CHAPTER 13A

California's Resources and Natural Hazards

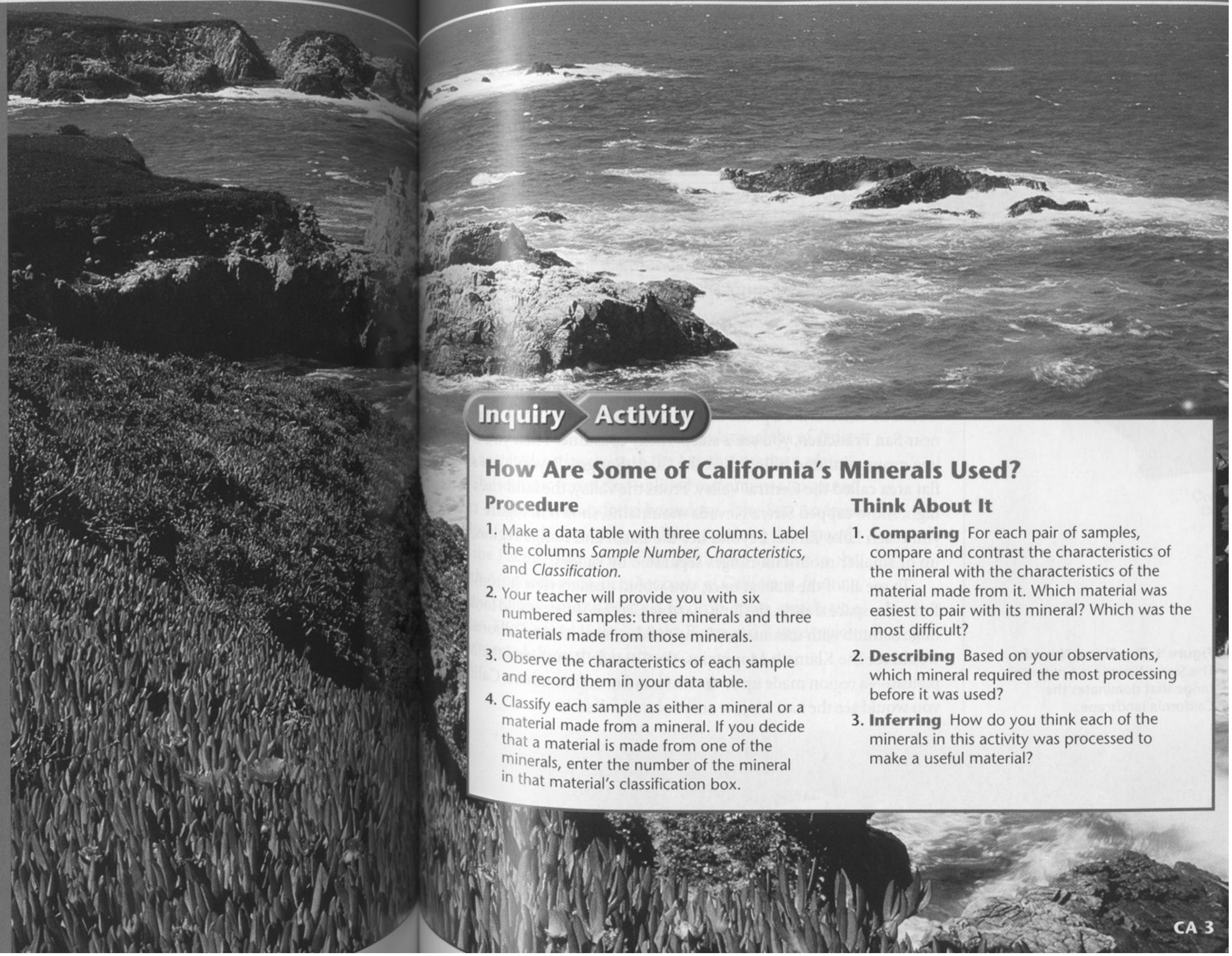
California Earth Science Standards

9.a. Students know the resources of major economic importance in California and their relation to California's geology.

9.b. Students know the principal natural hazards in different California regions and the geologic basis of those hazards.

9.c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.

9.d. Students know how to analyze published geologic hazard maps of California and know how to use the map's information to identify evidence of geologic events of the past and predict geologic changes in the future.



Big Sur, California, owes its spectacular coastline to tectonic forces that uplift Earth's crust—and to the power of ocean waves that cause erosion.

Chapter Preview

Inquiry Activity

How Are Some of California's Minerals Used?

Procedure

1. Make a data table with three columns. Label the columns *Sample Number, Characteristics,* and *Classification.*
2. Your teacher will provide you with six numbered samples: three minerals and three materials made from those minerals.
3. Observe the characteristics of each sample and record them in your data table.
4. Classify each sample as either a mineral or a material made from a mineral. If you decide that a material is made from one of the minerals, enter the number of the mineral in that material's classification box.

Think About It

1. **Comparing** For each pair of samples, compare and contrast the characteristics of the mineral with the characteristics of the material made from it. Which material was easiest to pair with its mineral? Which was the most difficult?
2. **Describing** Based on your observations, which mineral required the most processing before it was used?
3. **Inferring** How do you think each of the minerals in this activity was processed to make a useful material?

13A.1 California's Mineral, Energy, and Soil Resources

Reading Focus Standard: 9a

Key Concepts

- What geologic processes formed the main features of the California landscape?
- What are California's major mineral resources?
- How do California's energy resources relate to the state's geology?
- What are California's soil resources?

Vocabulary

- source rocks
- reservoir rocks
- geothermal field

Reading Strategy

Summarizing Copy and complete the table below as you read the section.

California Resource	How the Resource Formed	Where the Resource Occurs
Industrial Minerals	a. ___?___	b. ___?___
Metallic Minerals	c. ___?___	d. ___?___
Nonmetallic Minerals	e. ___?___	f. ___?___
Oil and Natural Gas	g. ___?___	h. ___?___
Geothermal Energy	i. ___?___	j. ___?___
Soils	k. ___?___	l. ___?___

How could you describe the topography of California? One way would be to describe a plane flight across the state. As your trip begins near San Francisco, you see a steep, rocky coastline. Then you fly over low mountains and hills, called the Coast Ranges. Beyond lies a wide, flat area called the Central Valley. From the valley, the land rises to the high, snow-capped Sierra Nevada mountains, shown in Figure 1. Soon you reach Lake Tahoe. Beyond lies the Basin and Range region, made up of smaller mountain ranges separated by valleys.

To see all of the state at once, you would need to view it from space. From the space shuttle, the long, narrow Central Valley would look like a huge bathtub with mountains along its sides. In northern California, you would see the Klamath Mountains, the Cascade Range, and the Modoc plateau—a region made up of ancient lava flows. In southern California, you would see the vast Mojave and Colorado deserts.

Figure 1 The Sierra Nevada The Sierra Nevada is a mountain range that dominates the California landscape.

Geology of California

Each of California's regions is defined by the major geologic features within that region. **Some of the features of the California landscape formed as the result of tectonic processes that took place deep beneath the surface. Wind, water, ice, and other agents of erosion at the surface carved other features of the landscape.**

Geologic Processes Inside Earth California's scenic mountains attract visitors from around the world. But the mountains are not just beautiful; they also provide a record of California's geologic history.

Interactions between tectonic plates built the mountains in California. Millions of years ago, the subduction of an oceanic plate beneath the North American plate formed large pools of magma. Some of the magma crystallized beneath the surface to form large masses of igneous rock. Uplift and erosion eventually exposed these batholiths, which form the Sierra Nevada. East of the Sierras, the subduction of the oceanic plate produced stresses that caused faulting. Movements along these faults formed the Basin and Range mountains.

Subduction of the Juan de Fuca plate beneath the North American plate produced the volcanoes in the Cascade Range, including Mount Shasta and Lassen Peak. The Coast Ranges, too, are the result of plates moving together. The Coast Ranges formed as large slabs of crust were accreted, or stuck, onto the North American plate.

The tectonic forces that uplifted mountains also caused other changes. A transform boundary—the San Andreas Fault—formed in southern California. Along this boundary, the Pacific plate is moving northward relative to the North American plate. In other parts of California, faulting caused other portions of crust to drop down, producing basins. The Central Valley and the Basin and Range region were formed through this process.

Figure 2 Regions of California Major geologic features such as mountains, valleys, and deserts define the regions of California. **Interpreting Maps** *In which region is the Salton Sea located?*

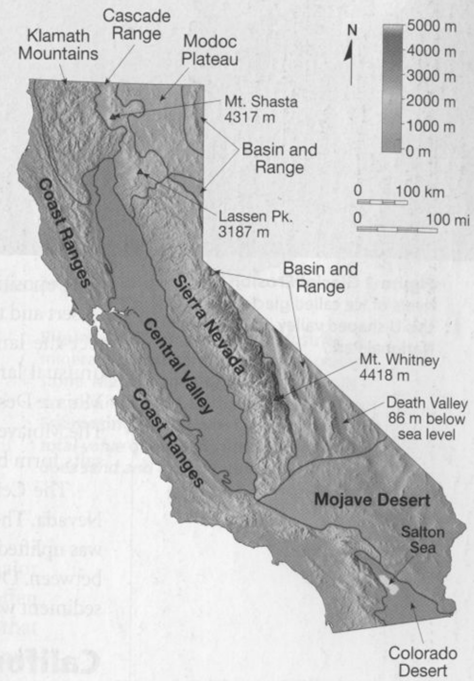


Figure 3 Glacial Erosion Huge rivers of ice called glaciers carved this U-shaped valley in Yosemite National Park.

Surface Geologic Processes Tectonic forces built up California's landforms over millions of years. At the same time, flowing water, glaciers, and wind reshaped the surface through erosion and deposition.

