Section 2.2

Objectives

- **Compare and contrast** different types of maps.
- **Explain** why different maps are used for different purposes.
- **Calculate** gradients on a topographic map.

Review Vocabulary

parallel: extending in the same direction and never intersecting

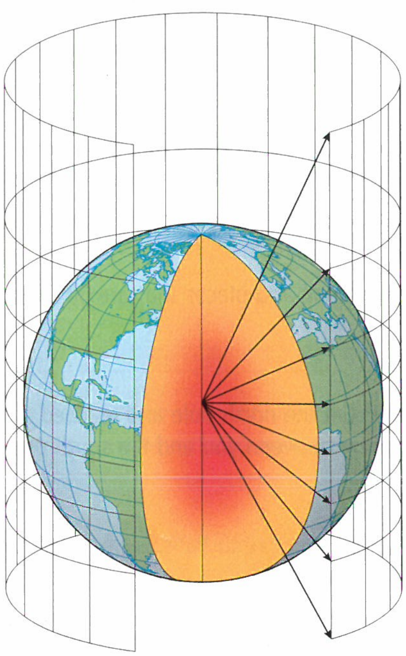
New Vocabulary

Mercator projection
conic projection
gnomonic projection
topographic map
contour line
contour interval
geologic map
map legend
map scale

Concepts In Motion

Interactive Figure To see an animation of map projections, visit glencoe.com.

Figure 2.5 In a Mercator projection, points and lines on a globe are transferred onto cylinder-shaped paper. Mercator projections show true direction but distort areas near the poles.



Types of Maps

MAIN Idea Maps are flat projections that come in many different forms.

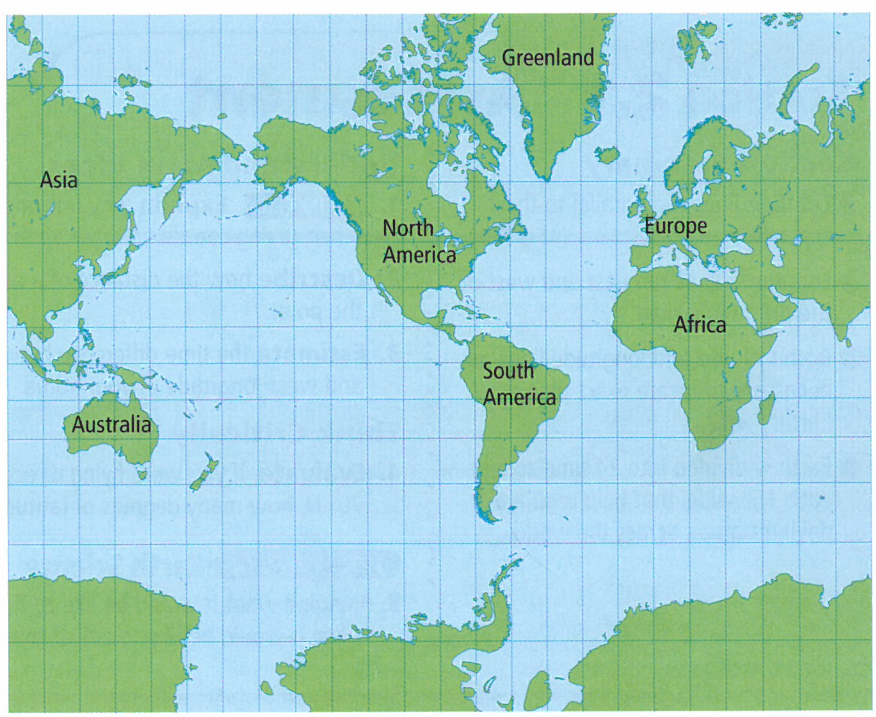
Real-World Reading Link Just as a carpenter uses different tools for different jobs, such as a hammer to drive in a nail and wrench to tighten a bolt, a cartographer uses different maps for different purposes.

Projections

Because Earth is spherical, it is difficult to represent on a piece of paper. Thus, all flat maps distort to some degree either the shapes or the areas of landmasses. Cartographers use projections to make maps. A map projection is made by transferring points and lines on a globe's surface onto a sheet of paper.

