1.2 A View of Earth

Reading Focus

Key Concepts

- What are the four major spheres into which Earth is divided?
- What defines the three main parts of the solid Earth?
- Which model explains the position of continents and the occurrence of volcanoes and earthquakes?

Vocabulary

- hydrosphere
- atmosphere
- geosphere
- biosphere
- core
- mantle
- crust

Reading Strategy

Predicting Before you read, predict the meaning of the vocabulary words. After you read, revise your definition if your prediction was incorrect.

Vocabulary Term	Before You Read	After You Read
hydrosphere	a. ___?___	b. ___?___
atmosphere	c. ___?___	d. ___?___
geosphere	e. ___?___	f. ___?___
biosphere	g. ___?___	h. ___?___
core	i. ___?___	j. ___?___
mantle	k. ___?___	l. ___?___
crust	m. ___?___	n. ___?___

A view such as the one in Figure 5A provided the *Apollo 8* astronauts with a unique view of our home. Seen from space, Earth is breathtaking in its beauty. Such an image reminds us that our home is, after all, a planet—small, self-contained, and in some ways even fragile.

If you look closely at Earth from space, you may see that it is much more than rock and soil. The swirling clouds and the vast global ocean emphasize the importance of water on our planet.

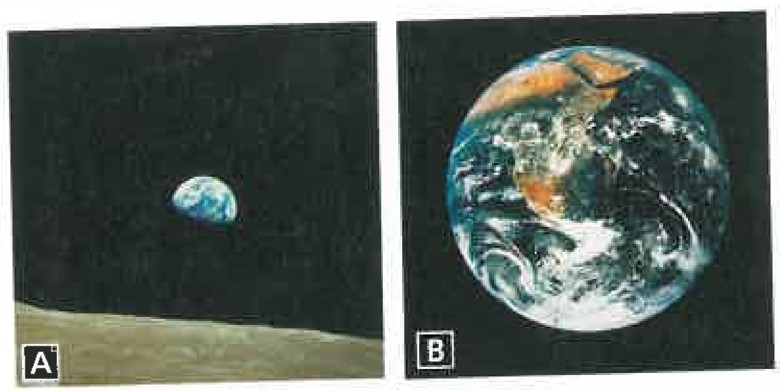


Figure 5 A View that greeted the *Apollo 8* astronauts as their spacecraft emerged from behind th Moon. **B** Africa and Arabia are prominent in this image of Earth taken from *Apollo 17*. The tan areas are desert regions. The bands of clouds over central Africa are associated with rainforests. Antarctica, which is covered by glacial ice, is visible at the south pole. The dark blue oceans and white swirling clouds remind us of the importance of oceans and the atmosphere.

Earth's Major Spheres

The view of Earth shown in Figure 5B should help you see why the physical environment is traditionally divided into three major spheres: the water portion of our planet, the **hydrosphere;** Earth's gaseous envelope, the **atmosphere;** and the **geosphere.**

Our environment is characterized by the continuous interactions of air and rock, rock and water, and water and air. The **biosphere,** which is made up of all the life-forms on Earth, interacts with all three of these physical spheres. **Earth can be thought of as consisting of four major spheres: the hydrosphere, atmosphere, geosphere, and biosphere.**

Hydrosphere Water is what makes Earth unique. All of the water on Earth makes up the hydrosphere. Continually on the move, water evaporates from the oceans to the atmosphere, falls back to Earth as rain, and runs back to the ocean. The oceans account for approximately 97 percent of the water on Earth. The remaining 3 percent is fresh water and is present in groundwater, streams, lakes, and glaciers.

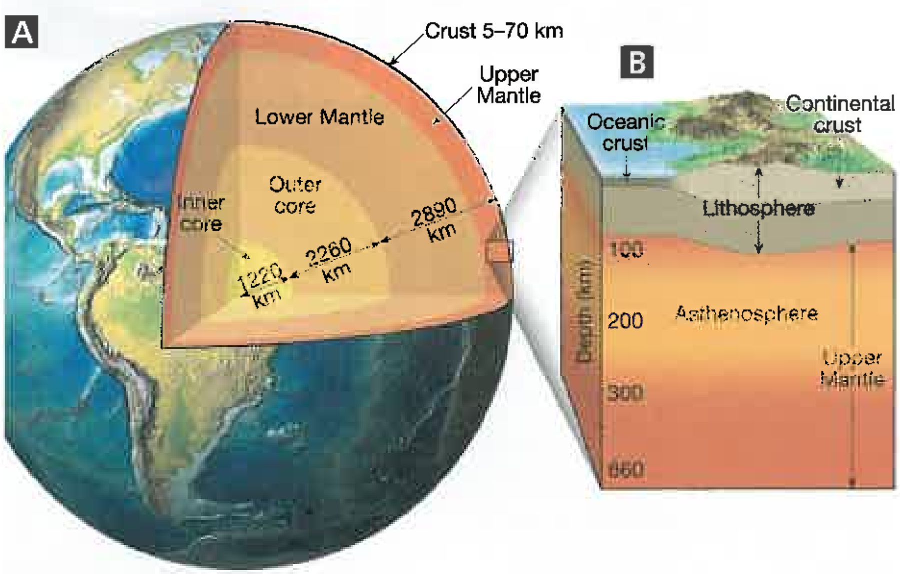
Although these freshwater sources make up a small fraction of the total amount of water on Earth, they are quite important. Streams, glaciers, and groundwater are responsible for sustaining life and creating many of Earth's varied landforms.