Water erosion shaped the state's mountains, hillsides, and river valleys. Rivers that begin in the Sierras, for example, cut steep-sided, V-shaped valleys where they flow through the mountains. On valley floors, however, the rivers flow slowly, producing meanders and leaving thick alluvial deposits.

Glacial ice has also shaped California's landscape. Thousands of years ago, massive glaciers covered the mountainous regions of the state. As these glaciers advanced and retreated, they carved mountain peaks and vast U-shaped valleys, like the one shown in Figure 3.

Deposition of sediment produced landscapes as diverse as the Mojave Desert and the Central Valley. Deserts generally have few plants to protect the land surface from erosion. As a result, deserts often have unusual landforms produced by water and wind. For example, the Mojave Desert includes areas of large sand dunes shaped by the wind. The Mojave also has flat, dry lake beds known as playas, where mineral salts form by evaporation.

The Central Valley lies between the Coast Ranges and the Sierra Nevada. The valley began as an inland sea. Then the land on both sides was uplifted to form the Sierras and the Coast Ranges, leaving a basin in between. Over millions of years, this basin filled with huge amounts of sediment washed down from the nearby mountains.

California's Mineral Resources

California's geology has resulted in a wealth of mineral resources, including industrial, metallic, and nonmetallic minerals. These minerals are important to the state's economy. The term *mineral resources* includes minerals plus various types of rocks and sediment. It also includes products made from these materials. **California's major mineral resources include sand, gravel, crushed stone, building stone, gold, silver, iron, evaporite minerals, and clay.** (An evaporite is a mineral formed as a solution containing dissolved salts evaporates. Evaporation causes the concentration of salts in the solution to increase, and the mineral begins to precipitate.) As you read, think about how you use these resources every day.

Reading Checkpoint *What does the term* mineral resources *mean?*

Industrial Minerals You may be surprised to learn that sand and gravel are California's most valuable industrial minerals. The graph in Figure 4 shows their contribution to the state's economy. These mineral resources are used in road-building and construction. Most sand and gravel is mined from alluvial deposits, which include sediment from streams and alluvial fans. Alluvial fans form when a stream flows out of a mountain canyon, spreads out, loses velocity, and deposits sediment.

Another important industrial mineral of California is crushed stone. Most of the crushed stone is limestone that is used to make cement. Most limestone forms from the shells and skeletons of marine organisms. California's limestone formed millions of years ago when parts of the state were covered by the Pacific Ocean.

Some of California's limestone is quarried in large slabs that are used to construct buildings. Other sedimentary rocks, including sandstone and shale, provide decorative building stone.

Much of the granite quarried in California is from the Sierra Nevada batholith. Because of its hardness and beauty, the granite is used for building stone, counter tops, and cemetery markers.

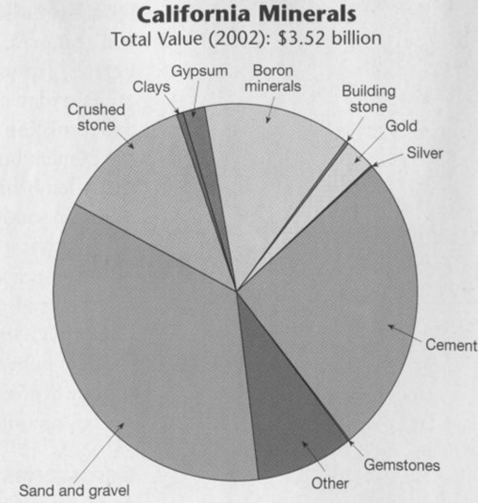
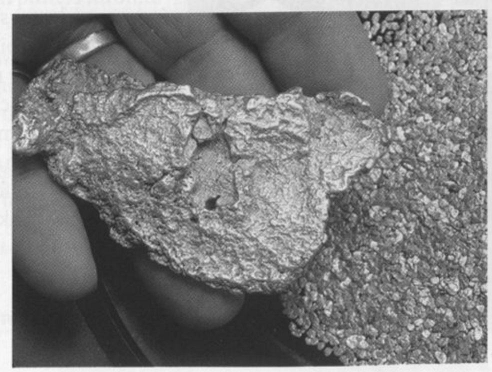


Figure 4 California's major industrial minerals include sand, gravel, and crushed stone. Metallic and nonmetallic minerals are also important to the state's economy. **Estimating** ***About what proportion of the total value of minerals produced in 2002 does sand and gravel represent?***

Metallic Minerals Gold, silver, and iron are the major metallic minerals mined in California. Gold and silver often occur in quartz veins in igneous and metamorphic rocks that formed during mountain building. When moving water and ice weather the veins, the gold and silver may collect to form placers. Recall that placer deposits form when dense minerals settle out of moving water. Placer deposits of gold include large particles called nuggets, like those shown in Figure 5. The most productive gold mining areas in California today include the Sierra Nevada, the Klamath Mountains, and the Mojave Desert. Silver is mined in the Sierra Nevada.

While not as rare as gold and silver, iron is an important metal from the Mojave Desert region. Deposits of minerals containing iron formed in areas where magma heated rock and water beneath the surface. This heating produced hot water solutions that were rich in iron. As the solutions cooled, iron minerals were deposited in fractures in the rock.

Figure 5 California Gold Gold nuggets can sometimes be found in placer deposits.



Nonmetallic Minerals California has an abundance of mineral resources in addition to metals. Three of the most significant are borates, gypsum, and clay.

Everyday materials such as fiberglass, detergents, glass, ceramics, and insulation often contain borates. Borates form when water rich in the element boron flows into desert lakes and evaporates. The boron that is left behind combines with oxygen to form borates. Borates are mined in southern California.

Gypsum, a compound of calcium, sulfur, and oxygen, forms when salt water evaporates. It also forms when sulfur-rich waters evaporate in caves and around hot springs. Much of the gypsum mined in California is used in wallboard, plaster, and cement.

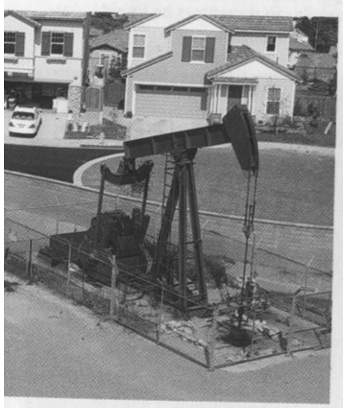
Clay minerals are a group of silicates that contain water. Most of the clay deposits in California formed from weathered feldspar. Clay is used in ceramics and in building materials such as bricks.

Gemstones Gemstones form when mineral-rich solutions crystallize deep underground. Small quantities of gemstones, such as tourmaline, garnet, agate, and jade, are found in California. The state gem, benitoite, is a deep blue mineral found in the Diablo Range in San Benito County.

California's Energy Resources

California is a leading producer of energy resources. **California's major energy resources—oil, natural gas, and geothermal energy—are the result of geologic processes that occur deep beneath the surface.**

Figure 6 Oil Production This oil well, part of the Signal Hill oil field in Long Beach, was drilled in 1921. Wells like this one marked the beginning of oil as a major industry in California.



Oil About 15 percent of the oil produced in the United States comes from California. In Chapter 4, you learned that oil (petroleum) forms when tiny marine organisms die and become buried by sediment on the ocean floor. As more and more sediment accumulates, the organic matter undergoes many physical and chemical changes that convert it to oil. The rocks in which the oil forms are called **source rocks.** Most source rocks are shale.

Over time, oil often migrates from the source rocks into nearby porous rocks, or **reservoir rocks,** and becomes trapped. Wells drilled into reservoir rocks bring the oil to the surface.

The first commercial oil production in California took place in 1876. Since then, oil has been found in 18 of the 58 counties in the state. Today, California has hundreds of active oil and natural gas fields. Many of them, like the one shown in Figure 6, are on land. Other wells extract oil and natural gas from offshore fields.

Reading Checkpoint *What are source rocks?*

Figure 7 Geothermal Energy Production Some of San Francisco's electricity comes from this geothermal power plant at The Geysers geothermal field.

Natural Gas Natural gas often forms along with oil. Natural gas is a mixture of several gases, including methane. Because it is less dense than oil, natural gas rises to the top of a reservoir, where it remains until the reservoir is tapped. In 2003, California wells produced nearly 350 billion cubic feet of natural gas. People used some of this natural gas for heating and cooking and as fuel for home appliances. Natural gas is also used to generate electricity.

Geothermal Energy California's geology makes it a leading state in the production of geothermal energy. Recall from Chapter 4 that geothermal energy is abundant in volcanic areas or where there is igneous activity close to the surface. A **geothermal field** is in an area where magma that is relatively close to the surface heats the groundwater. How is geothermal energy harnessed? Engineers drill wells that tap into steam in rock beneath the surface. The steam powers turbines that generate electricity.

The nation's first geothermal power plant was built at The Geysers—a geothermal field located about 100 kilometers northeast of San Francisco. At its peak in 1987, The Geysers, shown in Figure 7, generated enough electricity for nearly 2 million homes and businesses.

Today, many high-temperature geothermal fields around the state generate electricity. Geothermal energy is also used to heat numerous commercial buildings including more than three dozen municipal buildings in the city of San Bernardino.

