

Examples of visual similarity at two Site 610 holes. A. Correlation lines were picked at prominent contacts between layers of different color or lithology, such as the light-to-dark color contrast in the middle of Section 610B-9-1. B. Correlation of glacial (dark) and interglacial (light) intervals from sediment wave crest to wave trough on the Feni Sediment Drift. The beds were correlated using a combination of visual observations and biostratigraphic and paleomagnetic correlations (Ruddiman, Clement, and Cameron, this volume). Note the high resolution of correlation between crest and trough holes as well as the pelagic nature of sedimentation (Kidd and Hill, this volume). Few sedimentary structures indicating significant current transport were observed at either Feni or Gardar Drift sites.

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 XCIV, Part 1

covering Leg 94 of the cruises of the Drilling Vessel Glomar Challenger Norfolk, Virginia, to St. John's, Newfoundland June-August 1983

PARTICIPATING SCIENTISTS

William F. Ruddiman, Robert B. Kidd, Jack G. Baldauf, Bradford M. Clement, James F. Dolan, Margaret R. Eggers, Philip R. Hill, Lloyd D. Keigwin, Jr., Margie Mitchell, Isabelle Philipps, Frank Robinson, Sassan A. Salehipour, Toshiaki Takayama, Ellen Thomas, Gerhard Unsold, and Philip P. E. Weaver

SHIPBOARD SCIENCE REPRESENTATIVE

Ellen Thomas

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 the whole or to part of this volume be made in one of the following forms, as appropriate:

Ruddiman, W. F., Kidd, R. B., Thomas, E., et al., 19. Init. Repts. DSDP, 94: Washington (U.S. Govt. Printing Office).

Thomas, E., 19. Late Oligocene to Recent benthic foraminifers from Deep Sea Drilling Project Sites 608 and 610, northeastern North Atlantic. *In* Ruddiman, W. F., Kidd, R. B., Thomas, E., et al., *Init. Repts. DSDP*, 94: Washington (U.S. Govt. Printing Office), ____.

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 83—April, 1985 Volume 84—May, 1985 Volume 85—October, 1985 Volume 86—November, 1985 Volume 87—June, 1986 Volume 90—January, 1986

Printed January 1987

Library of Congress Catalog Card Number 74-603338

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

Foreword

The world's first major oceanographic expedition took place between 1872 and 1876. This expedition, aboard the H.M.S. Challenger covering nearly 70,000 nautical miles and gathering oceanographic data from 362 stations, expanded our knowledge of the ocean and provided a solid foundation for future studies in marine geology. A century later, another vessel also named Challenger continued to expand our knowledge of the world's ocean and helped revolutionize our concepts of how the seafloor and the continents form and change. The drilling vessel Glomar Challenger sailed 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 is leading to a greater understanding of our planet and more intelligent use of its resources.

Since 1968, the Deep Sea Drilling Project (DSDP) has been supported by the National Science Foundation, primarily through a contract with the University of California which, in turn, subcontracted to Global Marine Incorporated for the services of the D/V Glomar Challenger.

Through contracts with Joint Oceanographic Institutions, Inc. (JOI, Inc.), the National Science Foundation supported the scientific advisory structure for the project and funded predrilling geophysical site surveys. Scientific planning was conducted under the auspices of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). The JOIDES advisory group consisted of over 250 members who made up 24 committees, panels, and working groups. The members were distinguished scientists from academic institutions, government agencies, and private industry all over the world.

In 1975, the International Phase of Ocean Drilling (IPOD) began. The IPOD member nations, Federal Republic of Germany, Japan, United Kingdom, Soviet Union, and France, partially supported the project. Each member nation actively participated in the scientific planning of the project through membership in JOIDES. Scientists from these countries also took part in the field work aboard the D/V *Glomar Challenger* and postcruise 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 seafloor 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.

Technological advances have provided new tools which in turn have opened new dimensions of scientific discovery. The introduction of the Hydraulic Piston Corer in 1979 permitted virtually undisturbed cores of soft sediment layers to be obtained. This technological advance has greatly enhanced the ability of scientists to study ancient ocean environments, as recorded by sediment characteristics and flora and fauna preserved in these deposits.

A second major advance has been the use of the hole after drilling. The project routinely log-

ged holes and performed geophysical and geochemical studies before, during, and after drilling. Long-term downhole geophysical seismic monitoring devices have been implanted successfully in DSDP holes. These new listening devices and geophysical studies have provided valuable information about the origin and nature of the dynamic processes of plate tectonics.

These reports contain the results of the initial studies of the recovered core material and the associated geophysical information. All the world's people benefit either directly or indirectly from this fundamental research. Knowledge about past and present conditions and processes are the foundations for future predictions and developments. Both short- and long-term benefits are obtained by advances in drilling technology and instrumentation. Information is being obtained about the origin and geographic distribution of natural resources. Just as the H.M.S. Challenger had a profound impact on scientific thought for over a century, this second Challenger expedition has given a greater understanding of the oceans and the processes that form and shape the earth.

Erich Bloch, Director

Washington, D.C.

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, 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 Natural Environment Research Council of the United Kingdom, the University of Tokyo of Japan, and 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 shorebased 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):¹

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 Sciences²

Woods Hole Oceanographic Institution

University of Texas at Austin

¹ Includes member organizations during time of cruise.

