CHAPTER 3

SEISMICITY OF THE EARTH
AND
VOLCANOES

In the picture you can see an eruption of a volcano. These eruptions affect the land and the air for kilometers around. Earthquakes, like volcanoes, can cause a great deal of damage.

In this chapter you will read about earthquakes and volcanoes on Earth. This chapter also suggest some "signs" that scientists are using in an effort to predict earthquakes and volcanic eruptions.

CHAPTER OBJECTIVES

1. Explain the relationship between faults, earthquakes, and plate boundaries.

2. Explain how scientists use seismic waves to locate the epicenters of earthquakes.

3. Contrast the formation of intrusive and extrusive rocks.

4. Describe four types of volcanic cones.

3.1 EARTHQUAKES

An earthquake is a trembling or shaking of the earth. What causes an earthquake? Huge explosions can shake the earth, or magma moving up in a volcano may cause an earthquake. Most earthquakes, however, happen because rocks move along a fault. Think about these questions as you read about earthquakes:

a. How are earthquakes related to faults?

b. Where do most earthquakes occur?

c. What does the Richter scale tell you about an earthquake?

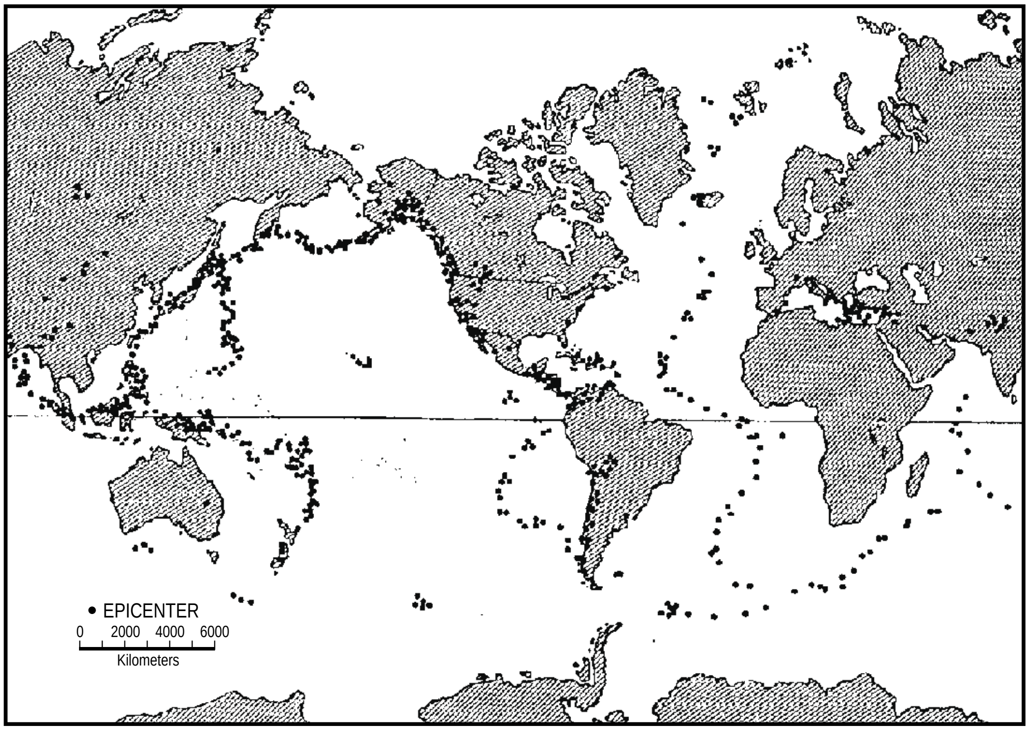
d. What are aftershocks?

• *Earthquakes and Faults*

Imagine what happens when you bend a plastic ruler. if you bend it far enough, the ruler breaks. Both pieces snap back to a straight position. Rocks in the earth's crust that are under pressure also bend, break, and snap back. A fault is a break in rocks along which rocks have moved.

When the break occurs, energy is released as seismic waves. This energy makes the earth shake, and we feel an earthquake.

With the installation of highly sensitive seismographs in many locations around the world, it is relatively easy to record the seismic disturbances, even if they are not felt by man. Once seismic waves have been detected and recorded at several seismic stations, it is possible to determine where they were produced. There are several institutions which are dedicated to determining earthquake parameters for all the seismic activity of the world. With this information it is possible to determine the pattern of places of high and low seismicity.



World distribution of earthquakes.

From this diagram it can be concluded that the distribution of seismic events is not homogeneous. There are very well defined seismic areas. In the middle of the oceans seismic events are concentrated along very narrow strips which coincide with the location of the mid-oceanic ridges. Away from these areas, most of the oceanic floor is aseismic.

