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List of Changes

Environmental Geology
4th Edition
Reichard

ISBN: 1260368270 / 9781260368277 / © 2021

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Readers familiar with *Environmental Geology* should find that the changes to the fourth edition have significantly improved the already outstanding pedagogy and photo and art program of the previous editions. Perhaps the most significant improvement is the addition of five new case studies, bringing the total to 24. Increasing the number of case studies was a priority for the fourth edition because instructors commonly have students use case studies to explore chapter concepts in more detail. In addition to the new case studies, the chapter narratives have been thoroughly revised to include recent geologic events and scientific advances. Likewise, care was taken to ensure that all of the graphs and tables include the most recently available data at the time the text was revised. Several new photos were added to enhance the pedagogy and increase student interest. Finally, a considerable number of the existing graphics were modified to improve student comprehension.

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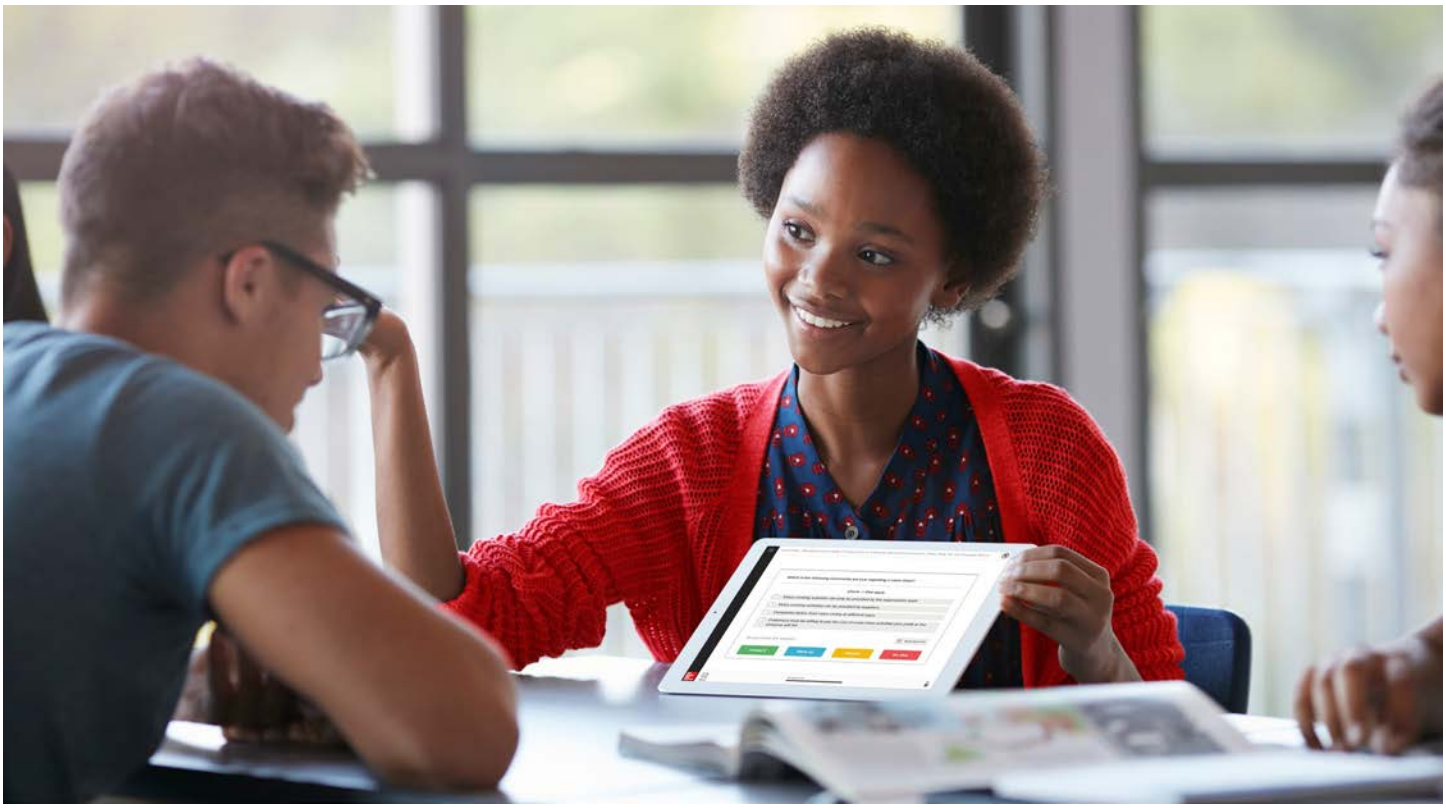

Although changes in the fourth edition are too numerous to be listed individually, some of the more significant improvements are described below. Note that the chapters with the most revisions are those on conventional energy resources (Chapters 13) and pollution and waste disposal (Chapter 15).

