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VOLUME 107 SCIENTIFIC RESULTS

TYRRHENIAN SEA

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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

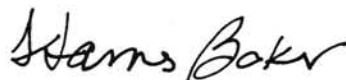
with a scientific and technical crew of 50 and a ship's crew of 65.

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 televiwer 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
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Preface

The *Scientific Results* volumes of the *Proceedings of the Ocean Drilling Program* contain specialty papers presenting the results of up to one and one-half years of research in various aspects of scientific ocean drilling. I acknowledge with thanks the authors of the papers published in this volume, who thereby have enabled future investigators to gain ready access to the results of their research.

Each of the papers submitted to a *Scientific Results* volume undergoes rigorous peer review by at least two specialists in the author's research field. A paper typically goes through one or more revision cycles before being accepted for publication. Our goal is to maintain a peer-review system comparable to those of the most highly regarded journals in the geological sciences.

The Editorial Review Board for a *Scientific Results* volume is responsible for obtaining peer reviews of papers submitted to the volume. This board usually is made up of the two co-chief scientists for the cruise, the ODP staff scientist for the cruise, and one external specialist who is familiar with the geology of the area investigated. In addition, the ODP staff editor assigned to the volume helps with any manuscripts that require special attention, such as those by authors who need assistance with English expression.

Scientific Results volumes may also contain short reports consisting of good data that are not ready for final interpretation. Papers in this category are segregated in a section in the back of the volume called Data Reports. Although no interpretation is permitted, these papers ordinarily contain a section on methodology or procedures. Data Report papers are read carefully by at least one specialist to make sure they are well organized, comprehensive, and discuss the techniques thoroughly. A paper that has undergone regular peer review is not eligible for later consideration as a Data Report.

In acknowledgment of the contributions made by this volume's Editorial Review Board, names of the individual Board members are listed on the title page. Reviewers of manuscripts for this volume, whose efforts are so essential to the success of the publication, are listed in the front portion of the book, without attribution to a particular manuscript.

On behalf of the Ocean Drilling Program, I extend sincere appreciation to members of the Editorial Review Boards and to the reviewers for giving so generously of their time and efforts in ensuring that only papers of high scientific quality are published in the *Proceedings*.



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TABLE OF CONTENTS

VOLUME 107—SCIENTIFIC RESULTS

SECTION 1: OVERVIEW

1. THE GEOLOGICAL EVOLUTION OF THE TYRRHENIAN SEA: AN INTRODUCTION TO THE SCIENTIFIC RESULTS OF ODP LEG 107 3
K. Kastens and J. Mascle

SECTION 2: STUDIES ON CRYSTALLINE BASEMENT

2. TYPES AND SOURCES OF LARGE ROCK CLASTS AND OF HEAVY MINERALS FROM ODP SITES 652, 653, 654, AND 656 IN THE TYRRHENIAN SEA: IMPLICATIONS ABOUT THE NATURE OF THE EAST SARDINIA PASSIVE CONTINENTAL MARGIN. 29
R. Sartori, G. Mascle, J. P. Bouillin, J. Girault, G. Naud, M. Pasini, and M. Piboule
3. PERIDOTITES DRILLED FROM THE TYRRHENIAN SEA, ODP LEG 107. 37
E. Bonatti, M. Seyler, J. Channell, J. Giraudeau, and G. Mascle
4. GEOCHEMISTRY AND MINERALOGY OF VOLCANIC ROCKS FROM ODP SITES 650, 651, 655, AND 654 IN THE TYRRHENIAN SEA 49
L. Beccaluva, E. Bonatti, C. Dupuy, G. Ferrara, F. Innocenti, F. Lucchini, P. Macera, R. Petrini, P. L. Rossi, G. Serri, M. Seyler, and F. Siena
5. PETROLOGY AND GEOCHEMISTRY OF BASALTS FROM THE VAVILOV BASIN (TYRRHENIAN SEA), OCEAN DRILLING PROGRAM LEG 107, HOLES 651A AND 655B. 75
H. Bertrand, P. Boivin, and C. Robin
6. ³⁹AR-⁴⁰AR ANALYSIS ON BASALTIC LAVA SERIES OF VAVILOV BASIN, TYRRHENIAN SEA (OCEAN DRILLING PROGRAM, LEG 107, HOLES 655B AND 651A) 93
G. Feraud
7. MAGNETIC PROPERTIES AND PALEOMAGNETISM OF BASALTS FROM LEG 107 (HOLES 651A AND 655B) 99
L. Vigliotti, M. Torii, and J. Channell

