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RECEIVED

Physical Geology

fifth edition

Physical Geology Earth Revealed



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PHYSICAL GEOLOGY: EARTH REVEALED
FIFTH EDITION

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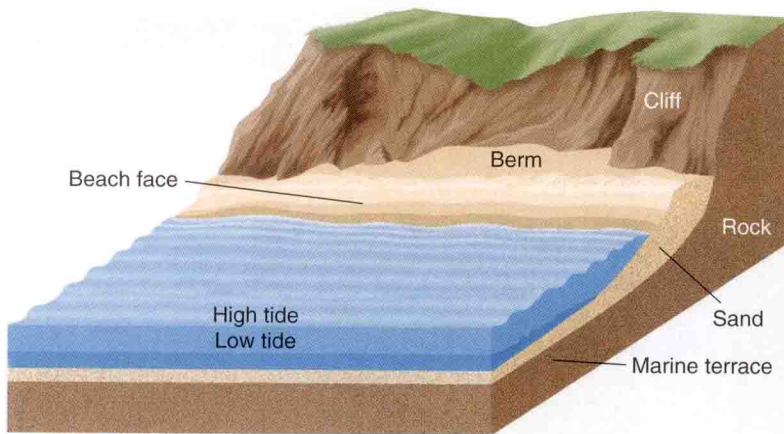
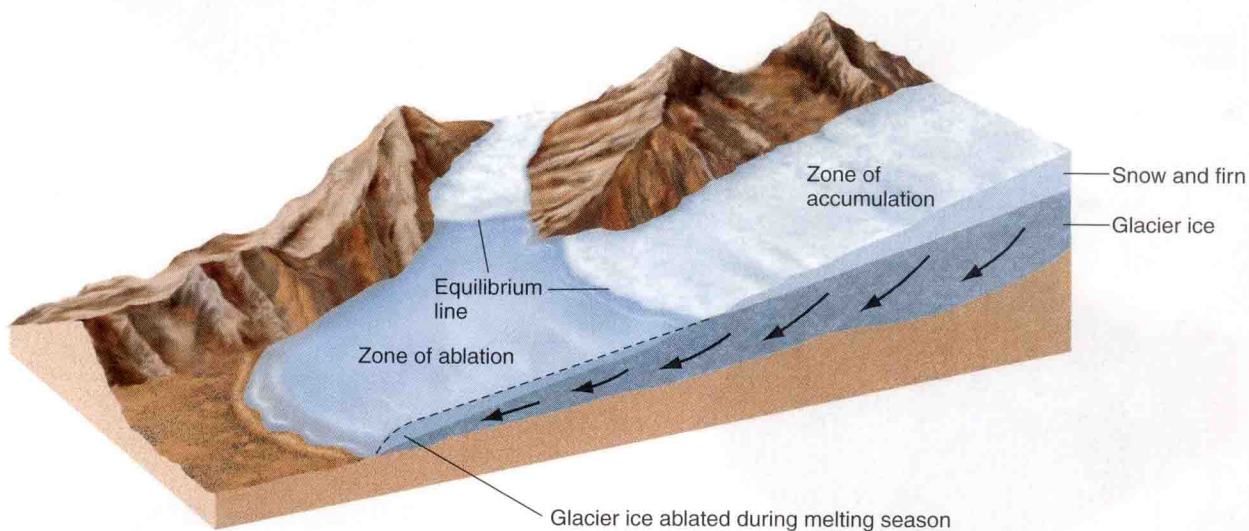
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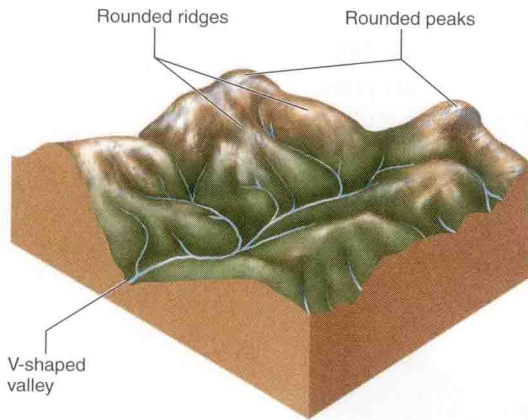
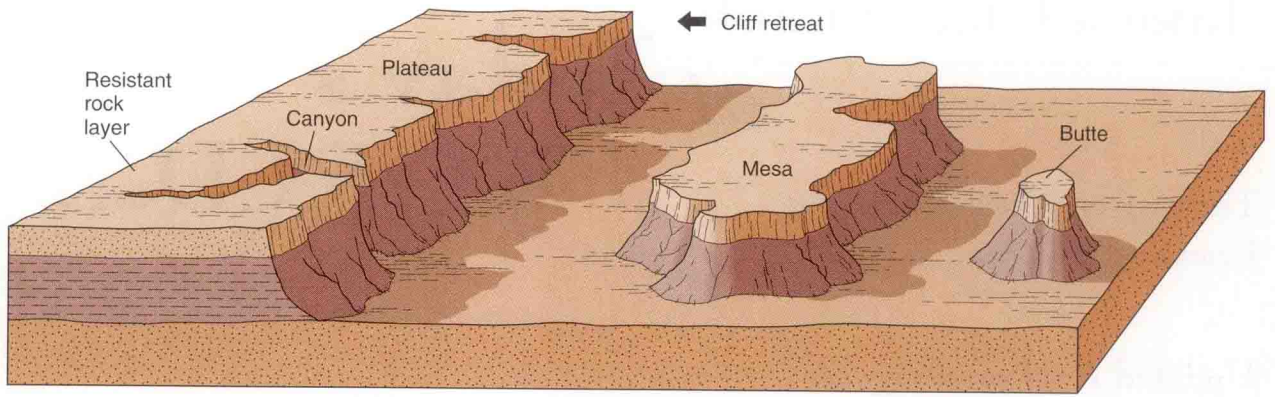
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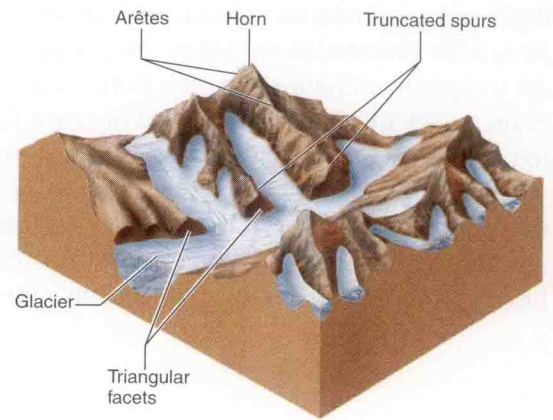
Updated Art Program

