Review Questions, Chapter 7, 12th Ed.

1. Alfred Wegener is credited with developing the continental drift hypothesis.
2. The puzzle-like fit of the continents, especially Africa and South America.
4. Wegener and his associates found that the fit of the continents, fossil evidence, paleoclimatic evidence, and similarities in rock type and structural features all seemed to link the now-separated continental landmasses.

5. If *Mesosaurus* was able to swim well enough to cross the vast ocean currently separating Africa and South America, its remains should also be found on other continents. Since this is not the case, we conclude that South America and Africa were joined during the time period that these animals existed.

7. Wegener thought that if the continents had previously been at different latitudes, they would have been in different climatic zones.

8. The first approximations of plate boundaries were made on the basis of earthquake and volcanic activity.

9. Divergent boundaries —where plates are moving apart
Convergent boundaries—where plates are moving together
Transform fault boundaries—where plates slide past one another along faults

10. Sea-floor spreading refers to the creation of new sea floor at the oceanic ridges along with its conveyor belt movement away from the ridge crests. Sea-floor spreading occurs today along the oceanic ridges.

11. Subduction zones occur in the deep-ocean trenches where slabs of oceanic crust are descending into the mantle. Subduction zones are associated with convergent plate boundaries.
12. Lithosphere is being consumed at convergent boundaries where a slab of oceanic crust is plunging into the asthenosphere. The production and the destruction of the lithosphere must occur at about the same rate, because Earth is neither growing nor shrinking in size.
13. The Himalayan Mountains formed as a result of a collision between the Indian landmass and the Asian continent.

Review Questions, Chapter 7, 12th Ed. cont.

14. Transform fault boundaries, like the San Andreas fault, represent areas where plates slip past one another. Lithosphere is neither produced (as along divergent boundaries) nor destroyed (as along convergent boundaries) along transform faults.

18. The age of the oldest sediments recovered by deep-ocean drilling is about 160 million years. Some continental crust has been dated at 3.9 billion years.

19. Hot spots are relatively stationary plumes of molten rock rising from Earth's mantle. According to the plate tectonics theory, as a plate moves over a hot spot, magma often penetrates the surface, thereby generating a volcanic structure. In the case of the Hawaiian Islands, as the Pacific plate moved over a hot spot, the associated igneous activity produced a chain of five major volcanoes. The oldest of the Hawaiian Islands is Kauai. The youngest, and only active volcanic island in the chain, is the island of Hawaii.

21. Himalayas: formed along a convergent continent–continent collisional boundary between the Indian subcontinent and Eurasia.
Aleutian Islands: islands are the oceanward part of a volcanic island arc situated on the northwestern margin of the North American plate; the volcanoes lie above the subducting Pacific plate.
Red Sea: The Red Sea occupies a major rift zone and very young seafloor spreading center that has opened between Africa and the Arabian block.
Andes Mountains: The Andes are a volcanic and plutonic arc resting on the western margin of the South American plate; they lie above subducting, oceanic lithosphere of the Nazca and Antarctic plates.
San Andreas fault: This is a transform fault that forms the boundary between the North American and Pacific plates. The crustal sliver composed of westernmost California and the Baja California peninsula on the eastern edge of the Pacific plate is moving northwestward with respect to North America.
Iceland: Iceland and nearby smaller islands constitute a major zone of basaltic volcanism that probably overlies a mantle hot spot located directly beneath the Mid-Atlantic Ridge, the divergent boundary between the Eurasian and North American plates.
Japan: The Japanese Islands lie on the eastern margin of the Eurasian plate, above subducting parts of the Pacific and Philippine oceanic plates.
Mount Saint Helens: This is a very young stratovolcano in the state of Washington; it is part of the Cascade Range, a continental-margin, volcanic arc extending from the Canadian border to northern California.

Answers to Review Questions Chapter 8, 12th edition

1. An *earthquake* is the vibration of Earth produced by the rapid release of energy, usually along a fault. A *fault* is a fracture along which there is or has been movement. When slippage occurs, an earthquake results.

2. A fault is the plane or zone of fracture separating two blocks that are abruptly displaced during an earthquake. The *focus* is the point at depth, usually in a fault zone, where the displacement and sudden release of elastic energy are initiated. It marks the initial rupture site associated with the earthquake. The *epicenter* is the point on the surface directly above the focus.

