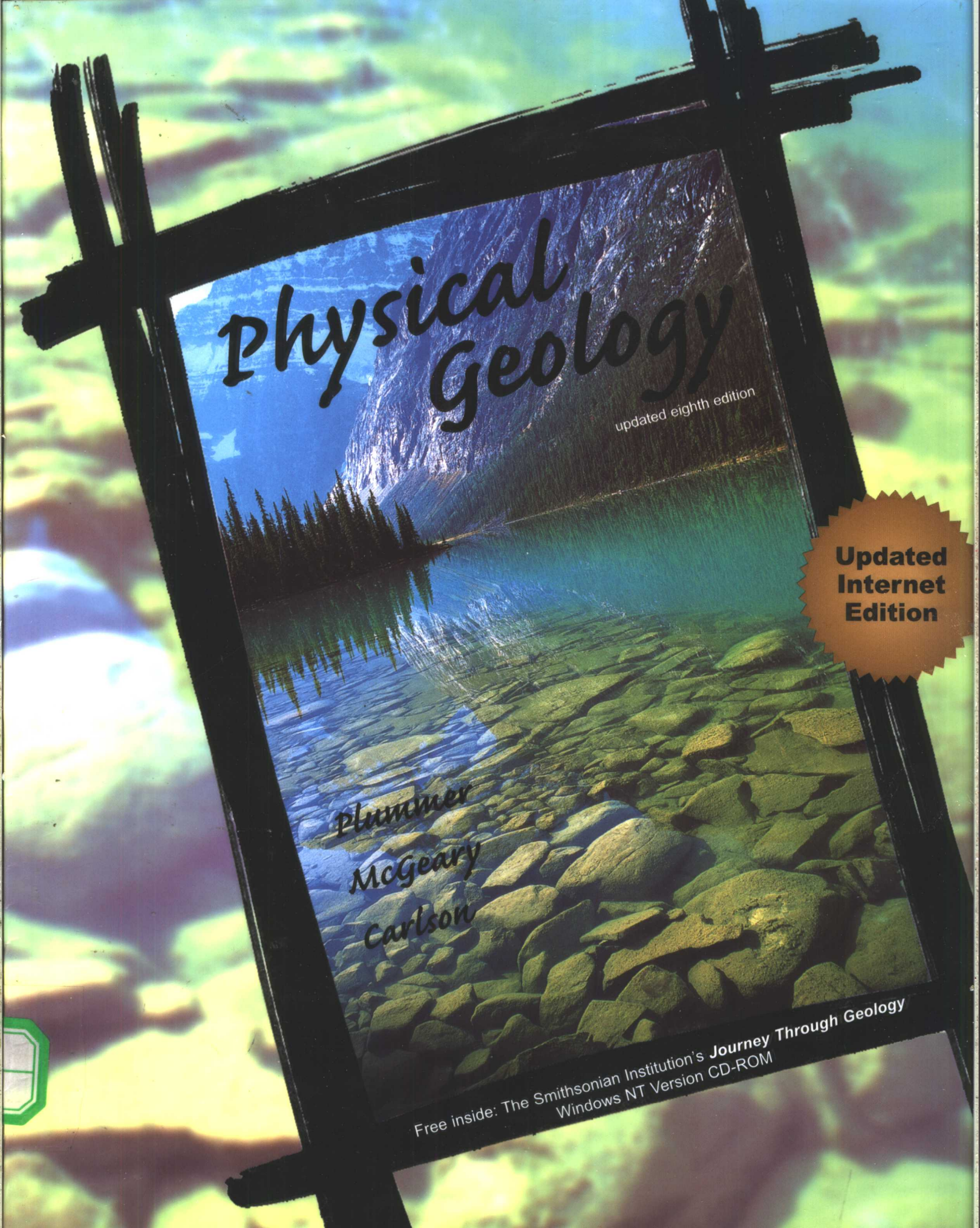
Physical Geology
updated eighth edition
Updated Internet Edition
Plummer
McGeary
Carlson
Free inside: The Smithsonian Institution's Journey Through Geology Windows NT Version CD-ROM

Updated Eighth Edition

PHYSICAL GEOLOGY

Featuring The Smithsonian Institution's *Journey Through Geology* CD-ROM

Charles C. Plummer
California State University at Sacramento

David McGeary
Emeritus of California State University at Sacramento

Diane H. Carlson
California State University at Sacramento

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Preface

Physical Geology is a straightforward, easy-to-read introduction to geology both for nonscience majors and for students contemplating majoring in geology. The organization of the book is traditional and matches the organization of most lab manuals. The book contains more information than can be normally covered during a college term. This provides flexibility for the instructor who wishes to emphasize some topics while covering other topics superficially. It is also useful to the student who wants to pursue topics beyond what is covered in the classroom.

The updated Internet Edition of the Eighth Edition expands and improves upon the use of electronic resources (the Internet and the enclosed CD-ROMS). We have also taken the opportunity to improve the text and illustrations, based on suggestions from a panel of reviewers.

The upgrading of the World-Wide Web section at the end of each chapter should make it easier and more meaningful for the student to enrich his or her knowledge through the World-Wide Web. We have listed websites that we personally checked for usefulness. We have replaced website listings that are inactive or obsolete with new and better sites. The universal resource locators (URLs) are printed in blue and are easier to read. However, typing a lengthy URL will not be necessary as we have the sites listed as links on the book's website. The website will list each URL and its title under the appropriate chapter heading. The user need only click on the link. Appropriate new websites that are discovered after publication will be added to that website.