² This institution and its committees and panel members were noncontributing members of JOIDES at time of 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. M. N. A. Peterson Principal Investigator Project Manager

Mr. Robert S. Bower Assistant Project Manager for Administration and Contracts

Dr. Yves Lancelot Chief Scientist

Mr. Ed Dean Finance Administrator

Ms. Sue Strain Personnel Officer

Participants aboard GLOMAR CHALLENGER for Leg Ninety-four

Dr. William F. Ruddiman Co-Chief Scientist Lamont-Doherty Geological Observatory Palisades, New York 10964

Dr. Robert B. Kidd Co-Chief Scientist Institute of Oceanographic Sciences Wormley, Godalming Surrey GU8 5UB United Kingdom

Dr. Jack G. Baldauf Paleontologist (diatoms) Paleontology and Stratigraphy Branch U.S. Geological Survey Menlo Park, California 94025

Mr. Bradford M. Clement Paleomagnetist Lamont-Doherty Geological Observatory Palisades, New York 10964

Dr. James F. Dolan Sedimentologist Department of Earth Sciences University of California, Santa Cruz, Santa Cruz, California 95060

Ms. Margaret R. Eggers Sedimentologist Department of Geology University of South Carolina Columbia, South Carolina 29208

Dr. Philip R. Hill Sedimentologist Atlantic Geoscience Centre Geological Survey of Canada Bedford Institute of Oceanography Dartmouth, Nova Scotia Canada B2Y 4A2

Dr. Lloyd D. Keigwin, Jr. Sedimentologist Department of Geology and Geophysics Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543 Ms. Margie Mitchell Paleontologist (radiolarians) Geological Research Division Scripps Institution of Oceanography La Jolla, California 92093

Dr. Isabelle Philipps Sedimentologist Laboratoire de Géologie et Océanographie Université de Bordeaux I 33605 Talence Cedex France

Mr. Frank Robinson Sedimentologist Lamont-Doherty Geological Observatory Palisades, New York 10964

Mr. Sassan A. Salehipour Physical Properties Specialist Ocean Engineering No. 2 University of Rhode Island Kingston, Rhode Island 02882

Dr. Toshiaki Takayama Paleontologist (nannofossils) Department of Geology Kanazawa University Kanazawa 920 Japan

Dr. Ellen Thomas Paleontologist (foraminifers)/Staff Science Representative Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Dr. Gerhard Unsold Sedimentologist Geologisch-Paläontologisches Institut Universität Kiel D-2300 Kiel Federal Republic of Germany Dr. Philip P. E. Weaver Paleontologist (foraminifers) Institute of Oceanographic Sciences Wormley, Godalming Surrey GU8 5UB United Kingdom

Mr. Don Cameron Cruise Operations Manager Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Mr. Melvin Fields Weatherman Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Captain Joseph A. Clarke Master of the Drilling Vessel Global Marine Drilling Co. San Diego, California 92111

Mr. Howard P. Guillot Drilling Superintendent Global Marine Drilling Co. San Diego, California 92111

Mr. Burnette W. Hamlin Laboratory Officer Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Mr. James Pine Chemist Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Ms. Paula Weiss Curatorial Representative Deep Sea Drilling Project-ECR Lamont-Doherty Geological Observatory Palisades, New York 10964

Mr. William Meyer Computer Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Randy Current **Electronics** Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Tom Haldeman Marine Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Craig Hallman Marine Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Will Sooter Marine Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Tom Witte Marine Technician Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Mr. Victor Sotelo Photographer Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093 Ms. Barbara Long Yeoperson Deep Sea Drilling Project Scripps Institution of Oceanography La Jolla, California 92093

Deep Sea Drilling Project Publications Staff

Publications Manager Jan H. Blakeslee

Editors Susan Orlofsky Katie L. Turner Production Manager Mary A. Young

Próduction Assistants Patricia Duley Madeleine A. Mahnken

Production Coordinator Carolina Bertling Art-Photo Supervisor Virginia L. Roman

Illustrators Aileen Bobryk Vicki Cypherd Kathleen Sanderson (this volume) Alice N. Thompson

JOIDES Advisory Groups¹

Executive Committee Dr. D. James Baker, Jr. University of Washington Prof. Dr. Friedrich Bender Bundesanstalt für Geowissenschaften und Rohstoffe Dr. Alan Berman, Chairman Rosenstiel School of Marine and Atmospheric Sciences Dr. Bernard Biju-Duval Centre National pour l'Exploitation des Océans Dr. John C. Bowman Natural Environment Research Council Dr. G. Ross Heath Oregon State University Dr. Charles E. Helsley Hawaii Institute of Geophysics Dr. Jose Honnorez (ex-officio Planning Committee Representative) Rosenstiel School of Marine and Atmospheric Science Dr. John A. Knauss University of Rhode Island Dr. Arthur Maxwell University of Texas at Austin Dr. Noriyuki Nasu University of Tokyo Dr. William A. Nierenberg Scripps Institution of Oceanography Dr. Melvin N. A. Peterson (ex-officio) Scripps Institution of Oceanography Dr. Barry Raleigh Lamont-Doherty Geological Observatory Dr. Robert D. Reid Texas A&M University Dr. Alexander V. Sidorenko U.S.S.R. Academy of Sciences Dr. John Steele Woods Hole Oceanographic Institution **Planning Committee** Dr. Jean Aubouin Université Pierre et Marie Curie Dr. Helmut Beiersdorf Bundesanstalt für Geowissenschaften und Rohstoffe Dr. William R. Bryant Texas A&M University Dr. Richard Buffler University of Texas at Austin

¹ Membership at time of cruise.

