

A NEW GEOMORPHOLOGY TEXTBOOK, CREATED IN A NEW WAY

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Abstract

We have completed a new textbook, *Key Concepts in Geomorphology*, applying a model of extensive community involvement at all stages from initial outlining through chapter development and revision to final review. The textbook is designed to serve undergraduate students in first year courses about Earth Surface Processes, Physical Geography, and Quaternary Geology. It differs from existing textbooks because it is shorter and focuses on the key concepts of the discipline rather than on esoteric details or place-based examples. Such details are covered in a series of >250 electronic resources developed by community members as part of this project (see abstract by C. Massey and visit <http://serc.carleton.edu/vignettes>).

The US National Science Foundation provided support for review of each chapter by two experts well-versed in the chapter's content as well as review of the entire textbook by two senior geomorphologists and a technical editor with expertise in Surface Processes and Quaternary History. Each chapter was vetted by 8 to 10 generalist reviewers before extensive copyediting.

The textbook has 14 chapters organized into four sections. Each chapter includes between 10 and 14 newly drafted, full-color figures designed specifically for novice learners. Between 20 and 30 annotated color photographs fill the chapters along with a worked problem and a series of questions that allow students to test their mastery of the material. At the end of each chapter, the Digging Deeper section presents an in depth look at the development of scientific thought on a problem relevant to the chapter.

14 Chapters each begin with an outline and image.

Geomorphologist's Tool Kit



Introduction
 Geomorphology has been revolutionized in the past several decades by rapidly advancing technologies. Today, geomorphologists routinely use laser altimetry, measure rates of erosion, and quantify the morphology of Earth's surface with high precision. Techniques geomorphologists use today for generalizing the study of rocks, sediments, and landforms, high-precision, satellite-based topographic surveys, multibeam bathymetry, and high-resolution computer modeling have moved from the experimental realm to widespread application. These techniques and others provide fundamental data about the rates of our Earth surface processes and the distribution of Earth materials, such data allow geomorphologists to understand when, where, and how quickly our planet's surface changes.

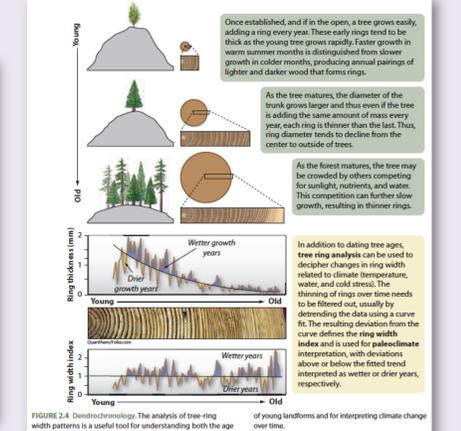
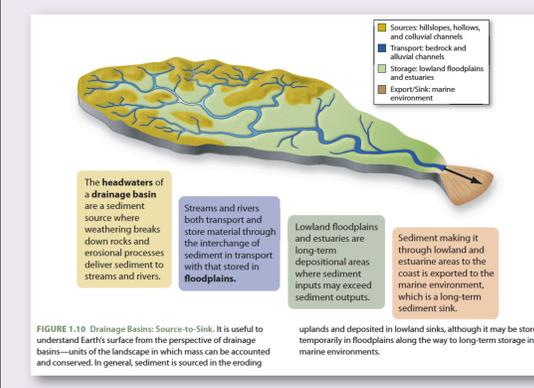
IN THIS CHAPTER
 Introduction
 Characterizing Earth's Surface
 Field Surveys
 Active Surface Mapping
 Passive Surface Mapping
 Digital Topographic and Landscape Analysis
 Modeling Methods
 Landscape Degradation
 Rock Weathering and Development
 Rock Movement
 Calculating Relative Dates

Numerical Dating Methods
 Radiocarbon Dating
 K-Ar Dating
 U-Th Dating
 Luminescence Dating
 In Situ Cosmogenic Nuclide Analysis
 Measuring Rates of Geomorphic Processes
 Sediment Generation Rates
 Sedimentation Rates
 Landscape Change at Outcrop and Watershed Scale
 Landscape Change of Basin-Scale
 Erosion Rates from U-Th Dating
 Truncation

Experiments
 Field Experiments
 Laboratory Experiments
 Laboratory Experiments
 Proxy Records
 Applications
 Selected Submissions and Further Reading
 Digging Deeper: How Does a Dating Method Work?
 Worked Problem
 Knowledge Assessment

