

Student Study Guide

to accompany

Fifth Edition

Environmental GEOLOGY



Carla W. Montgomery

Prepared by
Steven D. Carey

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Environmental Geology

Fifth Edition

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Boston, Massachusetts Burr Ridge, Illinois Dubuque, Iowa
Madison, Wisconsin New York, New York San Francisco, California St. Louis, Missouri

WCB/McGraw-Hill

A Division of The McGraw-Hill Companies

Student Study Guide to accompany
ENVIRONMENTAL GEOLOGY, FIFTH EDITION

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Carla W. Montgomery

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3 4 5 7 8 9 0 QPD QPD 0

ISBN 0-697-34282-4

<http://www.mhhe.com>

INTRODUCTION

This study guide was written to assist the student using the textbook Environmental Geology, fifth edition, by Carla W. Montgomery. The objectives of this guide are to familiarize you with the main ideas and concepts of environmental geology and to test your comprehension of these ideas and concepts prior to examination. In addition to working the exercises in this guide, you are encouraged to pay careful attention to the review questions at the end of each chapter in Environmental Geology. The questions in this guide are designed to supplement, not supplant, the essay-type questions in your text.

The chapters in the study guide are keyed to the chapters in Environmental Geology and are organized as follows: Each chapter begins with an overview of the important concepts followed by a listing of the key terms. Following the key terms are batteries of multiple choice, fill in the blank, and true or false questions. In some chapters, matching questions follow the true or false questions. All of the questions are based on material presented in the body of the parent text, or on the information included in the figures, boxes, and/or tables that accompany each chapter. The page number(s) in the text, or a reference to a figure, box, or table, that relates to a specific question appears in parenthesis with each multiple choice and fill in the blank question. Similarly, page numbers are also included with the key terms and indicate where each term is first defined. The true or false questions ask you to determine not only if a statement is true or false, but to also correct a false statement to make it true. The answers to all questions are found in the answer key at the end of each chapter in the guide.

New to this edition of the Study Guide is the addition of internet sites at the end of the question batteries of each chapter. I have tried to include interesting and informative sites that compliment and enhance the text material without duplicating the internet sites given in the text.

A special feature of this guide is the inclusion of six crossword puzzles (all new with this edition of the Study Guide) whose clues review the key terms and concepts presented in each of the six sections in Environmental Geology. The Section 6 Crossword also includes important terms from Appendices A and B.

I want to express my sincere appreciation to the individuals who assisted in the preparation of this edition of the study guide. Lucy Carey did some light editing of the draft manuscript. I should also thank Darryl Bruflodt, Associate Editor with WCB/McGraw-Hill for his assistance and patience during the preparation of this study guide.

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CHAPTER 1—AN OVERVIEW OF OUR PLANETARY ENVIRONMENT

Important Concepts

1. Most astronomers believe that the universe originated in a “Big Bang” about 15 to 20 billion years ago.
2. The solar system formed from a rotating cloud of gas and dust starting about 5 billion years ago.
3. The planets of the solar system differ in their compositions as a function of their distance from the sun. The compositions of most of the planets are quite different from that of the earth.
4. The early earth, which lacked oceans and an atmosphere, was heated by three sources:
 - Impact of colliding particles.
 - Compression of the interior by gravity.
 - Decay of radioactive elements.
5. The melting and subsequent cooling of the earth resulted in the formation of three main compositional zones:
 - A high-density, central core.
 - The mantle, composed mainly of iron, magnesium, silicon, and oxygen.
 - A low-density crust composed mainly of oxygen and silicon.
6. The heating and cooling of the early earth led to the formation of the atmosphere and the oceans. The early atmosphere lacked free oxygen and probably consisted of nitrogen, carbon dioxide, methane, ammonia, and various sulfur gases. The photosynthetic activity of primitive plantlike organisms released free oxygen into the atmosphere.
7. The first multicellular oxygen-breathing organisms appeared on earth about 1 billion years ago; the first modern humans about half a million years ago.
8. Geology is a quantitative and interdisciplinary science that seeks to explain geologic phenomena and provide solutions to problems posed by geologic hazards.
9. The earth is a changing, dynamic planet. Many geological and chemical processes are interrelated and cyclic in nature.

10. Human activities cause or accelerate permanent changes in natural systems. The impact of these activities is broadly proportional to the size of the population and the level of technological development.
11. The world's population is predicted to exceed 6 billion by the year 2000 and reach about 10 billion the year 2050. Global population may be on the verge of exceeding the earth's carrying capacity.
12. Extraterrestrial colonization is not a practical solution to global overpopulation.