The art program for this edition of *Physical Geology: Earth Revealed* has been carefully revised and developed for clarity and consistency to help students master fundamental concepts. In total, 150 new or revised art pieces have been introduced, including more three-dimensional diagrams and line art and photo combinations than ever before. We have digitized the art program which allowed us not only to improve the printed illustrations, but also to provide the artwork in electronic format, making it easier to include relevant figures and art in classroom presentations. We've also developed nearly 60 animations and 12 pieces of Active Art from this new art program. Active Art allows instructors to adapt figures for their lecture environment and illustrate complex processes and concepts more easily.

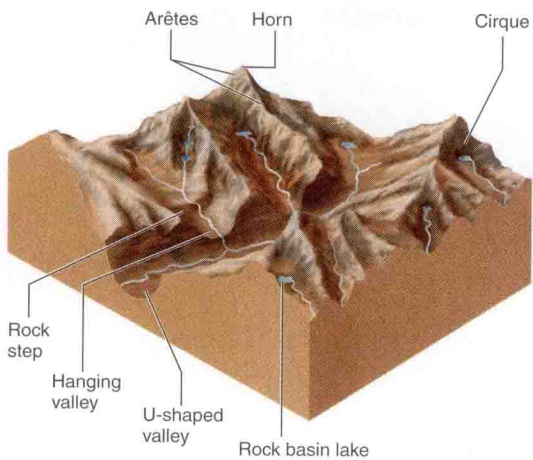




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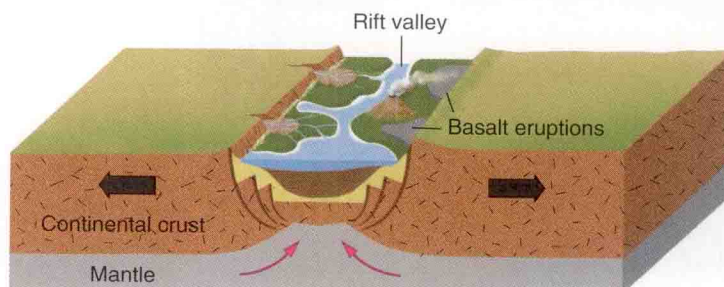


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Learn more about this text.
 Visit the Physical Geology website:
www.mhhe.com/plummer9e



Preface

Physical Geology Earth has been updated to include the latest technology and most current information. *Physical Geology* is for both non-science majors and students contemplating majoring in geology. The new art program and interactive writing style will grab your students' attention and further their interest in the subject.

This book contains the same text and illustrations as the ninth edition of *Physical Geology* by Plummer, McGeary, and Carlson. The chapter order has been changed so that internal processes (plate tectonics, earthquakes, etc.) are covered in the first part of the book and external processes (rivers, glacier, etc.) are described toward the end of the book. This ordering is favored by many geology instructors. *Physical Geology: Earth Revealed* is featured as the companion text to *Earth Revealed Introductory Geology*, a PBS television course and video resource produced in collaboration with the Annenberg/CPB project. *Earth Revealed* is a series of twenty-six half-hour video programs organized around the chapters of this text. The television programs document evidence of geologic principles at geographically diverse sites, often using a case study approach. Videocassettes can be purchased individually or as a thirteen-tape set. A *Study Guide* and *Faculty Guide* are also available to supplement the programs. For information regarding the use of *Earth Revealed Introduction Geology* as a television course, or to purchase videocassettes for institutional or classroom use, contact the Annenberg/CPB Multimedia Collection at 1-800-LEARNER.

