

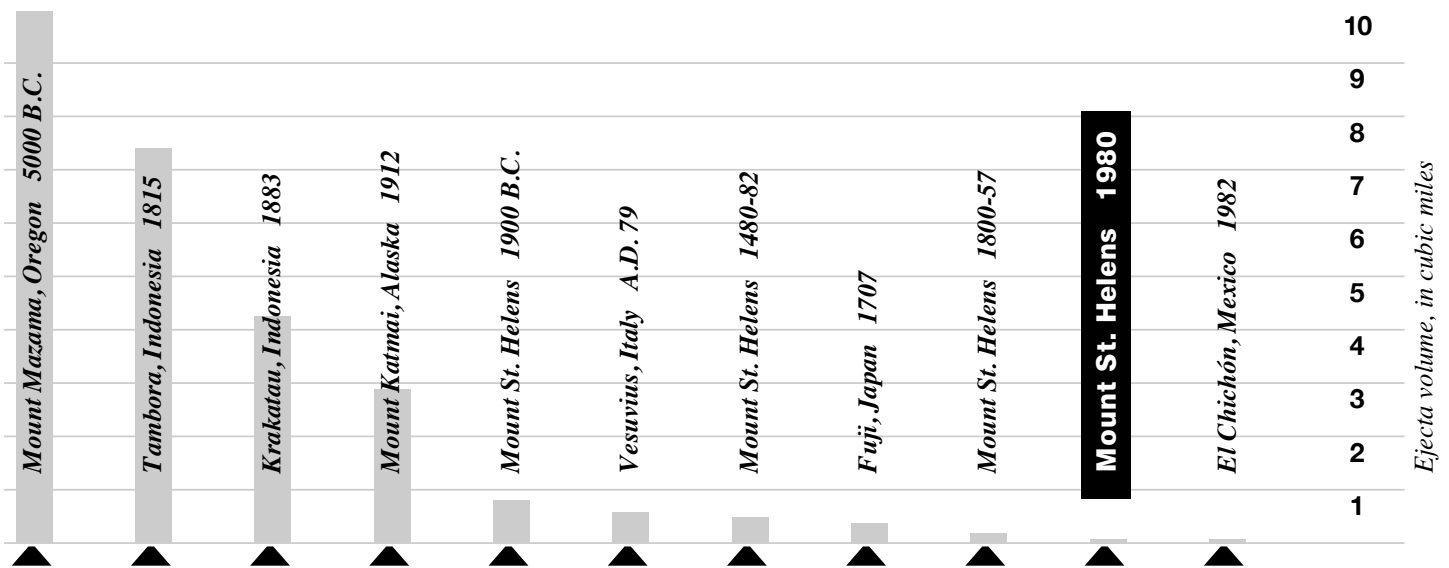
UP IN THE AIR

VOLCANOES!

LESSON 3

fig. 1

Comparison of Eruptions



The volume of ash ejected during an eruption is one factor in measuring the size of an eruption. Note that the May 18 volume was less than several earlier eruptions of Mount St Helens and considerably less than eruptions of other volcanoes.

In less than 10 minutes after the onset of the cataclysmic eruption of Mount St. Helens, a column of *tephra*, steam, *aerosols*, and gases reached an altitude of 19 kilometers (12 miles). Although the largest fragments of tephra fell back to the ground close to the volcano, the smallest fragments, *ash* and dust, were carried eastward by the *prevailing winds*. Five days after the eruption, monitoring instruments in New England detected ash from Mount St. Helens. Some of the ash eventually circled the globe and the smallest fragments and aerosols remained suspended for years in the *stratosphere*.

Day Becomes Night

Moving at an average speed of 95 kilometers per hour (60 miles per hour), the

ash cloud reached Yakima, Wash., by 9:45 a.m. Pacific Daylight Time and Spokane, Wash., about 2 hours later. In Yakima, a city of 51,000, day became night. Automobile and street lights remained on for the rest of the day as the eruption continued for more than 9 hours. Ash as fine as talcum powder clogged engine air filters and choked people—face masks or handkerchiefs were a necessity for those who ventured out of doors.

Ash blanketed the ground like snow, but snow that would not melt. Residents shoveled and bulldozed ash from streets, sidewalks, and roofs; an estimated 600,000 tons of ash were removed from the city. It took 10 weeks to haul it away!

