INQUIRY 4.1

PLOTTING EARTHQUAKES TO IDENTIFY PATTERNS

PROCEDURE

1. Examine Table 4.1: Earthquake Data Set on pages 52–53. Listen as your teacher describes how you will use the lines of latitude and longitude to plot the earthquake epicenters on your group's world map and on a transparency.

2. Find the word "Magnitude" on Table 4.1. What do you think it means? Discuss your ideas with the class. Then read "Magnitude and Intensity" on pages 56–59. Give the magnitude of three different earthquakes. Of the three you chose, which earthquake released the most energy?

3. Find the word "Depth" on Table 4.1. What do you think it means? Give three examples of the depth of different earthquakes from Table 4.1.

4. Obtain one transparency copy of Inquiry Master 4.1: World Map, one blue transparency marker, and 10 blue dots for your group.

5. You and your group will be assigned 10 earthquakes from Table 4.1. Have two members of your group plot the epicenter of each of the 10 earthquakes on the transparency using the blue marker, while the other two members use the blue dots to plot those same earthquakes on the laminated Plate Tectonics World Map from Lesson 1. If you are working on the laminated Plate Tectonics World Map, write the Earthquake Number from the table on the blue dot. This will help you tell the difference between the earthquakes you plot in this lesson and those you plotted in Lesson 1.

Inquiry 4.1 *continued*

TABLE 4.1 EARTHQUAKE DATA SET

EARTHQUAKE NUMBER	DATE	LATITUDE	LONGITUDE	DEPTH (km)	MAGNITUDE ON RICHTER SCALE	LOCATION
1	1/25/09	43.3° N	80.8° E	19	5.3	Kazakhstan-Xinjiang border
2	10/7/09	13.0° S	166.2° E	35	7.7	Vanuatu Islands
3	12/19/09	23.7° N	121.7° E	45	6.4	Taiwan
4	12/19/09	23.8° N	121.7° E	45	6.4	East of Taiwan
5	2/26/10	25.9° N	128.4° E	22	7.0	Ryukyu Islands
6	2/27/10	35.9° S	72.7° W	35	8.8	Off coast of Chile
7	3/11/10	34.3° S	71.9° W	11	6.9	Chile
8	4/4/10	32.3° N	115.3° W	10	7.2	Northern Baja California
9	6/30/10	16.5° N	97.8° W	20	6.2	Acapulco coast, Mexico
10	7/7/10	33.4° N	116.5° W	14	5.4	Southern California, U.S.
11	8/5/10	43.6° N	110.4° W	5	4.8	Wyoming, U.S.
12	8/14/10	12.2° N	141.4° E	22	6.6	NW of Mariana Island
13	8/22/10	37.5° N	20.3° E	16	5.6	Ionian Sea
14	10/23/10	63.5° N	23.7° W	10	4.8	Iceland
15	11/4/10	12.8° N	44.9° W	10	5.6	Northern Mid-Atlantic Ridge
16	12/8/10	56.4° S	25.9° W	17	6.5	South Atlantic
17	1/10/11	23.1° N	143.2° E	73	5.7	Volcano Islands region
18	1/18/11	28.7° N	63.9° E	68	7.2	Pakistan
19	3/1/11	29.6° S	112.1° W	10	6.0	Easter Island region
20	3/6/11	56.4° S	27.0° W	84	6.5	South Sandwich Islands region

EARTHQUAKE NUMBER	DATE	LATITUDE	LONGITUDE	DEPTH (km)	MAGNITUDE ON RICHTER SCALE	LOCATION
21	3/22/11	33.1° S	16.0° W	11	6.1	Tristan de Cunha region
22	4/7/11	17.4° N	94.0° W	167	6.5	Southern Mexico
23	5/14/11	32.9° S	22.1° E	5	4.1	South Africa
24	5/15/11	0.5° N	25.6° W	10	6.0	Central Mid-Atlantic Ridge
25	7/26/11	2.7° S	76.6° W	124	5.2	Peru–Ecuador border
26	7/27/11	10.7° N	43.4° W	6	5.9	Northern Mid-Atlantic Ridge
27	8/1/11	34.7° N	138.5° E	16	6.2	Japan
28	8/13/11	14.5° N	94.7° W	28	5.6	Off coast of Southern Mexico
29	9/9/11	49.5° N	127.0° W	23	6.4	Vancouver Island region
30	9/24/11	7.6° S	74.5° W	145	6.8	Peru–Brazil border
31	10/13/11	43.4° N	127.2° W	10	5.3	Off coast of Oregon
32	10/19/11	38.0° N	31.4° W	11	4.9	North Atlantic Ocean
33	10/28/11	40.6° S	126.4° E	10	4.7	South of Australia
34	10/28/11	14.5° S	76.0° W	24	6.9	Coastal Peru
35	10/31/11	52.4° N	177.9° E	152	5.8	Aleutian Islands
36	11/18/11	37.6° S	179.3° E	26	6.0	Near North Island, New Zealand
37	11/22/11	15.4° S	65.1° W	557	6.6	Bolivia
38	11/25/11	63.4° N	150.5° W	150	3.0	Alaska, U.S.
39	11/29/11	1.7° S	15.4° W	10	5.9	East of Ascension Island
40	12/1/11	23.8° N	103.6° W	14	4.6	Mexico City, Mexico

