

***Foundations of Earth Science, 8e (Lutgens/Tarbuck/Tasa)***  
**Chapter 2 Rocks: Materials of the Solid Earth**

2.1 Multiple-Choice Questions

- 1) An igneous rock that shows a vesicular texture \_\_\_\_\_.
- A) contains many small holes, like Swiss cheese
  - B) must be intrusive
  - C) must be coarse grained
  - D) appears glassy

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

- 2) An igneous rock that cools rapidly is likely to have \_\_\_\_\_ crystals.
- A) small
  - B) medium-sized
  - C) large
  - D) pink

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

- 3) Which one of the following is an igneous rock?
- A) limestone
  - B) rhyolite
  - C) slate
  - D) quartz

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 1.3 Earth science investigations take many different forms.

4) Which one of the following is a sedimentary rock?

- A) limestone
- B) rhyolite
- C) slate
- D) quartz

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

5) Which one of the following is a metamorphic rock?

- A) limestone
- B) rhyolite
- C) slate
- D) quartz

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.

6) Rocks that contain crystals that are roughly equal in size and can be identified with the unaided eye are said to exhibit a \_\_\_\_\_ texture.

- A) fine-grained
- B) coarse-grained
- C) glassy
- D) porphyritic

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

7) Magma that might have cooled slowly to produce a diorite is instead erupted at Earth's surface. It would chill rapidly and produce a(n) \_\_\_\_\_.

- A) rhyolite
- B) andesite
- C) basalt
- D) granite

Answer: B

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

8) Which igneous texture is characterized by two distinctively different crystal sizes?

- A) fine-grained
- B) coarse-grained
- C) glassy
- D) porphyritic

Answer: D

Diff: 1

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

9) Granite is \_\_\_\_\_.

- A) fine-grained and dominated olivine, pyroxene and plagioclase feldspar crystals
- B) coarse-grained and dominated by quartz and feldspar crystals
- C) coarse-grained and dominated by olivine, pyroxene and plagioclase feldspar crystals
- D) fine-grained and dominated by quartz and feldspar crystals

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

10) To transform an igneous rock into a sedimentary rock, which of the following processes must take place?

- A) melting and recooling, followed by crystallization
- B) chemical reactions under conditions of elevated temperature or pressure
- C) weathering, transport, deposition, and lithification
- D) impact by a meteorite

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.1 Earth as a System: The Rock Cycle

Focus/Concepts: 2.1

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

11) Chemical weathering would be most effective \_\_\_\_\_.

- A) in a warm, wet climate
- B) in a cold, dry climate
- C) in a warm, dry climate
- D) deep beneath a mountain range

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

12) A crystal of potassium feldspar ( $\text{KAlSi}_3\text{O}_8$ ) will produce a variety of weathering products after it is weathered. Which of the following is **not** a product that results from the weathering of potassium feldspar?

- A) silica
- B) potassium ions
- C) clay minerals
- D) iron oxides

Answer: D

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 1.3 Earth science investigations take many different forms.

13) \_\_\_\_\_ is a weak acid that reacts to the mineral calcite.

- A) Carbonic acid
- B) Nitric acid
- C) Sulfuric acid
- D) Acetic acid

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 1.3 Earth science investigations take many different forms.

14) Which kind of rocks may contain fossils?

- A) igneous
- B) sedimentary
- C) metamorphic
- D) minerals

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 1.3 Earth science investigations take many different forms.

15) Most rock outcrops (about 75% of the total) are \_\_\_\_\_.

- A) igneous
- B) sedimentary
- C) metamorphic
- D) fossil-bearing

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

16) Detrital sedimentary rocks are classified and named principally on the basis of \_\_\_\_\_.

- A) grain size
- B) location
- C) rock color
- D) composition

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

17) Which rock type is most likely to have been deposited in a high-energy environment (such as a very turbulent stream)?

- A) conglomerate
- B) shale
- C) chert
- D) microcrystalline limestone

Answer: A

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

18) The skeletal remains of plankton make up the sedimentary rock \_\_\_\_\_.

- A) flint
- B) breccia
- C) travertine
- D) chalk

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

19) Which of the following rock types represents the highest grade of metamorphism?

- A) slate
- B) phyllite
- C) schist
- D) gneiss

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.

