td>
</tr>
<tr>
<td>9. MICROSTRUCTURES IN SEMI-CONSOLIDATED SEDIMENTS OF DEEP SEA DRILLING PROJECT LEG 59 (PHILIPPINE SEA TRANSECT) AND THEIR RELATION TO REGIONAL TECTONIC SETTING</td>
<td>509</td>
</tr>
<tr>
<td>Pierre Chotin</td>
<td></td>
</tr>
<tr>
<td><strong>SECTION B: PALEONTOLOGY</strong></td>
<td>545</td>
</tr>
<tr>
<td>14. OLIGOCENE TO RECENT CALCAREOUS NANNOPLANKTON FROM THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>547</td>
</tr>
<tr>
<td>Erlend Martini</td>
<td></td>
</tr>
<tr>
<td>15. OLIGOCENE TO QUATERNARY FORAMINIFERS FROM THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>567</td>
</tr>
<tr>
<td>Mary E. Heiman</td>
<td></td>
</tr>
<tr>
<td>16. RADIOLARIAN BIOSTRATIGRAPHY OF THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>581</td>
</tr>
<tr>
<td>F. Theyer and P. Lineberger</td>
<td></td>
</tr>
<tr>
<td>17. SYNTHESIS OF OLIGOCENE TO QUATERNARY BIOSTRATIGRAPHY OF THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>587</td>
</tr>
<tr>
<td>Erlend Martini, Mary E. Heiman, and Fritz Theyer</td>
<td></td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>SECTION C: SEDIMENTOLOGY</td>
<td>595</td>
</tr>
<tr>
<td>18. CENOZOIC CLAY-MINERAL STRATIGRAPHY IN THE SOUTH PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>597</td>
</tr>
<tr>
<td>Katherine M. Balshaw</td>
<td></td>
</tr>
<tr>
<td>19. TECTONIC, VOLCANIC, AND SEDIMENTOLOGIC SIGNIFICANCE OF VOLCANIC GLASSES FROM SITE 450 IN THE EASTERN PARECE VELA BASIN, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>603</td>
</tr>
<tr>
<td>Kelvin S. Rodolfo and Russell J. Warner</td>
<td></td>
</tr>
<tr>
<td>20. TECTONIC SIGNIFICANCE OF THE SEDIMENTARY COLUMN AT SITE 449 (WESTERN PARECE VELA BASIN), DEEP SEA DRILLING PROJECT LEG 59</td>
<td>609</td>
</tr>
<tr>
<td>Renzo Sartori</td>
<td></td>
</tr>
<tr>
<td>21. MINERALOGY OF ALTERED BASAL VOLCANICLUSTIC SEDIMENTS AT SITES 447 (WEST PHILIPPINE BASIN) AND 450 (PARECE VELA BASIN), DEEP SEA DRILLING PROJECT LEG 59</td>
<td>615</td>
</tr>
<tr>
<td>Renzo Sartori and Luciano Tomadin</td>
<td></td>
</tr>
<tr>
<td>22. SEDIMENTOLOGIC SUMMARY: CLUES TO ARC VOLCANISM, ARC SUndering, AND BACK-ARC SPREADING IN THE SEDIMENTARY SEQUENCES OF DEEP SEA DRILLING PROJECT LEG 59</td>
<td>621</td>
</tr>
<tr>
<td>Kelvin S. Rodolfo</td>
<td></td>
</tr>
<tr>
<td>SECTION D: GEOCHEMISTRY AND PETROLOGY</td>
<td>625</td>
</tr>
<tr>
<td>23. INTERSTITIAL WATER STUDIES, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>627</td>
</tr>
<tr>
<td>Joris M. Gieskes and Jeff Johnson</td>
<td></td>
</tr>
<tr>
<td>24. ISOTOPIC COMPOSITION OF OXYGEN, CARBON, AND SULFUR IN INTERSTITIAL WATER AND CORES FROM DEEP SEA DRILLING PROJECT LEG 59</td>
<td>631</td>
</tr>
<tr>
<td>A. A. Migdisov, V. M. Belyi, V. A. Grinenko, Yu. P. Girin, M. A. Kiselevsky, and G. S. Zakariadze</td>
<td></td>
</tr>
<tr>
<td>25. GEOCHEMISTRY OF CARBON: DEEP SEA DRILLING PROJECT LEGS 58 AND 59</td>
<td>641</td>
</tr>
<tr>
<td>Karl S. Schorno</td>
<td></td>
</tr>
<tr>
<td>26. ORGANIC GEOCHEMICAL STUDIES OF TWO SAMPLES FROM HOLES 447A AND 448 FROM DEEP SEA DRILLING PROJECT LEG 59</td>
<td>647</td>
</tr>
<tr>
<td>S. C. Brassell and G. Eglinton</td>
<td></td>
</tr>
<tr>
<td>27. METALLOGENESIS IN THE PARECE VELA MARGINAL BASIN COMPLEX OF THE PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>649</td>
</tr>
<tr>
<td>Martha R. Scott and George W. Bolger</td>
<td></td>
</tr>
<tr>
<td>28. NEUTRON ACTIVATION ANALYSIS OF RARE EARTH ELEMENTS AND SOME OTHER TRACE ELEMENTS IN VOLCANIC ASHES AND PELAGIC CLAYS, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>653</td>
</tr>
<tr>
<td>29. PETROLOGY OF BASALTS OF HOLES 447A, 449, AND 450, SOUTH PHILIPPINE SEA TRANSECT, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>669</td>
</tr>
<tr>
<td>G. S. Zakariadze, L. V. Dmitriev, A. V. Sobolev, and N. M. Suschevskaya</td>
<td></td>
</tr>
<tr>
<td>30. PETROLOGY AND GEOCHEMISTRY OF ARC THOLEIITES ON THE PALAU-KYUSHU RIDGE, SITE 448, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>681</td>
</tr>
<tr>
<td>Robert B. Scott</td>
<td></td>
</tr>
<tr>
<td>31. PYROXENE GEOTHERMOMETRY OF BASALTS AND AN ANDESITE FROM THE PALAU-KYUSHU AND WEST MARIANA RIDGES, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>693</td>
</tr>
<tr>
<td>Teruaki Ishii (Appendix: &quot;Data on Major-Element Compositions of DSDP Leg 59 Tholeiitic Basalt, Calc-Alkalic Andesite, and Glass Obtained by Wet Chemical Analysis, XRF, and EPMA Methods,&quot; by Teruaki Ishii and Hiroshi Haramura)</td>
<td></td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>32. CHEMICAL AND SR-ISOTOPIC COMPOSITION OF IGNEOUS ROCKS FROM DEEP SEA DRILLING PROJECT LEGS 59 AND 60</td>
<td>719</td>
</tr>
<tr>
<td>Richard Lee Armstrong and Graham T. Nixon</td>
<td></td>
</tr>
<tr>
<td>33. K/Ar and $^{40}\text{Ar}/^{39}\text{Ar}$ DATING OF BASALTIC ROCKS FROM DEEP SEA DRILLING PROJECT LEG 59</td>
<td>729</td>
</tr>
<tr>
<td>John F. Sutter and Lawrence W. Snee</td>
<td></td>
</tr>
<tr>
<td>34. ALTERED ROCKS FROM DEEP SEA DRILLING PROJECT LEG 59</td>
<td>735</td>
</tr>
<tr>
<td>Andrew Hajash</td>
<td></td>
</tr>
<tr>
<td>35. ALTERATION OF REMNANT ARC DEBRIS, SITE 448, PALAU-KYUSHU RIDGE, PHILIPPINE SEA, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>737</td>
</tr>
<tr>
<td>Jeffrey B. Aldrich, Thomas T. Tieh, and Robert B. Scott</td>
<td></td>
</tr>
<tr>
<td>36. A GEOCHEMICAL STUDY OF 17 SELECTED SAMPLES FROM THE BASEMENT CORES RECOVERED AT SITES 447, 448, 449, 450, AND 451, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>743</td>
</tr>
<tr>
<td>37. THE GEOCHEMISTRY, MINERALOGY, AND PETROLOGY OF BASALTS FROM THE WEST PHILIPPINE AND PARECE VELA BASINS AND FROM THE PALAU-KYUSHU AND WEST MARIANA RIDGES, DEEP SEA DRILLING PROJECT LEG 59</td>
<td>753</td>
</tr>
<tr>
<td>David P. Mattey, Nicholas G. Marsh, and John Tarney</td>
<td></td>
</tr>
<tr>
<td>PART III: SYNTHESIS</td>
<td>801</td>
</tr>
<tr>
<td>38. EVOLUTION OF THE SOUTH PHILIPPINE SEA: DEEP SEA DRILLING PROJECT LEG 59 RESULTS</td>
<td>803</td>
</tr>
<tr>
<td>Robert B. Scott, Loren Kroenke, Guram Zakariadze, and Anatoli Sharaskin</td>
<td></td>
</tr>
<tr>
<td>INDEX</td>
<td>817</td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENTS