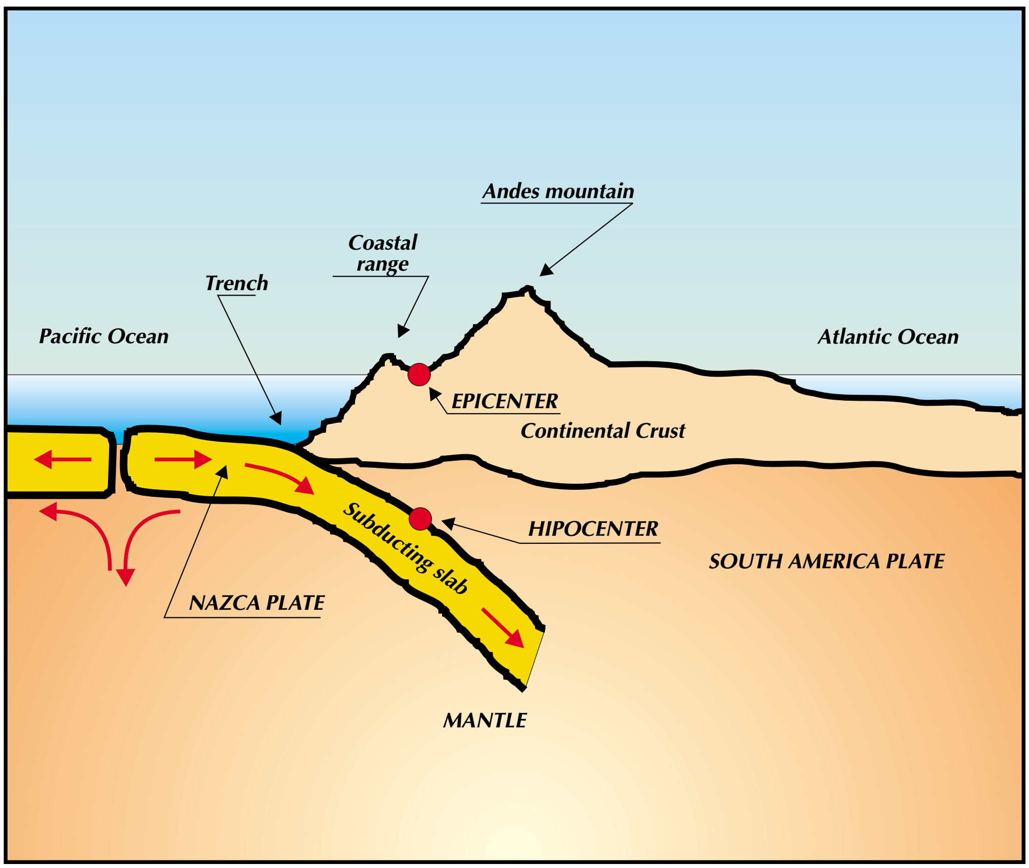
The most important mid-oceanic ridges are: the Mid-Atlantic ridge, the Mid-Indian ridge which divides in two branches to the south, and the East Pacific Rise. The East Pacific Rise starts in the Gulf of California and divides in two at Easter Island (Chile), one going south-west, and one going up to Taitao Peninsula, in continental Chile. Normally all the seismic activity in these areas is shallow and of small magnitude.

Equally concentrated and most numerous are the seismic events located in structures called island arcs. The most important island arcs are located in strips around the Pacific Ocean. The main island arcs are: Alaska-Kodiak Islands, Kamchatka Peninsula, Kuril Islands, Japan, Mariana Islands, Solomon Islands, New Hebrides Islands, Fiji Islands, Phillipines-Sunda-Adaman islands. in the Atlantic Ocean we find the Lesser Antilles and the South Sandwich Islands. Similar seismic strips are found along the coast of Central and South America. The deepest and largest magnitude earthquakes are all located in these regions. The wider seismic belt along the southern part of Europe, the Himalayas and

South East Asia, is a more complicated area, where earthquakes are more sparse.

Minor seismicity (or almost null) areas are the continental shields, like the Canadian shield in the eastern part of North America, the Brazilian shield in South America, the eastern part of Australia, Central Europe, South Africa and the oceanic floors far from the mid-oceanic ridges.

The point inside the earth where the rock breaks or moves is the focus of the earthquake. The focus of most earthquakes is inside the earth where plates rub; the place on the surface of the earth immediately above the focus is the epicenter of the earthquake. if the focus is at the surface of the earth, the focus and epicenter coincide.



Profile across South America.

If the focus is located at depths between 0 and 60 kilometers, the earthquake is shallow. If the focus is located at depths between 60 and 300 kilometers, the earthquake is of intermediate depth. If the focus is between depths of 300 and 700 kilometers, the earthquake is of deep focus.

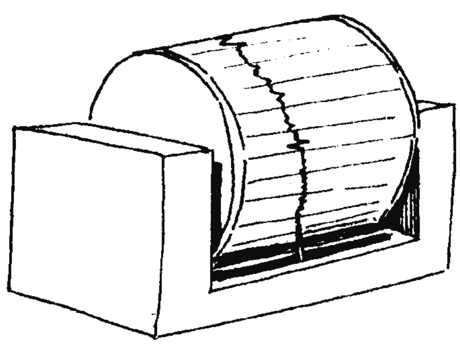
• SIZE OF AN EARTHQUAKE

To measure an earthquake two scales are used to determine intensity and magnitude.

The intensity of an earthquake is the violence with which the earthquake is felt at different locations in the affected area. Its value is determined by assessing the damage produced, the effect on objects, buildings and grounds, and the impact on people. The intensity value of an earthquake is determined according to a previously established intensity scale, which is different for different countries.

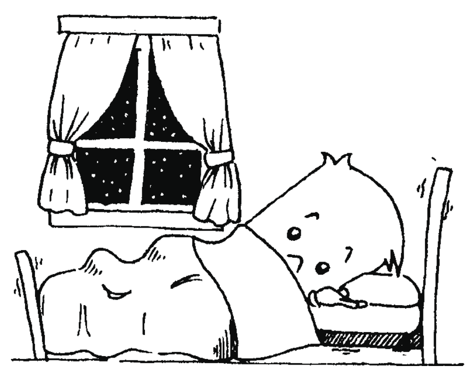
In most countries of America, the scale in use is the Modified Mercalli Intensity Scale which has 12 intensity levels. Following diagrams show the different intensity levels.

INTENSITY I



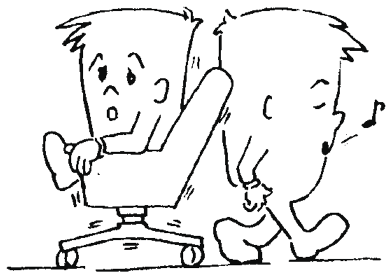
Not felt except by a very few persons under especially favorable circumstances.

INTENSITY II



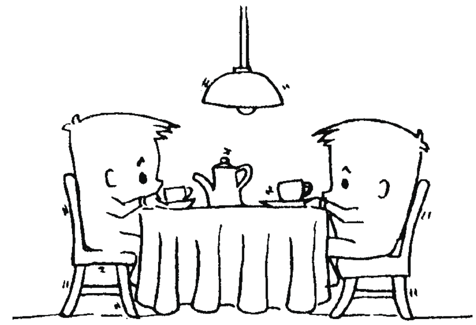
Felt only by a few persons at rest, especially on upper floors of buildings.

INTENSITY III



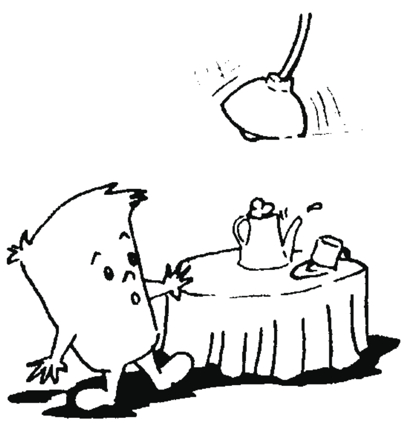
Felt quite noticeable indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake.