Dr. Joe R. Cann University of Newcastle-upon-Tyne Dr. Joe S. Creager University of Washington Dr. Dennis E. Haves Lamont-Doherty Geological Observatory Dr. Jose Honnorez, Chairman Rosenstiel School of Marine and Atmospheric Science Dr. James P. Kennett University of Rhode Island Dr. Kazuo Kobayashi University of Tokyo Dr. Yves Lancelot (ex-officio) Scripps Institution of Oceanography Dr. Ralph Moberly Hawaii Institute of Geophysics Dr. Lev Nikitin U.S.S.R. Academy of Sciences Dr. Hans Schrader Oregon State University Dr. Richard P. Von Herzen Woods Hole Oceanographic Institution Dr. Edward L. Winterer Scripps Institution of Oceanography **Advisory Panel on Sedimentary Petrology** and Physical Properties Dr. Richard Bennett National Oceanic and Atmospheric Administration Mr. Robert E. Boyce (ex-officio) Scripps Institution of Oceanography Dr. Richard Carlson Texas A&M University Dr. Walter E. Dean, Jr. U.S. Geological Survey Dr. George deVries Klein, Chairman University of Illinois, Urbana Dr. Leland Kraft McClelland Engineers, Inc.

- Dr. Michael T. Ledbetter University of Georgia, Athens Dr. I. Nick McCave
- University of East Anglia
- Dr. Frédéric Mélières Université Pierre et Marie Curie
- Dr. Ralph Moberly (ex-officio) Hawaii Institute of Geophysics

Dr. Gregory Mountain Lamont-Doherty Geological Observatory Dr. Peter Rothe Universität Mannheim Dr. Peter P. Timofeev U.S.S.R. Academy of Sciences

Advisory Panel on Organic Geochemistry

Dr. Earl W. Baker *Florida Atlantic University*Dr. Miriam Baltuck (ex-officio) *Scripps Institution of Oceanography*Dr. Simon C. Brassell

University of Bristol Dr. Egon T. Degens

Universität Hamburg

Dr. Eric Galimov U.S.S.R. Academy of Sciences

- Dr. John M. Hunt Woods Hole Oceanographic Institution
- Dr. Keith A. Kvenvolden U.S. Geological Survey

Dr. Philip A. Meyers University of Michigan

Dr. Hans Schrader (ex-officio) Oregon State University

Dr. Bernd R. T. Simoneit, Chairman Oregon State University

Advisory Panel on Information Handling

Dr. Daniel E. Appleman, Chairman Smithsonian Institution Dr. Joe S. Creager (ex-officio)

University of Washington

Dr. John C. Hathaway U.S. Geological Survey

Dr. Alfred Loeblich, Jr. University of California, Los Angeles

Dr. Michael S. Loughridge National Oceanic and Atmospheric Administration

Dr. Marthe Melguen Bureau National des Données Océaniques

Dr. Russell Merrill (ex-officio) Scripps Institution of Oceanography

Mrs. Judit Nowak Bundesanstalt für Geowissenschaften und Rohstoffe Dr. John B. Saunders Naturhistorisches Museum Basel Dr. Valery V. Zdorovenin

U.S.S.R. Academy of Sciences

Industrial Liaison Panel

Mr. R. L. Adams Conoco Inc. Prof. Nikolai P. Budnikov Ministry of Geology of the U.S.S.R.
Mr. Melvin J. Hill Gulf Oil Exploration and Production Company
Dr. Ing. Guenter Peterson Gewerkschaft Walter
Mr. W. A. Roberts, Chairman Energy Concepts, Inc.
Dr. Gilbert Rutman Société Nationale des Pétroles d'Aquitaine
Mr. G. Williams United Kingdom Offshore Operators Association, Ltd.

Advisory Panel on Ocean Crust

Dr. Roger N. Anderson Lamont-Doherty Geological Observatory
Dr. Henri Bougault Centre Océanologique de Bretagne (CNEXO)
Dr. John R. Delaney

University of Washington

Dr. Donald Elthon University of Houston

- Prof. Dr. Rolf Emmermann Universität Giessen
- Dr. Kenneth C. MacDonald University of California, Santa Barbara

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

Dr. James Natland (ex-officio) Scripps Institution of Oceanography

Dr. Minoru Ozima University of Tokyo

Dr. Paul Robinson, Chairman Dalhousie University

Dr. Hans Schouten Woods Hole Oceanographic Institution

Dr. Ralph Stephen Woods Hole Oceanographic Institution Dr. John Tarney

University of Leicester

Dr. Andrei A. Tsvetkov U.S.S.R. Academy of Sciences

Advisory Panel on Ocean Margin (Active)

