Interval 120-747A-19X-2, 109-130 cm: lower Eocene to Danian hardground with large filled burrows, cracks, pyrite, and coated grains.

Section 120-747C-4R-CC: Maestrichtian to Danian polygenic breccia with smectite clay matrix and chert, limestone, soft clay pellets, and diverse volcanic rocks, including weathered scoria, fresh basalt with filled vesicles, hard phenocryst basalt, and an inoceramid fragment.

Interval 120-747A-21X-4, 104-122 cm: Maestrichtian nannofossil ooze with laminated phosphatic hardground.

Section 120-747C-16R-3, Piece 5: aphyric, red, weathered basalt with irregular stretched vesicles filled with zeolites, clay, and minor calcite.

Section 120-748C-45R-CC: glauconitic bioclastic rudstone with bryozoan, inoceramid, red algal, benthic foraminifer, and sponge debris.

Section 120-748C-45R-CC: glauconitic bioclastic rudstone with bryozoan, inoceramid, red algal, benthic foraminifer, and sponge debris.

Interval 120-748C-79R-4, 104-118 cm: alkaline basalt cobble conglomerate with analcime alteration, and sediment infill with shallow-water molluscs and volcanic grains.

Section 120-748C-79R-7 at 40 cm: thin section from alkali basalt with analcime alteration (gray), red hematite weathering, and blue-green celadonite vein and vesicle fillings.

Section 120-751A-6H-1: diverse irregular, Pliocene, lepisphere porcellanite cavings from a bed at about 20 mbsf, which was fragmented into disturbed diatom nannofossil ooze.

Interval 120-748C-32R-1, 32-38 cm: thin section in cross nicols of a large, obliquely cut bryozoan fragment, about 1.4 mm long, with well-preserved zooecia and zones of partial silicification.

Interval 120-748C-32R-1, 32-38 cm: thin section under cross nicols of a coralline red algae fragment, about 1 mm long, showing rows of sporangia and dense cellular laminations. Also shows ovid crinoid section.

Interval 120-748C-79R-4, 113-114 cm: thin section under cross nicols across a mollusc fragment from matrix of basaltic cobbles showing thick shell and excellent preservation of laminations.

Interval 120-750A-15R-3, 78-94 cm: Cretaceous/Tertiary boundary sequence, with slight disturbance at boundary. Danian greenish gray nannofossil chalk vs. white Maestrichtian foraminifer-nannofossil chalk with scattered dark chert bits.

Interval 120-750B-9W-1, 134-148 cm: Upper Cretaceous, pale grayish green chalk and silicification front with darker silicified limestone below.

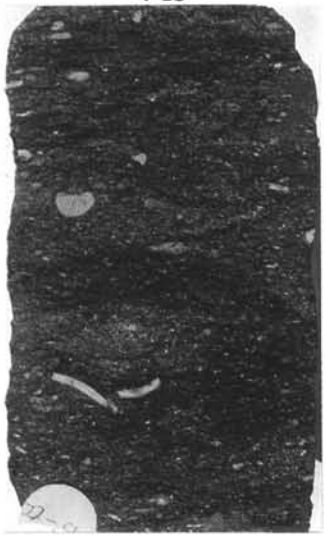
Interval 120-750B-11W-1, 75-87 cm: greenish gray, Cenomanian, burrowed nannofossil chalk with black marly interbeds.

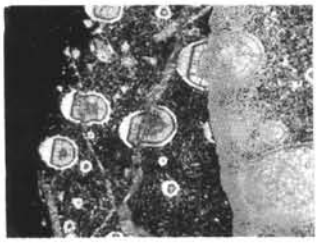
Interval 120-750B-13W-1, 55-70 cm: mud pebble conglomerate with kaolinite clays, multicolored ferruginous volcaniclastic components, siderite, and black coaly fragments.

Section 120-750B-14R-1, Piece 3: grayish green, fine-grained plagioclase phyric basalt with irregular vesicles filled with light green clays and veins with calcite.