Reading Checkpoint *What is a geothermal field?*

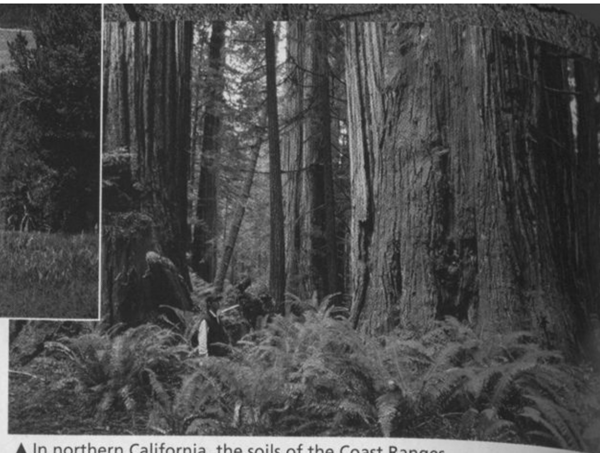
Q&A

Q *How much energy can be produced from a geothermal well?*

A The depth of the well determines the energy output. A well named Vonderahe 1, drilled at the Salton Sea geothermal field in southern California, can produce about 1 million kilograms of hot water per hour. This translates into 30 megawatts of electricity, enough to operate thousands of average households.

▲ Wildflowers thrive in the thin, rocky soils of the Sierra Nevada.

Figure 8 Soils of California California's soils vary with topography and climate and with the bedrock from which the soil formed.



▲ In northern California, the soils of the Coast Ranges support giant redwoods.

California's Soil Resources

Foods grown in California feed people throughout the nation and around the world. The state's vast orchards and crop fields depend on one of the Golden State's most precious resources—its soil.

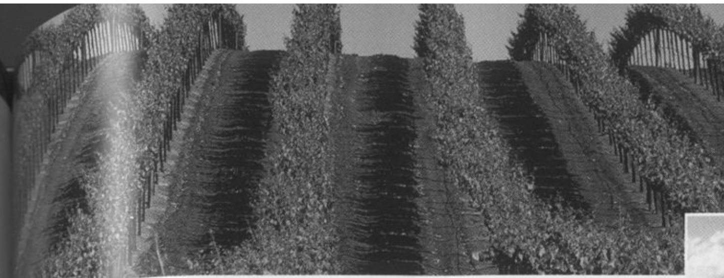
Soils California's soils can be classified in terms of the major geographic regions where they form. **The soils of California include soils of the Sierras, soils of the Coast Ranges and Cascades, valley soils (including the Central Valley), and desert soils.** In general, California's fertile valley soils are its most important soil resource. The soils of Napa Valley, one of the locations shown in Figure 8, make that area an important grape-growing region.

In the Sierra Nevada region, soils vary with topography. Soils on steep slopes tend to be thin and low in humus. Mature soils at lower elevations and in mountain valleys can be quite fertile.

The Coast Ranges also have a wide range of soil types. In wetter northern California, the heavy rains wash away, or leach, the nutrients from the soil. This results in areas with reddish, acidic, low-fertility soils. Other areas have very fertile, thick, dark soils that develop under grasslands. In drier southern California, soils of the Coast Ranges also form a complex pattern. But the soils of this region generally contain more nutrients because there is less rainfall to leach them.

Most of the fertile soils suitable for agriculture are located in flat areas or valleys. In the Central Valley, immature but fertile soils have formed on alluvial deposits and floodplains that were formerly grassland.

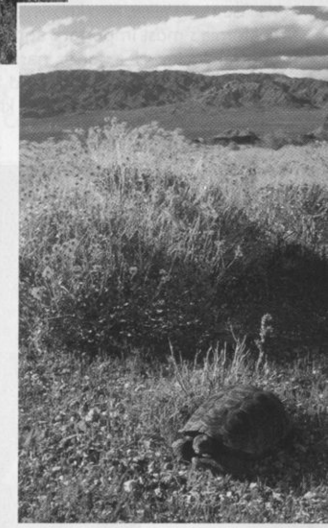
California's desert areas, such as the Mojave Desert, generally have light, sandy soils that are low in nutrients. Some parts of desert areas are rocky and barren because much of the soil has been washed away.



◀ The fertile, well-drained soils of Napa Valley are ideal for growing grapes.

Conserving California's Soils Conservation is important to protect California's valuable soil resources. Every year, many acres of the state's farmland are lost or damaged because of soil erosion or the spread of urban areas. It can take over 500 years to build up 2.5 centimeters of soil. Because soil forms so slowly, soil erosion can be a serious problem.

Another problem that threatens soil in California is salinization, or the buildup of salt in the soil. Salinization occurs in irrigated areas such as the Central Valley. The water applied to the land by irrigation can cause the water table to rise. At the same time, the water dissolves mineral salts in the soil. Evaporation then pulls the salty water toward the surface. As the water evaporates, the salts are left behind in the soil. Farmers can reduce salinization by installing drainage systems to carry away excess water.



After winter rains, plants blossom in the ▶ Mojave Desert's thin, sandy soils.

Section 13A.1 Assessment

Reviewing Concepts

1. What two types of geologic processes formed the major features of the California landscape?
2. What are California's major mineral resources?
3. List California's energy resources and describe where they are formed.
4. What are four regional categories of California's soils? Which region's soils are most important to California's economy?

Critical Thinking

5. **Classifying** Classify the following geologic features according to whether they formed as a result of tectonic or surface processes: playa, volcano, U-shaped valley, batholith, basin.
6. **Inferring** Geothermal fields occur only in several places around California. Why do you think geothermal energy is available in some areas and not in others?
7. **Applying Concepts** You are a farmer planning to buy some farm land. You have a choice of two available farms, one in a wide valley and the other on the side of a steep mountain slope. Which would probably be better for growing crops? Explain.

Writing in Science

Research Report Research a geologic resource (mineral, energy, or soil) that is important to your area of California. Write a research report that includes details about how each resource formed and how it is extracted and used.

understanding **EARTH**

California's Central Valley

The Central Valley, also known as the Great Valley, is California's most important agricultural region. The Central Valley is a long, narrow basin that lies between the Sierra Nevada and the Coast Ranges. The Central Valley is about 725 kilometers long and 64 kilometers wide.

The Central Valley can be divided into two major sections. The Sacramento Valley, which is drained by the Sacramento River, forms the northern part. The San Joaquin Valley, drained by the San Joaquin River, makes up the southern part of the Central Valley.

Irrigation provides water for these rice fields in the Sacramento Valley.

Forming the Central Valley

The Central Valley began to form in the Late Mesozoic era as the Pacific plate converged with the North American plate. The ocean basin between the two plates filled with sediment eroded from mountains on the North American plate. The great weight of the sediment caused the entire area to sink, forming the Central Valley. Over time, the sediment was compacted and cemented to form sandstones and shales. In the southern part of the valley, organic matter trapped in the sediments formed oil and natural gas deposits that today are an important part of the state's economy.

During the past 5 million years, weathering and erosion have produced thousands of meters of sediment in the Central Valley. Most of the sediment is in the form of alluvial deposits. Some of this sediment has weathered to form soil.

The Central Valley Today

The rich soils of the Central Valley originally supported grassland, marsh, and woodland plant communities. The growth of agriculture in the valley, however, has changed the natural vegetation of the area. People introduced new plant and animal species that have changed the ecology of the valley. Urbanization and flood control have reduced the size of many wetlands. Damming rivers for irrigation and constructing channels for shipping have changed the flow of the Sacramento and San Joaquin rivers.

Change has also had a very positive effect on the Central Valley. The changes have made the region one of the richest farming areas in the world, where crops such as cotton, fruits, grains, and vegetables are easily grown.

13A.2 California's Water Resources

Reading Focus Standard: 9c

Key Concepts

- What are the main sources of California's freshwater supply?
- How is California's water distributed to where it is needed?
- What are the main uses of water in California?

Vocabulary

- desalination
- aqueduct

Reading Strategy

Outlining Copy and complete this outline as you read.

I. California's Water Supply
- A. Precipitation
- B. Surface Water
- C. Groundwater
- D. Desalination of Sea Water

II. California's Water Projects
- A. Local Water Projects

Gold, oil, fertile soil—these are among California's important natural resources. But one resource is so precious that Californians couldn't survive without it. Much of it gleams high in the mountains. Some of it seeps or trickles deep beneath the surface. And some flows in channels and depressions at the surface. You may have guessed that this valuable resource is fresh water. Where does California get its fresh water?

California's Water Supply

The main sources of California's freshwater supply are precipitation, surface water, and groundwater. As you can see in Figure 9, much of the state's fresh water begins as snow that falls in the mountains of northern California.

Whether the precipitation falls as rain or snow, more than half evaporates or is lost through plant leaves in transpiration. Some runs off back to the ocean. Only about 35 percent of California's precipitation stays at the surface or seeps into the ground. This water helps to meet the state's needs.