Chapter 1—The opening photo was replaced with an aerial view of the skyline of Hong Kong, China, illustrating how humans have built complex societies by growing large amounts of food and extracting vast quantities of energy and water from the Earth system. In addition to the chapter opening, two photos were replaced (Figures 1.7 and 1.21) with ones that should help improve student comprehension. The most significant change to this chapter has been the addition of a new case study on how human modifications to the Earth system can lead to undesirable consequences for society. In this example, the author describes how draining the extensive swamps of Northwest Ohio and subsequent widespread use of agricultural fertilizers has led to increased algae blooms and water-quality problems on Lake Erie, which is the primary water supply for the region.

Chapter 2—In addition to minor text changes, the discussion on NASA's Near-Earth Object program was updated to include the most recent results. Also, a discussion was added on NASA's new telescopes that are designed to continue the search for life on exoplanets. With respect to the graphics, minor modifications were made to the line art in Figures 2.7 and 2.36 to help improve accuracy and student comprehension. Lastly, the existing satellite images in Figure 2.25 depicting the ozone hole over Antarctica were replaced with higher quality images, including a more recent image from 2017.

Chapter 3—The section on igneous rocks has been moved so that it precedes sedimentary rocks rather than weathering processes. This was done in order to keep the three rock types together and to create a more logical sequence, which now goes from rock-forming minerals to weathering to the three rock types. Also in this chapter, more visually meaningful photos were found for Figures 3.13, 3.14, 3.19, 3.21, 3.24, and 3.32.
Chapter 4—A new photo (Figure 4.1) has been added showing an outcrop of strongly deformed sedimentary rocks, thereby providing a visual example of tectonic forces that operate in Earth's interior. Also, the photo in Figure 4.26 was replaced with a satellite image of the Appalachian Mountains so as to provide a better example of a suture zone at a convergent plate boundary. Lastly, Case Study 4.1 was renamed *The Wallace Line: An Example of Evolution and Plate Tectonics*.

Chapter 5—The opening photo was replaced with an image of an office building that collapsed during the 2018 earthquake in Hualien, Taiwan. The most significant change in this chapter has been the addition of a new case study on the earthquake hazards facing Anchorage, Alaska. Here the author demonstrates how the geologic setting puts the city at increased risk of structural failure, liquefaction, landslides, and tsunamis. In addition, new photos were used in Figure 5.1 and 5.20B and the line art in Figure 5.3 was re-labeled for improved clarity. Finally, a new laser image (Figure 5.40) was added, showing the trace of the San Andreas Fault through the urban area of Berkeley, California.

Chapter 6—The discussion on the 1883 Krakatau eruption under *Explosive Blast* hazards was completely rewritten to reflect the results from more recent research. This updated section also includes a new 2018 satellite image (Figure 6.16) showing Anak Krakatau emerging from the center of the original collapsed caldera. Similarly, the discussion on using geologic history and topographic changes to predict volcanic eruptions and hazards was largely rewritten and updated. Here a new map of Lassen Peak was added (Figure 6.30) to help illustrate how volcanic deposits can be used to assess volcanic hazards. Lastly, new and better photos were found and used to replace the existing photos in Figures 6.6B, 6.9A, 6.10, and 6.14

Chapter 7—The opening photo was replaced with a new, dramatic image of one of the numerous landslides that occurred across northern Japan during an earthquake in 2018. Perhaps the most important change was that the section on *Slope Stability* and *Triggering Mechanisms* was rewritten to more accurately describe the relationship between shear force (weight) and shear resistance (internal friction and cohesive forces)—the discussion was previously too simplified and general. Likewise, the graphics in Figures 7.4 and 7.9 were modified to reflect the updated discussion on stress relationships. A new figure was added (Figure 7.10), consisting of two oblique aerial images to help illustrate the role climate and vegetation play in slope stability. Also, the section on *Climate and Vegetation* was rewritten and expanded to more accurately reflect the

relationship between root systems and infiltrating water and how this affects slope stability. The mass wasting classification table in Figure 7.11 was modified and now includes slump movement as a separate category. In addition, the graphics in Figures 7.6, 7.7, 7.13, 7.22, and B7.4 were all modified for improved accuracy and clarity. Finally, the sinkhole photo in Figure 7.21 was replaced with a more meaningful example.