747

748





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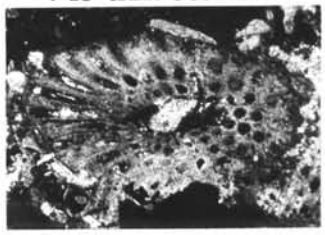
748 thin sections



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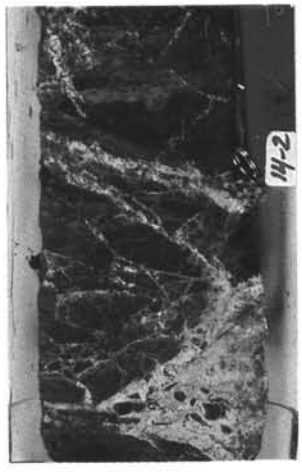

PROCEEDINGS OF THE OCEAN DRILLING PROGRAM

VOLUME 120
INITIAL REPORTS

CENTRAL KERGUELEN PLATEAU

Covering Leg 120 of the cruises of the Drilling Vessel *JOIDES Resolution*,
Fremantle, Australia, to Fremantle, Australia, Sites 747—751,
20 February to 30 April 1988

Roland Schlich, Sherwood W. Wise, Jr., Amanda A. Palmer Julson,
Marie-Pierre Aubry, William A. Berggren, Peter R. Bitschene, Neal A. Blackburn,
James Breza, Millard F. Coffin, David M. Harwood, Franz Heider, Mary Anne Holmes,
William R. Howard, Hiroo Inokuchi, Kerry Kelts, David B. Lazarus, Andreas Mackensen,
Toshiaki Maruyama, Marc Munschy, Elizabeth Pratson, Patrick G. Quilty, Frank Rack,
Vincent J. M. Salters, James H. Sevigny, Michael Storey, Atsushi Takemura,
David K. Watkins, Hubert Whitechurch, and James Zachos
Participating Scientists

Amanda A. Palmer Julson
Shipboard Staff Scientist

Prepared by the
OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY

Eva M. Barbu
Volume Editor

in cooperation with the
NATIONAL SCIENCE FOUNDATION
and
JOINT OCEANOGRAPHIC INSTITUTIONS, INC.

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Aubry, M.-P., and Berggren, W. A., 1989. Age of the upper volcaniclastic debris flow at Site 747: a special study. *In* Schlich, R., Wise, S. W., Jr., et al., *Proc. ODP, Init. Repts.*, 120: College Station, TX (Ocean Drilling Program), - .

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Foreword

By the National Science Foundation

The scientists of the Ocean Drilling Program (ODP) have embarked on what could prove to be one of the most important earth science initiatives of the decade—an initiative rivaling in scope and impact the exploration of the frontiers of outer space. The program explores our planet's last frontier—the Earth's structure and history as it is revealed beneath the oceans. The scope of the program's scientific goals excites the imagination, challenges the intellect, and enhances the spirit of cooperation among peoples in countries around the world.

Between 1872 and 1876, HMS *Challenger* undertook the world's first major oceanographic expedition. That expedition greatly expanded man's knowledge of the world's oceans and revolutionized our ideas about planet Earth. From 1968 to 1983, another ship named *Challenger* logged more than 375,000 miles on 96 voyages across every ocean for the Deep Sea Drilling Project (DSDP), operated by Scripps Institution of Oceanography. Among the project's many remarkable discoveries were the confirmation of seafloor spreading and the establishment of the relative youth of the seafloor, thus verifying the dynamic and changing nature of the Earth's crust.

Today, the Ocean Drilling Program, which began in 1983, brings new resources to bear on scientific ocean drilling. A new drillship is in operation—the *JOIDES Resolution*—one of the world's most modern and best equipped drillships with enhanced capability for drilling and coring in polar areas and rough weather, expanded laboratory space, facilities for more scientists, and a major drill-hole logging program. The name of the ship was derived from the international scientific partnership that directs the program—the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES)—and from the flagship of Captain Cook's second voyage to the Pacific Ocean in the late 18th century. Texas A&M University is responsible for science operations in the program, and Lamont-Doherty Geological Observatory is responsible for the logging program.