Atmosphere A life-sustaining, thin, gaseous envelope called the atmosphere surrounds Earth. It reaches beyond 100 kilometers above Earth, yet 90 percent occurs within just 16 kilometers of Earth's surface. This thin blanket of air is an important part of Earth. It provides the air that we breathe. It protects us from the sun's intense heat and dangerous radiation. The energy exchanges that continually occur between space, the atmosphere, and Earth's surface produce weather and climate.

If Earth had no atmosphere, life on our planet as we know it could not exist. Many of the processes and interactions that make the surface such a dynamic place would not occur. For example, without weathering and erosion, the face of our planet might more closely resemble the moon.

Geosphere Lying beneath both the atmosphere and the ocean is the geosphere. **Because the geosphere is not uniform, it is divided into three main parts based on differences in composition—the core, the mantle, and the crust.** Figure 6A shows the dense or heavy inner sphere that is the core; the less dense mantle; and the lighter, thin crust. The crust is not uniform in thickness. It is thinnest beneath the oceans and thickest beneath the continents. Figure 6B shows that the crust and uppermost mantle make up a rigid outer layer called the lithosphere. Beneath the lithosphere, the rocks become partially molten, or melted. They are able to slowly flow because of the uneven distribution of heat deep within Earth. This region is called the asthenosphere. Beneath the asthenosphere, the rock becomes more dense. This region of Earth is called the lower mantle.

Figure 6 A On this diagram, the inner core, outer core, and mantle are drawn to scale but the thickness of the crust is exaggerated by about 5 times. **B** There are two types of crust—oceanic and continental. The lithosphere is made up of the crust and upper mantle. Below the lithosphere are the asthenosphere and the lower mantle.



Biosphere The biosphere includes all life on Earth. It is concentrated in a zone that extends from the ocean floor upward for several kilometers into the atmosphere. Plants and animals depend on the physical environment for life. However, organisms do more than just respond to their physical environment. Through countless interactions, organisms help maintain and alter their physical environment. Without life, the makeup and nature of the solid Earth, hydrosphere, and atmosphere would be very different.

Reading Checkpoint *What are Earth's four major spheres?*

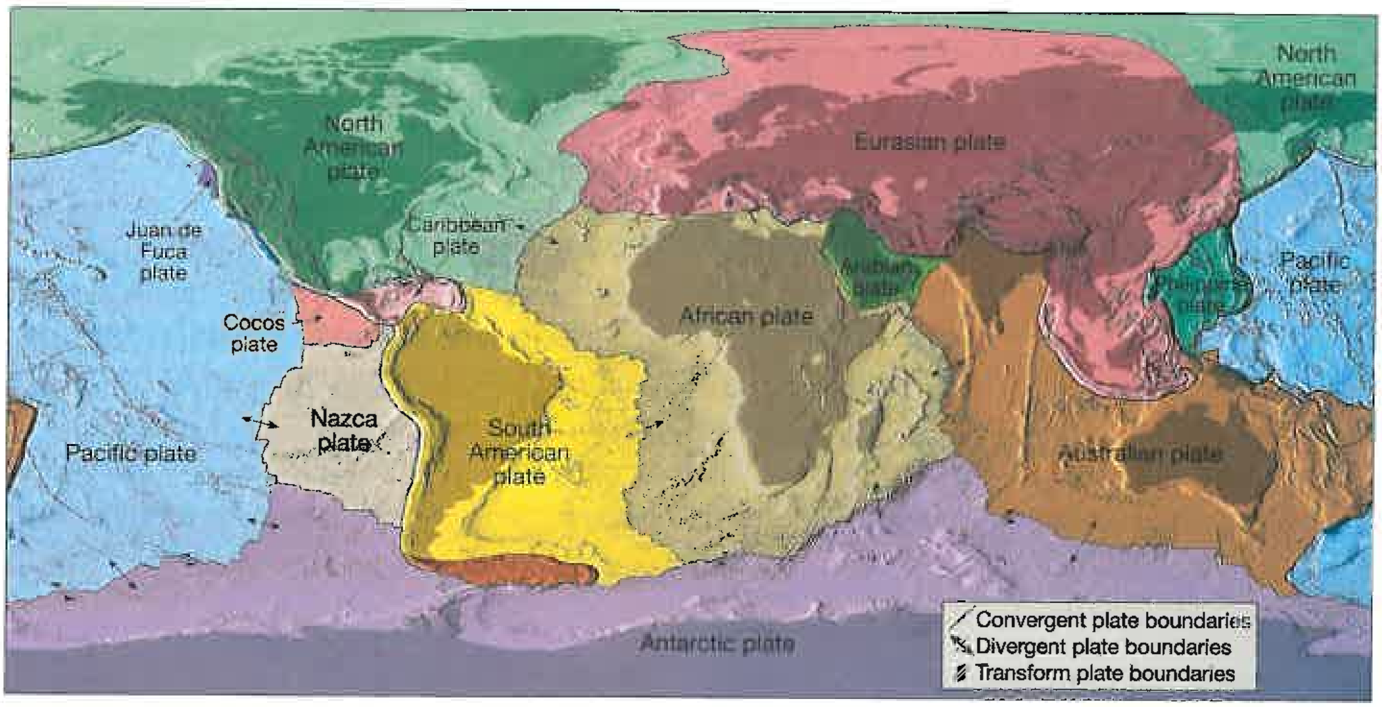


Plate Tectonics

You have read that Earth is a dynamic planet. If we could go back in time a billion years or more, we would find a planet with a surface that was dramatically different from what it is today. Such prominent features as the Grand Canyon, the Rocky Mountains, and the Appalachian Mountains did not exist. We would find that the continents had different shapes and were located in different positions from those of today.