Key Terms

carrying capacity (16)

core (6)

crust (6)

doubling time (13)

exponential growth (13)

hypothesis (8)

mantle (6)

scientific method (8)

theory (9)

Multiple Choice

1. Most astronomers believe that the universe (3)
 - a. has existed in its present state since the beginning of time.
 - b. formed from a huge rotating cloud of gas.
 - c. came into existence as the result of a "Big Bang."
 - d. is no more than 5 billion years old.
2. Most of the mass of the solar system is concentrated in (3)
 - a. Jupiter and Saturn.
 - b. Earth.
 - c. the planets.
 - d. the sun.
3. The solar system formed about (3)
 - a. 5 million years ago.
 - b. 4.5 billion years ago.
 - c. 10 billion years ago.
 - d. 15 to 20 billion years ago.
4. The planet closest to the sun is (table 1.1, p. 4)
 - a. Venus.
 - b. Mars.
 - c. Mercury.
 - d. Earth.

5. Which one of the following planets most closely resembles Earth in size? (table 1.1, p. 4)
 - a. Mercury
 - b. Mars
 - c. Pluto
 - d. Venus
6. A planet whose density reflects a significant iron content and relatively little gas is (table 1.1, p. 4)
 - a. Neptune.
 - b. Jupiter.
 - c. Venus.
 - d. Saturn.
7. A planet having ice caps composed of carbon dioxide ice is (figure 1.2, p. 5)
 - a. Earth.
 - b. Mars.
 - c. Mercury.
 - d. Jupiter.
8. Which one of the following heat sources did not contribute to the melting of the primitive earth? (6)
 - a. radioactive decay
 - b. gravitational compression of the earth's interior
 - c. collisions of infalling particles
 - d. heat energy radiated by the sun
9. Continental crust differs from oceanic crust in that it (figure 1.3, p. 6)
 - a. has a composition more like that of the mantle.
 - b. is denser than oceanic crust.
 - c. is thinner than oceanic crust.
 - d. contains more light minerals than oceanic crust.
10. Of the earth's major compositional zones, the largest is the (figure 1.3, p. 6)
 - a. inner core.
 - b. outer core.
 - c. mantle.
 - d. crust.
11. The earth's outer core is (figure 1.3, p. 6)
 - a. solid.
 - b. semisolid.
 - c. liquid.
 - d. gaseous.

12. The earth's core is composed mostly of (6)
- iron.
 - silicon.
 - nickel.
 - magnesium.
13. The three most abundant elements in the earth's crust are oxygen, silicon, and (table 1.2, p. 6)
- iron.
 - magnesium.
 - calcium.
 - aluminum.
14. Earth's early atmosphere (6)
- was similar in composition to today's atmosphere.
 - consisted mainly of sulfur gases.
 - consisted mainly of methane and ammonia.
 - contained little or no oxygen.
15. There are few fossils of the earth's earliest living organisms because (7)
- most of the rocks containing these fossils have been destroyed by various geologic processes.
 - most of the rocks containing these fossils are deeply buried beneath younger strata and are not available for examination.
 - most early life lived in the sea thus making their fossils difficult to locate.
 - the earliest living organisms were soft-bodied and thus did not preserve well as fossils.
16. Of the following eras of geologic time, the correct sequence from oldest to youngest is (figure 1.4, p. 7)
- Cenozoic, Paleozoic, Mesozoic.
 - Cenozoic, Mesozoic, Paleozoic.
 - Mesozoic, Paleozoic, Cenozoic.
 - Paleozoic, Mesozoic, Cenozoic.
17. A scientific theory (9)
- is proven beyond doubt and is never subjected to revision.
 - is an untested trial answer to a scientific question.
 - represents a "common sense" explanation of a natural phenomenon that cannot be tested in a laboratory.
 - may be modified or completely discarded if it fails to explain new kinds of data or observations.

18. Which one of the following regions of the world had the highest average growth rate (%/yr) between 1990 and 1995? (table 1.4, p. 13)
- Europe
 - South America
 - Africa
 - Asia
19. North and Central America is projected to contain _____ percent of the world's population by the year 2025. (figure 1.14, p. 13)
- 8.9
 - 6.0
 - 7.4
 - 4.1
20. The term "carrying capacity" refers to (16)
- the maximum number of people a spacecraft can transport to another planet.
 - the ability of the earth to sustain its population in reasonably healthy and comfortable conditions.
 - the maximum number of people that could inhabit the earth.
 - the maximum amount of food one acre of farmland can produce without the use of fertilizers and mechanized equipment.