The Ocean Drilling Program truly has international participation. In 1975, the International Phase of Ocean Drilling began with member nations—the U.S.A., U.S.S.R., the Federal Republic of Germany, Japan, the United Kingdom, and France—all providing funds and scientific guidance for the project. Today, ODP partners include the U.S.A., the Canada/Australia Consortium for the Ocean Drilling Program, France, the Federal Republic of Germany, Japan, the United Kingdom, and the European Science Foundation, which represents Sweden, Finland, Norway, Iceland, Denmark, Belgium, the Netherlands, Spain, Switzerland, Italy, Greece, and Turkey. The National Science Foundation, with funds contributed by the United States and international partners, supports the scientific operations and planning for the ODP through a contract with Joint Oceanographic Institutions, Inc. (JOI).

The information gained by the program leads to a better understanding of the Earth and its dynamic processes. Drilled sediment cores and logs reveal clues to past climatic history and tie into parallel studies of paleoclimates from glacial ice cores drilled on the continents. Understanding these sediment cores will enable scientists to complete the map of major geologically active regions of the Earth, and to identify processes that lead to dynamic change such as earthquakes, volcanic eruptions, and mountain and continental growth. We are far from being able to predict such changes accurately now; but with the new tools and understanding, the accuracy of such predictions can be improved. This better understanding of the Earth's system(s) will allow us to identify regions of potential mineral and energy resource development, an issue of worldwide human interest. The Ocean Drilling Program is not in itself aimed at finding resources, but the knowledge of the Earth's processes that is gained through such a basic research program will inevitably provide pieces of information required for such resource discovery and exploitation.

The program is fully under way in its aim to further the understanding of the Earth's dynamic systems. People of our planet will benefit directly and indirectly from this research in both their daily living and work activities. This multinational endeavor will perhaps foster other cooperative efforts in science or among societies. The Ocean Drilling Program has distinguished ancestors in the original *Resolution* and *Challenger* expeditions and the Deep Sea Drilling Project. The National Science Foundation is proud to be playing a leading role in this program, and we are looking forward to significant and innovative science for many years to come.

Erich Bloch
Director
National Science Foundation

Washington, D.C.

Foreword

By Joint Oceanographic Institutions, Inc.

This volume presents results from the Ocean Drilling Program (ODP), where scientists use a specially equipped ocean drilling ship to sample and measure the properties of the submerged part of the Earth's crust. These data are then synthesized with other information to yield new insights into earth processes.

These results address the scientific goals of the program, which include providing a global description of geological and geophysical structures and materials, studying in detail areas of major geophysical activity such as mid-ocean ridges and the associated hydrothermal circulations, and studying passive and active continental margins. In addition, the ODP data support the study of sea-level and ocean-circulation changes, the effects of the Earth's orbital variations on climate, and the study of processes and mechanisms of evolution from the biological records in the cores which are recovered from drilling.

The Ocean Drilling Program is a partnership of scientists and governments. Overall scientific policy and management guidance is provided by Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES), which consists of committees and panels made up of representatives of the participating institutions and other scientific and engineering experts. The JOIDES Executive Committee (EXCOM) provides general oversight; the JOIDES Planning Committee (PCOM) is the focal point for all scientific planning for the ODP and is key to the scientific success of the program.

The PCOM has a network of panels and working groups which screen drilling proposals, evaluate instrumentation and measurement techniques, and assess geophysical survey data and other safety and siting information. PCOM uses the recommendations of these panels and committees to select drilling targets, to specify the major scientific objectives of each two-month drilling segment or leg, and to provide the science operator with nominations for co-chief scientists. The science operator, Texas A&M University, in turn is responsible for planning the detailed ship's operations, actual drilling schedules, and final scientific rosters, which are developed in close cooperation with PCOM and the cognizant panels.

