EXERCISE 3

Introduction to Aerial Photographs and Topographic Maps

Aerial photographs, satellite images, and topographic maps are important research tools that provide insight into the various processes that shape the surface of the land. Each is an indispensable method for reducing vast amounts of data to a scale that can be easily managed. The ability of an Earth scientist to effectively interpret and use these tools is essential to identifying and understanding Earth features.

Objectives

After you have completed this exercise, you should be able to:

1. Use a stereoscope to view a stereogram, a pair of aerial photographs.
2. Explain what a topographic map is and how it can be used to study landforms.
3. Use map scales to determine distances.
4. Determine the latitude and longitude of a place from a topographic map.
5. Use the Public Land Survey system to locate features.
6. Explain how contour lines are drawn and be able to use contours to determine elevation, relief, and slope of the land.
7. Construct a simple contour map.
8. Construct a topographic profile.

Materials

ruler
hand lens

Materials Supplied by Your Instructor

stereoscope
string
topographic map
United States and world wall maps

Terms

topographic map
stereoscope
stereogram
datum
quadrangle
magnetic declination
map scale
fractional scale
graphic scale
Public Land Survey
base line
principal meridian
township
range
congressional township
section
contour line
contour interval
index contour
bench mark
slope
relief
topographic profile

Aerial Photographs

Aerial photographs are useful for geological, environmental, agricultural, and related studies. Photographs of the same feature, when taken sequentially and overlapped, can be viewed in three dimensions through a viewer called a **stereoscope.**

To view a stereoscopic aerial photograph, called a **stereogram,** the stereoscope is placed directly over the line separating any two photos of the same feature (Figure 3.1). As you look through a stereoscope, it may have to be moved around slightly until the image appears in three dimensions. The observed heights will be vertically exaggerated, and the difference in heights you see through the stereoscope will not be the same as the actual difference in heights on the land.

To provide some practice viewing stereograms, obtain a stereoscope from your instructor, unfold it, and center it over the line that separates the two aerial photographs of the volcanic cone in Figure 3.2. As you view the photographs, adjust the stereoscope until the cone appears in three dimensions. You may have to be patient until your eyes focus.

Use the stereogram in Figure 3.2 to answer questions 1–5.

1. Identify and label the crater at the summit of the volcano.

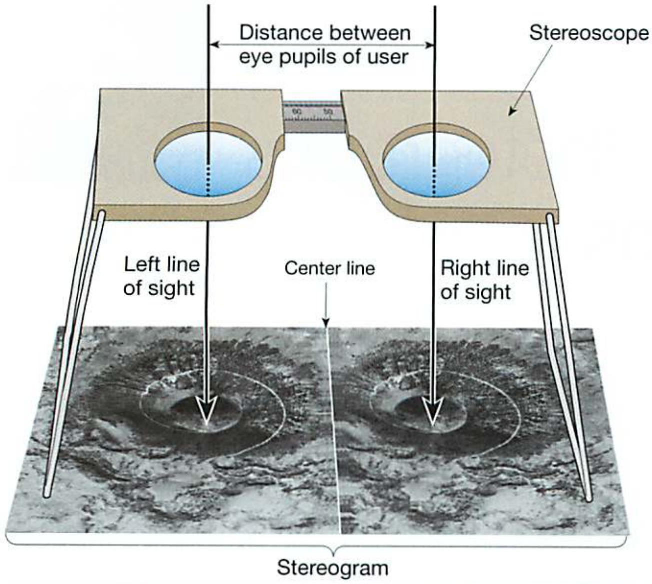

Figure 3.1 Aligning a stereoscope to view a stereogram.

2. Outline and label the lava flow, located at the intersection of the two coordinates, 1.5 and A.8, at the base of the volcano.
3. What is the white, curved feature that extends from the base of the cone to its summit?

____

4. Mark the highest point on the volcano with an "X."
5. Assume the summit of the volcanic cone is 1,500 feet above the surrounding land. While viewing the cone through the stereoscope, draw lines around the volcano at approximately 400-foot intervals above the local surface.

In addition to aerial photographs, beginning in the early 1970s, the United States began launching several satellites that systematically collect images of Earth's surface using a variety of remote sensing techniques.

