



Interactions of the **MAJOR** **BIOGEOCHEMICAL** **CYCLES**

Global Change and
Human Impacts

Jerry M. Melillo
Christopher B. Field
Bedrich Moldan

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Interactions of the Major Biogeochemical Cycles

Global Change and Human Impacts

Edited by
Jerry M. Melillo, Christopher B. Field,
and Bedrich Moldan

A project of SCOPE, the Scientific Committee on
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Foreword

The Scientific Committee on Problems of the Environment (SCOPE) is one of twenty-six interdisciplinary bodies established by the International Council for Science (ICSU) to address cross-disciplinary issues. SCOPE was established by ICSU in 1969 in response to environmental concerns emerging at that time. When establishing SCOPE, ICSU recognized that many of these concerns required scientific input spanning several disciplines represented within its membership. Today, representatives of forty member countries and twenty-two international, disciplinary-specific unions, scientific committees, and associates currently participate in the work of SCOPE, which directs particular attention to environmental issues in developing countries. The mandate of SCOPE has four parts: to assemble, review, and synthesize the information available on environmental changes attributable to human activity and the effects of these changes on humans; to assess and evaluate methodologies for measuring environmental parameters; to provide an intelligence service on current research; and to provide informed advice to agencies engaged in studies of the environment.

This synthesis volume continues SCOPE's discourse on the important biogeochemical cycles that are essential to life on this planet. It discusses our understanding of the major biogeochemical life cycles with special reference to the advances made in the past decade. It should provide a timely examination of the practical consequences of this knowledge for the sustainability of ecosystems affected by humans.

SCOPE publishes this book as the first of a series of rapid assessments of environmental issues. Our aim is to make sure that experts meet on a regular basis, summarize recent advances in related disciplines, and discuss their possible significance in understanding environmental problems and potential solutions. We aim to make this information available within six to nine months of an assess-

ment's synthesis meeting. We hope that these assessments provide an important service to younger environmental scientists who want to remain informed about new developments and their significance across disciplines.

John W. B. Stewart, Editor-in-Chief

SCOPE Secretariat

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Véronique Plocq Fichelet, Executive Director

Preface

Almost three decades ago SCOPE launched a major series of projects on the biogeochemical cycles. Initially these projects focused on the study of carbon, nitrogen, sulfur, and phosphorus separately, with much of the work on individual cycles being coordinated by separate SCOPE/UNEP (Scientific Committee on Problems of the Environment/United Nations Environmental Programme) units. Participants understood that none of these cycles operates independently and made attempts to include studies of element interactions in each of the unit's activities. In 1983 SCOPE produced its first major scientific assessment on interactions among biogeochemical cycles—*The Major Biogeochemical Cycles and Their Interactions*, edited by B. Bolin and R. B. Cook—a book that has guided biogeochemical research since its publication. The assessment's foundation was the basic stoichiometric model of life—the formation of the organic compounds in life processes requires the availability of the elements C, O, H, N, P, S, and a number of trace elements in distinct proportions.

Although SCOPE 21 challenged the stoichiometric model, the model stood up well as a basic paradigm for thinking about element interactions. After two decades of biogeochemical research using radioactive and stable isotopes, applying ever more sophisticated mathematical modeling approaches, and conducting a host of field manipulations, SCOPE delegates meeting at the XIth General Assembly in Bremen, Germany, decided that it was time to reevaluate how knowledge about element interactions had progressed. How insightful is the stoichiometric model? Have fundamental exceptions to it been found? What are they? What basic insights into biogeochemistry do these exceptions give us? Where applicable, does the stoichiometric model move easily across spatial and temporal scales? These and related questions form the basis for a new scientific assessment of element interactions in the biosphere.

The meeting on element interactions held in Prague, Czech Republic, in early October 2002 examined progress in several areas, including theory, measurements, design and interpretation of observation studies and manipulative experiments, and diagnostic and prognostic modeling. In the future sound management of element cycles and their interactions will be essential to fostering the transition to sustainable use of our planet's environment.

Acknowledgments

SCOPE acknowledges with thanks the financial support from the Andrew W. Mellon Foundation, the International Council for Science (ICSU), the US National Academy of Sciences (NAS), and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) that allowed this assessment to be undertaken. The synthesis meeting for the assessment was held in the Congress Center in the historical complex of the Charles University “Karolinum” in Prague, Czech Republic. This complex is located in the Old Town, only 300 meters from the historic Old Town Square. SCOPE is indebted to Professor Bedrich Moldan and Charles University for hosting the meeting in such a wonderful place. Special thanks are given to Ms. Susan Greenwood Etienne of the SCOPE secretariat and Dr. Jiri Dlouhy of the Environment Center, Charles University, for their extraordinary efforts to make the Prague meeting a great success.

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