Section Objectives

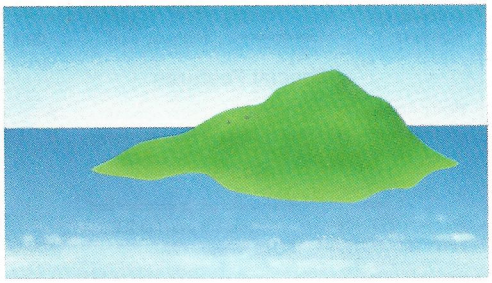
- **Explain how elevation and topography can be shown on a map.**
- **Interpret a topographic map.**

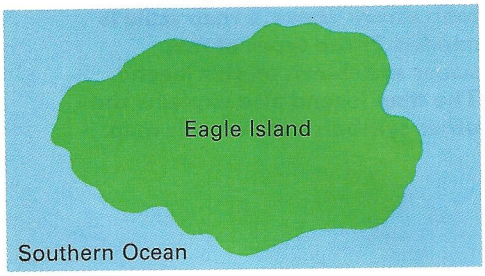
3.3 Topographic Maps

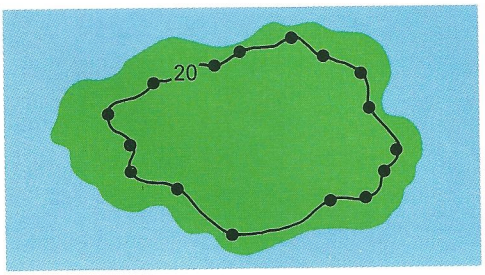
A type of map that is especially useful in earth science is called a **topographic map.** Topographic maps show the surface features, or **topography,** of the earth. Most topographic maps show both natural features, such as rivers and hills, and constructed features, such as buildings and roads.

The top illustration in Figure 3–9 shows a side view of an island in the ocean. The drawing shows a hill on the island, but it does not indicate the size of the island or the height of the hill. The middle illustration shows the same island on a political map. The map shows the shape of the island at sea level and the relative length and width of the island. However, the political map gives no information about the height of the island, the steepness of its slopes, or the shape of the land above sea level. A topographic map provides more detailed information about the surface of the island than either the drawing or the political map does.

Figure 3–9. A drawing gives little information about the surface of the island (top). A political map shows only the shape of the island (middle). To start making a topographic map of the island, a topographer connects points at an elevation of 20 m above sea level to form a contour line (bottom). In the completed map (right), additional contour lines have been drawn. An *X* marks the highest point.





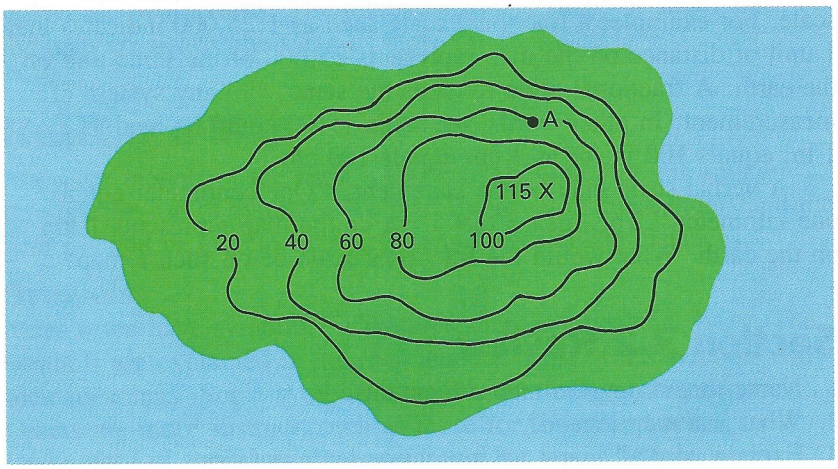


Making a Topographic Map

A topographic map of the island shows the **elevation,** or height above sea level, of various island locations. Elevation is measured from **mean sea level,** the point midway between the highest and lowest tide levels of the ocean. The elevation at mean sea level is zero. Other elevations are measured as distances above or below mean sea level.