Obsolete or defunct websites will be so noted. To help students effectively and efficiently use the Internet from the website, we include step-by-step procedures and pose questions. The primary purpose of the questions is to guide students through thinking about the topic at hand. We expect that many students will explore topics beyond where we have led them.

Also integrated into this updated edition is David McConnell's *The Good Earth,* an Internet Resource for Introductory Geology. This digital method of teaching will give students a more "hands-on" approach to learning geology. *The Good Earth* is organized into chapters, with animations used to explain certain processes. Chapter summaries, quizzes, exercises, and web links to related websites are also included. With the purchase of a new textbook, the student will gain access to this resource, which can be found at http://www.mhhe.com/earthsci/geology/plummer. Look for the post-it notes on chapter opener pages to find out how *The Good Earth* can help you understand geology.

Other changes to this updated version include replacement of many photos and fine-tuning the artwork. Recent major disasters, such as the devastating earthquakes in Taiwan and Turkey, and the tsunami in New Guinea are incorporated. We now use "numerical age" rather than "absolute age" in the geologic time chapter.

Journey Through Geology (the two CD-ROMs that accompany this book) is an exciting supplement. This was produced in partnership with The Smithsonian Institution. "Interacting with Journey Through Geology" at the end of each chapter has questions to help the student get the maximum benefit from use of the disks. We have added to and improved on these questions in this updated version of the book.

Some of the changes we made for the eighth edition (relative to the seventh edition) follow. Chapters 3 and 4 have been reversed. Chapter 3 is on igneous rocks, intrusive activity, and the origin of igneous rocks, whereas chapter 4 is about volcanic activity. We have taken pains to be sure either chapter could be covered before the other. Other chapters or groups of chapters have been written to be as self-contained as possible allowing the instructor to reorganize the chapter sequence if desired. We have taken a number of descriptions and examples of geologic resources from the final chapter of the book and integrated them into appropriate chapters elsewhere in the book. The rock cycle (in chapter 2) has been expanded to include a plate tectonic example. The discussion of the origin of magmas at convergent boundaries places more emphasis on the current view by researchers that mafic magmas are generated in the asthenosphere above the subducted oceanic crust. In the chapter on geologic time we have introduced the term "actualism" and discussed why it might be preferable to "uniformitarianism." In the metamorphic chapter we have related foliation to the modern concept of gravitational collapse and spreading. We moved unconformities from the structural geology chapter to the geological time chapter. A section on changing concepts of the age of the earth has been added. The relationship between isotopic dating and the geologic time scale has been expanded. The 1996 (and 1999) rockfall at Yosemite is used as an example of mass wasting. The stream chapter underwent a major revision and now includes an expanded discussion of flooding with examples from the 1997 floods in the upper Midwest and California. In the structure chapter, the section on stress and strain and the behavior of rocks was rewritten and new examples and figures are included to clarify these difficult concepts. An appendix listing commonly used prefixes, suffixes, and root words was added.

We added new boxes on water and ice—molecules and crystals, flight hazards associated with volcanoes, the eruptions on Montserrat compared to the disastrous eruption that destroyed St. Pierre on Martinique in 1902, the Bingham Canyon copper mine, highlights of biological evolution through time, the meteorite from Mars with possible signs of former life. A box on water beneath glaciers describes the recently discovered lake beneath the East Antarctic Ice Sheet, surging glaciers, and subglacial volcanism and flooding in Iceland. The stream chapter includes boxes on the planned flood in the Grand Canyon and how the recurrence interval of large floods is calculated. The structure chapter includes a box on how to find oil and the salt dome box has been expanded. The interior of the earth chapter now includes a box on the spinning inner core. In the mountains chapter we added a box on a systems approach to understanding mountains and expanded a former box, retitling it "Dance of the continents (with SWEAT)."

Supplements to Accompany *Physical Geology, Eighth Edition:*

- *Journey Through Geology two CD-ROM set*
- *Instructor's Manual*
- *computerized testing software*
- *224 transparencies and 350 slides*
- *Visual Resource Library CD-ROM*

- *Student Study Guide*
- *Solutions to Questions for Thought by Noltimier*
- *Online Learning Center located at www.mhhe.com/plummer/*
- *Website for Journey Through Geology located at www.mhhe.com/jtg*
- *Ready Notes*

Additional classroom tools include:

- *JLM Visuals Physical Geology Photo CD*
- *Interactive Plate Tectonics CD-ROM*
- *Annual Editions: Geology 99/00*
- *Student Atlas of Environmental Issues*
- *The Good Earth Internet Resource by David McConnell located at www.mhhe.com/earthsci/geology/mcconnell/*
- *Physical Geology Lab Manuals*
- *GeoScience Videotape Library*

For additional information on *Physical Geology, Updated Internet Edition* or *Journey Through Geology CD-ROM,* please visit our Websites at http://www.mhhe.com/plummer or www.mhhe.com/jtg.

We have tried to write a book that will be useful to both students and instructors. We would be grateful for any comments by users, especially regarding mistakes within the text or sources of good geological photographs.

We would like to thank Susan Slaymaker for writing the original boxed material on planetary geology, and Judi Kushick for writing the questions to accompany the Journey Through Geology CD-ROM.

We are also very grateful to the following reviewers of the seventh and eighth editions of this text for their careful evaluation and useful suggestions for improvement.

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Michael Katuna *College of Charleston*
Peter Kresan *University of Arizona*
James Miller *Southwest Missouri State University*

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The proven *Physical Geology* Learning System.