Mercator projections A **Mercator projection** is a map that has parallel lines of latitude and longitude. Recall that lines of longitude meet at the poles. When lines of longitude are projected as being parallel on a map, landmasses near the poles are exaggerated. Thus, in a Mercator projection, the shapes of the landmasses are correct, but their areas are distorted.

As shown in **Figure 2.5,** Greenland appears much larger than Australia. In reality, Greenland is much smaller than Australia. Because Mercator projections show the correct shapes of landmasses and also clearly indicate direction in straight lines, they are used for the navigation of planes and ships.



Conic projections A **conic projection** is made by projecting points and lines from a globe onto a cone, as shown in **Figure 2.6.** The cone touches the globe at a particular line of latitude. There is little distortion in the areas or shapes of landmasses that fall along this line of latitude. Distortion is evident, however, near the top and bottom of the projection. As shown in **Figure 2.6,** the landmass at the top of the map is distorted. Because conic projections have a high degree of accuracy for limited areas, they are excellent for mapping small areas. Hence, they are used to make road maps and weather maps.

Gnomonic projections A **gnomonic** (noh MAHN ihk) **projection** is made by projecting points and lines from a globe onto a piece of paper that touches the globe at a single point. At the single point where the map is projected, there is no distortion, but outside of this single point, great amounts of distortion are visible both in direction and landmass, as shown in **Figure 2.7.**

Because Earth is a sphere, it is difficult to plan long travel routes on a flat projection with great distortion, such as a conic projection. To plan such a trip, a gnomonic projection is most useful. Although the direction and landmasses on the projection are distorted, it is useful for navigation. A straight line on a gnomonic projection is the straightest route from one point to another when traveled on Earth.

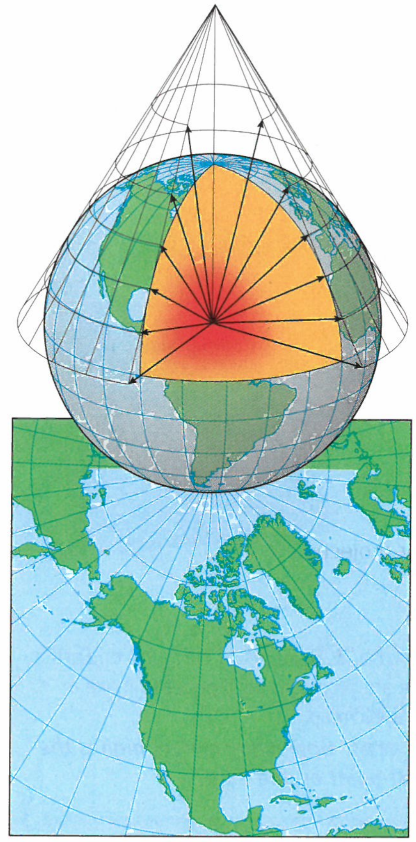


Figure 2.6 In a conic projection, points and lines on a globe are projected onto cone-shaped paper. There is little distortion along the line of latitude touched by the paper.

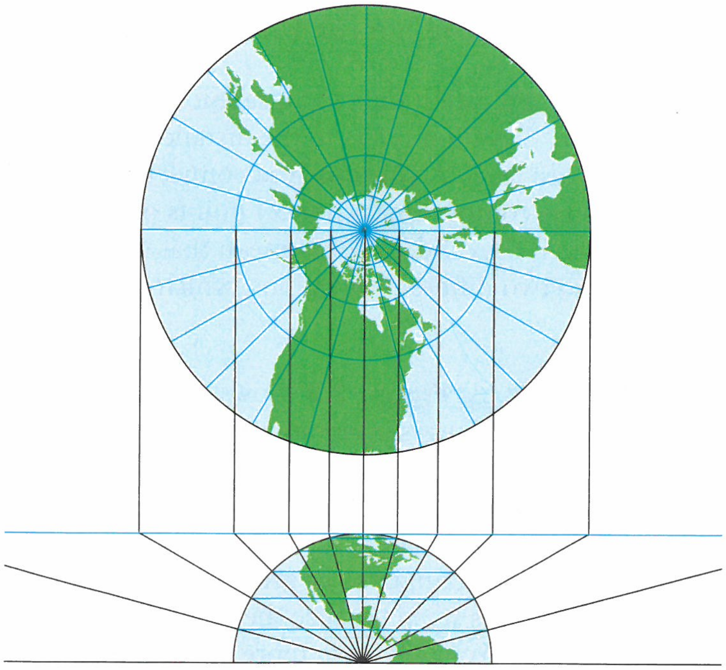


Figure 2.7 In a gnomonic projection, points and lines from a globe are projected onto paper that touches the globe at a single point.

