

PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 135 SCIENTIFIC RESULTS LAU BASIN

Covering Leg 135 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Suva Harbor, Fiji, to Honolulu, Hawaii, Sites 834-841,
17 December 1990-28 February 1991

James W. Hawkins, Lindsay M. Parson, James F. Allan,
Niels Abrahamsen, Ulrich Bednarz, Gerard Blanc, Sherman H. Bloomer,
Reidulv Bøe, Terry R. Bruns, Wilfred B. Bryan, George C.H. Chaproniere,
Peter D. Clift, Anthony Ewart, Martin G. Fowler, Janet M. Hergt,
Richard A. Hodkinson, Dawn Lavoie, Jaquelyn K. Ledbetter,
Christopher J. MacLeod, Kristen Nilsson, Hiroshi Nishi,
Cristelle E. Pratt, Paula J. Quintero, Robin R. Reynolds,
Robin G. Rothwell, William W. Sager, Dietmar Schöps,
Sione Soakai, Michael J. Styzen
Shipboard Scientists

James F. Allan
Shipboard Staff Scientist

Editorial Review Board:
James W. Hawkins, Lindsay M. Parson, James F. Allan, Johanna Resig, Phil Weaver

Prepared by the
OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY

Eva M. Maddox
Volume Editor

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Foreword

By the National Science Foundation

The Ocean Drilling Program (ODP) is a major component of the National Science Foundation's continuing commitment to the study of the geologic processes that have shaped our planet and modified its environment. The scientific problems being addressed range from the geologic history and structure of continental margins to the processes responsible for the formation and alteration of the ocean's crust. In a time of enhanced public and scientific interest in problems of global change, ODP provides critical data on changes in ocean circulation, chemistry, and biologic productivity and their relation to changes in atmospheric circulation and glacial conditions. The Ocean Drilling Program has a unique role in addressing these problems, since it is the only facility for continuously sampling the geologic record of the ocean basins, which cover 70% of our planet.

The ODP is the successor to the Deep Sea Drilling Project (DSDP), which was a global reconnaissance of the ocean basins. DSDP began operations in 1968 at Scripps Institution of Oceanography, using a 400-foot drillship, the *Glomar Challenger*. DSDP was supported initially by only the National Science Foundation, with extensive involvement of international scientists who were invited to participate on drilling cruises. As this international interest continued to grow in the early 1970's, formal participation in the project was offered to the international geoscience community. In 1975, five nations (France, the Federal Republic of Germany, Japan, the United Kingdom, and the Soviet Union) accepted this commitment to joint planning and conduct of the project, as well as to financial support for operations. This International Phase of Ocean Drilling (IPOD) continued to 1983. Although the *Challenger* had reached the limits of her capabilities, the remarkable scientific success of the DSDP and the new questions it had generated demanded a continuing capability for drilling in the oceans.

The Ocean Drilling Program was organized, international participation was coordinated, a new drillship (the *JOIDES Resolution*) was contracted and outfitted, and her first cruise sailed in early 1985, within 18 months of the retirement of the *Challenger*. This is a remarkable accomplishment that reflects the efforts and excellence of the Joint Oceanographic Institutions, Inc. (prime contractor for ODP), Texas A&M University (science and ship operator), Lamont-Doherty Earth Observatory (logging operator), and the international science community in organizing and planning the new program. It was argued in planning for the ODP that a larger drillship was required to provide space for the increasing U.S. and international demand for shipboard participation, improved and expanded laboratory capabilities, and improvements in coring and logging systems. A larger and better equipped vessel would also provide better stability and working conditions in high-latitude regions of the oceans. The success of the *JOIDES Resolution* has proven the wisdom of these early arguments.

ODP now has operated in all oceans except the ice-covered Arctic. We have drilled above the Arctic circle and within sight of the Antarctic continent. Over 1000 scientists from 25 nations have participated in the initial ODP cruises. The larger scientific parties have allowed an increased emphasis on student participation and training aboard ship. The state-of-the-art laboratories support rapid and complete initial analyses of samples that provide both scientific results and guide subsequent shore-based studies. Nearly 1000 additional scientists have used these data and requested samples from the program's core and data archives for continuing study. The geochemical and geophysical logging capability is unsurpassed in either academia or industry and has provided remarkable new data with which to study the Earth. New experiments to measure and monitor geologic processes have been deployed in ODP boreholes.

The international commitment to ocean drilling has increased in the ODP. In addition to our four partners in IPOD—France, the Federal Republic of Germany, Japan, and the United Kingdom—two consortia have joined ODP: Canada-Australia and the European Science Foundation (representing Belgium, Denmark, Finland, Greece, Iceland, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey). The 19 countries of the ODP represent the community of nations that have a global interest in the geosciences and oceanography. This global scientific participation has assured the program's scientific excellence by focusing and integrating the combined scientific knowledge and capabilities of the

program's 19 nations. It has allowed problems of a global nature to be addressed by providing databases and background studies which are openly shared for planning and interpreting drilling results. It has eased problems of access to territorial waters, allowing comparative studies to be done among oceans. Finally, the international sharing of program costs has allowed this important and large program to proceed without detrimental impact to the research budgets of any one nation.