There are two types of forces affecting Earth's surface. *Destructive forces* such as weathering and erosion work to wear away high points and flatten out the surface. *Constructive forces* such as mountain building and volcanism build up the surface by raising the land and depositing new material in the form of lava. These constructive forces depend on Earth's internal heat for their source of energy.

Figure 7 Plate Tectonics There are currently 7 major plates recognized and numerous smaller plates.
Relating Cause and Effect ***What is the relationship between mountain chains and plate boundaries?***

Within the last several decades, a great deal has been learned about the workings of Earth. In fact, this period is called a revolution in our knowledge about Earth. This revolution began in the early part of the twentieth century with the idea that the continents had moved about the face of the Earth. This idea contradicted the accepted view that the continents and ocean basins are stationary features on the face of Earth. Few scientists believed this new idea. More than 50 years passed before enough data were gathered to transform this hypothesis into a widely accepted theory. **The theory that finally emerged, called plate tectonics, provided geologists with a model to explain how earthquakes and volcanic eruptions occur and how continents move.**

Reading Checkpoint ***What is the difference between destructive forces and constructive forces?***

According to the plate tectonics model, Earth's lithosphere is broken into several individual sections called plates. Figure 7 on page 9 shows their current position. These plates move slowly and continuously across the surface. This motion is driven by the result of an unequal distribution of heat within Earth. Ultimately, this movement of Earth's lithospheric plates generates earthquakes, volcanic activity, and the deformation of large masses of rock into mountains. You will learn more about the powerful effects of plate tectonics in Chapter 9.

Section 1.2 Assessment

Reviewing Concepts

1. Which of Earth's spheres do each of these features belong: lake, meadow, canyon, cloud?
2. What are the three main parts of the geosphere?
3. Why is the solid Earth layered?
4. The plate tectonics theory explains the existence and occurrence of what features?
5. What sort of energy allows the tectonic plates to move?
6. Describe an example of how water moves through the hydrosphere.

Critical Thinking

7. **Inferring** Using the definitions of spheres as they occur on Earth, what spheres do you think are present on Venus?
8. **Applying Concepts** Describe a situation in which two or more of Earth's spheres are interacting.
9. **Classifying** Choose an Earth science branch. List how some of its studies relate to Earth's spheres.

Connecting Concepts

Earth's Spheres You learned in Section 1.1 that Earth is a dynamic planet. Explain how features in each of Earth's spheres are changing over time.

1.3 Representing Earth's Surface

Reading Focus

Key Concepts

- What lines on a globe are used to indicate location?
- What problems do mapmakers face when making maps?
- How do topographic maps differ from other maps?

Vocabulary

- latitude
- longitude
- topographic map
- contour line
- contour interval

Reading Strategy

Monitoring Your Understanding Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn. After reading, state what you learned about each item you listed.

What I Expect to Learn	What I Learned
a. ?	b. ?
c. ?	d. ?

Determining Location

Today we use maps and computer programs to help us plan our routes. Long ago, people had to rely on maps that were made using data and information that were collected by travelers and explorers. Today computer technology is available to anyone who wants to use it. Mapmaking has changed a lot throughout recorded history.

After Christopher Columbus and others proved that Earth was not flat, mapmakers began to use a global grid to help determine location.

Global Grid Scientists use two special Earth measurements to describe location. The distance around Earth is measured in degrees. **Latitude is the distance north or south of the equator, measured in degrees. Longitude is the distance east or west of the prime meridian, measured in degrees.** Earth is 360 degrees in circumference. Lines of latitude are east-west circles around the globe. All points on the circle have the same latitude. The line of latitude around the middle of the globe, at 0 degrees (°), is the equator. Lines of longitude run north and south. The prime meridian is the line of longitude that marks ° of longitude as shown in Figure 8.

