

Chapter 3

Models of the Earth

Aerial photographs, such as this one, reveal much about the earth's surface. For example, an aerial photograph can show the course of a river, the curve of a shoreline, or the general shape of other landforms. Sometimes, however, photographs do not provide the specialized information that earth scientists need. As a result, earth scientists often rely on maps as models of the earth's surface. This chapter explains how various types of maps are made and used.

Chapter Outline

3.1 Finding Locations on the Earth

- Latitude
- Longitude
- Great Circles
- Finding Direction

3.2 Mapping the Earth's Surface

- Map Projections
- Reading a Map

3.3 Topographic Maps

- Making a Topographic Map
- Interpreting a Topographic Map

◀ This aerial photograph was taken over Maurelle Island Wilderness, Tongass National Park, Alaska.

3.1 Finding Locations on the Earth

Section Objectives

- Distinguish between latitude and longitude.
- Explain how latitude and longitude can be used to locate places on the earth.
- Explain how a magnetic compass can be used to find directions on the earth.

The earth is very nearly a sphere. A sphere has no top, bottom, or sides to use as reference points for finding locations on its surface. The earth does rotate, however. The points on the surface of the earth that are intersected by the earth's axis of rotation are used as reference points for establishing direction. These reference points are called the *North* and *South Geographic Poles*. Halfway between the poles, a circle called the *equator* divides the earth into the Northern and Southern Hemispheres. Based on these reference points, an entire system of intersecting circles has been established to locate places on the earth's surface.

Latitude

One set of circles describes positions north and south of the equator. These are called **parallels** because they are circles that run east and west around the world parallel to the equator.

The angular distance north or south of the equator is called **latitude**. Latitude is measured in degrees, beginning at the equator with 0°. A full circle has 360°. Since the distance from the equator to either of the poles is one-quarter of a circle, the latitude of both the North and South Poles is $\frac{1}{4}$ of 360°, or 90°. See Figure 3-1. In actual distance, one degree of latitude equals $\frac{1}{360}$ the earth's circumference (over 40,000 km), or about 111 km.

Parallels of latitude north of the equator are labeled N; those south of the equator are labeled S. For example, in the Northern Hemisphere, Washington, D.C., is located near a parallel of latitude that is 39° north of the equator. The latitude of Washington, D.C., is 39° N. In the Southern Hemisphere, Melbourne, Australia, has a latitude of 39° S.

Each degree of latitude consists of 60 equal parts, called *minutes*. One minute (symbol: ') of latitude equals 1.85 km. A more precise latitude for Washington, D.C., is 38°53' N. For even greater precision, each minute is divided into 60 equal parts, called *seconds* (symbol: "). Using degrees, minutes, and seconds, the latitude of Washington, D.C., is 38°53'51" N. How much distance on the earth's surface does one second of latitude equal?

Longitude

The latitude of a particular place indicates only its position north or south of the equator. To determine the specific location of a place, you also need to know how far east or west the location is along its circle of latitude. **Meridians** are used to establish east-west locations. As shown in Figure 3-2, each meridian is a semicircle (half of a circle) running from pole to pole.

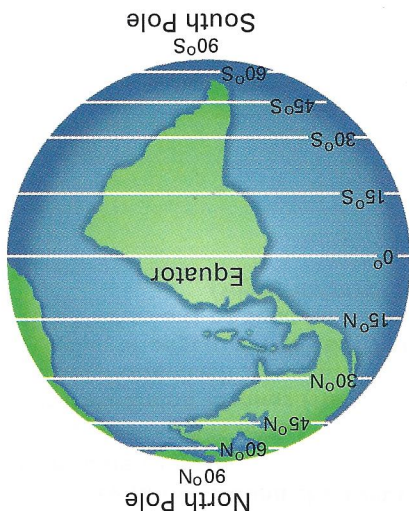


Figure 3-1. Parallels are circles describing positions north and south of the equator. Each parallel forms a complete circle around the globe.

