

# PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

## VOLUME 137/140 SCIENTIFIC RESULTS COSTA RICA RIFT

Covering Legs 137 and 140 of the cruises of the Drilling Vessel *JOIDES Resolution*  
Leg 137: Honolulu, Hawaii, to Balboa, Panama, Site 504  
20 March–1 May 1991  
Leg 140: Victoria, Canada, to Balboa, Panama, Site 504,  
11 September–12 November 1991

### Leg 137

Keir Becker, Anne Gilbert Graham, Jeffrey C. Alt, Greg Bayhurst, Basil G. Christaras,  
Robert Gable, Anton Krammer, Andrew J. Magenheim, Roger H. Morin, Raymond Solbau  
*Science Participants*

Glen N. Foss, Eugene Pollard  
*Engineering Participants*

### Leg 140

Jörg A. Erzinger, Henry J.B. Dick, Laura B. Stokking,  
Pierre Agrinier, Simon Allerton, Jeffrey C. Alt, Lars O. Boldreel, Martin R. Fisk, Peter K.H. Harvey,  
Gerardo J. Iturrino, Kevin T.M. Johnson, Deborah S. Kelley, Pavel K. Kepezhinskas,  
Christine Laverne, Frederic C. Marton, Andrew W. McNeill, Howard R. Naslund, Janet E. Pariso,  
Nikolai N. Pertsev, Philippe Pezard, Eva S. Schandl, Joel W. Sparks, Paola Tartarotti,  
Susumu Umino, David A. Vanko, Evelyn Zuleger  
*Shipboard Scientists*

Laura B. Stokking  
*Shipboard Staff Scientist*

Editorial Review Board:  
Jörg A. Erzinger, Keir Becker, Henry J.B. Dick, Laura B. Stokking

Prepared by the  
OCEAN DRILLING PROGRAM  
TEXAS A&M UNIVERSITY

Jennifer A. Marin  
*Volume Editor*

in cooperation with the  
NATIONAL SCIENCE FOUNDATION  
and  
JOINT OCEANOGRAPHIC INSTITUTIONS, INC.

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Institut Français de Recherche pour l'Exploitation de la Mer (France)

National Science Foundation (United States)

Natural Environment Research Council (United Kingdom)

University of Tokyo, Ocean Research Institute (Japan)

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# Foreword

By the National Science Foundation

The National Science Foundation is proud to play a leading role in partnership with the U.S. oceanographic community in the operation and management of the Ocean Drilling Program (ODP). We are equally proud of the cooperation and commitment of our international partners, who contribute both financial and intellectual resources required to maintain the high quality of this unique program. The Ocean Drilling Program, like its predecessor, the Deep Sea Drilling Project (DSDP), is a model for the organization and planning of research to address global scientific problems that are of high priority internationally and of long-term interest to the scientific community and general public.

Major scientific themes guiding the development of specific drilling cruises range from determining the causes and effects of oceanic and climatic variability to understanding the circulation of fluids in the ocean crust and the resultant formation of mineral deposits. Although such studies are at the forefront of basic scientific inquiry into the processes that control and modify the global environment, they are equally important in providing the background for assessing man's impact on the global environment or for projecting resource availability for future generations.

The transition from the DSDP to the ODP was marked by a number of changes. The 471-foot *JOIDES Resolution*, which replaced the *Glomar Challenger*, has allowed larger scientific parties and the participation of more graduate students, a larger laboratory and technical capability, and operations in more hostile ocean regions. The *JOIDES Resolution* has drilled in all of the world's oceans, from the marginal ice regions of the Arctic to within sight of the Antarctic continent. Over 1,200 scientists and students from 26 nations have participated on project cruises. Cores recovered from the cruises and stored in ODP repositories in the United States and Europe have provided samples to an additional 1,000 scientists for longer term post-cruise research investigations. The downhole geochemical and geophysical logging program, unsurpassed in either academia or industry, is providing remarkable new data with which to study the Earth.

In 1994, NSF and our international partners renewed our commitment to the program for its final phase. Of the 20 countries that supported ODP initially, only one, Russia, has been unable to continue for financial reasons. As the reputation and scientific impact of the program continue to grow internationally, we hope to add additional members and new scientific constituencies. This global scientific participation continues to assure the program's scientific excellence by focusing and integrating the combined scientific knowledge and capabilities of its member nations.

We wish the program smooth sailing and good drilling!



Neal Lane  
Director  
National Science Foundation

Arlington, Virginia

# 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 permit 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.

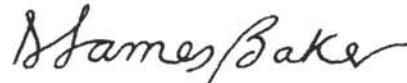
Texas A&M University (TAMU) serves as science operator for ODP. In this capacity, TAMU is responsible for planning the specific ship operations, actual drilling schedules, and final scientific rosters, which are developed in close cooperation with PCOM and the relevant panels. The science operator also 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 four sites: ODP Pacific and Indian Ocean cores at TAMU, DSDP Pacific and Indian Ocean cores at the Scripps Institution of Oceanography, ODP and DSDP Atlantic and Antarctic cores through Leg 150 at LDEO, and ODP Atlantic and Antarctic cores since Leg 151 at the University of Bremen, Federal Republic of Germany.