INTENSITY IV



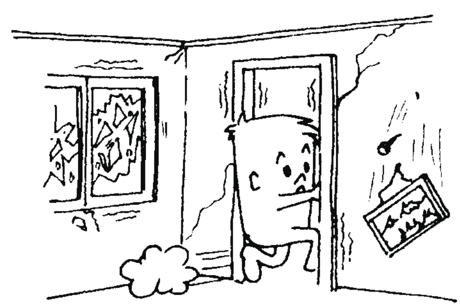
During the day, felt indoors by many people. Dishes, windows and doors, disturbed; walls make cracking sound; liquids in open vessels disturbed.

INTENSITY V



Felt by nearly everyone. Some dishes, windows, etc., broken. Unstable objects overturned.

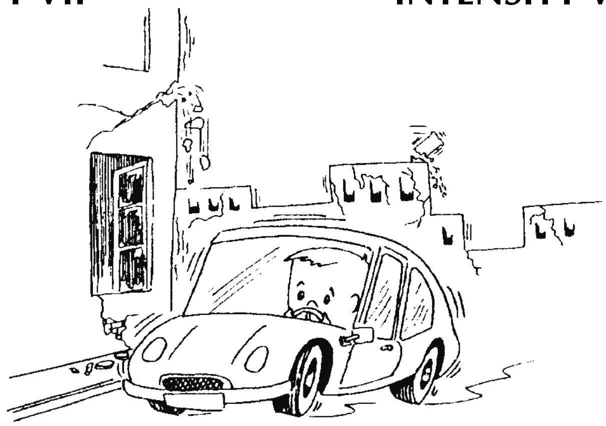
INTENSITY VI



Felt by everyone. Some heavy furniture moved. A few instances of fallen plaster or damaged chimneys.

INTENSITY VII

INTENSITY VIII

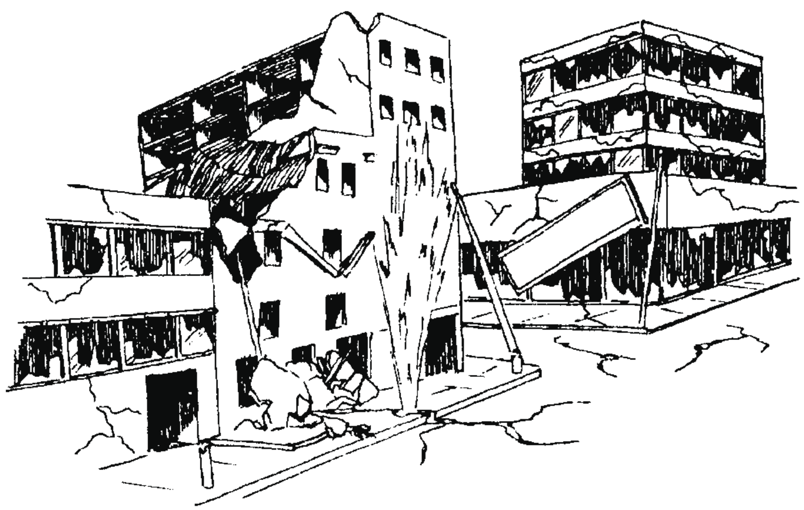


Everyone frightened. Overturned furniture in many instances. Trees and bushes shaken strongly. Noticed by persons driving cars. Cornices, brickwork, tiles and stones dislodged.

Damage slight in specially designed structures. Great in poorly built structures. Chimneys, factory stacks, columns, monuments and walls collapse.

INTENSIDAD IX

INTENSIDAD X



Every building damaged and partially collapsed. Ground cracked conspicuously. Underground pipes broken. Several landslides reported.

Some well-built wooden structures destroyed. Most masonry and frame structures destroyed along with their foundations.

INTENSITY XI **INTENSITY XII**

Few, if any structures remain standing. Bridges destroyed. Great damage to dams, dikes, and embankments. Rails bent greatly.

Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

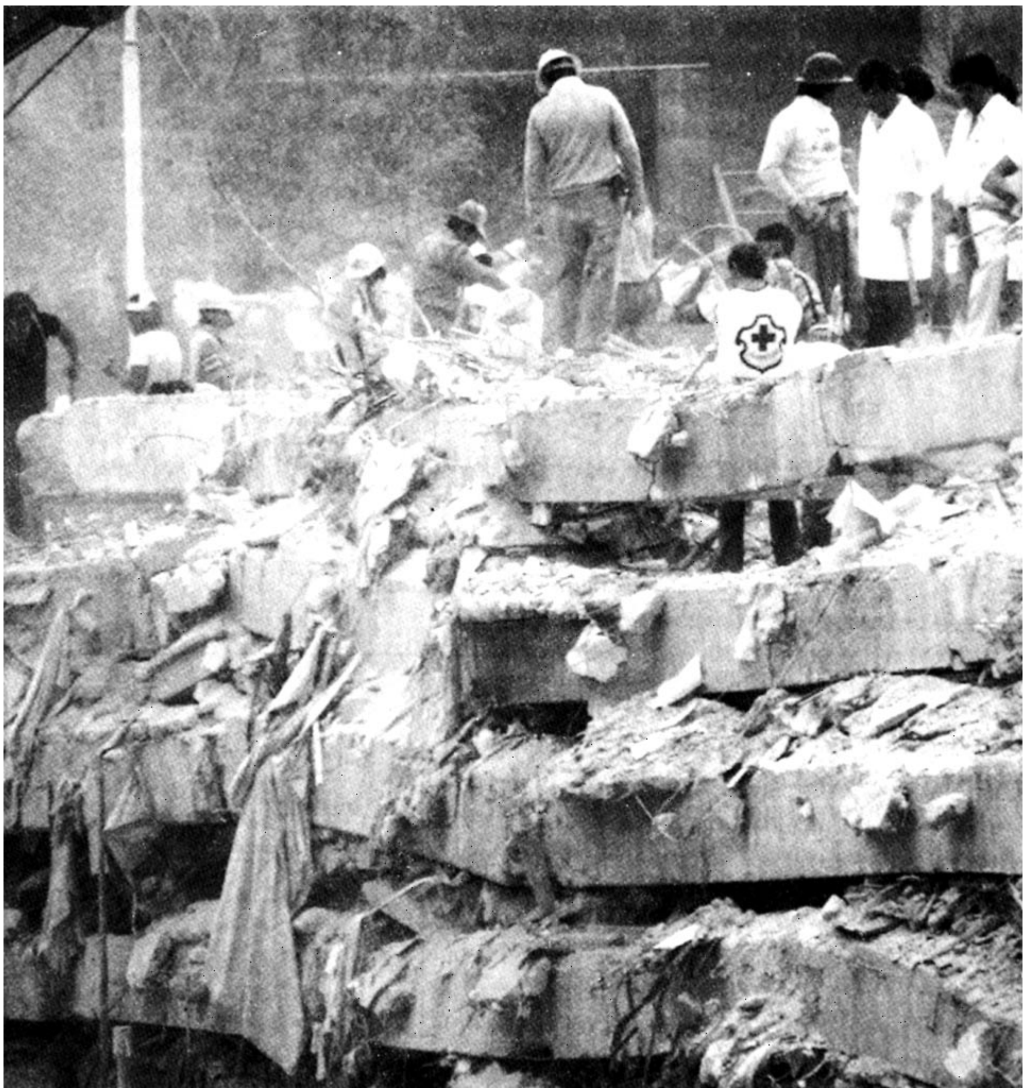
The magnitude of an earthquake is the energy released at the focus of the earthquake. It is measured with the help of an instrument called seismograph. The instrument's reading (amplitude of seismic waves) indicates the amount of strain energy released by an earthquake. The greater the wave amplitude, the greater the magnitude. A magnitude scale was devised by the American seismologist Charles Richter in 1935. It uses Arabic numerals. Richter's scale is logarithmic and open-ended; that is, there is no upper or lower limit to Richter magnitudes. Each whole-number increase in the magnitude of an earthquake represents about a thirty-fold increase in the amount of energy released.