Dr. Peter F. Barker University of Birmingham

Dr. Jean-Paul Cadet Université d'Orleans

Dr. William Coulbourn (ex-officio) Scripps Institution of Oceanography

Dr. Darrell Cowan University of Washington

Dr. Joe S. Creager (ex-officio) University of Washington Dr. Yury I. Dmitriev U.S.S.R. Academy of Sciences Dr. Dennis E. Hayes (ex-officio) Lamont-Doherty Geological Observatory Dr. Donald M. Hussong, Chairman Hawaii Institute of Geophysics Dr. Daniel Karig Cornell University Dr. John W. Ladd Lamont-Doherty Geological Observatory Dr. Kazuaki Nakamura University of Tokyo Dr. Roland von Huene U.S. Geological Survey Dr. Hansjust Walther Bundesanstalt für Geowissenschaften und Rohstoffe Advisory Panel on Ocean Margin (Passive) Dr. Mikhail E. Artemiev U.S.S.R. Academy of Sciencies Dr. Arnold H. Bouma Gulf Science and Technology Company Dr. William R. Bryant (ex-officio) Texas A&M University Dr. Karl Hinz Bundesanstalt für Geowissenschaften und Rohstoffe Dr. Hideo Kagami University of Tokyo Dr. Charlotte Keene Geological Survey of Canada Dr. Yves Lancelot (ex-officio) Scripps Institution of Oceanography Dr. Lucien Montadert Institut Français du Pétrole Dr. David G. Roberts, Chairman British Petroleum Co., Ltd. Dr. William B. F. Ryan Lamont-Doherty Geological Observatory Dr. Sigmund Snelson Shell Oil Company Dr. Jørn Thiede Universiteit I Oslo Dr. Brian E. Tucholke Woods Hole Oceanographic Institution Dr. Peter R. Vail Exxon Production Company Dr. Jan E. van Hinte Vrije Universiteit

Dr. Edward L. Winterer (ex-officio) Scripps Institution of Oceanography Advisory Panel on Pollution Prevention and Safety Dr. Nikolai J. Beliv Ministry of Gas Industry, U.S.S.R. Dr. Rustum Jean Byramjee Compagnie Français des Pétroles Dr. George Claypool U.S. Geological Survey Dr. Louis E. Garrison, Chairman U.S. Geological Survey Dr. Arthur E. Green EXXON Production Research Laboratory Dr. Jose Honnorez (ex-officio) Rosenstiel School of Marine and Atmospheric Science Prof. A. J. Horn Atherton, California Dr. Ernst Hotz Deminex, Essen, Federal Republic of Germany Dr. Yves Lancelot (ex-officio) Scripps Institution of Oceanography Dr. David B. MacKenzie Marathon Oil Company Dr. Geoffrey D. Taylor British Petroleum Company, Ltd. **Advisory Panel on Inorganic Geochemistry** Dr. Miriam Baltuck (ex-officio) Scripps Institution of Oceanography Dr. Stephen E. Calvert University of British Columbia Dr. Joe R. Cann (ex-officio) University of Newcastle-upon-Tyne Dr. Henry Elderfield University of Leeds Dr. Michael Hoffert Université de Bretagne Occidentale Dr. Miriam Kastner, Chairman Scripps Institution of Oceanography Dr. Margaret Leinen University of Rhode Island Dr. Igor D. Ryabchikov U.S.S.R. Academy of Sciences Dr. Sam Savin Case Western Reserve University Dr. Fred L. Sayles Woods Hole Oceanographic Institution Dr. Hubert Staudigel Lamont-Doherty Geological Observatory

Dr. Karl-Heinz Wedepohl Universität Göttingen

Stratigraphic Correlations Panel

Dr. Ivan Basov U.S.S.R. Academy of Sciences Dr. Lloyd H. Burckle Lamont-Doherty Geological Observatory

Dr. James P. Kennett (ex-officio) University of Rhode Island

Prof. Dr. Erlend Martini Universität Frankfurt

Dr. Richard Z. Poore, Chairman U.S. Geological Survey

Dr. Ellen Thomas (ex-officio) Scripps Institution of Oceanography

Downhole Measurements Panel

Dr. Keir Becker (ex-officio) Scripps Institution of Oceanography

Dr. William R. Bryant (ex-officio) Texas A&M University

Dr. Nikolas I. Christensen University of Washington

Dr. Timothy J. G. Francis Natural Environment Research Council

Dr. Roy Hyndman Department of Energy, Mines and Resources, British Columbia

Mr. Alfred H. Jageler Amoco Production Research Company

Dr. Reinhard Jung Bundesanstalt für Geowissenschaften und Rohstoffe

Dr. Hajimu Kinoshita Chiba University

Dr. Mark Mathews Los Alamos National Laboratory

Dr. Yury Neprochnov U.S.S.R. Academy of Sciences

Dr. Lev Nikitin (ex-officio) U.S.S.R. Academy of Sciences

Dr. Vincent Renard Centre National pour l'Exploitation des Océans

Dr. Richard P. Von Herzen, Chairman Woods Hole Oceanographic Institution

Advisory Panel on Ocean Paleoenvironment

Dr. Michael Arthur, Chairman University of South Carolina, Columbia

Dr. Helmut Beiersdorf (ex-officio) Bundesanstalt für Geowissenschaften und Rohstoffe Dr. Hervé Chamley Université des Sciences et Techniques de Lille Dr. Robert G. Douglas University of Southern California Dr. Dieter Fütterer Universität Kiel Dr. Robert E. Garrison University of California, Santa Cruz Dr. James D. Hays Lamont-Doherty Geological Observatory Dr. James P. Kennett (ex-officio) University of Rhode Island Dr. Robert B. Kidd Natural Environment Research Council Dr. Theodore C. Moore, Jr. EXXON Production Research Company Dr. Seymour O. Schlanger Northwestern University Dr. Yokichi Takayanagi Tohoku University Dr. Fritz Theyer Hawaii Institute of Geophysics Dr. Ellen Thomas (ex-officio) Scripps Institution of Oceanography Dr. Peter P. Timofeev U.S.S.R. Academy of Sciences Advisory Panel on Site Surveying Dr. Helmut Beiersdorf (ex-officio) Bundesanstalt für Geowissenschaften und Rohstoffe Mr. Carl Brenner (ex-officio) Lamont-Doherty Geological Observatory Dr. Fred Duennebier Hawaii Institute of Geophysics Dr. Dennis Hayes (ex-officio) Lamont-Doherty Geological Observatory Dr. E. John W. Jones, Chairman University College of London Dr. Shozaburo Nagumo University of Tokyo Dr. Vincent Renard Centre Océanologique pour l'Exploitation des Océans Dr. Matthew Salisbury (ex-officio) Scripps Institution of Oceanography Dr. Alexander A. Schreider U.S.S.R. Academy of Sciences Dr. Wilfried Weigel Universität Hamburg