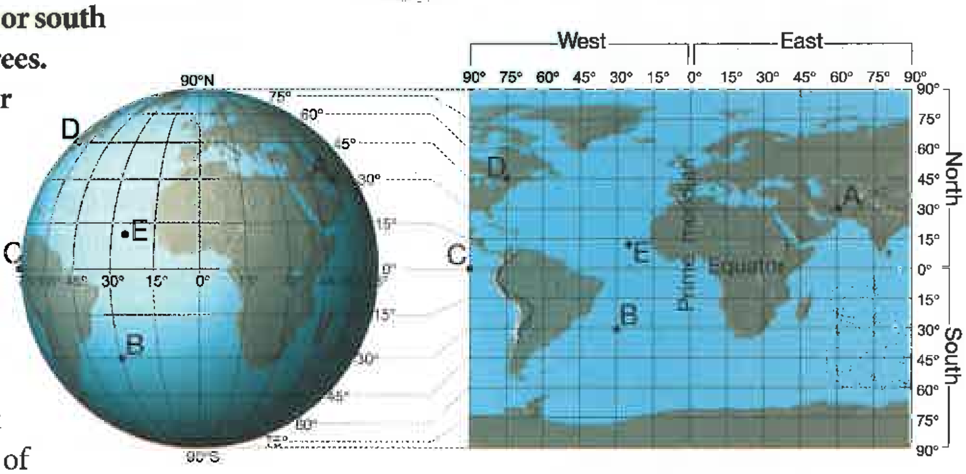


Figure 8 Global Grid

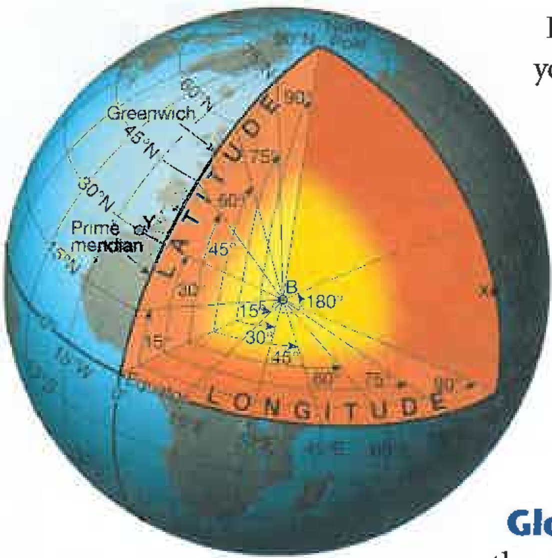


Figure 9 Measuring Latitude and Longitude

Lines of latitude and longitude form a global grid. This grid allows you to state the absolute location of any place on Earth. For example, Savannah, Georgia, is located at 32° north latitude and 81° west longitude.

The equator divides Earth in two. Each half is called a hemisphere. The equator divides Earth into northern and southern hemispheres. The prime meridian and the 180° meridian divide Earth into eastern and western hemispheres.

Reading Checkpoint ***How does the global grid divide Earth?***

Globes As people explored Earth, they collected information about the shapes and sizes of islands, continents, and bodies of water. Mapmakers wanted to present this information accurately. The best way was to put the information on a model, or globe, with the same round shape as Earth itself. By using an accurate shape for Earth, mapmakers could show the continents and oceans of Earth much as they really are. The only difference would be the scale, or relative size.

But there is a problem with globes. Try making a globe large enough to show the streets in your community. The globe might have to be larger than your school building! A globe can't be complete enough to be useful for finding directions and at the same time small enough to be convenient for everyday use.

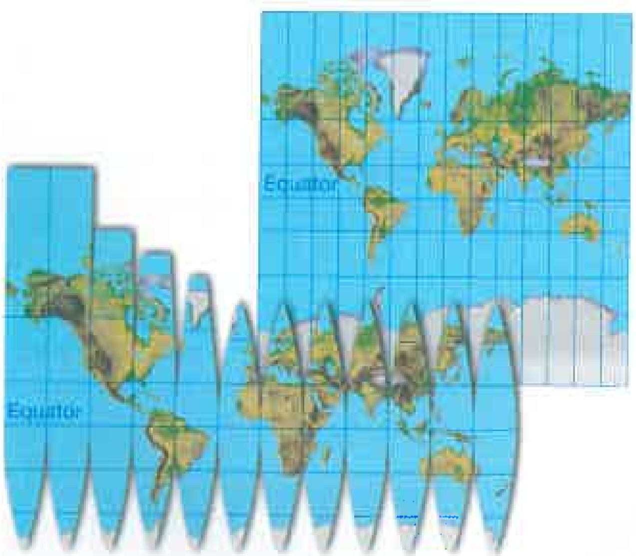


Figure 10 Mercator Map To make a Mercator map, mapmakers have to carve an image of Earth's surface into slices and then stretch the slices into rectangles. Stretching the slices enlarges parts of the map. The enlargement becomes greater toward the north and south poles. **Observing** ***What areas on the map appear larger than they should?***

Maps and Mapping

A map is a flat representation of Earth's surface. But Earth is round. Can all of Earth's features be accurately represented on a flat surface without distorting them? The answer is no. **No matter what kind of map is made, some portion of the surface will always look either too small, too big, or out of place. Mapmakers have, however, found ways to limit the distortion of shape, size, distance, and direction.**

The Mercator Projection In 1569, a mapmaker named Gerardus Mercator created a map to help sailors navigate around Earth. On this map, the lines of longitude are parallel, making this grid rectangular, as shown on the map in Figure 10. The map was useful because, although the sizes and distances were distorted, it showed directions accurately. Today, more than 400 years later, many seagoing navigators still use the Mercator projection map.

Figure 11 Robinson Projection Map Compare this map to the Mercator projection.
Comparing and Contrasting *How do the shapes in the continents differ between these maps? Are there any other differences?*

Figure 12 Conic Projection Map Because there is little distortion over small areas, conic projections are used to make road maps and weather maps.