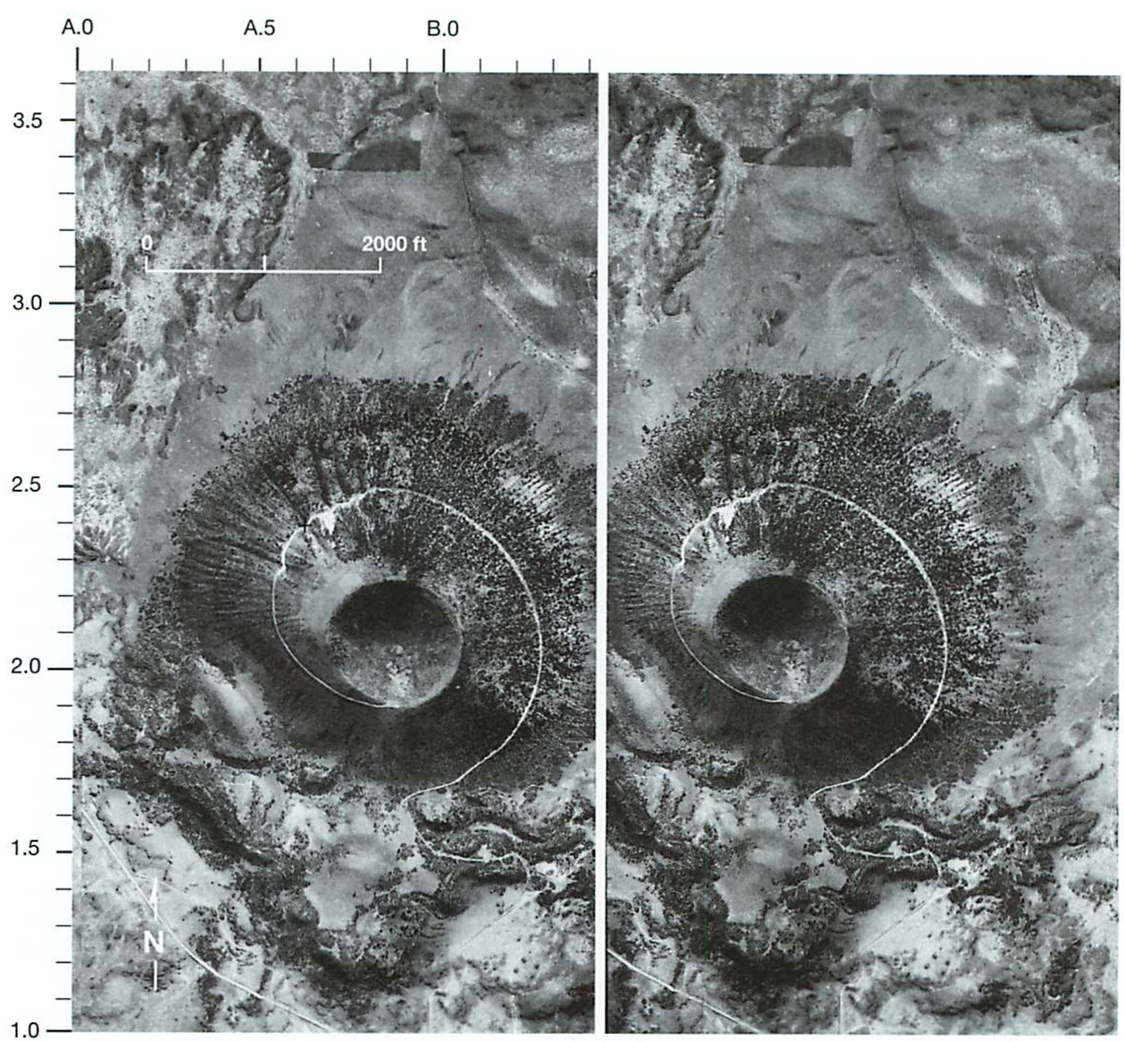

Figure 3.2 Stereogram of Mt. Capulin, a volcanic cinder cone located in northeastern New Mexico. The stereogram is composed from two overlapping aerial photographs taken from an altitude of approximately 16,000 feet. To view the three-dimensional image of the volcano, center a stereoscope over the line that separates the two photographs. Then, while looking through the stereoscope, adjust the stereoscope until the image appears in three dimensions. (Courtesy of U.S. Geological Survey)

Figure 3.3 Satellite image of a portion of the delta of the Mississippi River in May 2001. The image covers an area of 54 × 57 kilometers. For the past 600 years or so, the main flow of the river has been along its present course, extending southeast from New Orleans. During that span, the delta advanced into the Gulf of Mexico at a rate of about 10 kilometers (6 miles) per century. For a more detailed investigation of satellite images see the Internet activities at the URL listed at the end of this exercise. (Photo courtesy of NASA)

The ability of the images to be computer manipulated and enhanced has made a tremendous amount of new data available to Earth scientists (Figure 3.3). (Further investigations of satellite imagery can be found at the URL indicated at the end of this exercise.)

Topographic Maps

One type of map, the **topographic map,** is most useful when investigating the many kinds of landforms that exist on Earth's surface.