Contour Lines

On topographic maps, **contour lines** are used to show elevation. Each contour line connects all points on the map that have the same elevation. For example, one contour line would connect all points on the map that have an elevation of 100 m. Another line would connect all points with an elevation of 200 m. Because all points at any given elevation are connected, the shape of the contour lines reflects the shape of the land.



Contour Intervals

The difference in elevation between one contour line and the next is called **contour interval.** A cartographer chooses a contour interval suited to the size of the map and the **relief** of the land. Relief is the difference in elevation between the highest and lowest points of the area being mapped. On maps of mountainous areas where the relief is high, the contour interval may be as large as 50 m or 100 m. Where the relief is low, the interval may be only 1 m or 2 m.

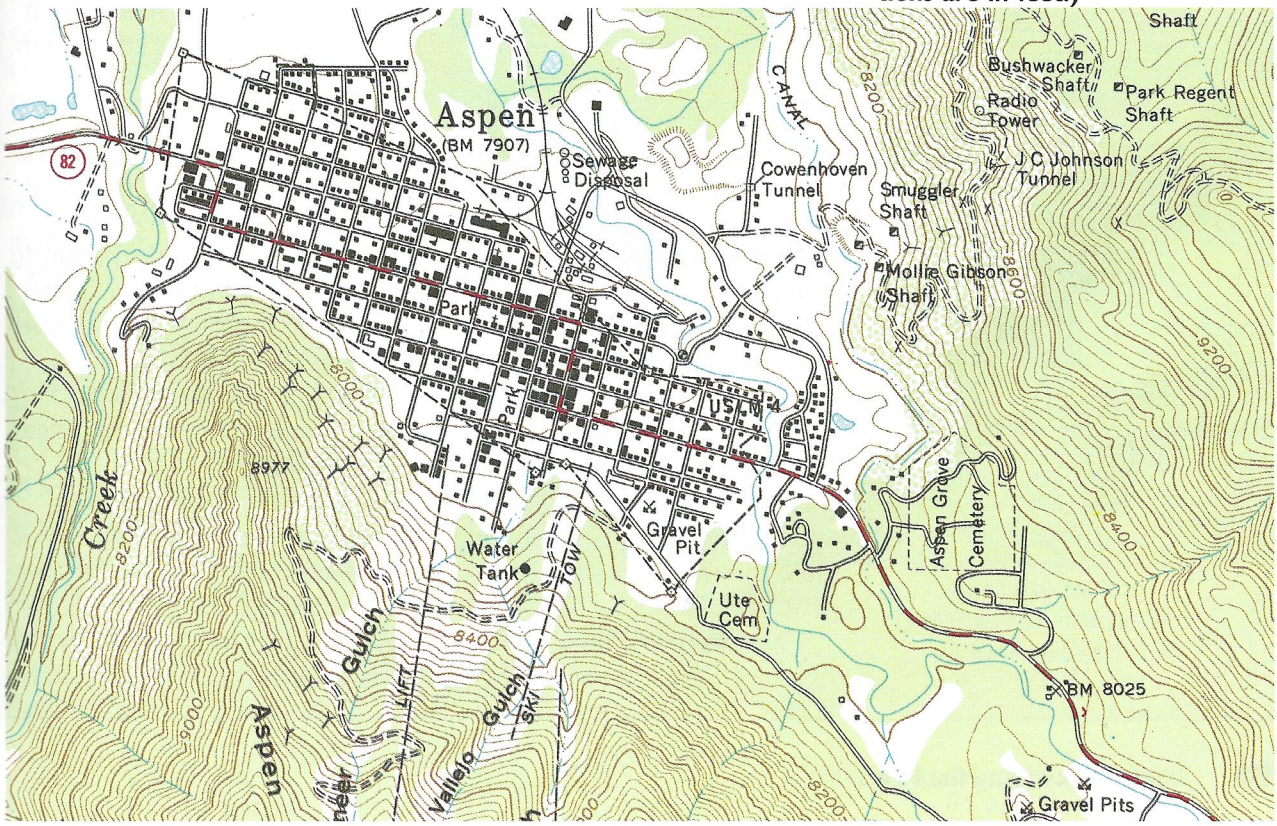
In mapping the island shown in Figure 3–9, the map maker chooses a contour interval of 20 m. The map maker then marks a series of points surveyed at 20 m above sea level and connects the points with a contour line. Next the map maker marks points and contour lines for elevations of 40, 60, 80, and 100 m. The shoreline serves as the contour line for points at sea level. The completed topographic map in Figure 3–9 shows the elevation of the island and the general shape of the land above sea level. Find point *A* on the map. What is its elevation?

