

## *Chapter 18*

### *Answers to the Review Questions*

1. Absolute dating involves a numerical age measurement in actual time units, like thousands or millions of years. Relative dating involves placing sequences of rocks, geological features, and events in the correct order in which they occurred, without necessarily knowing their absolute ages.
2. The law of superposition is the idea or notion that beds in a sequence of horizontal, sedimentary strata become younger upward in the sequence. In other words, younger strata are deposited over older strata. A feature that truncates or cuts across another geologic feature is the younger of the two. This is known as the principle of cross-cutting relationships. For example, a dike of basalt injected into a crack in sedimentary strata is younger than the strata.
3. The principle of original horizontality states that, in general, stratification in sedimentary beds was horizontal when the beds were deposited.
4.
  - (a) Is fault A older or younger than the sandstone layer? Fault A cuts the sandstone layer so the fault is younger.
  - (b) Is dike A older or younger than the sandstone layer? Dike A also crosscuts the sandstone layer so the dike is younger.
  - (c) Was the conglomerate deposited before or after fault A? Fault A stops at the base of the conglomerate; thus the conglomerate layer truncates the fault and is younger than the fault.
  - (d) Was the conglomerate deposited before or after fault B? The conglomerate is cut and displaced by fault B; thus fault B is younger.
  - (e) Which fault is older, A or B? The faults do not cross, but the relationship between the faults and the conglomerate proves that fault A is older than fault B.
  - (f) Is dike A older or younger than the batholith? Dike A does not cut the batholith so other relationships must be used. Dike B clearly cuts the batholith; the sill fed by dike B is crosscut by dike A, proving that dike A is younger than dike B and younger than the batholith.
5. A depositional contact or unconformity would be proven if detrital rock and mineral grains from the granite were found in the sandstone. Also the granite just below the contact might show reddish discoloration or other evidences of having been weathered before the sandstone was deposited. Bedding in the sandstone will be parallel or nearly parallel to the contact; there will be no evidence for contact metamorphism in the sandstone; and the sandstone will not be cut by the granitic dikes.

If the contact is intrusive, the sandstone may be cut by granitic dikes and may show contact metamorphism. Rock and mineral grains in the sandstone will not show any direct correlation to the granite, and bedding in the sandstone will probably not be parallel to the contact.

6. These are all erosion surfaces buried beneath younger strata. The older strata below an angular unconformity were tilted before the younger strata were deposited; thus the older and younger strata exhibit a sharp, angular, erosional discordance. Strata above and below a disconformity exhibit parallel stratification or bedding orientations, indicating that the underlying, older strata were not tilted or deformed before the younger strata were deposited. Younger, sedimentary beds deposited on an eroded mass of older, igneous or metamorphic rock comprise a nonconformity.
7. Correlation is the process of establishing equivalency of rock units, ages, depositional environments, and events in geologic history (faults, tectonic events, unconformities, etc.) in different areas. Correlation can be local (between rocks intersected in neighboring drill holes) or world-wide (continent to continent).
8. Different types of fossilization include;
  - (a) *actual remains*: usually hard parts from organisms of the recent geologic past
  - (b) *petrified*: the original substance has been replaced by mineral matter or pore spaces have been filled with a mineral
  - (c) *mold*: when a shell or other structure is buried in sediment and then dissolved by underground water
  - (d) *cast*: the hollow space of a mold is subsequently filled with mineral matter
  - (e) *tracks*: animal footprints made in soft sediment that was later lithified
9. Smith was an English naturalist who first convinced other geologic thinkers of his day that strata containing the same assemblages of fossils were correlative from place to place. Thus Smith can be thought of as the founder of the study of stratigraphy and as a leading advocate of using fossil assemblages to correlate equivalent-aged strata (the principle of faunal succession).
10. Fossil organisms have great diversity, and certain individual organisms and/or assemblages of organisms are characteristic of beds deposited during specific periods of geologic time. Thus fossils are useful for correlating the same bed or same sequence of beds among different localities and for determining the geologic ages of the beds.
11. Fossils are very useful environmental indicators.
12. Each time beta decay occurs the atomic number raises by one and does not affect the mass number. Each alpha decay decreases the atomic number by 2 and the mass number by 4. Thus, for 6 alpha decays and 4 betas, the atomic number of the daughter would be  $(90 - 6 \times 2 + 4) = 82$ , which is the atomic number of lead. The mass number of the daughter would be  $(232 - 6 \times 4) = 208$ . The stable daughter is lead-208.
13. With careful sample collection and laboratory procedures, the radiometric methods consistently give accurate, reliable, absolute ages. No other method can be applied to all of geologic time. Fossils are accurate and reliable for Phanerozoic sedimentary rocks but are not found in most igneous and metamorphic rocks and are very rare in Precambrian rocks. The Phanerozoic time scale has been accurately calibrated with

radiometric ages, and Proterozoic and Archean chronologies are based entirely on radiometric dates.

14. A ratio of 1:1 would be produced in 10,000 years (one half-life). After two half-lives, 25 percent of the original parent would be left and 75 percent of the daughter would have formed. The ratio (25 : 75) is 1: 3, so the sample is 20,000 years old (2 half-lives x 10,000 years in one half-life = 20,000 years).
15. Tree rings are the concentric rings visible at the end of a log or a tree stump. They represent the layer of wood that is added each year to the tree in a temperate region. The size and density of rings reflect the environmental conditions (primarily climate) that existed during the year in which the tree formed. Because rings are added each year, the age of the tree when it was cut down can be determined. This procedure could be used to help date recent geologic events if such events, like a landslide or flood, created a new land surface. Fallen trees or stumps could then be used to determine the minimum number of years since the geologic event occurred.
16. If the abundances of the parent or daughter isotopes in a mineral or rock sample have been changed by any process other than radioactive decay, the parent to daughter ratio will not be a true measure of the age of the sample.

17. The work must be done carefully, and the laboratory environment must be free of materials that might contaminate the sample and produce a change in the measured, parent to daughter isotopic ratio. Other precautions include careful sample collection, good mineral separations, repeated analyses of the same samples to establish precision limits, and age determinations by other methods to check for consistency and accuracy. Finally, careful attention to geologic relationships will reduce the chances of misinterpreting the results.

18. To make calculations easier, let us round the age of Earth to 5 billion years.

(a) What fraction of geologic time is represented by recorded history (assume 5000 years for the length of recorded history)? The percentage is  $5 \times 10^3$  yrs divided by  $5 \times 10^9$  yrs x 100 % which equals  $1 \times 10^{-4}$  % or 0.0001 %.

(b) The first abundant fossil evidence does not appear until the beginning of the Cambrian period (570 million years ago). What percentage of geologic time is represented by abundant fossil evidence? The percentage is  $6 \times 10^8$  yrs divided by  $5 \times 10^9$  yrs x 100 % = 1.2 x 10% or 12%.

19. The following are the various divisions listed from longest to shortest time intervals: eons, eras, periods, and epochs.
20. In general, sedimentary rocks do not contain minerals that are both suitable for dating and that crystallized when the bed was deposited. One exception would be feldspar or mica grains in volcanic ash deposited at the time of the eruption. Minerals such as

glauconite crystallize as sedimentary grains but contain large quantities of non-radiogenic daughter element, making an age determination imprecise.

21. The contact between sedimentary beds I (younger and horizontal) and sedimentary beds A (older and tilted) is an angular unconformity. The contact between igneous rock D (older) and the sedimentary beds I is a nonconformity.