Topography means "the shape of the land." Each topographic map shows, to scale, the width, length, and variable height of the land above a **datum** or reference plane—generally average sea level. The maps, which are also referred to as **quadrangles,** are two-dimensional representations of the three-dimensional surface of Earth. Their primary value to the Earth scientist is for determining locations, landform types, elevations, and other physical data.

Topographic maps have been produced by the United States Geological Survey (USGS) since the late 1800s. Today, a vast area of the United States has been accurately portrayed on these commercially available maps.

To facilitate their use, topographic maps follow a similar format. In addition to standard colors and symbols, each contains information about where the area mapped is located, the date when the mapping was done or revised, scale, north arrow, and the names of adjoining quadrangle maps.

To help understand the basics of topographic maps, obtain a copy of a topographic map from your instructor and examine it. You will use this map to answer specific groups of questions that follow. PLEASE DO NOT WRITE OR MARK ON THE MAP.

General Map Information

Every topographic map contains useful information printed in its margin. Locate and record the following information for your map.

Each topographic map is assigned a name for reference. The name of a topographic map is located in the upper-right corner of the map.

6. What is the name of your map?

   Map name: ____________________

Notice the small reference map and compass arrow in the lower margin of the map.

7. In what part of the state (north, southwest, etc.) is the area covered by your map located?

   ____

The names of adjoining maps are given along the four margins and four corners of the map.

8. What is the name of the map that adjoins the northeast corner of your map?

   Adjoining map: ____________________

Information about when the area was surveyed and the map published is provided in the margin of the map.

9. When was the area surveyed? When was the map published? If the map has been revised, when was the revision completed?

   Surveyed: _____ Published: _____ Revised: _____

Since the geographic North Pole and North Magnetic Pole of Earth do not coincide, the north arrow on a topographic map often shows the difference between true north (TN) and magnetic north (MN), the direction a compass would point, for the area represented. This difference in degrees is called the **magnetic declination.**

10. What is the magnetic declination of the area shown on your map?

    Magnetic declination: ____________________

Map Colors and Symbols

Each symbol and color used on a U.S. Geological Survey topographic map has a meaning. Refer to the inside cover of this manual and carefully examine the standard U.S. Geological Survey topographic map symbols.

Using the standard map symbols as a guide, locate examples of various types of roads, buildings, and streams on the topographic map supplied by your instructor.

11. In general, what color(s) are used for the following types of features?

Highways and roads: ______________________

Buildings: ______________________

Urban areas: ______________________

Wooded areas: ______________________

Water features: ______________________

Map Scale

Many people have built or seen scale model airplanes or cars that are miniature representations of the actual objects. Maps are similar in that they are "scale models" of Earth's surface. Each map will have a **map scale** that expresses the relation between distance on the map to the true distance on Earth's surface. Different map scales depict an area on Earth with more or less detail. On a topographic map, scale is usually indicated in the lower margin and is expressed in two ways.

Fractional scale (e.g., 1/24,000 or 1:24,000) means that a distance of 1 unit on the map represents a distance of 24,000 of the *same* units on the surface of Earth. For example, one inch on the map equals 24,000 inches on Earth, or one centimeter on the map equals 24,000 centimeters on Earth. Maps with small fractional scales (fractions with large numbers in the denominator; e.g., 1/250,000) cover large areas. Those with large fractional scales (fractions with small numbers in the denominator; e.g., 1/1,000) cover small areas. The United States Geological Survey publishes maps at various scales to meet both the need for broad coverage and detail (see Figures 3.4 and 3.5).

Graphic, or **bar, scale** is a bar that is divided into segments that show the relation between distance on the map to actual distance on Earth (Figure 3.6). Scales showing miles, feet, and kilometers are generally included. The left side of the bar is often divided into fractions to allow for more accurate measurement of distance. The graphic scale is more useful than the fractional scale for measuring distances between points. Graphic scales can be used to make your own "map ruler" for measuring distances on the map using a piece of paper or string.

12. Examine your topographic map as well as the large wall maps in the laboratory and write out the fractional scale for each in the following space. Then answer questions 12a and 12b.

Topographic map: __________ : __________

Wall map of the United States (if available):

______________ : ______________

World map (if available):

______________ : ______________

a. Which of the three maps has the smallest scale (largest denominator in the fractional scale)?

____

b. Which of the three maps covers more square miles?