20) Regional metamorphism occurs during \_\_\_\_\_.

- A) intrusion of magma
- B) mountain building
- C) sheeting of exposed plutons of granite
- D) chemical weathering of limestone in caves

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.

21) Limestone is dominated by the mineral \_\_\_\_\_.

- A) quartz
- B) calcite
- C) gypsum
- D) hematite

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

22) Which of the following is the parent rock of marble?

- A) sandstone
- B) basalt
- C) granite
- D) limestone

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

23) Coal primarily comprises \_\_\_\_\_.

- A) rocks
- B) crystals
- C) inorganic matter
- D) organic matter

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

24) Mud cracks and ripple marks are common features of \_\_\_\_\_.

- A) sedimentary rocks
- B) igneous rocks
- C) metamorphic rocks
- D) minerals

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 2.1 Earth's rocks and other materials provide a record of its history.



25) \_\_\_\_\_ and \_\_\_\_\_ are the most common forms of lithification.

- A) Fossilization; fragmentation
- B) Partial melting; decompression melting
- C) Compaction; cementation
- D) Weathering; erosion

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

26) Which of the following is a nonfoliated metamorphic rock?

- A) conglomerate
- B) marble
- C) gneiss
- D) slate

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.

27) Granite and gabbro have a similar \_\_\_\_\_.

- A) composition
- B) coarse-grained texture
- C) fine-grained texture
- D) vesicular appearance

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 1.3 Earth science investigations take many different forms.

28) Obsidian is characterized by its \_\_\_\_\_ texture.

- A) coarse-grained
- B) fine-grained
- C) vesicular
- D) glassy

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 1.3 Earth science investigations take many different forms.

29) \_\_\_\_\_ is formed when carbon dioxide dissolves in rainwater, and this mildly reactive substance aids chemical weathering.

- A) Carbonic acid
- B) Hydrochloric acid
- C) Clay
- D) Limestone

Answer: A

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

30) Before sedimentary rock can be formed, sediment must be produced (weathered from preexisting rocks), transported, deposited, and \_\_\_\_\_.

- A) eroded
- B) melted
- C) lithified
- D) dissolved

Answer: C

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

31) In contact metamorphism, \_\_\_\_\_ is the dominant agent of change.

- A) acid
- B) water
- C) pressure
- D) heat

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 3.7 Changes in part of one system can cause new changes to that system or to other systems, often in surprising and complex ways.

32) The rock \_\_\_\_\_ is a description of how one rock may be transformed into another kind of rock through various internal and external processes.

- A) formation
- B) chart
- C) cycle
- D) group

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.1 Earth as a System: The Rock Cycle

Focus/Concepts: 2.1

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

33) A detrital sedimentary rock dominated by sand is a \_\_\_\_\_.

- A) limestone
- B) conglomerate
- C) siltstone
- D) sandstone

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

34) Which of the following is a chemical sedimentary rock?

- A) travertine
- B) coquina
- C) coal
- D) sandstone

Answer: A

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

35) Layers in sedimentary rocks are called \_\_\_\_\_.

- A) foliation
- B) deposits
- C) beds
- D) striations

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

36) A detrital sedimentary rock with large angular fragments is called a(n) \_\_\_\_\_.

- A) shale
- B) conglomerate
- C) arkose sandstone
- D) breccia

Answer: D

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 1.3 Earth science investigations take many different forms.

37) Rock salt and rock gypsum are examples of \_\_\_\_\_ sedimentary rocks.

- A) biochemical
- B) chemical
- C) organic
- D) detrital

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 1.3 Earth science investigations take many different forms.

38) Exfoliation domes are formed from which of the following processes?

- A) sheeting
- B) oxidation
- C) melting
- D) metamorphism

Answer: A

Diff: 2

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 1.3 Earth science investigations take many different forms.

39) Which of the following is not an agent of metamorphism?

- A) differential stress
- B) dissolution
- C) heat
- D) confining pressure

Answer: B

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 3.7 Changes in part of one system can cause new changes to that system or to other systems, often in surprising and complex ways.