Interpreting a Topographic Map

Just as printed words on a page transmit ideas, contour lines and other symbols on topographic maps give a picture of the earth's surface. Because of the specialized nature of topographic maps, some training and practice are needed in order to read and interpret these maps accurately.

The United States Geological Survey (USGS), a branch of the federal government, has made topographic maps for virtually all of the United States. These detailed maps are called *topographic sheets,* or *quadrangles*. The earlier series of USGS maps represent

Figure 3–10. This portion of a topographic sheet produced by the USGS shows the area around Aspen, Colorado. (Note: elevations are in feet.)



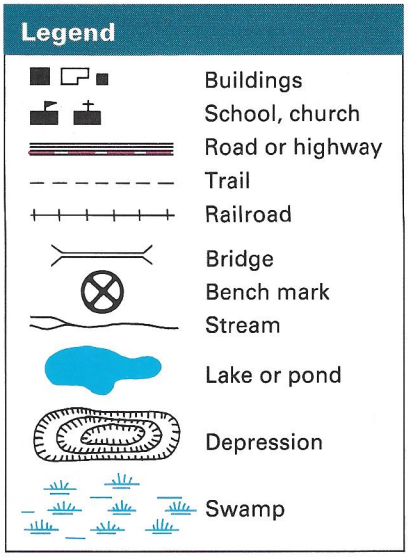


Figure 3–11. Symbols used on topographic maps represent both natural and constructed features.

quadrangles that cover 15′ of latitude and 15′ of longitude. The newer series of maps represent quadrangles that cover 7.5′ of latitude and 7.5′ of longitude. The 7.5′ topographic sheets show a smaller area than the 15′ sheets, but with greater detail.

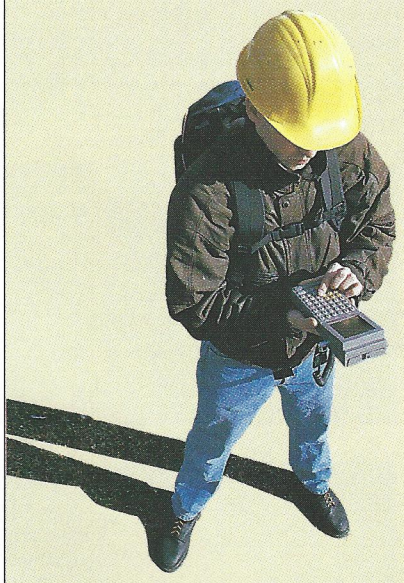
As shown in Figure 3–11, symbols are used to show certain features on topographic maps. Different colors are used for different types of symbols. In general, constructed features, such as buildings, roads, and railroads, are shown in black. Major highways are shown in red. Bodies of water are shown in blue, and forested areas are printed in green. Contour lines are shown in brown.

On most topographic maps, direction is found by following lines of latitude and longitude. On maps published by the USGS, north is located at the top of the map and marked by a parallel of latitude. The southern boundary, at the bottom of a map, is also marked by a parallel. At least two additional parallels are usually drawn in or indicated by cross hairs (+) at 2.5′ intervals.