SAMPLE DISTRIBUTION POLICY*

Distribution of Ocean Drilling Program and of Deep Sea Drilling Project samples is undertaken in order to (1) provide support to shipboard scientists in achieving the scientific objectives of their cruise, and support shorebased investigators who are preparing contributions to DSDP and ODP reports; (2) provide individual investigators with materials to conduct detailed studies beyond the scope of ODP reports; (3) provide paleontological reference centers with samples for reference and comparison purposes; and (4) provide educators with samples for teaching purposes.

Funding for sample-related activities must be secured by the investigator independently of requesting the samples.

The Ocean Drilling Program Curator is responsible for distributing samples and for preserving and conserving core material. The Curator, who may accept advice from chairmen of the appropriate JOIDES advisory panels, is responsible for enforcing the provisions of this sample distribution policy. He is responsible for maintaining a record of all samples that have been distributed, both onboard ship and subsequently from the repositories, indicating the recipients and the nature of investigations proposed. This information is available to interested investigators on request.

Every sample distributed from the ship or from a repository is labeled with a standard identifier, which includes leg number, hole number, core and section numbers, and interval within the section from which the sample was removed. It is imperative that this standard identifier be associated with all data reported in the literature, and that residues of the sample remain labeled throughout their lives, so that later workers can relate the data to the cores.

Distribution of sample materials is made directly from the repositories (Lamont-Doherty Geological Observatory, Scripps Institution of Oceanography, or Texas A&M University) by the Curator or his designated representative.

1. Distribution of Samples for Research Leading to Contributions to ODP Reports

Any investigator who wishes to contribute to the reports of a scheduled cruise may write to the Curator, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A., in order to request samples from that cruise. Requests for a specific cruise must be received by the Curator at least TWO MONTHS in advance of the departure of that cruise, in order to allow time for the review of the request in conjunction with other requests, so that a suitable shipboard sampling program can be assembled. The request should include a statement of the nature of the proposed research, size and approximate number of samples required to complete the study, and any particular sampling technique or equipment which may be required. Requests will be reviewed by the staff representative and co-chief scientists of the cruise and by the Curator. Approval/disapproval will be based upon the scientific requirements of the cruise as determined by the appropriate JOIDES advisory panel(s). The scope of a request must be such that samples can be processed, that proposed research can be completed, and that the paper can be written in time for submission to the relevant ODP cruise report.

Except for rare, specific instances involving ephemeral properties, the total volume of samples removed during a cruise-related sampling program will not exceed one-quarter of the volume of core recovered, and no interval will be depleted. One-half of all recovered materials will be retained in the archives in as pristine a condition as is practicable. Investigators requesting shipboard samples of igneous materials may receive a maximum of 100 igneous samples per cruise.

Because many sample requests are received for shipboard work and because the time of the shipboard party is at a premium, co-chief scientists are strongly urged to limit shipboard sampling to the minimum necessary to accomplish the cruise objectives. Shorebased investigators whose requests for cruise-related samples are approved should expect that they will receive the samples after the cores are returned to the repository, and should schedule research activities accordingly.

Co-chief scientists may invite investigators who are not cruise participants to perform special studies of selected core samples in direct support of shipboard activities. If this occurs, the names and addresses of these investigators and details of all samples loaned or distributed to them must be forwarded to the Curator, via the ODP Staff Representative to that cruise, immediately after the cruise. These investigators are expected to contribute to the cruise reports as though they had been cruise participants. All requirements of the Sample Distribution Policy apply.

Any publication of results other than in ODP reports within twelve (12) months of completion of the

^{*}Revised October 1984

cruise must be approved and authored by the whole shipboard party and, where appropriate, shorebased investigators. After twelve months, individual investigators may submit related papers for open publication provided they have already submitted their contributions to ODP reports. Investigations which are not completed in time for inclusion in ODP reports for a specific cruise may be published in a later edition of ODP reports; however, they may not appear in another journal until the ODP report for which they were intended has been published.

- 2. Distribution of Samples for Research Leading to Publication Outside of the DSDP and ODP Reports
 - A. Researchers who wish to use samples for studies beyond the scope of the DSDP or ODP reports should obtain sample request forms from the Curator, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A. Requestors are required to specify the quantities and intervals of core required, to make a clear statement of the nature of the proposed research, to state the time which will be required to complete the work and to submit results for publication, and to specify funding status and the availability of equipment and space for the research.

Additionally, if the requestor has received samples from ODP or from DSDP previously, he/ she will be required to account for the disposition of those samples by citing published works, six (6) copies of which must be sent to the Curator. If no report has been published, this requirement can be fulfilled by sending a brief (two or three page) report of the status of the research. Unused and residual samples should be returned and data should be sent to the Curator if the project has terminated. Paleontological materials may be returned either to the Curator at ODP or to one of the designated paleontological reference centers. If material is returned to a reference center, notify the Curator when it is sent.

