

The background of the cover is a photograph of a swan in a lake. The swan is in the lower right foreground, facing away from the camera. Its white feathers are detailed, and its red beak is visible. The water is dark blue with some ripples. In the background, a large, snow-capped mountain rises against a clear blue sky. The overall scene is peaceful and natural.

ENVIRONMENTAL

SIXTH EDITION

GEOLOGY

CARLA W.
MONTGOMERY

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MONTGOMERY
Northern Illinois University



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Environmental Geology is affectionately dedicated to the memory of Ed Jaffe, whose confidence in an unknown author made the first edition possible.

-CWM-

PREFACE



The *environment* is the sum of all the features and conditions surrounding an organism that may influence it. An individual's physical environment encompasses rocks and soil, air and water, such factors as light and temperature, and other organisms present. One's social environment might include a network of family and friends, a particular political system, and a set of social customs that affect one's behavior.

Geology is the study of the earth. Because the earth provides the basic physical environment in which we live, all of geology might in one sense be regarded as environmental geology. However, the term *environmental geology* is usually restricted to refer particularly to geology as it relates directly to human activities, and that is the focus of this book. Environmental geology is geology applied to living. We will examine how geologic processes and hazards influence human activities (and sometimes the reverse), the geologic aspects of pollution and waste-disposal problems, and several other topics.

Why environmental geology? One reason for studying environmental geology might simply be curiosity about the way the earth works, about the *how* and *why* of natural phenomena. Another reason is that we are increasingly faced with environmental problems to be solved and decisions to be made, and in many cases, an understanding of one or more geologic processes is essential to finding an appropriate solution.

Of course, many environmental problems cannot be fully assessed and solved using geologic data alone. The problems vary widely in size and in complexity. In a specific instance, data from other branches of science (such as biology, chemistry, or ecology), as well as economics, politics, social priorities, and so on may have to be taken into account. Because a variety of considerations may influence the choice of a solution, there is frequently disagreement about which solution is "best." Our personal choices will often depend strongly on our beliefs about which considerations are most important.

An introductory text cannot explore all aspects of environmental concerns. Here, the emphasis is on the physical constraints imposed on human activities by the geologic processes that have shaped and are still shaping our natural environment. In a real sense, these are the most basic, inescapable constraints; we cannot, for instance, use a resource that is not there, or build a secure home or a safe dam on land that is fundamentally unstable. Geology, then, is a logical place to start in developing an understanding of many environmental issues. The principal aim of this book is to present the reader with a

broad overview of environmental geology. Because geology does not exist in a vacuum, however, the text, from time to time, introduces related considerations from outside geology to clarify other ramifications of the subjects discussed. Likewise, the present does not exist in isolation from the past and future; occasionally, the text looks both at how the earth developed into its present condition and where matters seem to be moving for the future. It is hoped that this knowledge will provide the reader with a useful foundation for discussing and evaluating specific environmental issues, as well as for developing ideas about how the problems should be solved.

ABOUT THE BOOK

This text is intended for an introductory-level college course. It does not assume any prior exposure to geology or college-level mathematics or science courses. The metric system is used throughout, except where other units are conventional within a discipline. (For the convenience of students not yet "fluent" in metric units, a conversion table is included in appendix D, and in some cases, metric equivalents in English units are included within the text.)

Each chapter opens with an introduction that sets the stage for the material to follow. In the course of the chapter, important terms and concepts are identified by boldface type, and these terms are collected as "Terms to Remember" at the end of the chapter for quick review. Many chapters include actual case histories or specific examples. To these, each reader could no doubt add others from personal experience. Each chapter concludes with review questions and exercises, which allow students to test their comprehension and to apply their knowledge, and also suggested readings and pertinent references. Additional references, including older and more technical ones, are found at the book's Web site.

A feature introduced with the fifth edition is the inclusion of "NetNotes" at the end of each chapter. These are modest collections of Internet sites that provide additional information and/or images. An effort has been made to concentrate on sites with material at an appropriate level for the book's intended audience and also on sites likely to be relatively stable in the very fluid world of the Internet (government, agency, educational-institution, or professional-association sites). Though limited by space, this selection should particularly help the novice user get started exploring, and it has been significantly updated in the latest edition.

With this edition, each chapter includes a boxed reading relating to chapter material that involves a situation, problem, or application that might be encountered in everyday life. The tone, in many cases, is light, but the underlying issues are nonetheless real. While some boxes were inspired by actual events, and some include specific factual information, all of the characters quoted, and their interactions, are wholly fictitious. (Users who may miss boxed readings from earlier editions will find some of their contents incorporated into the text in this edition, and the old boxes, intact, at the Online Learning Center.)

The book starts with some background information: a brief outline of earth's development to the present, and a look at one major reason why environmental problems today are so pressing—the large and rapidly growing human population. This is followed by a short discussion of the basic materials of geology—rocks and minerals—and some of their physical properties, which introduces a number of basic terms and concepts that are used in later chapters.