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, the members of the Board are designated Editors of the volume and are listed on the title page as well. 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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Washington, D.C.

David A. Falvey  
Director, Ocean Drilling Programs

## **OPERATING INSTITUTION**

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Texas A&M University  
College Station, Texas

Robert A. Duce  
Dean

## **OCEAN DRILLING PROGRAM**

Philip D. Rabinowitz  
Director  
Timothy J.G. Francis  
Deputy Director  
Richard G. McPherson  
Administrator  
Jack G. Baldauf, Manager  
Science Operations  
Barry W. Harding, Manager  
Engineering and Drilling Operations  
Russell B. Merrill, Curator and Manager  
Science Services  
Robert E. Olivas, Manager  
Technical and Logistics Support  
John 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 137\***

Keir Becker  
Chief Scientist

*Division of Marine Geology and Geophysics  
Rosenstiel School of Marine and Atmospheric Science  
University of Miami  
4600 Rickenbacker Causeway  
Miami, Florida 33149-1098  
U.S.A.*

Anne Gilbert Graham  
ODP Staff Representative  
*Ocean Drilling Program  
Texas A&M University Research Park  
1000 Discovery Drive  
College Station, Texas 77845-9547  
U.S.A.*

Jeffrey C. Alt  
Igneous Petrologist  
*Department of Geological Sciences  
University of Michigan  
1006 C.C. Little Building  
Ann Arbor, Michigan 48109-1063  
U.S.A.*

Greg Bayhurst  
Downhole Sampler Specialist  
*Los Alamos National Laboratory  
P.O. Box 1663  
Los Alamos, New Mexico 87545  
U.S.A.*

Basil G. Christaras  
Physical Properties Specialist  
*Department of Geology and Physical Geography  
Aristotle University  
School of Geology  
54006 Thessaloniki, Box 351-1  
Greece*

Robert Gable  
Temperature Logging Specialist  
*Département de Géophysique  
Bureau de Recherches Géologiques et Minières  
B.P. 6009  
45060 Orléans Cedex 2  
France*

Anton Krammer  
Logging Scientist  
*Geophysikalisches Institut  
Universität Karlsruhe  
Hertzstrasse 16  
D-7500 Karlsruhe 21  
Federal Republic of Germany*

Andrew J. Magenheimer  
Inorganic Geochemist  
*Graduate Department, MS A008  
Scripps Institution of Oceanography  
University of California, San Diego  
La Jolla, California 92093-0208  
U.S.A.*

Roger H. Morin  
Flowmeter/Physical Properties Specialist  
*Borehole Geophysics Research Project, MS 403  
U.S. Geological Survey  
Box 25046  
Denver Federal Center  
Denver, Colorado 80225  
U.S.A.*

Raymond Solbau  
Downhole Sampler Specialist  
*Lawrence Berkeley Laboratory  
Earth Science Division  
University of California, Berkeley  
1 Cyclotron Road  
Berkeley, California 94720  
U.S.A.*

### **ENGINEERING PARTICIPANTS**

Glen N. Foss  
Senior Operations Superintendent  
*Ocean Drilling Program  
Texas A&M University Research Park  
1000 Discovery Drive  
College Station, Texas 77845-9547  
U.S.A.*

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

### **SEDCO OFFICIALS**

Edwin G. Oonk  
Master of the Drilling Vessel  
*Underseas Drilling, Inc.  
707 Texas Avenue South, Suite 103D  
College Station, Texas 77840-1917  
U.S.A.*

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

\*Addresses at time of cruise.

## LEG 137 ODP TECHNICAL AND LOGISTICS PERSONNEL

Mary Ann Cusimano	Chemistry Technician
Edwin Garrett	Computer System Manager
Ted ("Gus") Gustafson	Marine Scientist
Michiko Hitchcox	Yeoperson
Robert Kemp	Curatorial Representative
Ken McCormick	Marine Scientist
Matt Mefferd	Laboratory Officer
Jeffrey Millard	Marine Scientist
William G. Mills	Laboratory Officer
Shan Pehlman	Photographer
Chieh Peng	Chemistry Technician
Don Sims	X-ray Technician
William Stevens	Marine Engineer
Mark Watson	Marine Engineer
Barry Weber	Marine Engineer

## **PARTICIPANTS ABOARD THE JOIDES RESOLUTION FOR LEG 140\***

Jörg A. Erzinger

Co-Chief Scientist/Geochemist  
*Institut für Geowissenschaften und  
Lithosphärenforschung  
Universität Giessen  
Senckenbergstrasse 3  
D-6300 Giessen  
Federal Republic of Germany*

Henry J.B. Dick

Co-Chief Scientist  
*Woods Hole Oceanographic Institution  
Woods Hole, Massachusetts 02543  
U.S.A.*

Laura B. Stokking

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

Pierre Agrinier

Geochemist  
*Laboratoire de Géochimie des Isotopes Stables  
U.F.R. Sciences Physiques de la Terre  
Université Paris 7  
2 Place Jussieu 75251  
Paris Cedex 05  
France*