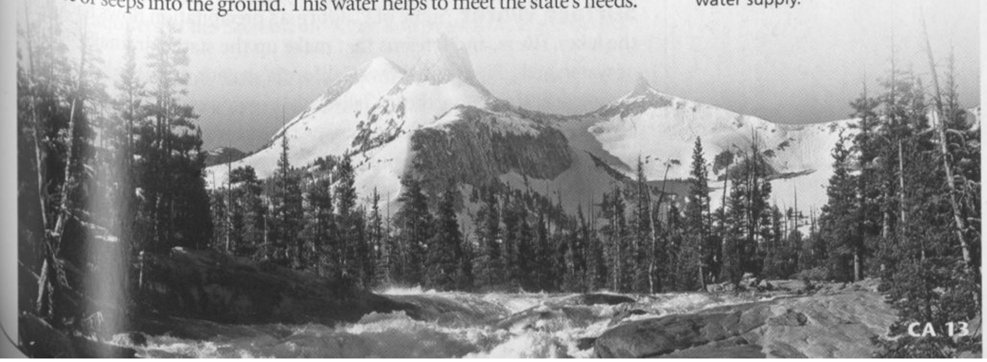
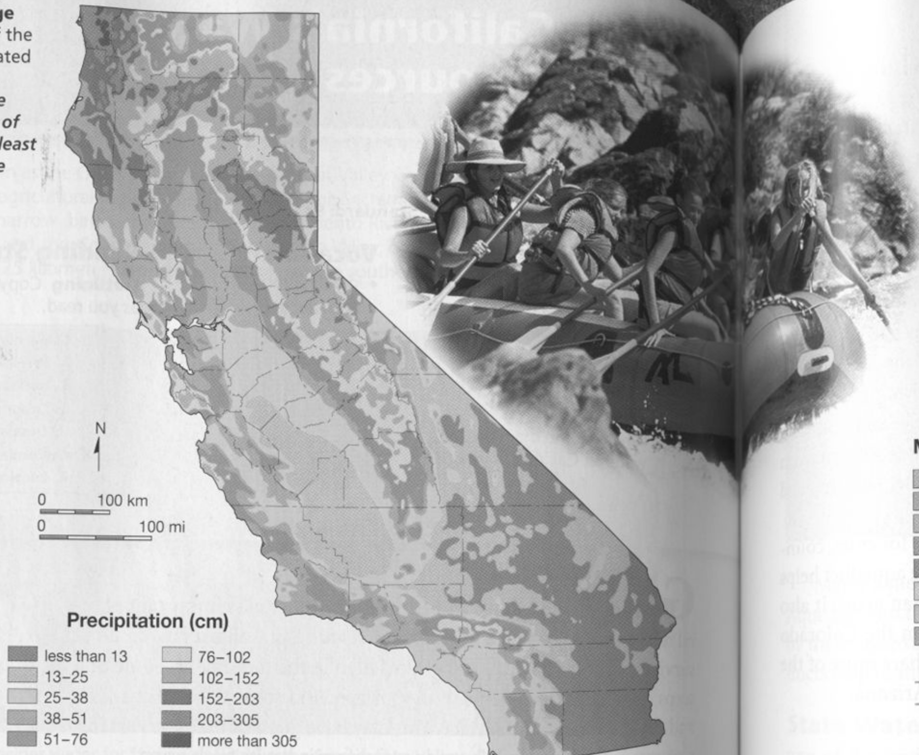


Figure 9 Fresh Water Snow that falls in the Sierra Nevada is a major source of California's water supply.

Figure 10 California's Average Annual Precipitation Most of the state's precipitation is concentrated in northern California.
Interpreting Maps *What is the most precipitation that an area of the state receives? What is the least precipitation that an area of the state receives?*

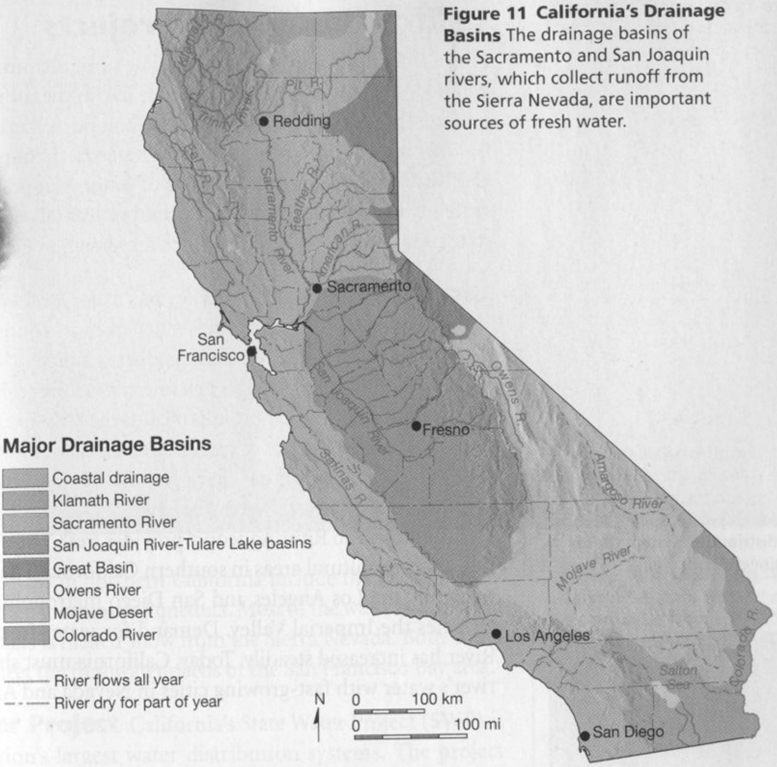


Precipitation Southern California is known for its movie industry. One reason the industry flourished here is because of the variety of climate conditions. Dry deserts, lush forests, or snow-covered mountains are never more than a few hours' drive for a movie crew. Varying amounts of precipitation produce this variety of climate conditions. California receives an average of about 58 cm of precipitation per year. But as Figure 10 shows, it is not evenly distributed. Northern California and the state's mountains receive most of the precipitation.

Surface Water Some of California's precipitation flows back into the lakes, rivers, and streams that make up the state's drainage basins, or watersheds. Figure 11 shows California's major drainage basins. The drainage basins in northern California provide more than half of the state's freshwater needs during an average year of precipitation.

One of California's major sources of water originates far beyond the state's borders. The Colorado River, which forms California's border with Arizona, begins high in the Rocky Mountains of Colorado. The Colorado River's vast drainage basin provides a source of fresh water for California, the other southwestern states, and Mexico.

Figure 11 California's Drainage Basins The drainage basins of the Sacramento and San Joaquin rivers, which collect runoff from the Sierra Nevada, are important sources of fresh water.



Groundwater Some precipitation seeps into the ground to become groundwater. Groundwater accounts for about 30 percent of the fresh water used in California. During a drought year, however, a greater volume of groundwater is used. Unlike California's surface water, which is often transported from one part of the state to another, most groundwater is used in the area from which the water is withdrawn. Recall from Chapter 6 that rocks or soils containing groundwater are called aquifers. Much of the state's groundwater comes from aquifers in the San Joaquin–Tulare Lake drainage basin. Other sources of groundwater include aquifers in the Sacramento River and coastal drainage basins.

Desalination of Sea Water Most of California's fresh water comes from surface water or groundwater. But desalinated ocean water, although expensive, is growing in importance as a source of fresh water for some coastal communities. **Desalination** is the removal of salt from ocean water to obtain fresh water. Today, most desalination plants use a process in which salt water under high pressure is forced through filters designed to remove the salt.

Reading Checkpoint ***What is desalination?***

California's Water Projects

Like California's precipitation, the state's population is unevenly distributed. The majority of Californians live in the more arid, southern part of the state. Thus, freshwater demand is greater in southern California. **To meet freshwater needs throughout the state, California has an intricate network of water storage and distribution systems, or water projects.** Local, state, or federal agencies operate the state's water projects, some of which are shown in Figure 12.

Local Water Projects California's major local water projects consist of long aqueducts that carry water from its sources to where it is needed. As Figure 13 shows, an **aqueduct** is a pipe or channel through which water flows from a higher elevation to a lower elevation. In southern California, local water projects include the Los Angeles and Colorado River aqueducts. The Los Angeles Aqueduct carries water 359 km from the Owens River east of the Sierra Nevada. The aqueduct has provided greater Los Angeles with water since 1913.

The Colorado River Aqueduct provides fresh water for cities, counties, and agricultural areas in southern California. The aqueduct helps to supply the Los Angeles and San Diego metropolitan areas. It also irrigates the Imperial Valley. Demand for water from the Colorado River has increased steadily. Today, California must share more of the river's water with fast-growing cities in Nevada and Arizona.

Figure 12 California's Water Projects The complex network of canals, aqueducts, and reservoirs in California produces a statewide water distribution system that is an engineering marvel.

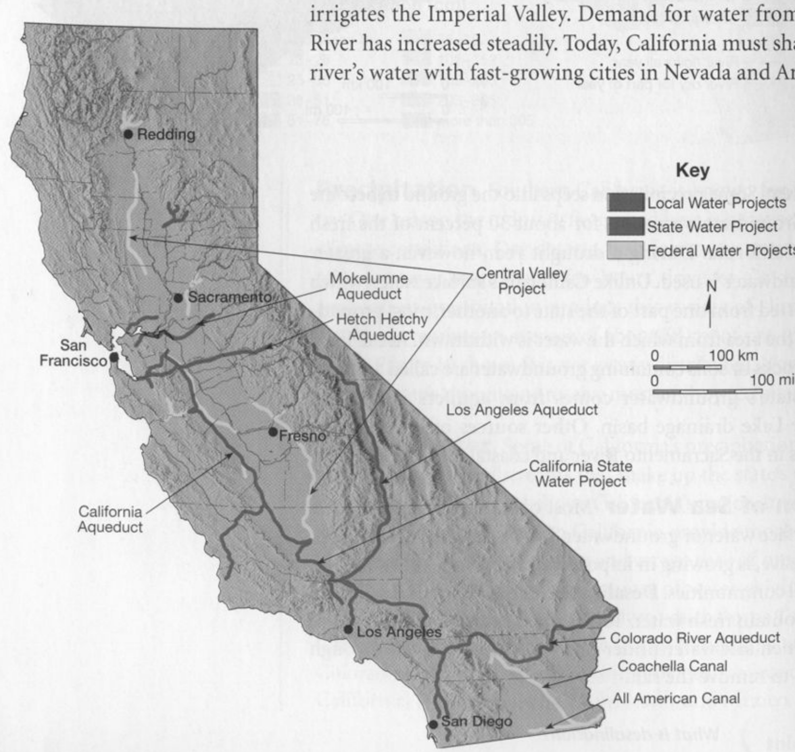


Figure 13 Distributing Water California's State Water Project moves water from the northern part of the state to the south. These aqueducts are near Bakersfield.
Inferring *What is one disadvantage of moving water through an open aqueduct rather than a pipeline?*

Major aqueducts in northern California include the Hetch Hetchy Aqueduct and the Mokelumne Aqueduct. Most of the water transported by these aqueducts is melted snow from the Sierra Nevada. Both aqueducts help to meet the freshwater needs of the San Francisco Bay area.

