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Volume 170
Scientific Results
Fluid, Mass, and Thermal Fluxes
in the Pacific Margin of Costa Rica

Covering Leg 170 of the cruises of the Drilling Vessel *JOIDES Resolution*
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Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, the participating agencies, Joint Oceanographic Institutions, Inc., Texas A&M University, or Texas A&M Research Foundation.

Current policy requires that all figures published in *Scientific Results* volumes of the *Proceedings of the Ocean Drilling Program* be provided by the authors.

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 map at the front of this volume was produced using Generic Mapping Tools (GMT) of Paul Wessel and Walter H.R. Smith (imina.soest.hawaii.edu/gmt/). A site map showing the drilling locations for this leg and maps showing the drilling locations of all Ocean Drilling Program (ODP) and Deep Sea Drilling Project (DSDP) drilling sites are available on the volume CD-ROM in PDF format.

Cover photograph looking aft from the bow of the *JOIDES Resolution* by ODP Photographer Roy Davis.

FOREWORD

BY JOINT OCEANOGRAPHIC INSTITUTIONS, INC.

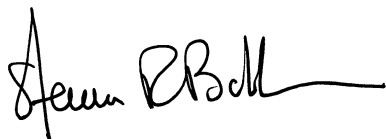
This volume presents scientific and engineering results from the Ocean Drilling Program (ODP). These results address the scientific and technical goals of the program, which are focused on the study of the dynamics of Earth's interior and environment, the evolution of oceanic crust, and the fluctuations of climate. In addition, study of the Earth's deep biosphere is an emergent research objective.

ODP, an international partnership of scientists and research institutions from 22 countries, operates the drillship *JOIDES Resolution*. This state-of-the-art research vessel contains eight levels of laboratories and other scientific facilities required for carrying out the program's objectives.

The management of ODP involves a partnership of scientists and governments. International oversight and coordination are provided by the ODP Council, which is made up of representatives from the member countries. Overall scientific and management guidance is provided by representatives from the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES).

Joint Oceanographic Institutions, Inc. (JOI), a nonprofit consortium of 13 U.S. oceanographic institutions, serves as the National Science Foundation's prime contractor for ODP. JOI implements scientific objectives, plans, and recommendations of the JOIDES committees through major subcontracts to Texas A&M University (TAMU) for science operations and to Lamont-Doherty Earth Observatory (LDEO) of Columbia University for geochemical and geophysical well-logging services.

JOI, TAMU, and LDEO have worked together successfully for many years to manage the Ocean Drilling Program. We look forward to many exciting discoveries and continued international collaboration as we further our scientific mission, especially the planning for the future of ocean drilling beyond 2003.



Steven R. Bohlen
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PREFACE

THE VOYAGES OF DISCOVERY

The *Scientific Results* volumes of the *Proceedings of the Ocean Drilling Program* are about Earth and her oceans.

These volumes contain contributions to a better understanding of the history of our planet through time. This exploration of Earth's past is based on scientific analyses of layers of strata sampled by the *JOIDES Resolution* at key locations throughout the global ocean. These volumes are a tribute to the scientific exploration carried out by the men and women who contributed to these voyages of discovery. Like the pioneering exploration and research of Captain Cook aboard the first *Resolution*, these volumes are a credit to the human spirit, which sees no boundaries.

The papers in this volume are published in a new online format that will be archived on CD-ROM. The *Proceedings* contents are available to students, scientists, and the public throughout the world. Volumes, once housed in the libraries of the member nations of ODP, are now published on the Internet for a worldwide audience and are also available in CD-ROM format. This electronic publication enables future investigators to gain easier access to the results of ocean drilling research. I acknowledge and thank the authors for their contributions and willingness to participate in this new venture.

Each *Scientific Results* volume has an Editorial Review Board that 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 investigated area. ODP staff coordinate the peer-review process and also edit and produce each paper.