The Ocean Drilling Program, like its predecessor, DSDP, serves as a model for planning, conducting, and financing research to address problems of global importance. The National Science Foundation is proud to have a leading role in this unique international program, and we look forward to its continuing success.

A handwritten signature in black ink, appearing to read "Walter E. Massey", with a long, sweeping horizontal line extending to the right.

Walter E. Massey
Director
National Science Foundation

Washington, D.C.

Foreword

By Joint Oceanographic Institutions, Inc.

This volume presents scientific and engineering results from the Ocean Drilling Program (ODP). The papers presented here address the scientific and technical goals of the program, which include providing a global description of geological and geophysical structures including passive and active margins and sediment history, and studying in detail areas of major geophysical activity such as mid-ocean ridges and the associated hydrothermal circulations.

The Ocean Drilling Program, an international activity, operates a specially equipped deep-sea drilling ship, the *JOIDES Resolution* (Sedco/BP 471), which contains state-of-the-art laboratories, equipment, and computers. The ship is 471 feet (144 meters) long, is 70 feet (21 meters) wide, and has a displacement of 18,600 short tons. Her derrick towers 211 feet (64 meters) above the waterline, and a computer-controlled dynamic-positioning system stabilizes the ship over a specific location while drilling in water depths up to 27,000 feet (8230 meters). The drilling system collects cores from beneath the seafloor with a derrick and drawworks that can handle 30,000 feet (9144 meters) of drill pipe. More than 12,000 square feet (1115 square meters) of space distributed throughout the ship is devoted to scientific laboratories and equipment. The ship sails with a scientific and technical crew of 51 and a ship's crew (including the drill crew) of 62. The size and ice-strengthening of the ship allow drilling in high seas and ice-infested areas as well as permitting a large group of multidisciplinary scientists to interact as part of the scientific party.

Logging, or measurements in the drilled holes, is an important part of the program. ODP provides a full suite of geochemical and geophysical measurements for every hole deeper than 1300 feet (400 meters). For each such hole, there are lowerings of basic oil-industry tools: nuclear, sonic, and electrical. In addition, a borehole televiewer is available for imaging the wall of the hole, a 12-channel logging tool provides accurate velocity and elastic property measurements as well as sonic waveforms for spectral analysis of energy propagation near the wall of the hole, and a vertical seismic profiler can record reflectors from below the total depth of the hole.

The management of the Ocean Drilling Program involves a partnership of scientists and governments. International oversight and coordination are provided by the ODP Council, a governmental consultative body of the partner countries, which is chaired by a representative from the United States National Science Foundation. The ODP Council periodically reviews the general progress of the program and discusses financial plans and other management issues. Overall scientific and management guidance is provided to the operators of the program by representatives from the group of institutions involved in the program, called the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES).

The Executive Committee (EXCOM), made up of the administrative heads of the JOIDES institutions, provides general oversight for ODP. The Planning Committee (PCOM), with its advisory structure, is made up of working scientists and provides scientific advice and detailed planning. PCOM has a network of panels and working groups that screen drilling proposals, evaluate instrumentation and measurement techniques, and assess geophysical-survey data and other safety and siting information. PCOM uses the recommendations of the panels and committees to select drilling targets, to specify the location and major scientific objectives of each two-month drilling segment or leg, and to provide the science operator with nominations for co-chief scientists.

Joint Oceanographic Institutions, Inc. (JOI), a nonprofit consortium of U.S. oceanographic institutions, serves as the National Science Foundation's prime contractor for ODP. JOI is responsible for seeing that the scientific objectives, plans, and recommendations of the JOIDES committees are translated into scientific operations consistent with scientific advice and budgetary constraints. JOI subcontracts the operations of the program to two universities: Texas A&M University and Lamont-Doherty Earth Observatory of Columbia University. JOI is also responsible for managing the U.S. contribution to ODP.

Texas A&M University (TAMU) serves as science operator for ODP. In this capacity, TAMU is responsible for planning the specific ship operations, actual drilling schedules, and final scientific rosters, which are developed in close cooperation with PCOM and the relevant

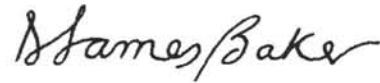
panels. The science operator also ensures that adequate scientific analyses are performed on the cores by maintaining the shipboard scientific laboratories and computers and by providing logistical and technical support for shipboard scientific teams. Onshore, TAMU manages scientific activities after each leg, is curator for the cores, distributes samples, and coordinates the editing and publication of scientific results.