Volcanic Ash's Deadly Effects

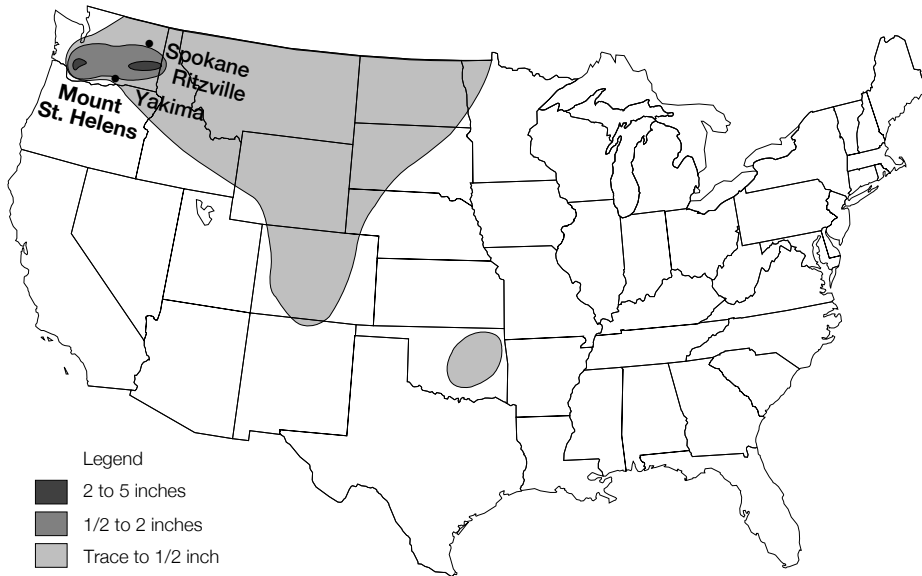
Ash fall, however, is more than an inconvenience. It can be lethal to plants, wildlife, and humans. Swirling particles of ash in the atmosphere generated lightning, which in turn ignited hundreds of forest fires near the volcano. Autopsies revealed that most of the human deaths in the blast area resulted from asphyxiation, from inhaling hot volcanic ash during the first few minutes of the eruption.

As the ash settled to the ground, it also took its toll. Eastern Washington became known as the “ash belt” where many farm crops were destroyed in areas of thick accumulation. Volcanic ash can also affect aircraft operations. Jet engines are susceptible to damage: the volcanic ash coats and melts turbine blades, often causing the engines to stall.

Activity 1

Tracking an Ash Cloud

fig. 2



This map shows the distribution of ash fallout from the May 18, 1980, eruption.

Impact on Climate

Volcanic eruptions can also affect climate and weather patterns. Mount St. Helens' 1980 eruptions did not have a significant effect on global climate, but the 1982 eruption of El Chichòn in Mexico, for example, had measurable effects. El Chichòn's magma was much richer in sulfur than Mount St. Helens'. As a result, the Mexican volcano produced sulfuric acid aerosols (a fine mist of particles) that formed a layer of haze in the stratosphere. This haze, which can remain in the atmosphere for years, reflects the sun's radiation and reduces surface temperatures. For example, more than a year after the April 1815 eruption of Indonesia's Tambora volcano, its effects were felt. In the northeastern

United States, 1816 was so cold that snow fell in some New England States in June and July. It was known in New England as the "year without a summer."

How Much Ash Fell?

In comparison to other historic eruptions, the volume of ash fall from the 1980 eruption of Mount St. Helens was relatively small (*fig. 1*). The eruption of Tambora ejected 150 times more ash than Mount St. Helens in 1980. And ash ejected by Mount Mazama (now Crater Lake), located about 125 kilometers (200 miles) south of Mount St. Helens, was even greater than Tambora. The 1980 eruption of Mount St. Helens was only an inkling of the destructive potential of a volcanic eruption.

15-minute demonstration

45-minute work session

Students observe a **demonstration** of a "dust box" to help them understand that some volcanic ash (tephra) may be difficult to see. In a **work session**, they will then use the equation, $D = R \times T$ (*distance is equal to the rate of speed times the time of travel*) to calculate the time it took volcanic ash erupted into the atmosphere to travel to different parts of the United States following the May 18, 1980, eruption of Mount St. Helens.