Requests for samples from researchers in industrial laboratories will be honored in the same manner as those from academic organizations. Industrial investigators have the same obligations as other investigators to publish all results promptly in the open literature and to provide the Curator with copies of all reports published and of all data acquired in their research.

In order to ensure that all requests for highly desirable but limited samples can be consid-

ered together, approval of requests and distribution of samples will be delayed until twelve (12) months after completion of the cruise or two (2) months after official publication of the core descriptions, whichever occurs earlier. The only exceptions to this policy will be made for specific requests involving ephemeral properties. Requests for samples may be based on core descriptions published in ODP reports produced by the shipboard party, 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 ODP, and at the repositories at Lamont-Doherty Geological Observatory and at Scripps Institution of Oceanography.

B. Most investigations can be accomplished handily with sample volumes of 10 ml or less. Investigators must provide explicit justification of requests for larger sample sizes or for frequent intervals within a core. Requests which exceed reasonable size or frequency limits will require explicit justifications and more time to process, and are unlikely to be granted in their entirety.

Requests for samples from thin layers, from stratigraphically important boundaries, from sections which are badly depleted or in unusually high demand may be delayed in order to coordinate requests from several investigators or while the Curator seeks advice from the community. Investigators who submit such requests may expect to receive suggestions for alternative sampling programs or that they join a research consortium which will share the samples. In any event, such exceptional requests will require more time for processing than will more routine requests.

Investigators who wish to study ephemeral properties may request a waiver of the waiting period; however, such requests will be referred automatically to the relevant co-chiefs. If approved, the investigator will join the shorebased contributors to the shipboard science effort, and will incur the obligations thereof (see section 1).

C. Samples will not be provided until the requestor assures the Curator that funding for the proposed research is available or unnecessary. If a sample request is dependent in any way upon proposed funding, the Curator is prepared to provide the proposed funding organization with information on the availability (or potential availability) of suitable samples.

D. Investigators who receive samples incur the following obligations:

(1) To publish significant results promptly; however, no contribution may be submitted for publication prior to twelve (12) months following the termination of the relevant leg unless it is approved and authored by the entire shipboard party.

(2) To acknowledge in all publications that the samples were supplied through the assistance of the international Ocean Drilling Program and others as appropriate.

(3) To submit six (6) copies of reprints of all published works to the Curator, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A. These reprints will be distributed to the repositories, to the ship, to the National Science Foundation, and to the Curator's reprint file.

(4) To submit all final analytical data obtained from the samples to Data Base Manager, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A. Please consult recent issues of the JOIDES Journal or call (409-845-2673) for information on acceptable data formats. Investigators should be aware that they may have other data obligations under NSF's Ocean Science Data Policy or under relevant policies of other funding agencies which require submission of data to national data centers.

(5) To return all unused or residual samples, in good condition and with a detailed explanation of any processing they may have experienced, upon termination of the proposed research. In particular, all thin sections and smear slides manufactured onboard the vessel or in the repositories are to be returned to the Curator. Paleontological materials may be returned either to the Curator at ODP or to one of the designated paleontological reference centers.

Failure to honor these obligations will prejudice future applications for samples.

E. Cores are available for examination by interested parties at the repositories. Investigators are welcome to visit the repositories in order to inspect cores and to specify sample locations when that is required for their research; however, time and space in the workrooms are limited, so advance appointments are required. Occasionally, the space may be fully booked several weeks in advance, so investigators are urged to call for appointments well ahead in order to avoid disappointment. Only the Curator or his delegate may actually remove samples from the cores.

F. A reference library of thin sections, smear slides, and archive photographs is maintained in the repositories for the use of visting investigators. All thin sections and smear slides produced onboard the ship or in the repositories belong to this library.

3. Distribution of Samples to Paleontological Reference Centers

As a separate and special category of repository activity, selected samples are being distributed to paleontological reference centers, where the prepared material may be studied by visitors. As of this writing (mid-1984), Foraminifera and Calcareous Nannofossils can be viewed; Radiolaria and Diatoms will be prepared in the future. The present centers are Scripps Institution of Oceanography, California (W. R. Riedel, tel. 619-452-4386); Basel Natural History Museum, Switzerland (J. B. Saunders, tel. 061-25.82.82); and New Zealand Geological Survey, Lower Hutt, New Zealand (A. R. Edwards, tel. 699.059). Future centers are likely to include Texas A&M University, College Station, Texas (S. Gartner, tel. 409-845-8479); Smithsonian Institution, Washington, D.C.; Lamont-Doherty Geological Observatory, Palisades, New York; and an as yet undesignated center in Japan.

Further details concerning the paleontological reference centers are reported periodically in the JOIDES Journal.

4. Distribution of Samples for Educational Purposes

Samples may be available in limited quantities to college-level educators for teaching purposes. Interested educators should request application forms from the Curator, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A. Requestors are required to specify preferred sample size and location, to make a very clear statement of the nature of the coursework in which the samples will be used, to explain how the core samples will be prepared and how they will be used in the classroom, to explain in detail why they cannot use similar materials derived from outcrops or dredge hauls (it is NOT acceptable to argue that it requires less effort for the requestor to obtain samples from ODP than to assemble them from other sources), and to certify that funds are available to prepare the materials for classroom use. In general, only samples of materials which are abundant in the collection and which are in little demand for research purposes should be requested for educational purposes. The Curator will not approve requests for materials which are limited in supply or for which demand (real or potential) is great, including most paleontological materials.