____

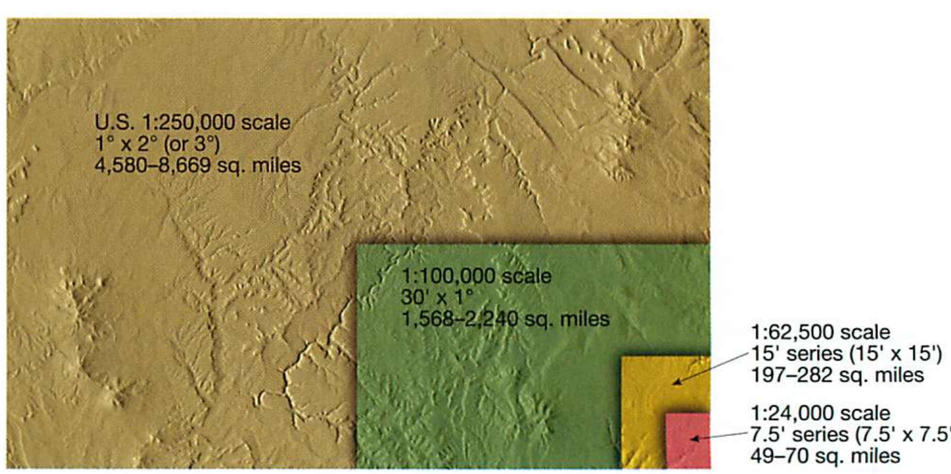

Figure 3.4 Standard U.S. Geological Survey topographic map scales, sizes, and coverage.

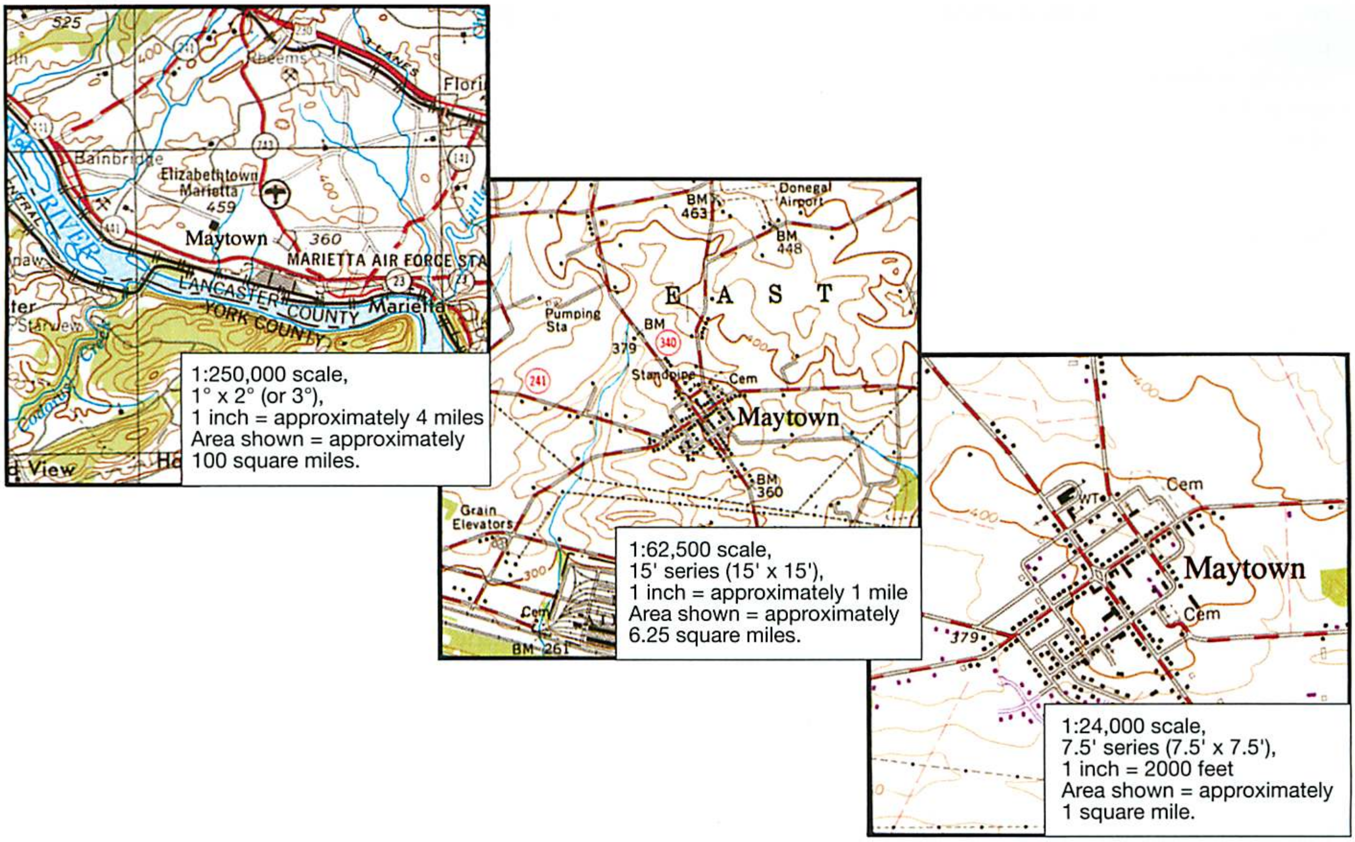

Figure 3.5 Portions of three topographic maps of the same area showing the effect that different map scales have on the detail illustrated.