The next several chapters treat individual processes in detail. Some of these are large-scale processes, which may involve motions and forces in the earth hundreds of kilometers below the surface, and may lead to dramatic, often-catastrophic events like earthquakes and volcanic eruptions. Other processes—such as the flow of rivers and glaciers or the blowing of the wind—occur only near the earth's surface, altering the landscape and occasionally causing their own special problems. In some cases, geologic processes can be modified, deliberately or accidentally; in others, human activities must be adjusted to natural realities.

A subject of increasing current concern is the availability of resources. A series of five chapters deals with water resources, soil, minerals, and energy, the rates at which they are being consumed, probable amounts remaining, and projections of future prospects. In the case of energy resources, we consider both those sources extensively used in the past, and new sources that may or may not successfully replace them in the future.

Increasing population and increasing resource consumption seem to lead to an increasing volume of waste to be disposed of; thoughtless or inappropriate waste disposal commonly leads to increasing pollution. Three chapters examine the interrelated problems of air and water pollution and the strategies available for the disposal of various kinds of wastes.

The final two chapters deal with a more diverse assortment of subjects. Environmental problems spawn laws intended to solve them; the environmental-law chapter looks briefly at a sampling of laws and international agreements related to geologic matters discussed earlier in the book, as well as at some of the problems with such laws and accords. The land-use planning and engineering geology chapter examines geologic

constraints on construction schemes and the broader issue of trying to determine the optimum use(s) for particular parcels of land, matters that become more pressing as population growth pushes more people to live in marginal places. While the "Geomedicine" chapter no longer appears, aspects of the subject are now integrated into several other chapters, and the emerging topic of health and climate change is recognized in chapter 9.

Relative to the length of time we have been on earth, humans have had a disproportionate impact on this planet. Appendix A explores the concept of geologic time and its measurement, and looks at the rates of geologic and other processes by way of putting human activities in temporal perspective. Appendix B gives an introduction to topographic and geologic maps and satellite and other kinds of imagery, highlighting some new techniques for examining the earth. Appendix C provides short reference keys to aid in rock and mineral identification, and Appendix D includes units of measurement and conversion factors. The Glossary collects definitions of boldface terms and select additional terms for quick reference.

Available with this text is an Instructor's Manual containing over 750 test questions. The test questions found in the Instructor's Manual are also available on McGraw-Hill classroom testing software, for use with the Macintosh® and IBM® PC computers. Also available are 170 acetate transparencies of key text illustrations and 120 color slides. These are designed to aid instructors in class presentations and to enhance student learning activities.

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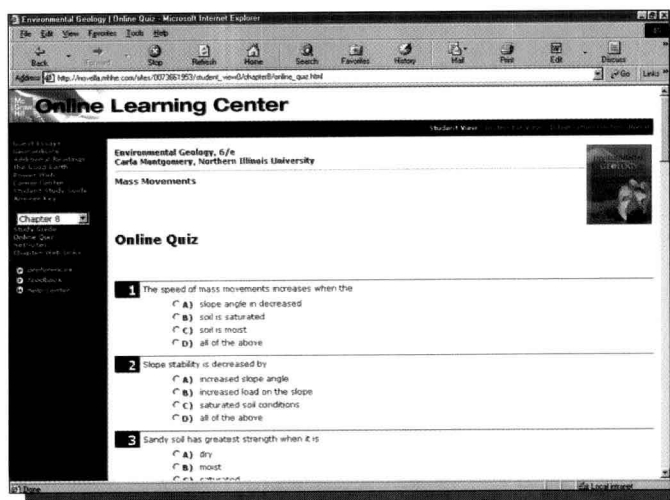
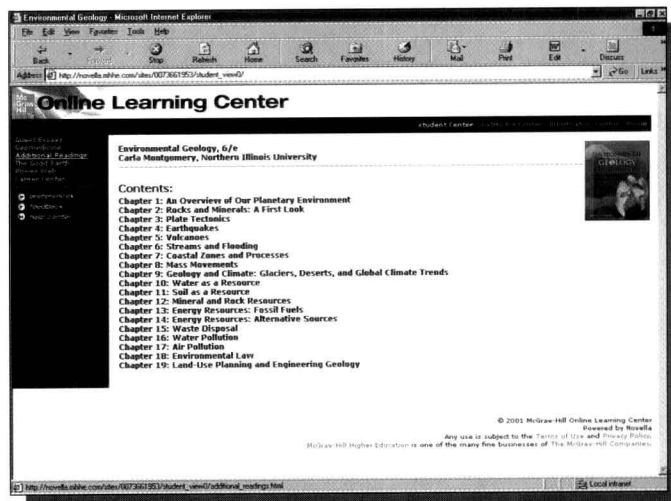
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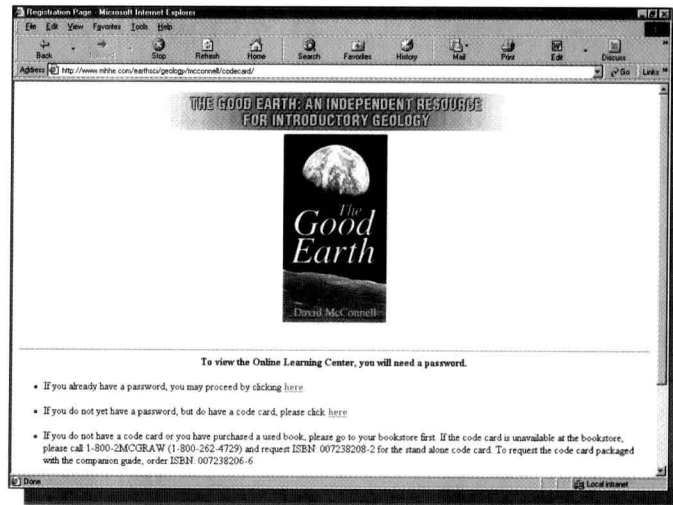