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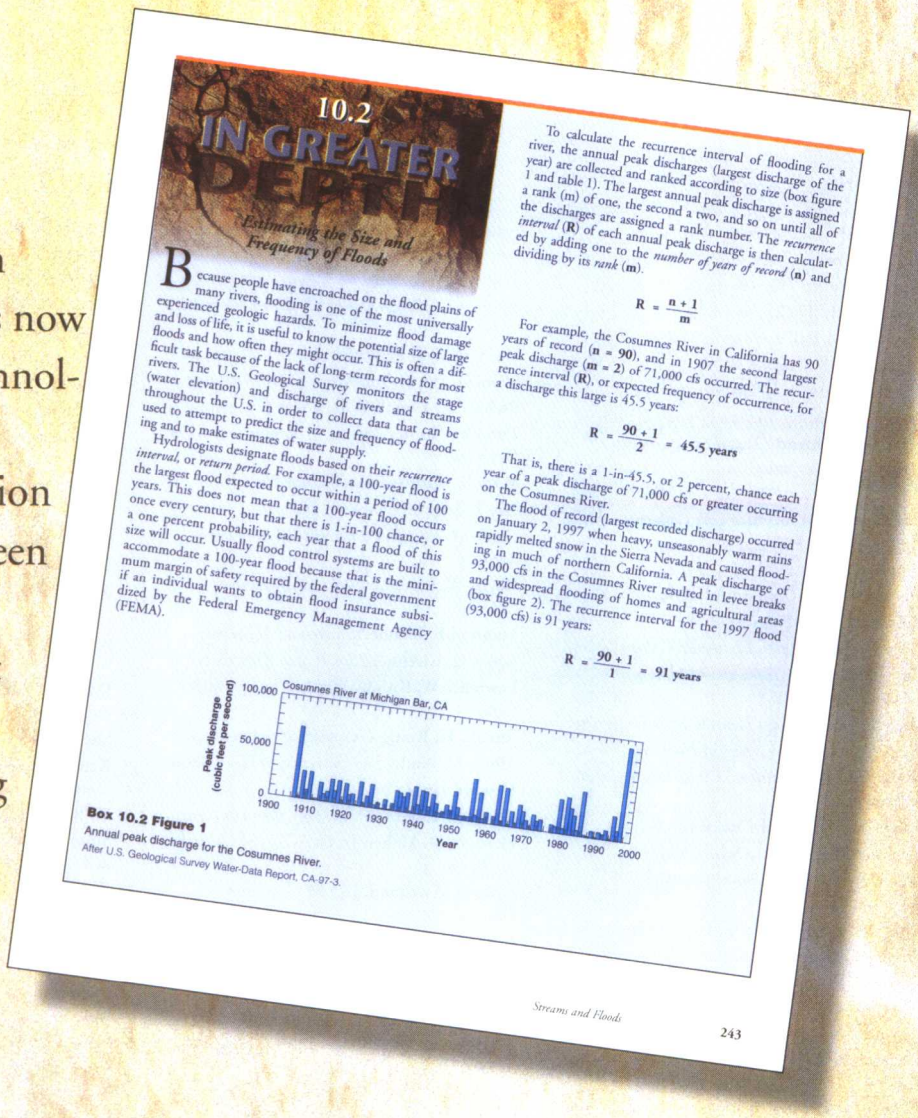
This updated Internet edition of ***Physical Geology*** has been thoroughly enhanced to bring you the most current information on how physical geology is working in your world today.

One of the most exciting additions to this package is the incorporation of ***The Good Earth Website.***

This visionary method of teaching gives students a more hands-on approach to learning geology by allowing them to view animations that explain processes, access quizzes and exercises, and explore web links.



10.2 IN GREATER DEPTH

Estimating the Size and Frequency of Floods

Because people have encroached on the flood plains of many rivers, flooding is one of the most universally experienced geologic hazards. To minimize flood damage and loss of life, it is useful to know the potential size of large floods and how often they might occur. This is often a difficult task because of the lack of long-term records for most rivers. The U.S. Geological Survey monitors the stage (water elevation) and discharge of rivers and streams throughout the U.S. in order to collect data that can be used to attempt to predict the size and frequency of flooding and to make estimates of water supply.

Hydrologists designate floods based on their *recurrence interval*, or *return period*. For example, a 100-year flood is the largest flood expected to occur within a period of 100 years. This does not mean that a 100-year flood occurs once every century, but that there is 1-in-100 chance, or a one percent probability, each year that a flood of this size will occur. Usually flood control systems are built to accommodate a 100-year flood because that is the minimum margin of safety required by the federal government if an individual wants to obtain flood insurance subsidized by the Federal Emergency Management Agency (FEMA).

To calculate the recurrence interval of flooding for a river, the annual peak discharges (largest discharge of the year) are collected and ranked according to size (box figure 1 and table 1). The largest annual peak discharge is assigned a rank (m) of one, the second a two, and so on until all of the discharges are assigned a rank number. The *recurrence interval* (**R**) of each annual peak discharge is then calculated by adding one to the *number of years of record* (**n**) and dividing by its *rank* (**m**).

$$R = \frac{n + 1}{m}$$

For example, the Cosumnes River in California has 90 years of record (**n = 90**), and in 1907 the second largest peak discharge (**m = 2**) of 71,000 cfs occurred. The recurrence interval (**R**), or expected frequency of occurrence, for a discharge this large is 45.5 years:

$$R = \frac{90 + 1}{2} = 45.5 \text{ years}$$

That is, there is a 1-in-45.5, or 2 percent, chance each year of a peak discharge of 71,000 cfs or greater occurring on the Cosumnes River.