Chapter 8—In this chapter the opening photo was replaced with a dramatic image showing rescue efforts in Houston, Texas, during the 2017 flooding associated with Hurricane Harvey. This historic flooding event is also the subject of new case study that focuses on Houston's chronic flooding problems and how they have been exacerbated by land-use changes, population growth, and climate change. The graphics in Figures 8.5, 8.14, 8.15, 8.18, and B8.5 underwent modifications to improve accuracy and clarity. Table 8.2 and the plot in Figure 8.20, which shows the relationship between discharge and recurrence interval, were updated based on the most recent stream data for the Tar River in North Carolina. A new pair of satellite photos was added to Figure 8.21 to help illustrate the severity of the historic Midwestern floods of 2019. Lastly, a new figure (Figure 8.22) was added that includes a set of photos showing overland flow actively taking place during a heavy rain event.

Chapter 9—This chapter opens with a new photo showing the destruction in Mexico Beach, Florida, after taking a direct hit from Hurricane Michael in 2018. This photo also relates to a new case study about the unusual string of powerful hurricanes that made landfall in the United States in 2017 and 2018. Here the author explores the question of whether this string of hurricanes, which includes 3 of the 6 costliest hurricanes in U.S. history, can be attributed to global warming and climate change. As part of the updated section on hurricanes, a new table (Table 9.2) lists the ten most costly hurricanes in U.S. history. The map in Figure 9.20 showing hurricane recurrence intervals in the U.S. was completely revised based on more current data. There were also a number of small, but significant improvements in the chapter content, such as a more detailed discussion on how tides result from the physical movement of the Earth, Moon, and Sun. Likewise, Figure 9.4 has been modified to reflect the more accurate explanation of the tides. A new photo was added to Figure 9.6 to help illustrate the physical changes that occur when waves approach shore and begin interacting with the seafloor. A new photo was added (Figure 9.29) illustrating how buildings fall into the sea when storm waves undercut the bottom of the slope. Finally, the photos in Figures 9.12, 9.13, 9.23, and B9.2A were all replaced with more meaningful examples, and the graphics in Figures 9.10, 9.11, and 9.26A underwent modifications to improve accuracy and clarity.

Chapter 10—For this chapter, the opening photo was replaced with a new image that reinforces the chapter theme, namely, how our human food supply is inextricably linked to soils. Also, a new graphic (Figure 10.16) was added that helps illustrate the difference in permeability and drainage characteristics of clay-rich and sand-rich soils. Another new graphic (Figure 10.28) was added showing how removing natural vegetation from the landscape leads to increased overland flow and soil erosion. Lastly, the graphic in Figure 10.15 was modified to help improve clarity and student comprehension.

Chapter 11—A key graphic showing the hydrologic cycle (Figure 11.1) was modified and now includes the relative size of Earth's major water reservoirs in terms of volume percentages. Under the section on *Human Use of Freshwater*, a discussion was added on the need to prioritize water usage because of limited supplies and population growth. With respect to new graphics and photos, Figure 11.25 was added to show how freshwater can be produced from saline water using desalination techniques. Also new is Figure 11.27, which illustrates how municipalities can use treated wastewater for a variety of non-drinking purposes, thereby conserving drinking water supplies for human consumption. Related to this figure, the section on *Municipal Wastewater Recycling* was expanded and now includes a discussion on the direct and indirect reuse of treated wastewater. A new graphic was added in Figure 11.28 to help illustrate the process of aquifer storage and recovery, where surplus surface water is stored underground and then later removed during periods of high water demand. With respect to images, a new photo showing a hand-dug well was added to Figure 11.17, whereas the photos in B11.3A and 11.31B were replaced with new, more meaningful examples. Finally, the plot of U.S. water withdrawals in Figure 11.4 was updated using the most recently available data.

Chapter 12—The opening chapter photo was replaced with a better example of a spinning bucket excavator in a surface mine. The section on *Rare Earth Elements* was rewritten to better reflect their important applications in modern society. This section was also expanded to include a discussion on lithium due to its major role in the production of rechargeable batteries. A new figure (Figure 12.17) was also included with examples of modern applications of rare earth elements and lithium that students should easily recognize. Three data tables (Tables 12.1, 12.4, and 12.5) were updated based on recently released USGS mineral reports. Similarly, new data from the USGS were used to update the plots showing U.S. mineral imports (Figure 12.25) and yearly mineral consumption (Figure 12.26).

