

FOURTH EDITION

THE CHANGING EARTH

EXPLORING GEOLOGY AND EVOLUTION

James S. Monroe ♦ Reed Wicander



EDITION

The Changing Earth

Exploring Geology and Evolution

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Preface

Earth is a dynamic planet that has changed continuously during its 4.6 billion years of existence. The size, shape, and geographic distribution of the continents and ocean basins have changed through time, as have the atmosphere and biota. We have become increasingly aware of how fragile our planet is and, more important, how interdependent all of its various systems are. We have learned that we cannot continually pollute our environment and that our natural resources are limited and, in most cases, nonrenewable. Furthermore, we are coming to realize how central geology is to our everyday lives. For these and other reasons, geology is one of the most important college or university courses a student can take.

The Changing Earth: Exploring Geology and Evolution, Fourth Edition, is designed for an introductory course in geology that can serve both majors and nonmajors in geology and the Earth sciences. One of the problems with any introductory science course is that students are overwhelmed by the amount of material that they must learn. Furthermore, most of the material does not seem to be linked by any unifying theme and does not always appear to be relevant to their lives.

The goals of this book are to provide students with a basic understanding of geology and its processes and, more important, with an understanding of how geology relates to the human experience—that is, how geology affects not only individuals but society in general. It is also our intention to provide students with an overview of the geologic and biologic history of Earth, not as a set of encyclopedic facts to memorize but rather as a continuum of interrelated events that reflect the underlying geologic and biologic principles and processes that have shaped our planet and life upon it. With these goals in mind, we introduce the major themes of the book in the first chapter to provide students with an overview of the subject and enable them to see how Earth's various systems are interrelated. We also discuss the economic and environmental aspects of geology throughout the book rather than treating these topics in separate chapters. In this way, students can see, through relevant and interesting examples, how geology affects our lives.

NEW FEATURES IN THE FOURTH EDITION

The Fourth Edition has undergone considerable rewriting and updating to produce a book that is easier to read, with a great amount of cur-

rent information, many new photographs, a completely revamped art program, and various new features to help students maximize their learning and understanding of Earth and its systems. Drawing on the comments and suggestions of reviewers, we have incorporated many new features into this edition.

Perhaps the most noticeable change is that Chapter 19 in the Third Edition, "A History of the Universe, Solar System, and Planets," has now been incorporated into Chapter 1 to give students a complete view of Earth's earliest development and relation to the rest of the planets in our solar system. Because plate tectonic theory is such an important theme in geology, it is now covered in Chapter 2 so that students can appreciate its significance to material covered in subsequent chapters. In addition, a new Chapter 24 provides students with an overview of the concepts presented throughout the book and ties together the various themes covered.

The former Prologue and Introduction in each chapter are now combined into a new Introduction. These new sections begin each chapter with a story related to the chapter material and also address why each chapter's material is relevant and important to the student's overall understanding of the topic.

Concept art spreads are found throughout the book. These two-page art pieces are designed to enhance students' interest in the chapter material by visual learning. Some of the topics are "The Burren Area of Ireland," "Rock Art for the Ages," and "The Many Uses of Marble," to name a few.

Another new feature, *Geology in Unexpected Places*, discusses interesting geology or geologic phenomena in unusual places. We think this feature will be particularly appealing to students because it relates geology to the human experience. "Time Marches On—The Great Wall of China," "Diamonds and Earth's Interior," "Ancient Ruins and Geology," and "Floating Burial Chambers" are just a few of the topics covered.

We also have a powerful new interactive media program called *GeologyNow*, which has been seamlessly integrated with the text, enhancing students' understanding of important geologic processes. It brings geology alive with animated figures, media-enhanced activities, tutorials, and personalized learning plans. And, like other features in the Fourth Edition, it encourages students to be curious, to think about geology in new ways, and to connect their new-found knowledge of the world around them to their own lives.

Many of the popular *What Would You Do?* boxes have been rewritten, posing new topics and questions. These boxes are designed to encourage students to think

critically about what they're learning. They incorporate material from each chapter and ask open-ended questions to elicit discussion and formulate reasoned responses to particular situations.

The Third Edition's Perspectives have been replaced by Geo-Focus sections on a variety of new topics and updated previous ones.