13. Depending on the map scale, one inch on a topographic map represents various distances on Earth. Convert the following scales.

SCALE	1 INCH ON THE MAP REPRESENTS
1 : 24,000	_______ feet on Earth
1 : 63,360	_______ mile(s) on Earth
1 : 250,000	_______ miles on Earth

14. Use the graphic scale provided on your topographic map to construct a "map ruler" in miles, and measure the following distances that are represented on the map.

Width of the map along the south edge = ____ miles

Length of the map along the east edge = ____ miles

15. How many square miles are represented on your topographic map? (*Hint:* The area of a rectangle is calculated using the formula, area = width × length.)

Map area equals _______ square miles

Location

One of the most useful functions of a topographic map is determining the precise location of a feature on Earth's surface. Two frequently used methods for designating location are (1) latitude and longitude to determine the location of a point and (2) the **Public Land Survey** (PLS) system to define an area. Because topographic maps

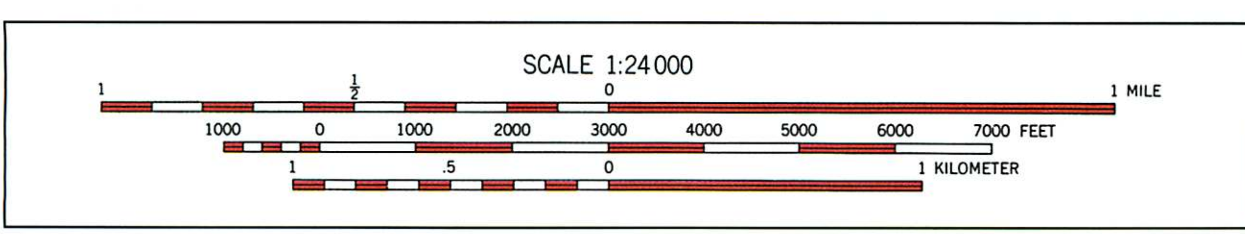

Figure 3.6 Typical graphic scale.

are very accurate, both methods of location can be used to provide information helpful to engineers, surveyors, realtors, and others. A third method, the Universal Transverse Mercator (UTM) grid, is investigated at the website located at the URL listed at the end of this exercise.

Latitude and Longitude. Topographic maps are bounded by parallels of latitude on the north and south, and meridians of longitude on the east and west. The latitudes and longitudes covered by the quadrangles are printed at the four corners of the map in degrees (°), minutes (′), and seconds (″) and are indicated at intervals along the margins. Maps that cover 15 minutes of latitude and 15 minutes of longitude are called *15-minute series topographic maps,* and although no longer produced by the USGS are still available. A $7\frac{1}{2}$-minute series topographic map covers $7\frac{1}{2}$-minutes of latitude and $7\frac{1}{2}$-minutes of longitude (see Figure 3.4). [*Note:* There are 60 minutes of arc in one degree and 60 seconds of arc in one minute of arc. Therefore, $\frac{1}{2}$-minute is the same as 30 seconds.] A more complete examination of latitude and longitude can be found in Exercise 22 "Location and Distance on Earth."

Use the topographic map supplied by your instructor to answer questions 16–22. PLEASE DO NOT WRITE OR MARK ON THE MAPS.

16. What are the latitudes of the southern edge and northern edge of the map to the nearest $\frac{1}{2}$ minute of latitude?

    Latitude of southern edge: ________________

    Latitude of northern edge: ________________

17. How many total minutes of latitude does the map cover?

    _______ minutes of latitude

18. What are the longitudes of the eastern edge and western edge of the map to the nearest $\frac{1}{2}$ minute of longitude?

    Longitude of eastern edge: ________________

    Longitude of western edge: ________________

19. How many total minutes of longitude does the map cover?

    _______ minutes of longitude

20. The map is a _______-minute series topographic map because it covers _______ minutes of latitude and _______ minutes of longitude.

21. The total minutes of latitude and total minutes of longitude covered by the map are equal. Why is the appearance of the map rectangular rather than square?

    ____

    ____

22. Your instructor will supply you with the names of two features (school, church, etc.) located on the map. Write the name of each feature, as well as its latitude and longitude to the nearest minute, in the following spaces.