What's New in This Edition

The Internet has revolutionized the way we learn. This edition expands upon the integration of the Internet and textbook. We have added boxes that have a brief summary in the book, while the complete boxes are accessible through this book's website. We have shortened some boxes from previous editions, but placed the full box on the website. When we have found excellent and appropriate websites, we have added URLs in the text and in figure captions. Our website has enjoyable and enlightening web exercises that we have tested with our students. An exciting addition to this edition is the figures that have been animated to more clearly illustrate processes active in geology.

We have added new and revised artwork and photos. Some of the changes we have made for this edition include the following items.

In chapter 1, we have added boxes on geology as a career and the origin of the solar system. We have added isostatic adjustment to the important concepts covered in the introductory chapter and have expanded the introduction to plate tectonics. In the minerals chapter, we have added a brief section on polarizing microscopy to the discussion of double refraction and referred the interested reader to a website for more information. The introduction to the rock cycle has been moved to the beginning of the chapter on igneous rocks. In the chapter on igneous rocks and processes, we have overhauled our presentation of Bowen's reaction series to present what students need to know to understand igneous processes and use the website for a more complete presentation of the reaction series. We give a thorough, illustrated explanation of how partial melting takes place in circulating asthenosphere above subducting crust. In the volcanoes chapter we have added a section on volcanoes and myths. We have also added a section that quantifies volcanic hazards. A new box looks at Mexico's Popocatepetl's recent eruptions and the potential for a disastrous eruption.

We have added a discussion of the twelve soil orders and updated the description and diagram of a soil profile to include the E Horizon.

Abrasion has been removed as an agent of erosion. Chapter 14 has been expanded to include a discussion and diagram of the relation of plate tectonic settings and types of sedimentary rock. A new astrogeology box featuring the latest Mars Global Surveyor images discusses the importance of sedimentary rock for determining whether water and life once existed on Mars; the regression and transgression box has been moved to the website and now includes animated diagrams.

In chapter 15, we have enhanced the description of the role of water in metamorphism to include why retrograde metamorphism is uncommon. We tie in the dehydration of metamorphic minerals during subduction to supplying the water necessary to partial melting of asthenosphere as described in the chapter on igneous rocks. In the chapter on geologic time, we have greatly expanded our coverage of isotopic dating to include descriptions of the mechanisms of radioactive decay. The recently dated 4.004 billion-year-old zircon crystal and its implications regarding early Earth history are discussed in that chapter.

Chapter 16 includes new photos of Niagara Falls and braided streams. The stream piracy section has been removed. The astrogeology box has been updated to include a discussion and latest photos of streamlike features on Mars from Nanedi Vallis canyon. Website URLs provide easy access to additional images from the Mars Orbiter Camera. Chapter 17 includes a rewrite of the Darcy's Law box to address the influence of porosity on groundwater velocity through sediment or rock as well as revision of several diagrams showing the details of ground-water flow and fluctuation. The term *speleothem* has been added, and a discussion of thermophillic bacteria around hot springs and the implication for early life is presented.

In the glaciers chapter, we have added a figure showing the extent of glaciation during the ice ages for the world (rather than just North America). We have pointed out that our present sea level is not permanent because of episodes of more extensive glaciation and global warming.

Chapter 18 has improved maps of deserts and photos of desert features and more realistic diagrams of blowouts and migration of sand dunes; an image of barchan dunes from Mars Proctor Crater has also been added. In Chapter 20, the box on rising sea level has been updated and many diagrams have been redrawn to look more realistic while retaining clarity for the beginning geology student.

In the structure chapter, text and diagrams have been rewritten and redrawn to improve clarity of difficult concepts. An exciting addition to this new edition is the animated diagrams of folding and faulting to show the mechanics of movement and accommodation of strain in the crust.

Chapter 7 has undergone a major revision to include information and spectacular photos of the recent major earthquakes that have struck around the world—Seattle, India, El Salvador, Turkey, and Taiwan. New boxes on earthquake engineering and lifesaving tips on what to do before, during, and after an earthquake have been added. The discussion of tsunamis has been revised and expanded to include new diagrams, photos, and a map of travel-time and early warning systems throughout the Pacific rim.

In the chapter on Earth's interior and its geophysical properties, we have updated and expanded our coverage of the core-mantle boundary to include a discussion of the D layer and ultra low velocity zone (ULVZ) as well as incorporating exciting new discoveries about the dynamics of the deep interior of Earth. Chapter 3 includes a new astrogeology box on the origin of the ocean. Maps of features on the sea floor have been revised.

The plate tectonics chapter has been partially rewritten and expanded to include an illustrated discussion of the paleontological evidence for continental drift. It also includes new information and an accompanying figure presenting the latest ideas about the dynamics of plates and mantle plumes at depth in the mantle.