Many photographs in the Third Edition have been replaced, including most of the chapter opening photographs. In addition, many photographs within the chapters have been enlarged to enhance their visual impact.

The art program has been completely revamped to provide the most accurate and visually stimulating figures possible. In addition, new paleogeographic maps have been commissioned that vividly illustrate in stunning relief the geography during the various geologic periods. Students will find two global views of Earth for each time period.

We think that the rewriting and updating done in the text as well as the addition of new photographs and newly rendered art greatly improve the Fourth Edition by making it easier to read and comprehend as well as a more effective teaching tool. Additionally, improvements have been made in the ancillary package that accompanies the book.

TEXT ORGANIZATION

Plate tectonic theory is the unifying theme of geology and this book. This theory has revolutionized geology because it provides a global perspective of Earth and allows geologists to treat many seemingly unrelated geologic phenomena as part of a total planetary system. Because plate tectonic theory is so important, it has been moved to Chapter 2 and is discussed in most subsequent chapters as it relates to the subject matter of that chapter.

Another theme of this book is that Earth is a complex, dynamic planet that has changed continuously since its origins some 4.6 billion years ago. We can better understand this complexity by using a systems approach to the study of Earth and emphasizing this approach throughout the book.

We have organized *The Changing Earth: Exploring Geology and Evolution*, Fourth Edition, into several informal categories. Chapter 1 is an introduction to geology and Earth systems, geology's relevance to the human experience, the origin of the solar system and Earth's place in it, a brief overview of plate tectonic theory, the rock cycle, organic evolution, and geologic time and uniformitarianism. Chapter 2 deals with plate tectonics in detail, whereas Chapters 3–7 examine Earth's materials (minerals and igneous, sedimentary, and metamorphic rocks) and the geologic processes associated with them, including the role of plate tectonics in

their origin and distribution. Chapters 8–10 deal with the related topics of Earth's interior, the seafloor, earthquakes, and deformation and mountain building. Chapters 11–16 cover Earth's surface processes. Chapter 17 discusses geologic time, introduces several dating methods, and explains how geologists correlate rocks. Chapter 18 explores fossils and evolution. Chapters 19–23 constitute our chronological treatment of the geologic and biologic history of Earth. These chapters are arranged so that the geologic history is followed by a discussion of the biologic history during that time interval. We think that this format facilitates easier integration of life history with geologic history. Chapter 24 summarizes and synthesizes the concepts, themes, and major topics covered in this book.

Of particular assistance to students are the end-of-chapter summary tables found in Chapters 20–22. These tables are designed to give an overall perspective of the geologic and biologic events that occurred during a particular time interval and to show how the events are interrelated. The emphasis in these tables is on the geologic evolution of North America. Global tectonic events and sea-level changes are also incorporated into these tables to provide global insights. In the Fourth Edition, we have reduced these tables so that each fits on one page instead of spreading over two pages.

We have found that presenting the material in the order discussed above works well for most students. We know, however, that many instructors prefer an entirely different order of topics, depending on the emphasis in their course. We have therefore written this book so that instructors can present the chapters in any order that suits the needs of a particular course.

CHAPTER ORGANIZATION

All chapters have the same organizational format. Each chapter begins with a photograph that relates to the chapter material, an Outline that engages students by having many of the headings in the form of questions, an Objectives list that alerts students to the learning outcome objectives of the chapter, followed by a new Introduction that is intended to stimulate interest in the chapter by discussing some aspect of the material and showing students how the chapter material fits into the larger geologic perspective.

The text is written in a clear, informal style, making it easy for students to comprehend. Numerous newly rendered color diagrams and photographs complement the text and provide a visual representation of the concepts and information presented. In addition, GeologyNow icons appear throughout the text, indicating opportunities to explore interactive tutorials, animations, or practice problems available on the

GeologyNow website at <http://earthscience.brookscole.com/changingearth4e>.

Each chapter contains one Geo-Focus section that presents a brief discussion of an interesting aspect of geology or geologic research. What Would You Do? boxes, usually two per chapter, are designed to encourage students to think as they attempt to solve a hypothetical problem or issue that relates to the chapter material.

Topics relating to environmental and economic geology are discussed throughout the text. Integrating economic and environmental geology with the chapter material helps students relate the importance and relevance of geology to their lives. Mineral and energy resources are discussed in the final sections of a number of chapters to provide interesting, relevant information in the context of the chapter topics. In addition, each of the chapters on geologic history in the second half of the book contains a final section on mineral resources characteristic of that time period.

