Answer Key

Answers to Study Questions

1. *Weathering* can be defined as "the response of materials that were once in equilibrium within the Earth's crust to new conditions at or near contact with air, water, and living matter" (Judson, Kauffman, & Leet, 1987, p. 77; after Reich, 1950). Weathering refers to the destructive processes that change the physical and chemical character of rock at or near the Earth's surface.

2. *Weathering* breaks down rocks that are either stationary or moving. *Erosion* is the picking up or physical removal of rock particles. *Transportation* is the movement of the eroded particles by agents such as rivers, waves, glaciers, or wind.

3. Yes. For example, rocks can be plucked out and eroded by moving water without being weathered.

4. Rocks are rounded by weathering because chemical weathering acts more rapidly and intensely on the corners and edges of a rock than on the smooth rock faces.

5. Three processes of mechanical weathering are frost action (wedging and heaving), abrasion, and pressure release (sheet-jointing and exfoliation).

6. Minerals that formed under conditions other than those found at the Earth's surface weather because they are out of equilibrium with their present conditions.

7. The three types of reactions involved in chemical weathering are oxidation, hydrolysis, and dissolution. Compare your descriptions of how these reactions occur with the explanations given in Unit 4, Section 1, in this *Study Guide*.

8. Hematite is an oxide of iron (Fe_2O_3) which commonly occurs in weathering environments when iron-bearing minerals react with oxygen during alteration. Limonite is a general term for a mixture of hydrated iron oxides and hydroxides in varying proportions. The general formula for limonite is $FeO(OH) \cdot nH_2O$ and it commonly forms when iron oxides such as hematite and magnetite react with water. The oxidation and hydration of iron rich sulphide minerals such as pyrite or the chemical weathering of mafic minerals can also result in limonite.

9. Three kinds of natural acids that can accelerate weathering are carbonic acid (i.e., dissolved CO_2 in water); sulphuric acid, emitted during many volcanic eruptions or evolving from sulphur gases given off by some hot springs and from drainage of mines containing minerals such as pyrite; and hydrofluoric acid, emitted during many volcanic eruptions. The most significant weathering agent is carbonic acid.

10. Limestone caves form when calcite from the limestone goes into solution when exposed to carbon dioxide and water. The calcite is then removed in solution by the water.

11. Carbon dioxide from the atmosphere and soil combines with rainwater to form carbonic acid. If this carbonic acid comes into contact with a K-feldspar, the hydrogen ion displaces the potassium ion of the feldspar and disrupts the crystal structure. It then combines with the aluminum in feldspar and forms a clay mineral. The weathering of feldspar by weak acidic rainwater is described in the textbook.

12. a. Augite would weather more rapidly than hornblende.

    b. Calcic feldspar would weather more rapidly than potassic feldspar.

13. According to Bowen's reaction series, gabbro should break down first at the Earth's surface. Gabbro is composed of ferromagnesian minerals and plagioclase feldspar (see Figure 3.15 of the textbook), all of which are high temperature minerals that weather rapidly at the Earth's surface. Granite is composed mostly of quartz and potassium feldspar, which are relatively low temperature minerals that weather more slowly at the Earth's surface.

14. Differential weathering is caused by the presence of a variety of rock types that weather at different rates.

15. The effects of weathering:
    granite: expansion joints and exfoliation develop due to the release of pressure when overlying rocks are eroded; feldspars alter to clay minerals; mica alters more slowly to chlorite or clay minerals; and quartz is very resistant to weathering. Quartz is the most significant fragment resulting from the weathering of granite.
    basalt: Since quartz is not present in basalt, and the grains in basalt are very fine, it weathers rapidly to a red or brown soil composed of clay and iron oxides.
    sandstones: Chemical decomposition of sandstone consists largely of decomposition of the cement and the minor amounts of unstable rock fragments and feldspar. The quartz grains are very resistant to weathering. The end product of intense weathering of sandstone consists of mixtures of quartz sand and clay, ratios of which vary depending on the original composition of the sandstone.

shale: Shale weathers rapidly to soil because it is fine grained, soft, and able to absorb and expel large amounts of water.

limestone: Limestone rocks are composed mostly of calcite, and they weather by dissolution. Limestone in arid areas can form resistant cliffs, but in humid areas, solution activity forms a network of caverns and caves in the limestone.

16. The three factors most important in controlling the rate of weathering are rock type, surface area exposed to the weathering elements, and climate.

17. *Regolith* is the "layer of soft disaggregated rock material formed in place by the decomposition and disintegration of the bedrock that lies beneath it" (Hamblin, 1989, p. 158). *Soil* is the uppermost layer of the regolith that contains varying amounts of organic matter.