State Water Project California's State Water Project (SWP) is one of the nation's largest water distribution systems. The project transports rain and melted snow from the Feather River drainage basin in northern California to points farther south. The SWP provides fresh water for nearly 22 million people who live in the Bay area, southern California, and the Central Coast. The SWP also supplies much of the water needed for the crops grown in the San Joaquin Valley. This vast system includes numerous reservoirs, pumping plants, canals and pipelines, including the California Aqueduct. In addition, the SWP operates five hydroelectric plants to generate electricity.

Federal Water Projects The federal government has also constructed major water projects in California. These federal water projects include the All-American Canal, the Coachella Canal, and the Central Valley Project. The All-American Canal system, which includes the Coachella Canal, diverts water from the Colorado River. Much of the diverted water is used to irrigate crops grown in the Imperial and Coachella valleys near the border of the United States and Mexico.

California's Central Valley Project uses hundreds of kilometers of canals to move water into the Central Valley and Bay area. Much of this water is used for irrigation. Bay area households use most of the remaining water. Some water is directed into wildlife refuges.

Quick Lab

I & E Standard: 1m

How Much Water Does a Household Use?

Procedure

1. Study the table to the right. It shows how much water a person uses per day, on average, for certain household activities.
2. Use the information in the table to answer the questions.

Analyze and Conclude

1. **Analyzing Data** Excluding baths and showers, which use of water consumes the most water in a day? Which use consumes the least water?
2. **Analyzing Data** Which uses less water: a bath or a 5-minute shower? A bath or a 10-minute shower?
3. **Predicting** How might the amount of water used each day change for a family of four? Would every amount in the table change? Explain your answer.
4. **Inferring** Based on the information in the table, what are some ways that your household could conserve water?

Household Water Use

Activity	Liters of Water Per Person Per Day
Taking bath	130
Taking shower	15 per minute
Brushing teeth with water running	7
Cooking and drinking	19
Running dishwasher	57 per load
Running washing machine	171 per load
Flushing toilet	106

Q & A

Q *Which of California's crops use the most water?*

A Cotton and alfalfa require the largest volumes of water to produce. Much water is also needed to produce ornamental plants, grains, and grapes.

Water Needs

California's water projects collect, store, and distribute much of the state's fresh water. How do you think most of the water is used? The answer may surprise you. **Most of California's water supply is used to grow crops. The rest is used in homes, businesses, and industries, or has been set aside for recreation or wildlife use.**

Agriculture About 80 percent of the fresh water used in California each year goes toward irrigating crops. Almost two-thirds of the water used in agriculture is surface water. The remaining water is groundwater.

Houses and Businesses How many ways do you use water? Your list probably includes drinking, cleaning, cooking, washing, bathing, flushing, and watering the lawn and household plants. These are all urban uses of water, or water used in houses, apartments, and businesses. In the United States, this all adds up to about 380 liters per person per day! For the future, more of California's drinking water may come from desalination plants.

Industry Water is one of the most important industrial resources. Some of the state's industries require water to make products, such as beverages or paper. But the major use of water in industry is as a coolant—either to cool products or the equipment used to make the products. Power plants also require water to produce the steam that is used to generate electricity.

Recreation and Wildlife California has set aside some of the state's freshwater resources for recreation and wildlife. Wild and scenic rivers account for the largest such use in the state. Recreational activities along these rivers include canoeing, kayaking, rafting, and fishing. Water projects cannot use rivers that are classified as wild and scenic as a source of water. The state does not allow the diversion of water or the building of dams or reservoirs along these rivers.

California preserves some streams and rivers as fisheries where fish such as trout and salmon are grown. The state also sets aside some rivers and streams solely for navigation or recreation. Other bodies of fresh water set aside for wildlife are wetlands, which provide habitats for wildlife such as waterfowl, amphibians, and fishes.

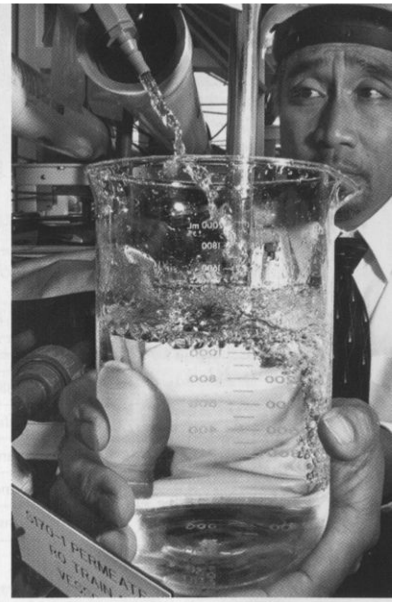


Figure 14 Fresh Water from Sea Water This technician is taking a sample of the fresh water produced by a desalination plant in El Segundo, California.

Section 13A.2 Assessment

Reviewing Concepts

1. What are the main sources of California's fresh water?
2. How is California's water distributed around the state?
3. What are the main uses of water in California?

Critical Thinking

4. **Using Maps** Use Figure 11 to identify the drainage basin in which the cities of Bakersfield, San Diego, and Stockton, California are located.
5. **Inferring** Why do you think the San Francisco Bay area uses relatively little groundwater to meet its freshwater needs? Refer to Figures 10 and 11 to help you answer.
6. **Solving Problems** A fast-growing community along the coast of southern California faces an increasing demand for water. Suggest one way in which this community could meet its water needs. Explain.
7. **Inferring** Give at least three reasons why California's residents might use less water than normal during a given year.

Connecting Concepts

An Unforeseen Effect Los Angeles's use of water from the Owens River has caused Owens Lake to dry up. Winds blowing across the dry lake bed sometimes cause an environmental problem. Infer what this problem might be.

13A.3 California's Natural Hazards

Reading Focus Standard: 9b

Key Concepts

- What are California's earthquake hazards?
- What are California's volcanic hazards?
- What are California's storm hazards?

Vocabulary

- natural hazard
- seismic shaking
- modified Mercalli scale
- volcanic field

Reading Strategy

Understanding Cause and Effect Copy and complete the table below as you read this section.

Hazard	Cause(s)/Effects	
Seismic shaking	a. ?	b. ?
Landslides	c. ?	d. ?
Liquefaction	e. ?	f. ?
Tsunamis	g. ?	h. ?
Volcanoes	i. ?	j. ?
Storms	k. ?	l. ?

Figure 15 San Francisco Earthquake The fires that caused much of the damage from the 1906 earthquake could not be put out because of ruptured water lines.

On April 18, 1906, at 5:12 A.M., the land on opposite sides of the San Andreas fault suddenly moved. The Pacific plate and the North American plate slid several meters past each other in an instant. The result was a powerful earthquake beneath San Francisco that jolted the city's residents awake. About a minute later, many buildings lay in ruins. The earthquake also broke gas lines, causing fires that destroyed much of the city, as you can see in Figure 15.

Earthquakes such as the 1906 quake that struck San Francisco are natural hazards. A **natural hazard** is an event that results from Earth processes and that can cause damage and endanger human life. Earthquakes aren't the only source of natural hazards in California. Northern California has several volcanoes that pose natural hazards. Other natural hazards that affect the state are the result of processes at work on Earth's surface.

California's Earthquake Hazards

When Californians think of natural hazards, earthquakes probably come to mind first. Hundreds of earthquakes occur each day in California. Most of them are so weak that they cannot be felt. But stronger earthquakes—especially quakes with a magnitude of 5 or more—can be dangerous. **Natural hazards that result from California's earthquakes include tsunamis, seismic shaking, liquefaction, and landslides.**

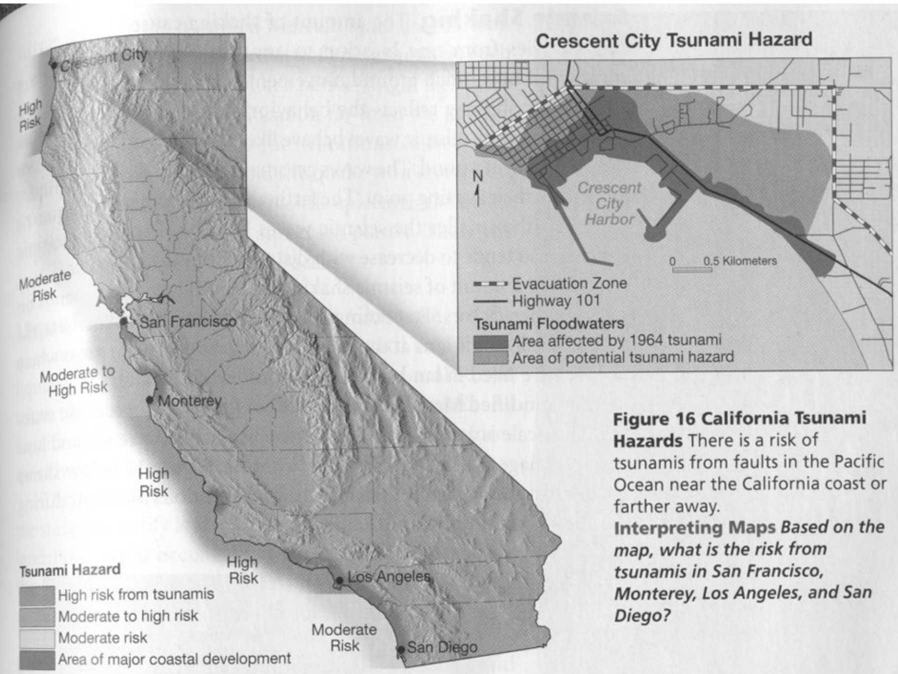


Figure 16 California Tsunami Hazards There is a risk of tsunamis from faults in the Pacific Ocean near the California coast or farther away.
***Interpreting Maps** Based on the map, what is the risk from tsunamis in San Francisco, Monterey, Los Angeles, and San Diego?*

Tsunamis In addition to the hazards produced on land, earthquakes can also cause tsunamis. Recall that a tsunami is a wave formed when the ocean floor shifts suddenly during an earthquake. As a tsunami nears land and begins to break, the tsunami can grow to enormous size. Earthquakes along faults in the Pacific Ocean near California can produce tsunamis. Scientists think that massive undersea "landslides" of ocean sediment could also trigger tsunamis along the state's coast.