5. Distribution of Data

The Deep Sea Drilling Project and the Ocean Drilling Program routinely capture much of the data generated onboard ship and published in Program reports. Additionally, data supplied by investigators who have received samples are incorporated into the data bases, so data sets which are larger than can be published are available to investigators. Magnetics, downhole logging, seismic reflection, bathymetric data, and other data collected by the drilling vessel become available for distribution to investigators at the same time as core samples. At least through mid-1986, DSDP data will continue to be distributed by the Data Base Manager, Deep Sea Drilling Project, A-031, University of California, San Diego, California 92093, U.S.A. A charge will be made to recover expenses in excess of \$50.00 incurred in filling individual requests. If required, estimates of charges can be furnished before the work is performed. As DSDP phases down, DSDP data will be available primarily from the National Geophysical Data Center, Boulder, Colorado.

Requests for ODP data should be addressed to the Data Base Manager, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843-3469, U.S.A. Many varieties of DSDP data will be included in ODP data bases. Information on sources of DSDP data will be available from the ODP Data Base Manager.

CONTENTS

Cha	pter	Page	Cha	pter	Page	
ACKNOWLEDGMENTS		1	6.	SITE 610 Shipboard Scientific Party	351	
PART I: INTRODUCTION AND SITE REPORTS						
1.	INTRODUCTION, BACKGROUND, AND EXPLANATORY NOTES, DEEP SEA		7.	SITE 611 Shipboard Scientific Party	471	
	DRILLING PROJECT LEG 94, NORTH		PAF	PART II: ADDITIONAL DATA REPORTS		
	ATLANTIC OCEAN	. 5				
	Shipboard Scientific Party		8.	SITE SURVEYS OF DEEP SEA DRILLING	503	
2	SITE COC			PROJECT SITES 608, 610, AND 611		
2.	Shipboard Scientific Party	21		C. L. Jacobs		
			9.	MIDDLE EOCENE TO MIOCENE PLANK-		
3.	SITE 607	. 75		TONIC FORAMINIFERS FROM DEEP		
	Shipboard Scientific Party			SEA DRILLING PROJECT SITES 608	22.2	
a.		10 45 51		AND 610, NORTHEASTERN ATLANTIC	605	
4.	SITE 608 Shipboard Scientific Party	149		D. G. Jenkins		
			10.	K-Ar DATES OF DEEP SEA DRILLING		
5.	SITE 609	247		PROJECT SITE 608 BASALTS	613	
	Shipboard Scientific Party			D. E. Seidemann		

ACKNOWLEDGMENTS

This volume exists thanks to the efforts of many people. Robert Douglas and the JOIDES Ocean Paleoenvironment Panel initiated the integration of objectives related to surface-water and deep-water paleoceanography, drift sedimentation, and King's Trough tectonics. Yves Lancelot guided the cruise staffing with a firm and helpful hand.

At sea, Captain Joseph Clarke was as usual very helpful; we are grateful to the captain and his crew for their cooperation and consistent high level of professionalism. Particular thanks go to the rigfloor crew, who were instrumental in recovering high-quality core material that will be a paleoenvironmental research source for years to come. DSDP cruise operations manager Don Cameron aided immeasurably in helping us to understand and overcome the reasons for HPC coring disturbance and under-recovery, and we are proud that the now highly acclaimed Advanced Hydraulic Piston Corer (APC) was successfully tested on Leg 94. The Leg 94 DSDP marine technicians rose superbly to the task of processing nearly two miles of sediment cores. Yeoman Barbara Long is thanked for her steadfast endeavors to ensure that British English got translated into American English, for documentation of the "millionth foot," and for an endless supply of medicinal hugs.

Yves Lancelot deserves two further acknowledgments: for permitting us to keep stowaway Frank Robinson on board when his presence was discovered five days out at sea; and for encouraging us to go "play with the toy" (the *Glomar Challenger* was indeed an impressive tool for research).

We acknowledge Andrew McIntyre for the two liters of memorial scotch, and Vic Sotelo won the gratitude of all but one of the cochiefs for shooting the moon. Thanks also to Captain Clarke for raising everyone's consciousness of World War II operations in the Pacific sector, and for advice on eating habits, exercise, and epidermal damage. Also acknowledged are those special samplers, Peter Schultheiss and Nick Shackleton, who kept us well occupied at sea to no avail.

The co-chiefs especially want to thank DSDP Science Representative Ellen Thomas, who doggedly saw this volume through to completion despite the inconvenience of often absentee co-chiefs and an unscheduled visit to Nova Scotia. Susan Orlofsky handled the editorial chores with care and patience in the difficult period of DSDP wind-down; she was ably assisted by James Shambach and Jan Blakeslee. Thanks for preparing the volume are also due to illustrator Kathleen Sanderson; Carol Bertling, who coordinated the volume; and Mary Young, who handled the production.