## 2.2 Matching Questions

***Match the following items with the correct descriptions.***

- A) Reactions that take place, often facilitated by water, to create new products, mainly clay minerals, which are stable at Earth's surface
- B) A substance that forms when carbon dioxide in the air combines with water. It is an important agent of chemical weathering.
- C) When water freezes, it expands in volume. Water-filled cracks can be enlarged when this new ice exerts outward pressure on the walls of the fracture.
- D) The reaction of a substance (often a metal ion) with oxygen. Rust is an example.
- E) Pressure that is equal in every direction, such as results from the burial of sediments.
- F) The expansion of rocks that formed under high confining pressure, once they are uplifted and exposed at Earth's surface produce fractures that are broadly curved and parallel to the land surface.
- G) Pressure that is unequal in different directions, such as results from the convergence of tectonic plates (mountain-building).
- H) The breaking of rock into smaller pieces.

### 1) Differential stress

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

### 2) Confining pressure

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

### 3) Frost wedging

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

4) Sheeting

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

5) Oxidation

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

6) Carbonic acid

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

7) Mechanical weathering

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

8) Chemical weathering

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 3.6 Earth's systems are dynamic; they continually react to changing influences.

Answers: 1) G 2) E 3) C 4) F 5) D 6) B 7) H 8) A



***Match the corresponding characteristics with the correct igneous rock.***

- A) coarse-grained, mafic composition
- B) glassy texture
- C) ultramafic composition
- D) vesicular texture
- E) coarse-grained, felsic composition
- F) fine-grained, felsic composition
- G) intermediate composition
- H) fine-grained, mafic composition

9) Obsidian

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

10) Granite

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

11) Basalt

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

12) Pumice

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

13) Peridotite

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

14) Rhyolite

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

15) Diorite

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

16) Gabbro

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

Answers: 9) B 10) E 11) H 12) D 13) C 14) F 15) G 16) A

***Match the textural term to the correct rock.***

- A) nonfoliated rock with large calcite crystals
- B) coarse-grained rock containing plagioclase, quartz, potassium feldspar, and hornblende
- C) biochemical rock comprising shells made from calcite
- D) pyroclastic rock with particles less than 4 mm in diameter
- E) coarse-grained rock with large angular particles cemented with mud
- F) foliated rock exhibiting banding

17) Marble

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

18) Breccia

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

19) Tuff

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

20) Granite

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

21) Coquina

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

22) Gneiss

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

Answers: 17) A 18) E 19) D 20) B 21) C 22) F

### 2.3 Essay Questions

1) Discuss how the following variables influence the rate of weathering: mineral content, climate, and topography.

Answer: More stable minerals, like quartz, are more resistant to weathering. Minerals that are less stable (less at equilibrium at Earth surface conditions) are less resistant to weathering; they fall apart more rapidly. Hence a tombstone made of granite will last longer than a tombstone made of marble ... or worse, rock salt. Warmer, wetter climates encourage weathering, as water helps facilitate chemical reactions like dissolution, oxidation, and hydrolysis, and more heat means more energy to drive those reactions. Steeper slopes are more likely to shed any sediment produced, meaning that physical weathering will dominate over chemical weathering. Shallower slopes tend to see less movement of the sediment that results from weathering, resulting in thick sections of "rotted" (chemically weathered) bedrock. The student could refer to Bowen's Reaction Series and discuss how silica content affects the surface stability of rocks.

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

2) What is the source of energy that transforms igneous rocks into sedimentary rocks? What is the source of energy that transforms sedimentary rocks into metamorphic rocks? What is the source of energy that transforms metamorphic rocks into igneous rocks? Are these sources of energy internal or external? Explain.

Answer: Sedimentary rocks result from external processes, including weathering, transport, and deposition. The energy to break down and move sediment comes ultimately from the sun. To get rocks to a place where they can be weathered, energy from plate tectonics must also be involved. Igneous rocks are certainly related to internal heat and plate tectonics; metamorphic rocks are also more internal-process related. A sedimentary rock that is going to be transformed into an igneous rock by melting will most likely first metamorphose as it warms up. So, metamorphic and igneous rocks form as a result of Earth's internal energy, the same energy that drives plate tectonics. The surface processes that generate, move, and dump sediments are ultimately driven by solar energy.

Diff: 3

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

3) Why would intrusive rocks chemically weather more quickly than extrusive rocks? Why would mafic rocks chemically weather more easily than felsic rocks?