Many of the scientific goals can be met only with new technology. Thus the program has identified engineering goals, which include the ability to start a hole and to core on bare rock at mid-ocean ridge sites, to drill in high-temperature and corrosive regions typical of hydrothermal areas, and to core in high latitudes with minimum interference from high seas and sea ice. To meet these needs, the program operates a specially equipped drillship, the *JOIDES Resolution*, which contains laboratories and equipment that are state-of-the-art, and carries a major new logging program.

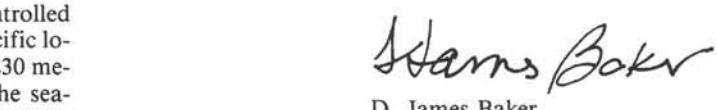
The ship, registered as SEDCO/BP 471 after her owners and her length in feet (144 meters), is 70 feet (21 meters) wide, and has a displacement of 16,595 long tons. Her derrick towers 200 feet (61 meters) above the waterline, and a computer-controlled dynamic-positioning system stabilizes the ship over 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 50 and a ship's crew of 65.

Logging is a major part of the overall operation. The program 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 well-bore wall, 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 well bore, and a vertical seismic profiler records reflectors from below the total depth of the hole.

Texas A&M University serves as science operator for the Ocean Drilling Program. In this capacity, they operate and staff the drillship to collect cores from JOIDES-designated sites from around the world. The science operator also ensures that adequate scientific analyses are performed on the cores by maintaining the shipboard scientific laboratories and by providing logistical and technical support for shipboard scientific teams. Onshore, Texas A&M manages scientific activities after each leg, is curator for the cores, distributes samples, and coordinates the editing and publication of the scientific results. Lamont-Doherty Geological Observatory (LDGO) of Columbia University manages the program's logging operations, which include processing the data and provision of assistance to scientists in 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 Texas A&M University, ODP and DSDP Atlantic and Antarctic cores at Lamont-Doherty Geological Observatory, and DSDP Pacific and Indian Ocean cores at Scripps Institution of Oceanography.

International oversight and coordination are provided by the ODP Council, a governmental consultative body of partner country representatives, chaired by the United States, which periodically reviews the general progress of the program and discusses financial plans and other management issues. Joint Oceanographic Institutions, Inc., a nonprofit consortium of U.S. oceanographic institutions, serves as the National Science Foundation's prime contractor and manages the ODP. JOI is responsible for seeing that the scientific objectives and plans are translated into scientific operations consistent with JOIDES recommendations and budgetary constraints.

Scientific achievements of the ODP already include new data on early seafloor spreading and how continents separate and their margins evolve. We have new insight into glacial cycles and the fluctuations of currents throughout geological time. Technical achievements include the first bare-rock coring, and logging data more accurate and complete than ever before. JOI is pleased to have played a facilitating role in the Ocean Drilling Program.



D. James Baker
President
Joint Oceanographic Institutions, Inc.

Washington, D.C.

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University of Rhode Island, Graduate School of Oceanography

Texas A&M University, College of Geosciences

University of Texas at Austin, Institute for Geophysics

University of Washington, College of Ocean and Fishery Sciences

Woods Hole Oceanographic Institution

Canada/Australia Consortium for the Ocean Drilling Program, Department of Energy, Mines and Resources (Canada) and Department of Primary Industries and Energy (Australia)

European Science Foundation Consortium for Ocean Drilling (ECOD), Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland, and Turkey

Federal Republic of Germany, Bundesanstalt für Geowissenschaften und Rohstoffe

France, Institut Français de Recherche pour l'Exploitation de la Mer

Japan, University of Tokyo, Ocean Research Institute

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Thomas E. Pyle
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OPERATING INSTITUTION

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Texas A&M University
College Station, Texas

Melvin Friedman, Principal Investigator

OCEAN DRILLING PROGRAM

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Science Services

Robert E. Olivas, Manager
Technical and Logistics Support

LOGGING OPERATOR

Borehole Research Group
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York