Inquiry 4.1 *continued*

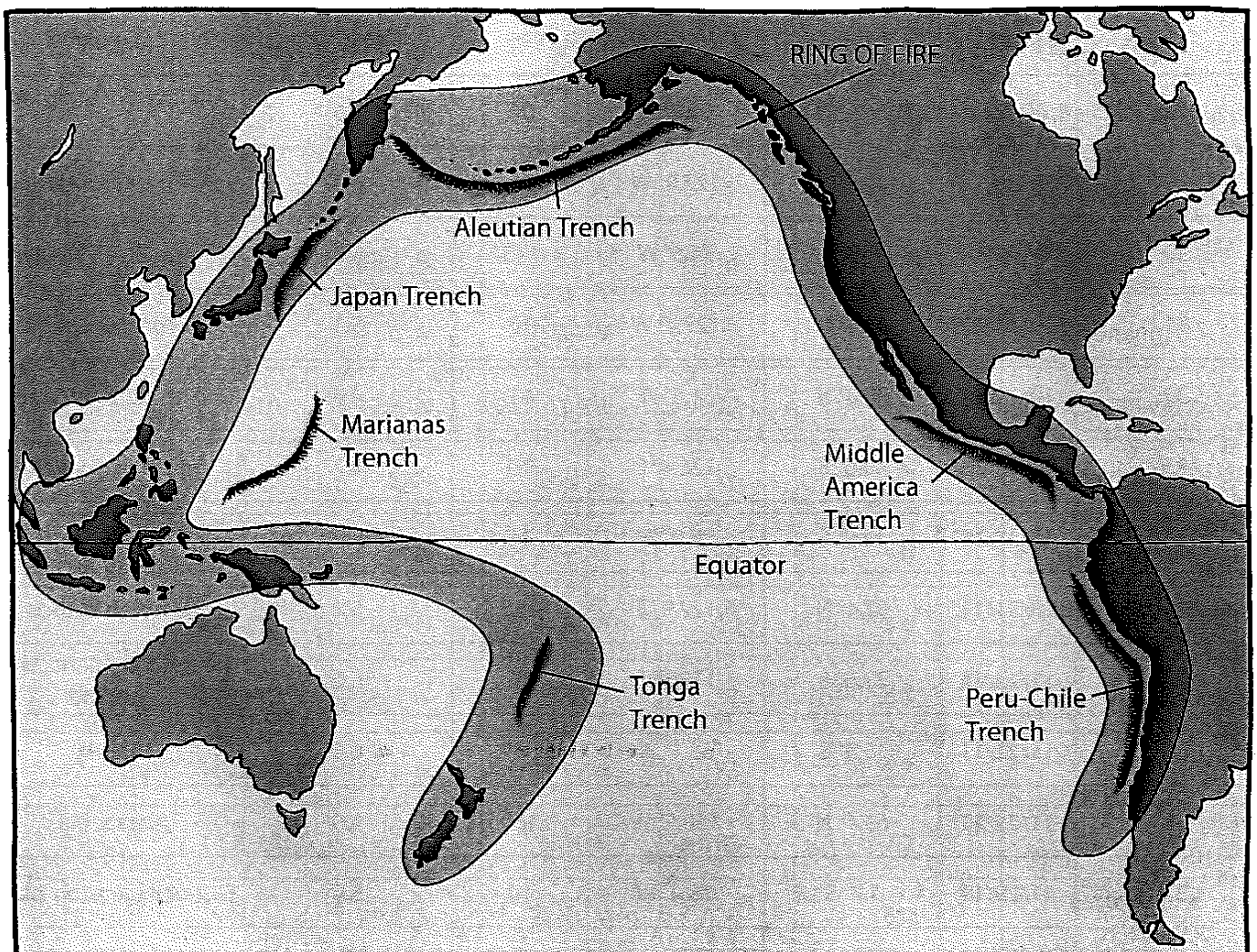
6 Share your results with the class by showing them the data points on both your transparency and your Plate Tectonics World Map.