Meridians of longitude indicate the eastern and western boundaries of USGS maps. Additional meridians may also be shown. All parallels and meridians shown on these maps are labeled in degrees and minutes.

SCIENCE & TECHNOLOGY

Navstar: A Global Positioning System



▲ GPS receivers equipped with minicomputers have revolutionized surveying techniques.

Have you ever been lost in the woods? Even with a compass and a topographic map, most people would still have difficulty guiding themselves through a wilderness area without a trail. Realizing that this is true for military personnel as well, the United States Department of Defense designed *Navstar,* which stands for *Nav*igation *S*atellite *T*racking *a*nd *R*anging. Over 20 years in the making, the recently completed *Navstar* Global Positioning System, or GPS, may make compasses obsolete.

Navstar provides a way to pinpoint a location anywhere in the world with a small, relatively inexpensive radio receiver. The *Navstar* system consists of 24 satellites that orbit the earth at an altitude of about 20,000 km. Each satellite transmits high-frequency radio waves, or microwaves, containing precise information about its position and the time of day. A GPS receiver uses this information to calculate its distance, or range, to several satellites. The receiver then determines its three-dimensional location by finding the common intersection point of these ranges.

Since *Navstar*'s introduction, many new applications have been explored. For example, meteorologists are able to use GPS signals to measure the temperature and water content

Distance on Topographic Maps

As on other maps, distance on topographic maps is determined by referring to the map scale. A common scale used on USGS maps is 1:24,000. Based on this scale, 1 in. on the map is equal to 2,000 ft. on the earth's surface. You can use a ruler to measure distances on the map and then convert the inches to feet or miles. If a graphic scale is used, you can mark off distance on a piece of paper and then compare it with the scale.

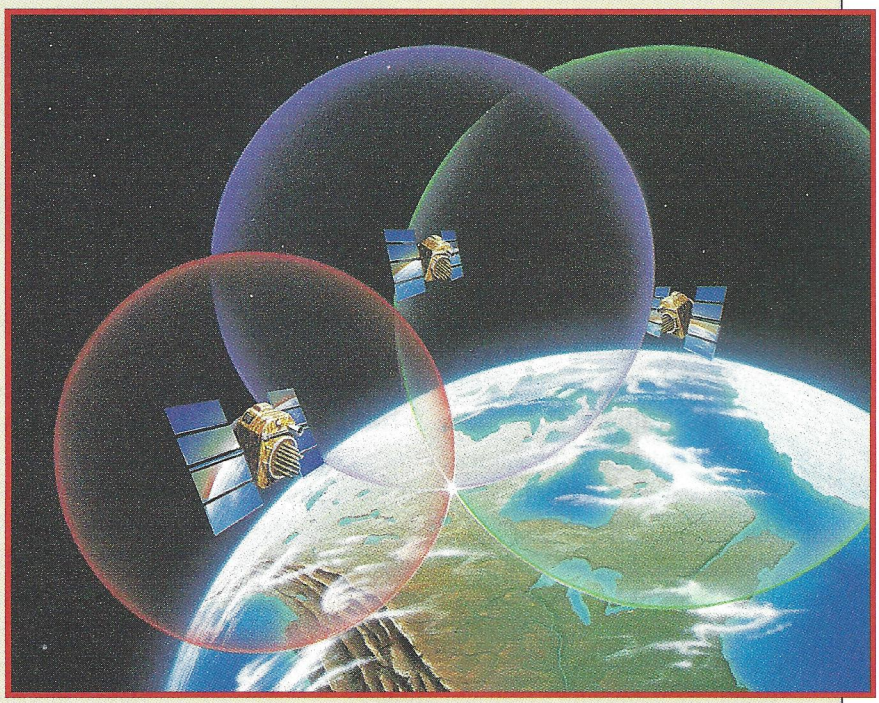
Elevation on Topographic Maps

On a topographic map, the contour interval determines the elevation at which each contour line is drawn. If the contour interval is 10 m, contour lines will be shown for elevations of 10, 20, 30, 40, 50, 60 m, and so on. To make reading the map easier, every fifth contour line is printed bolder than the others. These lines are called **index contours** and are labeled by elevation. A point located between two contour lines has an elevation somewhere between the elevations of the two lines. For example, if a point is located halfway between the 50-m and 100-m contour lines, its elevation is approximately 75 m. Exact elevations are marked by an × and labeled.