The flood of record (largest recorded discharge) occurred on January 2, 1997 when heavy, unseasonably warm rains rapidly melted snow in the Sierra Nevada and caused flooding in much of northern California. A peak discharge of 93,000 cfs in the Cosumnes River resulted in levee breaks and widespread flooding of homes and agricultural areas (box figure 2). The recurrence interval for the 1997 flood (93,000 cfs) is 91 years:

$$R = \frac{90 + 1}{1} = 91 \text{ years}$$

Box 10.2 Figure 1
Annual peak discharge for the Cosumnes River.
After U.S. Geological Survey Water-Data Report, CA-97-3.

Streams and Floods 243

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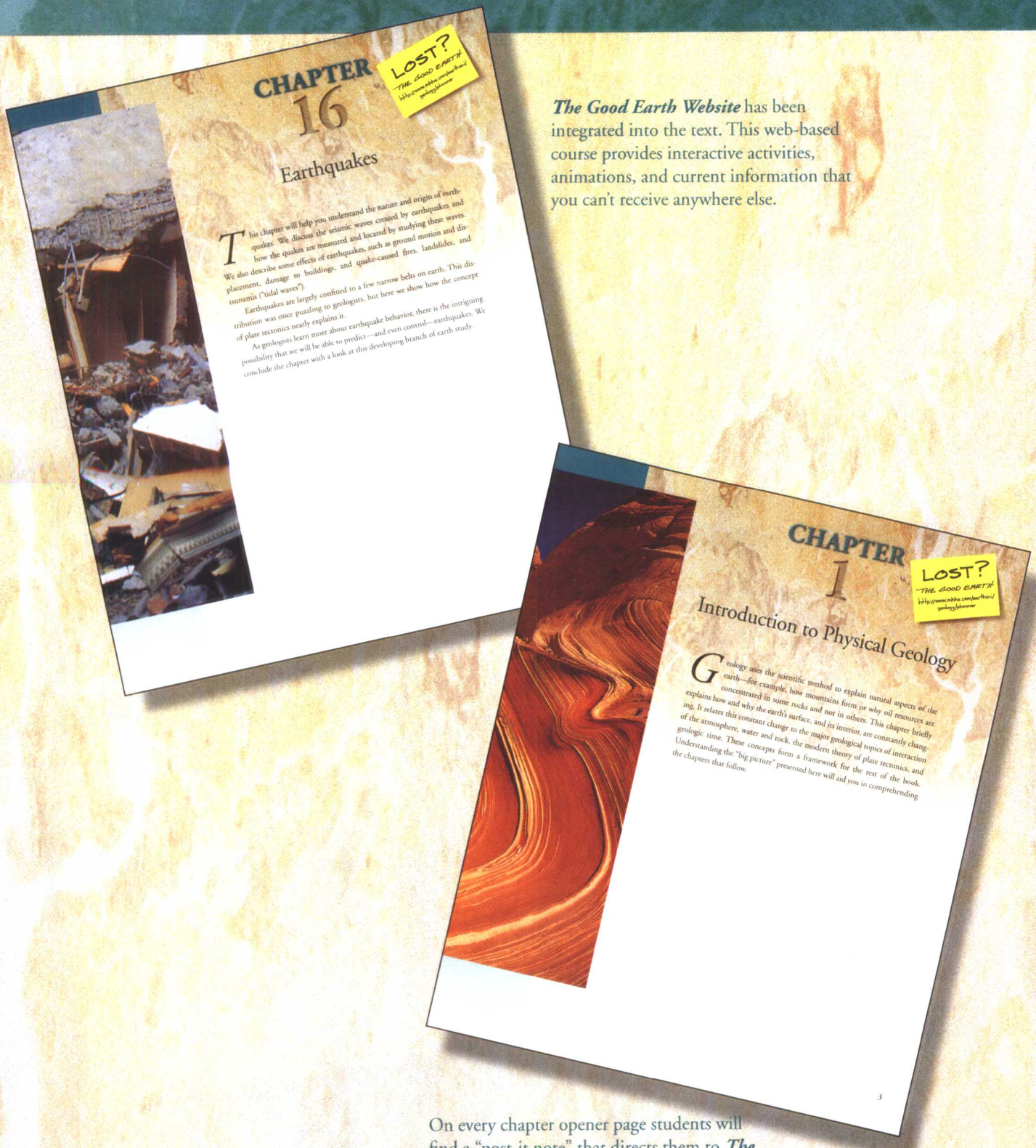

The Good Earth Website has been integrated into the text. This web-based course provides interactive activities, animations, and current information that you can't receive anywhere else.

On every chapter opener page students will find a "post-it note" that directs them to ***The Good Earth Website***. This interactive presentation of material will not only help students understand some of the more difficult concepts being presented, but it will intrigue them with geological phenomena.

. . . THROUGH TODAY'S RESOURCES.