7 Discuss patterns in the locations of these earthquakes. Answer the following questions, and support your answers with evidence from your map:

A. On (or near) which coast of North America do most earthquakes occur?

B. Which states in the United States are most earthquake-prone?

THE RING OF FIRE, OR CIRCUM-PACIFIC BELT, CONSISTS OF A CHAIN OF EARTHQUAKES AND VOLCANOES AROUND THE EDGES OF THE PACIFIC OCEAN. DEEP, NARROW DEPRESSIONS IN THE SEAFLOOR—CALLED DEEP-SEA TRENCHES—CIRCLE THE PACIFIC OCEAN ALONG THE RING OF FIRE.
FIGURE **4.1**



C. Are the earthquakes located within specific areas or scattered throughout the world?

D. If the earthquakes are in specific areas, how would you describe those areas?

8 Discuss with your class why it is important for scientists to identify patterns of earthquake activity.

9 Your teacher will show you Color Image 4.1: Seismic Activity Around the World. Which areas seem to have the most earthquakes? Share your ideas with the class. Your teacher will outline these areas of intense earthquake activity on the transparency.

10 Now look at Color Image 4.2: Seismic Belts, which your teacher will show you. On the transparency, find the Mid-Atlantic Ridge, the Mediterranean-Himalayan Belt, and the Circum-Pacific Belt (or Ring of Fire). (Figure 4.1 shows where the Ring of Fire is.) These are areas of intense earthquake activity. Label these areas on your group's world map.

REFLECTING ON WHAT YOU'VE DONE

1 Think about the patterns you outlined on your map. Answer these questions:

A. Are there any earthquakes near mountain ranges? Continental coasts? Ocean basins? Trenches? Volcanic islands? Give specific examples for each one.

B. Why do you think earthquakes are located in these specific areas? Think about what might be causing the earthquakes to occur.

C. Look at the position of the earthquakes you plotted and the depths of the earthquakes. Are there any relationships that you can identify? If so, what do you think this might mean?

2 What causes patterns in earthquake activity? Your teacher will place Color Image 4.3: Plate Boundaries over Color Image 4.1, which shows seismic activity around the world. What do these two maps together tell you? The outer layer of the earth is broken into segments called plates. Earthquakes and volcanic activity are closely related to the movement of these plates.

3 Compare the locations of the earthquakes you plotted in Lesson 1 with those plotted in today's lesson. Do you want to revise any of your original ideas? Use your copy of Inquiry Master 1.1 to document your new ideas. Be sure to use a different color pen to show your new thinking.

4 Read "Using a Network for Seismic Monitoring" on pages 62–65. Looking at your Plate Tectonics World Map, discuss with your class where a seismic monitoring system might want to locate its sensors and stations.

