Full-Color Images for *Learning to Read the Earth and Sky*

Figure 3.1
Experiment to create a wave-cut scarp, sandy beach, and muddy lake bottom in preparation for a field trip to see the field evidence for the former presence of glacial Lake Agassiz

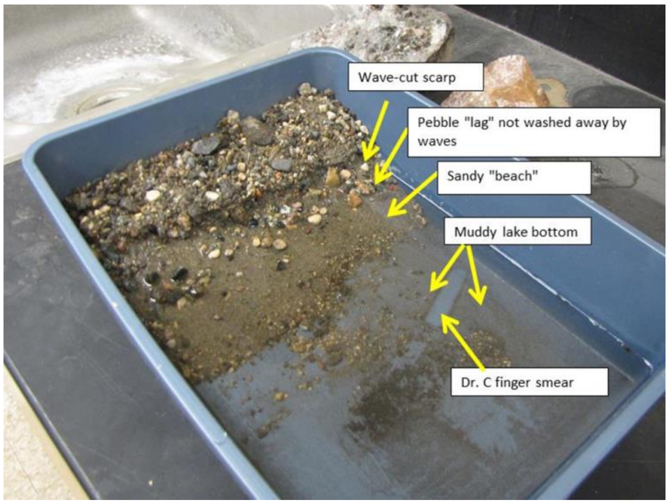


Figure 3.3
Topographic maps for recording initial observations and a simulated student geological map

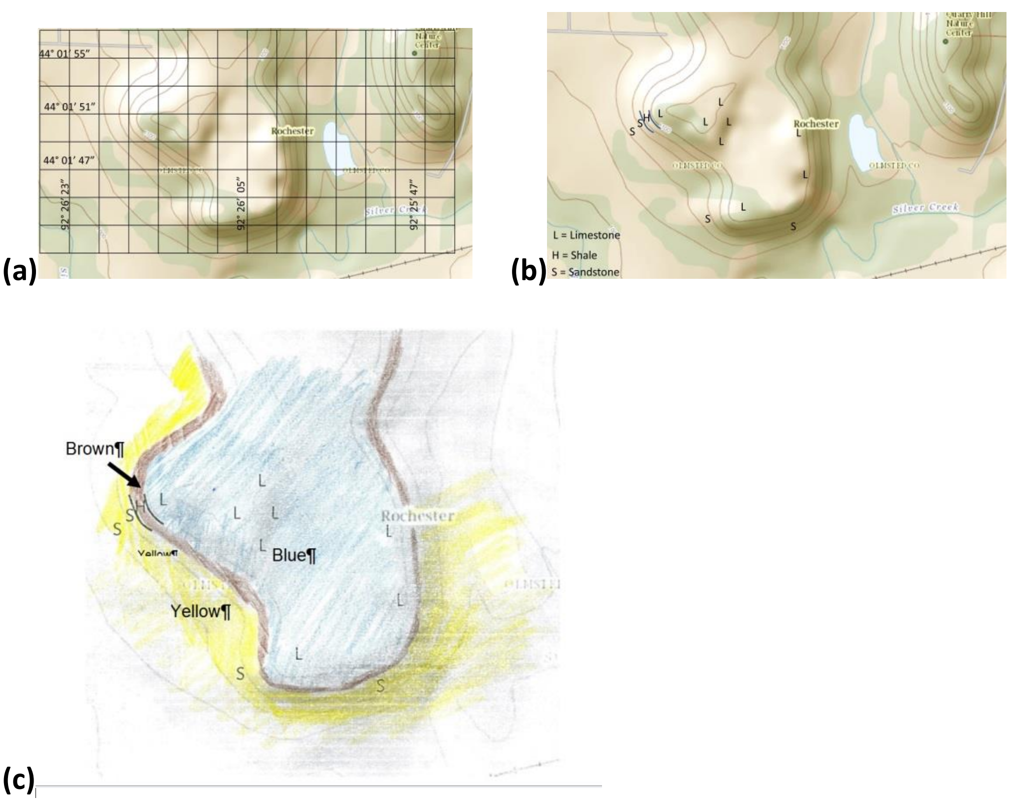


Figure 4.6
Graph of seismic wave travel times versus surface travel distance

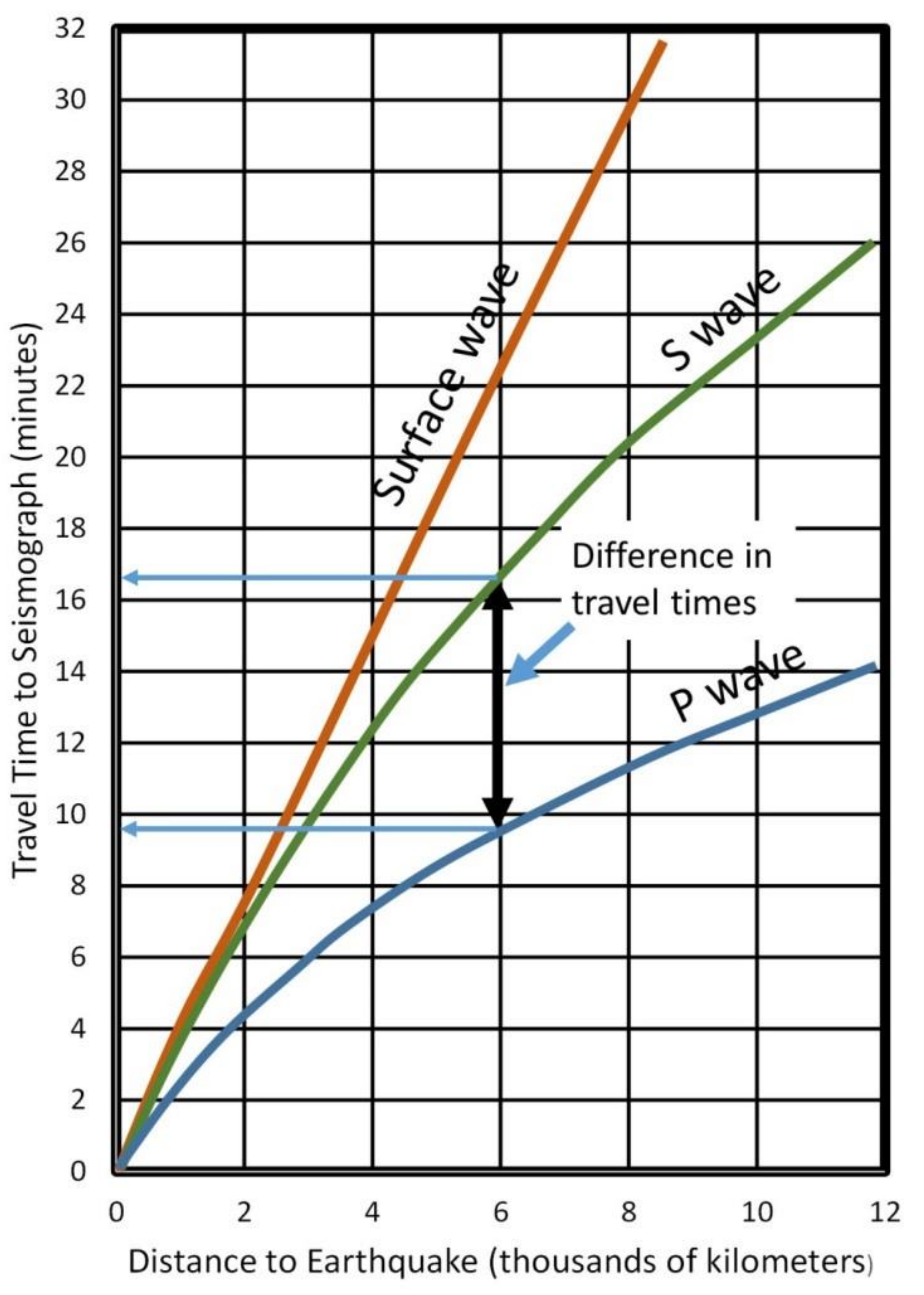
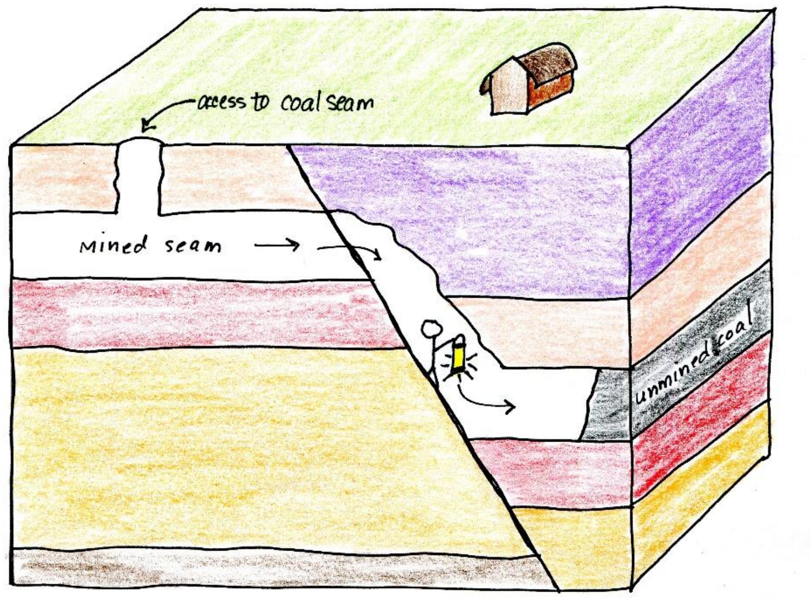
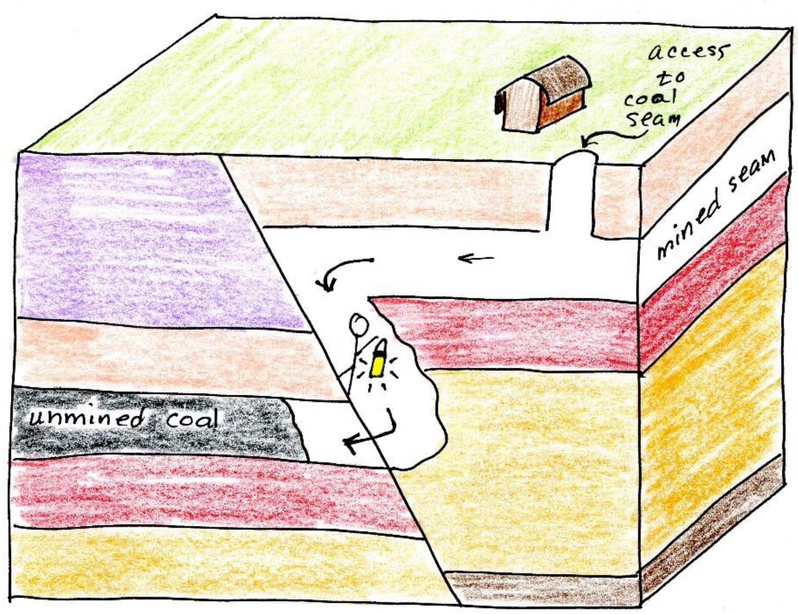


Figure 5.1
Cross-sectional illustrations of normal and reverse faults



(a)



(b)

Figure 5.8
Buffalo River (Minnesota) topographic map with hand-drawn topographic profile

