

# EARTH'S DYNAMIC SYSTEMS

## SIXTH EDITION



W. KENNETH HAMBLIN

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Brigham Young University, Provo, Utah

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Cover: Earth's dynamic systems are vividly displayed in the Sulaiman Range of Pakistan, "the foothills of the Himalaya Mountains." The mountain belt was formed when the Indian subcontinent drifted northward and collided with Asia. This image of the Zinda Pir area shows the type of crustal deformation resulting from that collision. Folds form elliptical patterns of rock layers, as expressed by the different colors and textures in the photograph. Faults are identified by displacement of these patterns. Stream erosion dissects the folded mountain belt into a series of ridges and valleys, illustrating the effects of geologic processes operating on Earth's surface.

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# Preface

We are privileged to live in an unprecedented period of scientific research. Scientists around the world are unraveling the genetic code of life, probing the fundamental particles of matter, and extending the frontiers of astronomy to the beginning of the universe. Geology is also in a “golden age,” a time of new enlightenment, with major discoveries and revolutionary theories giving us profound insights into the origin of our planet and how it works. New technological abilities allow us to see Earth from space and to compare our planet with other bodies in the solar system. We can now measure directly the motion of Earth’s crustal plates and their effect upon rock structures and the surface topography. We can even “X-ray” the internal structure of our planet and see the hot material in the interior moving in convection cells.

With this era of enlightenment comes an increased awareness of how our planet is continually changing, and a fresh awareness of how fragile it is. Earth is a finite sphere with limited resources, so it is impossible for the population to grow indefinitely. We may find more oil, gas, and coal by improved detection methods, yet nature requires more than a million years to concentrate the oil now consumed in only 12 months. We have created nuclear waste, yet are unsure of the effects of its disposal in the geologic system. What can we do about the fact that rivers today transport more agricultural and industrial waste than natural sediment? To live efficiently on Earth, we must understand its dynamic systems and how they operate.

The sixth edition of *Earth’s Dynamic Systems* introduces students to how our planet works and will help them understand and participate in the solution of these problems. It is written for freshmen-level students at both two- and four-year schools who are taking their first course in physical geology for one semester or less.

## THE THEME OF THIS BOOK

Beginning geology students commonly suffocate in an avalanche of information without a unifying theme to help them focus on important concepts and grasp fundamental ideas and relationships. The core theme in this book is Earth’s dynamic systems, just as the title states. There are two major energy systems that make Earth a dynamic planet: (1) the hydrologic system, the circulation of water over Earth’s surface, which involves the movement of



water in oceans, rivers, underground, and in glaciers; (2) the tectonic system, the movement of material powered by heat from Earth's interior. This system involves the evolution of continents, ocean basins, and mountain-building. These two systems are the focus of this book and everything discussed in it can be related to these unifying themes.

## NEW TO THIS EDITION

This book has been significantly revised in an effort to make it a more effective learning tool.

1. All chapters were updated and checked for accuracy. Previous users will note we have written a new beginning chapter discussing the planet Earth in its cosmic setting. We have also combined the chapters on river systems and have added a new chapter on mass movement. However, we have retained two chapters covering the most rapidly changing field in geology—plate tectonics. This subject is introduced near the beginning of the book in Chapter 3 in order to serve as a background for all that follows. It is then treated more fully in Chapter 18 with a discussion on the history of its development and refinements in the concepts that have occurred since the last edition.
2. Special attention was given to the art program. We have expended great effort to develop line illustrations and to take photographs that visually teach the basic concepts of geology. The publisher and I have been uncompromising in our effort to make each figure an efficient learning tool. I have traveled over much of North America and many other parts of the world to take photographs specifically for this edition. Our objective was to achieve a new degree of integration of text and illustration that would help the student understand modern geology and catch a glimpse of some of its splendor. We hope the student will find that reexamining the figures and captions is one useful method of reviewing the content of the chapter.
3. We have continued to use space photography to introduce our chapters. With the high resolution of Landsat images we can view Earth as never before. By beginning each chapter with a space photograph and briefly discussing what we see, we present the student with a new and up-to-date perspective of the Earth. The twenty-four space images in the book could stand alone as a visual summary of physical geology.
4. We have rewritten every major section of each chapter in an effort to briefly state the main ideas and to enhance them with supportive discussion. The thesis statement of each topic is printed in italics and separated from the body of the text by horizontal rules.
5. We have included guiding questions for each major topic in the margin of the page. They are intended to stimulate thought and provide direction and focus for the students' reading.

## IN-TEXT LEARNING AIDS

In an effort to make this book more effective and useful to the student, we have designed a number of learning aids and have incorporated them into each chapter.

**Outline of Major Concepts.** Students taking an introductory course in geology will probably not know enough about geology to identify all key concepts in page after page of text. To help the student focus on the key points of each chapter, we have identified them at the beginning of each chapter under the title of *Major Concepts*.

