PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 146
INITIAL REPORTS
PART 1: CASCADIA MARGIN

Covering Leg 146 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Victoria, Canada, to San Diego, California, Sites 888–892,
20 September–22 November 1992

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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.

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

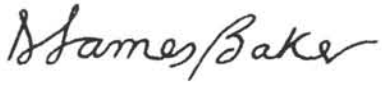
panels. The science operator also ensures that adequate scientific analyses are performed on the cores by maintaining the shipboard scientific laboratories and computers and by providing logistical and technical support for shipboard scientific teams. Onshore, TAMU manages scientific activities after 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.



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University of Rhode Island, Graduate School of Oceanography

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(For a listing of JOIDES Advisory Groups and the ODP Sample-Distribution Policy, see Part 2 of this volume, pp. 85–92)

Leg 146 Cascadia Margin Well-log Data CD-ROM (in back pocket)

Structure

The CD-ROM in the back of this volume is a "data-only" CD-ROM, containing depth-shifted and processed logging data provided by the Borehole Research Group at Lamont-Doherty Earth Observatory as well as shipboard GRAPE (gamma-ray attenuation porosity evaluation), index property, and magnetic susceptibility data of cores collected on board *JOIDES Resolution* during Leg 146. CD-ROM production was conducted by the Borehole Research Group at Lamont-Doherty Earth Observatory, Wireline Logging Operator for the Ocean Drilling Program.

The CD-ROM is structured as follows:

- GENERAL INFORMATION directory
  - Format documentation file
  - INDEX file
  - Software documentation file
- LOG DATA directory
  - README file
  - HOLE # subdirectory
    - Conventional logs subdirectory
    - General information subdirectory
      - Acronyms and units file
      - Processing history of log data file
    - Log data subdirectory
      - Individual tool data files
    - FMS and dipmeter data subdirectory
      - Dipmeter in ASCII format file(s)
      - FMS images in PBM (portable bit map—8-bit binary) format subdirectory
        - 1:1 ratio image raster files (every 10 m) subdirectory
          - Data files
          - Raster documentation file
        - 1:10 ratio image raster files (every 100 m) subdirectory
          - Data files
          - Raster documentation file
- CORE DATA directory
  - README document
  - SITE # subdirectory
    - GRAPE documentation file
    - Index properties documentation file
    - Magnetic susceptibility documentation file
    - HOLE # subdirectory
      - GRAPE data file
      - MAGSUS data file

The preceding structure is identical in each hole.

The INDEX file contains a summary of all the files loaded on the CD-ROM.

The software documentation file in the GENERAL INFORMATION directory contains information on which software packages work best to import PBM (portable bit map—8-bit binary) raster files. It also includes network sources for the graphics software and data compression information. The README file gives information on whom to contact with any questions about the production of or data on the CD-ROM.

All of the ASCII files (basic log, dipmeter, GRAPE, index property, and magnetic susceptibility files) are TAB delimited for compatibility with most spreadsheet and database programs. Holes that have more than one logging pass with the same tools are labeled Pass 1, Pass 2, etc. Holes that have long logging

runs are often divided into TOP, MIDDLE, and BOTTOM sections. This is noted by adding "top," "mid," or "bot" to the data file names where space permits or a "t," "m," or "b" where there is room for only one character.

In the FMS-PBM format subdirectory there are two subdirectories, 1:1 ratio with maximum 10-m-long image raster files and 1:10 ratio with maximum 100-m-long image raster files. The image raster files are named according to their depth interval. The raster documentation files contain image file parameter information necessary for use with most graphic software packages.

Summary of Leg 146 Cascadia Margin Log Data
- Hole 888C:
  - Conventional logs
- Hole 889A:
  - Conventional logs
  - FMS data
  - Dipmeter data
- Hole 891C:
  - Conventional logs
  - FMS data
  - Dipmeter data
  - Geochemical logs (element and oxide weight %)
- Hole 892C:
  - Conventional logs
  - FMS data
  - Dipmeter data

Summary of Leg 146 Cascadia Margin Core Data
- Holes 888A and 888B:
  - GRAPE data
  - Index property data
  - MAGSUS data
- Holes 889A:
  - Index property data
  - MAGSUS data
- Hole 889B:
  - GRAPE data
  - Index property data
  - MAGSUS data
- Hole 889D:
  - Index property data
- Hole 890B:
  - GRAPE data
  - Index property data
  - MAGSUS data
- Hole 891A:
  - GRAPE data
  - MAGSUS data
- Hole 891B:
  - Index property data
  - MAGSUS data
- Holes 892A, 892D, and 892E:
  - GRAPE data
  - Index property data
  - MAGSUS data

Back-pocket Foldout

Chapter 10: Figure 10. Multichannel seismic sections along lines 89-04 (**A**), 89-08 (**B**), and 89-10 (**C**) across the Leg 146 drill sites.

ACKNOWLEDGMENTS

The Cascadia Margin drilling program conducted during Leg 146 presented a variety of challenges, from difficult drilling conditions and the testing and operation of new downhole equipment, through bad weather and the twin hazards of mustard gas (anticipated, but fortunately not encountered) and hydrogen sulfide (not anticipated, and potentially deadly). Through all this the ship's crew and the marine specialists performed all that we asked them, and a great deal more. We would especially like to recognize the contributions of the Captain, Tom Ribbens, and the SEDCO Drilling Superintendent, Bob Caldow, who went out of their way to meet the operational demands we placed on them. ODP Operations Superintendent Glen Foss displayed a remarkable combination of an understanding of what the scientific party wanted and a determination to achieve those ends. Brad Julson, the Laboratory Officer, dealt with a challenging range of requests with skill and good humor. Tom Pettigrew was essential to the successful deployment of borehole seals at Sites 889 and 892, and to the successful packer test at the latter site.

The ODP marine specialists performed efficiently and tirelessly; we especially thank them for their Olympian effort during many VSP runs. Their professionalism during the mustard gas and hydrogen sulfide alerts was greatly admired. We would also like to thank guest marine specialist Bob MacDonald and Hartley Hoskins for his work in preparing the VSP equipment at the Victoria port-call and during the rendezvous with the *New Horizon*.