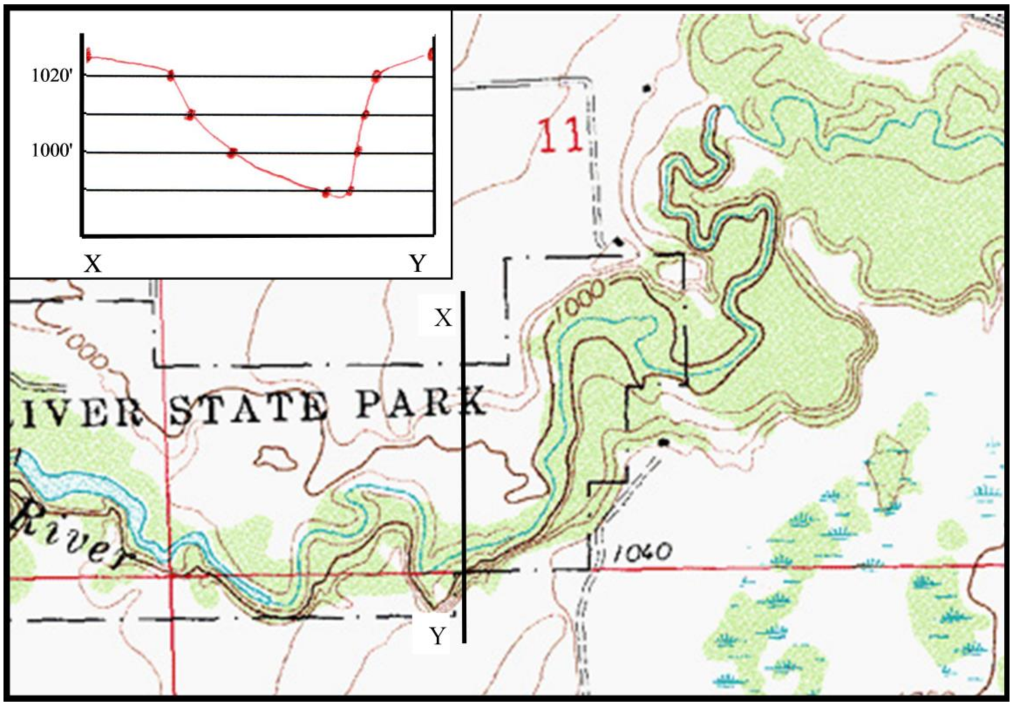


Figure 5.9
Simplified conceptual geological cross-sections of the Grand Canyon

Figure 5.10
Geological maps and cross sections of Quarry Hill Nature Center in Minnesota and Somerset County in Pennsylvania

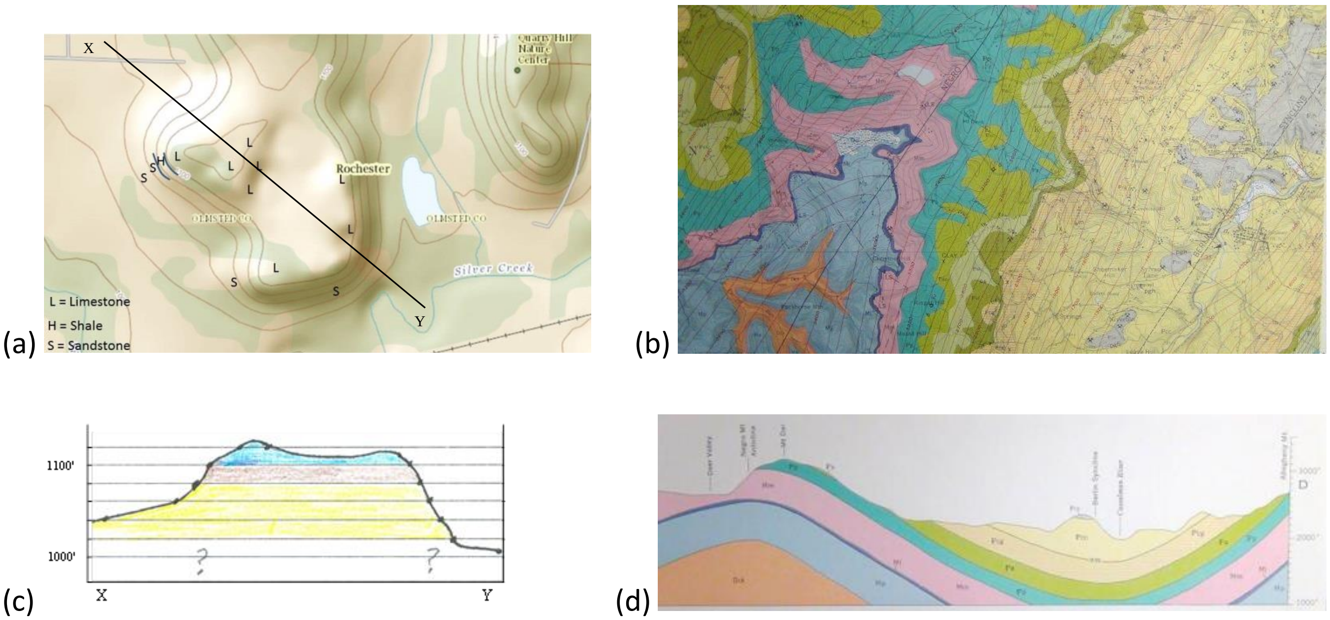


Figure 5.11
Illustration of a contouring and spatial reasoning activity with barometric pressure data

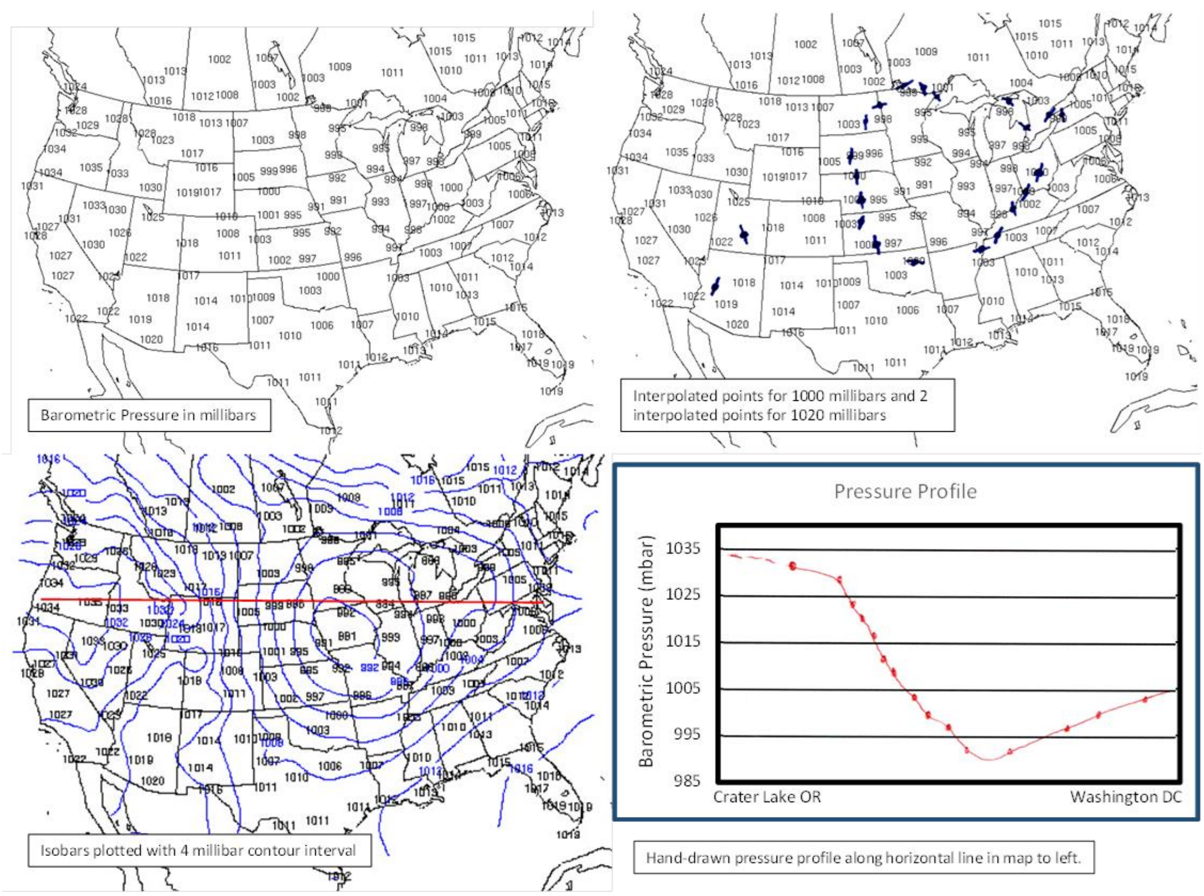


Figure 6.3
A simple classroom barometer

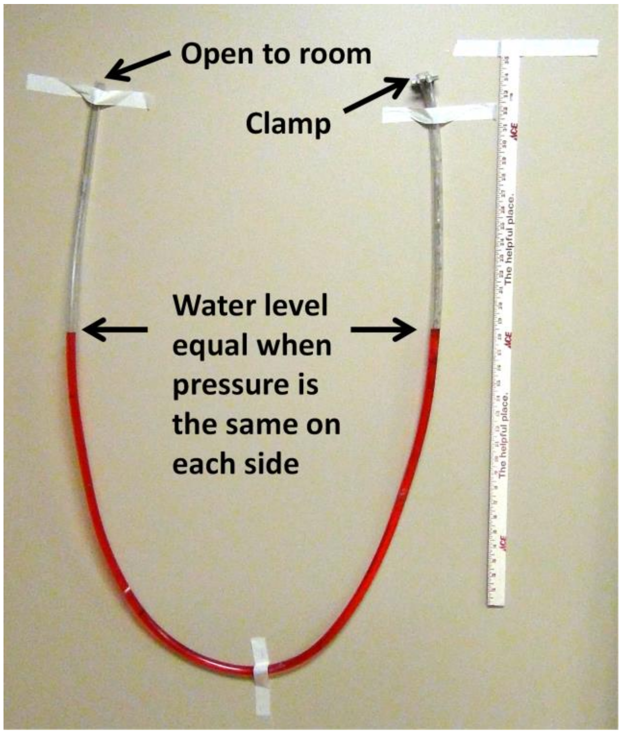


Figure 6.7
Modification of a simple classroom barometer to improve performance

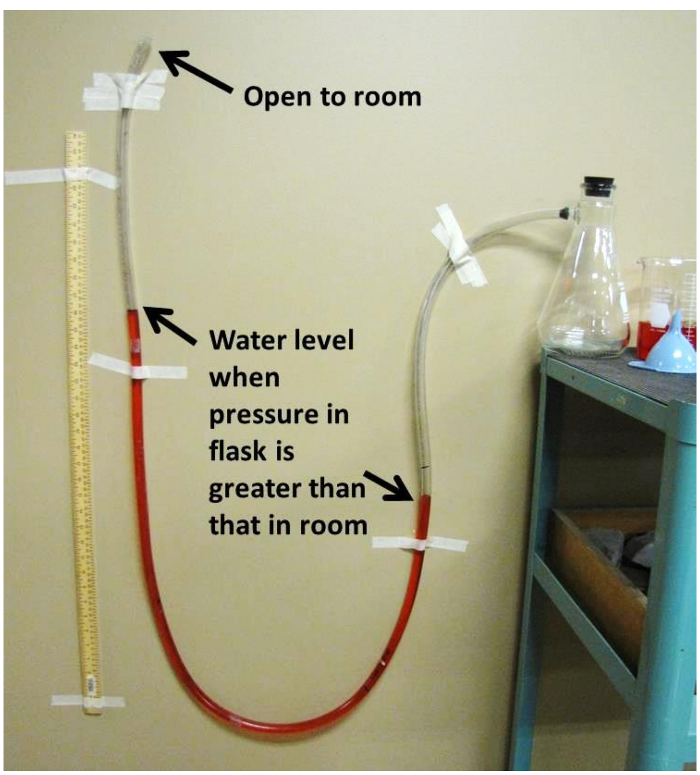


Figure 7.4

Simulated data trends for the four example models

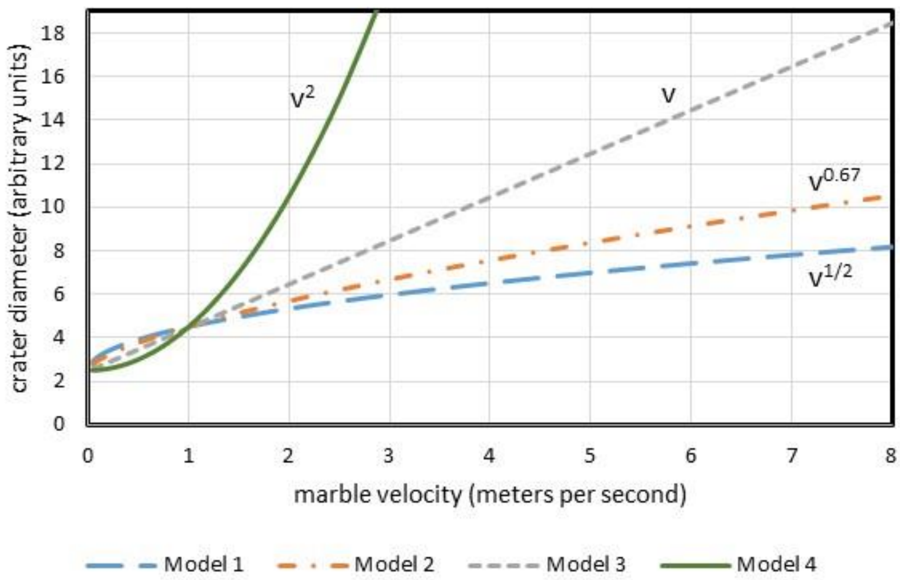


Figure 7.6

Model trend line showing the relationship between kinetic energy (mass and velocity) and crater diameter