Key teaching points

1. Explosive volcanoes can erupt large quantities of tephra, gases, and aerosols into the atmosphere.
2. The smallest of these particles are suspended in the atmosphere and are sometimes carried by wind great distances from the immediate site of an eruption. Some of these particles are too small to see.

Materials

Demonstration

1. Large cardboard box such as a photocopy paper box
2. Black construction paper, dark cloth bed sheet, or black spray paint
3. Glue, tape, or staples
4. Scissors
5. Pencil or pen
6. Flashlight
7. Two erasers with chalk dust

Work Session

1. Activity Sheets 3.1a–b
2. Atlas
3. Colored pens or pencils
4. Calculators (optional)

Procedures

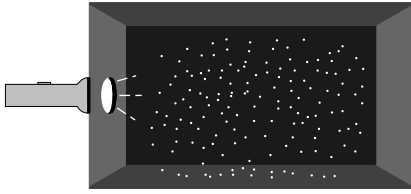
Preparation:

Assembling the "dust box" (fig. 3)

1. Remove the flaps from one side of the box.
2. Line the interior of the box with black construction paper or a dark sheet, or spray paint it black.

fig. 3

"Dust Box"



3. On one side, cut a hole the same size as the lamp end of the flashlight.

Introduction

Use *side 1 of the poster* and point out the column of **ash** rising above Mount St. Helens. Remind students that in Lesson 1 they learned that explosive volcanoes like Mount St. Helens erupt rock and lava fragments, gases, and aerosols into the atmosphere. The rock fragments, which are called tephra, can range in size from car-sized boulders to ash or dust that is so small it is invisible to the naked eye.

Demonstration

1. With the lights on, beat two erasers together inside of the "dust box."
2. Ask students to raise their hands when they can no longer see any "dust" in the air. When the last student has raised his or her hand, turn on the flashlight. Ask students to put their hands down if they now see dust.

Work Session

1. Discuss the photographs and captions in the atmosphere section of the poster (*poster figs. 12–14.*). Remind students of the "dust box" demonstration. Like chalk dust, the smallest volcanic particles stay suspended in the atmosphere. Once in the atmosphere, they can be carried by wind great distances from the volcano. (*fig. 2*)
2. Some of these particles are so small that they form invisible clouds, which are particularly dangerous to airplanes that unknowingly encounter volcanic ash clouds. Volcanic ash sucked into jet engines can cause the engines to stall, as the following story illustrates:

Following the 1989 eruption of Mount Redoubt in Alaska, a Boeing 747 aircraft lost power in all four of its engines after flying into a volcanic ash cloud. Finally after losing 4,267 meters (14,000 feet) in altitude the pilot was able to restart the engines. The airliner landed safely, but the damage to the aircraft has been estimated to exceed \$80 million. Because of the potential hazard posed by ash clouds to aircraft, air traffic controllers need to issue warnings to aircraft flying in the air space they monitor.

3. Tell the students that they are air traffic controllers. They have just received word that Mount St. Helens has had a major eruption. They should stand by to receive critical data so that they can calculate when airborne ash will reach the air space they monitor. Discuss with the class the type of data they will need to gather, such as
 - the time of the eruption,
 - the wind direction,
 - the rate of speed the airborne tephra is traveling, and
 - how far their city is located from the eruption.
4. Divide the class into teams of air traffic controllers for each of the following locations:
 - Great Falls, Mont.
 - Rapid City, S. Dak.
 - Madison, Wis.
 - Minneapolis, Minn.
 - Chicago, Ill.
 - Detroit, Mich.
 - Pittsburgh, Pa.
 - Boston, Mass.
5. On their activity sheet, each team will use the data to calculate the time the ash is expected to arrive in the air space they monitor. (The ash cloud is moving at a rate of 96 kilometers per hour.)
6. Distribute the Activity Sheets.

7. Before students begin, review with the class the formula ($D=RT$). Demonstrate how to use the formula to calculate both rate and time.

8. As a homework assignment, ask each student to calculate the time it took the



ash cloud to circle the Earth. The Earth is 40,000 kilometers (20,500 miles) at the Equator.