Table 16.2 Earthquake Magnitudes

		Richter Magnitude	Moment Magnitude
1811–12	New Madrid, Missouri area	7.5, 7.3, 7.8	7.7, 7.6, 7.9
1857	Fort Tejon, S. Calif.	7.6	7.9
1872	Lone Pine, Calif.	7.5	7.8
1886	Charleston, South Carolina	6.7	7.0
1906	San Francisco, N. Calif.	8.25	7.7
1915	Pleasant Valley, Nevada	7.7	7.1
1933	Long Beach, S. Calif.	6.3	6.2
1952	Kern County, S. Calif.	7.2	7.5
1954	Dixie Valley, Nevada	7.2, 7.1	7.3, 6.9
1957	Aleutian Islands, Alaska	8.1	8.8
1958	Southeastern Alaska	7.9	8.3
1959	Hebgen Lake, Montana	7.7	7.3
1960	Chile	8.5	9.5
1964	near Anchorage, Alaska	8.6	9.2
1965	Aleutian Islands, Alaska	8.2	8.7
1970	Peru	7.75	7.9
1971	San Fernando Valley, S. Calif.	6.4	6.6
1975	Hawaii	7.2	7.5
1976	China	7.6	7.5
1980	Humboldt County, N. Calif.	6.9	7.2
1983	Coalinga, Calif.	6.7	6.2
1983	Challis, Idaho	7.2	7.0
1983	Adirondack Mountains, New York	5.1	4.9
1983	Hawaii	6.6	
1985	Ixtapa, Mexico		8.1, 7.5
1987	Lawrenceville, Illinois	5.0	5.0
1987	Whittier, S. Calif.	5.9	5.9
1988	Quebec	6.0	
1989	Loma Prieta, N. Calif.	7.0	7.2
1989	Hawaii	6.1	6.4
1992	Humboldt County, N. Calif.	7.1, 6.6, 6.7	
1992	Landers, S. Calif.	7.6, 6.7	7.25, 6.4
1994	Northridge, S. Calif.	6.4	6.7
1995	Kobe, Japan (7.2 on Japanese scale)	6.8	6.9
1998	Papua, New Guinea		7.1
1999	Izmit, Turkey		7.4
1999	Taipei, Taiwan		7.6

U.S. Geological Survey and other sources

A hallmark of ***Physical Geology*** is the inclusion of timely topics. Recent geologic events like the devastating earthquake in Turkey and the tsunami in Papua, New Guinea are incorporated.

To support these timely topics, you'll find the text is filled with updated resources. These *"Exploring Resources"* are found at the end of every chapter and provide you and your students with opportunities to expand your knowledge. Every chapter also includes *"Interacting with Journey Through Geology CD-ROM"* questions that help tie the concepts of the chapter to modules of **The Smithsonian Institution's Journey Through Geology** two CD-ROM set.

Exploring Resources

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U.S. Geological Survey, 1965–70. *The Alaska earthquake*. Professional Papers 541–546.

U.S. Geological Survey, 1971. *The San Fernando, California, earthquake of February 9, 1971*. Professional Paper 733.

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U.S. Geological Survey, 1990. *The San Andreas fault system*. Professional Paper 1515. On-line version: http://pubs.usgs.gov/gip/earthq3/safaultgip.html

U.S. Geological Survey, 1993. *Seismicity of the United States, 1568–1989 (revised)*. Professional Paper 1527.

http://www.geophys.washington.edu/seismosurfing.html
Exhaustive list of worldwide Internet sites for information about earthquakes.

http://quake.wr.usgs.gov/
U.S. Geological Survey Earthquake Information. Gives information on reducing earthquake hazards, earthquake preparedness, latest quake information, historical earthquakes, and how earthquakes are studied. Also a good starting place for links to other earthquake sites.

http://quake.wr.usgs.gov/recenteqsfaq.html
Frequently Asked Questions about recent earthquakes maintained by the U.S. Geological Survey.

http://www.seismo.unr.edu/
University of Nevada, Reno Seismological Laboratory site contains information about recent earthquakes, earthquake preparedness, and links to other earthquake sites.

http://www.seismo.berkeley.edu/seismo/Home.page.html
Seismographic information page maintained by U.C.–Berkeley that has many links to other earthquake sites (particularly in California), 3-D earthquake movie, Northridge earthquake rupture movies, and information on earthquake preparedness.

http://quake.calstatela.edu/
California State University, Los Angeles *Virtual Earthquake*. Create and analyze an earthquake.

http://pubs.usgs.gov/gip/earthq3/seismogip.html
General information about the site of an earthquake. Discussion of Richter and Mercalli scales.

http://pubs.usgs.gov/publications/text/dynamic.html
General information about plate tectonics.

http://walrus.wr.usgs.gov/tsunami/p99s2home.html
U.S. Geological Survey web page gives information about the devastating July 17, 1998 tsunami at Papua, New Guinea and links to other sites.

Earthquake: Nova.
Day the Earth Shook: Nova.
Killer Quakes: The History Channel

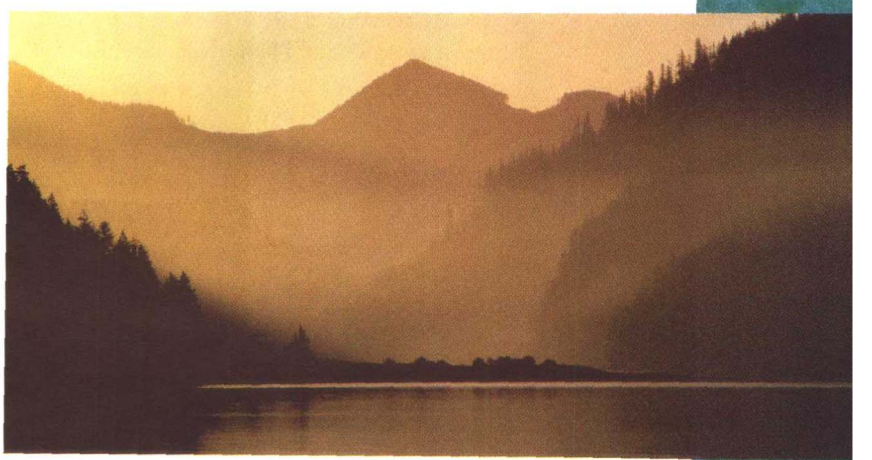
Interacting with Journey Through Geology CD-ROM

Expand your knowledge of the concepts presented in this chapter by using the CD-ROM to answer the following questions.