Roger N. Anderson, Head

PARTICIPANTS ABOARD *JOIDES RESOLUTION* FOR LEG 120

Roland Schlich
Co-Chief Scientist
Institut de Physique du Globe
Université Louis Pasteur
5, Rue René Descartes
67084 Strasbourg Cedex
France

Sherwood W. Wise, Jr.
Co-Chief Scientist
Department of Geology
Florida State University
Tallahassee, Florida 32306

Amanda A. Palmer Julson
ODP Staff Scientist/Sedimentologist
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, Texas 77840

Marie-Pierre Aubry
Paleontologists (nannofossils)
Département des Sciences de la Terre
Université Claude Bernard
15-43 Bd. du Novembre
69622 Villeurbane
France
(current address:
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Quissett Campus
Woods Hole, Massachusetts 02543)

William A. Berggren
Paleontologist (foraminifers)
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Quissett Campus
Woods Hole, Massachusetts 02543)

Peter R. Bitschene
Inorganic Geochemist
Institut für Mineralogie
Ruhr-Universität Bochum
Postfach 102148
D-4630 Bochum
Federal Republic of Germany

Neal A. Blackburn
Logging Scientist
Britoil PLC.
301 St. Vincent Street
Glasgow G25 DD
United Kingdom

James Breza
Sedimentologist
Department of Geology
Florida State University
Tallahassee, Florida 32306

Millard F. Coffin
Physical Properties Specialist
Division of Marine Geosciences
Bureau of Mineral Resources, Geology and Geophysics
P. O. Box 378
Canberra City, A.C.T. 2601
Australia

David M. Harwood
Paleontologist (diatoms)
Byrd Polar Research Center
Ohio State University
125 South Oval Mall
Columbus, Ohio 43210

Franz Heider
Paleomagnetist
Geophysics Laboratory
University of Toronto
Toronto, Ontario M5S 1A7
Canada
(current address:
Instutut für Allgemeine und Angewandte Geophysik
Ludwig-Maximilians-Universität
Theresienstrasse 41
8000 München 2
Federal Republic of Germany)

Mary Anne Holmes
Sedimentologist
Department of Geology
University of Nebraska
Lincoln, Nebraska 68588-0340

William R. Howard
Sedimentologist
Department of Geological Sciences
Brown University
Providence, Rhode Island 02912-1846

Hiroo Inokuchi
Paleomagnetist
Faculty of Science
Department of Earth Sciences
Kobe University
Nada, Kobe 657
Japan
(current address:
Marine Biological Station
Faculty of Science
Kobe University
Iwaya, Awaji, Tsuha
Awaji Island, Hyogo 656-24
Japan)

Kerry Kelts
Sedimentologist
Geology Section
EAWAG/ETH
CH-8600 Dübendorf
Switzerland

David B. Lazarus
Paleontologist (radiolarians)
Department Geology and Geophysics
Woods Hole Oceanographic Institution
Quissett Campus
Woods Hole, Massachusetts 02543
(current address:
Geologisches Institut
Eidgenossische Technische Hochschule
Sonneggstrasse 5
CH-8092 Zurich
Switzerland

Andreas Mackensen
Paleontologist (foraminifers)
Alfred Wegener Institute for Polar and Marine Research
Columbusstrasse
D-2850 Bremerhaven
Federal Republic of Germany

Toshiaki Maruyama
Paleontologist (diatoms)
Department of Earth Science
College of General Education
Tohoku University
Kawauchi, Sendai 980
Japan

Marc Munschy
Geophysicist/Logging Scientist
Institut de Physique de Globe
Université Louis Pasteur
5, Rue René Descartes
67084 Strasbourg Cedex
France

Elizabeth Pratson
LDGO Logging Scientist
LDGO-Borehole Research Group
Columbia University
Palisades, New York 10964

Patrick G. Quilty
Paleontologist (foraminifers)
Antarctic Division
Channel Highway
Kingston 7050
Tasmania
Australia