Activity Sheet 1 Answers

City	Kilometers	Hours
Great Falls	850	9
Rapid City	1,450	16
Madison	2,500	27
Minneapolis	2,100	23
Chicago	2,700	29
Detroit	3,050	33
Pittsburg	3,400	37
Boston	3,900	42

Activity 2 In the Rain Shadow

45 minutes

By recording the annual precipitation (rain and snow) for cities on the east and west sides of the Cascade Mountains, students will discover that volcanic mountains do not have to erupt to affect the atmosphere.

Key Teaching Points

1. The Cascade Range comprises a 1,130-kilometers (about 700 miles) long chain of volcanoes lying about 160 to 240 kilometers (100 to 150 miles) inland from the coast of the Pacific Ocean. Their location affects the climate of the Pacific Northwest region.
2. Because the Cascades act as a geographic barrier to moisture-laden masses of air arriving from the Pacific Ocean, cities on the west side of the mountain receive more precipitation annually than those on the east side. The cities on the east side are in the “rain shadow” created by the mountains.

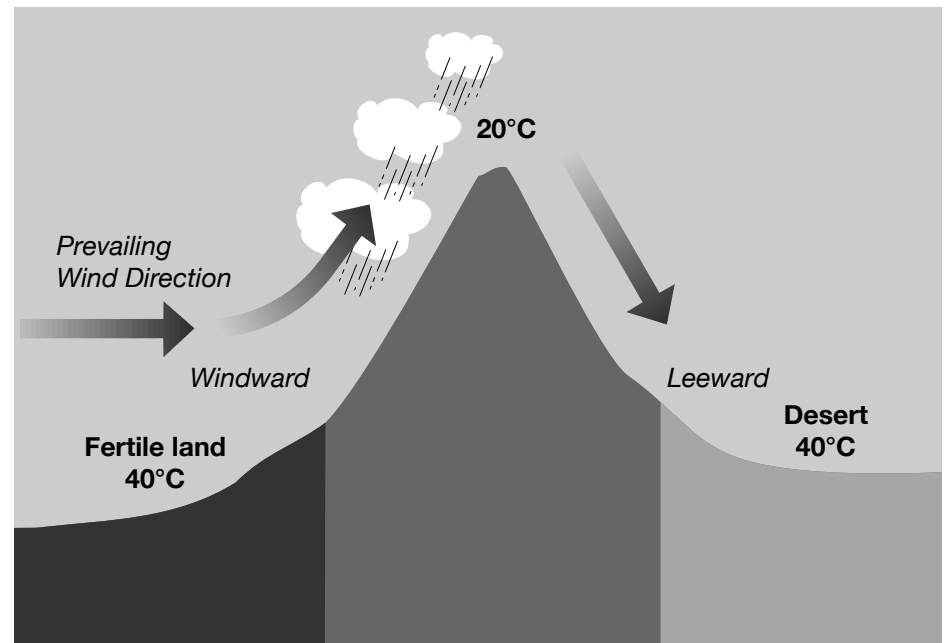
Materials

1. Activity Sheets 3.2 a–b
2. Wall map of the United States
3. Glass of ice water

Procedures

1. Using a large wall map, locate the Cascade Range. Remind students that Mount St. Helens is one of the volcanic mountains that make up the Cascade Range.
2. Tell students that in the Pacific Northwest region, the **prevailing winds** blow from west to east. That means that most of the weather that affects the region forms over the Pacific Ocean where it picks up a great deal of moisture. Given this fact, ask students if they think annual precipitation is greater or lesser on the west or east side of the mountains.
3. Distribute Activity Sheets 3.2 a–b.
4. After the students have completed their activity sheets, discuss with them the reasons why cities on the west side of the Cascade Range have a greater precip-

fig. 4



The windward side of a mountain receives a higher annual precipitation than the leeward side.

itation than those on the east side of the mountains.

- The mountains act as a barrier: Air must rise to get over the mountains. As the air rises, the temperature of the air falls and moisture in the air condenses. As the moisture condenses, it falls as rain or snow. By the time the air reaches the top of the mountain, most of the moisture has been lost as rain or snow.
- As the air descends on the other side of the mountain, most of the moisture that remains is lost through evaporation instead of falling as precipitation.
- That is why cities on the western, or **windward**, side of the Cascades receive a higher annual precipitation than those on the eastern, or **leeward**, side of the Cascades. The mountains have produced a “rain shadow” on the leeward side (fig. 4).