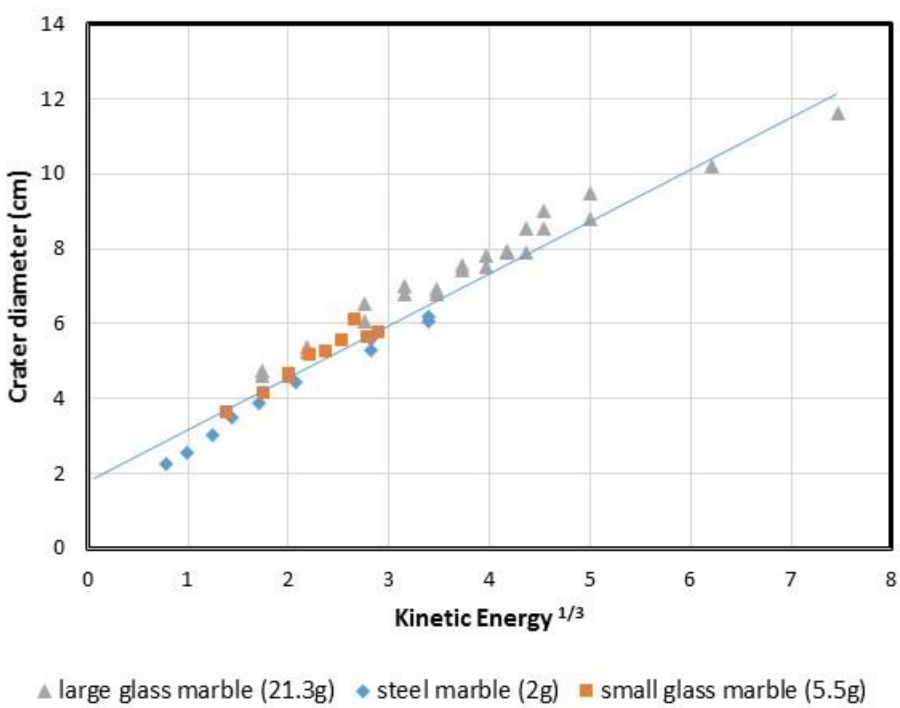


Figure 7.8
Simulation using the model illustrated in Figure 7.7 for the case in which 2 inches of rain falls in 2 hours over a drainage basin 4 square miles in size with an average slope of 3%

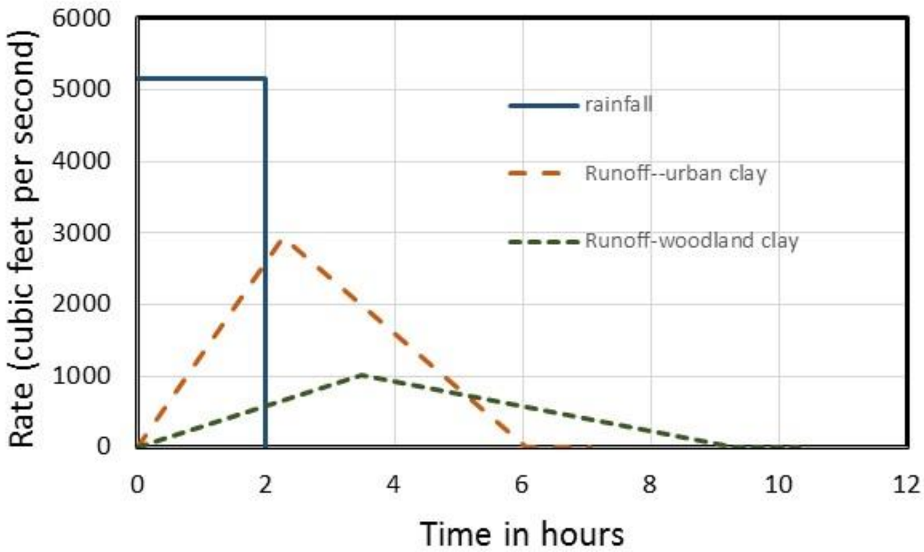


Figure 10.1
Rocks and images for the *Edmontosaurus* activity

Figure 10.2
Rock from the Gale Crater on Mars

Figure 10.3
A simplified Hjulström diagram and the results of a group of fourth, fifth, and sixth graders doing an activity similar to the one described in the “Lab Assignment” section but using only two sizes of particle

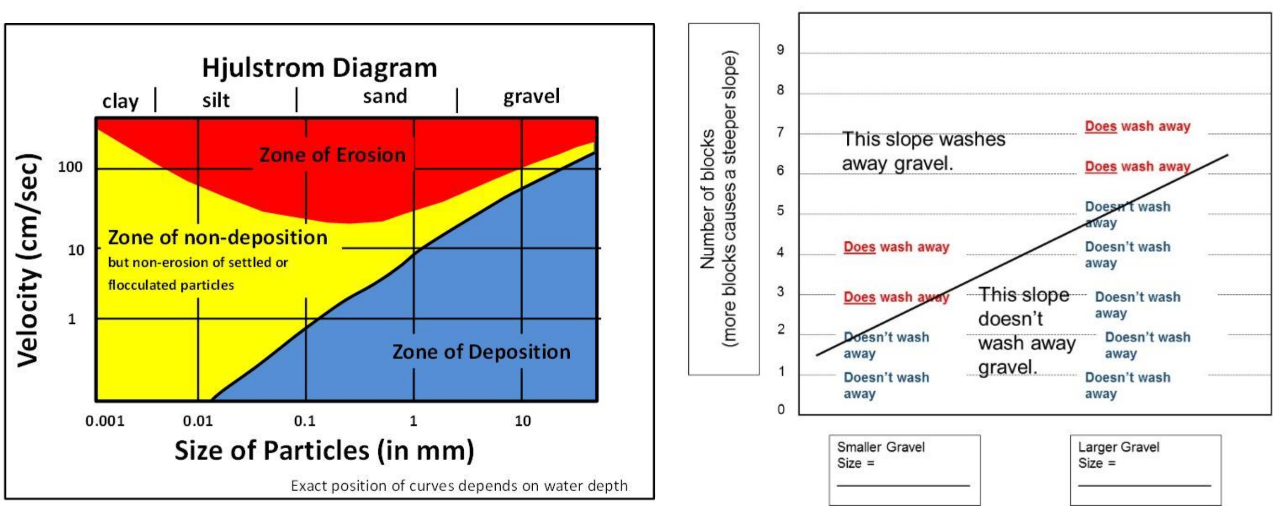


Figure 11.3
Science reasoning challenge for Powell's unit A rocks in the Grand Canyon

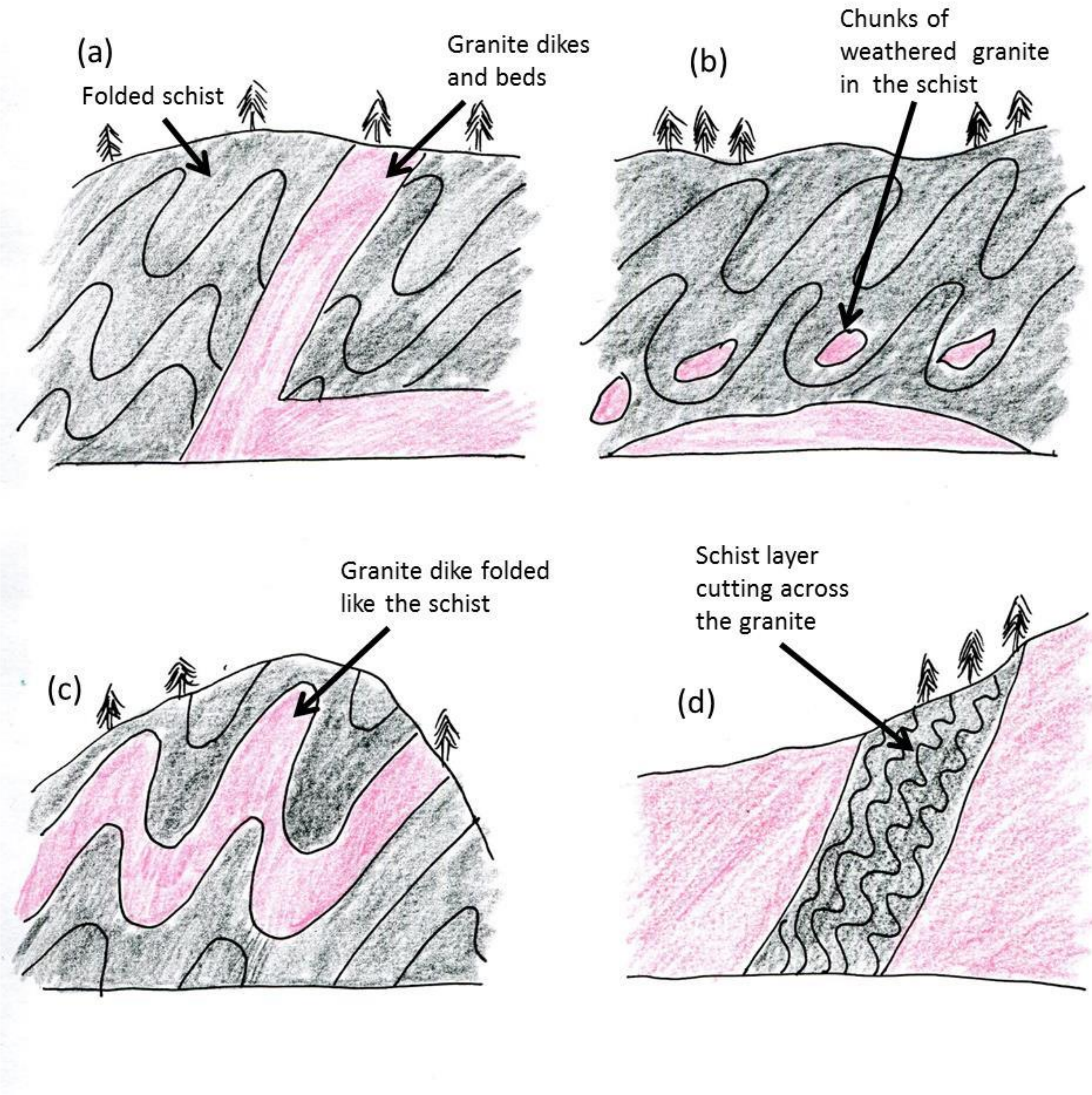


Figure 11.4
First science reasoning challenge for Powell's unit B rocks in the Grand Canyon