SECTION 3: STUDIES ON SEDIMENTS

8. CONTRASTING MAGNETIC PROPERTIES IN LEG 107 SEDIMENTS: PRESERVATION AND ALTERATION OF TITANOMAGNETITE AT ADJACENT SITES 113
J.E.T. Channell, T. Hawthorne, and M. Torii
9. PLIOCENE BASAL DOLOMITIC AND FE-MN SEDIMENTS FROM THE TYRRHENIAN SEA, WESTERN MEDITERRANEAN, ODP LEG 107 129
A.H.F. Robertson
10. BASAL DOLOMITIC SEDIMENTS, TYRRHENIAN SEA, OCEAN DRILLING PROGRAM LEG 107 141
J. A. McKenzie, A. Isern, A. M. Karpoff, and P. K. Swart
11. MINERALOGICAL AND GEOCHEMICAL INVESTIGATIONS ON LATEST MIOCENE DEPOSITS IN THE TYRRHENIAN SEA (ODP LEG 107) 153
H. Chamley, P. Debrabant, C. Robert, G. Mascle, J.-P. Rehault, and J. Aprahamian
12. MESSINIAN AND PRE-MESSINIAN SEDIMENTS FROM ODP LEG 107 SITES 652 AND 654 IN THE TYRRHENIAN SEA: SEDIMENTOLOGIC AND PETROGRAPHIC STUDY AND POSSIBLE COMPARISONS WITH ITALIAN SEQUENCES 169
A. M. Borsetti, P. V. Curzi, V. Landuzzi, M. Mutti, F. Ricci Lucchi, R. Sartori, L. Tomadin, and G. G. Zuffa

13. SEDIMENTARY AND DIAGENETIC EVOLUTION OF MESSINIAN EVAPORITES IN THE TYRRHENIAN SEA (ODP LEG 107, SITES 652, 653, and 654): PETROGRAPHIC, MINERALOGICAL, AND STABLE ISOTOPE RECORDS.....	187
C. Pierre and J. M. Rouchy	
14. MESSINIAN PALEOENVIRONMENTS: NEW EVIDENCE FROM THE TYRRHENIAN SEA (ODP LEG 107)	211
M. B. Cita, S. Santambrogio, B. Melillo, and F. Rogate	
15. MINERALOGICAL STUDY OF UPPER MIOCENE SEDIMENTS FROM WIRE-LINE LOGS AND CORE MEASUREMENTS, SITE 652, OCEAN DRILLING PROGRAM LEG 107 (TYRRHENIAN SEA)	229
C. Broglia, B. C. Schreiber, M. B. Cita, H. Chamley, and R. Dove	
16. GEOCHEMISTRY AND MINERALOGY OF IRON- AND TRACE-METAL-RICH MESSINIAN AND PLIOCENE MUDSTONES CORED ON THE SARDINIAN MARGIN: ODP LEG 107, TYRRHENIAN SEA (CENTRAL MEDITERRANEAN)	245
A.H.F. Robertson	
17. SEDIMENTATION IN THE MARSILI BASIN DURING QUATERNARY (ODP SITE 650, TYRRHENIAN SEA).....	255
W. Hieke, G. Glaçon, S. Hasegawa, C. Müller, and J. P. Peypouquet	
18. VOLCANICLASTIC SEDIMENTS IN THE TYRRHENIAN BASIN	291
F. W. McCoy and W. Cornell	
19. MINERALOGY OF FIRM MUDS AND MUDSTONES ASSOCIATED WITH VOLCANOSEDIMENTARY LAYERS FROM THE TYRRHENIAN SEA, HOLES 650A AND 651A, O.D.P. LEG 107	307
J. Allouc and Y. Champetier	
20. CLAY MINERALOGY OF THE PLIOCENE AND PLEISTOCENE OF HOLE 653A, WESTERN TYRRHENIAN SEA (ODP LEG 107).....	323
J. P. de Visser and H. Chamley	
SECTION 4: STRATIGRAPHY AND PALEOENVIRONMENT	
21. MAGNETOSTRATIGRAPHY OF SEDIMENTS RECOVERED AT SITES 650, 651, 652, AND 654 (LEG 107, TYRRHENIAN SEA)	335
J.E.T. Channell, M. Torii, and T. Hawthorne	
22. TWO "EVENTS" RECORDED IN THE BRUNHES CHRON AT HOLE 650A (ODP LEG 107, TYRRHENIAN SEA): GEOMAGNETIC PHENOMENA?.....	347
J.E.T. Channell and M. Torii	
23. OXYGEN AND CARBON ISOTOPE STRATIGRAPHY OF ODP HOLE 653A AND SITE 654: THE PLIOCENE-PLEISTOCENE GLACIAL HISTORY RECORDED IN THE TYRRHENIAN BASIN (WEST MEDITERRANEAN)	361
C. Vergnaud Grazzini, J. F. Saliège, M. J. Urrutiaguer, and A. Iannace	
24. PLIOCENE-PLEISTOCENE STABLE ISOTOPE RECORD FOR OCEAN DRILLING PROGRAM SITE 653, TYRRHENIAN BASIN: IMPLICATIONS FOR THE PALEO-ENVIRONMENTAL HISTORY OF THE MEDITERRANEAN SEA.....	387
R. Thunell, D. Williams, E. Tappa, D. Rio, and I. Raffi	
25. STRONTIUM ISOTOPE STRATIGRAPHY OF THE PLIOCENE-PLEISTOCENE "DEEP-SEA TYPE SECTION" AT ODP HOLE 653A.....	401
J. A. McKenzie, S. C. Palmer, and P. A. Mueller	
26. PALEOCEANOGRAPHIC CONDITIONS FOLLOWING THE EARLIEST PLIOCENE FLOODING OF THE TYRRHENIAN SEA	405
J. A. McKenzie and R. Sprovieri	