In the chapter on mountains and the continental crust, we have expanded our coverage of the Appalachians by discussing their post-orogenic erosional and uplift history. Our geologic resources chapter now includes a box on frozen methane hydrates as a potential new energy resource along with its potential to contribute to global warming.

Features

The Internet has revolutionized the way we obtain knowledge and this book makes full use of its potential to help students learn. We have made the process student-friendly by having all websites that we mention in the book, a mouse-click away from this book's website. (We also include all URLs in the textbook for those who wish to go directly to a site.) Within our website we have Internet exercises to allow students to get the most out of appropriate sites as well as to raise interest for independent, further exploration on a topic. We expect to add more sites and exercises to our web pages as we discover new ones after the book has gone to press. Our website also features online quizzes and exercises to help a student succeed in a geology course.

Technology-Related Supplements

For Instructors:

- Online Learning Center at www.mhhe.com/plummer9e/ containing:
 - Access to PowerWeb—Geology
 - Password Protected Instructor's Manual
 - Web Links and more!
- Digital Content Manager CD-ROM with most of the line art and photographs from the text
- Interactive Plate Tectonics CD-ROM

William W. Atkinson, Jr., *University of Colorado–Boulder*

J. Bret Bennington, *Hofstra University*

Stephen K. Boss, *University of Arkansas–Fayetteville*

Kevin Cornwell, *California State University, Sacramento*

P. Thompson Davis, *Bentley College*

Dave Evans, *California State University, Sacramento*

Tim Flood, *St. Norbert College*

Norm Harris, *Nassau Community College*

Tim Horner, *California State University, Sacramento*

Chris Hill, *Fullerton College*

Paul Hudak, *University of North Texas*

Leslie Kanat, *Johnson State College*

Alan Lester, *University of Colorado–Boulder*

Donald Lindsley, *SUNY at Stony Brook*

Jerry F. Magloughlin, *Colorado State University*

Penelope Morton, *University of Minnesota–Duluth*

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Kevin J. Smart, *University of Oklahoma*

Mark Swanson, *University of Southern Maine*

Sarah Ulerick, *Lane Community College*

Andrew Warnock, *Colorado State University*

John Wickham, *University of Texas–Arlington*

- Geoscience Videotape Library (available to qualified adopters)
- Computerized testing software

For Students:

- Online Learning Center at www.mhhe.com/plummer9e/ containing:
 - 60 new Animations
 - Interactive Quizzing
 - Key Term Flashcards
 - Access to PowerWeb—Geology
 - Web Links and more!

Printed Supplements

- 200 Transparencies
- 477 Slides
- *Laboratory Manual for Physical Geology*, 11th edition, by Zumberge, Rutford, and Carter, ISBN 0-07-239195-2
- *Laboratory Manual for Physical Geology*, 4th edition, by Jones, ISBN 0-07-243655-7
- *Student Atlas of Environmental Issues*, by Allen, ISBN 0-697-36520-4
- *You Can Make a Difference: Be Environmentally Responsible*, by Getis, ISBN 0-07-292416-0

Acknowledgments

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.

Diane Carlson would like to thank her husband, Reid Buell, for his support and technical assistance with several chapters. We thank Susan Slaymaker for writing the planetary geology material originally in early editions.

We are also very grateful to the following reviewers of the fifth edition for their careful evaluation and useful suggestions for improvement.

Boxed Readings

Each chapter contains at least one of 3 types of boxes—**In Greater Depth**, **Environmental Geology**, and **Astrogeology**. The *In Greater Depth* boxes cover interesting topics that are usually not an essential part of an introductory geology course. *Environmental Geology* boxes show how material pertaining to physical geology relates to environmental concerns such as oil spills, exploiting natural resources, and mitigating natural disasters. *Astrogeology* boxes relate topics discussed in the text to what has been discovered on other planets or the solar system.

9.2 ENVIRONMENTAL GEOLOGY

LOS ANGELES, A MOBILE SOCIETY

The following satirical newspaper column was written by humorist Art Buchwald in 1973, a year, like the "El Niño" year of 1998, in which southern California had many landslides because of unusually wet weather.

Los Angeles—I came to Los Angeles last week for rest and recreation, only to discover that I had become a man forest.

I didn't realize how bad it was until I went to dinner at a friend's house. I had the right address, but when I arrived there was nothing there. I went to a neighboring house where I found a man bailing out his swimming pool.

I beg your pardon, I said. Could you tell me where the Cables live?

"They used to live above us on the hill. Then, about two years ago, their house slid down in the mud, and they lived next door to us. I think it was last Monday, during the storm, that their house slid again, and now they live two streets below us, down there. We were sorry to see them go—they were really nice neighbors."

I thanked him and said straight down the hill to the new location of the Cables' house. Cable was clearing out the mud from his car. He apologized for not giving me the new address and explained, "Frankly, I didn't know until this morning whether the house would stay here or continue sliding down a few more blocks."