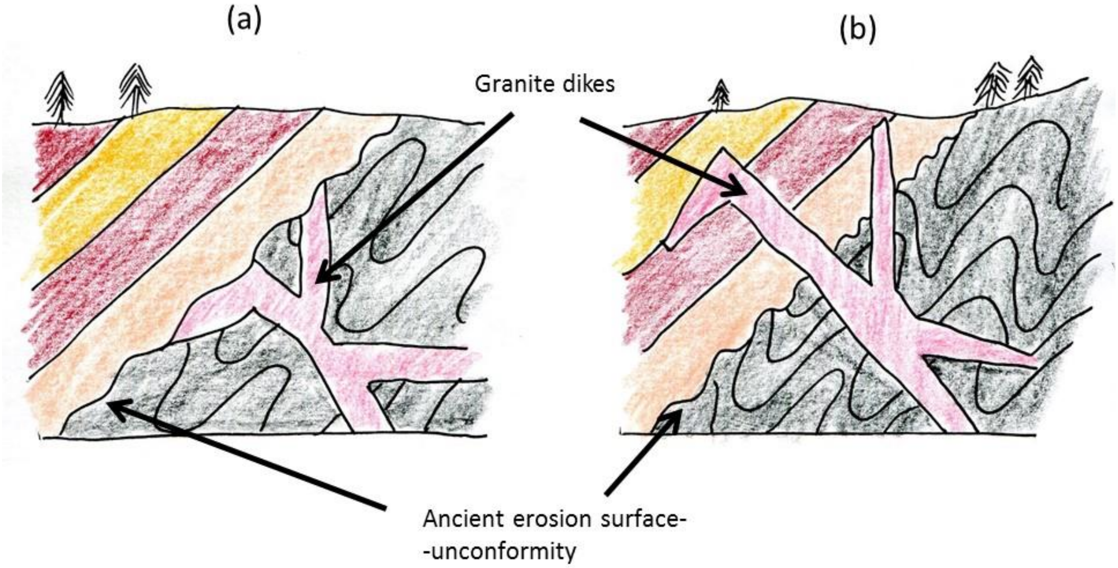


Figure 11.5
Second science reasoning challenge for Powell's unit B rocks in the Grand Canyon

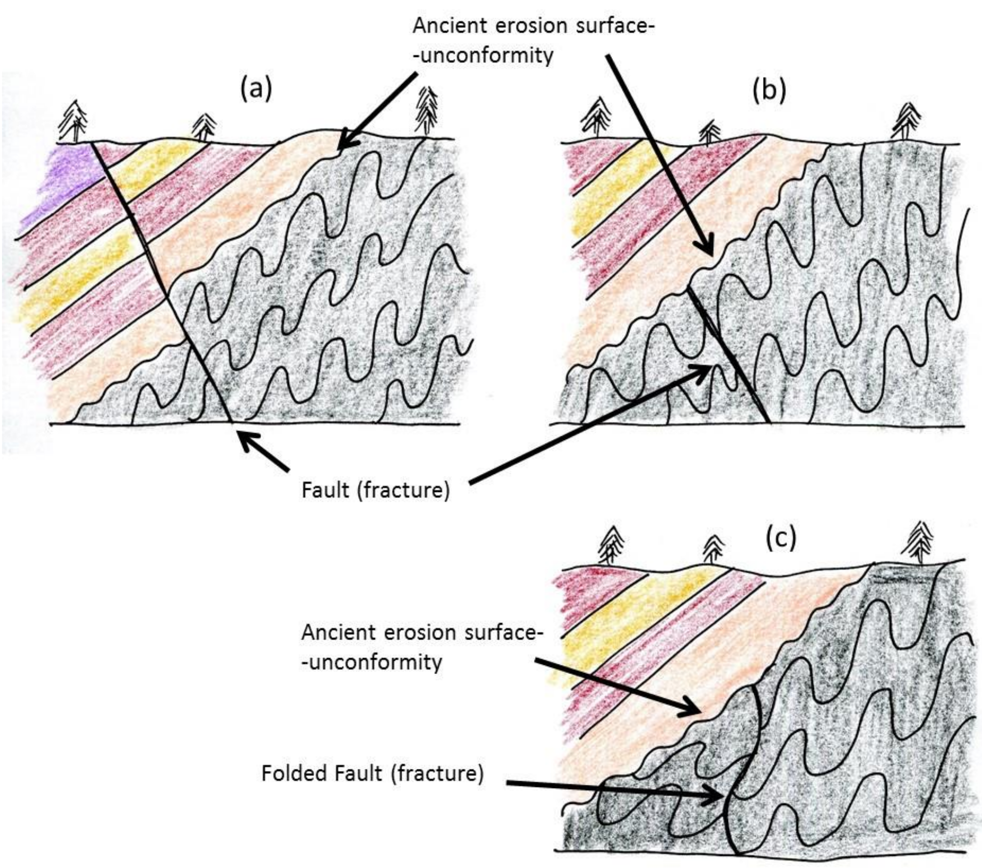


Figure 11.7
Modern cross-section illustration of the rocks at the Grand Canyon showing the relationship to Powell's units A, B, and C

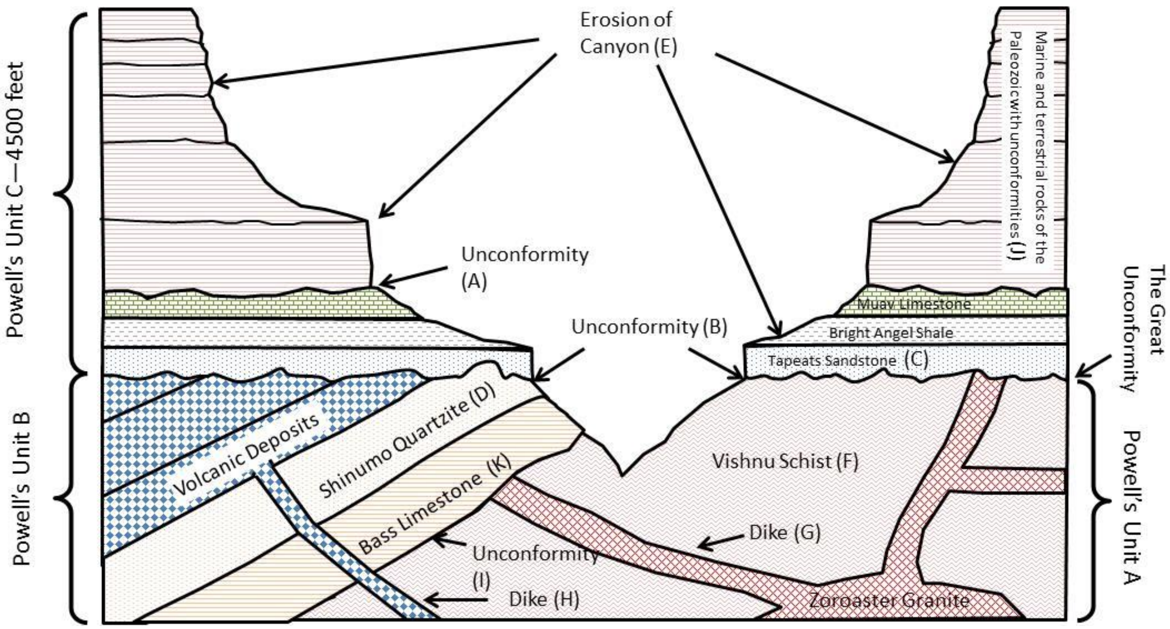


Figure 11.8
Pattern of sediment off the East Coast of the United States

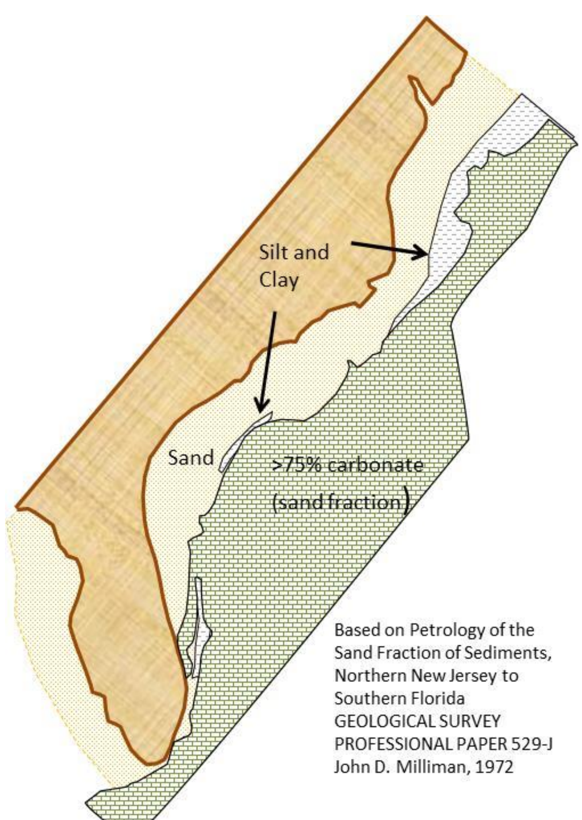
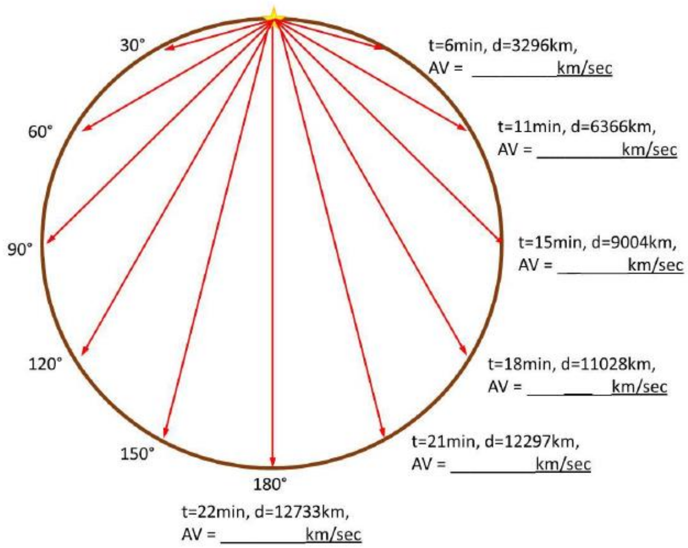


Figure 11.9
The Great Uncomformity: An angular uncomformity between Powell's unit B rocks and the overlying Tapeats Sandstone

Figure 12.3
Simple lab setup to allow students to use seismic methods to measure an unknown and unseen distance—the length of the nonlatex elastic band string hidden within the long box

Figure 12.4

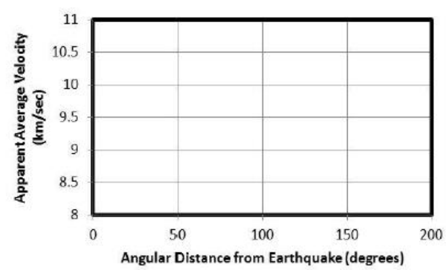
High school–level activity based on Richard Oldham's study of Earth's interior



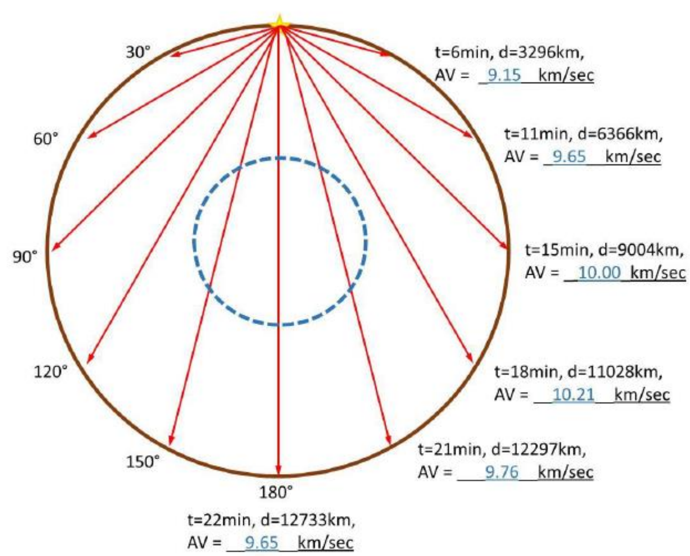
t = travel time for a P-wave to a seismograph that is 30°, 60°, 90°, 120°, 150°, and 180° from the earthquake, d = distance along chord, AV = apparent average velocity along chord. Values are from Oldham, 1906 for 'first phase' = P-wave.