Answer: There are several reasons that intrusive rocks would chemically weather more quickly than extrusive rocks. The place they form is the first reason: by definition, extrusive igneous rocks form at Earth's surface, which is also where weathering happens. For intrusive igneous rocks to experience weathering at Earth's surface, they must first go through an additional step: uplift sufficient to cause exposure. Second is the issue of grain size. Minerals weather from the outside in. Smaller mineral grains have a greater amount of surface per unit of volume, while relatively coarse crystals in plutons have less reactive surface area. Basaltic (mafic) rocks have a greater proportion of dark silicate minerals, which are enriched in the elements iron and magnesium, both of which are susceptible to oxidation. Felsic rocks have a higher proportion of quartz, which is stable at Earth surface conditions. The higher the temperature of formation of the minerals in the rock, the quicker that rock will weather and breakdown. If you look at Bowen's, the higher the temperature regime, the order is predicted in this sequence.

Diff: 3

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

4) Consider the history of a single crystal of quartz. Describe how could this quartz grain could (a) form in a granite, (b) become incorporated into a sandstone, and (c) be transformed into a quartzite? Explain the processes which act on the quartz crystal and the transformations it experiences. Detail the processes which would take place along each portion of this journey.

Answer: The quartz crystal would originally form from magma, cooling deep in Earth's interior. Because it's part of an intrusion of magma, it cools slowly, so there's plenty of time to grow a nice coarse quartz crystal. It forms last among the minerals in the crystallizing magma, as predicted in Bowen's reaction series. Because of the felsic composition and the coarse grain size, the rock that this quartz (mineral) grain is part of would be referred to as a granite. Once solidified, time goes by, and the granite is uplifted towards the surface. When it gets to the surface, it is attacked by chemical and mechanical weathering. Sheetting occurs, and carbonic acid in rainwater helps to break down the quartz's neighboring feldspars. The few dark silicate minerals in the granite are oxidized. One day, in a big storm, the quartz crystal breaks free and is tumbled down a small stream along with a bunch of clay minerals. The small stream feeds into a big river, and the quartz grain eventually is transported to the ocean. There, it is deposited on a beach full of similar sand-sized grains of quartz. Over geologic time, these sand layers are buried and subjected to confining pressure, and they become lithified to form a sandstone. A new intrusion of magma occurs nearby, and the sandstone is "cooked" by its heat. The small quartz grains recrystallize, fusing together and forming large, equidimensional grains that are randomly oriented. It is now a quartzite, a metamorphic rock.

Diff: 3

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

5) Olivine is often found in ultramafic and mafic igneous rocks, but not felsic. Explain why you wouldn't expect to find olivine form inside a granite or rhyolite.

Answer: Olivine is seldom found in felsic rocks because granite/rhyolite crystallizes at a much lower temperature than olivine. Olivine is the first mineral to crystallize when a body of magma begins to cool therefore all of the olivine would have crystallized to form peridotite. Olivine forms in a higher temperature regime than granite, refer to Bowen's Reaction Series.

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

6) Consider a sample of porphyritic andesite, which is common in Pacific Rim volcanoes. Speculate how this sample may have formed (simply defining porphyritic isn't enough, be specific).

Answer: The formation of porphyritic igneous rocks typically involves a two-stage cooling process. Deep inside the volcano the minerals that form andesite begin to crystallize. As the volcano erupts, the liquid portion of the lava cools rapidly, inhibiting mineral growth and thus creating two crystal sizes within the groundmass. Hornblende is a typical phenocryst for andesite.

Diff: 3

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

7) Both sedimentary and metamorphic rocks exhibit layering. Explain how the layers develop for each rock type and give the name for the layering.

Answer: Sedimentary rocks form layers through deposition. The sediment is compacted and cemented (lithified) to create a sedimentary rock. This type of layering is called *bedding*. Metamorphic rocks may develop layers when differential stress is applied to the rock. The minerals become reoriented and realigned at right angles to the stress. This type of layering is called *foliation*.

Diff: 3

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G7

Section: 2.1 Earth as a System: The Rock Cycle

Focus/Concepts: 2.1

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

8) Discuss the differences between contact and regional metamorphism.