4. When stress is applied to crustal rocks, they respond by bending and in doing so they store elastic energy much like a rubber band does when it is stretched. Once the strength of the rock is exceeded, the rock fractures, and movement takes place along this fracture or fault. This slippage allows the deformed rocks to snap back to their original shape—a process called elastic rebound. It is the springing back of the rock that produces the vibration we call an earthquake.

8. P waves travel through all materials, whereas S waves are propagated only through solids. Further, in all types of rock, P waves travel faster than S waves.

10. Circum-Pacific belt.

12. Each Richter number is about Thirty (30) times more energy than the lower.

11. The nature of the material on which the structures had been built, the design and construction of the buildings, the distance to the epicenter.

14. Many factors can be noted, particularly, the amplitude of the ground displacement or acceleration, the length of time that shaking occurs, and the character of the ground shaking. In general, vertical ground motion is not so dangerous as lateral or horizontal shaking, and short-period (high-frequency) vibrations are less dangerous than longer-period vibrations. Stability of the foundation material, building design, and construction quality are also important factors.

15. Fire, landslides, and seismic sea waves (tsunami) are all capable of adding to the destructive nature of earthquakes.

Answers to Review Questions Chapter 8, 11th edition cont.

16. The Richter scale is a measure of earthquake magnitude,, that is, the total amount of energy released during an earthquake. The Mercalli scale, in contrast, is an attempt to measure the intensity of the earthquake by examining the damage caused by the tremor

17. A tsunami, or seismic sea wave, is associated with an earthquake because it is generated by movement of the ocean floor (faulting). These waves transfer vast quantities of energy, often great distances. When the energy is released as the wave breaks in shallow water, it can cause tremendous destruction.

18. The moderate quake might have occurred nearer the surface. Also, it might have lasted longer or affected an area where the surface consisted chiefly of unconsolidated deposits as opposed to solid bedrock. The design of the structures in the affected area could also be significant.

19. P waves are bent and slowed upon entering the outer core, producing a shadow zone, and S waves cannot pass through liquids. Thus, geologists concluded the outer core is molten.

22. The continental crust has an average composition somewhere between that of granite and andesite, whereas the oceanic crust is basaltic in composition. The composition of the mantle is thought to be similar to the rock peridotite, which contains iron and magnesium-rich silicate minerals. Both the inner and outer cores are thought to be enriched in iron with lesser amounts of the other lighter, common elements.

Review Questions—Chapter 2 12th ed.

1. To be considered a mineral, a substance must exhibit the following characteristics: (1) be naturally occurring, (2) be a solid, (3) have an orderly crystalline structure, (4) have a definite chemical composition, and (5) generally be inorganic.

2. A rock is a more or less hardened (lithified) aggregate of minerals and/or amorphous solids, such as natural glass and organic matter.

4. (a) The number of protons—a neutral atom with 35 electrons has 35 protons. (b) The atomic number— the atomic number is 35, equal to the number of protons in the nucleus. (c) The number of neutrons—the mass number (80) is the sum of protons (35) and neutrons. Thus the nucleus contains 45 (80 – 35) neutrons.

8. Impurities often cause the same mineral to have many colors. For example, fluorite can be purple, clear, or yellow, and quartz can be practically any color.

9. The hardness test might help you make a determination, since diamond is the hardest mineral in nature.

11. The specific gravity of water is 1 by definition. Thus the weights of equal volumes of water and gold will be in the ratio 1:20. Because 5 gallons of water weighs 40 pounds, 5 gallons of gold will weigh almost 800 pounds (5 gallons x 160 pounds/gallon = 800 pounds).

12. The two most abundant elements in Earth's crust (by weight) are oxygen (46.6%) and silicon (27.7%). The basic building block of all silicate minerals is the silicon–oxygen tetrahedron.

13. Feldspars are by far the most plentiful group of silicate minerals, constituting more than 50 percent of Earth's crust. Quartz is the second most abundant mineral in the continental crust.

14. Three nonsilicate minerals that are commonly found in rocks are calcite, halite, and gypsum.

Review Questions—Chapter 3, 12th ed.

1. In short, the magma from which igneous rocks form may be produced when any rock is melted. Sedimentary rocks are formed from the weathered products of preexisting rocks, whether igneous, metamorphic, or sedimentary. Finally, metamorphic rocks are created when any rock type undergoes metamorphism.

