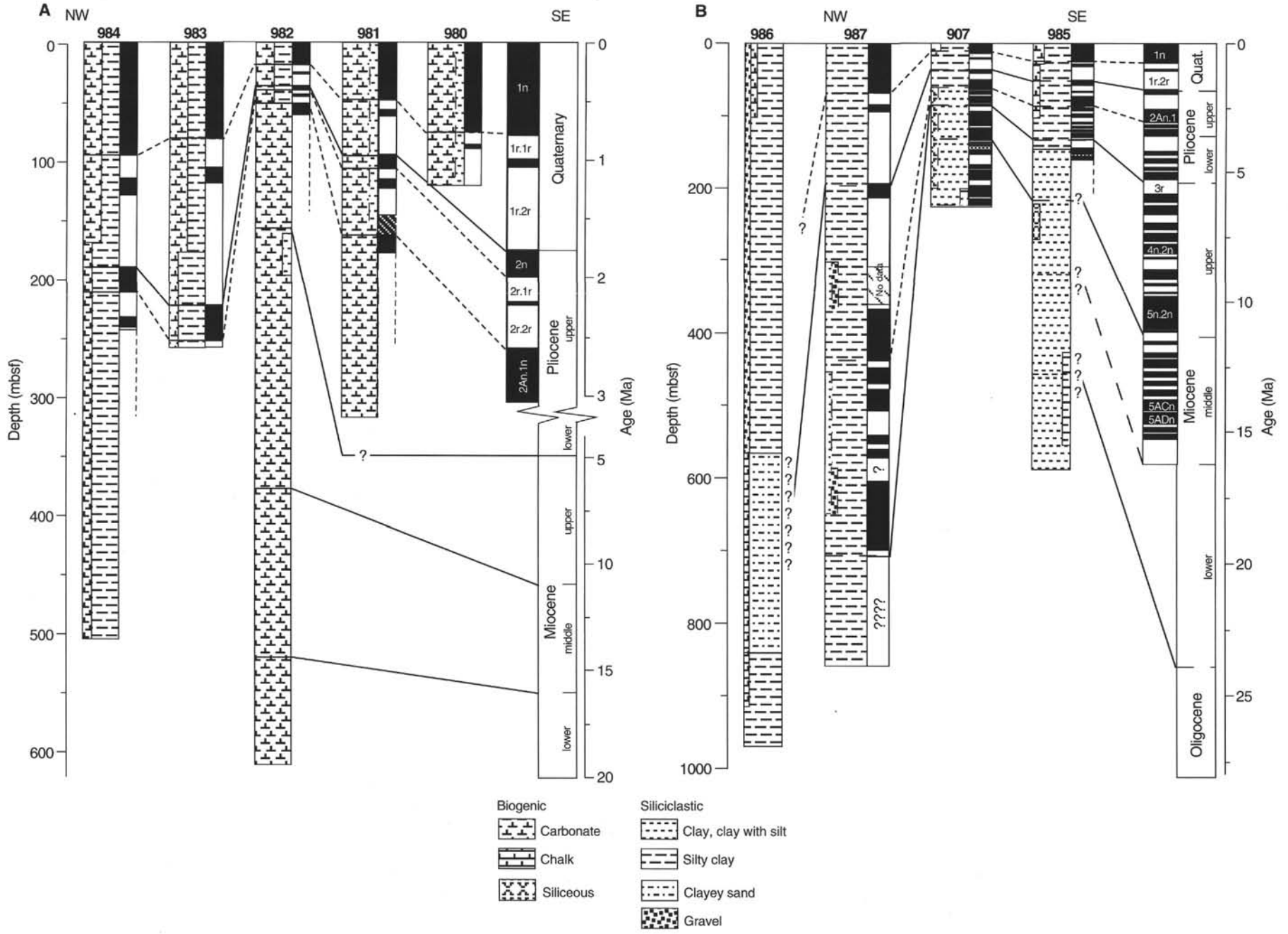

Summary of lithostratigraphy and paleomagnetic stratigraphy of sites drilled during Leg 162 in the North Atlantic (**A**) and Nordic Seas (**B**).

PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 162
INITIAL REPORTS
NORTH ATLANTIC–ARCTIC GATEWAYS II

Covering Leg 162 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Edinburgh, United Kingdom, to Málaga, Spain, Sites 980–987,
7 July–2 September 1995

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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 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.

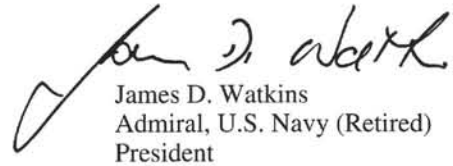
Lamont-Doherty Earth Observatory (LDEO) of Columbia University is responsible for the program's logging operation, including processing the data and providing assistance to scientists for data analysis. The ODP Data Bank, a repository for geophysical data, is also managed by LDEO.

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.



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Oregon State University, College of Oceanic and Atmospheric Sciences

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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 material on the Leg 162 CD-ROM represents information collected aboard ship. Some of this information has been refined in accord with post-cruise findings, but production schedules prohibit definitive correlation with subsequent findings. Thus, the reader is alerted that this is unedited material, except for the chapter tables.