1. Go to the *Spreading Ridges* module. After the introduction, click on "Iceland" and then click on "Earthquakes Through Time." Observe the pattern of earthquakes since 1960. Why do these earthquakes form such a regular pattern? What kinds of faults did these earthquakes occur along?
2. Use the *Convergent Margins* module. Go to "Himalaya" and click on "Earthquakes Through Time." Describe the geographic distribution of earthquakes in the Himalayan region and its relationship to plate tectonics. Why is the pattern of earthquakes narrowly defined bands in some areas (e.g., Southeast Asia) and broad diffuse areas elsewhere (e.g., north of the northern edge of the Indian Plate)?
3. Go to the *Convergent Margins* module and click on "Alaska." Carefully watch the "1964 Earthquake Footage" of the Good Friday earthquake. Identify each of these effects of earthquakes in the footage: ground motion, landslides, fire, displacement, tsunamis.

Earthquakes 413

Contents



*These end-of-chapter sections appear in every chapter.

Additional support helps you make the grade.

Use these helpful end-of-chapter learning aids to prepare for tests and quizzes.

Summary—overviews of chapter content.

Terms to Remember—important terms to review and remember.

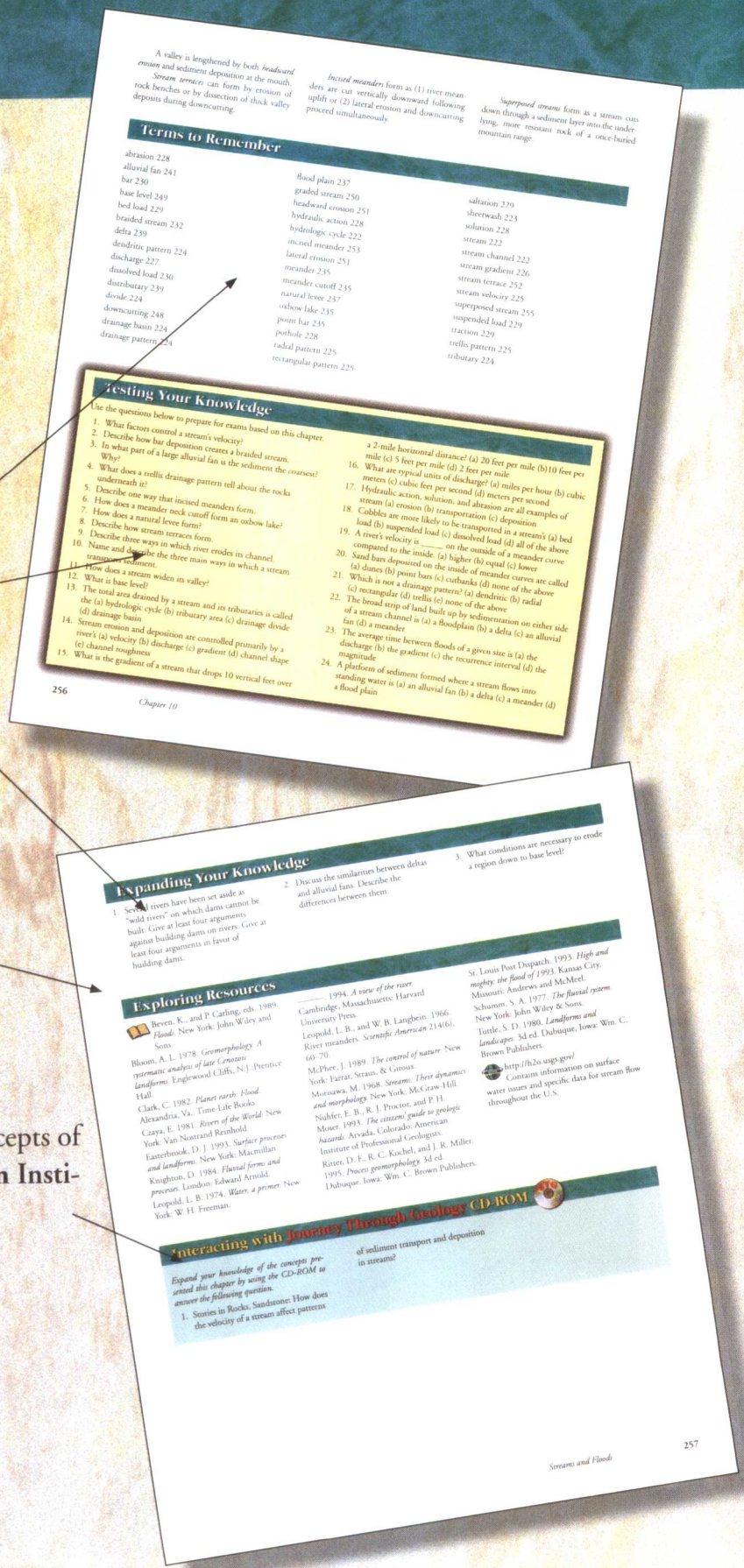
Testing Your Knowledge— realistic sample tests you can use to prepare for exams and improve your grades.

Expanding Your Knowledge—questions that help you develop critical thinking skills.

Exploring Resources—Supplemental references in a number of different media.

- Textbook reference
- CD-ROM
- Videotape
- World Wide Web addresses

Interacting with ***Journey Through Geology*** *CD-ROM*—questions that help tie the concepts of the chapter to modules of **The Smithsonian Institution's *Journey Through Geology*** **two CD-ROM set.**



A valley is lengthened by both *headward erosion* and sediment deposition at the mouth. *Stream terraces* can form by erosion of rock benches or by dissection of thick valley deposits during downcutting.