Scientists have evidence that in the past 200 years, more than a dozen locally generated tsunamis have struck the California coastline. Because the quakes that caused these waves were centered near California's coast, the waves reached shore within minutes. Earthquakes far across the Pacific can also produce tsunamis that affect California. For example, a major earthquake in Alaska in 1964 produced a tsunami that struck Crescent City hours later, killing 11 people.

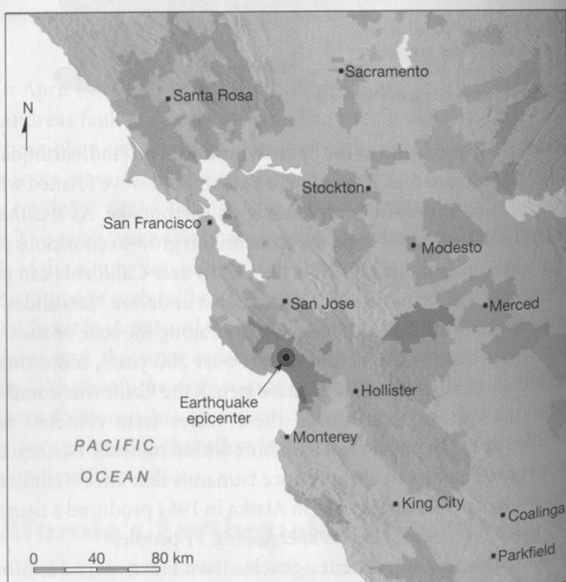
Scientists and government agencies have taken steps to inform people about the risks from tsunamis. Researchers have used simulations of tsunamis, along with the state's tsunami history, to make maps like the one in Figure 16. California also receives data from the Alaska/West Coast Tsunami Warning Center. This federal agency uses a network of instruments in the ocean to detect tsunamis and also issue warnings.

Seismic Shaking The amount of shaking caused by an earthquake varies from one location to another. **Seismic shaking** is a measure of how much ground movement occurs during a quake.

Seismic shaking reflects the behavior of an earthquake's seismic waves. In general, seismic waves behave like the waves you see when you drop a pebble in a pond. The waves get smaller and smaller as they move away from their starting point. The farther you are from an earthquake's epicenter, the smaller the seismic waves become. Therefore, seismic shaking also tends to decrease with distance from the epicenter.

But the amount of seismic shaking in a given location depends on several other factors. For example, one other important factor is the rock and soil conditions at the site of shaking. Loose soil or areas where people have filled in land can amplify, or increase, shaking.

The **modified Mercalli scale** describes the effects of seismic shaking. This scale is a measure of how strong an earthquake felt and how much damage it did at a particular location. Figure 17 below shows the intensity and effects of seismic shaking at various locations during the 1989 Loma Prieta earthquake.



Modified Mercalli Scale

Intensity	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
Damage	none	none	none	Very light (some windows break)	Light (some plaster falls)	Moderate (chimneys break)	Moderate to Heavy (chimneys and walls fall)	Heavy (buildings shift off foundations; ground cracks)	Very Heavy (most structures get destroyed; rails bend)

Figure 17 Loma Prieta Earthquake The map shows areas affected by different levels of shaking during the 1989 Loma Prieta earthquake.
Interpreting Maps *What level of shaking did Monterey, Hollister, and Merced experience during the Loma Prieta earthquake?*

Notice that the modified Mercalli scale uses Roman numerals to describe the intensity of an earthquake. Each step on the scale describes what a person might feel or see during an earthquake. In a location far from the epicenter, a quake might feel like the vibrations caused by a passing truck. At this location, the quake would receive a III on the Mercalli scale. Closer to the epicenter, the quake might shift heavy furniture and crack plaster. There the quake would receive a VI on the scale.

Liquefaction As you learned in Chapter 8, earthquakes can cause another natural hazard known as liquefaction. Liquefaction occurs when water-soaked soil turns to a thick, soupy liquid during an earthquake. As liquefaction takes place, buildings and other structures quickly collapse into the soft mud.

The Seismic Hazards Mapping Act of 1990 requires the state to identify and map areas where liquefaction and landslides might occur during earthquakes. By knowing the potential hazards of such areas, Californians can reduce their risk of injury and property damage.

Landslides Earthquakes often cause loose rock and soil on slopes to move. The result is a landslide. Landslides caused by earthquakes are common in many parts of California. Most landslides occur on steep slopes where sediment is loose or where rocks are highly fractured. An earthquake caused the landslide shown in Figure 18. Earthquakes can also cause landslides in areas that are underlain by weak soils. Landslides also become more likely after forest fires or periods of drought. These events damage the plants that hold the soil in place.

Reading Checkpoint *Where are landslides due to seismic shaking most likely to occur?*

Figure 18 Landslide An earthquake in 1994 triggered this landslide in Pacific Palisades, California. The bluffs had eroded dangerously close to some buildings, making it more likely that an earthquake would cause the collapse shown here.

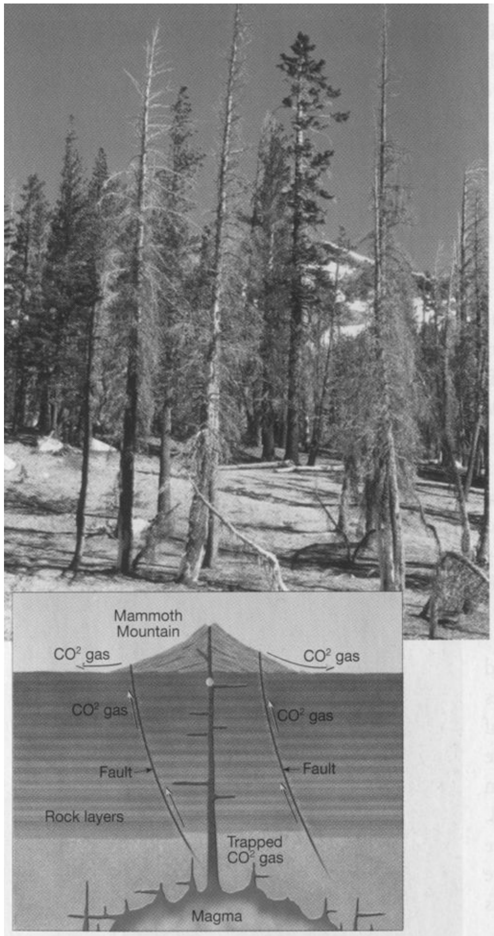


Figure 19 Carbon Dioxide Hazard High concentrations of carbon dioxide around Mammoth Mountain are killing many trees in the area. Because of the danger to people, signs warn visitors of the carbon dioxide hazard.

California's Volcanic Hazards

California's earthquake hazards are well-known. But you may be surprised to learn that parts of the state are at risk from volcanoes. **Natural hazards from volcanic eruptions in California include volcanic ash, lava flows, and volcanic gases.**

In Section 1, you read that subduction of the Pacific plate produced the volcanoes of the Cascade Range. The Cascade Range extends south from Washington State into northern California. Cascade volcanoes in California include Black Butte, Mount Shasta, Medicine Lake Volcano, and Lassen Peak. Of these peaks, Mount Shasta and Lassen Peak are classified as active volcanoes because they have erupted in historic time. Mount Shasta erupted in the late 1700s. Lassen Peak was last active in the early 1900s. The other volcanoes are dormant, which means that they haven't erupted in the recent past. But, whether active or dormant, any one of California's Cascade volcanoes could erupt again. The main hazards from these large, composite volcanoes include volcanic ash and lava flows.

Another potential source of volcanic hazards in California are the state's volcanic fields. A **volcanic field** is an area that is covered by volcanic rocks. Many of California's volcanic fields are in the eastern and south-central parts of the state. Most of these volcanic fields are probably extinct. But others are dormant and could pose hazards from lava flows if they become active again. For example, the Long Valley caldera is the focus of a large volcanic field near Mono Lake on the eastern side of the Sierra Nevada. Although now dormant, this volcanic field has erupted repeatedly over thousands of years. The most recent lava flows and craters are only a few hundred years old.

Another hazard from the Long Valley caldera is carbon dioxide gas. In high concentrations, this invisible gas can be deadly to plants, animals, and people. Carbon dioxide escaping from the ground beneath nearby Mammoth Mountain is killing trees in the area, as shown in Figure 19.

Reading Checkpoint *What is a volcanic field?*

California's Storm Hazards

Weather also contributes to natural hazards in California. Winter storms typically bring rain to lower elevations and snow to the mountains. **Two main storm-related hazards in California are mudflows and flooding.** The dry conditions in southern California make it very susceptible to mudflows and flooding, especially when precipitation is greater than normal. These natural hazards also occur in the northern part of the state.

Mudflows You might know from news reports or firsthand experience that the storms that hit California in late 2004 and early 2005 produced many mudflows. Recall from Chapter 5 that a mudflow is a mass of very wet soil, and sometimes rock, that flows quickly downhill. Mudflows in southern California are common during and after severe rainfall. In northern California, the rapid melting of snow contributes to the mudflow hazard. The risk of mudflows is also greater if rain occurs after fires destroy the vegetation that holds the soil on slopes.