    Feature name: ________________________

    Latitude: __________ Longitude: __________

    Feature name: ________________________

    Latitude: __________ Longitude: __________

Public Land Survey. The Public Land Survey (PLS) provides a precise method for identifying the location of land in most states west of the Appalachian Mountains by establishing a grid system that systematically subdivides the land area (Figure 3.7). The PLS begins at an initial point (generally there are one or more initial points for each state that utilizes the PLS). An east–west line, called a **base line,** and a north–south line, called a **principal meridian,** extend through the initial point and provide the basis of the grid (see Figures 3.7 and 3.8).

Horizontal lines at six-mile intervals that parallel the base line establish east–west tracts, called **townships.** Each township is numbered north and south from the base line. The first horizontal six-mile-wide tract north of the base line is designated Township One North (T1N), the second T2N, etc. Vertical lines at six-mile intervals that parallel the principal meridian define north–south tracts, called **ranges.** Each range is numbered east and west of the principal meridian. The first vertical six-mile-wide tract west of the principal meridian is designated Range One West (R1W), the second R2W, etc. *On a topographic map, the townships and ranges covered by the map are printed in red along the margins.*

The intersection of a township and a range defines a six-mile-by-six-mile rectangle, called a **congressional township,** which may or may not coincide with a civil township. Each congressional township is identified by referring to its township and range numbers. For example, in Figure 3.7A, the shaded congressional township would be identified as T1N, R4W.

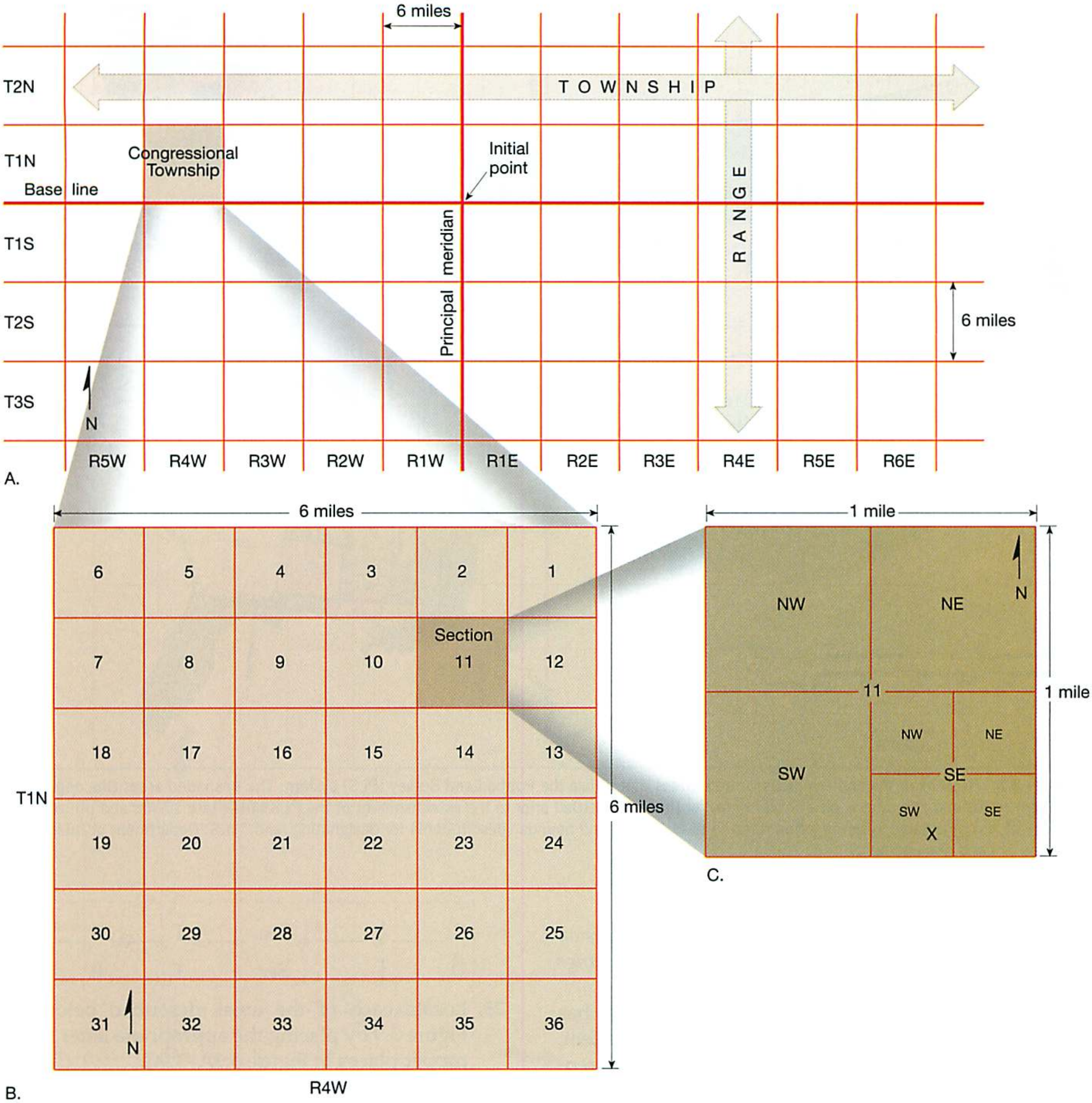

Figure 3.7 The Public Land Survey system (PLS).