Each *Scientific Results* volume contains one leg synthesis paper and other peer-reviewed papers that present the results of extensive research in various aspects of scientific ocean drilling related to each leg. Each paper submitted to a *Scientific Results* volume undergoes rigorous peer review by at least two specialists in the author's research field. Volumes may also contain short reports of useful data. These Data Reports do not include interpretation of results and are peer-reviewed by at least one specialist. We seek to maintain a peer-review system comparable to those of the most highly regarded journals in the geological sciences.

To acknowledge the contributions made by this volume's Editorial Review Board, the Board members are designated Editors of the volume. Reviewers of manuscripts for this volume, whose efforts are so essential to the success of the publication, are listed without attribution to any particular manuscript.

On behalf of the Ocean Drilling Program, I extend sincere appreciation to the members of the Editorial Review Board and to the reviewers for generously contributing their time and effort. This process ensures that only papers of high scientific quality are published in the *Scientific Results* volumes.



Paul J. Fox
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TABLE OF CONTENTS

Volume 170 *Scientific Results*

CHAPTERS¹

- | | |
|---|------|
| 1. Planktonic Foraminifers off Costa Rica in the East Pacific Ocean—
Biostratigraphic and Chronostratigraphic Analyses | 1–58 |
| Masako Ibaraki | |
| 2. Diatom Biostratigraphy of Sites 1039–1043, Costa Rica Margin | 1–22 |
| Lisa D. White | |
| 3. Microstructural and Geomechanical Constraints on Fluid Flow at the
Costa Rica Convergent Margin, Ocean Drilling Program Leg 170 | 1–32 |
| Alistair J. Bolton, Paola Vannucchi, M. Ben Clennell, and Alex Maltman | |
| 4. Leg 170: Synthesis of Fluid-Structural Relationships of the Pacific Margin
of Costa Rica | 1–11 |
| Eli A. Silver | |
| 5. Calcareous Nannofossil Biostratigraphy from a 15-km Transect (Cocos
Plate to Caribbean Plate) across the Middle America Trench,
Nicoya Peninsula, Costa Rica | 1–63 |
| Jay P. Muza | |
| 6. Pliocene–Pleistocene Paleooceanography in the East Pacific off Costa Rica
Determined by Planktonic Foraminifers | 1–28 |
| Masako Ibaraki | |
| 7. Plate Tectonic Evolution of the Cocos-Nazca Spreading Center | 1–10 |
| Martin Meschede and Udo Barckhausen | |
| Index | 1–21 |

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¹Chapters are listed in order of acceptance. Chapter 4 and the volume index appear in printed format and on the *Scientific Results* CD-ROM included with this booklet. All other contents are available on the volume CD.

DRILLING LOCATIONS MAPS

A site map showing the drilling locations for this leg and maps showing the drilling locations of all Ocean Drilling Program (ODP) and Deep Sea Drilling Project (DSDP) drilling sites are available on the volume CD-ROM in PDF format.

COMPILED ELECTRONIC INDEX

The Compiled Electronic Index of the *Proceedings of the Ocean Drilling Program* included on the volume CD-ROM contains individual indexes of Volumes 101–171A. The indexes are contained in the directory titled ODPINDEX and are named ###NDX.PDF (### = the leg number). These indexes can be searched individually or collectively.

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README.TXT (Information about the volume CD-ROM in ASCII format)		
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		UNIX
		WINDOWS
	README.TXT	
MAPS (Drilling locations maps)	170_MAP.PDF (Leg 170 site map)	
	ODPMAP.PDF (ODP map, Legs 100 through 170)	
	DSDPMAP.PDF (DSDP map, Legs 1 through 96)	
VOLUME (Leg 170 <i>Scientific Results</i> volume)	CHAPTERS (Volume chapters)	SR170_01.PDF (Planktonic Foraminifers off Costa Rica in the East Pacific Ocean)
		SR170_02.PDF (Diatom Biostratigraphy of Sites 1039–1043)
		SR170_03.PDF (Microstructural and Geomechanical Constraints on Fluid Flow)
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