Fill in the Blanks

- Each planet of the solar system is believed to have formed from an accumulation of dust and gas drawn together by _____. (3)
- The planet having the largest diameter relative to earth is _____. (table 1.1, p. 4)
- The name of the process by which simple plantlike organisms introduced free oxygen into the earth's atmosphere is called _____. (6)
- The dinosaurs appeared about _____ million years ago. (7)
- The means of discovering basic scientific principles is called the _____
_____. (8)
- Food, unlike minerals or land, is considered to be a _____ resource. (16)

7. On a global scale, the human population increases when its birthrate exceeds its _____ rate. (12)
8. _____ growth occurs when the number of individuals added per unit of time increases over time. (13)
9. _____ time is the length of time required for a population to double in size. (13)
10. The average worldwide population growth rate is about _____ percent per year. (14)

True or False

Indicate if the following statements are true or false. If false, correct the statement to make it true.

- _____ 1. According to most theories of the formation of the solar system, the sun formed independently from the planets, and the planets were later captured by the sun's gravitational field.
- _____ 2. The composition of a planet within the solar system is largely a function of its distance from the sun.
- _____ 3. Earth is unique among the planets of the solar system in having an abundance of surface water.
- _____ 4. The first mammals appeared on earth approximately 75 million years ago.
- _____ 5. The emphasis of geology today is on the observation and description of natural processes.

- _____ 6. A hypothesis is a generally accepted explanation for a set of data or observations.
- _____ 7. About 100 million tons of waste is generated in the United States per year.
- _____ 8. The country having the highest per capita consumption of most mineral and energy resources is the United States.
- _____ 9. Concern over human disruption of natural systems is largely unjustified since natural phenomena such as severe storms, volcanoes, and earthquakes disrupt natural systems to a greater extent than do man's activities.
- _____ 10. Every hour, the world population increases by 1500 people.

Surfing the Net

For an excellent overview of the solar system, including its origins, see
<http://seds.lpl.arizona.edu/nineplanets/nineplanets/overview.html>

An instantaneous reading of global population and world population information is found at The World Population Clock—
<http://www.census.gov/cgi-bin/ipc/popclockw>

An instantaneous reading of the population of the United States is found at The U.S. Population Clock—
<http://www.census.gov/cig-bin/popclock>

CHAPTER 1 ANSWER KEY

Multiple Choice

1. c 2. d 3. b 4. c 5. d 6. c 7. b 8. d 9. d 10. c 11. c 12. a 13. d 14. d 15. d 16. d
17. d 18. c 19. c 20. b

Fill in the Blanks

1. gravity
2. Jupiter
3. photosynthesis
4. 200
5. scientific method
6. renewable
7. death
8. exponential
9. doubling
10. 1.6

True or False

1. False. The sun and the planets formed together from a single rotating cloud of gas. (see p. 3)
2. True
3. True
4. False. Mammals first appeared on earth approximately 200 million years ago. (see p. 7)
5. False. Rather than merely describing natural processes, the modern science of geology seeks to explain how natural processes operate. (see p. 8)
6. False. A hypothesis is a tentative explanation for a set of observations or data. A hypothesis that is repeatedly supported by experimentation may be elevated to the status of a theory, which is a generally accepted explanation for a set of observations or data. (see p. 8)
7. False. About 300 million tons of waste is generated in the United States per year. (see p. 10)
8. True
9. False. Natural systems tend toward a balance among opposing forces, whereas human activities tend to cause or accelerate permanent changes in natural systems. (see p. 18)
10. False. Every hour, the world population increases by more than 10,000 people! (see p. 19)

CHAPTER 2—ROCKS AND MINERALS — A FIRST LOOK

Important Concepts

1. An atom is the smallest possible unit of an element and consists of a central nucleus and one or more negatively charged electrons in orbit about the nucleus. The nucleus consists of one or more positively charged protons and usually some electrically neutral particles called neutrons.
2. Isotopes are atoms of a given element that differ in the number of neutrons in their nuclei.
3. Ions are atoms that have lost or gained electrons. An atom that loses electrons becomes positively charged and is called a cation. An atom that gains electrons becomes negatively charged and is called an anion.
4. A compound is a chemical combination of two or more elements in specific proportions, and has a distinct set of physical properties.
5. Minerals are naturally occurring, inorganic, solid elements or compounds having definite chemical compositions and a regular internal crystal structure.
6. Physical properties of minerals include color, hardness (ability to resist scratching), density (mass per unit volume), and cleavage (tendency to split along certain planes).
7. Minerals can be classified into two broad groups: the silicates and the nonsilicates. Silicates are compounds of silicon and oxygen, usually with other elements as well. Examples of silicates include quartz, the feldspars, the ferromagnesian minerals, and the clay minerals. Nonsilicates are a diverse group of minerals including the carbonates, sulfates, sulfides, oxides, hydroxides, halides, and native elements.
8. Rocks are cohesive solids formed from one or more minerals. There are three categories of rocks:
 - Igneous rocks are formed by the solidification and crystallization of a cooling magma. Plutonic igneous rocks form from magmas that cool slowly at depth and are typically coarse-grained. Volcanic igneous rocks form at or near the earth's surface, and their rapid cooling and solidification usually results in fine-grained textures.