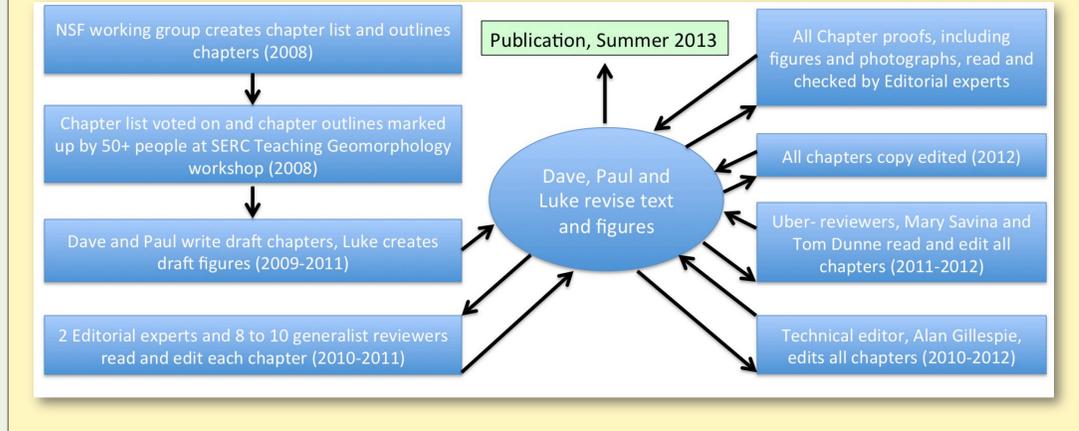
1. Earth's Dynamic Surface **Part 1**
2. Geomorphologist's Tool Kit **Part 1**
3. Weathering and Soils **Part 2**
4. Geomorphic Hydrology **Part 2**
5. Hillslopes **Part 2**
6. Channels **Part 2**
7. Drainage Basins **Part 2**
8. Coastal and Submarine Geomorphology **Part 2**
9. Glacial and Periglacial Geomorphology **Part 3**
10. Wind as a Geomorphic Agent **Part 3**
11. Volcanic Geomorphology **Part 3**
12. Tectonic Geomorphology **Part 4**
13. Geomorphology and Climate **Part 4**
14. Landscape Evolution **Part 4**

All new, full color art, 10 to 14 figures per chapter, uses explanatory text boxes and images to make learning new concepts easier for students.

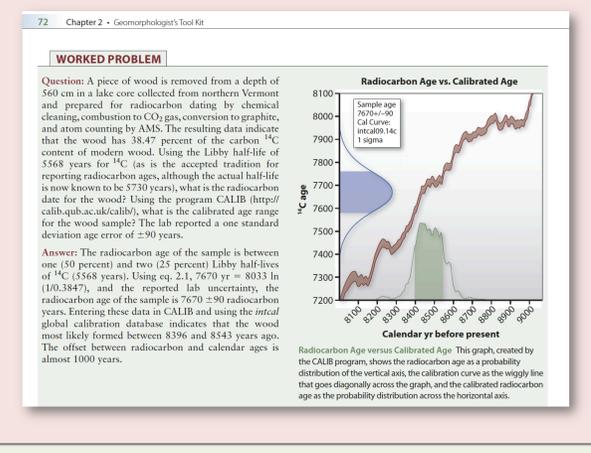


Community involvement and extensive peer review determined content and ensured accuracy.

We thank Editorial experts Ari Matmon, Arjun Heimsath, Beverley Wemple, Cam Wobus, Chuck Nittrouer, David Dethier, Derek Booth, Dorothy Merritts, Doug Clark, Ellen Wohl, Eric Leonard, Eric Steig, Frank Magilligan, Frank Pazzaglia, Gordon Grant, Grant Meyer, Kathy Cashman, Leslie McFadden, Lisa Ely, Milan Pavich, Missy Eppes, Nick Lancaster, Paul Bishop, Ray Torres, Sara Mitchell, Scott Burns, and Scott Linneman.



Worked problems at the end of each chapter provide written and numeric examples to aid student learning.



Digging Deeper sections end each chapter and provide an in-depth, referenced narrative detailing the development of thinking on important geomorphic problems.

DIGGING DEEPER: Why is Earth Habitable?

Earth is the only planet we know of that harbors life. So far, our planet appears to be a special place where the interactions and feedbacks among the solid Earth, the hydrosphere, the biosphere, and the atmosphere provide conditions favorable for living organisms.

What makes Earth so special? Earth is habitable because liquid water is stable on its surface; it is large enough to retain an atmosphere and some internal heat, and it has a composition of long-lived radioactive elements, along with the original accretionary heat, to warm the planet's interior even after 4.5 billion years. This heat warms and softens interior rocks, sustains mantle flow, and thereby drives plate tectonics. The same heat keeps the core partially molten, allowing for the generation of a strong magnetic field. Without our magnetic field and thick atmosphere, Earth's surface would be bombarded by life-threatening levels of cosmic radiation.