DO YOU KNOW ...?

Many people have reported seeing colored lights or a glow in the sky during earthquakes. Some scientists think that certain rocks in the earth take on an electrical charge when they are shaken violently. This charge causes lightning-like sparks that produce the strange lights.

• **Strong Earthquakes and Aftershocks**

The strongest recorded earthquakes in history took place in 1964 near the coast of Alaska, and in 1960 off the coast of southern Chile. These earthquakes had values over 8.9 on the Richter scale. Earthquakes of this type produce a lot of damage as seen in the picture below.

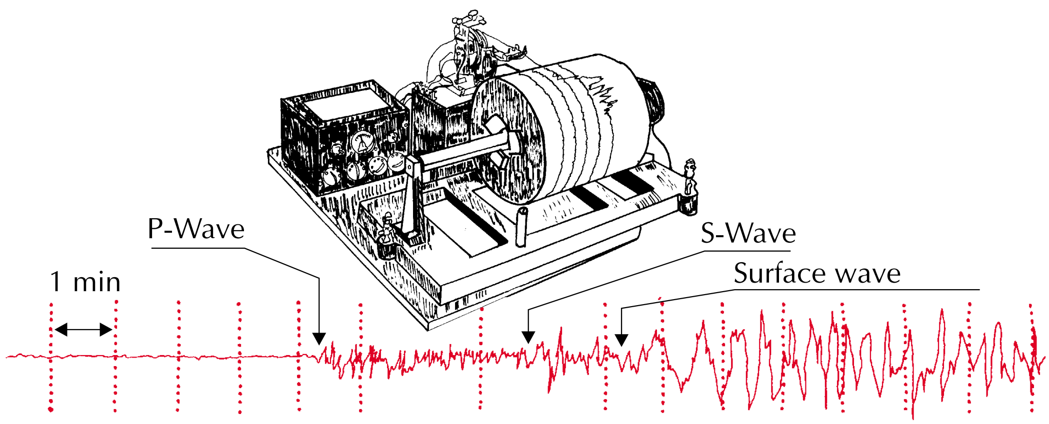


Mexico, earthquake, september 1985.
(From "National Geographic", May 1986)

Many small earthquakes, called aftershocks, usually follow a strong earthquake. The San Fernando, California, U.S.A., earthquake in 1971 registered 6.6 on the Richter scale. Within three days, more than 1,000 aftershocks followed the main earthquake. Some of the aftershocks measured up to 5.0 on the Richter scale.

• Using Seismographs to Find the Epicenter

As explained in Chapter 1, a seismograph is a sensitive instrument that measures and records seismic waves. When a seismic wave shakes the seismograph, the pen marks zigzag lines on a revolving paper roll. The lines are similar to this:



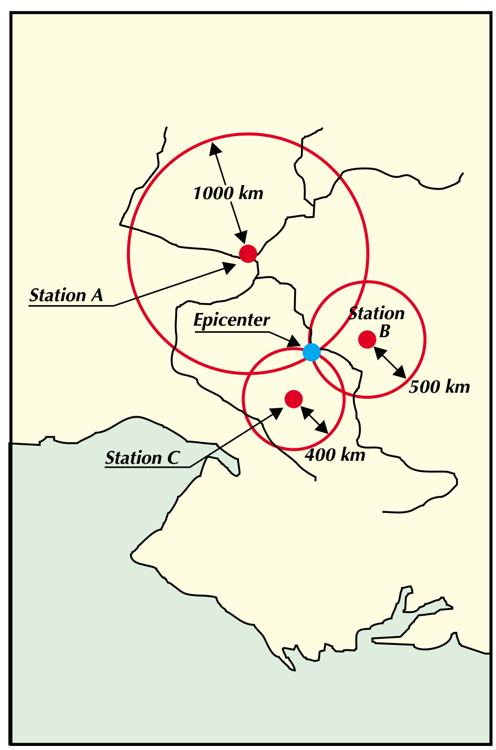
Seismograph and seismogram.

Since P-waves travel fastest, they arrive first at the seismograph, followed by S-waves. L-waves move across the surface of the earth, and arrive fast.

Scientists can calculate the distance to the epicenter of an earthquake by reading the seismogram and calculating the time difference between the arrival of the P-waves and the S-waves at the seismograph.