Geology in Unexpected Places sections are found in most chapters. This new feature is designed to focus on interesting geology in unusual places or settings you might not have thought about.

The end-of-chapter Geo-Recap begins with a concise review of important concepts and ideas in the Chapter Summary. The Important Terms, which are printed in boldface type in the chapter text, are listed at the end of each chapter for easy review along with the page numbers on which they are first defined. A full Glossary of important terms appears at the end of the text. The Review Questions are another important feature of this book; they include multiple-choice questions with answers as well as short-answer, essay, and thought-provoking and quantitative questions. Many new questions have been added in each chapter of the Fourth Edition. Each chapter concludes with World Wide Web Activities that provide students with the URL for this book. At the Brooks/Cole website, students can assess their understanding of each chapter's topics, take quizzes, and participate in comprehensive interactivities as well as access up-to-date weblinks and find additional readings.

ANCILLARY MATERIALS

FOR INSTRUCTORS

We are pleased to offer a full suite of text and multimedia products to accompany the Fourth Edition of *The Changing Earth*.

GeologyNow GeologyNow is the first assessment-centered student learning tool for a course that combines physical and historical geology. It is tied to your

lectures and the text through Living Lecture Tools, which bring geologic processes to life. GeologyNow is web-based and free with every new copy of the text.

The Brooks/Cole Earth Sciences Resource Center
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Book Companion Website <http://earthscience.brookscole.com/changingearth4e>

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ISBN 0-495-01397-8

Current Perspectives in Geology Michael McKinney, Kathleen McHugh, and Susan Meadows (University of Tennessee, Knoxville)

This book is designed to supplement any geology textbook and is ideal for instructors who include a writing component in their course. The articles are culled from a number of popular science magazines (such as *American*

Scientist, National Wildlife, Discover, Science, New Scientist, and Nature). Available for sale to students or bundled at a discount with any Brooks/Cole geology text.
ISBN 0-534-37213-9

Essential Study Skills for Science Students Daniel Chiras (University of Colorado—Denver)

Designed to accompany any introductory science text. It offers tips on improving your memory, learning more quickly, getting the most out of lectures, preparing for tests, producing first-rate term papers, and improving critical thinking skills.
ISBN 0-534-37595-2

Book Companion Website <http://earthscience.brookscole.com/changingearth4e>

This website features a rich array of learning resources, including quizzing and other web-based activities that will help you explore the concepts that are presented in the text.

GeologyNow GeologyNow is available through the book companion website at <http://earthscience.brookscole.com/changingearth4e>. In addition to GeologyNow, students who use the website have access to maps, weblinks, Internet and InfoTrac[®] College Edition exercises, learning objectives, discussion questions, chapter outlines, and much more.

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James S. Monroe
Reed Wicander

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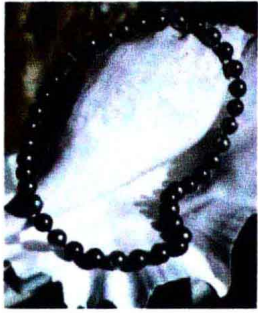
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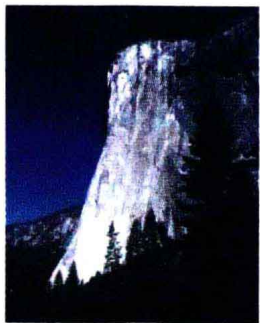


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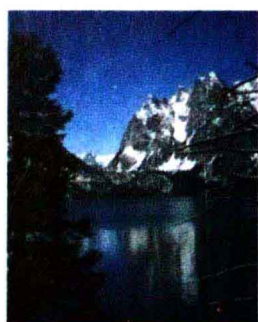
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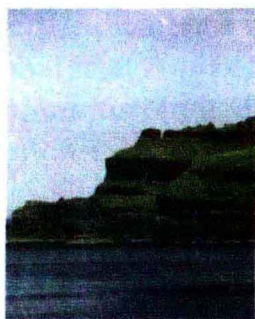
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FOURTH EDITION

THE CHANGING EARTH

EXPLORING GEOLOGY AND EVOLUTION

James S. Monroe ♦ Reed Wicander