Each congressional township is divided into 36 one-mile-square parcels of land, called **sections,** with each section containing 640 acres. Sections are numbered beginning with number one in the northeast corner of the congressional township and ending with number 36 in the southeast corner (Figure 3.7B). The shaded section of land in Figure 3.7B would be designated as Section 11, T1N, R4W. *On a topographic map, the sections are outlined and their numbers are printed in red.*

For more detailed descriptions, sections may be subdivided into halves, quarters, or quarters of a quarter (Figure 3.7C). Each of these subdivisions are identified by their compass position. For example, the forty acre area designated with the letter *X* in Figure 3.7C would be described as the SW$\frac{1}{4}$ (southwest $\frac{1}{4}$), of the SE$\frac{1}{4}$ (southeast $\frac{1}{4}$) of Section 11. Hence, the complete locational description of the area marked with the letter X would be SW$\frac{1}{4}$, SE$\frac{1}{4}$ Sec. 11, T1N, R4W.

Notes and calculations.

Introduction to Aerial Photographs and Topographic Maps

Date Due: ______________________

Name: ______________________

Date: ______________________

Class: ______________________

After you have finished Exercise 3, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

1. Use Figure 3.17, a portion of the Ontario, California, topographic map, to answer questions 1a.–1i.

   a. One inch on the map is approximately _________ mile(s).

   b. The fractional scale of the map is (1:12,000; 1:24,000; 1:62,500; 1:250,000). Circle your answer.

   c. What is the direction and shortest distance a hiker would have to travel to reach the "Big