Extension

Have students prepare reports discussing how the differences in precipitation in the Pacific Northwest affect the natural resources and economy of the region.

Activity Sheet 2 Answers

3.

Western	Eastern
Eugene	Burns
Olympia	Pendleton
Portland	Spokane
Salem	Walla Walla
Seattle	Yakima
Tacoma	
4. Western average precipitation: 162 centimeters
Eastern average precipitation: 52 centimeters
5. The cities on the west side receive more precipitation

This teaching packet was originally published and printed in 1997. The online edition contains full text from the original publication. Some images have been modified or added to improve the scientific visualization of information. This document has undergone official review and approval for publications established by the National Mapping Division, U.S. Geological Survey.

VOLCANOES!

Activity Sheet 3.1a Tracking an Ash Cloud

Volcanic ash can be a serious hazard to jet airplanes when they are flying. Because pilots may not see volcanic ash clouds, they can fly into them. When ash is sucked into a jet engine, it can cause the engine to stall.

Fortunately, when this has occurred, the pilots were able to restart their engines, but only after losing many thousands of meters in altitude.

You are air traffic controllers and you have just received a warning that there was a major eruption of Mount St. Helens this morning. The air space you monitor is in the path of an ash cloud. Your job is to calculate approximately how many hours it will take the ash cloud to move into the air space you monitor. **The warning notice states that the ash cloud is moving at a rate of 96 kilometers per hour (60 miles per hour).**

Knowing how fast the ash cloud is moving, **your job is to calculate approximately how many hours (the time) it will take the ash cloud to reach your air traffic control tower.**

What to do

List the following information:

1. On the map, find the location of your tower: Mark it on the map.
2. Find Mount St. Helens. Mark it on the map.
3. Look at the map legend. Calculate the number of kilometers (distance) your tower is from Mount St. Helens. My tower is _____ kilometers from Mount St. Helens.
4. Use this formula to find how many hours (time) it will take the ash cloud to reach your tower.