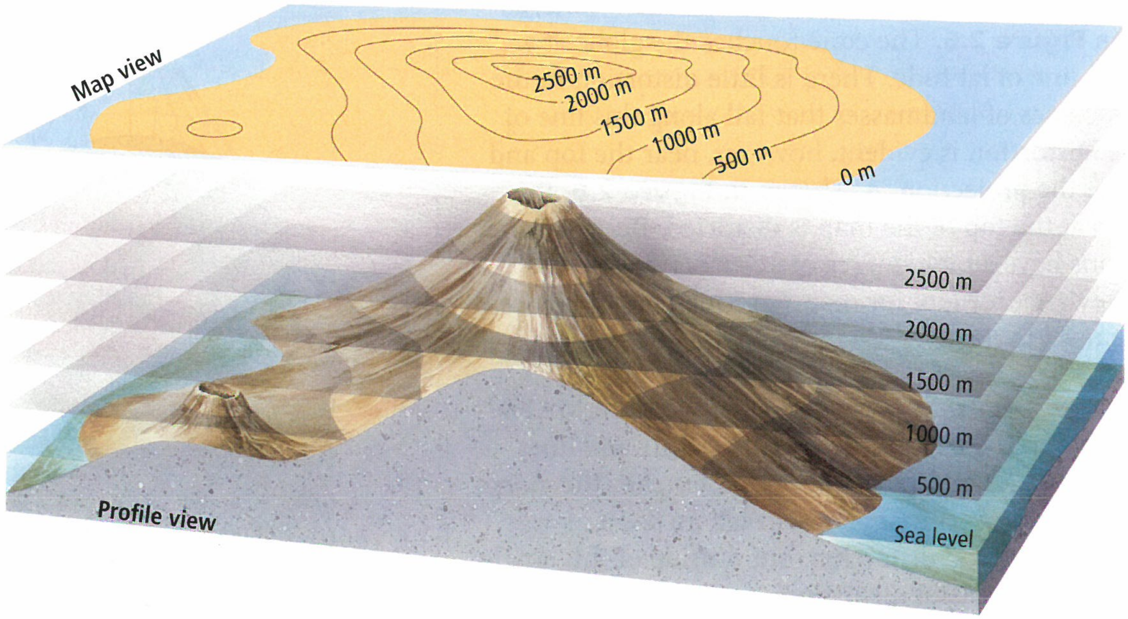


Figure 2.8 Points of elevation on Earth's surface are projected onto paper to make a topographic map.

Interpret ***How many meters high is the highest point on the map?***

Topographic Maps

Detailed maps showing the hills and valleys of an area are called topographic maps. **Topographic maps** show changes in elevation of Earth's surface, as shown in **Figure 2.8.** They also show mountains, rivers, forests, and bridges, among other features. Topographic maps use lines, symbols, and colors to represent changes in elevation and features on Earth's surface.

Contour lines Elevation on a topographic map is represented by a contour line. Elevation refers to the distance of a location above or below sea level. A **contour line** connects points of equal elevation. Because contour lines connect points of equal elevation, they never cross. If they did, it would mean that the point where they crossed had two different elevations, which would be impossible.

Contour intervals As **Figure 2.8** shows, topographic maps use contour lines to show changes in elevation. The difference in elevation between two side-by-side contour lines is called the **contour interval.** The contour interval is dependent on the terrain.

For mountains, the contour lines might be very close together, and the contour interval might be as great as 100 m. This would indicate that the land is steep because there is a large change in elevation between lines. You will learn more about topographic maps in the Mapping GeoLab at the end of this chapter.