Lamont-Doherty Earth Observatory (LDEO) of Columbia University is responsible for the program's logging operation, including processing the data and providing assistance to scientists for data analysis. The ODP Data Bank, a repository for geophysical data, is also managed by LDEO.

Core samples from ODP and the previous Deep Sea Drilling Project are stored for future investigation at three sites: ODP Pacific and Indian Ocean cores at TAMU, ODP and DSDP Atlantic and Antarctic cores at LDEO, and DSDP Pacific and Indian Ocean cores at the Scripps Institution of Oceanography.

Scientific achievements of ODP include new information on early seafloor spreading and how continents separate and the margins evolve. The oldest Pacific crust has been drilled and sampled. We have new insights into glacial cycles and the fluctuations of ocean currents throughout geological time. Many of the scientific goals can be met only with new technology; thus the program has focused on engineering as well as science. To date, ODP engineers have demonstrated the capability to drill on bare rock at mid-ocean-ridge sites and have developed techniques for drilling in high-temperature and corrosive regions typical of hydrothermal vent areas. A new diamond coring system promises better core recovery in difficult areas.

In addition, ODP is cooperating closely with other geological and geophysical programs; for example, in 1991 the first hole was drilled by ODP for emplacement of a seismometer near Hawaii for the Ocean Seismic Network. JOI is pleased to have been able to play a facilitating role in the Ocean Drilling Program and its cooperative activities, and we are looking forward to many new results to come.



D. James Baker
President
Joint Oceanographic Institutions, Inc.

Washington, D.C.

Preface

The *Scientific Results* volumes of the *Proceedings of the Ocean Drilling Program* contain specialty papers presenting the results of up to one and one-half years of research in various aspects of scientific ocean drilling. I acknowledge with thanks the authors of the papers published in this volume, who thereby have enabled future investigators to gain ready access to the results of their research.

Each of the papers submitted to a *Scientific Results* volume undergoes rigorous peer review by at least two specialists in the author's research field. A paper typically goes through one or more revision cycles before being accepted for publication. Our goal is to maintain a peer-review system comparable to those of the most highly regarded journals in the geological sciences.

The Editorial Review Board for a *Scientific Results* volume is responsible for obtaining peer reviews of papers submitted to the volume. This board usually is made up of the two co-chief scientists for the cruise, the ODP staff scientist for the cruise, and one external specialist who is familiar with the geology of the area investigated. In addition, the ODP staff editor assigned to the volume helps with any manuscripts that require special attention, such as those by authors who need assistance with English expression.

Scientific Results volumes may also contain short reports consisting of good data that are not ready for final interpretation. Papers in this category are segregated in a section in the back of the volume called Data Reports. Although no interpretation is permitted, these papers ordinarily contain a section on methodology or procedures. Data Report papers are read carefully by at least one specialist to make sure they are well organized, comprehensive, and discuss the techniques thoroughly.

In acknowledgment of the contributions made by this volume's Editorial Review Board, names of the individual Board members are listed on the title page. Reviewers of manuscripts for this volume, whose efforts are so essential to the success of the publication, are listed in the front portion of the book, without attribution to a particular manuscript.

On behalf of the Ocean Drilling Program, I extend sincere appreciation to members of the Editorial Review Boards and to the reviewers for giving so generously of their time and efforts in ensuring that only papers of high scientific quality are published in the *Proceedings*.



Philip D. Rabinowitz
Director
Ocean Drilling Program
Texas A&M University

College Station, Texas

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Joint Oceanographic Institutions, Inc.
Washington, D.C.

Thomas E. Pyle
Director, Ocean Drilling Programs

OPERATING INSTITUTION

College of Geosciences and Maritime Studies
Texas A&M University
College Station, Texas

Robert A. Duce
Dean

OCEAN DRILLING PROGRAM

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Director

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Deputy Director

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Science Services

Robert E. Olivas, Manager
Technical and Logistics Support

John C. Coyne, Manager
Information Services

LOGGING OPERATOR

Borehole Research Group
Lamont-Doherty Earth Observatory
Columbia University
Palisades, New York

David Goldberg, Head

PARTICIPANTS ABOARD THE JOIDES RESOLUTION FOR LEG 135*

James W. Hawkins
Co-Chief Scientist

*Geological Research Division
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California 92093-0220
U.S.A.*

Lindsay M. Parson
Co-Chief Scientist

*Institute of Oceanographic Sciences
Wormley, Godalming
Surrey GU8 5UB
United Kingdom*

James F. Allan
ODP Staff Scientist/Igneous Petrologist

*Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, Texas 77845-9547
U.S.A.*

Niels Abrahamsen
Paleomagnetist

*Laboratoriet for Geofysik
Geologisk Institut
Aarhus Universitet
Finlandsgade 6
DK-8200 Aarhus N
Denmark*