of the atmosphere, surveyors are able to monitor deformation of the earth's crust caused by tectonic motion, and geologists can cheaply and precisely map changes in the Greenland ice sheet to understand global climatic changes.

More common applications of *Navstar* include an in-car navigation system that combines a GPS receiver with a computerized map display. The system not only determines the best route to follow but also tells the driver when to turn. Similar systems may one day serve as navigation aids for visually impaired people.

How does the information provided by a compass differ from that provided by a GPS receiver?



▲ Finding the intersection point of three spheres is the geometric basis for a GPS.

Landforms on Topographic Maps

By studying the spacing and the direction of contour lines, you can also determine the shapes of landforms shown on a topographic map. Contour lines spaced widely apart indicate that the change in elevation is gradual and that the land is relatively level. Closely spaced contour lines indicate that the change in elevation is rapid and that the slope is steep. Contour lines that are almost touching indicate a very steep slope or cliff. Evenly spaced contour lines indicate that the slope increases at about the same angle over a great distance. Find point *B* on the map in Figure 3–12. How would you describe the change in elevation in the area around point *B*?

Contour lines that bend to form a V-shape indicate a valley. The V points toward the higher end of the valley. If a stream or river flows through the valley, the V in the contour lines will point upstream, or in the direction from which the water flows. A river al-

SMALL-SCALE INVESTIGATION

Topographic Maps

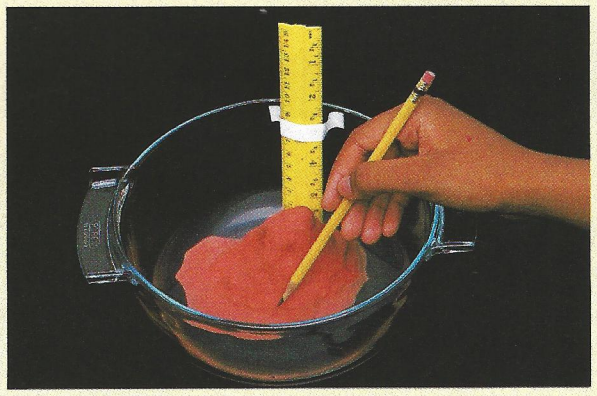
Contour lines show elevation and landforms on topographic maps. You can use contour lines to make a topographic map of a model mountain.

Materials

modeling clay (1–2 lb.); paper clip; large waterproof container, at least 8 cm deep; water; ruler; pencil; adhesive or masking tape