Three years of planning by the JOIDES Active Margin Panel, Ocean Crust Panel, and Planning Committee resulted in a proposed transect of drill sites, aligned more or less along the 18th parallel, designed to investigate each major basin and ridge between the central part of the West Philippine Sea and the Mariana Trench and the Pacific Ocean plate immediately to the east. Deep Sea Drilling Project Legs 59 and 60 were designated to do the study. We wish to express our gratitude to the individuals serving on those panels during the planning stages and to all other individuals and institutions who contributed to the preparation for Leg 59; the success of the leg was greatly due to their efforts.

Acknowledgment is made to John Tarney in whose laboratories at the Department of Geological Sciences, University of Birmingham, the preliminary X-ray fluorescent data was determined. We also gratefully acknowledge Dr. J. P. Beckmann (Swiss Federal Institute of Technology, Zürich, Switzerland) for his identification of the larger foraminifers recovered at Site 451.

Much of the success of Leg 59 is to be credited to the crew of the Glomar Challenger under Captain Joseph Clarke, to the engineers and drillers of Global Marine, and to our Cruise Operations Manager, Glen Foss. To the marine technicians under Lab Officer Mike Lehman we express sincere thanks for their untiring efforts and consistent good humor.

We are most grateful to members of the DSDP Editing and Production Department, in particular Susan Orlofsky, editor, and artists Tommy Hilliard and Lisa Peters, whose conscientious efforts and professionalism made this a volume of superior editorial and illustrative quality.

Finally, we also are indebted to Sally Walker, who generously spent considerable time and effort proofing the text and tables of the volume.