27.	PLANKTONIC FORAMINIFERAL EVENTS AND STABLE ISOTOPE RECORDS IN THE UPPER MIOCENE, SITE 654	415
	G. Glacon, C. Vergnaud Grazzini, S. Iaccarino, J.-P. Rehault, A. Randrianasolo, J. F. Sierrro, P. Weaver, J. Channell, M. Torii and T. Hawthorne	
28.	PLIO-PLEISTOCENE BENTHIC FORAMINIFERA STRATIGRAPHIC DISTRIBUTION IN THE DEEP-SEA RECORD OF THE TYRRHENIAN SEA (ODP LEG 107)	429
	R. Sprovieri and S. Hasegawa	
29.	QUANTITATIVE ANALYSIS OF BENTHIC FORAMINIFERAL ASSEMBLAGES FROM PLIO-PLEISTOCENE SEQUENCES IN THE TYRRHENIAN SEA, ODP LEG 107.....	461
	S. Hasegawa, R. Sprovieri, and A. Poluzzi	
30.	RELATIONSHIP BETWEEN THE BENTHIC FORAMINIFERS AND THE OSTRACODES IN THE PLIOCENE-PLEISTOCENE TYRRHENIAN DEEP-SEA RECORD (ODP LEG 107, SITE 654)	479
	M. L. Colalongo, G. Pasini, A. Poluzzi, and R. Sprovieri	
31.	NANNOPLANKTON BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL INTERPRETATIONS FROM THE TYRRHENIAN SEA, ODP LEG 107 (WESTERN MEDITERRANEAN)	495
	C. Müller	
32.	PLIOCENE-PLEISTOCENE CALCAREOUS NANNOFOSSIL DISTRIBUTION PATTERNS IN THE WESTERN MEDITERRANEAN.....	513
	D. Rio, I. Raffi, and G. Villa	