A mudflow often starts in a depression on a steep hillside. At first, a mudflow moves fairly slowly—about 16 kilometers per hour. But as the mud engulfs more and more loose debris, it picks up speed. At top speed, a mudflow can move nearly 60 kilometers per hour, destroying everything in its path. Figure 20 shows the power of a mudflow.

Figure 20 Mudflows A winter storm in 2005 brought heavy rains that triggered this deadly mudflow in La Conchita, California. The mudflow killed 10 people and destroyed more than a dozen homes.

Figure 21 Regional Flooding In 2004, flooding on the Middle River near Holt, California, washed out this highway and covered a wide area with rushing floodwaters.

Flooding Flooding is another California storm hazard. Some of the state's floods are regional floods. They occur when too much rain and melting snow fill river channels in a short period of time. Frequent winter storms in northern California often cause regional flooding. Other floods in California are flash floods. They occur in mountains and deserts. Flash floods can be deadly because the floodwaters rise rapidly and move quickly.

Some flooding in California occurs when excessive rainfall causes dams and levees to fail. In the summer of 2004, many of the farms in the San Joaquin-Sacramento River Delta were destroyed when a levee broke and waters rushed into the region. As a result of the flooding, vast areas of farmland in the area were submerged, some beneath as much as 4 meters of water.

Section 13A.3 Assessment

Reviewing Concepts

1. What are four main earthquake hazards in California?
2. What are California's volcanic hazards?
3. What are two hazards that result from storms in California?

Critical Thinking

4. **Inferring** How do you think earthquake intensity as described on the modified Mercalli scale varies with distance from the epicenter?
5. **Applying Concepts** What kinds of hazards might result from a volcanic eruption in one of California's Cascade peaks ?
6. **Generalizing** What factors are responsible for most of the floods in California?

Writing in Science

Descriptive Writing Use your personal experiences or a newspaper article to write a description of a recent natural hazard that occurred in California.

Exploration Lab

I & E Standards: 1h, 1m
Standard: 9d

Mapping Earthquake Hazards

In earthquake-prone areas, geologists make maps of faults. They combine this information with data on historic earthquakes and the Earth materials—soils, loose sediment, and solid rock—at and beneath the surface. The result is a map of the potential for strong seismic shaking in the area. Using data on slopes and soils, geologists also produce maps showing the risk of landslides and liquefaction. By combining data from several maps, you can construct your own map of earthquake hazards.

Problem

How can maps of earthquake-related hazards be used to determine the areas with the greatest risk of damage?

Materials

- colored pencils
- tracing paper
- masking tape, or other removable tape
- metric ruler
- photocopies of the maps on pages CA 28–29

Skills

Interpreting Maps, Inferring, Predicting

Procedure

Part A: Plan Your Map

1. Your teacher will give you photocopies of the four maps on pages CA 28–29. The maps show earthquake-related hazards for Napa County in California.
2. Study each map. What is the scale of the maps? Which direction is north on the map? Read the map's title and key to determine what data are represented. Notice what symbols the mapmakers have used to represent the data. Map symbols can be points, lines, or areas of color.
3. In this lab, you will combine the data from the four maps into one map. On a separate sheet of paper, make a list of the types of data that you will want to include in your map key.
4. Pick the colors and symbols that you will use for each type of data on your map. Pick darker colors for symbols that will be points (such as historic earthquakes) or lines (active faults). Pick lighter colors for patterns that will form areas of color. (*Hint:* The simplest patterns, such as diagonal parallel lines, often work best.)

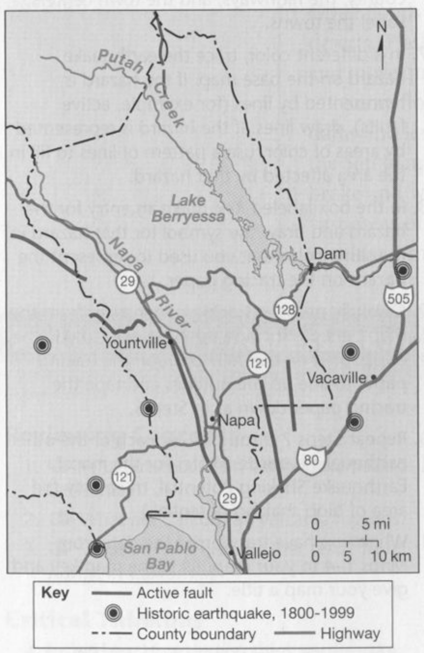
Part B: Make Your Map

5. Tape Map 1 (Active Faults and Historic Earthquakes) to your desktop as a base map. Then tape the tracing paper on top of the base map.
6. Using a black pencil, trace the outlines of the county, the highways, and the town centers. Label the towns.
7. In a different color, trace the earthquake hazard on the base map. If the hazard is represented by lines (for example, active faults), draw lines. If the hazard is represented by areas of color, use a pattern of lines to fill in the area affected by that hazard.
8. In the box labeled *Key,* make an entry for the hazard and draw the symbol for that hazard in the same color that you used to represent the hazard on the tracing paper.
9. Carefully peel the tracing paper away from the map beneath it. Tape the next map to your desktop. Then carefully position the tracing paper to line up the outlines and tape the tracing paper down as in Step 5.
10. Repeat Steps 7 through 9 for each of the other earthquake hazards. (*Note:* For the map Earthquake Shaking Potential, trace only the area of high shaking potential.)
11. When you have transferred the data from Maps 1–4 to your map, fill in the map key and give your map a title.

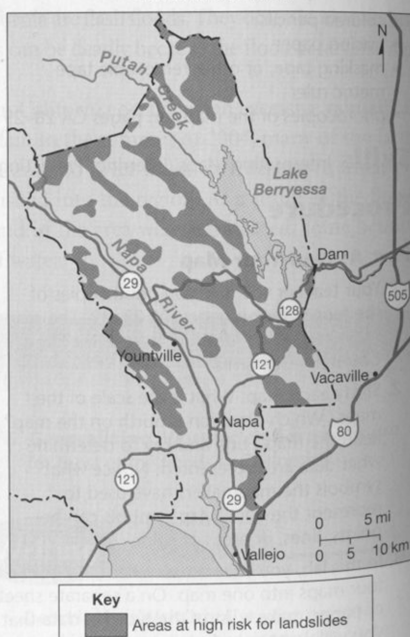
Analyze and Conclude

1. **Interpreting Maps** What are two types of data on your map that provide evidence of past seismic activity? Explain.
2. **Interpreting Maps** Which areas of Napa County are at highest risk of soil liquefaction? Which areas are at highest risk of landslides?
3. **Interpreting Maps** Find the dam at the outlet of the reservoir, Lake Berryessa. Based on your map, how would you rate the risk of earthquake shaking near the dam?
4. **Inferring** Given what you know about landslides, what characteristics would you expect the areas at high risk of landslides to have in common? Explain.
5. **Solving Problems** In Yountville, voters must decide whether to approve a housing subdivision that is planned for an area about 3 km due west of the town center. Based on your map, would you vote to approve this plan? Explain. (*Hint:* Use the map scale to measure distance on the map).
6. **Predicting** In which parts of Napa County is it most important to build structures to withstand a strong earthquake? Explain.
7. **Communicating** Write a short paragraph describing the overall risk from earthquake-related geologic hazards in Napa County. In your paragraph, explain which hazards should be of most concern to the county's residents. Also explain how these hazards vary from one part of the county to another.

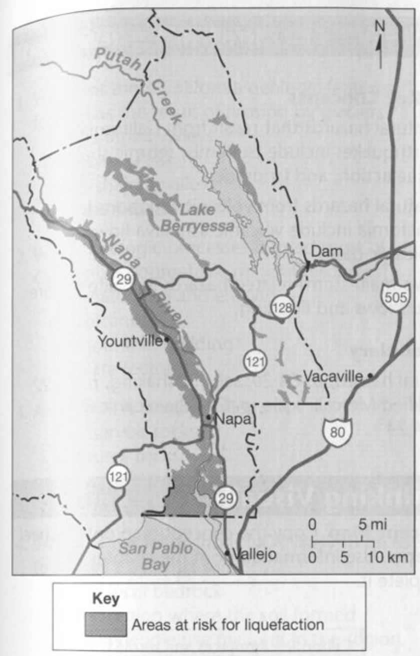
Active Faults and Historic Earthquakes



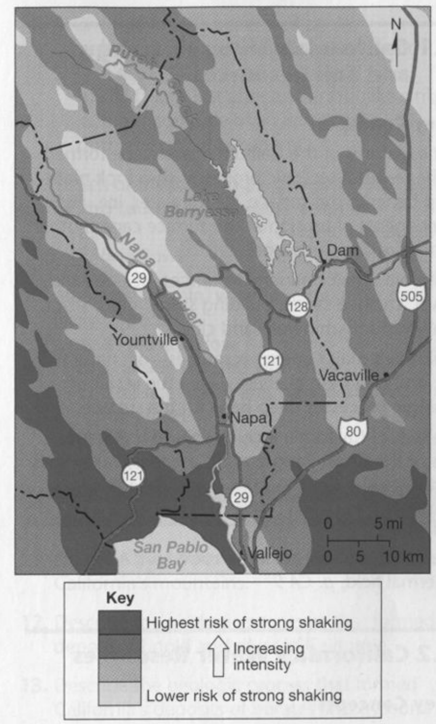
Landslide Hazard



Liquefaction Hazard



Earthquake Shaking Potential



Go Further Suppose that you work for an organization that is planning to build a new hospital in your area. How would you decide on the safest place to build the hospital? Using information from maps published by the California Geological Survey (CGS), use the method in this lab to analyze your area's earthquake-related geologic hazards. Then recommend a location for the hospital. Write a short paragraph explaining your choice.