- Sedimentary rocks are formed from sediments at low temperatures. Clastic sedimentary rocks are formed from fragments of preexisting rocks; examples include sandstone, shale, and conglomerate. Chemical sedimentary rocks are formed by direct precipitation from solution; examples include limestone and rock salt.
- Metamorphic rocks are formed from other, preexisting rocks that were subjected to heat and/or pressure. Examples include marble, quartzite, slate, schist, and gneiss.

9. All rocks are transformed over time into new rocks through various geologic processes. This is known as the rock cycle.

Key Terms

| | |
|--------------------------------|----------------------------|
| anion (27) | lithification (35) |
| atom (25) | magma (34) |
| atomic mass number (25) | metamorphic (37) |
| atomic number (25) | mineral (27) |
| carbonate (32) | native element (33) |
| cation (27) | neutron (25) |
| chemical sedimentary rock (36) | nucleus (25) |
| clastic sedimentary rock (35) | oxide (33) |
| compound (27) | periodic table (26) |
| contact metamorphism (37) | plutonic (34) |
| covalent bonding (27) | proton (25) |
| crystalline (27) | regional metamorphism (37) |
| electron (25) | rock (34) |
| ferromagnesian (32) | rock cycle (34) |
| foliation (37) | sediment (35) |
| glass (35) | sedimentary (35) |
| igneous (34) | silicate (31) |
| ion (27) | sulfate (32) |
| ionic bonding (27) | sulfide (32) |
| isotope (25) | volcanic (35) |
| lava (35) | |

Multiple Choice

1. The number of naturally occurring chemical elements is approximately (25)
 - a. 36.
 - b. 90.
 - c. 106.
 - d. 200.
2. Electrons are (25)
 - a. found within atomic nuclei.
 - b. electrically neutral.
 - c. positively charged.
 - d. negatively charged.
3. An element's chemical identity is determined by its (25)
 - a. number of isotopes.
 - b. atomic number.
 - c. number of neutrons.
 - d. atomic mass number.
4. Isotopes of the same element (25)
 - a. differ in atomic number.
 - b. have different atomic mass numbers.
 - c. differ in their number of electrons.
 - d. differ in their chemical behavior.
5. The Russian scientist Dmitri Mendeleev (box 2.1, p. 26)
 - a. proved that matter is composed of atoms.
 - b. published the first periodic table.
 - c. showed that atoms of the same element can differ in their number of neutrons.
 - d. was the first to verify the existence of electrons.
6. The inert gases (box 2.1, p. 26)
 - a. tend to form cations of +1 charge.
 - b. tend to form anions of -1 charge.
 - c. contain one electron in the outermost shells.
 - d. contain fully filled electron shells.
7. Elements whose atoms lack only one electron in their outermost shells (box 2.1, p. 26)
 - a. are halogens.
 - b. are alkali metals.
 - c. are chemically inert.
 - d. occupy the right-hand (last) column of the periodic table.

8. An atom of a certain isotope of carbon has 6 protons, 6 electrons, and 8 neutrons. Its atomic mass number is (27)
- 6.
 - 12.
 - 14.
 - 20.
9. In an electrically neutral atom (27)
- electrons and protons have no charge.
 - the electron shells are completely filled.
 - the number of protons and the number of electrons are the same.
 - the number of neutrons is equal to the sum of the number of protons and electrons.
10. Ionic bonding occurs when (27)
- atoms share electrons.
 - ions share electrons.
 - atomic nuclei gain or lose protons.
 - oppositely charged ions attract each other.
11. All of the following statements are correct concerning minerals except (27)
- minerals are crystalline solids
 - some minerals are produced by biological processes
 - minerals are naturally occurring substances
 - minerals exist as elements or compounds
12. The two fundamental characteristics that distinguish a mineral from all other minerals are its (27)
- color and hardness.
 - hardness and cleavage.
 - composition and crystal structure.
 - density and shape.
13. Which one of the following compounds contains three elements and six atoms? (box 2.2, p. 28)
- CaCO_3
 - Na_2SO_4
 - PbSO_4
 - Fe_2O_3