And finally we want to thank the following for reviewing manuscripts: J. Abbott, S. K. Addy, J. B. Anderson, M.-P. Aubry, W. Balsam, J. A. Barron, K. R. Bjørklund, A. Berger, W. A. Berggren, J. R. Boles, B. P. Boudreau, J. P. Bujak, D. Bukry, R. Casey, R. Cranston, W. B. Curry, L. J. Doyle, R. D. Flood, J. Flynn, S, Gartner, J. M. Gieskes, D. S. Gorsline, P. C. de Graciansky, N. Hamilton, R. Harland, C. G. A. Harrison, J. Hein, D. Hodell, K. A. Hofmann, C. A. Hollister, J. C. Ingle, J. Imbrie, S. K. Kennedy, W. J. Kennedy, J. P. Kenneth, M. Ledbetter, G. P. Lohmann, T. S. Loutit, J. MacKenzie, I. N. McCave, G. Miller, K. G. Miller, T. C. Moore, C. A. Nigrini, J. P. A. Noble, N. D. Opdyke, J. Orr, N. G. Pisias, C. W. Poag, W. Prell, C. Pujol, P. J. Quinterno, D. G. Roberts, F. Rögl, T. Saito, D. Schnitker, H. Schrader, D. Scott, R. Searle, W. J. Showers, S. Srivastava, J. Stebbins, E. Steurbaut, D. A. V. Stow, J. Sutter, J. Syvitski, L. Tauxe, F. Theyer, R. C. Thunell, D. Williams, C. A. Williams, W. J. Zachariasse, and H. B. Zimmerman.

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 XCIV, Part 2

covering Leg 94 of the cruises of the Drilling Vessel Glomar Challenger Norfolk, Virginia, to St. John's, Newfoundland June-August 1983

PARTICIPATING SCIENTISTS

William F. Ruddiman, Robert B. Kidd, Jack G. Baldauf, Bradford M. Clement, James F. Dolan, Margaret R. Eggers, Philip R. Hill, Lloyd D. Keigwin, Jr., Margie Mitchell, Isabelle Philipps, Frank Robinson, Sassan A. Salehipour, Toshiaki Takayama, Ellen Thomas, Gerhard Unsold, and Philip P. E. Weaver

SHIPBOARD SCIENCE REPRESENTATIVE

Ellen Thomas

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

CONTENTS

Chapter

Page

PART III: STRATIGRAPHY

- PALYNOLOGY AND DINOFLAGELLATE BIOSTRATIGRAPHY OF DEEP SEA DRILLING PROJECT LEG 94, SITES 607 AND 611, NORTH ATLANTIC OCEAN......785 P. J. Mudie

- Chapter 20. MAGNETOBIOSTRATIGRAPHY OF

Page

PART IV: PALEOCEANOGRAPHY

iii

Chapter

Page

- 27. PLIOCENE STABLE-ISOTOPE RECORD OF DEEP SEA DRILLING PROJECT SITE
 606: SEQUENTIAL EVENTS OF ¹⁸O EN-RICHMENT BEGINNING AT 3.1 MA911 L. D. Keigwin
- 29. PALEOCEANOGRAPHIC SIGNIFICANCE OF LATE MIOCENE TO EARLY PLIO-CENE PLANKTONIC FORAMINIFERS AT DEEP SEA DRILLING PROJECT SITE 609...925 P. W. P. Hooper and P. P. E. Weaver

- BENTHIC FORAMINIFERAL CARBON ISOTOPIC RECORDS AND THE DEVEL-OPMENT OF ABYSSAL CIRCULATION IN THE EASTERN NORTH ATLANTIC981 K. G. Miller, R. G. Fairbanks, and E. Thomas

- 35. A STREAMLINED FORAMINIFERAL TRANSFER FUNCTION FOR THE SUB-POLAR NORTH ATLANTIC......1045 W. F. Ruddiman and A. Esmay

PART V: SEDIMENT DRIFTS

- DEEP CIRCULATION IN THE SOUTH-ERN ROCKALL TROUGH—THE OCEAN-OGRAPHIC SETTING OF SITE 610.....1061 R. R. Dickson and R. B. Kidd
- 37. CHARACTERISTICS OF SEDIMENTS FROM FENI AND GARDAR DRIFTS, SITES 610 AND 611, DEEP SEA DRILL-ING PROJECT LEG 94.....1075 P. R. Hill
- 38. THE MAGNETIC FABRIC OF NEOGENE AND QUATERNARY SEDIMENTS ON THE FENI AND GARDAR DRIFTS, NORTHEASTERN ATLANTIC, DEEP SEA DRILLING PROJECT SITES 610 AND 611...1083 E. A. Hailwood, R. B. Kidd, and L. Dowling

PART VI: KING'S TROUGH STUDIES

43. CHALK SOLUTION STRUCTURES IN CORES FROM DEEP SEA DRILLING PROJECT LEG 941129 P. R. Hill

Chapter

Chapter

PART VII: SYNTHESES

- 46. MAGNETOSTRATIGRAPHIC AND BIO-STRATIGRAPHIC SYNTHESIS, DEEP SEA DRILLING PROJECT LEG 94.....1159 J. G. Baldauf, E. Thomas, B. Clement, T. Takayama, P. P. E. Weaver, J. Backman, G. Jenkins, P. J. Mudie, and M. J. Westberg-Smith

BACK POCKET FOLDOUTS:

- CHAPTER 49: FIGURE 3. GLORIA SONOGRAPH MOSAIC OF THE KING'S TROUGH COMPLEX.
- CHAPTER 49: FIGURE 4. BATHYMETRY OF KING'S TROUGH IN CORRECTED METERS SHOWING THE LOCATIONS OF DETAILED DREDGE AND ROCK CORE SAMPLING AT KING'S TROUGH AXIS AND PALMER RIDGE AND OF DRILLING AT SITE 608.

v