Distance

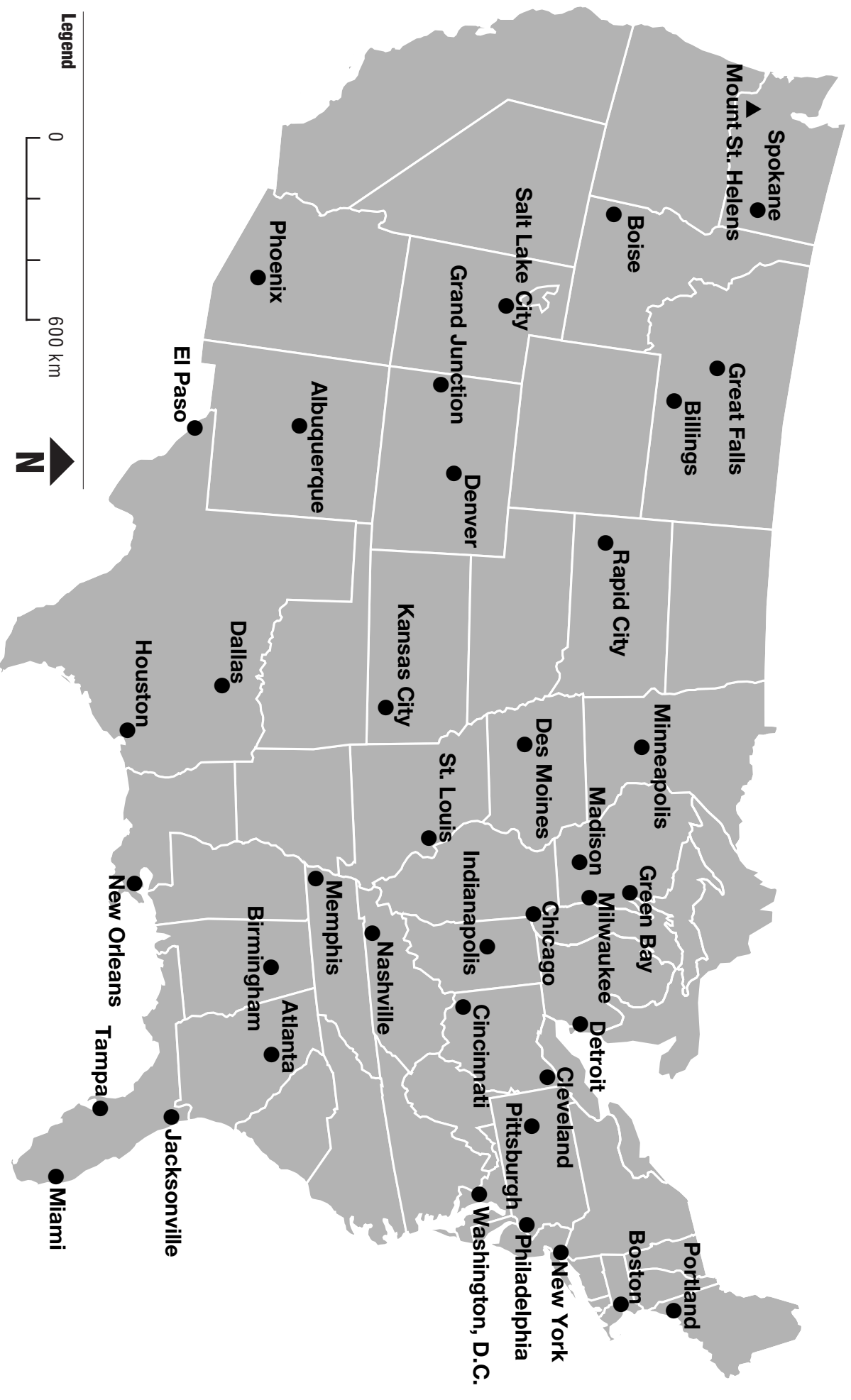
$$\frac{D}{R \times T}$$

Rate (speed) x Time

5. The ash cloud will reach your air traffic control tower in _____ hours.

VOLCANOES!

Activity Sheet 3.1b Tracking an Ash Cloud



VOLCANOES!

Activity Sheet 3.2a In the Rain Shadow

Mount St. Helens is one of the volcanic mountains that make up the Cascade Range. The Cascade Range is about 1,130 kilometers (700 miles) long. It is located about 160 to 240 kilometers (100 to 150 miles) inland from the coast of the Pacific Ocean. The location of the mountains

affects the climate in the Pacific Northwest. Cities located on the western side of the mountains receive different amounts of precipitation (rain and snow) than cities located on the eastern side of the mountains.

What to do

1. On the map, the symbol ▲ marks a volcanic mountain in the Cascade Range. Find each of the volcanoes listed below. Then, on the map draw a line connecting all the ▲ symbols. The line you have drawn will show you the approximate location of the Cascade Range.

Mt. Adams	Mt. Jefferson
Mt. Baker	Lassen Peak
Glacier Peak	Mt. Rainier
Mt. Hood	Mt. Shasta
	Mount St. Helens

2. On the map, find the **west** side of the Cascade Range and write the letter “**W.**” Then find the **east** side of the Cascade Range and write the letter “**E.**” (Hint: the Pacific Ocean is to the west of the Cascade Range.)
3. On the map, each of the following cities is marked with the symbol ●.

Name	Annual Precipitation
Burns, Oreg.	47 centimeters (12 inches)
Eugene, Oreg.	169 centimeters (43 inches)
Olympia, Wash.	201 centimeters (51 inches)
Pendleton, Oreg.	47 centimeters (12 inches)
Portland, Oreg.	146 centimeters (37 inches)
Salem, Oreg.	158 centimeters (40 inches)
Seattle, Wash.	154 centimeters (39 inches)
Spokane, Wash.	71 centimeters (18 inches)
Tacoma, Wash.	146 centimeters (37 inches)
Walla Walla, Wash.	62 centimeters (16 inches)
Yakima, Wash.	32 centimeters (8 inches)

Find each city on the map. Is it **east** or **west** of the Cascade Range? On the chart below, list each city in either the “Eastern Cities” or “Western Cities” column and write in the annual precipitation for each city.

