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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

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 Formation MicroScanner is available for high-resolution 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 (NSF). 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 under a separate cooperative agreement with NSF.

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. ODP has also provided valuable data that shed light on fluid pathways through the lithosphere, global climate change both in the Arctic and near the equator, past sea-level change, seafloor mineralization, the complex tectonic evolution of oceanic crust, and the evolution of passive continental margins.

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 a close, collaborative effort between ODP engineers and scientists, a system has been developed that seals selected boreholes ("CORKs") and monitors downhole temperature, pressure, and fluid composition for up to three years. When possible, ODP is also taking advantage of industry techniques, such as logging while drilling, to obtain continuous downhole information in difficult-to-drill formations.

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, exciting results in the future.

James D. Watkins
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Texas A&M University, College of Geosciences and Maritime Studies

University of Texas at Austin, Institute for Geophysics

University of Washington, College of Ocean and Fishery Sciences

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Publisher's Notes

Abbreviations for names of organizations and publications in ODP reference lists follow the style given in *Chemical Abstracts Service Source Index* (published by American Chemical Society).

The information on the Leg 161 CD-ROM is unedited material collected aboard ship. A copy of the CD is located in the back pocket of this book.

TABLE OF CONTENTS

LEG 161—INITIAL REPORTS

SECTION 3: CORES

Core-description forms and core photographs for:

SECTION 4: SMEAR SLIDES

Smear-slide descriptions for:

SECTION 5: THIN SECTIONS

Thin-section descriptions for:

(For JOIDES Advisory Groups and ODP Sample and Data Distribution Policy, please see *ODP Proceedings, Initial Reports*, Volume 158, pp. 375–384.)

BACK-POCKET MATERIALS

Oversized Figure

Chapter 3: Figure 1. Seismic profiles collected during Leg 161.

CD-ROM Materials

The CD-ROM in the back of this volume is a "data-only" CD-ROM containing both depth-shifted and processed logging data provided by the Borehole Research Group at the Lamont-Doherty Earth Observatory as well as shipboard GRAPE (Gamma Ray Attenuation Porosity Evaluation), Index Property, Magnetic Susceptibility, *P*-wave, and Natural Gamma data from cores collected on board the *JOIDES Resolution* during Leg 161. The CD also contains detailed coring summary tables, structural geology tables, and text tables from Chapters 4–9. The CD-ROM was produced by the Borehole Research Group at the Lamont-Doherty Earth Observatory, Wireline Logging Operator for ODP.

Log and Core Data Directory Structure:

- NIH IMAGE directory
- GENERAL INFORMATION directory
  - Compression documentation file
  - Format documentation file
- INDEX file
  - Software documentation file
- LOG DATA directory
  - README document
  - HOLE number subdirectory
    - Conventional Logs subdirectory
      - Acronyms and units file
      - Compression documentation (when applicable)
      - Log Data subdirectories
        - Individual tool data files
        - Processing documentation
    - 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 images subdirectory
        - Data files (every 10 m)
        - Raster documentation file
      - 1:10 ratio image subdirectory
        - Data files (every 100 m)
        - Raster documentation file
- CORE DATA directory

- README document
- TABLES
  - CDtables
  - CoreSum
  - SGData
  - Readme document
- SITE number subdirectory
  - HOLE number subdirectory
    - GRAPE data file
    - INDEX data file
    - MAGSUS data file
    - NATGAM data file
    - GRAPE documentation file
    - Index properties documentation file
    - Magnetic susceptibility documentation file
    - Natural gamma documentation file

The above structure is identical for each site and hole.

The INDEX.DOC file contains a summary of all the files loaded on the CD-ROM. The software documentation file in the GEN_INFO 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 (with the exception of the sonic waveform 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 Main and Repeat for conventional logs, or Pass 1, Pass 2, etc., for FMS. If the files are not in separate directories, they may just be annotated with "m" and "r" or "1" and "2" in the data file names when there is room for only one character. Holes that have long logging runs are often divided into TOP and BOTTOM directories. The files may be simply annotated with "top" or "bot" in the data file names where space permits or a "t" or "b" when there is room for only one character. Check the documentation file for a given directory if it is not clear to you.