Frank Rack
Physical Properties Specialist
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, Texas 77840

Vincent J. M. Salters
Igneous Petrologist
Department of Earth, Atmospheric and Planetary Sciences
54-1116, M.I.T.
Cambridge, Massachusetts 02139

James H. Sevigny
Igneous Petrologist
Department of Geology and Geophysics
The University of Calgary
Calgary, Alberta T2N 1N4
Canada

Michael Storey
Igneous Petrologist
Department of Geology
University of Leicester
University Road
Leicester LEI 7RH
United Kingdom

Atsushi Takemura
Paleontologist (radiolarians)
Faculty of Science
Department of Geology and Mineralogy
Kyoto University
Kyoto 606
Japan
(current address:
Geoscience Institute
Hyogo University of Teacher Education
Yashiro-cho, Kato-qun
Hyogo, 673-14
Japan)

David K. Watkins
Paleontologist (nannofossils)
Department of Geology
University of Nebraska
Lincoln, Nebraska 68588-0340

Hubert Whitechurch
Igneous Petrologist
University de Géologie
Université Louis Pasteur
1 rue Blessig
67084 Strasbourg Cedex
France
(current address:
Institut de Physique de Globe
Université Louis Pasteur
5, rue Réne Descartes
67084 Paris Cedex
France

James Zachos
Sedimentologist/Organic Geochemist
Graduate School of Oceanography
University of Rhode Island
Narragansett Bay Campus
Narragansett, Rhode Island 02882-1197
(current address:
Department of Geological Sciences
University of Michigan
1006 C. C. Little Building
Ann Arbor, Michigan 48109-1063)

SEDCO OFFICIALS

Captain Edwin G. Oonk
Master of the Drilling Vessel
Underseas Drilling, Inc.
707 Texas Avenue South,
Suite 103D
College Station, Texas 77840-1917

Kenneth D. Horne
Drilling Superintendent
Underseas Drilling, Inc.
707 Texas Avenue South,
Suite 103D
College Station, Texas 77840-1917

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VOLUME 120—INITIAL REPORTS

DEDICATION

This volume is dedicated to the memory of Lamar P. Hayes, long-time Operations Superintendent for the Ocean Drilling Program and the Deep Sea Drilling Project, who deeply touched the lives of all of us and made our scientific dreams come true. Lamar died on 27 March 1988 of a heart attack suffered while supervising operations on board the *JOIDES RESOLUTION* at Site 749 on the central Kerguelen Plateau.

The Operations Superintendent is perhaps the key position on a scientific drillship, the hub about which all life and activity revolves. At sea, he serves not only as the primary liaison between the Ocean Drilling Program and the drilling contractor, but also between the scientific/technical staff and all other supporting groups on the ship. He must translate goals and objectives, problems and needs into a common language and understanding so that the overall mission of the cruise can be accomplished.

Lamar Hayes was no ordinary Operations Superintendent. By virtue of his talent and experience, he was the Dean of all such men who have performed this extraordinarily difficult task throughout the life of this unique 21-year old program. His death midway through ODP Leg 120, which was beset constantly with difficult weather conditions in one of the most remote sectors of the world's oceans, was felt immediately and profoundly not only by his 120 shipboard companions but by friends and colleagues around the world.

Born on 23 March 1928 in Lampkin, Texas, Lamar had gained experience as a roughneck by the time he graduated from high school in Sidney, Texas. After attending Howard Payne College in Brownwood, Texas, he began his professional career as a derrickman and driller in the oil patches of Midland, Texas, with time out only for duty with the U.S. Air Force during the Korean conflict. In the oil fields, he rose rapidly through the ranks, first as a toolpusher in South America and later as Field Superintendent and Senior Field Supervisor in Midland before joining Brown and Root in Houston. There, in the mid-1960s, he designed changes and supervised modifications of equipment and tools for Project Mohole, the program that gave birth to scientific deep-sea drilling.