It takes readings from three seismograph stations to locate the epicenter of an earthquake as seen in the diagram.

Assume a scientist finds that the distance from Station A to the epicenter of an earthquake is 1,000 kilometers. The epicenter, therefore, might be at any point on a circle with a radius of 1,000 kilometers around station A on a map.



Epicenter determination.

The scientist draws this circle around Station A on a map. Assume that scientists at Station B and Station C have also read the charts and determined the distances to the epicenter to be 500 kilometers from Station B, and 400 kilometers from Station C. Scientists draw circles around their stations at B and C on maps, using the distance to the epicenter for the radius of each circle as before. The epicenter of the earthquake, shown on the previous diagram, is the point where the three circles intersect on a map.

- **Warning Earthquake Ahead!**

Where and when will the next earthquake happen? How strong will it be? Scientists are trying to answer these questions.

People all over the world who watch faults find that certain "signs" often occur before earthquakes. The ground sometimes bulges or tilts near a fault before a big earthquake. An increasing number of small earthquakes on a fault could mean that a strong earthquake is coming. Also, changes in the water level in a well near a fault is often an earthquake sign.

Using these signs and many others, scientists have been able to correctly predict some big earthquakes. Perhaps in your lifetime earthquake forecasts will become accurate enough to save lives.

ACTIVITY

LOCATING AN EARTHQUAKE

Purpose

To find the epicenter of earthquake X.

Materials

- one sheet of unlined paper
- compass
- metric ruler

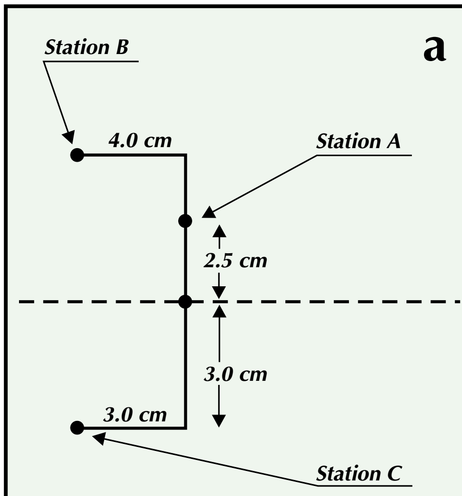
Procedure

1. Fold the paper in quarters (as shown in a), then unfold it; the intersection of the two folds is your centerpoint.

2. Mark Stations A, B, and C on the paper. Start by marking a point 2.5 cm above the center point on the paper. This is Station A. Draw in B and C using diagram a. You are making a map to find the epicenter.

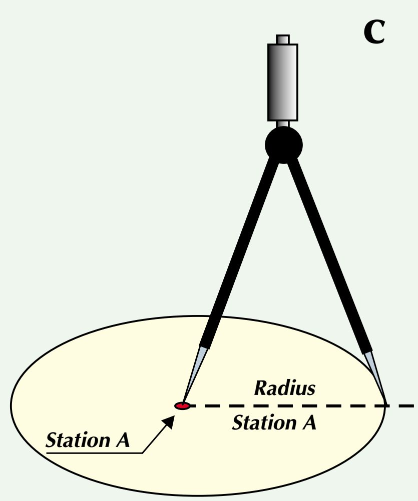
3. Scientist know how fast P and S waves travel. They can calculate the distance to the epicenter of an earthquake by measuring the difference in arrival time of P-waves and S-waves at their stations. The difference in arrival time of the waves are:

120 seconds at Station A
80 seconds at Station B
80 seconds at Station C



b

EPICENTER TABLE	
Distance to epicenter (km)	Difference in arrival time of P and S waves (sec)
200	40
300	60
400	80
500	100
600	120



Radius= distance in cm from station A to epicenter.

Using the Epicenter Table b, read and record the distance to the epicenter from each station.

4. Convert each distance to cm, so the data can be used on your map. Use the scale 1 cm = 100 km. This data will be the radius of each circle in step 5.
5. On your map draw a circle around Station A, as in c. The radius of the circle is the distance in cm that you recorded in step 4.
6. Repeat step 5 for the other two stations.
7. The location of the epicenter of earthquake X is the point where the three circles intersect. Mark this point with an X.

Analysis

1 . When do scientists need to use this method to find the epicenter?

2. Where is the focus of earthquake X?
3. Why is it necessary to draw a circle around each station with the distance to the epicenter as the radius?
4. How could someone predict the approximate location of an epicenter without a seismograph?

3.2 MAGMA AND LAVA

Like an earthquake, the eruption of a volcano means that something is happening inside the earth. Study these questions as you read:

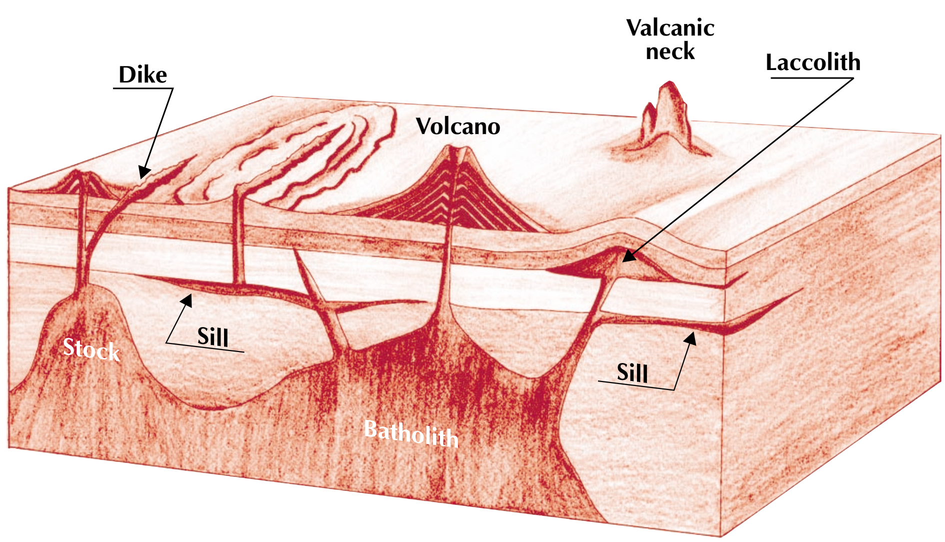
a. What forms when magma is trapped underground?
b. Where does lava reach the surface of the earth?
c. Why is lava important at plate boundaries?
d. How can you classify volcanoes by their activity?
e. How do the shapes of volcanic cones differ?