Different Projection Maps for Different Purposes

The best projection is always determined by its intended use. The Robinson projection map is one of the most widely used. Maps that use this projection show most distances, sizes, and shapes accurately. However, even a Robinson projection has distortions, especially in areas around the edges of the map. You can see this in Figure 11. Conic projection maps are made by wrapping a cone of paper around a globe at a particular line of latitude, as shown in Figure 12. Various points and lines are projected onto the paper. There is almost no distortion along the line of latitude that's in contact with the cone, but there can be much distortion in areas away from this latitude. Because accuracy is great over a small area, these maps are used to make road maps and weather maps. Gnomonic projections, as shown in Figure 13, are made by placing a piece of paper on a globe so that it touches a single point on the globe's surface. Various points and lines are then projected onto the paper. Although distances and directions are distorted on these maps, they are useful to sailors and navigators because they show with great accuracy the shortest distance between two points.

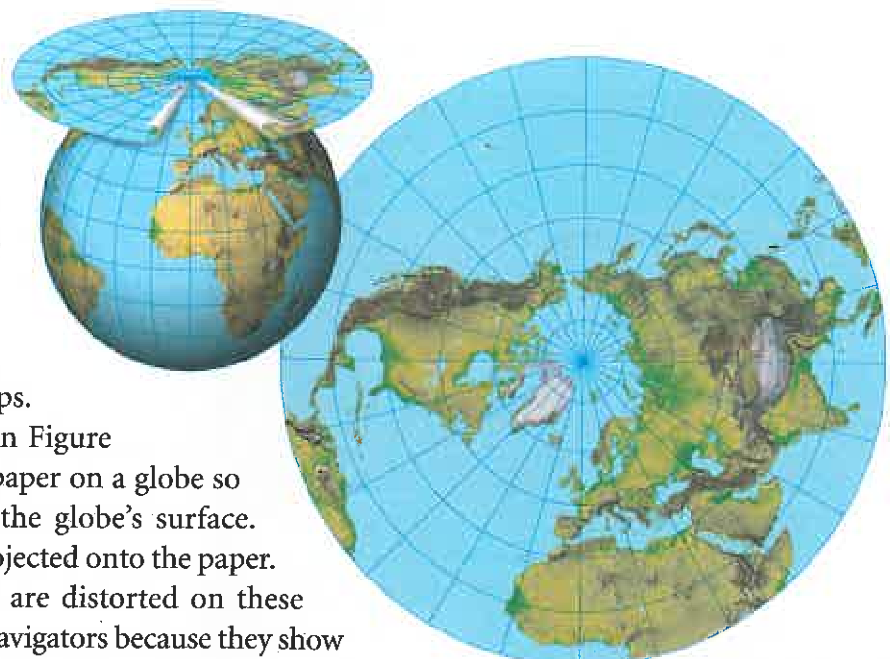


Figure 13 Gnomonic Projection Map Gnomonic projections allow sailors to accurately determine distance and direction across the oceans.

Reading Checkpoint *What major problem must mapmakers overcome?*

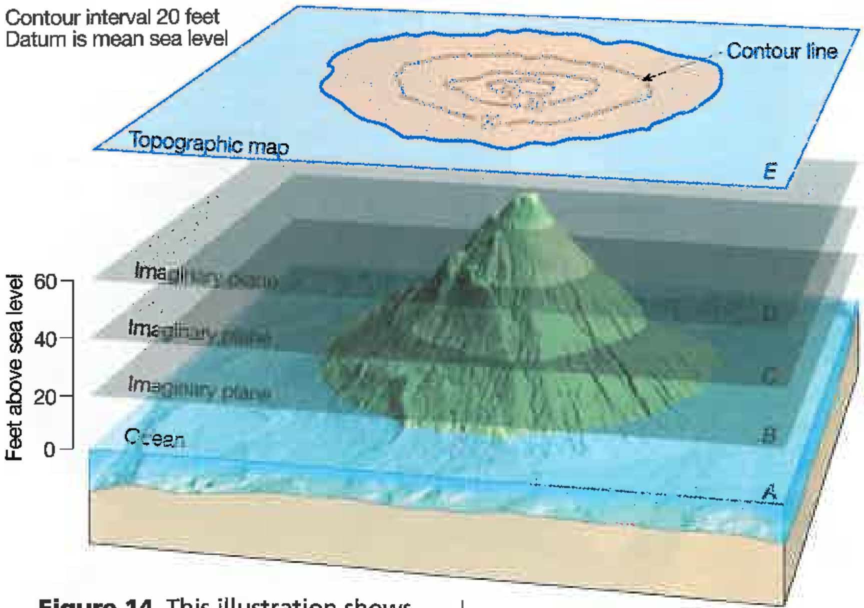


Figure 14 This illustration shows how contour lines are determined when topographic maps are constructed.