2. Basalt would be the probable rock type for the lava flow, since extrusive rock cools rapidly, yielding a fine-grained texture. If the same magma cooled below the surface, gabbro, the coarse-grained equivalent of basalt, would form.

3. It indicates that the magma likely changed environments and cooled at two different rates, yielding crystals of two distinctively different sizes.

4. Although both have the same mineral composition, granite is coarse-grained (intrusive), whereas rhyolite is fine-grained (extrusive).

5. Minerals that crystallize at about the same time (temperature) are most often found together in the same igneous rock.

17. Hydrothermal solutions can deposit metals as (1) vein deposits in fractures or (2) as disseminated deposits distributed as minute masses throughout an entire rock body.

18. The two broad categories of nonmetallic resources are (1) building materials, which include aggregate, gypsum, and clay, and (2) industrial minerals such as fluorite (used in making steel), common salt, sulfur, corundum (an abrasive), and sylvite (used in the production of fertilizers). Some substances, such as limestone, are found in both groups.

Review Questions—Chapter 9, 12th ed.

1. Magma and lava both refer to molten rock from which igneous rocks form. However, *magma* refers to molten rock below Earth's surface, and *lava* refers to molten rock at Earth's surface.

2. The nature of a volcanic eruption is determined by the (1) composition of the magma, (2) the temperature of the magma, and (3) the quantity of dissolved gases contained in the magma. The composition and temperature of the magma influence the viscosity of this material. The viscosity, in turn, helps determine whether the eruption will be violent or quiet. The viscosity is least for very hot magmas with relatively low silica content. The gases dissolved in the molten material provide the force to propel the liquid rock from the volcano. The quantity of gases present and the ease with which they can escape (dependent on viscosity) determines the nature of the eruption.

3. When magma migrates to a near-surface environment, the gases that were dissolved at great depth begin to rise and expand. The viscosity of the lava determines the ease with which these gases can escape. Highly viscous magma inhibits the escape of gas, which may then accumulate to the point at which the lava is violently ejected from the volcano.
4. Aa is rough-surfaced chunky basalt flow; pahoehoe has a ropy surface basalt flow.
5. Water vapor (70%), carbon dioxide (15%), nitrogen (5%), sulfur compounds (5%), and smaller amounts of Cl_2, H_2, and Ar.

8. Craters are constructive features, made of pyroclastic material. Calderas are collapse features, created when large amounts of magma are expelled from vents and the remaining surface collapses into the void left. Calderas are commonly much larger than craters.

9. Shield volcanoes are among the largest on Earth. These gently sloping domes are associated with relatively quiet eruptions of fluid basaltic lava. They contain very little pyroclastic material. Cinder cones are composed almost exclusively of pyroclastics, are steep-sided, and are the smallest of the volcanoes. Composite cones, as the name suggests, are composed of alternating layers of lava (usually andesitic or rhyolitic in composition) and pyroclastic debris. Their slopes are steeper than those of a shield volcano but gentler than a cinder cone. Composite cones are associated with violent periods of volcanic activity.

Review Questions—Chapter 9, 12th ed. cont.

10. The volcanoes making up the island of Hawaii serve as excellent examples of shield volcanoes. Paricutin, as well as many small cones on the Colorado Plateau north of Flagstaff, Arizona, are good examples of cinder cones. Mount Fuji in Japan and Mount Shasta, in California, as well as the many volcanoes of the Cascade Range, are examples of composite cones.

12. Crater Lake (Oregon) caldera is about 6 miles in diameter. It formed following a major eruption of ash and pyroclastic flows about 7000 years ago. Glacial valleys cutting through the caldera rim and other geologic evidence prove that a complex, composite volcano once existed above the site of the present-day caldera. In contrast, the summit caldera block of Kilauea is about 3 miles in diameter and acts somewhat like a floating cork, rising when magma is accumulating and sinking after an eruption. The rising and sinking movements are gradual, in contrast with the catastrophic collapse that follows large-volume pyroclastic flow eruptions.

19. Magma originates from partial melting of mantle material. It leaves behind the more mafic, higher-melting temperature minerals, so it is relatively enriched in silica (felsic minerals).

20. Spreading center volcanic rocks are basaltic. The magma comes from the decompression of the rising mantle material, which reduces its melting temperature (not the temperature of the rock).

21. The Ring of Fire refers to the volcanic mountains ranges and islands that surround much of the Pacific Ocean. Many of the active volcanoes on Earth today are located on the Ring of Fire.