• Magma Inside the Earth

Rock formed from magma that cools and hardens underground is intrusive rock. You cannot see intrusive rock unless some geologic process exposes the hidden rock. For example, water may wear away the rocks on the surface. Five intrusive structures are illustrated together below, so you can see the shape and relative size of each.

A batholith, shown in the diagram, is so large that its bottom is often unknown.

In fact, the cores of many mountain chains are batholiths. The stock is similar to, but smaller than, a batholith. When magma works its way between rock layers, a sill forms. The mushroom- shaped laccolith forms when magma pushes up on the rock above it. When magma cuts across existing rock layers at an angle, a dike is the result.



Distribution of intrusive and extrusive rocks.

- **Lava on the Earth's Surface**

When magma comes out on the surface of the earth, it is called lava. Lava reaches the surface through volcanoes or through cracks in the ground. These cracks are called fissures. Extrusive rocks are hardened lava on the earth's surface.

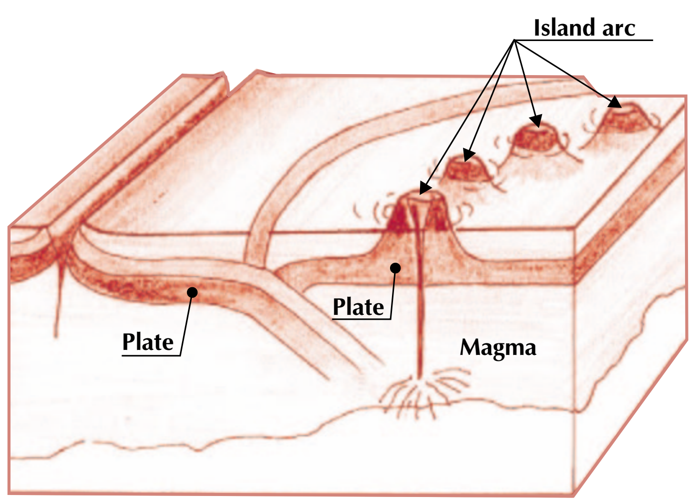
Lava from large fissures may flood wide areas of land, since they may have been several kilometers long.

- **Lava at Plate Boundaries**

Most extrusive rocks form where you cannot see them - on the ocean floor. These rocks are the new crust born at mid-ocean ridges. Vast amounts of lava rise through fissures or volcanoes at spreading boundaries. Occasionally volcanoes on the ocean floor grow large enough to become islands.

Many volcanoes are near colliding boundaries. The diagram below shows one ocean plate sinking under another ocean plate. The sinking crust melts in the asthenosphere. Then the magma that forms from the melted crust rises. This magma gives rise to volcanoes on islands called island arcs. The Japanese Islands are an example of an island arc.

Volcanoes may also form on land where an ocean plate sinks under a land plate. This type of boundary produced the Cascade Mountains of Washington and Oregon in the United States of America, as well as the Andes Mountains of South America.



Colliding boundary.

DO YOU KNOW?

Pillow lava is a type of lava that cooled and hardened under water. It is common at spreading boundaries. The strange, rounded lumps of hot lava pop, hiss, and crackle when they meet with cold ocean water.

- **Volcanic Activity**

Volcanoes differ in appearance and behavior. Some volcanoes explode, shooting out dust, ash and rocks, as well as water vapor and other gases. The 1980 eruption of Mount St. Helens in the United States of America, followed this pattern. Other volcanoes quietly ooze lava.

Why do some volcanoes blow up? Visualize the effects of shaking a warm soda pop. The bottle may explode, releasing the soda and the carbon dioxide, the dissolved gas in the soda. Cases and water vapor, which are under pressure inside a volcano, may also explode.

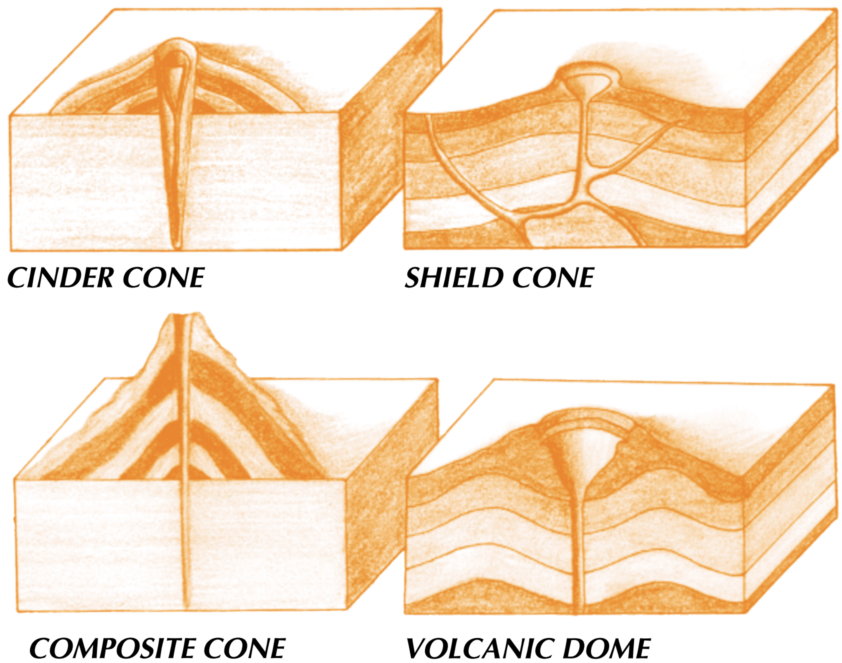
One of the biggest volcanic explosions that ever took place was the eruption of the volcano Krakatau, a volcanic island in the strait between Java and Sumatra. In 1883 it exploded so violently that people heard the explosion 3,200 kilometers away. Most of the island disappeared. Volcanic dust remained in the air around the world for two years. A giant sea wave created by the explosion killed more than 36,000 people on nearby islands.

Volcanoes often give warnings before they erupt. These warnings include gas and smoke from the volcano. Earthquakes may signal the rise of magma inside the volcano. The ground around or on the volcano may bulge or tilt slightly.