Discovering the Earth's Core with Richard Oldham

1) Based on the measurements from Oldham, 1906, calculate the apparent average velocity (AV) of the P-wave along each chord.
2) Plot on the graph your velocities as a function of angular distance from the earthquake.
3) Identify at what angular distance the P-wave begins to pass through the core and explain how the result provides evidence for a core.
4) Draw the location of the core on the cross section of the Earth
5) Based on the data, is the velocity of P-waves in the part of the Earth above the core constant or does it change with depth?
6) If velocity changes with depth, how does it change and what is your evidence?



This activity, which uses data from Oldham's study to engage students in a real research investigation, illustrates how new data that do not fit within a preexisting model can be used to modify an old model or create a new one. In this case, the model of a homogeneous Earth gave way to a model of an Earth with a core. The angular values in the figure come from Oldham's original paper. Exact angular values—and size of the core—were refined by later studies.



t = travel time for a P-wave to a seismograph that is 30°, 60°, 90°, 120°, 150°, and 180° from the earthquake, d = distance along chord, AV = apparent average velocity along chord. Values are from Oldham, 1906 for 'first phase' = P-wave.

Discovering the Earth's Core with Richard Oldham

1) See values.
2) See graph..
3) Waves first pass through the core at an angular distance between 120 and 150 degrees. The sharp change in velocity indicates a different material at depth—the core.
4) See drawing.
5) The velocity of the P-wave changes with depth.
6) The P-wave velocity increases with depth, as seen by the increasing AV for waves that travel through deeper parts of the Earth's interior.

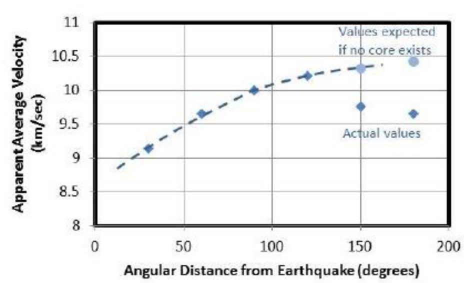
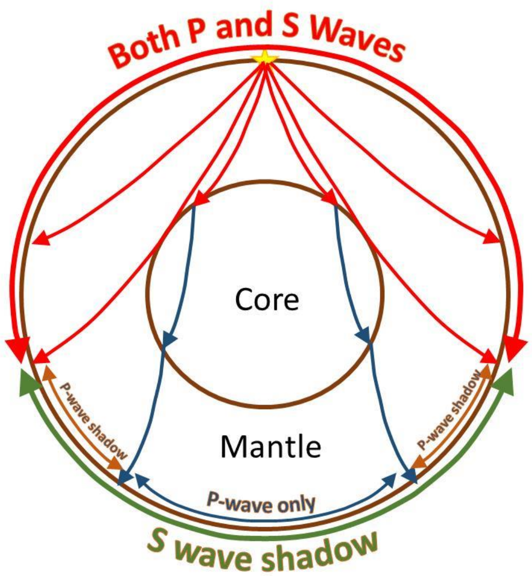


Figure 12.5

Illustration of the P- and S-wave shadow zones where P and S waves do not show up at seismic stations on the opposite side of the Earth from an earthquake



1) laboratory experiments show that S waves can't travel through liquids but do travel through solids;
2) seismographic observations show that S waves from earthquakes don't travel (directly) through the Earth's core; and
3) therefore, Earth's core must be liquid.

Figure 13.1

Common illustration of the phases of the Moon, as viewed from above the Earth's North Pole (sizes and distances of bodies are not to scale)

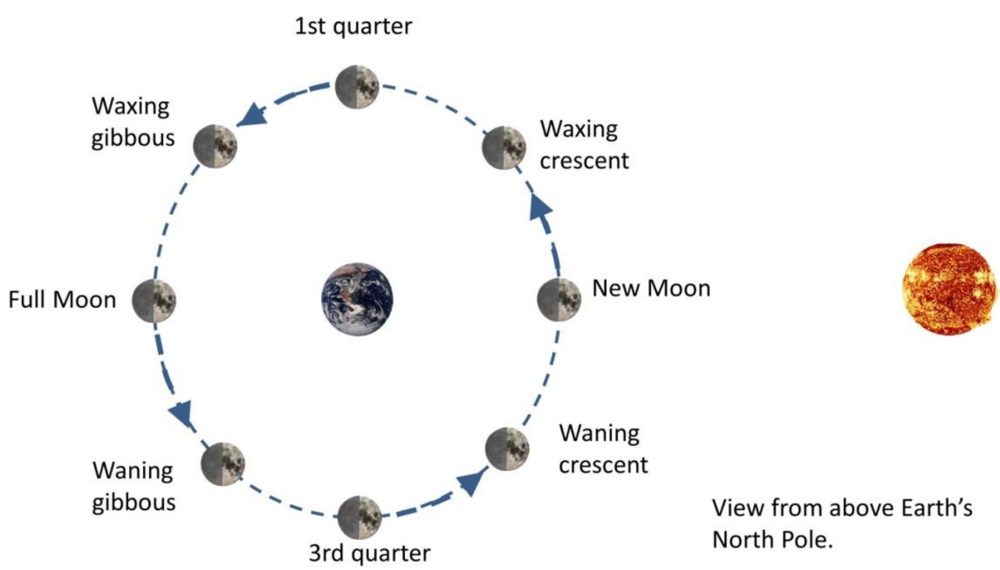


Figure 13.3

Illustration of a model for the phases of the Moon, showing the time of day at different locations on the Earth (e.g., midnight on the side of Earth away from the Sun and noon on the side of the Earth toward the Sun) (sizes and distances of bodies are not to scale)

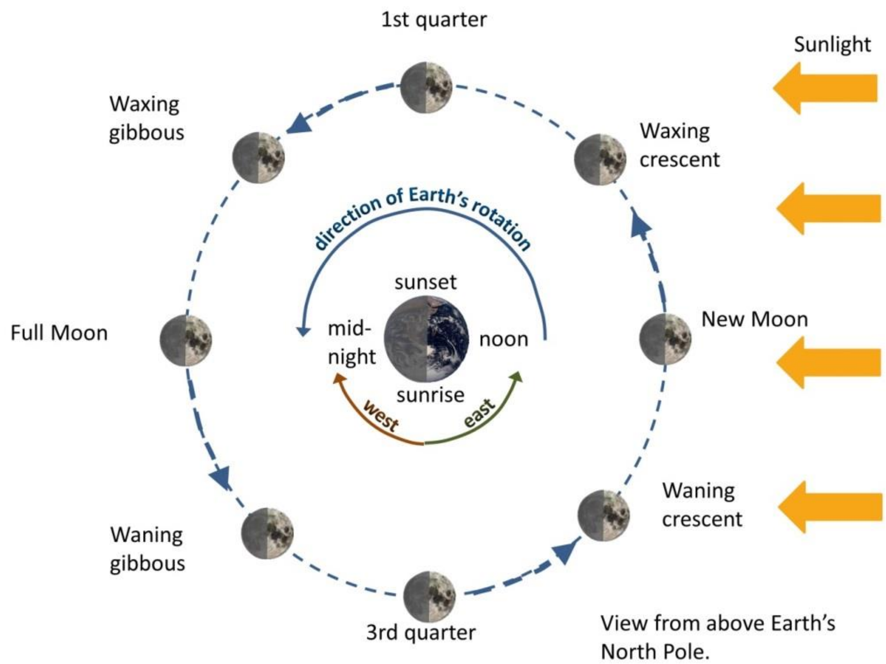


Figure 13.4

Illustration of a common misconception of the Ptolemaic (Earth-centered) model of the solar system, with only the Earth, Sun, Venus, and the Moon shown (sizes and distances of bodies are not to scale)

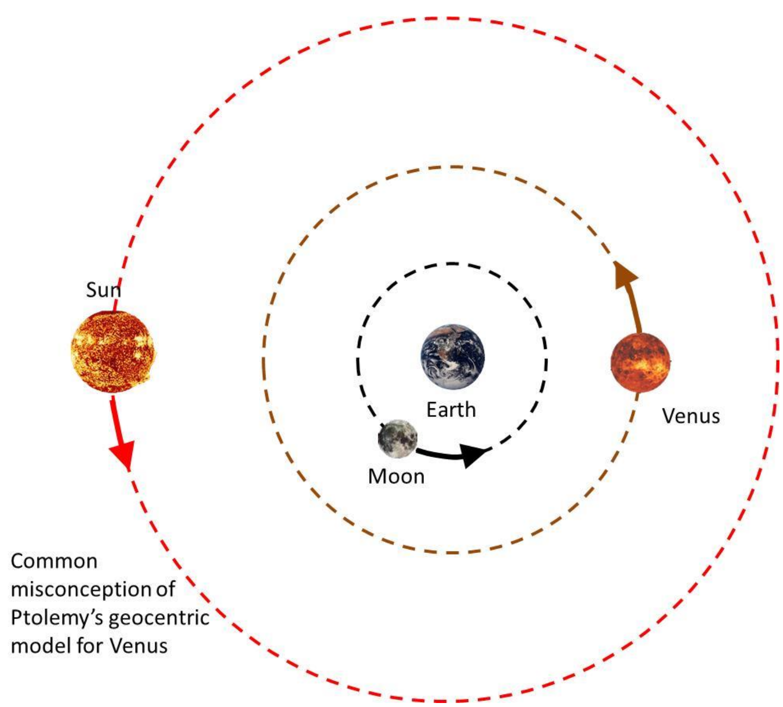


Figure 13.5
Illustration of the Ptolemaic model of the solar system, showing only the Earth, Sun, Venus, and Moon (sizes and distances of bodies are not to scale)

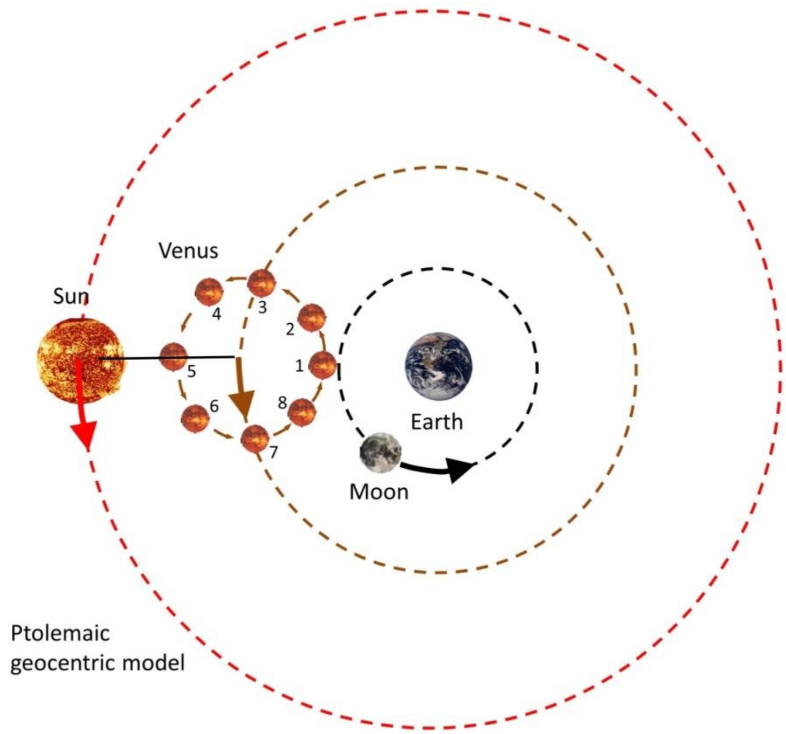


Figure 13.6
Simplified illustration of the Copernican (Suncentered) model of the solar system, showing the Earth, Sun, Venus, and Moon (sizes and distances of bodies are not to scale)