Incised meanders form as (1) river meanders are cut vertically downward following uplift or (2) lateral erosion and downcutting proceed simultaneously.

Superposed streams form as a stream cuts down through a sediment layer into the underlying, more resistant rock of a once-buried mountain range.

Terms to Remember

abrasion 228
alluvial fan 241
bar 230
base level 249
bed load 229
braided stream 232
delta 239
dendritic pattern 224
discharge 227
dissolved load 230
distributary 239
divide 224
downcutting 248
drainage basin 224
drainage pattern 224
flood plain 237
graded stream 250
headward erosion 251
hydraulic action 228
hydrologic cycle 222
incised meander 253
lateral erosion 251
meander 235
meander cutoff 235
natural levee 237
oxbow lake 235
point bar 235
pothole 228
radial pattern 225
rectangular pattern 225
saltation 229
sheetwash 223
solution 228
stream 222
stream channel 222
stream gradient 226
stream terrace 252
stream velocity 225
superposed stream 255
suspended load 229
traction 229
trellis pattern 225
tributary 224

Testing Your Knowledge

Use the questions below to prepare for exams based on this chapter.

1. What factors control a stream's velocity?
2. Describe how bar deposition creates a braided stream.
3. In what part of a large alluvial fan is the sediment the coarsest? Why?
4. What does a trellis drainage pattern tell about the rocks underneath it?
5. Describe one way that incised meanders form.
6. How does a meander neck cutoff form an oxbow lake?
7. How does a natural levee form?
8. Describe how stream terraces form.
9. Describe three ways in which river erodes its channel.
10. Name and describe the three main ways in which a stream transports sediment.
11. How does a stream widen its valley?
12. What is base level?
13. The total area drained by a stream and its tributaries is called the (a) hydrologic cycle (b) tributary area (c) drainage divide (d) drainage basin
14. Stream erosion and deposition are controlled primarily by a river's (a) velocity (b) discharge (c) gradient (d) channel shape (e) channel roughness
15. What is the gradient of a stream that drops 10 vertical feet over a 2-mile horizontal distance? (a) 20 feet per mile (b)10 feet per mile (c) 5 feet per mile (d) 2 feet per mile
16. What are typical units of discharge? (a) miles per hour (b) cubic meters (c) cubic feet per second (d) meters per second
17. Hydraulic action, solution, and abrasion are all examples of stream (a) erosion (b) transportation (c) deposition
18. Cobbles are more likely to be transported in a stream's (a) bed load (b) suspended load (c) dissolved load (d) all of the above
19. A river's velocity is _____ on the outside of a meander curve compared to the inside. (a) higher (b) equal (c) lower
20. Sand bars deposited on the inside of meander curves are called (a) dunes (b) point bars (c) cutbanks (d) none of the above
21. Which is not a drainage pattern? (a) dendritic (b) radial (c) rectangular (d) trellis (e) none of the above
22. The broad strip of land built up by sedimentation on either side of a stream channel is (a) a floodplain (b) a delta (c) an alluvial fan (d) a meander
23. The average time between floods of a given size is (a) the discharge (b) the gradient (c) the recurrence interval (d) the magnitude
24. A platform of sediment formed where a stream flows into standing water is (a) an alluvial fan (b) a delta (c) a meander (d) a flood plain

256 *Chapter 10*

Expanding Your Knowledge

1. Several rivers have been set aside as "wild rivers" on which dams cannot be built. Give at least four arguments against building dams on rivers. Give at least four arguments in favor of building dams.
2. Discuss the similarities between deltas and alluvial fans. Describe the differences between them.
3. What conditions are necessary to erode a region down to base level?

Exploring Resources

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http://h2o.usgs.gov/ Contains information on surface water issues and specific data for stream flow throughout the U.S.

Interacting with Journey Through Geology CD-ROM

Expand your knowledge of the concepts presented this chapter by using the CD-ROM to answer the following question.

1. Stories in Rocks, Sandstone: How does the velocity of a stream affect patterns of sediment transport and deposition in streams?

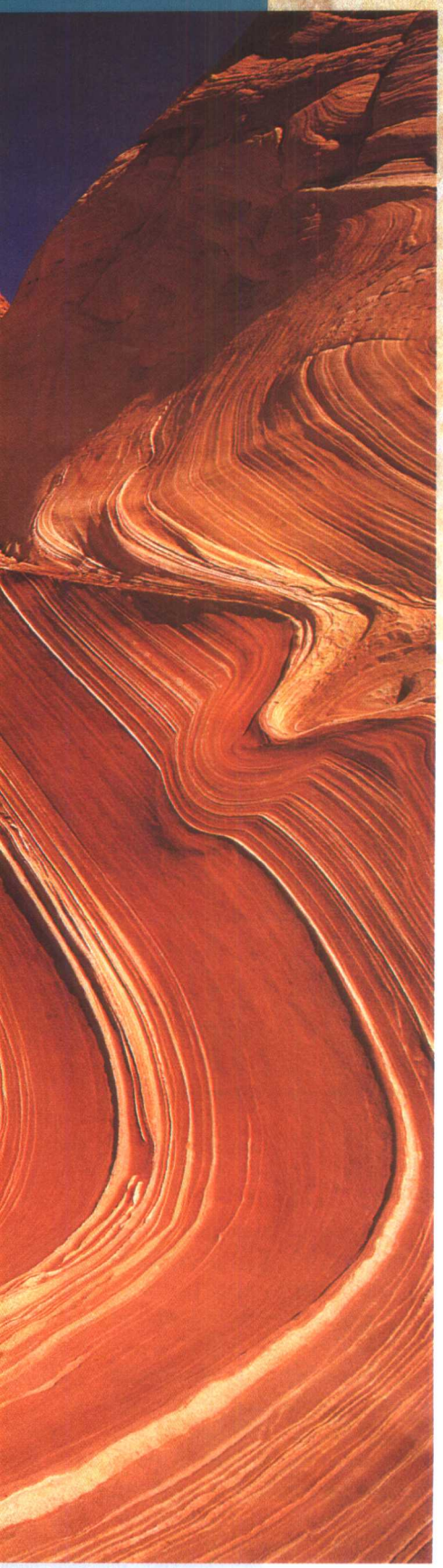
257 *Streams and Floods*

Learn more about this text.