In the FMS-PBM format directory 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 Log Data:

- Hole 974C:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms
  - Geochemical logs (element and oxide wt%)
  - FMS data
- Hole 975C:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms
  - Geochemical logs (element and oxide wt%)
  - Temperature logs
- Hole 976B:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms
  - Geochemical logs (element and oxide wt%)
  - FMS data
- Hole 976E:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms
  - Temperature logs
- Hole 977A:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms
  - FMS data
- Hole 979A:
  - High resolution logs
  - Conventional logs
  - Sonic waveforms

Summary of ODP Core Data:

- Site 974:
  - Hole A:
    - grape.dat
    - magsus.dat
    - pwave.dat
  - Hole B:
    - grape.dat
    - index.dat
    - magsus.dat
    - pwave.dat
  - Hole C:
    - grape.dat
    - magsus.dat
    - natgam.dat
    - pwave.dat
  - Hole D:
    - grape.dat
    - magsus.dat
    - natgam.dat
    - pwave.dat
- Site 975:
  - Hole A:
    - grape.dat
    - magsus.dat
    - natgam.dat
    - pwave.dat
  - Hole B:
    - grape.dat
    - index.dat
    - magsus.dat

natgam.dat
pwave.dat
Hole C:
grape.dat
index.dat
magsus.dat
natgam.dat
pwave.dat
Hole D:
grape.dat
magsus.dat
natgam.dat
pwave.dat
Site 976:
Hole A:
grape.dat
magsus.dat
natgam.dat
pwave.dat
Hole B:
grapeA.dat
grapeB.dat
index.dat
magsus.dat
natgam.dat
pwave.dat
Hole C:
grapeA.dat
grapeB.dat
magsus.dat
natgam.dat
pwave.dat
Hole D:
grape.dat
magsus.dat
natgam.dat
pwave.dat
Hole E:
grape.dat
magsus.dat
natgam.dat
pwave.dat
Site 977:
Hole A:
grapeA.dat
grapeB.dat
grapeC.dat
grapeD.dat
index.dat
magsusA.dat
magsusB.dat
magsusC.dat
natgam.dat
pwave.dat
Site 978:
Hole A:
grapeA.dat
grapeB.dat
index.dat
magsus.dat
natgam.dat
pwave.dat
Site 979:
Hole A:
grapeA.dat
grapeB.dat
grapeC.dat
grapeD.dat
grapeE.dat
index.dat
magsusA.dat
magsusB.dat
magsusC.dat
magsusD.dat
natgam.dat
pwave.dat

Text Table Directory Structure:

This CD contains text tables from Chapters 4–9 in the CDtables directory. Three physical properties (thermal conductivity, velocity, and index properties) tables from each chapter, though numbered sequentially, are not found in text and are only on the CD.

Chapter 4, Site 974:

Table 5. Correlation of organic-rich layers: 4tbl_5.txt

Table 7. Age of biostratigraphic events and depth of their occurrence: 4tbl_7.txt

Table 9. Composite depth table for Holes 974A, 974B, 974C, and 974D: 4tbl_9.txt

Table 10. Splice table for Site 974: 4tbl_10.txt

Table 12. Results of inorganic and total carbon (TC) analyses of sediment samples: 4tbl_12.txt

Table 15. Interstitial water data from Site 974, Tyrrhenian Sea: 4tbl_15.txt

Table 16. Thermal conductivity data from Holes 974B, 974C, and 974D (CD only): 4tbl_16.txt

Table 17. Sonic velocity data from Holes 974B, 974C, and 974D. Sensor codes are: L, longitudinal; T, transverse; H, Hamilton frame (CD only): 4tbl_17.txt

Table 18. Index properties from Holes 974A, 974B, and 974C (CD only): 4tbl_18.txt

Chapter 5, Site 975:

Table 4. Correlation of organic-rich layers: 5tbl_4.txt

Table 7. Age of calcareous nannofossil and planktonic foraminiferal biostratigraphic events and depths of their occurrence: 5tbl_7.txt

Table 9. Composite depth table for Holes 975A, 975B, 975C, and 975D: 5tbl_9.txt

Table 10. Splice table for Site 975: 5tbl_10.txt
Table 11. Results of inorganic and total carbon (TC) analyses of sediment samples: 5tbl_11.txt
Table 14. Interstitial water data: 5tbl_14.txt
Table 15. Thermal conductivity data from Holes 975B, 975C, and 975D (CD only): 5tbl_15.txt
Table 16. Sonic velocity data from Holes 975B, 975C, and 975D. Sensor codes are: L, longitudinal; T, transverse; H, Hamilton frame (CD only): 5tbl_16.txt
Table 17. Index properties from Holes 975A, 975B, and 975C (CD only): 5tbl_17.txt

Chapter 6, Site 976:

Table 3. Location of organic rich layers: 6tbl_3.txt
Table 4. Age of calcareous nannofossil and planktonic foraminiferal biostratigraphic events and depth of their occurrence in Hole 976B: 6tbl_4.txt
Table 5. Age (Ma) of calcareous nannofossil biostratigraphic events and depth of their occurrence (mbsf) in Hole 976C: 6tbl_5.txt
Table 9. Composite depth table for Holes 976A, 976B, 976C, and 976D: 6tbl_9.txt
Table 10. Splice table for Site 976: 6tbl_10.txt
Table 14. Results of inorganic and total carbon (TC) analyses of sediment samples: 6tbl_14.txt
Table 18. Interstitial water data from Hole 976B: 6tbl_18.txt
Table 19. Interstitial water data from Hole 976D: 6tbl_19.txt
Table 20. Thermal conductivity data from Holes 976A, 976B, 976C, and 976D (CD only): 6tbl_20.txt
Table 21. Index properties from Holes 976B and 976C (CD only): 6tbl_21.txt
Table 22. Sonic velocity data from Holes 976B and 976E. Sensor codes are: L = longitudinal, T = transverse, H = Hamilton frame (CD only): 6tbl_22.txt

Chapter 7, Site 977:

Table 3. Organic-rich layers: 7tbl_3.txt
Table 5. Age of calcareous nannofossil and planktonic foraminiferal biostratigraphic events and depth of their occurrence: 7tbl_5.txt
Table 10. Results of inorganic and total carbon (TC) analyses of Pliocene–Pleistocene sediment sample: 7tbl_10.txt
Table 13. Interstitial water data: 7tbl_13.txt
Table 14. Thermal conductivity data for Hole 977A (CD only): 7tbl_14.txt
Table 15. Index property data for Hole 977A (CD only): 7tbl_15.txt
Table 16. Sonic velocity data for Hole 977A. Sensor codes are: L = longitudinal, T = transverse, H = Hamilton frame (CD only): 7tbl_16.txt

Chapter 8, Site 978:

Table 3. Age of calcareous nannofossil and planktonic foraminiferal biostratigraphic events and depth of their occurrence: 8tbl_3.txt
Table 5. Results of inorganic and total carbon (TC) analyses of Pliocene–Pleistocene sediment samples: 8tbl_5.txt
Table 8. Interstitial water data: 8tbl_8.txt
Table 9. Thermal conductivity data for Hole 978A (CD only): 8tbl_9.txt
Table 10. Index property data for Hole 978A (CD only): 8tbl_10.txt
Table 11. Sonic velocity data for Hole 978A. Sensor codes are: L = longitudinal, T = transverse, H = Hamilton frame (CD only): 8tbl_11.txt

Chapter 9, Site 979:

Table 2. Location of organic-rich layer: 9tbl_2.txt
Table 4. Age of calcareous nannofossil and planktonic foraminiferal biostratigraphic events and depth of their occurrence: 9tbl_4.txt
Table 6. Results of inorganic and total carbon (TC) analyses of Pliocene–Pleistocene sediment samples: 9tbl_6.txt
Table 9. Interstitial water data: 9tbl_9.txt
Table 10. Thermal conductivity data for Hole 979A (CD only): 9tbl_10.txt
Table 11. Index property data for Hole 979A (CD only): 9tbl_11.txt
Table 12. Sonic velocity data for Hole 979A. Sensor codes are: L = longitudinal, T = transverse, H = Hamilton frame (CD only): 9tbl_12.txt

Detailed Coring Summary Table Directory:

This CD also contains extended coring summaries for Sites 974 through 979 in the CORESUM directory:

cs974.txt
cs975.txt
cs976ab.txt
cs976cde.txt
cs977.txt
cs978.txt
cs979.txt

Structural Geology Observations Table Directory:

This CD also contains structural geology tables for Site 974, 975, 976, 977, and 979 in the SGDATA directory:

Site 974:
974A:
1h.txt
974B:
1_7h.txt

8_10h.txt
10_12h.txt
12_15h.txt
15h_20x.txt
21_22x.txt
974C:
1_8h.txt
8_10h.txt
11_14h.txt
15_16h.txt
17_22h.txt
974D:
1_10h.txt
10_12h.txt
12_18h.txt
Site 975:
975A:
1_16h.txt
975B:
17_30x.txt
31_34x.txt
975C:
1h_24x.txt
25_34x.txt
975D:
13h.txt
Site 976:
976A:
1h.txt
976B:
1h_32x.txt
32_57x.txt
58x.txt
59_70x.txt
71x_77r.txt
77_80r.txt
80_83r.txt
83_95r.txt
95_97r.txt
97_102r.txt
102r_105.txt
105r_106.txt
976E:
12_12r.txt
12r.txt
13r.txt
14_15r.txt
15_20r.txt
20_21r.txt
22_24r.txt
25_28r.txt
Site 977:
977A:
3h_48x.txt
48_50x.txt
48x.txt
Site 979:
979A:
19_53x.txt
53x.txt

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