During his long career, Lamar served in a variety of supervisory positions with petroleum and engineering companies, but he always maintained a keen interest in scientific drilling. He came to Scripps Institution of Oceanography in August 1970 as an Operations Superintendent for the Deep Sea Drilling Project. His first voyage on the *Glomar Challenger* was Leg 18 to the Gulf of Alaska, which was also the first cruise for Sherwood W. Wise, Jr., one of the eventual co-chief scientists on Ocean Drilling Program Leg 120, who remembers well his gentle manner and unorthodox but winning approach to the game of ocean-going ping pong. Lamar went on to sail on six more DSDP legs before leaving DSDP to work as rig and operations manager on commercial drilling rigs around the world.

When ODP started up, Lamar returned in January 1984 to his interest in scientific drilling and was Operations Superintendent on the *JOIDES Resolution* for the inaugural cruise of the new program (Leg 101). His communication and "people" skills were extraordinary, a key to his success in translating the wildest of scientific ideas into a workable, realistic plan that could be carried out by the men on the rig floor. His talent for mobilizing the shipboard team to innovate and prove out new drilling techniques and systems at sea is the stuff of legends, and he was always looking for new ways to improve the quality and efficiency of shipboard operations. He was pleased and gratified when the crew was able to surpass a previous drilling or coring record or level of accomplishment.

On Leg 120, his pioneering use of the free-fall reentry cone for hard-rock drilling not only made possible two holes that could not otherwise have been drilled under the existing weather conditions, but also set records in the process. He also introduced an imaginative new technique that saved the site he was drilling on the night he became ill. Equally memorable during the leg were the informal daily gatherings for coffee in Lamar's office where, with a free flow of participants from the bridge to the rig floor, from the science office to the labs, much of the business of the ship would be transacted and coordinated with a good dose of humor and the latest anecdotes.

In recognition of his contributions to science through his service to DSDP/ODP, Leg 120 scientists have named in his honor a new fossil discovered during the leg, *Bolboforma lamari* (see Mackensen and Spiegler, this vol.). He will long be remembered by all of us who went to sea with him, and his influence on the art of deep-sea drilling will be part of the inheritance Lamar has left for the ocean science community.

ACKNOWLEDGMENTS

Leg 120 owes its success to the ingenuity, dedication, and perseverance of the many remarkable people involved with the planning, operations, and post-cruise stages of the leg. Site surveys by the Institut de Physique du Globe de Strasbourg (France) and the Bureau of Mineral Resources, Canberra (Australia) laid the foundation for Kerguelen Plateau drilling on Legs 119 and 120. Permission to drill the Leg 120 sites was obtained from France (Territoires des Terres Australes et Antarctiques Françaises) and Australia.

The drillship was deftly piloted in the tempestuous waters of the southern Indian Ocean by Captain Ed Oonk and his crew. SEDCO Drilling Superintendent Ken Horne and his group braved the elements to keep the rig floor operating as smoothly as possible during some of the most inhospitable drilling conditions imaginable. The ODP Marine Technicians, under the leadership of Lab Officer Brad Julson, lived up to their reputation of cheerfulness and professionalism despite the hardships imposed by a long cruise in remote and stormy waters. Doc Nickerson helped with phone patches to families and friends on the beach. Finally, the Catamar crew did their best to provide the comforts of home while we were all so far away from ours. Meanwhile, onshore, Phil Rabinowitz, Lou Garrison, Audrey Meyer, and the entire ODP organization provided us with moral, material, and logistical support when we needed it, including a 5-day cruise extension that allowed us to make a return trip to the Kerguelen Plateau in order to complete our mission.

After the cruise, our post-cruise meeting was handled superbly by Fabiola Byrne and Laura Young of the ODP Publications Group. Our site reports were transformed into the cruise volume thanks to the efforts of volume editor Eva Barbu and the ODP Art Section, under the direction of Chief Illustrator Karen Benson.

We truly appreciate all the hard work of everyone involved with Leg 120.