If a volcano has erupted in the recent past, it is called an active volcano. A dormant volcano is one that erupted in the past but has been quiet for many years. An extinct volcano is one that is not expected to erupt again. Most of the volcanoes in the Hawaiian Islands are extinct.

DO YOU KNOW?

Many countries of the world use hot water or steam from the ground to heat their homes or make electricity. Water in the ground is heated by igneous activity. Energy from the heat of the earth is called geothermal energy.



Types of volcanic cones.

- **The volcanic Cone**

The mountain built by a number of volcanic eruptions is the volcano's cone. It is made of lava, volcanic ash, and rocks. A cone usually has a central vent. The volcanic materials come up through the vent. The top of the cone ordinarily has a crater, which is a bowl-like depression. The shape of a volcano depends on the way it erupts and the type of volcanic material that leaves the cone.

A cinder cone, pictured above, forms when the eruptions throw out mostly rocks and ash but very little lava. Paricutin is a famous cinder cone volcano in Mexico. In 1943, this volcano appeared in a cornfield. in six days the cone was 150 meters high! The volcano reached 400 meters in height before it became dormant.

Non-explosive eruptions with easy flowing lava create shield cones, shown in the diagram. The volcanic islands of Hawaii with their gently sloping surfaces are typical shield volcanoes.

Alternating eruptions of dust, ash, and rocks followed by quiet lava flows build composite cones, shown above.

Volcanic domes result from violent eruptions of lava so thick that it barely flows. As you can see in the diagram, these volcanoes have sloping sides and dome-shaped tops. Mount Pelée is a dome volcano on the Caribbean Sea island of Martinique. It erupted violently and with little warning in 1902. A fiery cloud of gas and ash rolled down the side of the volcano, killing most of the people in the town below.

The effects of volcanic eruptions are far-reaching. Huge amounts of volcanic dust in the air contribute to beautiful sunsets and sunrises. If dense enough, volcanic dust can change the weather. The increased cloud cover from the dust can cause rain, and even cool weather. The fertile soils of the Hawaiian Islands developed from volcanic ash and rocks. Scientists think the gases in the air and the water in the oceans came from ancient volcanic eruptions.

ACTIVITY

EARTHQUAKES AND VOLCANOES

Purpose

To compare the locations of earthquakes and volcanoes around the Pacific.

Materials

- pencil
- outline map of Pacific and countries surrounding it
- globe or map of the world

Procedure

1. Using a globe or world map, locate on your outline map the earthquake areas named in a. Notice that the area names include cities, states, islands, and countries.

2. On your outline map mark with a Q the locations that you found in the step above.

3. Draw a line from one Q to the next nearest Q until all Qs are joined.

4. Using a globe or world map, locate the volcano sites listed on the next page. You will probably not be able to find the volcanoes themselves, but you can find the islands, states, countries, or areas where the volcanoes are located.

5. Mark these locations with a V on your outline map.

6. Repeat step 3 above for all of the Vs.

Analysis

1. Describe the figures that resulted from the joined Qs and the joined Vs.
2. What relationship exists between earthquake zones and volcano zones on your map?
3. How do the earthquake and volcano zones compare with plate boundaries shown on the map in Chapter 2?
4. At which of the three types of plate boundaries are all of the volcanoes and earthquakes located?
5. What other surface feature is likely to be near the volcanoes on your map?
6. Why do you think the area around the Pacific is called "The Ring of Fire"?

a)

Areas of Frequent Earthquakes	Volcanoes
Acapulco, Mexico	Tacora, Chile
Aleutian Islands	Misti, Peru
Anchorage, Alaska	Mt.St. Helens, U.S.A
Concepcion, Chile	Osorno, Chile
Costa Rica	Paricutin, Mexico
Ecuador	Pogromni, Aleutian 1
Fiji Islands	Sangay,Ecuador
Los Angeles, California, USA.	Sta.Maria, Guatemala
New Guinea	Ruapehu, New Zealand
Nicaragua	Taal, Philippines
New Zealand	Wrangell, Alaska
Portland, Oregon, USA.	Koryakskaya, Pacific
San Francisco, California, USA.	Coast of Russia
Santiago, Chile	Yokohama, Japan

A) REPORT

ERUPTIONS AND THEIR PRODUCTS

Extracted from "FACING GEOLOGIC AND HYDROLOGIC HAZARDS", U.S. Geological Survey, Professional Paper 1240-B

Volcanic eruptions can be broadly classed as non-explosive or explosive. Nonexplosive eruptions are generally caused by an iron and magnesium-rich magma (molten rock) that is relatively fluid and allows gas to escape readily. Lava flows that are common on the island of Hawaii are the characteristics product of nonexplosive eruptions. Explosive eruptions, in contrast, are violent and are derived from a silica-magma that is not very fluid; these eruptions are common at volcanoes in the volcanic chain of Alaska. Explosive eruptions produce large amounts of fragmental debris in the form of airfall ash, pyroclastic flows, and mudflows on and beyond the flanks of the volcanoes.

Tephra is one of the products of an eruption. Tephra is a term used to describe rock fragments of all sizes erupted into the air above a volcano, often in a vertical column that reaches into the outer layer of the stratosphere. Large rock fragments generally fall back onto, or near, the volcano. Small fragments are carried away by wind and fall to the ground at a distance determined by the grain size and density, the height to which the fragments are erupted, and the velocity of the wind. Eruption of a large volume of tephra will cause a distinct layer of ash to accumulate. The spatial distribution of ash accumulation is generally in the form of a lobe which is thickest directly downwind from the volcano and thinnest the boundaries; the thickness decreases as distance from the volcano increases. Tephra can endanger lives and damage property at considerable distances from a volcano by forming a blanket at the groundsurface and by contaminating the air with abrasive particles and corrosive acids. Close to a volcano, people can be injured or killed by breathing tephra-laden air; damage to property is caused by the weight of tephra and its smothering and abrasive effects.