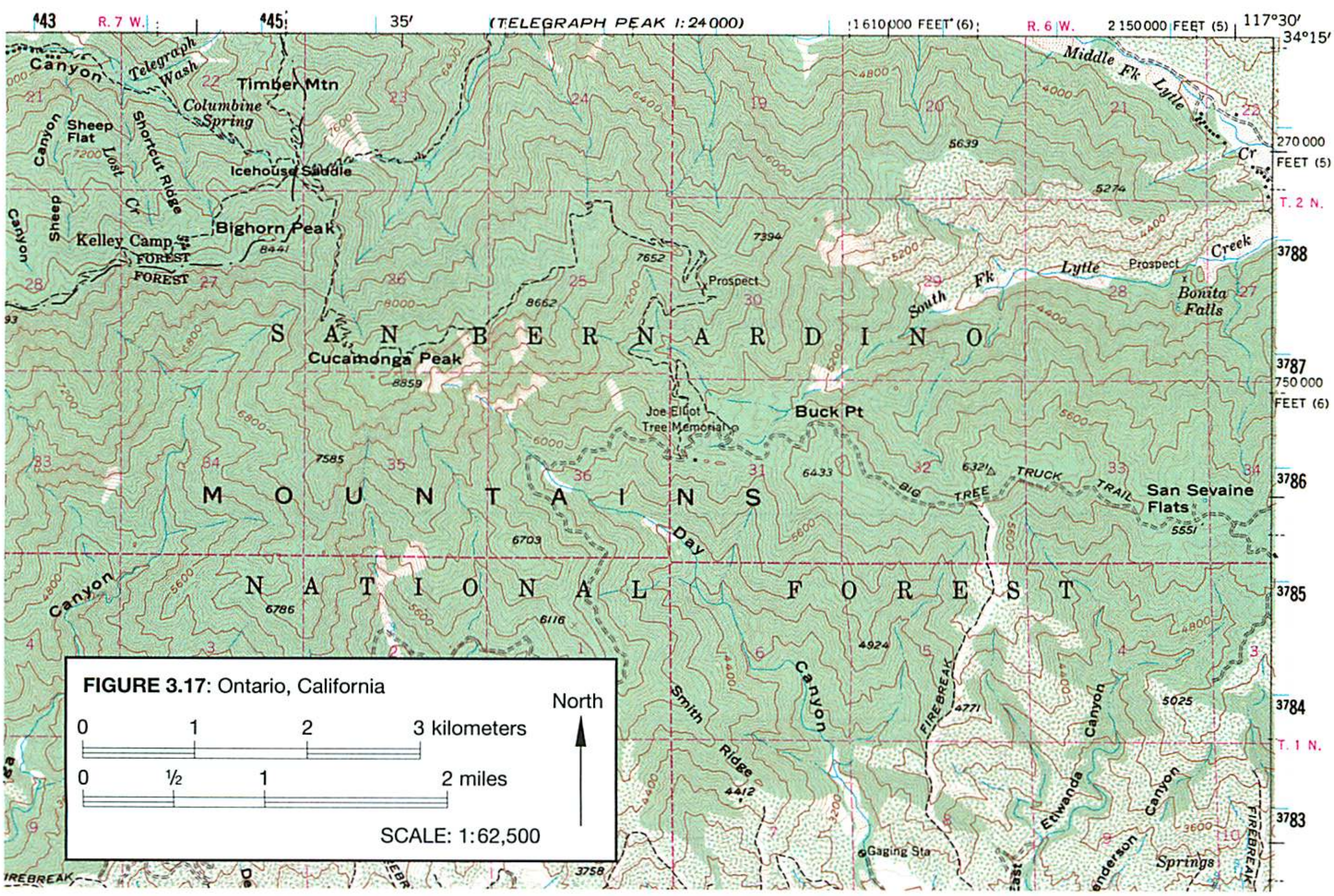

Figure 3.17 Portion of the Ontario, CA, topographic map to be used with question 1.

Tree Truck Trail" from Kelley Camp?

____

____

d. What is the approximate elevation of Kelley Camp?

____

e. What is the contour interval of the map?

____

f. Toward what direction does the stream in Day Canyon flow? How did you arrive at your answer?

____

____

g. Is the slope of the stream in Day Canyon steeper near Cucamonga Peak or the gaging station? How did you arrive at your answer?

____

____

h. Portions of which townships and ranges are covered by the map?

____

i. Give the complete PLS location of Kelley Camp to the nearest $\frac{1}{4}$ of a $\frac{1}{4}$ section.

____

2. What is the latitude and longitude to the nearest minute of the *exact center* of the topographic map supplied by your instructor?

Latitude: __________ Longitude: __________

3. The topographic map supplied by your instructor is a _____-minute series topographic map, which means that it:

____

4. What are the numbers of the townships and ranges covered by the topographic map supplied by your instructor?

Townships: ______________________________

Ranges: ______________________________

5. Use the Public Land Survey system to give the name and location of a feature your instructor requested that you locate on your topographic map in question 29.

Name of feature: ______________________________

Location:

______ $\frac{1}{4}$, ______ $\frac{1}{4}$, Sec. ______, T ______, R ______

6. What was your calculated slope for the mountain in question 37?

Slope: _____ feet/mile

7. What was the elevation of a feature your instructor requested that you determine on your topographic map in question 42?

Feature name: ______________________________

Elevation: ______________________________

8. In Figure 3.18, sketch a copy of the west–east topographic profile you constructed in question 48. Label the appropriate elevations on the vertical axis of your sketch.

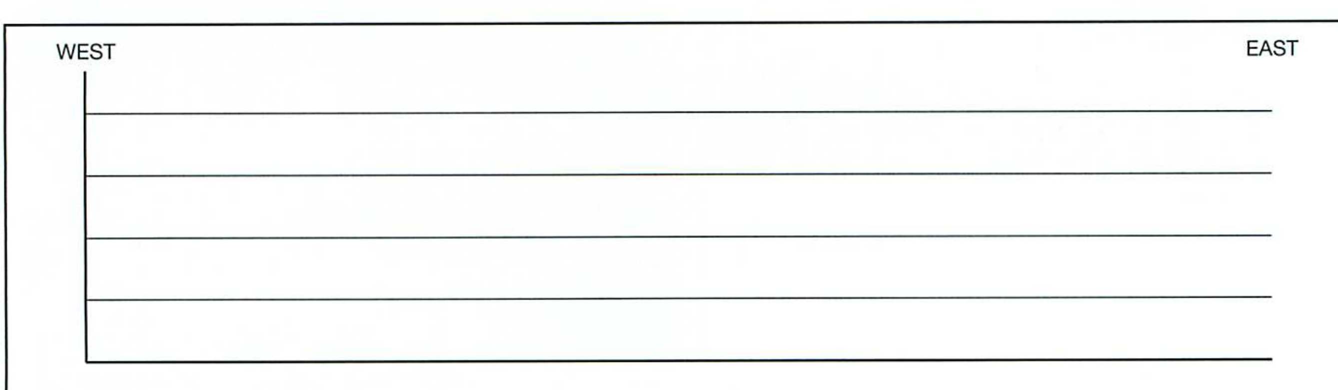

Figure 3.18 West–east topographic profile along the profile line on Figure 3.14.