Ulrich Bednarz
Sedimentologist

*Forschungszentrum für Marine Geowissenschaften
Christian-Albrechts-Universität zu Kiel
Postfach 102148
Wischhofstraße 1-3
D-2300 Kiel 14
Federal Republic of Germany*

Gerard Blanc
Inorganic Geochemist

*Institut de Géologie
Université Louis Pasteur
1 rue Blessig
67084 Strasbourg Cedex
France*

Sherman H. Bloomer
Igneous Petrologist

*Department of Geology
Boston University
675 Commonwealth Avenue
Boston, Massachusetts 02215
U.S.A.*

Reidulv Bøe
Sedimentologist

*Geological Survey of Norway
P.O. Box 3006, Lade
N-7002 Trondheim
Norway*

Terry R. Bruns
Physical Properties Specialist/Geophysicist/Logging Scientist

*Pacific Arctic Branch of Marine Geology
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
U.S.A.*

Wilfred B. Bryan
Igneous Petrologist

*Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Quissett Campus
Woods Hole, Massachusetts 02543
U.S.A.*

George C.H. Chaproniere
Paleontologist (foraminifers)

*Division of Marine Geosciences
Bureau of Mineral Resources, Geology and Geophysics
P.O. Box 378
Canberra City, A.C.T. 2601
Australia*

Peter D. Clift
Sedimentologist

*Grant Institute of Geology
University of Edinburgh
West Mains Road
Edinburgh EH9 3JW
United Kingdom*

Anthony Ewart
Igneous Petrologist

*Department of Geology and Mineralogy
University of Queensland
St. Lucia, Brisbane
Queensland 4067
Australia*

Martin G. Fowler
Organic Geochemist

*Institute of Sedimentary and Petroleum Geology
Geological Survey of Canada
3303 33rd Street N.W.
Calgary, Alberta T2L 2A7
Canada*

Janet M. Hergt
Igneous Petrologist

*Department of Earth Sciences
The Open University
Milton Keynes
Buckinghamshire MK7 6AA
United Kingdom*

*Addresses at time of cruise.

Richard A. Hodkinson
Sedimentologist

*Department of Geology
Royal School of Mines
Imperial College
Prince Consort Road
London SW7 2BP
United Kingdom*

Dawn Lavoie
Physical Properties Specialist

*Naval Oceanographic and Atmospheric Laboratory
Stennis Space Center, Mississippi 39529
U.S.A.*

Jaquelyn K. Ledbetter
Sedimentologist

*Department of Geosciences
University of Tulsa
600 South College Avenue
Tulsa, Oklahoma 74104
U.S.A.*

Christopher J. MacLeod
Structural Scientist/Logging Scientist

*Department of Earth Sciences
The Open University
Milton Keynes
Buckinghamshire MK7 6AA
United Kingdom*

Kristen Nilsson
Igneous Petrologist

*Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California 92093-0215
U.S.A.*

Hiroshi Nishi
Paleontologist (foraminifers)

*Department of Earth Sciences
Faculty of Science
Yamagata University
Yamagata 990
Japan*

Cristelle E. Pratt
Sedimentologist

*Mineral Resources Department
CCOP/SOPAC
Private Mail Bag
Suva
Fiji*

Paula J. Quinterno
Paleontologist (nannofossils)

*U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025
U.S.A.*

Robin R. Reynolds
LDGO Logging Scientist

*Borehole Research Group
Lamont-Doherty Geological Observatory
Palisades, New York 10964
U.S.A.*

Robin G. Rothwell
Sedimentologist

*Institute of Oceanographic Sciences
Wormley, Godalming
Surrey GU8 5UB
United Kingdom*

William W. Sager
Paleomagnetist

*Department of Oceanography
Texas A&M University
College Station, Texas 77843
U.S.A.*

Dietmar Schöps
Sulfide/Alteration Petrologist

*Institute of Mining and Economic Geology
Aachen University of Technology
Wüllnerstraße 2
D-5100 Aachen 1
Federal Republic of Germany*

Sione Soakai
Sedimentologist

*Ministry of Lands, Surveys and Natural Resources
P.O. Box 5
Nukualofa
Tonga*

Michael J. Styzyn
Paleontologist (nannofossils)

*Shell Offshore, Inc.
P.O. Box 61933
New Orleans, Louisiana 70161
U.S.A.*

SEDCO OFFICIALS

Captain Anthony Ribbens
Master of the Drilling Vessel

*Underseas Drilling, Inc.
707 Texas Avenue South
Suite 103D
College Station, Texas 77840-1917
U.S.A.*

Jack Tarbutton
Drilling Superintendent

*Underseas Drilling, Inc.
707 Texas Avenue South
Suite 103D
College Station, Texas 77840-1917
U.S.A.*

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