22. Very large composite volcanoes (stratovolcanoes), like those on the Ring of Fire, typically erupt explosively. The 1991 eruption of Pinatubo in the Philippines was the second most powerful eruption of the twentieth century, being surpassed only by the 1902 eruption of Santa Maria in Guatemala. The 1980 eruption of Mount Saint Helens is another good example.

23. Hawaii and Yellowstone are Intraplate volcanism.

24. Isolated islands in the deep ocean are Basalt, from mantle plume hotspot sources.

Review Questions, Chapter 10, 12th ed.

1. Rock deformation is the change of shape created by stresses: it includes folding, faulting and jointing.

2. Brittle deformation involves breaking the rock, often in near-surface areas of the crust. Ductile deformation is the stretching, thinning and folding of the rocks, usually deeper in the crust, created by higher temperatures and pressures than near-surface areas.

3. Temperature and pressure affect the strength of the rock…greater amounts of either will make it weaker. All rock types have an inherent strength…most sedimentary rocks behave in a ductile manner long before crystalline rocks would in the same physical conditions. The length of time will also affect brittle vs. ductile deformation…abrupt application favors brittle deformation, prolonged application is more likely to result in ductile deformation.

6. The Black Hills are a late Cretaceous–early Tertiary, elliptically shaped, domal uplift of crystalline rocks associated in an as yet unknown way with subduction of old Pacific Ocean floor (the Farallon plate) beneath western North America.

7. Both are dip-slip movements in which one block moves up and the other down along the fault surface. Assume that dip-slip faults with vertical dips (the fault surface is vertical) are normal faults. For dip-slip faults with inclinations or dips other than vertical, the hanging wall–footwall designation is very useful. The hanging wall block is the block that is entirely above the fault surface, and the footwall block is entirely below. In normal fault movement, the hanging wall block slides down along the fault surface with respect to the footwall block. In reverse fault movement, the hanging wall block slides upward along the fault surface with respect to the footwall block.

8. Based on the relations shown in the photo (Fig. 10.8), the sense of displacement is normal. The hanging wall block (left) slipped down with respect to the footwall block (right). Even without the arrows on the photograph showing relative motion, the stratigraphic sequence can be matched across the fault to determine the sense of movement along the fault.

Review Questions, Chapter 10, 12th ed. cont.

10. Fault-block mountains are associated with geologically young, high-angle normal faults that flatten or merge with a regional-scale low-angle fault at depth. Uplifted blocks form the mountain ranges and down-dropped blocks form the valleys. The topography replicates active or recently active fault movements. Long, linear fault-block ranges and valleys are horsts and grabens.

12. The San Andreas Fault is a strike-slip fault…a transform feature.

13. Joints are brittle deformation features that have had little or no relative movement across the break. Faults have had movement.

14. Mountain building is most directly associated with convergent plate boundaries.

15. A volcanic island arc occurs where two oceanic plates converge and one is subducted beneath the other. The interaction of these two plates results in partial melting of the mantle wedge located above the subducting plate. The rising magma creates volcanoes on the seafloor that eventually grow into a chain of volcanic islands known as a volcanic arc. The Aleutian Islands, Japan, and the volcanic islands of the Philippines all represent modern examples of island arcs.

18. Continental margins are characterized by their tectonic activity. Passive margins, the east coasts of North and South America for example, exhibit subdued, "quiet," tectonic movements such as slow uplift and subsidence punctuated by occasional localized faulting. They have wide continental shelves and their continental slopes merge seaward into abyssal plains. Passive margins form originally by continental rifting and are modified by erosion and deposition as they move away from a mid-ocean ridge. For this reason, they are also known as "trailing" margins.

    Active continental margins occupy areas of plate convergence, subduction, and local transform faulting. Tectonism, intrusion, and volcanism are active and long-lived. The western margins of North and South America are good examples.
    Cenozoic time. The subduction along the western margin of South America has been more or less continuous since early to middle Mesozoic time.

20. The Appalachian Mountains are considered a collision-type mountain range that formed in the late Paleozoic. Europe, northern Africa, and North America collided and were all part of the supercontinent Pangaea before it began to split apart less than 200 million years ago. Thus, the Appalachians formed from a collision-type mountain building episode (along with several other complex episodes) despite the fact that the nearest continent today is more than 5000 kilometers away.