Cable, I said, you and your wife are intelligent people, why do you build your house on the top of a canyon, when you know that during a rainstorm it has a good chance of sliding away?

"We did it for the view. It really was fantastic on a clear night up there. We could sit in our Jacuzzi and see all of Los Angeles, except of course when there were trash fires."

"Even when our house slid down two years ago, we still had a great sight of the airport. Now I'm not too sure what kind of view we'll have because of the house in front of us, which slid down with ours at the same time."

But why don't you move to safe ground so that you don't have to worry about ninestorms?

"We've thought about it. But once you live high in a canyon, it's hard to move to the plains. Besides, this house is built solid and has about three more good mudslides in it."

Still, it must be kind of hairy to sit in your home during a deluge and wonder where you'll wind up next. Don't you ever have the desire to just settle down in one place?

"It's hard for people who don't live in California to understand. Now we people out here think, Sure we have floods, and fire and drought, but that's the price you have to pay for living the good life. When Esther and I saw this house, we knew it was a dream come true. It was located right on the tippy top of the hill, way up there. We would wake up in the morning and listen to the birds, and eat breakfast out on the patio and look down on all the smog."

"Then, after the first mudslide, we found ourselves living next to people. It was an entirely different experience. But by that time we were ready for a change. Now we've slid again and we're in a whole new neighborhood. You can't do that if you live on solid ground. Once you move into a house below Sunset Boulevard, you're stuck there for the rest of your life."

"When you live on the side of a hill in Los Angeles, you at least know it's not going to last forever."

Then, in spite of what's happened, you don't plan to move out?

"Are you crazy? You couldn't replace a house like this in L.A. for \$500,000."

What happens if it keeps raining and you slide down the hill again?

"It's no problem. Esther and I figure if we slide down too far, we'll just pick up and go back to the top of the hill, and start all over again; that is, if the hill is still there after the earthquake."

Reprinted by permission of the author.

Further Reading
John McPhee's *The Control of Nature* contains a factual, and highly readable, account of 1978 landslides in southern California.

10.3 ASTROGEOLOGY

STREAM FEATURES ON THE PLANET MARS

There is probably no liquid water on the surface of Mars today. With the present surface temperatures, atmospheric pressures, and water content in the Martian atmosphere, any liquid water would immediately evaporate. There are some indications, however, that conditions may have been different in the past and that liquid water existed on Mars, at least temporarily. Certain features on Mars, called channels, closely resemble certain types of stream channels on Earth. They have tributary systems and meanders and are sometimes braided. The channels trend downslope and tend to get wider toward their mouths. These Martian channels are restricted to certain areas and appear to have been formed by intermittent episodes of erosion.

One type of stream channel on Mars appears to have formed by large flooding events and is similar in appearance to those observed in the Channelled Scablands of Washington state. The Channelled Scablands were formed by extensive flooding during the Pleistocene glacial ages when a naturally formed ice dam broke and released water from a large lake. The mouth of Aras Vallis, an ancient Martian flood channel similar to those observed in the Channelled Scablands, was selected for the July 4, 1997 landing of the Pathfinder spacecraft and Sojourner Rover. It was postulated that a variety of rock types should be present in the mouth of an ancient flood channel. The first photos from the Mars Pathfinder Lander and Sojourner Rover, a "robotic field geologist," revealed a variety of rock types (box figure 1); in what does appear to be an ancient outflow channel.



Box 10.3 — FIGURE 1
View from the Mars Pathfinder Lander showing the Sojourner Rover and a variety of rocks from Aras Vallis. Photo courtesy of Jet Propulsion Laboratory/NASA.



Box 10.3 — FIGURE 2
Meandering channel and fan terraces within the Nanedi Vallis canyon, which resembles stream features cut by running water on Earth. Photo courtesy NASA.

A second kind of Martian channel (box figure 2), a meandering streamlike feature, occurs on the older surfaces of Mars (more than 3.5 billion years old) and may indicate that early in the history of Mars temperature and atmospheric conditions were such that rainfall could have occurred and long-lived river systems

8.1 IN GREATER DEPTH

HIGHLIGHTS OF THE EVOLUTION OF LIFE THROUGH TIME

The oldest fossils found are prokaryotes—microscopic, single-celled organisms that lack a nucleus. These date back to around 3.6 billion years (b.y.) ago, so life on Earth is at least that old. It is likely that even more primitive organisms, similar to viruses, date back further in time but are not preserved in the fossil record. Fossils of much more complex, single-celled organisms that contained a nucleus (eukaryotes) are found in rocks as old as 1.4 b.y. These are the earliest living creatures to have reproduced sexually. Colonies of unicellular organisms likely evolved into multicellular organisms. Multicellular algae fossils date back at least a billion years.

Imprints of larger multicellular organisms appear in rocks of late Precambrian age, about 700 to 650 million years ago (m.y.). These resemble jellyfish and worms.