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SECTION 4: SMEAR SLIDES

Smear-slide 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 Figures

Chapter 8: Figure 3. GRAPE density, natural gamma radiation, and magnetic susceptibility data from Site 985 on the mcd (meters composite depth) scale. Line for Hole 985B (dotted) has been horizontally offset from line for Hole 985A (solid) for better display; therefore, values given on horizontal scale are the true values only for Hole 985A.

Chapter 9: Figure 4. GRAPE density, natural gamma radiation, and magnetic susceptibility data from Site 986 on the mcd (meters composite depth) scale. Lines for Holes 986B (dotted) and 986C (dashed) have been horizontally offset from line for Hole 986A (solid) for better display; therefore, values given on horizontal scale are the true values only for Hole 986A.

Chapter 10: Figure 2. GRAPE density and magnetic susceptibility data from Site 987 on the mcd (meters composite depth) scale. Lines for Holes 987B (dotted), 987C (dashed), and 987D (long dashed) have been horizontally offset from line for Hole 987A (solid) for better display; therefore, values given on horizontal scale are the true values only for Hole 987A.

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 provided by the Borehole Research Group at the Lamont-Doherty Earth Observatory as well as shipboard gamma ray attenuation porosity evaluation (GRAPE), index property, magnetic susceptibility, natural gamma, and *P*-wave data of cores along with core data tables collected on board the *JOIDES Resolution* during Leg 162. 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
  SITE number subdirectory
    HOLE number subdirectory
      GRAPE data file
      INDEX data file
      MAGSUS data file
      NATGAM data file
      PWAVE data file
      GRAPE documentation file
      Index properties documentation file
      Magnetic susceptibility documentation file
      Natural gamma documentation file
      P-wave documentation file

The above structure is identical in each site and/or 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 [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 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 UPPER and LOWER directories. The files may just be annotated in the data file names with a "u" or "l" when there is room for only one character. Check the documentation file for a given directory if it is not clear.

In the FMS-PBM format directory there are two subdirectories, 1:1 ratio with maximum 10-m-long raster image files and 1:10 ratio with maximum 100-m long raster image files. The raster image 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

Summary of ODP Core Data

Hole C:
grape.dat
magsus.dat
pwave.dat
Site 984:
Hole A:
grape.dat
magsus.dat
pwave.dat
Hole B:
grapeA.dat
grapeB.dat
index.dat
magsus.dat
pwave.dat
Hole C:
grapeA.dat
grapeB.dat
magsus.dat
pwave.dat
Hole D:
grape.dat
magsus.dat
pwave.dat
Site 985:
Hole A:
grapeA.dat
grapeB.dat
index.dat
magsusA.dat
magsusB.dat
pwave.dat
Hole B:
grape.dat
magsus.dat
pwave.dat
Site 986:
Hole A:
grape.dat
magsus.dat
pwave.dat
Hole B:
grape.dat
magsus.dat
pwave.dat
Hole C:
grape.dat
index.doc
magsus.dat
pwave.dat
Hole D:
grape.dat
index.dat
magsus.dat
Site 987:
Hole A:
grape.dat
magsus.dat
pwave.dat
Hole B:
grape.dat
magsus.dat
pwave.dat
Hole C:
grape.dat
magsus.dat
pwave.dat
Hole D:
grape.dat
index.dat
magsus.dat
pwave.dat
Hole E:
grapeA.dat
grapeB.dat
index.dat
magsus.dat

Text Table Directory:

All tables in this volume appear on the CD-ROM. The following tables appear in abbreviated form in the text and are contained in full only on CD-ROM:

Chapter 3: Tables 19, 20, 21, 22, 23, 24, and 25
Chapter 4: Tables 13, 14, and 15
Chapter 5: Tables 13, 14, and 15
Chapter 6: Tables 13, 14, 15, and 16
Chapter 7: Tables 15, 16, 17, and 18
Chapter 8: Tables 15, 16, and 17
Chapter 9: Tables 5, 13, 14, 15, and 16
Chapter 10: Tables 4, 12, 13, 14, 15, and 17

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Understanding the operation of the climate system and the mechanisms of climate change is an important task for humanity. The Ocean Drilling Program is a central element in this task, providing the sediment sections required for investigations of the long-term operation of the climate system and natural climate variability. Our leg was highly prioritized by the JOIDES advisory structure not only due to the central role played by the high-latitude oceans in the global climate system, but also because it brought ODP to new frontiers through drilling sites specifically aimed at studying the evolution of climate change on the time scale of human lives. We are grateful for the opportunity to use the tremendous resources of the drillship and its crew to reach our many exciting scientific objectives.

The successes of our leg in providing both continuous sections for millennial-scale climate studies and continuous deep sections on margins for studies of ice-sheet evolution would not have been possible without the dedication and skill of the ship's personnel under the supervision of Captain Tom Ribbens, Drilling Superintendent Bob Caldow, and ODP Operations Manager Mike Storms. The record-breaking core recovery of our leg placed the drill crew and in particular the ODP technical support staff under immense pressure, and we are extremely grateful for their professionalism, including maintaining a pleasant working atmosphere, improvising on-site solutions, and withstanding tough physical workloads.

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