Chapter 13—A photo of a drilling platform at sunset has replaced the opening photo to emphasis that fossil fuels, which our modern way of life has been based on, represent stored sunlight that accumulated as organic matter. With respect to the chapter content, much of the narrative and several section headings have been revised to reflect new developments in the supply and demand for fossil fuels. More specifically, the boom in U.S. tight oil and gas production has increased world supply, thereby keeping prices low. This has led to natural gas replacing coal as the primary means of producing electricity in the United States. Moreover, to minimize the impacts of climate change, the world is transitioning to clean sources of energy, which when combined with the low price of natural gas has led to a sharp decline in the use of coal. Also significant is that despite the recent boom in production, oil and gas are still finite resources, which means production will eventually decline. Therefore, even though the outlook for energy supplies has improved while economies around the world are transitioning to low-carbon sources of energy, there is still the potential that crude oil production will not be able to meet future demand. Due to the undesirable economic impacts associated with oil shortages, namely, price spikes and market volatility, the author explains why it is only prudent for society to make use of conservation and renewable energy sources to ensure that oil supplies continue to meet demand. In regard to specific changes, Figure 13.1 was added with a set of photos that reinforces the concept that fossil fuels currently form the basis for modern societies. Also, a new plot in Figure 13.32 shows how the daily world demand for crude oil is projected to keep increasing to at least 2025. Figure 13.33 contains a new plot, which shows historical U.S. crude production and how production is expected to reach a plateau around 2030. Finally, the graphics in Figures 13.12 and 13.29 were modified for improved comprehension, and the graphs and charts in Figures 13.4, 13.23 through 13.27, 13.35, and 13.36 were updated using the most recently available data.

Chapter 14—The chapter narrative was revised to better reflect the current efforts of developed nations to try and minimize the impact of climate change by transitioning from fossil fuels to clean and renewable sources of energy. In addition to the overall chapter narrative, the section on *Photovoltaic Cells* was rewritten and now incorporates the significant improvements in battery technology and storage that have occurred in recent years. Similarly, the discussion on bird and bat fatalities under the *Wind Power* section was updated and expanded along with the sections on *Ocean Thermal Energy Conversion* and *Tidal Power*. Finally, the photo in Figure 14.12 was relabeled for improved clarity, and Table 14.1 and Figures 14.7, 14.13, 14.32, and 14.36 were all updated with the most recent data.

Chapter 15—A new opening photo showing municipal solid waste being compacted in a landfill illustrates the enormous amount of waste generated in modern societies. Related to this topic, a new case study on plastic pollution was added, describing the history behind plastics and the proliferation of plastic consumer products. Because plastics are so cheap to produce, we now have huge volumes of single-use plastics entering the municipal solid waste stream. Unfortunately, a significant portion of this waste ends up littering the landscape and only to get washed off into rivers and oceans. This plastic pollution is being broken down into smaller particles and entering various food webs, which is a concern as the consequences to human health is not yet well understood. In addition, the section on *Municipal and Industrial Solid Waste* was expanded with a discussion on plastic recycling. A new section, called *Highway De-Icing Salt*, was added that describes how using rock salt to keep roads free of dangerous ice during the winter has contaminated streams and subsurface aquifers with high levels of chloride. The section *Radiation Hazard* also has an expanded discussion where the author puts various radiation risks in perspective by comparing exposure levels to natural background radiation. Finally, Table 15.1 and the graphics in Figures 15.14 and 15.42 were modified for improved comprehension, photos in Figure 15.1 and 15.36 were replaced with new examples, and the graphics and plots in Figures 15.3, 15.9, 15.13, 15.15, 15.16, 15.39, and 15.41 were updated using the most recently available data.

Chapter 16—The distinction between global warming and climate change was more clearly defined in the introduction, and greater care was taken throughout the chapter to use these terms in the appropriate manner. In addition to numerous minor updates that made the text more current, the latest temperature and sea-level rise projections by international scientists were used throughout the text. The section on *Strategy for Reducing Emissions* was expanded and now includes the decisions by the Trump Administration to withdraw from the Paris Climate Agreement and to replace the EPA's Clean Power Plan for reducing CO2 emissions. With respect to changes in the art and photos, a new NASA graphic was used in Figure 16.5 that shows how Earth's global average temperature has been rising sharply since 1960, whereas solar output from the Sun has remained fairly steady. Also new is a photo of a wildfire in Figure 16.28 and a new ocean acidification graphic in Figure 16.38, which shows atmospheric CO2 concentrations over time plotted along with dissolved ocean CO2 and pH. Lastly, Table 16.1 and Figures 16.2, 16.13, 16.14, 16.25, 16.26, 16.37, 16.39, and 16.40 were all updated using the most recently available data.

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