Index contours To aid in the interpretation of topographic maps, some contour lines are marked by numbers representing their elevations. These contour lines are called index contours, and they are used hand-in-hand with contour intervals to help determine elevation.

If you look at a map with a contour interval of 5 m, you can determine the elevations represented by other lines around the index contour by adding or subtracting 5 m from the elevation indicated on the index contour. Learn more about contour maps and index contours in the Problem-Solving Lab on this page.

Reading Check Analyze If you were looking at a topographic map with a contour interval of 50 m and the contour lines were far apart, would this indicate a rapid increase or slow increase in elevation?

Depression contour lines The elevations of some features such as volcanic craters and mines are lower than that of the surrounding landscape. Depression contour lines are used to represent such features.

On a map, depression contour lines look like regular contour lines, but have hachures, or short lines at right angles to the contour line, to indicate depressions. As shown in **Figure 2.9,** the hachures point toward lower elevations.

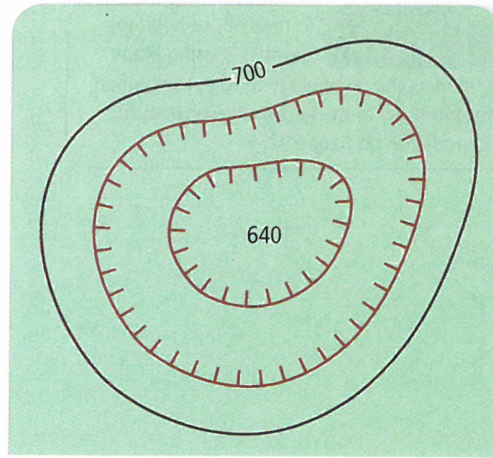


Figure 2.9 The depression contour lines shown here indicate that the center of the area has a lower elevation than the outer portion of the area. The short lines pointing inward are called hachures and indicate the direction of the elevation change.

PROBLEM-SOLVING LAB

Calculate Gradients

How can you analyze changes in elevation? Gradient refers to the steepness of a slope. To measure gradient, divide the change in elevation between two points on a map by the distance between the two points. Use the map to answer the following questions, and convert your answers to SI units.

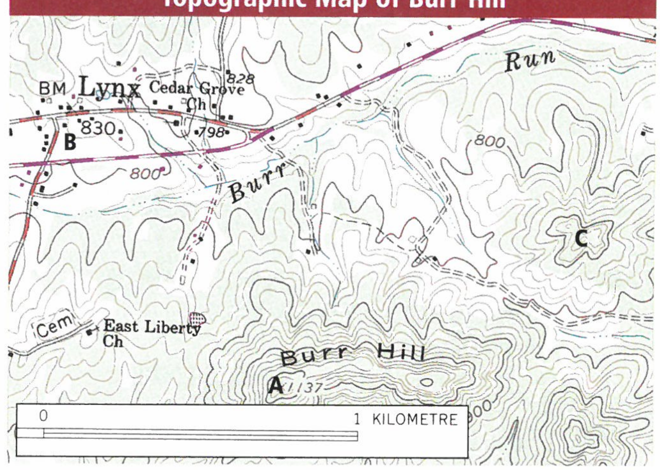
Analysis

1. **Determine** the distance from Point A to Point B using the map scale.
2. **Record** the change in elevation.
3. **Calculate** If you were to hike the distance from Point A to Point B, what would be the gradient of your climb?

Think Critically

4. **Explain** Would it be more difficult to hike from Point A to Point B, or from Point B to Point C?

Topographic Map of Burr Hill



5. **Calculate** Between Point A and Point C, where is the steepest part of the hike? How do you know?

NATIONAL GEOGRAPHIC To read about how one scientist is using maps and mapping technology to map the human footprint, go to the **National Geographic Expedition** on page 892.

