PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 154

INITIAL REPORTS

CEARA RISE

Covering Leg 154 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Bridgetown, Barbados, to Bridgetown, Barbados, Sites 925–929,
24 January–25 March 1994

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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
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(For JOIDES Advisory Groups and ODP Sample-Distribution Policy, please see ODP *Proceedings, Initial Reports*, Volume 151, pp. 919–926)

BACK-POCKET MATERIAL

CD-ROM

The CD-ROM in the back of this volume is a "data-only" CD-ROM, containing both depth-shifted and processed logging data that has been provided by the Borehole Research Group at Lamont-Doherty Earth Observatory as well as shipboard gamma-ray attenuation porosity evaluator (GRAPE), index properties, magnetic susceptibility, natural gamma, carbon, *P*-wave, and reflectance data of cores collected on board *JOIDES Resolution* during Leg 154. The CD-ROM production was conducted by the Borehole Research Group at Lamont-Doherty Earth Observatory, wireline logging operator for ODP.

The CD-ROM is structured as follows for Leg 154:

- GENERAL INFORMATION directory
  - 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 file(s) in ASCII format
      - FMS images in portable bit map (PBM; 8 bit binary)
        - 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
  - CORELOG.MCD data file
  - SITE NUMBER subdirectory
    - HOLE NUMBER subdirectory
      - CARBON data file
      - GRAPE data file
      - INDEX data file
      - MAGSUS data file
      - NATGAM data file
      - PWAVE data file
      - REFLECT data file
      - Carbon documentation file
      - GRAPE documentation file
      - Index properties documentation file
      - Magnetic susceptibility documentation file
      - Natural gamma documentation file
      - *P*-wave documentation file
      - Reflectance documentation file

The above structure is identical in each site and/or 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 portable bit map (PMB; 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 data on the CD-ROM or about production of the CD-ROM.

All of the ASCII files (with the exception of the SWF 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 directories. If the files are not in separate directories, they may just be annotated with "top," "mid," or "bot" in the data file names where space permits, or a "t," "m," or "b" where room permits 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 LDEO Log Data:

- Hole 925A:
  - High-resolution logs
  - Conventional logs
  - Sonic waveforms (compressed)
  - Temperature logs
  - FMS data
- Hole 925C:
  - High-resolution logs
  - Conventional logs
  - Sonic waveforms (compressed)
  - Temperature logs
  - FMS data
- Hole 926B:
  - High-resolution logs
  - Conventional logs
  - Sonic waveforms (compressed)

grape.mcd
index.dat
magsus.mcd
natgam.fin
pwave.mcd
reflect.mcd

Hole 929A:
carbon.dat
grape.mcd
index.dat
magsus.mcd
natgam.fin
pwave.mcd
reflect.mcd

Hole 929B:
grape.mcd
index.dat
magsus.mcd
natgam.fin
pwave.mcd
reflect.mcd

Hole 929C:
grape.mcd
magsus.mcd
natgam.fin
pwave.mcd
reflect.mcd

Hole 929D:
grape.mcd
index.dat
magsus.mcd
natgam.fin
pwave.mcd
reflect.mcd

Hole 929E:
carbon.dat
grape.mcd
index.dat
magsus.mcd
natgam.fin
reflect.mcd

ACKNOWLEDGMENTS

The *JOIDES Resolution* operated on the Ceara Rise from January through March 1994. The purpose of the leg was to recover sediments from a series of sites located on the slopes of the rise, primarily to develop a depth transect of samples for paleoceanographic reconstructions. The idea for drilling and coring on the Ceara Rise originated in community discussions at the Second Conference on Scientific Ocean Drilling (COSOD II) held in Strasbourg, 6–8 July 1987, and was promoted by the Ocean History Panel (OHP) of the JOIDES advisory structure. The Ceara Rise was identified as one of several low-latitude, well-sedimented features in the Earth's oceans suitable for diverse paleoceanographic research objectives. OHP took an active role in the development of the program by soliciting proposals from proponents and by helping to develop and modify cruise objectives.

Early on, it was apparent that excellent site survey data would be critical for a successful drilling operation in this region. These data were provided by G.S. Mountain and W.B. Curry, based on the results of *Maurice Ewing* Cruise 9209 (Ew9209). The high-resolution single-channel seismics, multibeam bathymetry, and piston cores acquired on Ew9209 were of high enough quality to permit sites for drilling to be precisely targeted and to allow Leg 154 to operate without pre-drilling surveys. The site survey cruise was supported by the Ocean Drilling Program of the National Science Foundation, whose support is gratefully acknowledged.

The operations of Leg 154 were carefully planned with the guidance of Glen Foss (ODP Drilling Superintendent). His expert knowledge and advice contributed tremendously to successful coring operations, which yielded more than 5.8 km of ooze, chalk, and limestone. This high recovery could not possibly have been achieved without the dedication of the crew of SEDCO/BP471 under the supervision of Captain Ed Oonk and Tool Pusher Wayne Malone. We particularly thank the rig crew for a level of success that far exceeded our hopes.

The productive and friendly working atmosphere prevailing on board the ship throughout the cruise was the result of the hard work, professionalism, and cheerful perseverance of the ODP shipboard technicians (all the more remarkable because they were below their full complement). We thank them for handling all 5.8 km of section with such good humor and skill, and for making it possible for us to achieve our shipboard goals of carefully documenting and making initial measurements on all the sediments that we recovered.

Finally, the Leg 154 Shipboard Scientific Party would like to thank the various governmental and academic institutions that provided the financial and logistical support to make our participation on this cruise possible.