Answer: Contact metamorphism occurs when a rock is intruded by magma. The heat alters the form of the rock while remaining a solid, causing a metamorphic reaction. Regional metamorphism occurs during mountain building events when large quantities of rock are subjected to intense pressure and high temperatures.

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G2

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.

9) Compare and contrast a high-energy environment to a low-energy environment. For each environment, cite an example of a common rock type and assess how it may form.

Answer: High-energy environments typically occur in fast-moving water, such as a rushing stream or river with high discharge. Common rock types in high-energy environments include breccia and conglomerate, where sediment is lithified. Low-energy environments form in organically rich sediments or areas where water is stagnant or barely moving, such as an ocean basin. Coal and black shale form from the compaction of organic debris and fine-grained muds, respectively.

Diff: 4

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G7

Section: 2.4 Sedimentary Rocks: Compacted and Cemented Sediment

Focus/Concepts: 2.4

ESLI: 4.8 Weathered and unstable rock materials erode from some parts of Earth's surface and are deposited in others.

10) Quartzite and marble are nonfoliated metamorphic rocks with similar appearances, which often confuse introductory geology students. Devise an experiment to differentiate between these two samples.

Answer: Quartzite often forms from quartz sandstone and contains the mineral quartz, which would scratch a glass plate. Marble contains the mineral calcite, which has a hardness of 3 and reacts with hydrochloric acid. Quartzite would also scratch marble.

Diff: 4

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G9

Section: 2.5 Metamorphic Rocks: New Rock from Old

Focus/Concepts: 2.5

ESLI: 1.3 Earth science investigations take many different forms.



## 2.4 Visual Questions

1) Examine the rock sample here. Did it form at or below Earth's surface? How do you know?



- A) It formed at the surface, because of its color (composition).
- B) It formed at the surface, because of its texture (grain size).
- C) It formed below the surface, because of its color (composition).
- D) It formed below the surface, because of its texture (grain size).

Answer: D

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

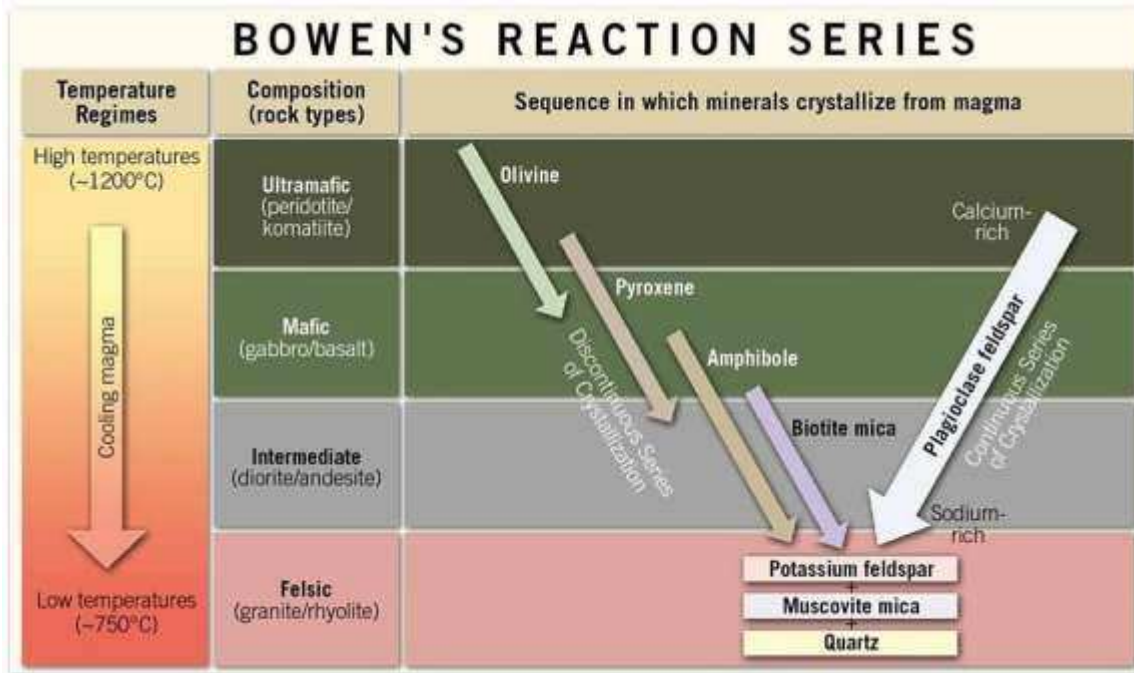
Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

2) In general, which of the statements below best describes what happens in terms of composition as crystallization proceeds down the Bowen's reaction series (shown in the figure)?