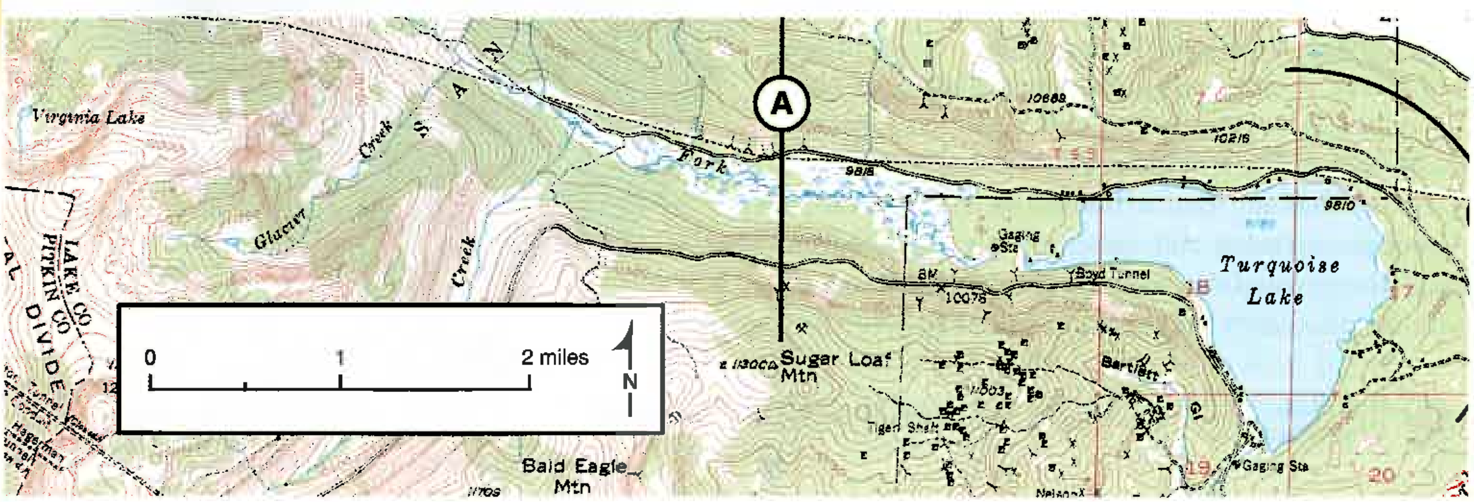
Topographic Maps

A **topographic map,** like the one shown in Figure 15, represents Earth's three-dimensional surface in two dimensions. **Topographic maps differ from the other maps discussed so far because topographic maps show elevation. Topographical maps show elevation of Earth's surface by means of contour lines.** Most also show the presence of bodies of water, roads, government and public buildings, political boundaries, and place names. These maps are important for geologists, hikers, campers and anyone else interested in the three-dimensional lay of the land.

Contour Lines The elevation of the land is indicated by using contour lines. Every position along a single contour line is the same elevation. Adjacent contour lines represent a change in elevation. Every fifth line is bold and labeled with the elevation. It is called an index contour. The **contour interval** tells you the difference in elevation between adjacent lines. The steepness of an area can be determined by examining a map. Lines that are closer together indicate a steeper slope, while lines farther apart indicate a gentler slope. You can see this relationship on the illustration in Figure 14. Contour lines that form a circle represent a hill. A depression is represented by circular contours that have hachure marks, which are small lines on the circle that point to the center. Contour lines never touch or intersect.

Reading Checkpoint *How do topographic maps indicate changes in elevation?*

Figure 15 Topographic Map
This is a portion of the Holy Cross, Colorado, topographic map. Contour lines are shown in brown.



Scale A map represents a certain amount of area on Earth's surface. So it is necessary to be able to determine distances on the map and relate them to the real world. Suppose you want to build a scale model of a boat that is 20 feet long. If your model is a 1/5-scale model, then it is 4 feet long.

In a similar way, a map is drawn to scale where a certain distance on the map is equal to a certain distance at the surface. Because maps model Earth's surface, the scale must be larger than that of the model boat. Look at the scale on the map in Figure 16. The ratio reads 1:24,000. This means that 1 unit on the map is equal to 24,000 units on the ground. Because the ratio has no units, it may stand for anything. We usually use inches or centimeters for our units. If the 1 stands for 1 centimeter on the map, how many kilometers does the 24,000 stand for on the ground?

Another scale provided on a map is a bar scale. See Figure 15. This allows you to use a ruler to measure the distance on the map and then line the ruler up to the bar to determine the distance represented.

Geologic Maps It is often desirable to know the type and age of the rocks that are exposed, or crop out, at the surface. This kind of map is shown in Figure 16. **A map that shows this information is called a geologic map.** Once individual rock formations are identified, and mapped out, their distribution and extent are drawn onto the map. Each rock formation is assigned a color and sometimes a pattern. A key provides the information needed to learn what formations are present on the map. Contour lines are often included to provide a more detailed and useful map.