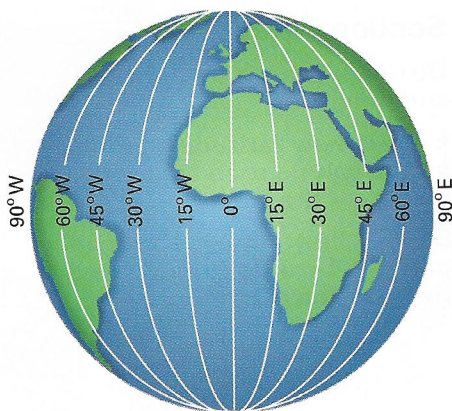


Figure 3-2. Meridians are semi-circles reaching around the earth from pole to pole.

By international agreement, one meridian was selected to be 0° . This meridian, called the **prime meridian**, passes through Greenwich, England. **Longitude** is the angular distance, measured in degrees, east or west of the prime meridian. Since a full circle is 360° , the meridian opposite the prime meridian, halfway around the world, is labeled 180° .

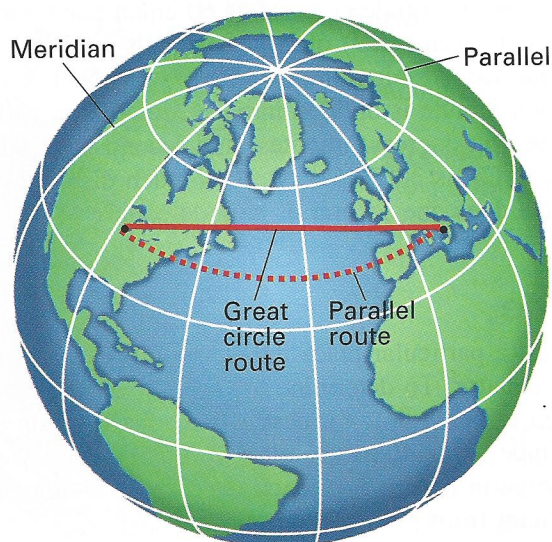
All locations east of the prime meridian have longitudes between 0° and 180° E. All locations west of the prime meridian have longitudes between 0° and 180° W. Washington, D.C., which lies west of the prime meridian, has a longitude of 77° W. As with latitude, longitude can be expressed in degrees, minutes, and seconds. Therefore, a more precise location for Washington, D.C., is $38^\circ 53' 51''$ N, $77^\circ 0' 33''$ W.

The distance covered by a degree of longitude depends on where the degree is measured. At the equator, 0° latitude, a degree of longitude equals approximately 111 km. However, all meridians meet at the poles. Thus, the distance measured by a degree of longitude decreases as you move from the equator to the poles. At a latitude of 60° N, for example, one degree of longitude equals about 55 km. At 80° N, one degree of longitude equals only about 20 km.

Great Circles

A **great circle** is often used in navigation, especially by long-distance aircraft. A great circle is any circle that divides the globe into halves. Any circle formed by two meridians of longitude directly across from each other on opposite sides of the globe is a great circle. The equator, however, is the only parallel of latitude that is a great circle. Great circles can run in any direction around the globe. Just as a straight line is the shortest distance between two points on a plane, a great-circle route is the shortest distance between two points on a sphere. As a result, air and sea routes often follow along great circles.

Figure 3-3. As the illustration shows, a great-circle route from Chicago to Rome is much shorter than a route following a parallel.



Section 3.1 Review

1. Define parallels. What do they measure?
2. Define meridians. What do they measure?
3. Name one way of determining direction on the earth.
4. Why is a great-circle route often used in navigation?

One way to find direction on the earth is to use a magnetic compass. A magnetic compass can indicate direction because the earth has magnetic properties, as if a powerful bar-shaped magnet were buried inside. As you can see in Figure 3-4, the earth's imaginary magnet is at an angle to the earth's axis of rotation.