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- A) The early-formed silicates are enriched in iron and magnesium, resulting in such rocks as andesite and granite. As crystallization proceeds, the later-formed silicates are enriched in sodium, potassium, and silicon, resulting in and basalt.
- B) The early-formed carbonates are enriched in calcium and carbonate, resulting in such rocks as limestone. As crystallization proceeds, the later-formed carbonates are enriched in fossils, resulting in fossiliferous limestone and coquina.
- C) The early-formed silicates are enriched in iron and magnesium, resulting in such rocks as peridotite and basalt. As crystallization proceeds, the later-formed silicates are enriched in sodium, potassium, and silicon, resulting in andesite and granite.
- D) The early-formed silicates are enriched in sodium, potassium, and silicon, resulting in such rocks as peridotite and basalt. As crystallization proceeds, the later-formed silicates are enriched in iron and magnesium, resulting in andesite and granite.

Answer: C

Diff: 2

Bloom's Taxonomy: Remembering/Understanding

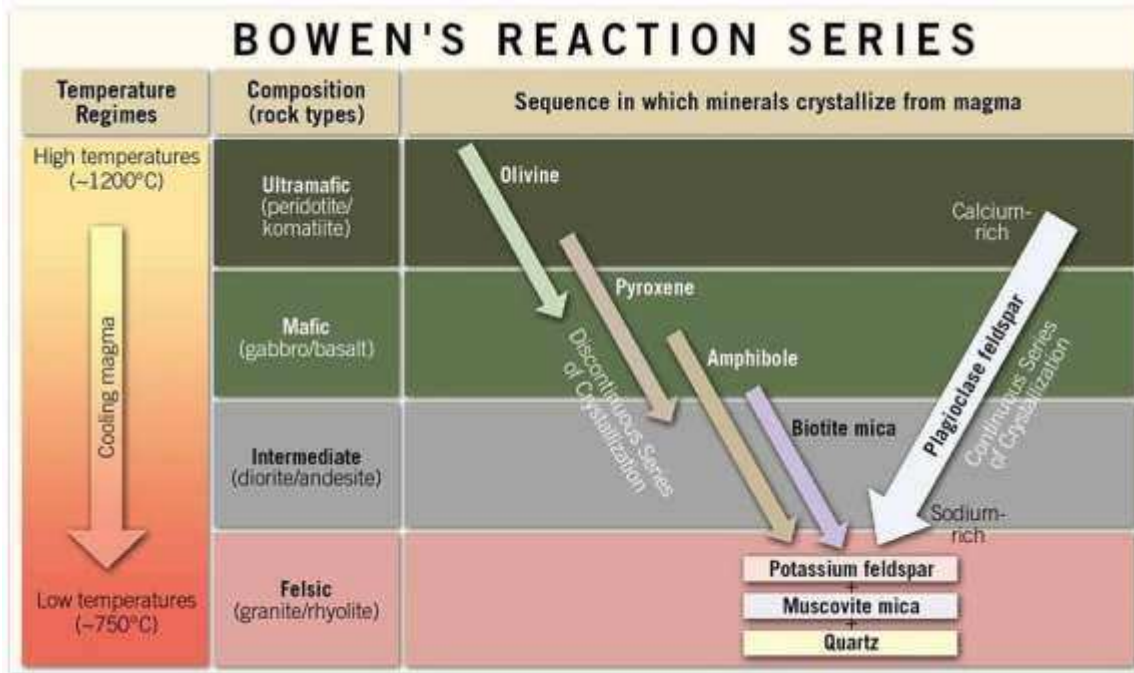
Global Sci Out: G2, G3

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

3) Consult the image that depicts Bowen's reaction series. What can be said of the temperature at which a granite crystallizes?