Visit the *Physical Geology* Website:

www.mhhe.com/plummer

Natural rock sculpture in Paria Plateau, Arizona. Sandstone formed from ancient sand dunes. Running water has eroded the rock into the present distinctive shapes.



CHAPTER 1

LOST?
THE GOOD EARTH
http://www.mhhe.com/earthsci/geology/plummer

Introduction to Physical Geology

Geology uses the scientific method to explain natural aspects of the earth—for example, how mountains form or why oil resources are concentrated in some rocks and not in others. This chapter briefly explains how and why the earth's surface, and its interior, are constantly changing. It relates this constant change to the major geological topics of interaction of the atmosphere, water and rock, the modern theory of plate tectonics, and geologic time. These concepts form a framework for the rest of the book. Understanding the "big picture" presented here will aid you in comprehending the chapters that follow.

Strategy for Using This Textbook

- As authors, we try to be thorough in our coverage of topics so the textbook can serve you as a resource. However, your instructor may choose to concentrate only on certain topics for *your* course. Find out which topics and chapters you should focus upon in your studying and concentrate your energies there.
- Your instructor may present additional material that is not in the textbook. Take good notes in class.
- Do not get overwhelmed by terms. (Every discipline has its own language.) Don't just memorize each term and its definition. If you associate a term with a concept or mental picture, remembering the term comes naturally when you understand the concept. (You remember names of people you know because you associate personality and physical characteristics with a name.) You may find it helpful to learn the meanings of frequently used prefixes and suffixes for geologic terms. These can be found in Appendix G.
- **Boldfaced** terms are ones you are likely to need to understand because they are important to the entire course.
- *Italicized* terms are not as important, but may be necessary to understand the material in a particular chapter.
- Pay particular attention to illustrations. Geology is a visually oriented science and the photos and artwork are at least as important as the text. You should be able to sketch important concepts from memory.
- Find out to what extent your instructor expects you to learn the material in the boxes. They offer an interesting perspective on geology and how it is used, but much of the material might well be considered optional for an introductory course and not vital to your understanding of major topics. Many of the "In Depth" boxes are meant to be challenging—do not be discouraged if you need your instructor's help in understanding them.
- Read through the appropriate chapter before going to class. Reread it after class, concentrating on the topics covered in the lecture or discussion. Especially concentrate on concepts that you do not fully understand. Return to previously covered chapters to refresh your memory on necessary background material.
- Use the end of chapter material for review. The Summary is just that, a summary. Don't expect to get through an exam by only reading the summary but not the rest of the chapter. Use the Terms to Remember to see if you can visually or verbally associate the appropriate concept with each term. Answer the Testing Your Knowledge questions in writing. Be honest with yourself. If you are fuzzy on an answer, return to that portion of the chapter and reread it. Remember that these are just a sampling of the kind of questions that might be on an exam.
- Geology, like most science, builds on previously acquired knowledge. You must retain what you learn from chapter to chapter. If you forget or did not learn significant concepts covered early in your course, you will find it frustrating later in the course. (To verify this, turn to chapter 20 and you will probably find it intimidating; but if you build on your knowledge as you progress through your course, the chapter material will fall nicely into place.)
- The Smithsonian Institution's *Journey Through Geology* CD-ROM accompanying this textbook is an exciting innovation. Try it out. The animation and film clips in it should provide a real boost to visualizing difficult concepts.
- Be curious. Geologists are motivated by a sense of discovery. We hope you will be too.

Who Needs Geology?

Imagine yourself as a student at California State University, Northridge (CSUN) in greater Los Angeles. At 4:30 A.M. on January 17, 1994, you are jolted awake when your apartment begins to sway violently. Dishes, bookcases, and ceiling plaster crash to the floor. The noise and shaking are terrifying as you struggle to stand up. In less than a minute the shaking stops and silence momentarily returns. You realize you survived an earthquake, but you are still scared and disoriented.

This seismic event took place because of a sudden shift of bedrock eighteen kilometers beneath Northridge. Shock waves spread in all directions with damaging effects in many parts of Los Angeles. Northridge and vicinity suffered the heaviest damage. You feel fortunate, you are safe and your apartment building was not destroyed. Others nearby were not so fortunate. Two University students were among the sixteen killed in one of the forty apartment buildings that collapsed (figure 1.1). (Emergency crews drove right past one apartment building because it appeared undamaged; but it had collapsed straight downward, completely crushing the first floor but leaving the upper floors standing.)

After the earthquake you and your neighbors do not have electricity (power was lost, temporarily, as far away as Edmonton, Canada). Water is in short supply because of broken water mains. Leaving the area is not a good option. Eleven major highway structures have been destroyed, including a segment of the Santa Monica Freeway, the nation's busiest highway. Despite the deprivations and the jitters caused by frequent aftershocks, you are comforted by how people pitch in to help each other. A tremendous sense of community grows from the shared adversity.