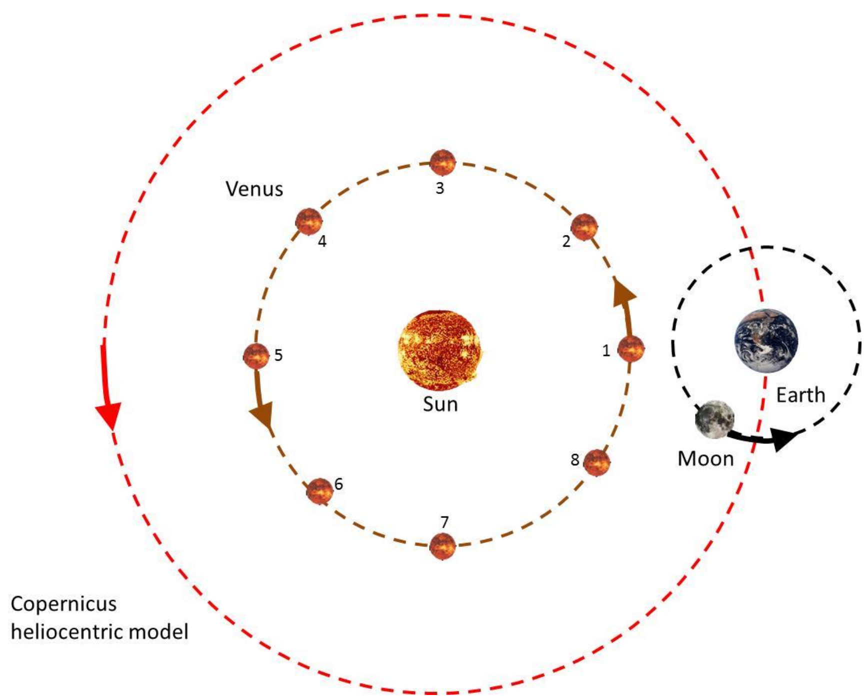


Figure 13.9
Model of the concept behind spectroscopy

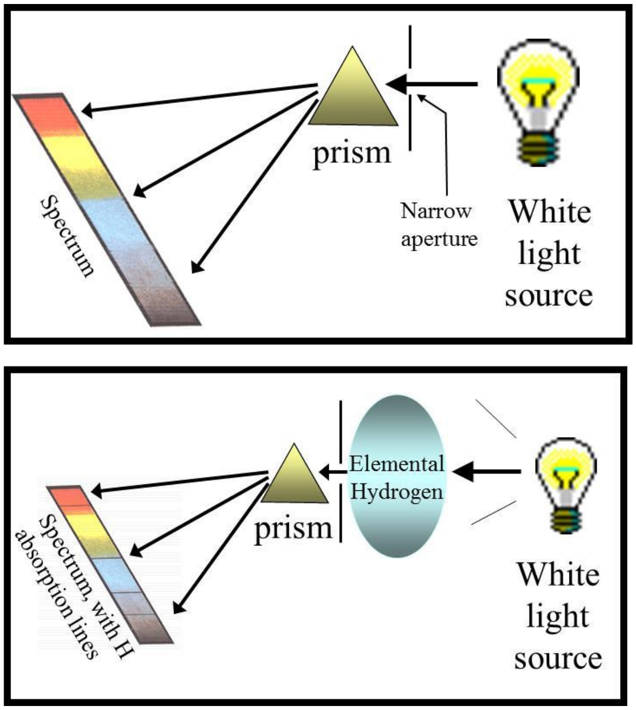


Figure 13.10
Example spectroscopy puzzle 1

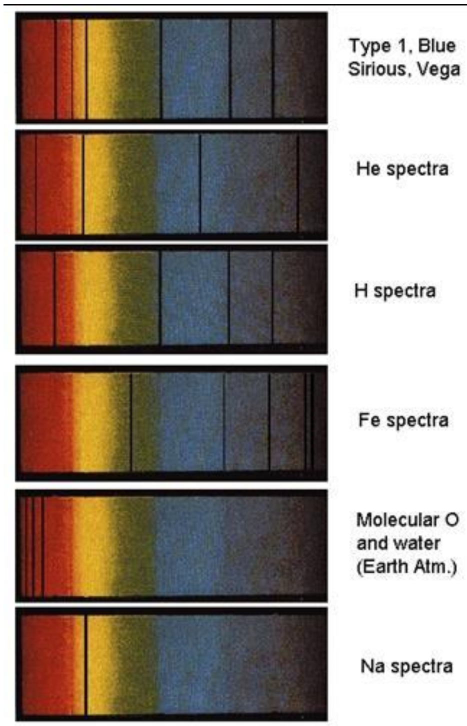


Figure 13.11
Example spectroscopy puzzle 2

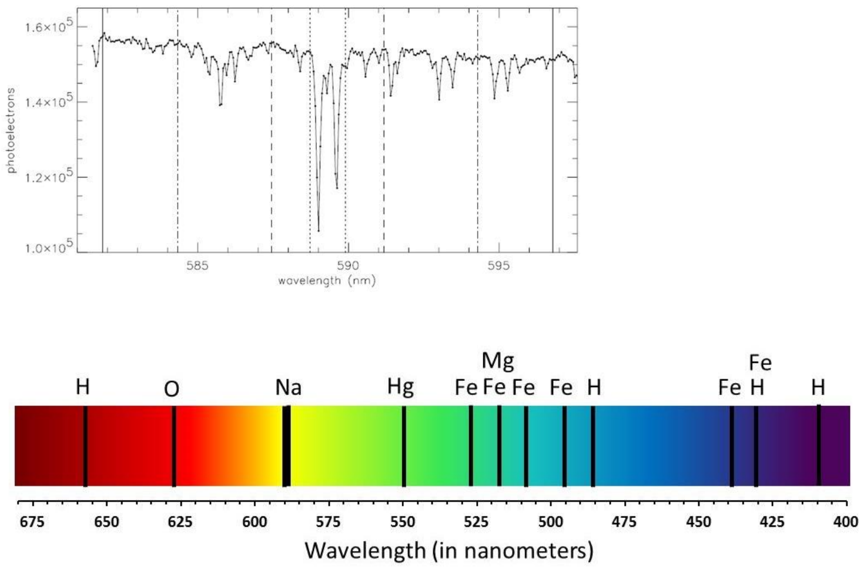


Figure 13.12
Using measurements and trigonometry to determine the angle between the Moon and the Sun

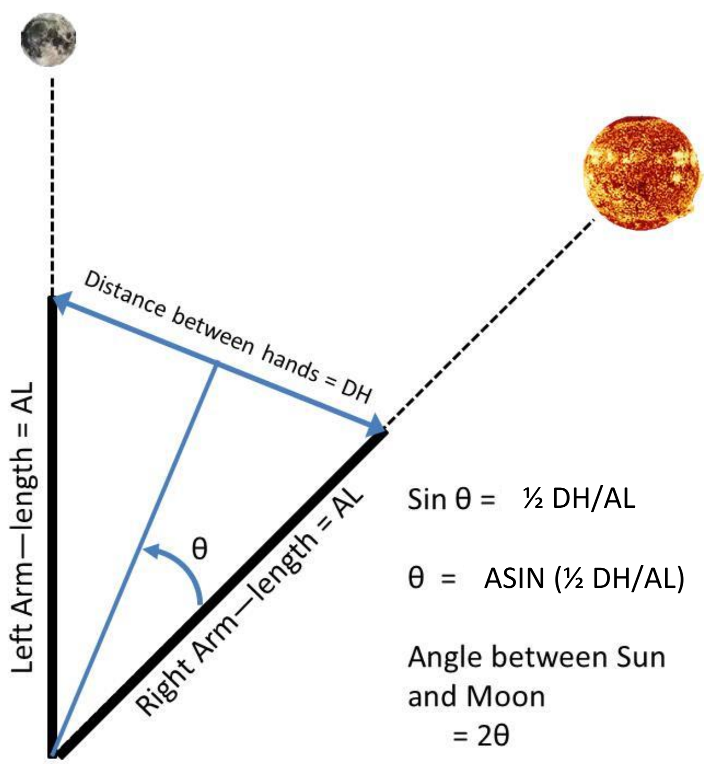
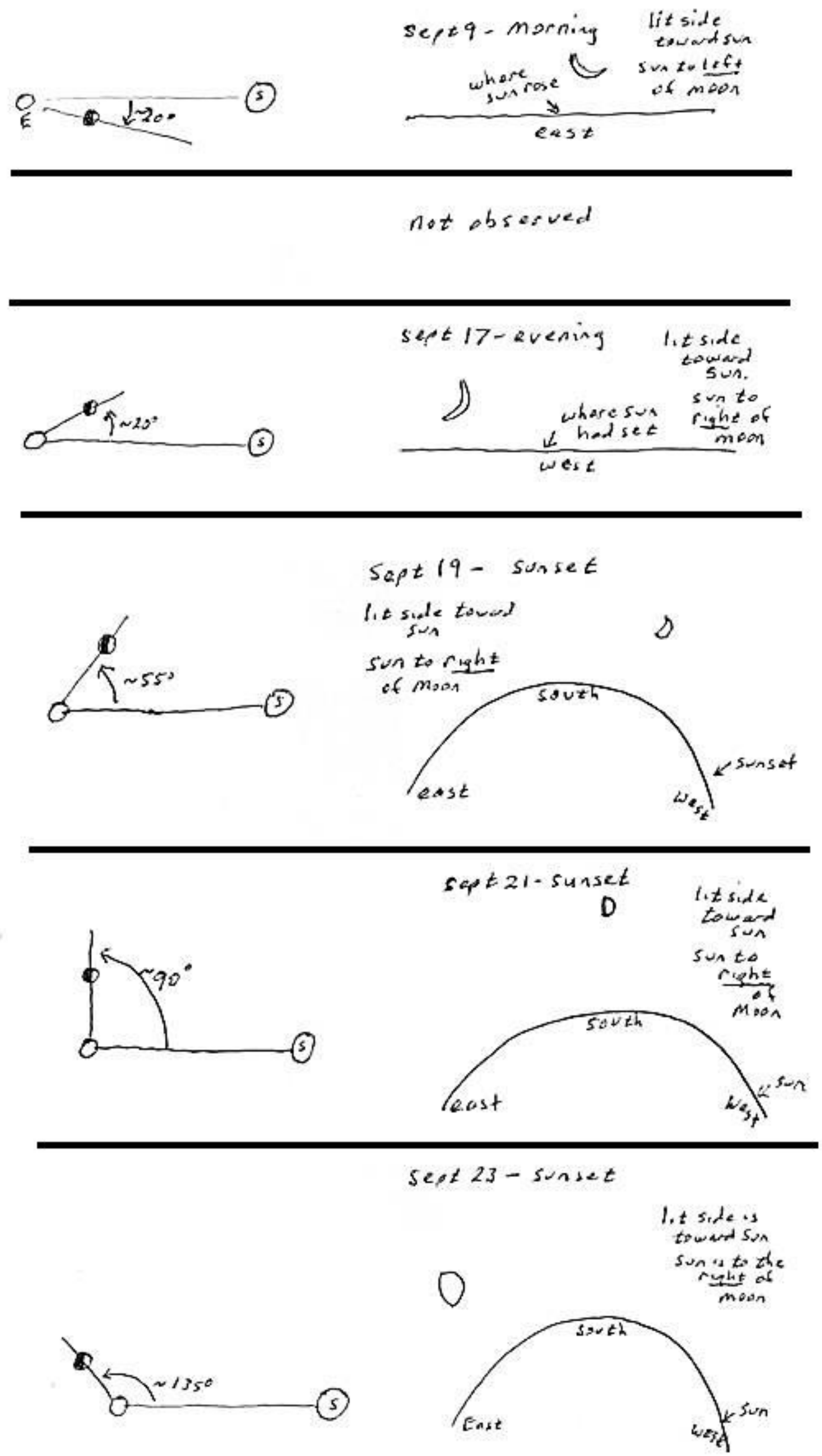
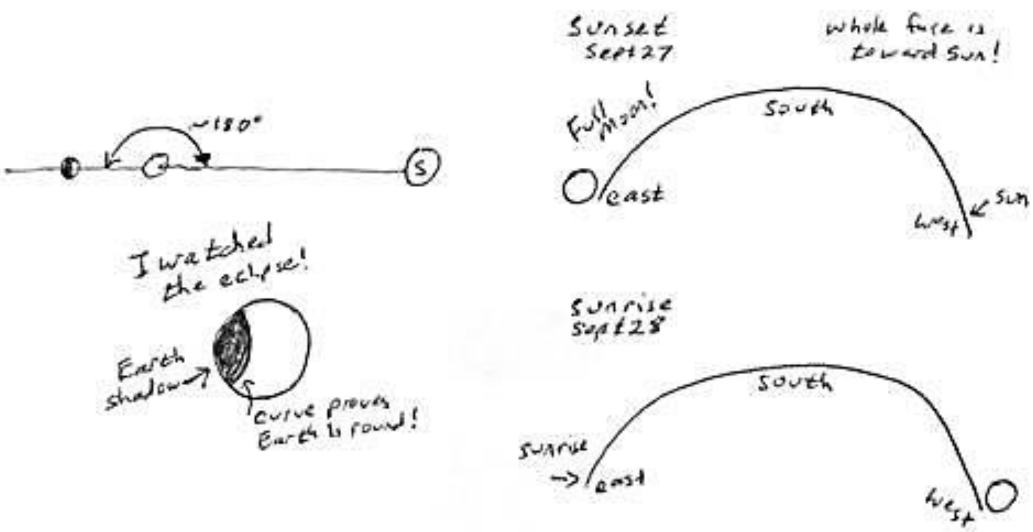
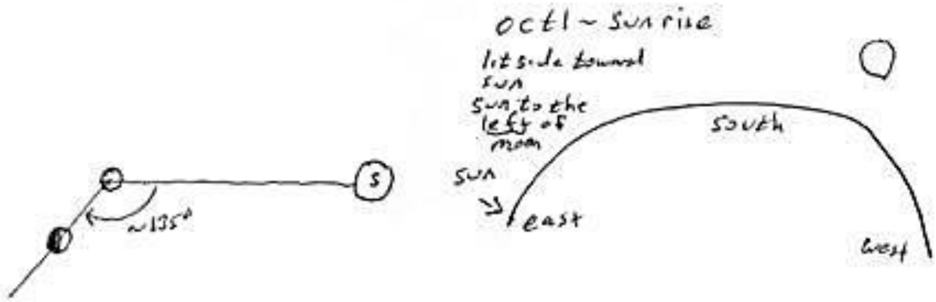
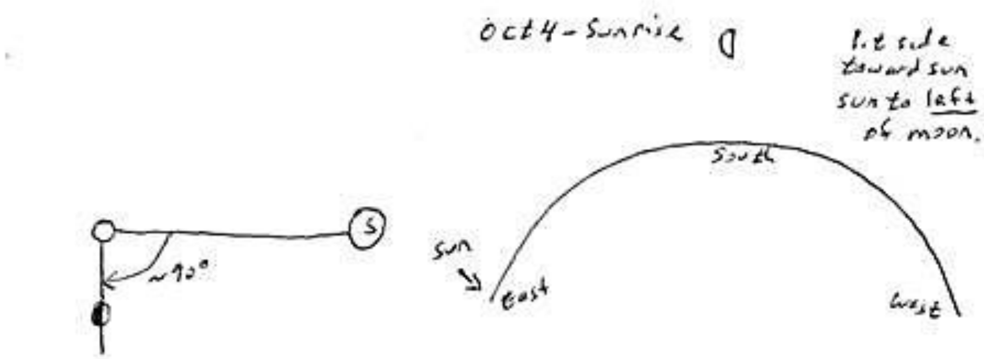