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- A) Granite crystallizes at temperatures of about 750° C.
- B) Granite crystallizes at temperatures of about 900° C.
- C) Granite crystallizes at temperatures of about 1200° C.
- D) Nothing can be deduced from this chart about the crystallization temperature of any igneous rock.

Answer: A

Diff: 2

Bloom's Taxonomy: Applying/Analyzing

Global Sci Out: G7

Section: 2.2 Igneous Rocks: "Formed by Fire"

Focus/Concepts: 2.2

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

4) What form of physical weathering is shown in this image?



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- A) frost wedging
- B) sheeting
- C) root wedging
- D) hydrolysis

Answer: C

Diff: 1

Bloom's Taxonomy: Remembering/Understanding

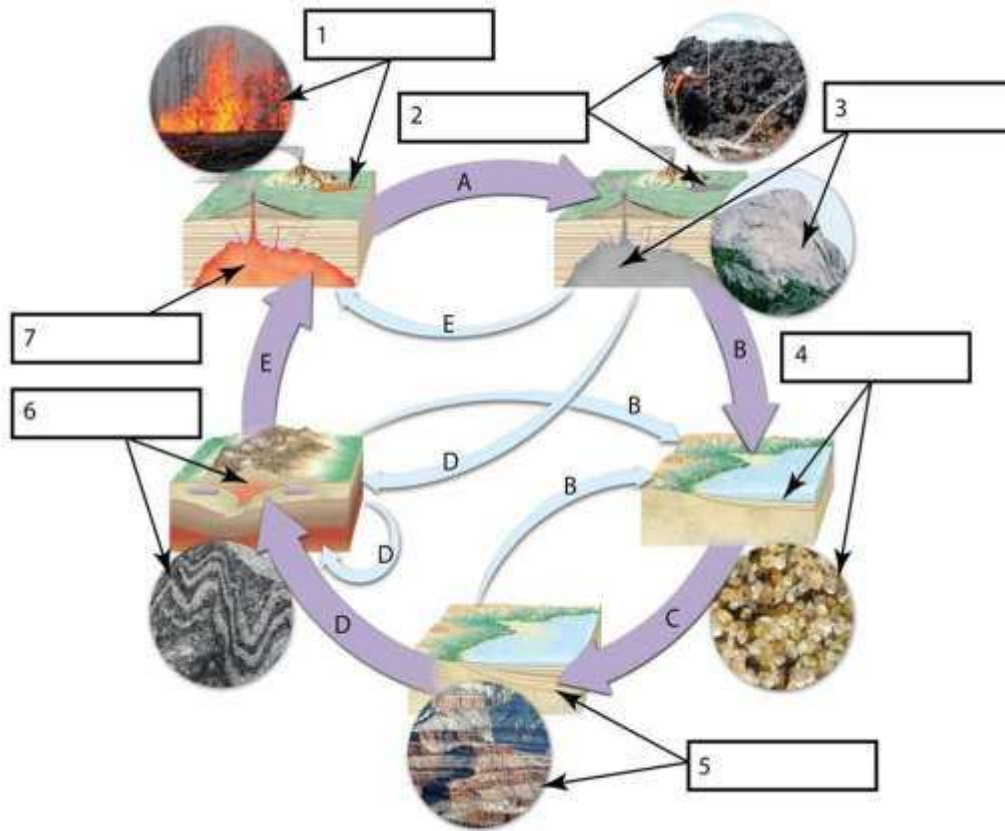
Global Sci Out: G2

Section: 2.3 Weathering of Rocks to Form Sediment

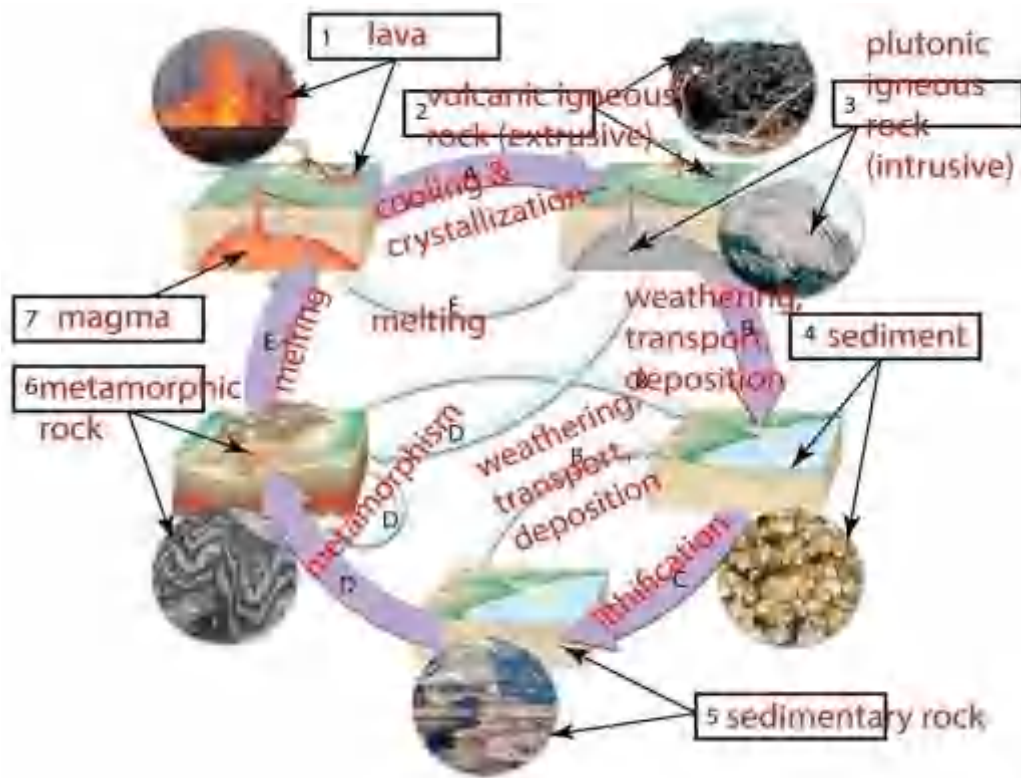
Focus/Concepts: 2.3

ESLI: 4.1 Earth's geosphere changes through geological, hydrological, physical, chemical, and biological processes that are explained by universal laws.

5) Label each process or set of processes (lettered arrows) and Earth materials (numbered boxes).



Answer:



Diff: 1

Bloom's Taxonomy: Remembering/Understanding

Global Sci Out: G2, G3

Section: 2.1 Earth as a System: The Rock Cycle

Focus/Concepts: 2.1

ESLI: 4.1 Earth's geosphere changes through geological, hydrological, physical, chemical, and biological processes that are explained by universal laws.

6) Identify each photo with a material name. Explain the processes which would have to occur as each material is transformed (arrows) into other materials. Include a plausible "next step" to replace the big question mark at the end.