5 Clean up. Use a paper towel to wipe all marks off the transparency.

6 Look ahead to Lessons 5–8. You will be learning more about movement along plate boundaries and why earthquakes occur.

READING SELECTION

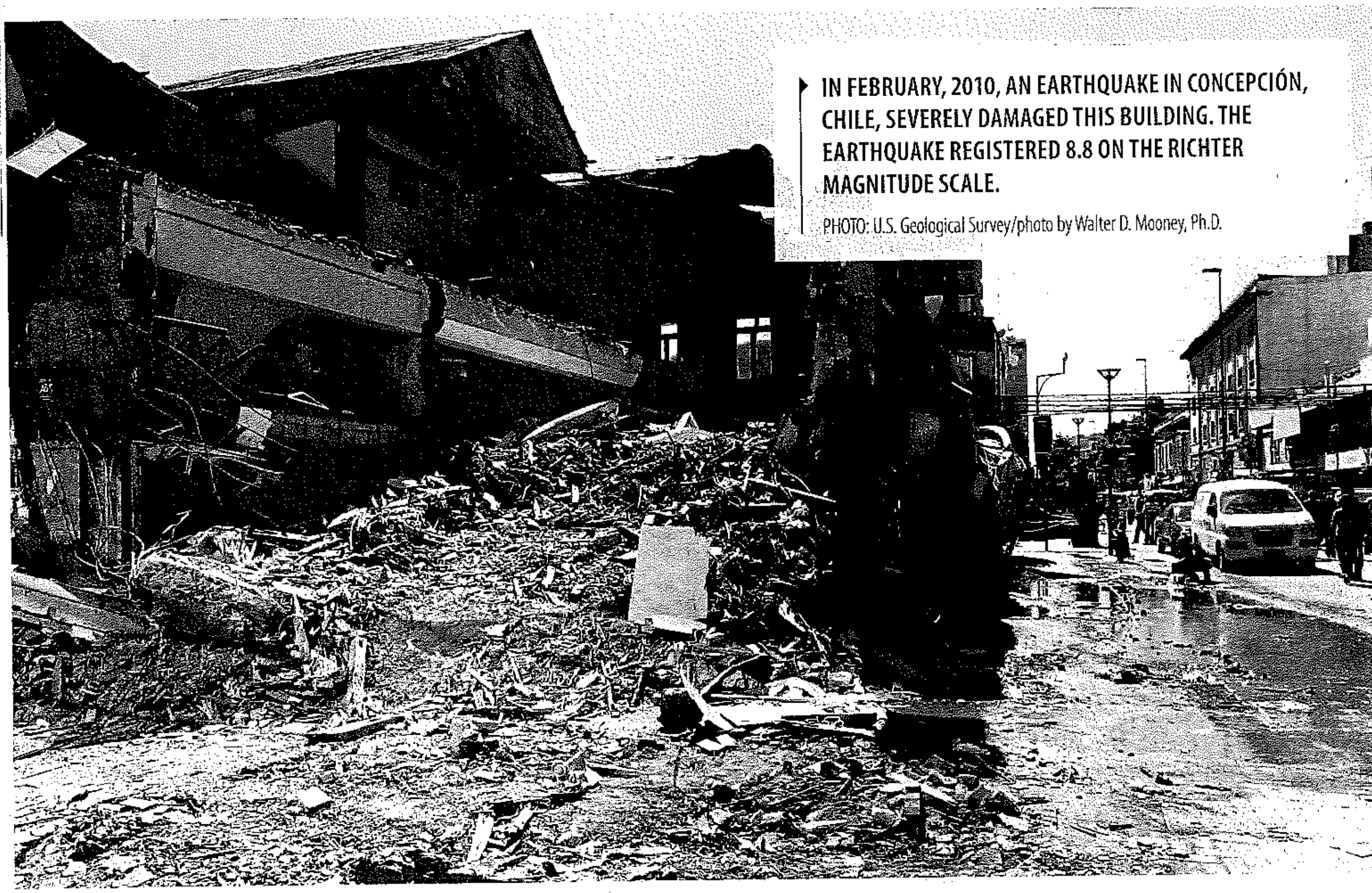
EXTENDING YOUR KNOWLEDGE

MAGNITUDE & INTENSITY

Geologists measure an earthquake in two ways—by its magnitude and by its intensity. Each method provides these scientists and others with important data about the earthquake and its effects. Geologists can use the data to assess the risks in earthquake-prone regions and prepare for future earthquakes.

MAGNITUDE

"An earthquake with a magnitude of 6.8 on the Richter scale occurred today ..." How many times have you heard a number like this being reported in the news?



IN FEBRUARY, 2010, AN EARTHQUAKE IN CONCEPCIÓN, CHILE, SEVERELY DAMAGED THIS BUILDING. THE EARTHQUAKE REGISTERED 8.8 ON THE RICHTER MAGNITUDE SCALE.

PHOTO: U.S. Geological Survey/photo by Walter D. Mooney, Ph.D.

In 1935, Charles Richter, a seismologist at the California Institute of Technology, developed the Richter Magnitude Scale. The Richter scale measures the magnitude, or total amount of energy, released at the source of an earthquake. The number that you normally hear on the news when an earthquake occurs is its magnitude. Richter scale ratings enable people to compare the strength of different earthquakes around the world.

The magnitude of an earthquake is determined by measuring the amplitude, or "swing," of the largest seismic wave on a seismogram. The Richter scale, shown in the table below, is open-ended; it has no maximum magnitude. As of the year 2010, the largest magnitude recorded on the Richter scale was 9.5. That earthquake occurred in Chile in 1960.