The points on the earth's surface just above the poles of the imaginary magnet are called the **geomagnetic poles**. Because of the tilt of the imaginary magnet inside the earth, the geomagnetic poles and the geographic poles are located in different places. A compass needle points to the geomagnetic North Pole.

The angle between the direction of the geographic pole and the direction in which the compass needle points is called **magnetic declination**. In the Northern Hemisphere, magnetic declination is measured in degrees east or west of the geographic North Pole. As Figure 3-4 shows, a compass needle at Boston, Massachusetts, points 15° west of **true north**, the direction of the geographic North Pole. At Cincinnati, Ohio, the compass needle lines up with the geographic and geomagnetic North Poles, so the declination is zero. At San Antonio, Texas, the declination is 10° east of true north, while at San Diego, California, it is 15° east of true north.

Magnetic declination has been determined for points all over the earth. By adjusting a measurement of magnetic north, a person can determine geographic north for any place on earth. Locating geographic north is important in navigation and map making. The magnetic declination for most of the United States is shown in Figure 3-4. What is the magnetic declination for western Illinois?

Finding Direction

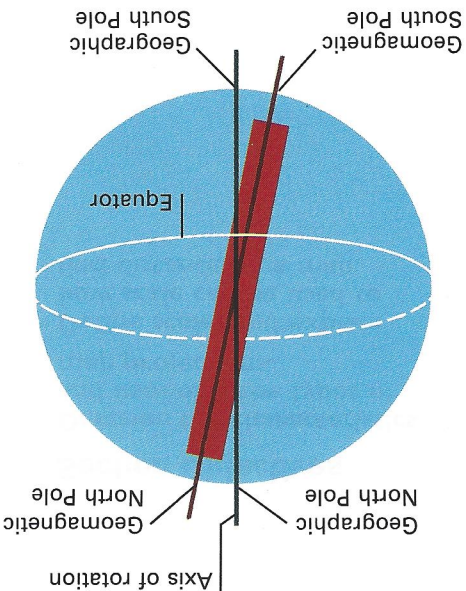
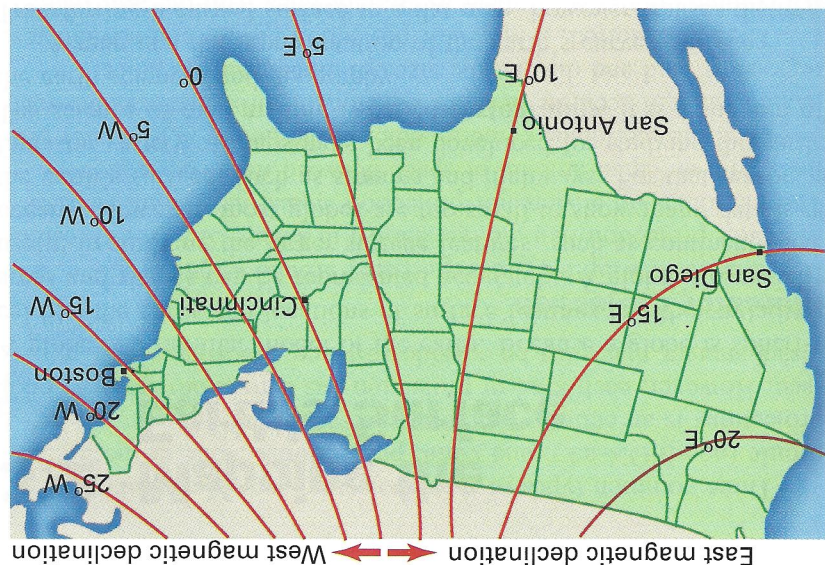


Figure 3-4. The red lines on the map (left) connect points with the same magnetic declination. Note that the earth's magnetic poles are at an angle to the earth's axis of rotation (right).