Sedimentary rocks from the Paleozoic, Mesozoic, and Cenozoic eras have abundant fossils. Large numbers of fossils appeared early in the Cambrian period. Trilobites (figure 8.21) evolved into many species and were particularly abundant during the Cambrian. They became less significant later in the Paleozoic and finally all trilobites became extinct by the end of the Paleozoic.

The most primitive fish, the first vertebrates, date back to late in the Cambrian. Fish similar to presently living species of fish (including sharks) flourished during the Devonian (named after Devonshire, England). The Devonian is often called the "age of fish." Amphibians evolved from fish that had developed lungs late in the Devonian. These were the first land animals. Land plants, however, date back to the Ordovician. Reptiles evolved from amphibians in Pennsylvanian times or perhaps earlier.

The Paleozoic ended with the greatest mass extinction ever to occur on earth. Over 95% of species that existed died out. During the Mesozoic new creatures evolved to occupy ecological domains left vacant by extinct creatures. Dinosaurs and mammals evolved from reptiles that survived the great extinction. Dinosaurs became the dominant group of land animals. Birds likely evolved from dinosaurs in the Mesozoic. Large, now extinct, marine reptiles, such as ichthyosaurs, lived in the Mesozoic seas while flying reptiles, pterosaurs, soared through the air.

The Cretaceous period (and Mesozoic era) ended with the second largest mass extinction (around 75% of species were wiped out).

The Cenozoic is often called the "age of mammals." Mammals, which were small, insignificant creatures during the Mesozoic, evolved into the many groups of mammals (whales, bats, canines, cats, elephants, primates, and so forth) that occupy the earth at present. Many species of mammals evolved and became extinct throughout the Cenozoic. Hominids (modern humans and our extinct ancestors) have a fossil record dating back 4 m.y., and likely evolved from a now extinct ancestor common to hominids, chimpanzees, and other apes.

We tend to think of mammals' evolution as being the great success story (because we are mammals), however, mammals pale in comparison to insects. Insects have been around far longer than mammals and now account for an estimated 1 million species.

Related Web Resource
University of California Museum of Paleontology
www.uctmp.berkeley.edu/

End-of-Chapter Learning Aids

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 understand.

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.

Summary

Major mountain belts are made up of a number of mountain ranges. Mountain belts are generally several thousand kilometers long but only a few hundred kilometers wide.

Mountain belts generally evolve as follows. First, a thick sequence of sedimentary and volcanic rock accumulates (the *accumulation stage*). Second, the accumulation stage is either accompanied or followed by an *orogenic stage*, which involves intense deformation of the layered rocks into folds and reverse (including thrust) faults, along with metamorphism and igneous activity. Third, the area is then subjected to a long period of uplift, often with block-faulting, and erosion. Eventually, the mountain belt is eroded down to a plain and incorporated into the *craton*, or stable interior of the continent.

According to the theory of plate tectonics, mountains on the edge of continents are formed by continent-oceanic convergence, and mountains in the interior of continents are formed by continent-continent collisions.

The uplift of a region following termination of an orogeny is generally attributed to isostatic adjustment of continental crust.

Continents grow larger when new mountain belts evolve along continental margins. They may also grow by the addition of terranes that may have traveled great distances before colliding with a continent.

Terms to Remember

accreted terrane 514 accumulation stage 505 craton 501 fault-block mountain range 511 fold and thrust belts 502	gravitational collapse and spreading 507 lithospheric delamination (or delamination) 511 major mountain belt 498 mountain range 498	orogeny 506 Precambrian shield 501 suspect terrane 514 terrane (tectonostratigraphic terrane) 514
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Testing Your Knowledge

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

- What does a fold and thrust belt tell us about what occurred during an orogeny?
- What is the difference between the forces that could explain fault-block mountains and the forces that could account for an orogenic stage?
- Explain how erosion and isostasy eventually produce stable, relatively flat, continental crust.
- How do the sequences of sedimentary rocks in cratons differ from those in mountain belts?
- What sequence of events accounts for a mountain belt that is bounded on either side by cratons?
 - Appalachians
 - North American Cordillera
 - Himalaya
 - Andes
 - Rockies
- The mountain belt that forms the western part of North America is called the
 - Appalachians
 - North American Cordillera
 - Himalaya
 - Andes
 - Rockies
- The craton
 - covers the central part of the United States and Canada
 - has only 1,000–2,000 m of sedimentary rock overlying basement rock
 - has rock beneath any sedimentary rock that is old plutonic and metamorphic rock
 - all of the above
- The Precambrian shield
 - contains geologically young rocks
 - occurs only in mountainous regions
 - is a complex of Precambrian metamorphic and plutonic rocks exposed over a large area
 - all of the above
- Folds and reverse faults in a mountain belt suggest
 - crustal shortening
 - tensional stress
 - deep water deposits
 - all of the above

Expanding Your Knowledge

- How are unconformities used to determine when orogenies occurred?
- How has seismic tomography contributed to our understanding of mountain belts?
- How do basalt and ultramafic rocks from the oceanic lithosphere become part of mountain belts?
- Why is a craton locally warped into basins and domes?
- How could fossils in a terrane's rocks be used to indicate that it is an exotic terrane?