**Guiding Questions.** Experience has shown that the most successful students are those who read with a specific purpose—those who read to answer a question. A major pedagogical tool in this edition is the development of guiding questions which are presented in the margins adjacent to the appropriate text material. The questions are intended to guide students in their study, stimulate their curiosity, and help focus their attention.

**Summary.** The major concepts are further reinforced by end-of-chapter summaries that are presented in outline form. Students can also use the summary to easily locate pertinent text discussion for more information.

**Key Terms.** Important terms are printed in bold type when first introduced in the text. In the Key Terms section that follows the Summary at the end of each chapter, the terms are listed alphabetically, with the number of the page on which each appears. These terms are also defined in the glossary at the end of the book.

**Review Questions.** These discussion questions are intended to reinforce the main concepts and stimulate further investigation by pointing out some of the intriguing questions on which scientists are working.

**Additional Readings.** A reading list at the end of each chapter includes both periodicals and more general book references to direct the student who would like to learn more about the topic.

**Glossary.** At the end of the book, the student will find an illustrated glossary including definitions of approximately 800 key terms introduced in the text that are illustrated where appropriate by more than 100 full-color illustrations. The definitions of the terms are in conformance with the latest edition of the Glossary published by the American Geologic Institution.

## SUPPLEMENTARY MATERIALS

**1. Student Study Guide.** In preparing the sixth edition, we have been acutely aware that effective learning involves more than attending lectures and reading textbooks. It involves the student's active participation, with as much one-to-one interaction with the instructor as possible. This is difficult in large introductory courses, but we have solved part of the problem by further developing the new technique of *latent image printing*, which we introduced in the fourth edition. This companion workbook–study guide utilizes an instant feedback system that is a form of personal tutor. The unique aspect of this workbook is that answers are printed next to the questions in invisible ink that can be activated by a special accompanying chemical felt-tip pen. The latent image gives students instant feedback on their work and, depending on how a student responds, provides further guidance for study. The system is similar to that used in many computer-assisted learning programs.

**2. Laboratory Manual.** The eighth edition of *Exercises in Physical Geology* written by Hamblin and Howard is available for laboratory work associated with a typical course in physical geology. It includes exercises on rocks, minerals, topographic maps, stereo aerial photographs, Landsat images and geologic maps.

**3. Slide Set.** A set of 200 slides to complement both lecture and laboratory presentations has been carefully selected as an aid to adopting instructors.

**4. Overhead Transparencies.** A set of 100 overhead transparencies includes four-color illustrations and photographs from the text for use in the classroom or the laboratory.

**5. Instructor's Guide.** This guide was prepared to help the instructor utilize the text and related supplemental material more efficiently. It contains suggestions for lecture preparation, discussion material, and a test bank of more than 1000 questions keyed to the text. This thoroughly class-tested test bank is also available on diskette for IBM or Apple personal computers.

The real test of any textbook is how well it helps the student learn. I welcome feedback from students and instructors who have used this book. Please address your comments, criticisms, and suggestions to:

W. K. Hamblin  
*Department of Geology*  
*Brigham Young University*

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Two artists who contributed to previous editions of *Earth's Dynamic Systems* deserve special recognition. William L. Chesser executed the drawings for the first edition. Many of his fine illustrations reappear here. Robert Pack prepared new figures for the third edition, many of which reappear here as well. In addition, Dale Claflin and Kim Baker have revised some of the artwork and prepared new illustrations for this book. The combined talents and imaginative work of these artists form a major contribution to this book.

My secretary, Sherrie Heywood, has my sincere thanks and appreciation for her typing and all her help on this project.

The editorial and production staff at Macmillan played a critical role in the development of this edition. I am especially indebted to Robert McConnin for his advice and supervision throughout the entire project. Madalyn Stone, the developmental editor, contributed greatly to this edition by her constructive criticism and keen insight. The production staff at Macmillan has provided much appreciated professional support. I especially appreciate the hard work, advice, cooperation, and patience of Raydelle Clement and Mary Harlan. They turned a difficult task into a pleasant experience.

W. K. H.

# To the Student

## OUR APPROACH TO WRITING

One of the most difficult problems you face as a student in beginning a course in a new subject is to identify fundamental facts and concepts and separate them from supportive material. This problem is often expressed by the question, *What do I need to learn?* We have attempted to overcome this problem by presenting the material in each chapter in a manner that will help you recognize immediately the essential concepts.

A brief thesis statement identifying the main ideas is presented at the beginning of each topic. This short statement expresses the facts and concepts of the subject in one all-embracing view. These may be difficult for you to comprehend fully the first time you read the "*Statement*," but you will gain further insight from the subsequent text material in which terms are defined, illustrations are presented, and evidence supporting the statement of principles is given. If it is pertinent to an understanding of a concept, a brief history of how it developed is included. This material is designed to help you grasp the ideas presented in the statement.

With this organization you can easily recognize the major facts and concepts that are separated from the supportive discussion and examples. The great value of this system is that you can focus on the main concepts in the statement and clearly understand it by the elaboration presented in the subsequent text.



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