Geologic Maps

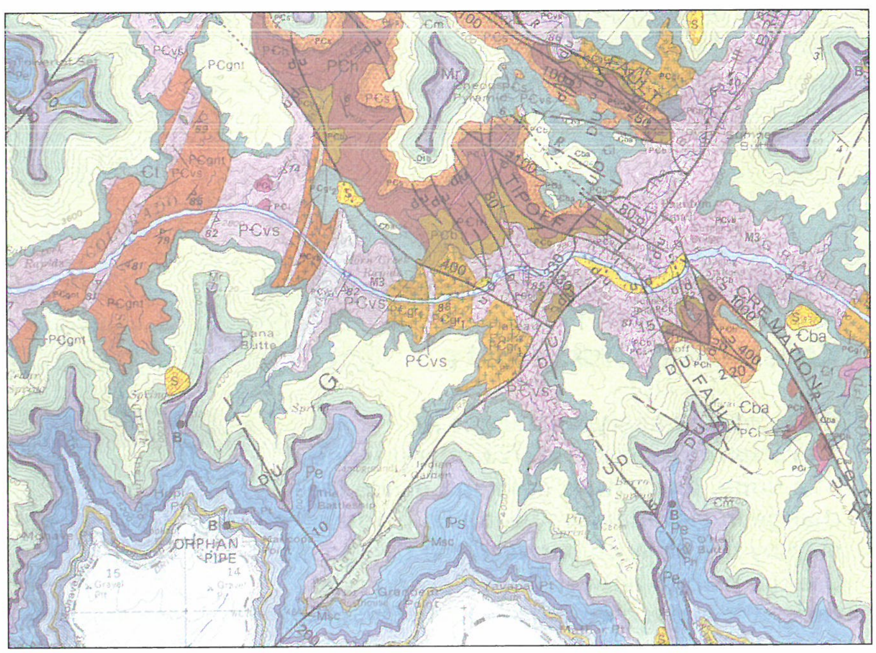
A useful tool for a geologist is a geologic map. A **geologic map** is used to show the distribution, arrangement, and type of rocks located below the soil. A geologic map can also show features such as fault lines, bedrock, and geologic formations.

Using the information contained on a geologic map, combined with data from visible rock formations, geologists can infer how rocks might look below Earth's surface. They can also gather information about geologic trends, based on the type and distribution of rock shown on the map.

Geologic maps are most often superimposed over topographic maps and color coded by type of rock formation, as shown in **Figure 2.10.** Each color corresponds to the type of bedrock present in a given area. There are also symbols that represent mineral deposits and other structural features. Refer to **Table 2.1** on the following page to compare geologic maps to the other maps you have learned about in this chapter.

Figure 2.10 Geologic maps show the distribution of surface geologic features. Notice the abundance of Older Precambrian rock formations.

Geologic Map of Grand Canyon



QUATERNARY
- S Landslides and rockfalls
- r River sediment

PERMIAN
- Pk Kaibab Limestone
- Pt Toroweap Formation
- Pc Coconino Sandstone
- Ph Hermit Shale
- Pe Esplanade Sandstone

PENNSYLVANIAN
- IPs Supai Formation

MISSISSIPPIAN
- Mr Redwall Limestone

DEVONIAN
- Dtb Temple Butte Limestone

CAMBRIAN
- Cm Muav Limestone
- Cba Bright Angel Shale
- Ct Tapeats Sandstone

YOUNGER PRECAMBRIAN
- PCi Diabase sills and dikes
- PCs Shinumo Quartzite
- PCh Hakatai Shale
- PCb Bass Formation

OLDER PRECAMBRIAN
- PCgr1 Zoroaster Granite
- PCgnt Trinity Gneiss
- PCvs Vishnu Schist

Concepts In Motion **Interactive Table** To explore more about maps and projections, visit glencoe.com.

Table 2.1 Types of Maps and Projections

Map or Projection	Common Uses	Distortions
Mercator projection	navigation of planes and ships	The land near the poles is distorted.
Conic projection	road and weather maps	The areas at the top and bottom of the map are distorted.
Gnomonic projection	great circle routes	The direction and distance between landmasses is distorted.
Topographic map	to show elevation changes on a flat projection	It depends on the type of projections used.
Geologic map	to show the types of rocks below the surface present in a given area	It depends on the type of projection used.

Three-dimensional maps Topographic and geologic maps are two-dimensional models of Earth's surface. Sometimes, scientists need to visualize Earth three-dimensionally. To do this, scientists often rely on computers to digitize features such as rivers, mountains, valleys, and hills.

