PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 138

INITIAL REPORTS
PART 1

EASTERN EQUATORIAL PACIFIC

Covering Leg 138 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Balboa, Panama, to San Diego, California, Sites 844–854,
6 May 1991–5 July 1991

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in cooperation with the
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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 Geological 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 five partners in IPOD—France, the Federal Republic of Germany, Japan, the Soviet Union, 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 20 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 excel-

lence by focusing and integrating the combined scientific knowledge and capabilities of the program's 20 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.

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 Geological 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 Geological Observatory (LDGO) 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 LDGO.

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 LDGO, 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
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*Back-pocket foldout, microfiche, and CD-ROM data are found in the back of Part 2.

Back-Pocket Microfiche*

Formation Microscanner images:

Hole 844B: Pass 1, scale 1:40, depth range 67–291 mbsf
Hole 844B: Pass 1, scale 1:6, depth range 67–291 mbsf
Hole 845B: Pass 2, scale 1:40, depth range 68–291 mbsf
Hole 845B: Pass 2, scale 1:6, depth range 68–290 mbsf
Hole 846B: Pass 2, scale 1:40, depth range 64–416 mbsf
Hole 846B: Pass 2, scale 1:6, depth range 64–416 mbsf
Hole 847B: Pass 1, scale 1:40, depth range 69–247 mbsf
Hole 847B: Pass 1, scale 1:6, depth range 69–247 mbsf

CD-ROM Data*

The CD-ROM in the back of Part 2 of this volume contains more than 500 MB of data collected during Leg 138. The data are subdivided into four main directories: TABLES, CORE DATA, SITE DATA, and PROGRAMS. A README file on the CD-ROM contains detailed information about each of these directories.

The TABLES directory contains many of the tables listed in the text (e.g., tables containing site sedimentation-rate data), as well as many tables only referenced in the text (e.g., tables containing site index-property data). A listing of the tables in this directory is found below and in the Table of Contents for Part 2.

The CORE DATA directory contains the basic ODP information associated with each recovered core (e.g., Site, Hole, Core, Core type, etc.), as well as the nominal ODP depth (in mbsf) and the composite depth (in mcd).

The SITE DATA directory contains data specific to a site. Each site directory contains at least five subdirectories: GRAPE density data, magnetic susceptibility data, color reflectance data, physical properties data, and geochemistry data. If downhole measurements were performed at the site, these data are stored in a sixth directory. In addition, the SITE DATA directory contains age-depth data and other data files that contain the information needed to construct composite sections for each site.

The PROGRAMS directory contains four computer programs (in FORTRAN-77) that were developed by Leg 138 scientists and were used extensively on UNIX-based workstations during Leg 138. While these programs are not intended to be used directly from the CD-ROM, they do provide the numerical procedures used to process data during the leg and the numerical strategy used to generate the composite depth section at each site. For help with using these programs, please approach their authors.

CD-ROM Tables*

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Table 2. Sedimentation rates based on data in Table 1.
Table 3. GRAPE density events from Table 1 and depths estimated for the equivalent events.
Table 4. Sedimentation rates based on data in Table 3.

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Table 3. Interval and depth constraints of nannofossil events.
Table 4. Interval and depth constraints of foraminifer events.
Table 5. Interval and depth constraints of radiolarian events.
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*Back-pocket foldout, microfiche, and CD-ROM data are found in the back of Part 2.

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Chapter 14, Figure 20. GRAPE density and percentage of reflectance for Site 849.
Chapter 15, Figure 25. Magnetic susceptibility, GRAPE density, and percentage of reflectance for Site 850.
Chapter 16, Figure 25. Magnetic susceptibility, GRAPE density, and percentage of reflectance for Site 851.
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Chapter 18, Figure 18. Magnetic susceptibility, GRAPE density, and percentage of reflectance for Site 853.
Chapter 19, Figure 18. Magnetic susceptibility, GRAPE density, and percentage of reflectance for Site 854.

Back-Pocket Microfiche*

Formation Microscanner images:

Hole 849B: Pass 2, scale 1:40, depth range 107–344 mbsf
Hole 849B: Pass 2, scale 1:6, depth range 107–344 mbsf
Hole 850B: Pass 2, scale 1:40, depth range 88–398 mbsf
Hole 850B: Pass 2, scale 1:6, depth range 88–398 mbsf
Hole 851B: Pass 2, scale 1:40, depth range 69–323 mbsf
Hole 851B: Pass 2, scale 1:6, depth range 69–323 mbsf

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CD-ROM Tables*

Chapter 13:

Table 1. Summary of coring operations at Site 848.
Table 3. Sample and depth constraints of nannofossil events for Site 848.
Table 4. Sample and depth constraints of radiolarian events for Site 848.
Table 5. Sample and depth constraints of diatom events for Site 848.
Table 7. Reversal boundary depths from Site 848.

*Back-pocket foldout, microfiche, and CD-ROM data are found in the back of Part 2.

ACKNOWLEDGMENTS

Like all ODP legs, Leg 138 was the culmination of years of hard work and planning on the part of many people and committees. While we could never list all those involved in this process, our appreciation must be expressed to the volunteers who serve in the ODP planning structure, particularly the members of the Ocean History Panel, the Planning Committee, and the Central Equatorial Pacific Panel, whose support and input helped make the scientific dream a reality. The success of any scientific expedition, however, depends ultimately on the people who execute the scientific plan. The efficiency and professionalism displayed by the technicians and crew of the *JOIDES Resolution* far exceeded the expectations of those of us who conceived and planned Leg 138. The hard work of the drilling crew provided an opportunity to drill an extra site along the western transect of the leg, as well as the extra time needed to assure complete recovery of the sediment section at all sites drilled. The material recovered in excess of the original drilling plan will provide an important legacy for future paleoceanographic studies. It is difficult to fully express the appreciation felt by the Scientific Party for the efforts of the *Resolution*'s crew.

During Leg 138, a number of ODP traditions were broken, changing many pre-cruise, shipboard, and post-cruise procedures. The willingness of all those involved to accommodate these changes was most appreciated and, in large part, was responsible for the success of the leg. Finally, the success of the leg reflects, in part, incredible luck. We recovered a record 5538 m of core and logged nine holes without an unplanned pipe trip and without the loss of a single core barrel, logging tool, or positioning beacon. Clearly, the gods of paleoceanography were on our side.