Simon Allerton

Paleomagnetist/Structural Geologist  
*Department of Earth Sciences  
University of Oxford  
Parks Road  
Oxford OX1 3PR  
United Kingdom*

Jeffrey C. Alt

Metamorphic Petrologist  
*Department of Geological Sciences  
1006 C.C. Little Building  
University of Michigan  
Ann Arbor, Michigan 48109-1063  
U.S.A.*

Lars O. Boldreel

Physical Properties Specialist  
*Geological Survey of Denmark  
Thoravej 8  
DK-2400 Copenhagen, NV  
Denmark*

Martin R. Fisk

Igneous Petrologist  
*Oceanography Administration Building 104  
College of Oceanography  
Oregon State University  
Corvallis, Oregon 97331-5503  
U.S.A.*

Peter K.H. Harvey

JOIDES Logging Scientist  
*Borehole Research  
Department of Geology  
University of Leicester  
Leicester, LE1 7RH  
United Kingdom*

Gerardo J. Iturrino

Physical Properties Specialist  
*Rosenstiel School of Marine and Atmospheric Science  
Marine Geology and Geophysics  
University of Miami  
4600 Rickenbacker Causeway  
Miami, Florida 33149-1098  
U.S.A.*

Kevin T.M. Johnson

Igneous Petrologist/Geochemist  
*Geological Institute  
University of Tokyo  
7-3-1 Hongo-Bunkyo-ku  
Tokyo 113  
Japan*

Deborah S. Kelley

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

Pavel K. Kepezhinskas

Igneous Petrologist  
*Institute of the Lithosphere  
Academy of Sciences  
Staromonetny Pereylok, 22  
Moscow 109180  
Russia*

Christine Laverne

Metamorphic Petrologist  
*Laboratoire de Pétrologie  
Faculté des Sciences et Techniques de St. Jérôme  
Avenue Escadrille Normandie Niemen  
13397 Marseille Cedex 13  
France*

Frederic C. Marton

Structural Geologist/Petrologist  
*Department of Geological Sciences  
Northwestern University  
Evanston, Illinois 60201  
U.S.A.*

Andrew W. McNeill

Igneous Petrologist  
*Geology Department  
University of Tasmania  
GPO Box 252C  
Hobart, Tasmania 7001  
Australia*

\*Addresses at time of cruise.

Howard R. Naslund  
Igneous Petrologist

*Department of Geological Sciences  
State University of New York  
Binghamton, New York 13902-6000  
U.S.A.*

Janet E. Pariso  
Paleomagnetist

*School of Oceanography  
University of Washington  
Seattle, Washington 98195  
U.S.A.*

Nikolai N. Pertsev  
Metamorphic Petrologist

*Institute of Geology of Ore Deposits  
Academy of Sciences  
35 Staromonetny  
Moscow 109017  
Russia*

Philippe Pezard  
LDGO Logging Scientist

*Institut Méditerranéen de Technologie  
Technopole de Château-Gombert  
13451 Marseille Cedex 13  
France*

Eva S. Schandl  
Metamorphic Petrologist

*Department of Mineralogy  
Royal Ontario Museum  
Toronto, Ontario M5S 2C6  
Canada*

Joel W. Sparks  
Geochemist

*Department of Geology  
Stanford University  
Stanford, California 94305-2115  
U.S.A.*

Paola Tartarotti  
Metamorphic Petrologist

*Dipartimento di Geologia  
Via Giotto 1  
35137 Padova  
Italy*

Susumu Umino  
Igneous Petrologist

*Institute of Geosciences  
Shizuoka University  
Ohya 836, Shizuoka-shi  
Shizuoka 422  
Japan*

David A. Vanko  
Metamorphic Petrologist

*Department of Geology  
Georgia State University  
Atlanta, Georgia 30303  
U.S.A.*

Evelyn Zuleger  
Geochemist

*Institut für Geowissenschaften und  
Lithosphärenforschung  
Universität Giessen  
Senckenbergstrasse 3  
D-6300 Giessen  
Federal Republic of Germany*

## **SEDCO OFFICIALS**

Captain Anthony Ribbens  
Master of the Drilling Vessel

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

Jack Tarbutton  
Drilling Superintendent

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

## LEG 140 ODP ENGINEERING AND OPERATIONS PERSONNEL

Eugene Pollard                      Operations Superintendent  
Patrick Thompson                  Staff Superintendent

## LEG 140 ODP TECHNICAL AND LOGISTICS PERSONNEL

Wendy J. Autio                      Assistant Laboratory Officer/Assistant System Manager  
Daniel Bontempo                  Marine Specialist  
Timothy Bronk                      Marine Specialist  
Jo Claesgens                        Yeoperson  
Valerie Clark                        Chemistry Specialist  
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John R. Eastlund                  Computer System Manager  
Mark Gilmore                        Photographer  
Dennis K. Graham                 Laboratory Officer  
Kazushi ("Kuro") Kuroki        Marine Specialist  
Jon S. Lloyd                         Marine Specialist  
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Eric Meissner                        Electronics Specialist  
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