Answer: Pebbles, a kind of sediment, could be transformed into a conglomerate through the process of lithification. After they were generated, transported (causing them to round), and deposited, the pebbles would then either be compressed or cemented together to form the sedimentary rock conglomerate. This conglomerate could be induced to melt with application of sufficient heat, rendering it into magma. That magma could cool and crystallize, producing the igneous rock granite. In terms of what happens next, this granite might experience differential stress and be metamorphosed in a mountain-building event to produce a gneiss. (Answers for this last part will vary.)

Diff: 3

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G7

Section: 2.1 Earth as a System: The Rock Cycle

Focus/Concepts: 2.1

ESLI: 4.6 Earth materials take many different forms as they cycle through the geosphere.

7) How are the two main categories of weathering represented in this image that shows human-made objects?



Answer: The broken glass bottles provide an example of mechanical weathering: to make them, a single glass bottle would have to be shattered into numerous shards of glass. Though many new pieces of glass result, the substance itself (glass) has not been transformed into anything new. In contrast, the rusty cans provide an example of chemical weathering: to make them, an initial can would have to react with oxygen in the atmosphere (an oxidation reaction facilitated by water) and a new substance (rust) would be produced at the expense of the material that composed the original cans.

Diff: 3

Bloom's Taxonomy: Evaluating/Creating

Global Sci Out: G7

Section: 2.3 Weathering of Rocks to Form Sediment

Focus/Concepts: 2.3

ESLI: 4.1 Earth's geosphere changes through geological, hydrological, physical, chemical, and biological processes that are explained by universal laws.