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The Good Earth

plate tectonics

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- Seafloor Spreading
- Plate Tectonics
- Divergent Boundaries
- Convergent Boundaries
- Transform Boundaries
- Summary
- Quiz & Exercises
- Web Links

Introduction

- Earth's lithosphere is divided into mobile plates.
- Plate tectonics describes the distribution and motion of the plates.
- The theory of plate tectonics grew out of earlier hypotheses and observations collected during exploration of the rocks of the ocean floor.

You will recall from a [previous chapter](#) that there are three major layers (crust, mantle, core) within the earth that are identified on the basis of their different compositions (Fig. 1).

The uppermost mantle and crust can be sub-divided vertically into two layers with contrasting **mechanical** (physical) properties. The outer layer, the **lithosphere**, is composed of the crust and uppermost mantle and forms a rigid outer shell down to a depth of approximately 100 km (63 miles). The underlying **asthenosphere** is composed of partially melted rocks in the upper mantle that acts in a plastic manner on long time scales. The asthenosphere extends from about 100 to 300 km (63-189 miles) depth. The theory of plate tectonics proposes that the lithosphere is divided into a series of plates that fit together like the **pieces of a jigsaw puzzle**.

Although **plate tectonics** is a relatively young idea in comparison with unifying theories from other sciences (e.g., law of gravity, theory of evolution), some of the basic characteristics that represent the foundation

Figure 1. The

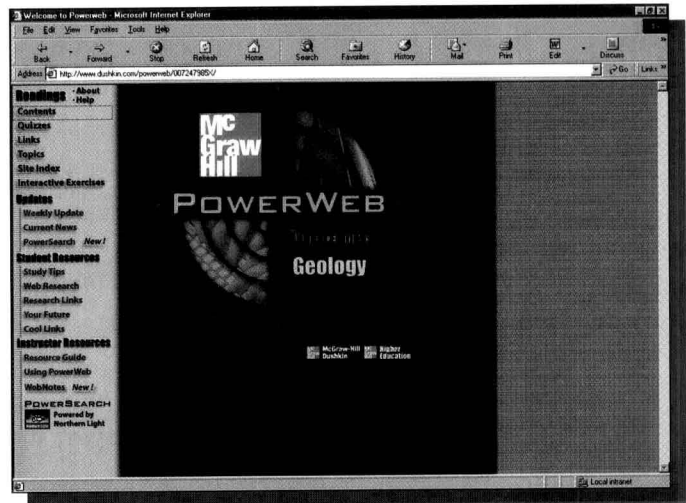
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Unit 1. Introduction to the Science of Geology

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Part A. Bias in Science

1. On a Toothed Bird's Place in Nature, Stephen Jay Gould, *Natural History*, February 1996
View in: [Acrobat](#) | [HTML](#) Fill out the [Test Your Knowledge form](#) Try a [Quiz Question](#)

Charles Darwin's theory of evolution did not jibe with James Dana's underlying perspective that organisms must somehow progress from simple to complex forms in each lineage. Although Dana was a fine scientist in his own right, his worldview allowed him only a begrudging acceptance of this viable theory.

2. The Great Scablands Debate, Stephen Jay Gould, *Natural History*, August/September 1978
View in: [Acrobat](#) | [HTML](#) Fill out the [Test Your Knowledge form](#) Try a [Quiz Question](#)

J Hulen Bretz's hypothesis of a catastrophic origin for the Channeled Scablands of eastern Washington was widely denounced by geologists who, at that time, were strongly biased in favor of gradual processes. Bretz did not have a source of water for the flooding, which further damaged his cause. He was eventually vindicated when the source of water was found

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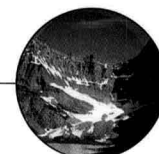
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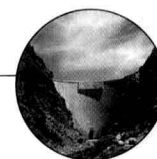
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