Hot fragments and gases can be ejected laterally at high speed from explosive volcanoes and can be extremely dangerous. Lateral blasts, the term for the phenomenon, commonly leaves deposits that are no more than 3 to 6 feet thick near source vent, theses deposits thin rapidly as distance from the vent increases. They generally do not extend more than several kilometers from the vent, but ocasionally a blast can reach as far as about 25 kilometers. Lateral blasts endanger people chiefly because of their heat, rock fragments carried, and high speed which may not allow sufficient time for them to escape or to find adequate cover. Damage to structures results chiefly from impact and high-speed "wind". Lateral blast phenomenon can grade outward to pyroclastic flows that move down from slopes. The effects of the two events are similar.

Pyroclastic flows are masses of hot dry rock debris that move like a fluid. They owe their mobility to hot air and other gases mixed with the debris. They often form when large masses of hot rock fragments are suddenly erupted onto a volcano's flanks. Pyroclastic flows can move downslope at speeds of as much as 160 kilometers per hour and tend to follow and bury valley floors. Clouds of hot dust generally rise from the basal coarse part of the flow and may blanket adjacent areas, especially downwind. Because of their great mobility, pyroclastic flows can afect areas 25 kilometers or more from a volcano. The principal losses from a pyroclastic flow are caused by the swiftly moving basal flow of hotrock debris, which can bury and incinerate everything in its path, and the accompanying cloud of hot dust and gases, which can extend beyond the basal flow and cause asphyxiation and burning of the lungs and skin.

Mudflows are masses of water-saturated rock debris that move down slopes in a manner resembling the flowage of wet concrete. The debris is commonly derived from masses of loose unstable rock deposited on the flanks of a volcano by explosive eruptions; the water may be provided by rain, melting snow, a crater lake, or a lake or reservoir adjacent to the volcano. The speed of mudflows depends mostly on their fluidity and the slope of the terrane; they sometimes move 80 kilometers or more down valley floors at speeds exceeding 35 kilometers per hour. Mudflows may reach even greater distances than pyroclastic flows, about 90 kilometers from their sources. The Chief threat to man is burial. Structures can be buried or swepts away by the vast carrying power of the mudflow.

Lava flows are generally erupted quietly, although they are often preceded by explosive volcanic activity. Lava flows typically appear only after an eruption has been in progress for hours, days, or a few weeks, rather than at the outset of the eruption. The fronts of lava flows usually advance at speeds ranging from barely perceptible to about as fast as a person can walk. Lava flows typically cause no direct danger to human life, but they generally cause total destruction in the areas they cover. Lava flows that extend into areas of snow may melt it and cause floods and mudflows; lava flows that extend into vegetated areas can start fires. On large central-vent volcanoes lava flows generally are short; therefore, lava-flow hazard zones include only the flanks of the volcano and the nearest 2 to 3 kilometers of adjacent valleys and basins.

Flow-hazard zones extend considerable distances down some valleys. Losses from a volcanic eruption can be reduced in several ways. These include (1) use of knowledge of the past eruptive activity of a volcano to define the potential kinds, scales, locations, extents, effects, and severity of future eruptions and to define hazard zones, (2) establishment of monitoring system to forescast an impending eruption and to provide warning, (3) disaster preparedness and emergency evacuation, (4) protective measures, (5) risk assessment and land-use planning, (6) insurance, and (7) relief and rehabilitation.

B) CHAPTER SUMMARY

- Most earthquakes are a result of the movement of rocks along a fault.
- Most earthquakes occur near plate boundaries.
- Numbers on the Richter scale indicate the strength of an earthquake.
- P-waves, S-waves, and L-waves carry energy away from the focus of an earthquake.
- Seismographs detect and record seismic waves.
- Rocks form inside the earth and on the surface of the earth because of volcanic activity.
- Most volcanic activity on the earth's surface is near plate boundaries.
- A volcano is called active, dormant, or extinct depending upon its history of eruptive behavior.
- Cinder cones, shield cones, composite cones,.and volcanic domes are different types of volcanoes.

C) QUESTION/PROBLEMS

1. What causes earthquakes in the middle of a plate?
2. Explain what is meant by a deep focus earthquake.
3. Why do scientists think that the outer core of the earth is liquid?
4. What causes volcanoes to occur on island arcs?
5. List four signs that might help scientists predict an earthquake.
6. How can you tell that a fault releases energy?
7. Where do most deep focus earthquakes occur?
8. What increase in energy is an increase of one number on the Richter scale?
9. Where did the strongest recorded earthquakes occur?
10. Which two seismic waves move through the earth?
11. Why do scientists need three seismograph readings to find an earthquake?
12. What might the slowing of P-waves indicate?
13. What is a batholith?
14. What is a fissure in the earth?
15. How does an island arc form?
16. What is an extinct volcano?
17. Which of the types of cones is not steep-sided?

D) CHAPTER TEST

A. Vocabulary. Match the definition in Column I with the term it defines in Column II, on the left margin between the brackets.

Column I

( ) 1. a volcano that has not erupted recently

( ) 2. a series of small earth-quakes that follow a large one

( ) 3. a volcano that is not expected to erupt again

( ) 4. the way in which energy travels through the earth

( ) 5. the point on the earth's surface which is above,the focus of an earthquake

( ) 6. an instrument that detects seismic waves from distant earthquakes

( ) 7. volcanic activity that takes place at the surface of the earth

Column II

a. aftershock

b. batholith

c. dormant

d. epicenter

e. extinct

f. extrusive

g. seismic wave

h. focus

i. laccolith

j. seismograph

B. Multiple Choice. Choose the letter that best completes the statement or answers the question, and write it on the column at the left margin between the brackets.

( ) 1. To locate the epicenter of an earthquake, scientists need at least

a) one seismograph report
b) two seismograph reports
c) three seismograph reports
d) four seismograph reports

( ) 2. A mushroomed-shaped intrusive rock mass is a

a) laccolith
b) stock
c) sill
d) volcanic dome

( ) 3. Most magma reaches the surface at

a) trenches
b) mid-oceanic ridges
c) faults
d) island arcs

( ) 4. When old ocean crust moves under younger ocean crust, the resulting volcanoes are

a) flood basalts
b) continental volcano chains
c) new ocean floors
d) on island arcs

( ) 5. Volcanoes composed of alternating layers of volcanic ash and lava are

a) composite cones
b) cinder cones
c) shield volcanoes
d) volcanic domes

( ) 6. A crack in the ground through which lava oozes is a

a) trench
b) fissure
c) stock
d) sill