18. Quartz and clay minerals are left after the complete chemical weathering of rock.

19. Basalts are fine grained and contain no quartz. Therefore, the resulting soil contains no sand. A granite has abundant quartz, which produces a sandy soil, which is less likely to be fertile.

20. A *laterite* is a highly leached soil formed in tropical regions where temperatures are high and rainfall is abundant. Laterites are usually red, and are composed almost entirely of iron and aluminum oxides.

21. Petroleum, groundwater, and iron are important resources concentrated in sedimentary rocks.

22. *Sediment* is the collective name for loose, solid particles that originate from weathering and erosion of pre-existing rock or from chemical precipitation from solution, including secretion by organisms in water.

23. *Deposition* is a physical process by which solid material that has been transported by some agent (e.g., water, wind, glacier) falls out of the transport medium and ceases to be transported (i.e., it gets deposited). *Precipitation* is a chemical process by which dissolved material is converted into a solid and separated from the liquid in which it was dissolved.

24. The texture of a sedimentary rock is the size, shape, and arrangement of the particles that make up the rock.

25. *Rounding* is the grinding away of sharp edges and corners of grains during transportation. *Sorting* is the process through which sediment grains are selected and separated according to grain size, grain shape, or specific gravity.

26. In rocks with a nonclastic texture, the grains are interlocked. Such rocks are formed by precipitation of crystals from fluids.

27. *Lithification* is the general term for a group of processes that convert loose sediment into sedimentary rock.

    Pore space is the open space between grains.

    Compaction is a shift to tighter packing of grains, with a resulting decrease in pore space.

    Cementation is the process by which precipitation of solid material into pore spaces binds loose sediment grains together.

28. *Diagenesis* is a series of physical, chemical, and biologically induced changes that a sediment undergoes after deposition.

29. Sedimentary rocks can be detrital, chemical, or organic, and are classified by grain size and composition.

30. A *breccia* is composed of angular fragments, while a *conglomerate* is composed of rounded fragments.

31. Shales contain both silt and clay (as do mudstones), but whereas shales are visibly layered and fissile, mudstones are massive and blocky. Siltstones consist mostly of silt grains.

32. *Limestone* is sedimentary rock composed mostly of calcite, and usually precipitated in shallow sea water through the actions of organisms.

33. Extensive layers of dolomite can form as magnesium-rich brines created by solar evaporation of sea water trickle through existing layers of limestone and as chemical reactions take place at the boundary between fresh underground water and sea water.

34. Chert nodules in limestones probably form when inorganic precipitation of underground water replaces part of the original rock with silica. Layered deposits may also form by the accumulation of hard, shell-like parts of microscopic marine organisms on the sea floor, or from a combination of both mechanisms.

35. Two types of evaporates are rock gypsum and rock salt.

36. Compare your diagrams to the appropriate figures in Chapter 6 of the textbook. You can illustrate bedding by drawing a series of horizontal lines.

37. The presence of mud cracks indicates that the sediment was aerially exposed, periodically. Mud cracks can form in a tidal environment, on a dried-up lake bed, on the flood plain associated with a river, or in any other environment where the water that deposited the sediment is removed. Mud cracks cannot form in a submarine environment.

38. *Fossils* are traces of plants or animals preserved in rock. Coal and petroleum are sometimes called fossil fuels because both form from ancient organic matter.

39. In turbidite deposits, grain size in the beds decreases upward. To determine which direction in a turbidite bed is the top, determine the direction in which the grains get finer. The shape of mud cracks in a vertical section can also indicate which direction is up (top).

40. A formation has some visible characteristic that makes it a recognizable unit (e.g., its rock type or sedimentary structures).

41. The boundary between two different rock types is called a *contact*.

42. a. The probable source of a sedimentary rock containing feldspar, quartz, and biotite is granite.

    b. The probable source of a sedimentary rock containing well-rounded quartz is pre-existing sandstone.

43. A geologist would use the evidence provided by the thickness of the deposit, the size of the grain, and the roundness of angularity of the grains to determine the distance of a sedimentary rock from its source area.

44. An examination of asymmetrical current ripples or cross beds could provide information about the direction in which the source rock lies.

45. Four characteristics of a sedimentary rock that are used to determine its environment of deposition are rock composition, sedimentary structures, size of the rock unit, and shape of the rock unit.

46. Compare your diagram to Figure 6.35 in the textbook.

47. Thick sequences of silt and shale are likely to form in a delta environment.

48. The most poorly sorted sediment is likely to form in a glacial environment.