SECTION 5: SEDIMENTARY GEOCHEMISTRY

33.	ORGANIC GEOCHEMISTRY OF ODP LEG 107 SEDIMENTS (SITES 652, 653, 654, 655).....	537
	E. Brosse and J. P. Herbin	
34.	PROVENANCE AND MATURITY OF ORGANIC CARBON IN LATE TERTIARY TO QUATERNARY SEDIMENTS FROM THE TYRRHENIAN SEA—(ODP LEG 107/HOLES 652A AND 654A).....	545
	K.-C. Emeis, B. Mycke, and E. T. Degens	
35.	ORGANIC FACIES AND MATURATION OF SEDIMENTS FROM THE TYRRHENIAN SEA, OCEAN DRILLING PROGRAM, LEG 107.....	579
	P. K. Mukhopadhyay	
36.	GEOCHEMISTRY OF LABILE ORGANIC MATTER IN SEDIMENTS AND INTERSTITIAL WATER RECOVERED FROM SITES 651 AND 653, LEG 107 ODP IN THE TYRRHENIAN SEA	591
	R. Seifert, K.-C. Emeis, A. Spitz, K. Strahlendorff, W. Michaelis, and E. T. Degens	
37.	STRONTIUM ISOTOPIC RATIOS AS FLUID TRACERS IN MESSINIAN EVAPORITES OF THE TYRRHENIAN SEA (WESTERN MEDITERRANEAN SEA).....	603
	D. W. Müller, P. A. Mueller, and J. A. McKenzie	

SECTION 6: GEOPHYSICS

38.	A REVISED SEISMIC STRATIGRAPHY OF THE TYRRHENIAN SEA: IMPLICATIONS FOR THE BASIN EVOLUTION	617
	J. Mascle and J.-P. Rehault	

SECTION 7: SYNTHESIS

39. SUMMARY AND SYNTHESIS OF LATE MIOCENE TO RECENT SEDIMENTARY AND PALEOCEANOGRAPHIC EVOLUTION OF THE TYRRHENIAN SEA, WESTERN MEDITERRANEAN: LEG 107 OF THE OCEAN DRILLING PROGRAM 639
A. Robertson, W. Hieke, G. Mascle, F. McCoy, J. McKenzie, J.-P. Rehaut, and R. Sartori

40. BIOMAGNETOSTRATIGRAPHIC CORRELATIONS FROM LEG 107 IN THE TYRRHENIAN SEA..... 669
J.E.T. Channell, D. Rio, R. Sprovieri, and G. Glaçon

41. CALCAREOUS PLANKTON PLIOCENE-PLEISTOCENE BIOSTRATIGRAPHY IN THE TYRRHENIAN SEA (WESTERN MEDITERRANEAN, LEG 107) 683
G. Glaçon, D. Rio, and R. Sprovieri

42. PLIOCENE-PLEISTOCENE PALEOENVIRONMENTAL HISTORY OF THE WESTERN MEDITERRANEAN: A SYNTHESIS OF ODP SITE 653 RESULTS 695
D. Rio, R. Sprovieri, R. Thunell, C. Vergnaud Grazzini, and G. Glaçon

43. PLIOCENE-EARLY PLEISTOCENE CHRONOSTRATIGRAPHY AND THE TYRRHENIAN DEEP-SEA RECORD FROM SITE 653 705
D. Rio, R. Sprovieri, and J. Channell

44. THE MAIN RESULTS OF ODP LEG 107 IN THE FRAME OF NEOGENE TO RECENT GEOLOGY OF PERITYRRHENIAN AREAS 715
R. Sartori

SECTION 8: DATA REPORT

45. TEXTURAL AND COMPOSITIONAL CHARACTERS OF EIGHT SAMPLES FROM HOLES 652A AND 654A (LEG 107, TYRRHENIAN SEA) 733
G. Cavarretta, G. Civitelli, E. Francaviglia, and G. Mariotti

SECTION 9: CORRECTION TO SR VOL. 101

Plate 2: ALBIAN-CENOMANIAN DINOFLAGELLATE CYSTS FROM SITES 627 AND 635, LEG 101, BAHAMAS..... 741
Edwige Masure

SECTION 10: POLICY

JOIDES ADVISORY GROUPS 745

SAMPLE-DISTRIBUTION POLICY 749

SECTION 11: INDEX

INDEX 753

BACK-POCKET MICROFICHE

SCIENTIFIC RESULTS: VOLUME 107: CHAPTER 28: TABLE 2. QUANTITATIVE RANGES OF PLIO-PLEISTOCENE BENTHIC FORAMINIFERS AT SITE 654. TABLE 3. QUANTITATIVE RANGES OF PLIO-PLEISTOCENE BENTHIC FORAMINIFERS AT HOLE 653A. TABLE 4. QUANTITATIVE RANGES OF PLIO-PLEISTOCENE BENTHIC FORAMINIFERS AT SITE 652.