Map Legends

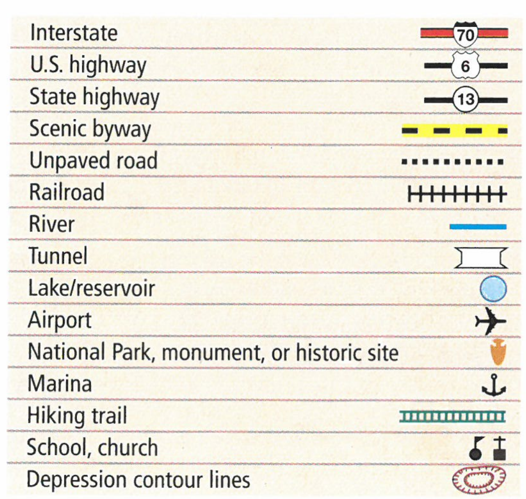
Most maps include both human-made and natural features located on Earth's surface. These features are represented by symbols, such as black dotted lines for trails, solid red lines for highways, and small black squares and rectangles for buildings. A **map legend,** such as the one shown in **Figure 2.11,** explains what the symbols represent. For more information about the symbols in map legends, see the *Reference Handbook.*

Reading Check **Apply** If you made a legend for a map of your neighborhood, what symbols would you include?

Map Scales

When using a map, you need to know how to measure distances. This is accomplished by using a map scale. A **map scale** is the ratio between distances on a map and actual distances on the surface of Earth. Normally, map scales are measured in SI, but as you will see on the map in the GeoLab, sometimes they are measured in different units such as miles and inches. There are three types of map scales: verbal scales, graphic scales, and fractional scales.

Figure 2.11 Map legends explain what the symbols on maps represent.



Verbal scales To express distance as a statement, such as "one centimeter is equal to one kilometer," cartographers and Earth scientists use verbal scales. The verbal scale, in this example, means that one centimeter on the map represents one kilometer on Earth's surface.

Graphic scales Instead of writing the map scale out in words, graphic scales consist of a line that represents a certain distance, such as 5 km or 5 miles. The line is labeled, and then broken down into sections with hash marks, and each section represents a distance on Earth's surface. For instance, a graphic scale of 5 km might be broken down into five sections, with each section representing 1 km. Graphic scales are the most common type of map scale.

VOCABULARY
ACADEMIC VOCABULARY
Ratio
the relationship in quantity, amount, or size between two or more things
The ratio of girls to boys in the class was one to one.

Reading Check **Infer** why an Earth scientist might use different types of scales on different types of maps.

Fractional scales Fractional scales express distance as a ratio, such as 1:63,500. This means that one unit on the map represents 63,500 units on Earth's surface. One centimeter on a map, for instance, would be equivalent to 63,500 cm on Earth's surface. Any unit of distance can be used, but the units on each side of the ratio must always be the same.

A large ratio indicates that the map represents a large area, while a small ratio indicates that the map represents a small area. A map with a large fractional scale such as 1:100,000 km would therefore show less detail than a map with a small fractional scale such as 1:1000 km.

Section 2.2 Assessment

Section Summary

- Different types of projections are used for different purposes.
- Geologic maps help Earth scientists study patterns in subsurface geologic formations.
- Maps often contain a map legend that allows the user to determine what the symbols on the map signify.
- The map scale allows the user to determine the ratio between distances on a map and actual distances on the surface of Earth.

Understand Main Ideas

1. MAIN Idea **Explain** why distortion occurs at different places on different types of projections.
2. **Describe** how a conic projection is made. Why is this type of projection best suited for mapping small areas?
3. **Determine** On a Mercator projection, where does most of the distortion occur? Why?
4. **Compare and contrast** Mercator and gnomonic projections. What are these projections commonly used for?

Think Critically

5. **Predict** how a geologic map could help a city planner decide where to build a city park.

MATH in Earth Science

6. Determine the gradient of a slope that starts at an elevation of 55 m and ends 20 km away at an elevation of 15 m.

Earth Science Online Self-Check Quiz glencoe.com