For: Links on mapping
Visit: www.SciLinks.org
Web Code: cjn-1013

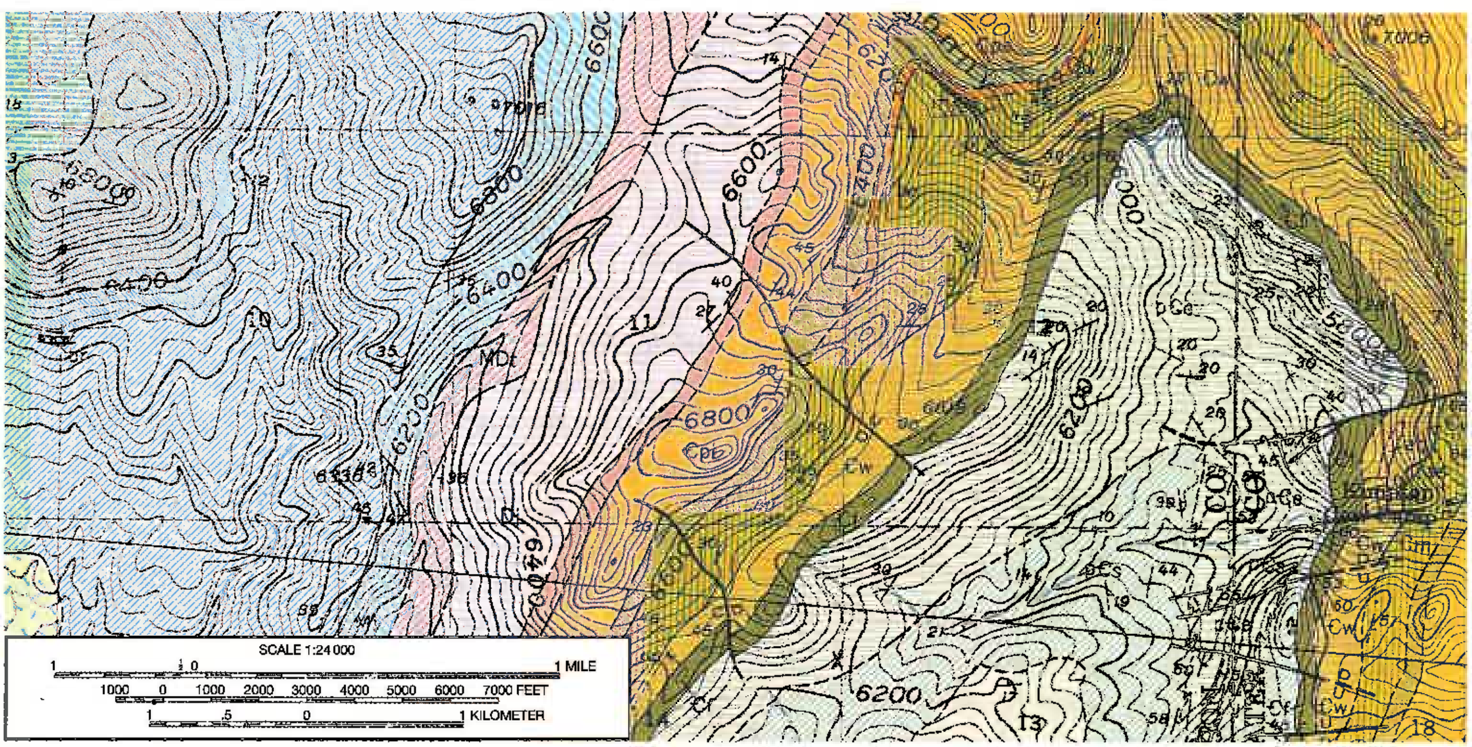


Figure 16 Geologic Map The color coding on the map represents some rock formations in Montana. Each color and pattern represents a different type of rock.