Together, these characteristics enable active tectonic and volcanic processes to continue. Tectonism and volcanism are critical for life because they recycle volatile elements and compounds critical for carbon-based life from the geosphere to the atmosphere and hydrosphere—making Earth's surface dynamic and life-supporting. Life is capable of reducing entropy (disorder) and driving chemical reactions that are not thermodynamically favorable. For example, without life, atmospheric oxygen is unlikely to occur in our atmosphere because it is easily and rapidly consumed in oxidation (weathering) reactions with rocks.

Life as we know it requires the presence of liquid water and is thus limited to average temperatures in the range of approximately -15°C to 115°C. The habitable zone around a star is defined as the range of distances at which surface temperatures on a planet could potentially support liquid water. For our solar system, the habitable zone extends from about 0.84 to 1.7 times Earth's distance from the Sun, a range that includes Earth and Mars but not Venus.

The presence of liquid water is not only important for life itself, but it is also important for the differentiation of continental crust through the formation of granitoid rocks (Campbell and Taylor, 1983). In our solar system, Earth is the only inner planet with abundant water and the only known planet with continents. The formation of continents occurred as partial melting of oceanic crust released silicon- and potassium-rich, felsic magmas, a process dependent on water being carried (by subduction) into the mantle to initiate partial melting. Creation of extensive continents with a density low enough to stand above sea level requires the transport of large amounts of water into the upper mantle and thus requires tectonic activity. Continental rocks weather substantially (under the atmosphere), consuming carbon dioxide (CO₂) and water, and thus in part control the composition of Earth's atmosphere (Figure DD1.1).

Planetary atmospheres are a key part of the habitability puzzle, in part because they buffer thermal swings that would otherwise occur between night and day and between seasons.

High quality photographs, 20 to 30 per chapter, illustrate key concepts, techniques, and landforms. Most are in color and taken by geoscientists. Annotations aid recognition.



Knowledge assessments provide study guides for students and reflect the most important content of each chapter.

- KNOWLEDGE ASSESSMENT Chapter 3**
1. Define and differentiate saprolite, soil, and regolith.
 2. Describe how physical, chemical, and biological weathering differ.
 3. How does chemical weathering influence physical weathering and vice versa?
 4. List three mechanisms of physical weathering and describe how each works.
 5. What are boulders, tons, and inselbergs?
 6. Propose a series of physical processes and rock history that could lead to exfoliation.
 7. What process likely created felsenmeer?
 8. Predict what will happen to boulders or outcrops of rock exposed to a forest or range fire in an arid or semi-arid setting in the desert zone.
 9. Explain how salts can physically weather rock.
 10. Why does chemical weathering occur?
 11. Explain how silica and most rock-forming minerals differ from calcium carbonate in terms of chemical weathering?
 12. Why are iron and aluminum oxides characteristic of materials left as residue after extensive chemical weathering?
 13. List the most important factors influencing the amount of leaching of liquid material from soil or rock.
 14. Discuss how various types of biological activity affect the physical and chemical weathering rates of rocks.
 15. What controls the swelling potential of clay minerals?
 16. Define ion exchange, identify which ions are most likely to be exchanged, and explain why ion exchange is an important process.
 17. What is oxidation of minerals and where can you see it occur?
 18. Sketch and explain Goldich's Weathering Series.
 19. Starting with feldspar, explain how it weathers over time to eventually become gibbsite.
 20. Compare rates of soil production to contemporary rates of soil loss and explain why this comparison is important.
 21. Why is the density of saprolite less than that of the rock from which it was derived?
 22. Describe the patterns of soil horizons between chemical and physical weathering on a global scale.
 23. Explain how vegetation type and density affect soil formation rates and the type of soil that results.
 24. Explain how topography (slope steepness) affects soil thickness.
 25. Give three examples of how rock type influences the soils that will eventually develop.
 26. How is soil texture related to the age of a soil?
 27. List three ways by which material can be added to and removed from soils.
 28. Define translocation and explain how it can occur in soils.
 29. Explain how bioturbation occurs and why it is important.
 30. List the most common soil horizons and explain how each forms.
 31. Describe the two general models relating soil production rates to soil depth.
 32. Compare and contrast pedogenesis and soil development.
 33. Make a table listing the 12 soil orders, describing their salient characteristics, and suggesting in what environment each might be found.
 34. List the five factors thought to control rates of pedogenesis (soil development).
 35. Define a soil catena and explain differences observed across a landscape in terms of soil-forming processes.
 36. Suggest in what geomorphic environment you might see a chronosequence and explain why dating a chronosequence could be useful to you as a geomorphologist.
 37. Compare a palusol and a cumulisol.
 38. List and describe several examples of weathering-induced landforms at both small and large scales.
 39. List several types of durancrusts and explain how they help shape landscapes.
 40. Compare rates of soil production to contemporary rates of soil loss and explain why this comparison is important.