Statewide CGS maps show historic earthquakes and present-day earthquake-shaking potential. In addition, CGS has published detailed seismic hazard zone maps for many areas showing the risk from landslides and liquefaction. CGS also publishes Alquist-Priolo earthquake fault zone maps for many areas. Your county government or public library may have other maps of geologic hazards in your area.

CHAPTER 13A Study Guide

13A.1 California's Mineral, Energy, and Soil Resources

Key Concepts

- Some features of the California landscape formed as the result of tectonic processes that took place deep beneath the surface. Wind, water, ice, and other agents of erosion at the surface carved other features of the landscape.
- California's major mineral resources include sand, gravel, crushed stone, building stone, gold, silver, iron, evaporite minerals, and clay.
- California's major energy resources—oil, natural gas, and geothermal energy—are the result of geologic processes deep beneath the surface.
- The soils of California include soils of the Sierras, soils of the Coast Ranges and Cascades, valley soils (including the Central Valley), and desert soils.

Vocabulary

source rocks, *p. CA 8;* reservoir rocks, *p. CA 8;* geothermal field, *p. CA 9*

13A.2 California's Water Resources

Key Concepts

- The main sources of California's freshwater supply are precipitation, surface water, groundwater, and desalination of sea water.
- To meet freshwater needs throughout the state, California has an intricate network of water storage and distribution systems, or water projects.
- Most of California's water supply is used to grow crops. The rest is used in homes, businesses, and industries, or has been set aside for recreation or wildlife use.

Vocabulary

desalination, *p. CA 15;* aqueduct, *p. CA 16*

13A.3 California's Natural Hazards

Key Concepts

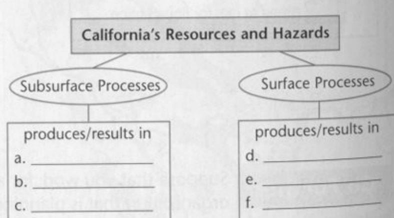
- Natural hazards that result from California's earthquakes include tsunamis, seismic shaking, liquefaction, and landslides.
- Natural hazards from volcanic eruptions in California include volcanic ash, lava flows, and volcanic gases.
- Two main storm-related hazards in California are mudflows and flooding.

Vocabulary

natural hazard, *p. CA 20;* seismic shaking, *p. CA 22;* modified Mercalli scale, *p. CA 22;* volcanic field, *p. CA 24*

Thinking Visually

Concept Map Copy the concept map onto a sheet of paper. Use information from the chapter to complete it.



CHAPTER 13A Assessment

Interactive textbook with assessment at PHSchool.com

Reviewing Content

1. Which of these California geologic features formed as the result of erosion by glaciers?
   a. V-shaped valleys
   b. Lassen Peak
   c. U-shaped valleys
   d. San Andreas fault
2. Which geologic processes formed most of California's nonmetallic mineral resources?
   a. weathering and erosion
   b. volcanism
   c. mountain building
   d. plate tectonics
3. An oil well is usually drilled into
   a. reservoir rocks.
   b. source rocks.
   c. a volcanic field.
   d. a geothermal field.
4. Which of the following is NOT likely to be used to classify California soils?
   a. the local bedrock
   b. the region where the soil formed
   c. how people use the land in the region
   d. the region's climate and plants
5. Which of the following best describes California's water supply?
   a. Most of the state's water needs are met with groundwater.
   b. Most of the state's water needs are met by removing the salt from seawater.
   c. There is more fresh water in the southern part of the state than in the northern part.
   d. There is more fresh water in the northern part of the state than in the southern part.
6. The part of a water project that carries fresh water to where it is needed is a(n)
   a. reservoir.
   b. hydroelectric plant.
   c. desalination plant.
   d. aqueduct.
7. Most of the fresh water used in California is used
   a. in homes. b. in offices.
   c. for recreation. d. for agriculture.
8. Seismic shaking is a measure of
   a. how much the ground shakes during a quake.
   b. soil failure just after an earthquake strikes.
   c. the magnitude of an earthquake.
   d. the height of a tsunami.
9. Which of the following is generally NOT a natural hazard caused by a volcanic eruption?
   a. ash b. regional flooding
   c. lava flows d. carbon dioxide
10. After a heavy rain, where is a mudflow most likely to occur?
    a. an old lava flow
    b. a hillside covered with trees
    c. a hillside where fires have destroyed the plants
    d. a U-shaped valley

Understanding Concepts

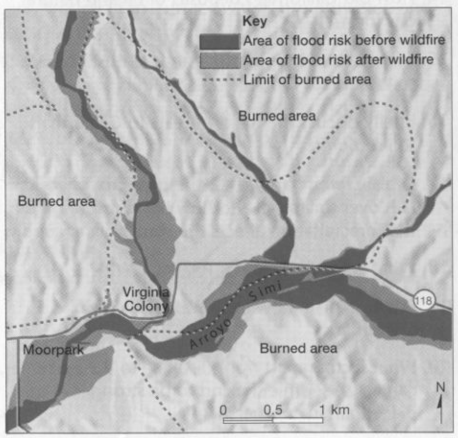
11. Describe the two main processes that formed California's mountains.
12. Describe the geologic processes that formed deposits of gold and silver in California.
13. Describe the geologic process that formed California's deposits of borates and gypsum.
14. How did California's deposits of oil and natural gas form?
15. In general, where are California's most important soil resources found?
16. Briefly discuss the major threats to California's soil resources.
17. Explain what happens to the precipitation that falls over California and how the distribution of that precipitation affects the state's water supply.
18. What is the State Water Project (SWP)?
19. Briefly explain how fresh water is used in California.
20. What factor, apart from distance to the epicenter, can cause seismic shaking to be stronger in one place than in another? Explain.

Assessment *continued*

21. What is the modified Mercalli scale?
22. Describe two types of flooding that are natural hazards in California.
23. Describe California's risk from tsunamis.

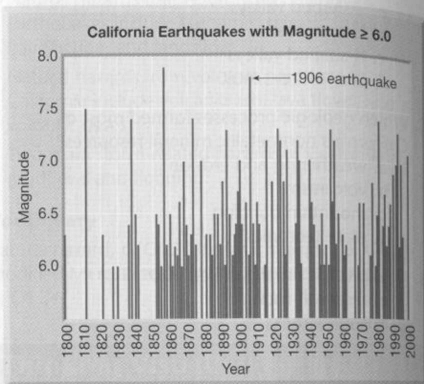
Critical Thinking

24. **Making Generalizations** Give two reasons why sand and gravel are the major economic minerals of California.
25. **Inferring** Is California's geothermal energy a renewable or a nonrenewable resource? Explain your choice.
26. **Interpreting Scientific Illustrations** Choose one of California's major cities. Use Figures 10, 11, and 12 to describe how the city most likely meets its freshwater needs.
27. **Comparing and Contrasting** How are landslides and liquefaction similar? How are they different?
28. **Interpreting Maps** The map below shows how the risk of flooding changed in part of Simi Valley, California, after a wildfire. How and where did the risk of flooding change after the fire? What factor might explain this change?



Math Skills

Use the graph below to answer Questions 29–31.



29. **Reading Graphs** Is there any pattern to the distribution of earthquakes? Explain.
30. **Reading Graphs** During which decade did the most severe earthquake occur?
31. **Reading Graphs** What was the magnitude of the major earthquake that struck California in 1906?

Concepts in Action

32. **Inferring** Why do you think some Californians use desalinated ocean water to meet their freshwater needs?
33. **Predicting** Predict what natural hazard might result in a region of steep-sided, grass-covered hills from several days of gentle rain. Explain.

Performance-Based Assessment

Researching Use references to find out about the major geologic features, the mineral resources, the water projects, or the natural hazards in your part of California. Display your findings on a poster.

Standardized Test Prep

Test-Taking Tip

Using Scientific Illustrations
Before you answer any questions that refer to an image, study the image to determine what is being shown. If the image is a map, use the key as you study the map. Use the map on this page to answer the question below.

Which of these is the best alternative title for this map?

(A) Number of Tsunamis that Struck Eureka
(B) Potential Landslides for Eureka
(C) Earthquake Intensities for Eureka
(D) Some Earthquake Risks for Eureka

Answer: D

Choose the letter that best answers the question or completes the statement. Use the map on this page to answer Questions 1–6.

1. Which area is at risk of damage due to liquefaction?
   (A) the power plant
   (B) the airport
   (C) the golf course
   (D) the hospital
2. Which school on the map is at greatest risk of damage due to a tsunami?
   (A) Grant School
   (B) Lincoln School
   (C) Rolph School
   (D) Junior High School
3. Which of the following is threatened by landslides?
   (A) South Bay Union School
   (B) the power plant
   (C) Lincoln School
   (D) the airport
4. According to the map, how would a major, local quake affect the shopping mall?
   (A) The soils around the mall might liquefy.
   (B) A tsunami might hit the mall.
   (C) A landslide might bury the mall.
   (D) The quake would cause very little damage to the mall.
5. What might happen to Highway 101 if a tsunami were generated by a major, local earthquake?
   (A) The damage would be slight and wouldn't affect the highway at all.
   (B) Landslides would probably close the highway in all directions.
   (C) Only the northern part of the highway would be affected by the tsunami and liquefaction.
   (D) The highway could be damaged by liquefaction of soils to the south.
6. If a powerful earthquake occurs off the coast of Alaska, what hazard might the quake cause in Eureka?
   (A) strong seismic shaking
   (B) liquefaction
   (C) a tsunami
   (D) landslides

Earthquake Hazard Map—Eureka, California