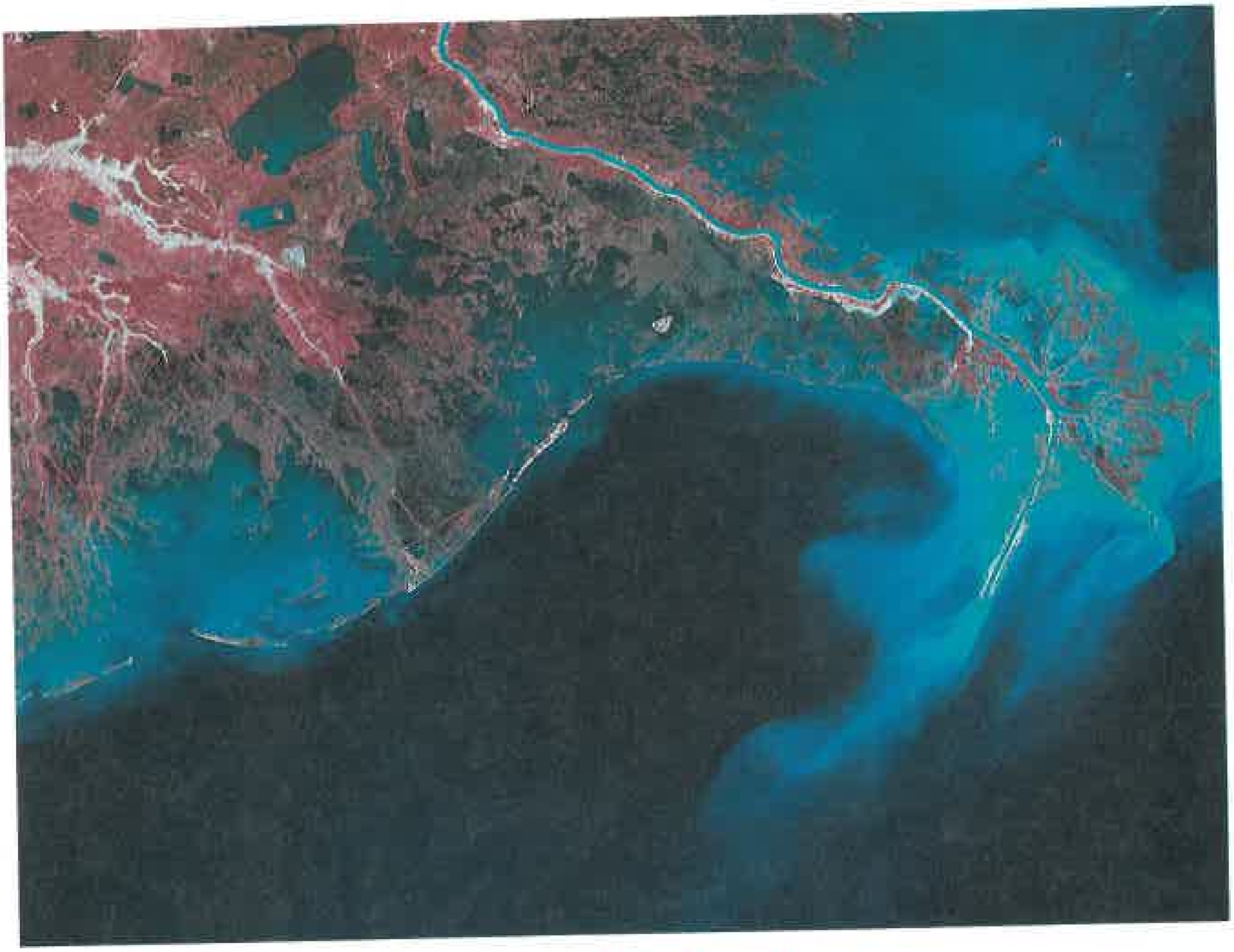


Figure 17 Satellite Image of the Mississippi River Delta Moving sediment (light blue) indicates current patterns. Red shows vegetation.

Advanced Technology

Advanced technology is used to make maps that are more accurate than ever before. **Today's technology provides us with the ability to more precisely analyze Earth's physical properties.** Scientists now use satellites and computers to send and receive data. These data are converted into usable forms such as pictures and numerical summaries.

The process of collecting data about Earth from a distance, such as from orbiting satellites, is called remote sensing. Satellites use remote sensing to produce views of Earth that scientists use to study rivers, oceans, fires, pollution, natural resources, and many other topics. How might a scientist use the image shown in Figure 17?

We can use this technology in our daily lives too. For example, Global Positioning Systems (GPS) can provide maps in our cars to help us reach our destinations. GPS consists of an instrument that receives signals to compute the user's latitude and longitude as well as speed, direction, and elevation. GPS is an important tool for navigation by ships and airplanes. Scientists use GPS to track wildlife, study earthquakes, measure erosion, and many other purposes. Table 1 describes some of the technology that is particularly useful in the study of Earth science.

Table 1 Technology and Earth Science	
Type of Equipment	**Capabilities**
Weather Satellites	• These monitor atmospheric temperature and humidity, ground and surface seawater temperature, cloud cover, and water-ice boundaries. • They can help locate sources of distress signals. • They are able to scan Earth's surface in one 24-hour period.
Navigation Satellites	• These assist ships and submarines to determine their exact location at any time.
Landsat Satellites	• The first Landsat satellite was launched in 1972. Landsat 7 was launched in 1999. • They provide data on Earth's landmasses, coastal boundaries, and coral reefs. • Pictures taken are transmitted to ground stations around the world. • They orbit Earth every 99 minutes and complete 14 orbits per day. • Total coverage of Earth is achieved in 16 days.
Global Positioning System (GPS)	• This system combines satellite information with computer technology to provide location information in three dimensions: latitude, longitude, and altitude. • Three satellite signals are detected by a receiver. The distance from the satellites to the receiver is calculated, and the location is determined using the triangulation method. A fourth signal is then used to mathematically determine exact position.
Very Long Baseline Interferometry (VLBI)	• VLBI utilizes a large network of antennas around the world to receive radio waves from space objects such as quasars. • In Earth science, VLBI is used in geodesy, or the measurement of the geosphere. • Using the arrival times of radio waves from quasars, the position of radio telescopes on Earth are determined to within millimeters of their position. • Small changes in the telescope positions allow scientists to study tectonic plate motions and other movements of Earth's crust with great precision and accuracy.

Section 1.3 Assessment

Reviewing Concepts

1. Describe the two sets of lines that are used on globes and some maps.
2. What happens to the images on the globe when they are transferred to a flat surface?
3. What is the purpose of contour lines on topographic maps?
4. What two lines mark zero degrees on the globe? In which directions do these lines run?
5. Why is the Mercator projection map still in use today?
6. What types of advanced technology are used in mapmaking today?

Critical Thinking

7. **Applying Concepts** Why are there so many different types of maps?
8. **Drawing Conclusions** How can data from VLBI be used in mapmaking today?
9. **Conceptualizing** An area on a topographic map has the following contour line configuration: First, the lines are fairly widely spaced. Then they are closely spaced. Finally, they are circular. Describe the topography represented by these lines.

Math Practice

Use the bar scale on Figure 15 to answer the following question.

10. Determine the distance along the shoreline of Turquoise Lake from the gaging station on the west shore to the gaging station on the south shore. Record your answer in kilometers.