Western Cities

Eastern Cities

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

4. Find the average amount of precipitation that the “Eastern Cities” get and the “Western Cities” get.

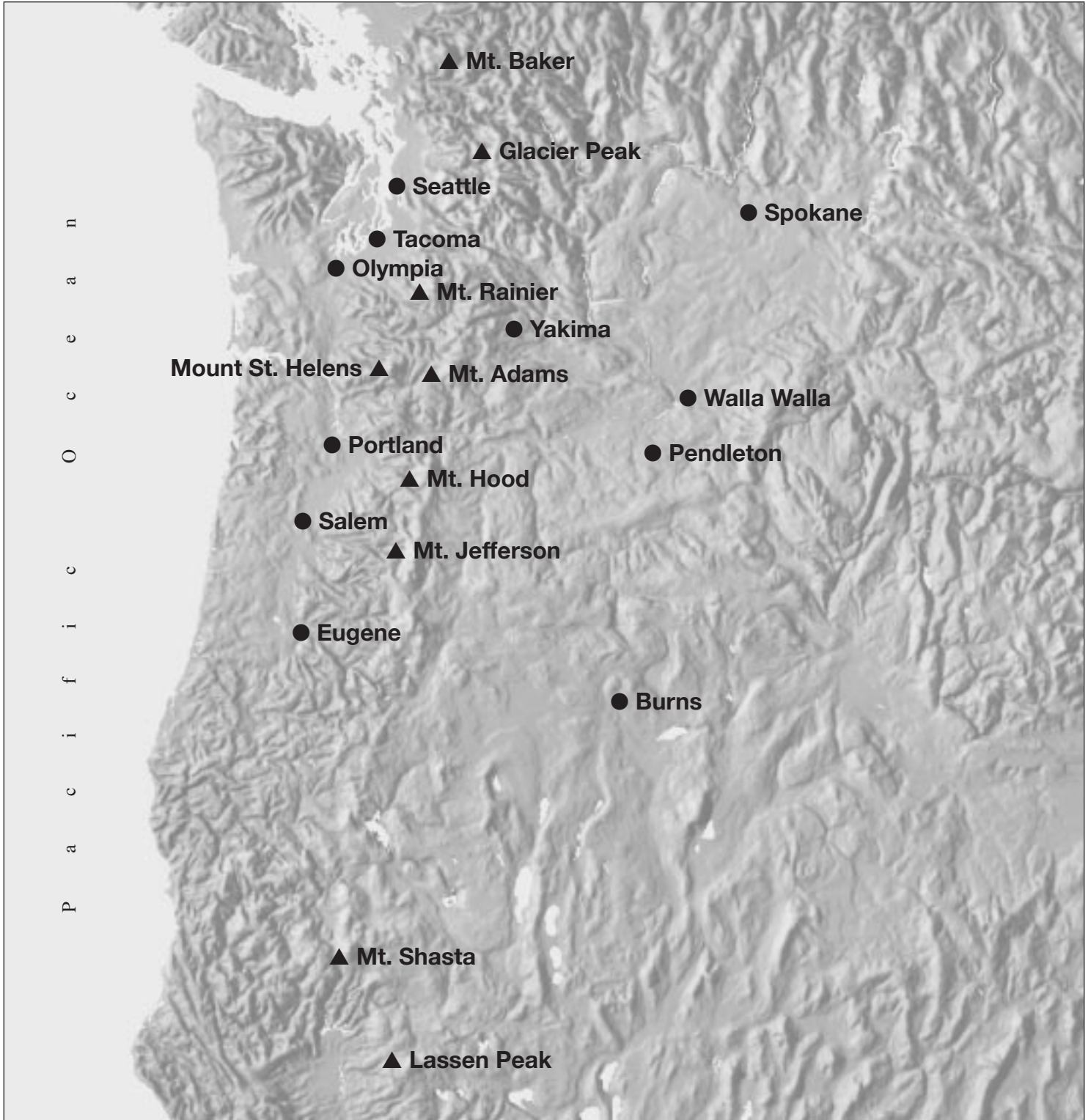
Average precipitation for “Eastern Cities”: _____

Average precipitation for “Western Cities”: _____

5. Do cities on the east or west side of the Cascade Range receive more precipitation? _____

VOLCANOES!

Activity Sheet 3.2b In the Rain Shadow



Legend

0 200 km

▲ Volcanic Mountains
● Cities