Exploring Web Resources

www.mhhe.com/plummer7e

Dance of the Continents (with SWEAT). Go to the Online Learning Center and read how building followed by breakup of supercontinents has taken place throughout geologic time. The process is compared to a dance. Each dance cycle, which takes about a billion years, is set to a symphony in four movements in which the continental fragments come together and later "dance" away. The creation, in the Paleozoic, and breakup, in the Mesozoic, of Pangea is only the latest of the several dance cycles.

Related to this is a hypothesis called SWEAT, which is an acronym for southwest United States–East Antarctic connection. According to this hypothesis, in one of the Precambrian supercontinents, the craton in the southwestern United States adjoined what is now Antarctica. This site also includes answers to the Testing Your Knowledge section, additional

quizzing, readings, and a great animation. Click on the links to go directly to the websites listed below.

www.hartwick.edu/geology/work/VFT-ss-lar/VFT.html

Hartwick College Virtual Field Trip. A field trip through part of the Appalachians in central New York state. The site includes a geologic history for this part of the Appalachians.


<http://vstweb.glg.nyu.edu/people/jhs/TDces/TDces.html>

Tibet: A Virtual Field Trip. You can take a trip through the Tibetan Plateau into the Himalaya. Good summaries of the geology of the Tibetan Plateau and the Himalayan Mountains are accessible through this site.

www.somoma.com/edu/geology/travel/himalayas.html

Geology of Grand Teton National Park, Wyoming. A photo, map, and text description of the spectacular Grand Teton Range and its geologic history.

Animations

 This chapter includes the following animation available on our Online Learning Center at www.mhhe.com/plummer7e.

20.15 History in a Mountain Belt

Digital Content Manager CD-ROM

The Digital Content Manager CD-ROM is a multimedia collection of visual resources that allows instructors to create powerful presentations to help their students visualize difficult concepts.

The Digital Content Manager CD-ROM contains:

- 385 color images from the text.
- 284 photographs from the text.
- 58 animations using art from the text.
- 12 pieces of Active Art, which allow instructors to adapt figures to meet the needs of their lecture environment and illustrate complex processes and concepts more easily.
- all tables from the text.
- chapter-specific PowerPoint Lecture Outlines to help instructors create exciting lecture presentations

The digital assets on this cross-platform CD-ROM are grouped by chapter within easy-to-use folders. The Art Library contains full-color digital files of most of the illustrations in the text. The Photo Library contains digital files of instructionally significant photographs from the text. The Power Point Lectures consist of ready-made presentations that have lecture notes specifically written to cover each chapter. Every table that appears in the text is provided in electronic form in the Table Library.



The Online Learning Center

Your Password to Success

www.mhhe.com/plummer9e/

The Online Learning Center offers a wealth of study aids for students as well as teaching aids for instructors. Take a look for yourself!

Students, learning geology can be easy and fun!

Visit the Online Learning Center for:

- nearly 60 animations of difficult concepts
- interactive quizzing
- visual and key term flashcards
- web links related to recent geologic events
- Internet exercises
- PowerWeb: Geology

Instructors, we've made your life just a little easier!

Just a sampling of the assets you will find:

- a password-protected Instructor's Manual
- a password-protected Test Item File
- web links related to recent geologic events
- professional resources
- PowerWeb: Geology

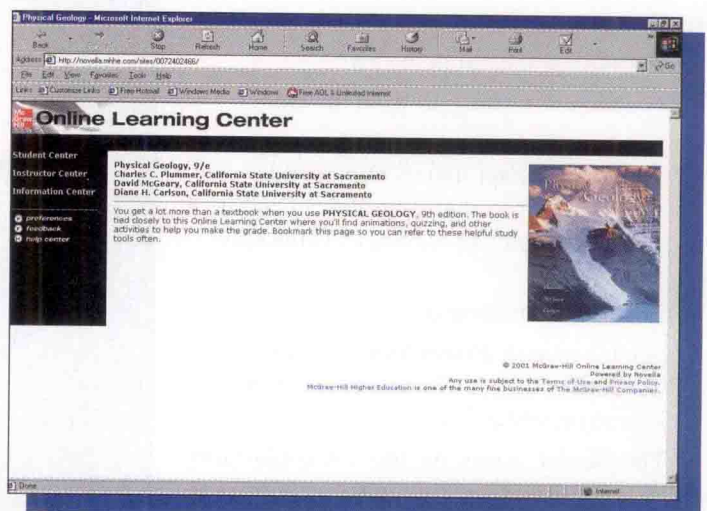
Access to PowerWeb: Geology

www.dushkin.com/powerweb

PowerWeb is a password-protected website developed by McGraw-Hill/Dushkin to give instructors and students:

- course-specific materials
- monitored course-specific web links and articles
- student study tools, including quizzing, review forms, time management tools, and web research
- interactive exercises
- weekly updates with assessment
- informative and timely world news
- access to Northern Light Research Engine (received multiple Editor's Choice awards for superior capabilities from *PC Magazine*)
- material on how to conduct web research
- daily news feed of topic-specific news

**Imagine the advantages of having so many learning and teaching tools
all in one place—all at your fingertips!**



Course Management Systems

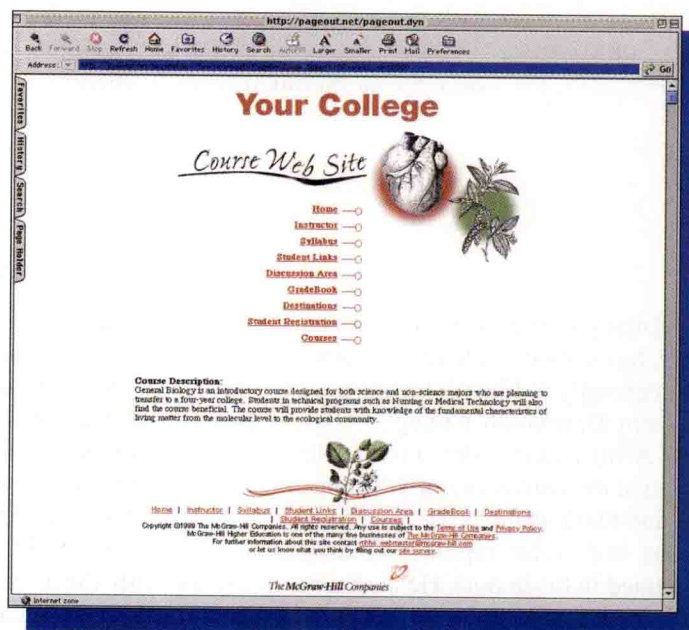
Course Management Systems expand the reach of your course. Online discussion and message boards can now complement your office hours. Also, because of a sophisticated tracking system, you will know which students need more attention—even if they don't ask for help. Online testing scores are recorded and automatically placed in your grade book. You can also create special alerts to show up if a student is struggling with coursework. Should you seek advice for your course, you have access to discussion and message boards where you can collaborate and communicate with other professors across campus or around the world. Our own specialists are also ready to answer your questions.

McGraw-Hill's Online Learning Center content is compatible with a variety of course management systems, including:

- **PageOut**, McGraw-Hill's exclusive course management system, which allows you to create a custom course website with links to book-specific course content. Simply select a template to post course information and an interactive syllabus links to Online Learning Center content.

Online Learning Center content is also compatible with these commercially produced course management systems:

- WebCT
- Blackboard
- Topclass
- eCollege



Contact your McGraw-Hill sales representative for more information or visit www.mhhe.com.



Meet the Authors

David McGeary, Diane Carlson, and Charles Plummer at an outcrop of a Sierra Nevadan intrusive body.

Charles Plummer

Professor Charles “Carlos” Plummer grew up in the shadows of volcanoes in Mexico City. There, he developed a love for mountains and mountaineering that eventually led him into geology. He received his B.A. degree from Dartmouth College. After graduation, he served in the U.S. Army as an artillery officer. He resumed his geological education at the University of Washington where he received his M.S. and Ph.D. degrees. His geologic work has been in mountainous and polar regions, notably Antarctica (where a glacier is named in his honor). He taught at Olympic Community College in Washington before joining the faculty at California State University, Sacramento.

At CSUS he taught optical mineralogy, metamorphic petrology, and field courses before his semiretirement. He continues to teach introductory courses. He flies airplanes, skis, and recently became a certified open water SCUBA diver. (plummercc@csus.edu)

David McGeary

David McGeary retired from teaching in 1992 and from textbook writing in 1995. His activities today are nongeological—tending his house and land, traveling, carpentry, blacksmithing, and acting in community theatre.

Diane Carlson

Professor Diane Carlson grew up on the glaciated Precambrian shield of northern Wisconsin and received an A.A. degree at Nicolet College in Rhinelander and her B.S. in geology at the University of Wisconsin at Eau Claire. She continued her studies at the University of Minnesota–Duluth where she studied the structural complexities of high-grade metamorphic rocks along the margin of the Idaho batholith for her master’s thesis. The lure of the West and an opportunity to work with the U.S. Geological Survey to map the Colville batholith in northeastern Washington led her to Washington State University for her Ph.D. Dr. Carlson accepted a position at California State University, Sacramento after her Ph.D. and teaches physical geology, structural geology, environmental geology, and field geology. Professor Carlson is a recipient of the Outstanding Teacher Award from the CSUS School of Arts and Sciences. She is also actively engaged in researching the structural and tectonic evolution of part of the Foothill Fault System in the northern Sierra Nevada of California. (carlsondh@csus.edu)



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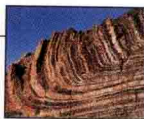
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