The largest earthquake in the U.S. occurred in Alaska in 1964. It registered 9.2 on the Richter scale.

Each increase in a magnitude number on the Richter scale represents a tenfold increase in the amplitude seen on the seismogram. This means that a magnitude-6 earthquake has an amplitude 10 times greater than a magnitude-5 earthquake and 100 times greater than a magnitude-4 earthquake. This greater amplitude translates into longer and higher energy shaking of the ground. For example, an earthquake with a magnitude around 5.0 might only shake the ground for 30 seconds or so, while the 9.2 Alaska earthquake shook the ground for over nine minutes. And for every increase of magnitude of 1.0, there is an increase of 32 times the amount of energy released.

RICHTER MAGNITUDE SCALE

DESCRIPTOR	MAGNITUDE	AVERAGE NUMBER EACH YEAR, WORLDWIDE
GREAT	8 and higher	1
MAJOR	7–7.9	18
STRONG	6–6.9	120
MODERATE	5–5.9	800
LIGHT	4–4.9	6200 (estimated)
MINOR	3–3.9	49,000 (estimated)
VERY MINOR	Less than 3.0	Magnitude 2–3: about 1000 per day Magnitude 1–2: about 8000 per day

SOURCE: National Earthquake Information Center, U.S. Geological Survey, Denver, CO

READING SELECTION

EXTENDING YOUR KNOWLEDGE

INTENSITY

Scientists use the word "intensity" to describe the kind of damage done by an earthquake, as well as people's reaction to the damage. In other words, intensity is a measure of the earthquake's effect on people, structures, and the natural environment.

Many factors affect intensity. These include the distance an area is from the epicenter, the depth of the earthquake, the population density of the area affected by the earthquake, the local geology of the area, the type of building construction in the area, and the duration of the shaking. Magnitude also affects intensity, since an earthquake of a higher magnitude has a higher intensity than an earthquake of lower magnitude. But, an earthquake in a densely populated area that results in many deaths and considerable damage (high intensity) may

MODIFIED MERCALLI INTENSITY SCALE

INTENSITY SCALE	DAMAGE AND FELT OBSERVATIONS
I	Not felt, except by a very few people under special circumstances.
II	Felt only by a few people at rest, especially on upper floors of buildings.
III	Felt only indoors, but many people did not recognize it as an earthquake. Stationary cars rocked slightly.
IV	Felt indoors by many, outdoors by few. At night some people were awakened by a sensation like a heavy truck hitting a building. Standing cars rocked noticeably.
V	Felt by nearly everyone. Many were awakened. Some dishes and windows were broken. Trees and other tall objects swayed.
VI	Felt by all. Many were frightened and ran outdoors. Heavy furniture moved. Plaster on walls and chimneys was damaged.
VII	Everyone ran outdoors. Slight to moderate damage to well-built structures. Considerable damage to poorly built structures. Some chimneys broken. Noticed by people driving cars.
VIII	Damage slight in well-designed structures, great in poorly built structures. Fallen chimneys, monuments, and walls. Heavy furniture was overturned. Sand and mud were ejected from the ground in small amounts.
IX	Damage was considerable in well-designed structures. Buildings shifted off foundations. Ground noticeably cracked. Underground pipes broken.
X	Well-built wooden structures destroyed. Ground badly cracked. Railroad tracks bent. Landslides considerable. Water splashed over riverbanks.
XI	Few, if any, masonry structures remained standing. Bridges were destroyed. Broad cracks formed in ground. Underground pipes completely out of service.
XII	Total damage. Waves seen on ground surfaces. Objects thrown upward into the air.

A 2008 EARTHQUAKE IN SICHUAN, CHINA, CAUSED A SECTION OF THIS BUILDING TO COLLAPSE.

PHOTO: U.S. Geological Survey/photo by Sarah C. Behan

have the same magnitude as an earthquake in a remote area that does no more than frighten the wildlife (low intensity).

The most common earthquake intensity scale used in the United States is shown in the table titled "Modified Mercalli Intensity Scale." This scale has intensity values ranging from I to XII. (Can you guess why it uses Roman numerals?) ■

DISCUSSION QUESTIONS

1. Look at the photo of earthquake damage in Sichuan, China. Where would you put this earthquake on the intensity scale?
2. On average, there are about 8000 earthquakes of magnitude 1–2 per day, and only one earthquake of magnitude 8 or higher each year. Why are there so many minor earthquakes and so few major ones?