Figure 13.13
Example observational data record from which a lunar phase model can be constructed




~180°
S
I watched the eclipse!
Earth shadow
curve proves Earth is round!
Sunset Sept 27
whole face is toward Sun!
Full moon!
South
east
west
sun
sunrise Sept 28
south
sunrise
east
west


S
~135°
oct 1 ~ sunrise
lit side toward sun
sun to the left of moon
south
sun
east
west


S
~90°
oct 4 - sunrise
lit side toward sun
sun to left of moon.
South
sun
east
west

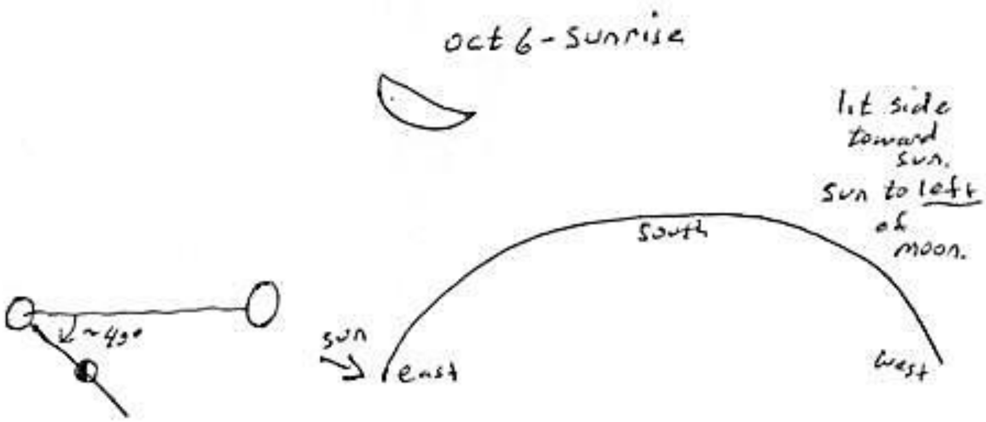
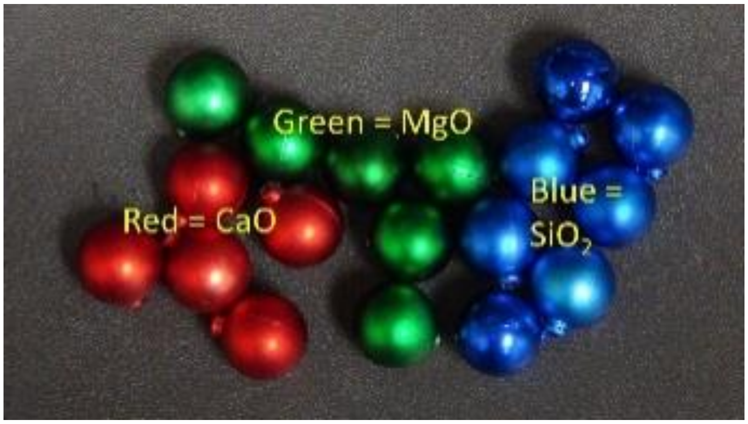

~45°
oct 6 - sunrise
lit side toward sun.
sun to left of moon.
South
sun
east
west

Figure 14.1
Illustration of a modeling puzzle in geochemical evolution



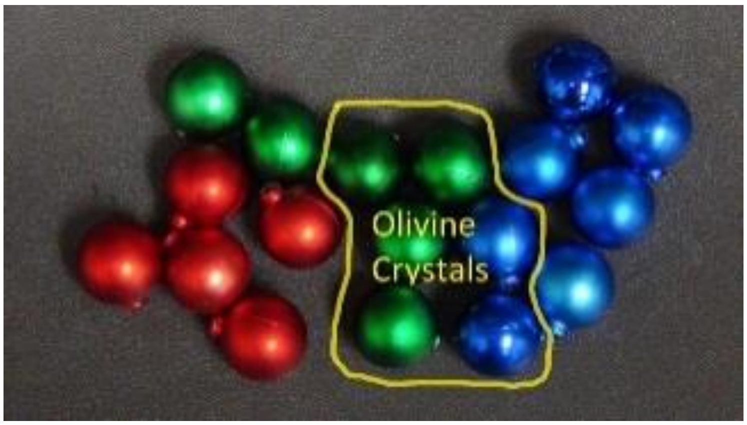


Figure 14.2
Illustration of a modeling puzzle in geochemical evolution similar to that in Figure 14.1, but starting with a different magma composition

Figure 14.6
Two experiments with two different kinds of sediment that address the question of whether the spilled pesticide will get into Grandma's well

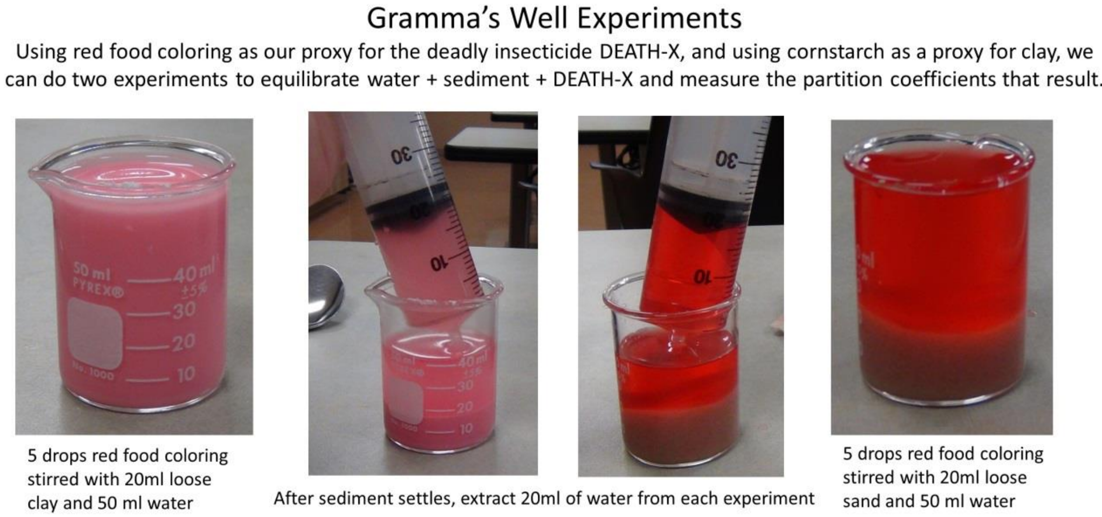


Figure 14.7
Manufacture of a set of standards by which the composition of water samples from the Grandma's well experiments can be measured