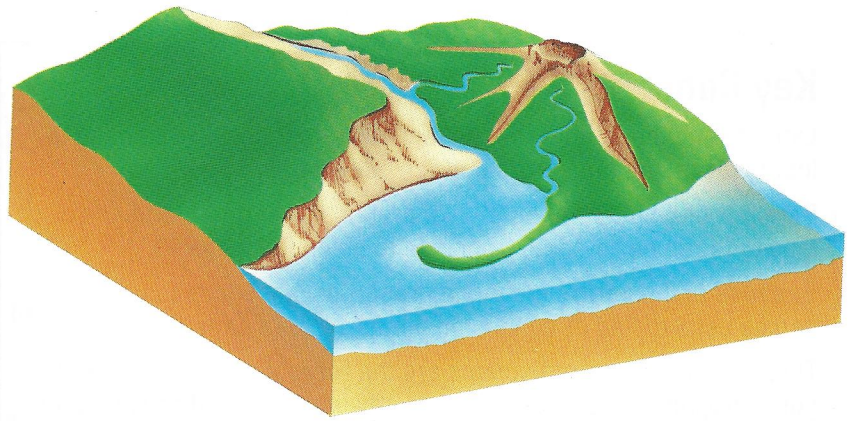
Procedure

1. Make a mountain 6–8 cm high out of modeling clay. Work on a flat surface and smooth out the mountain's shape, making the mountain slightly steeper on one side.
2. Run a paper clip down one side of the model to form a valley several millimeters wide.
3. Place the model in the center of the container. Tape the ruler upright in the container with one end resting on the bottom of the container. Make sure the container is resting on a level surface.
4. Add water to the container to a depth of 1 cm, using the ruler as a guide. With a sharp pencil, trace around the model and inscribe the clay along the waterline as shown above.
5. Raise the water level 1 cm at a time until you reach the top of the model. Each time you add water to the container, inscribe another contour line in the clay where the waterline meets the model.
6. When finished, carefully drain the water and remove the model from the container.



Analysis and Conclusions

1. What is the contour interval on your model?
2. Observe your model from directly above. Try to duplicate the size and spacing of the contour lines on a sheet of paper.
3. Compare the contour lines on a steep slope with those on a gentle slope. How do they differ?
4. How is a valley represented on your topographic map?



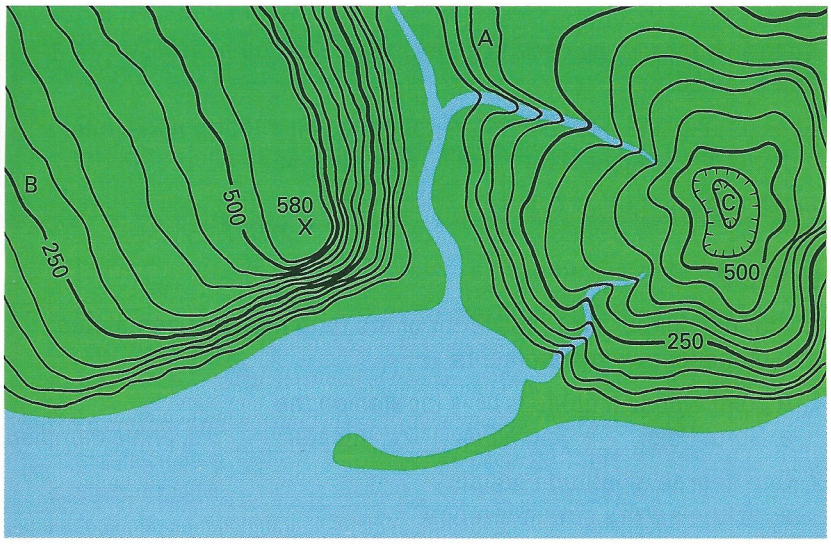


Figure 3–12. The features of the coastal valley shown in the diagram above are represented by contour lines on the topographic map below. What are the elevations at *A* and *X*?

INVESTIGATE!

To learn more about topographic maps, try the In-Depth Investigation on pages 58–59.

ways flows from higher to lower elevation. The steeper the course of the river or stream, the closer together are the contour lines that cross it. The width of the valley is shown by the width of the V formed by the contour lines.

Contour lines that form closed loops indicate a hilltop or a depression. To avoid confusion, a depression is usually shown by **depression contours,** which are marked with short, straight lines. These lines are drawn along the inside of the loop and point toward its center, indicating the direction of depression. Find point *C* on the map in Figure 3–12. Is it located on a hilltop or in a depression?

Section 3.3 Review

1. How is elevation shown on a topographic map?
2. Define *contour interval*.
3. How would you determine the elevation of a point that falls between two contour lines?
4. How is a depression shown on a contour map?
5. Why are topographic maps useful to someone who wishes to study earth science?