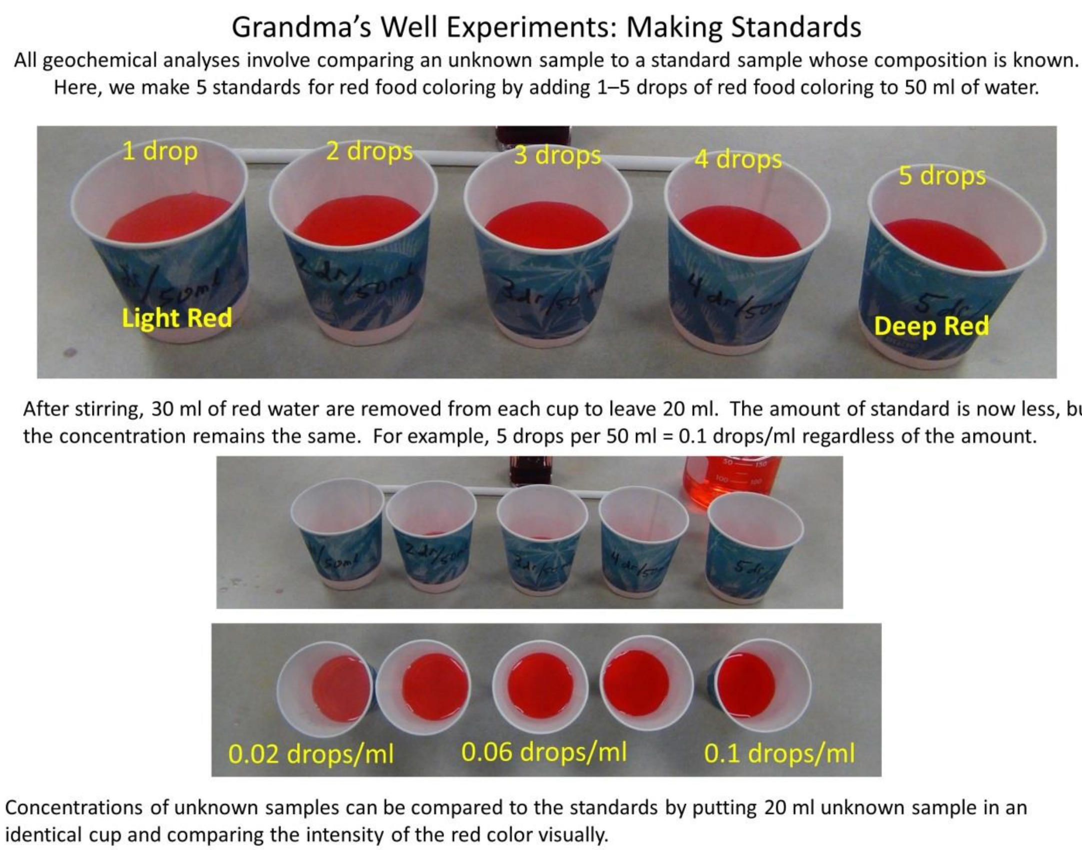


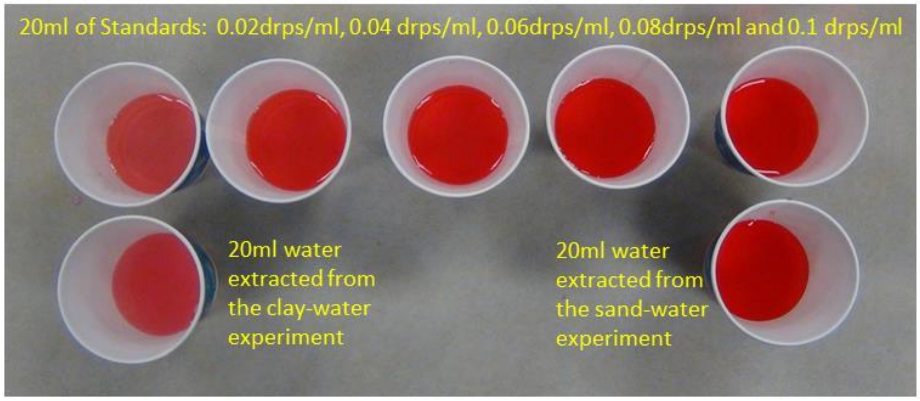
Figure 14.8
Illustration of the use of standards to analyze the concentration of red food coloring in the experimental water samples for the Grandma's well experiments

Gramma's Well Experiments—Analysis of Compositions

Samples of water from the two experiments are compared to the standards in order to determine the concentration of DEATH-X (red food coloring) in the water that equilibrated with sediment.

Concentration in clay (cornstarch) calculated by difference:

There is 1 drop of red food coloring in 50ml of water, leaving 4 of the original drops in 20ml of clay, for a concentration of 4drps/20 ml or 0.2drps/ml.



Concentration in sand calculated by difference:

There are 5 drops of red food coloring in 50ml of water, leaving 0 of the original drops in 20ml of sand, for a concentration of 0drps/20 ml or 0drps/ml.

Figure 14.9
Simplified version of Grandma's well experiment from Figure 14.6 for younger students or shorter duration

Gramma's Well Experiments—Qualitative Estimate of Partitioning

Results of experiments are estimated qualitatively without making standards or analyzing compositions
Might be more appropriate for middle school students

Light red color indicates that most food coloring stayed with the clay (cornstarch)

D clay/water > 1

20ml water extracted from the clay-water experiment

20ml water extracted from the sand-water experiment

Dark red color indicates that most food coloring stayed with the water.

D sand/water < 1

Figure 14.10
Model of a magmatic process and a hydrothermal process to concentrate gold

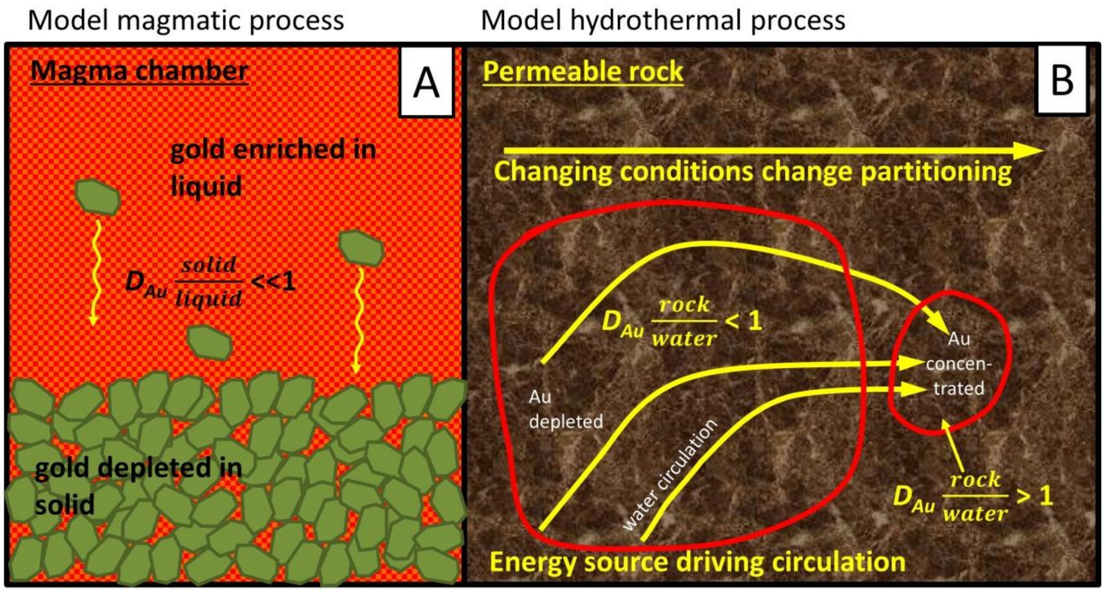


Figure 15.4
Illustration of the nested relationship among the three *NGSS* earth science DCIs, with superimposed big ideas

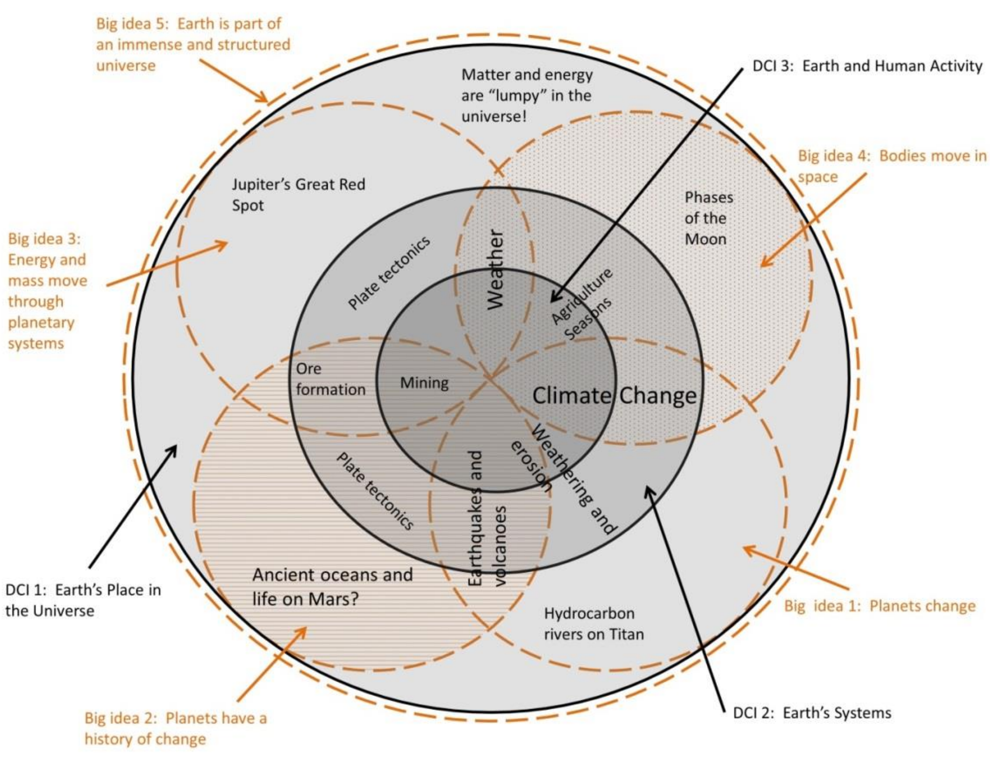


Figure 16.1
Delta feature in a farm field associated with a storm that hit northwestern Minnesota in June 2000, showing the relationships that were necessary to figure out before developing the question-asking game

Surfaces A, C, and E formed by wave action eroding into the farm field at a variety of water levels.

Gully B eroded downward rapidly because it was above the level of the standing water

The flat-topped feature D is a delta formed as sediment filled in a low area up to the surface of the standing water.

Because these features are related to changing water level as the water evaporated and/or soaked into the ground, the first events took place at the highest water level (A and D) and the later events at lower water level (C and E).

The wave-cut shoreline of the little pond cuts across the trend of the planted rows--so, the planted rows had to come first.

There isn't much dead plant material poking up from the pond. Thus, little if any plant growth had occurred before the storm and the water suppressed any growth subsequent to the storm.

Figure 16.2
Compression experiments with a Milky Way bar at room temperature

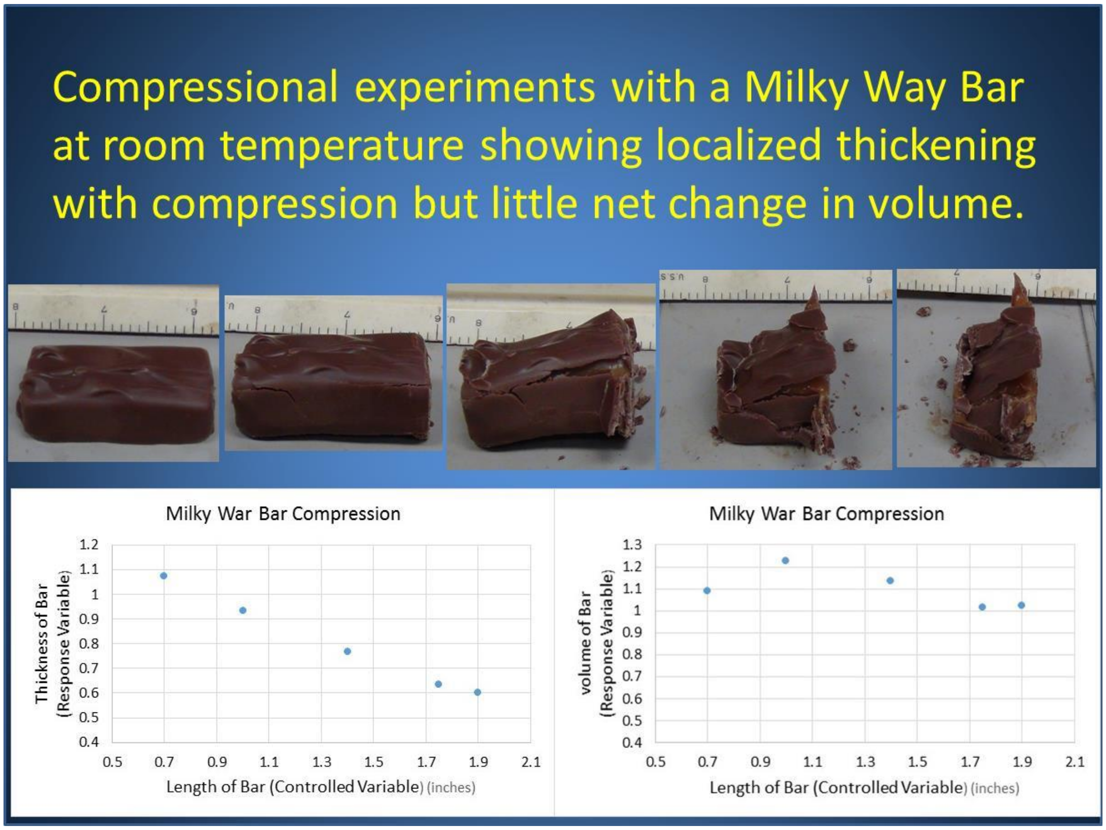


Figure 16.3
Compression experiments with a Milky Way bar at three different temperatures