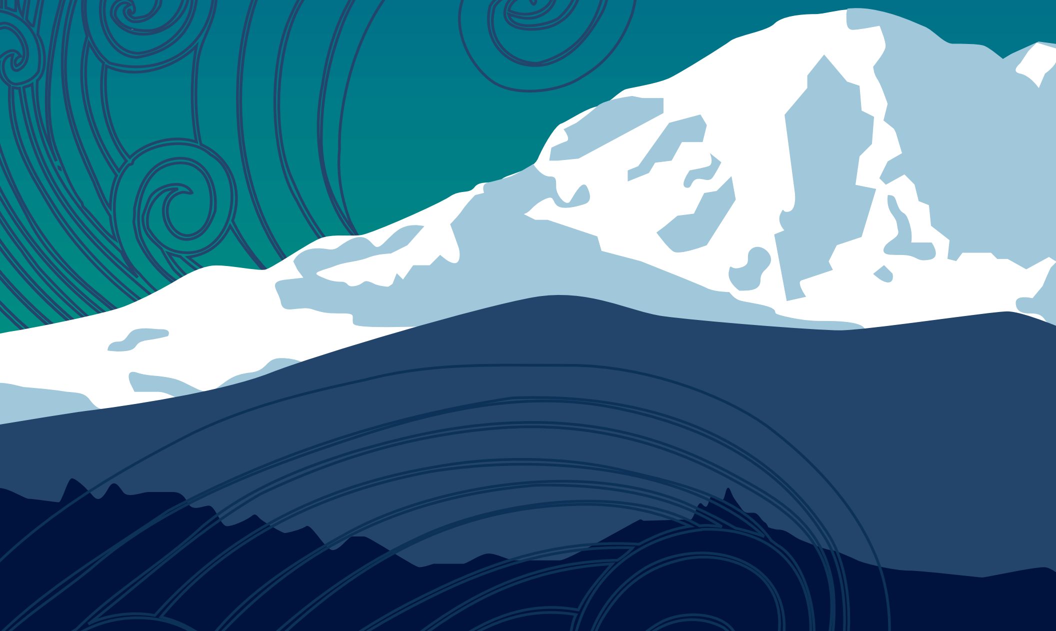
Media Guidebook for Natural Hazards in Washington



Washington Military Department
Emergency Management Division

USGS
science for a changing world
U.S. Geological Survey

National Tsunami Hazard
Mitigation Program

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Introduction

Active volcanoes dominate the skyline in many parts of the Pacific Northwest. These familiar snow-clad peaks are part of a 1,000 mile-long chain of volcanoes, the Cascade volcanic arc, which extends from northern California to southern British Columbia. This guide focuses on the five in Washington State (Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, and Mount Adams) and Mount Hood in northern Oregon that are long-lived volcanoes, having erupted recurrently for hundreds of thousands of years. All of these volcanoes have erupted in the recent geologic past and will erupt again in the future. In 1980 Mount St. Helens vividly demonstrated the power that Cascade volcanoes can unleash when they do erupt.

Frequency of eruptions in the Cascades

Seven major, long-lived volcanoes in the Cascades, including three in Washington and Mount Hood in northern Oregon, have erupted since early pioneers arrived in the region. Many of those eruptions would have caused considerable property damage, and potentially loss of life, had they happened today. Based on the frequencies of eruptions during the past 4,000 years, we expect that several eruptions will occur per century. Each eruptive episode is likely to last months or years to perhaps a decade or more. In addition to the major volcanoes, hundreds of small, typically short-lived, volcanoes dot the landscape in southwest Washington and northwest Oregon, the youngest of them a few thousand years old. These individual volcanoes probably won't erupt again; rather, new volcanoes will form among them and add to the broad regional volcanic fields that lie among the major volcanoes from Mount Rainier southward.

Water and volcanoes — a dangerous combination

Large parts of Washington's Cascade volcanoes are covered with permanent snow and ice that pose a special hazard during volcanic eruptions. Even small eruptions can melt a sufficient amount of snow and ice to trigger lahars that can travel tens of miles beyond the flanks of the volcano into populated valleys. For years after an eruption, erosion of deposits can cause increased sediment deposition that clogs channels, disrupts aquatic ecosystems, and worsens flooding.

Note to Media

This guidebook supplies background information about volcano hazards and an overview of the notification process used to send volcano alerts to emergency and land managers, the media, emergency broadcasters, and the public. It includes background information about volcanic hazards expectable at Washington volcanoes, maps showing areas most susceptible to these hazards, a volcano warning flow chart that shows how information is sent to emergency management and local media, and a list of published resources and specialists who can provide credible volcano information.

Communicating hazards information

The US Geological Survey's Cascades Volcano Observatory (USGS-CVO) issues alert-level notifications and information statements, and, whenever possible, specific forecasts regarding eruptions and their potential impacts. This process includes color codes for aviation hazards. Volcano alert levels and the aviation color codes are described in the Volcano Alert Notification System section (refer to Notification System tab section). Scientists notify emergency-management officials and the media using the process described in the Volcano Warning Flow Chart (see Flow Chart tab). At all times, the USGS-CVO provides information about volcanoes and volcano hazards to public officials, land-use planners, emergency response organizations, Federal Aviation Administration, National Weather Service, Federal Emergency Management Agency (FEMA), and other federal agencies, the news media, schools, and the general public.

Signs of unrest and eruption trigger alerts

Scientists cannot forecast when a volcano will become active, although once signs of unrest are noted and sufficient measurements are made, they may be able to estimate the likelihood of an eruption and sometimes its size and character. Volcanoes typically show signs of unrest, such as increased earthquakes, emission of volcanic gases, and subtle ground movement, days to months in advance of an eruption. Earthquake activity is often the first indicator of volcanic unrest. The USGS, in coordination with the Pacific Northwest Seismic Network (PNSN) at the University of Washington, monitors seismic unrest in the Washington Cascades.

Earthquake swarms at Cascade volcanoes

Swarms of small earthquakes that go on for up to several days are common features at many volcanoes. The vast majority of these earthquake swarms do not lead directly to eruptive activity but are signs of a still functioning volcano. Recent earthquake swarms shook Mount Rainier in 2002, 2004, 2007, and 2009, for example.

Volcano emergencies are times of great uncertainty

Restless volcanoes can challenge people at risk more than most other natural hazards because they present multiple uncertainties about when eruptive or other hazardous activity will begin, what its character and magnitude will be, how long it will last, and who will be affected. Unlike floods and earthquakes, volcanic eruptions are seldom singular events; activity is often prolonged over a period of weeks to years. Sometimes, volcanic unrest does not culminate in an eruption. But, even without eruptions, the uncertainty associated with volcanic unrest can cause a major psychological and economic impact on the population.

Volcano Warning Flow Chart

HOW THE VOLCANO WARNING SYSTEM WORKS

USGS Cascades Volcano Observatory (Vancouver WA)

→ **Volcano Alert Level Message**

→ **NWS** sends Volcano EAS Message

State EOC and

Local jurisdictions and **land managers** and

Broadcasters and

General distribution to public via NOAA Weather Radio and Internet

USGS Cascades Volcano Observatory → **Volcano Aviation Color Code Message** → **Washington DC, VAAC**, **NWS**, **FAA**

Volcano Alert Level Message → **State EOC** sends (via EAS)

EMD / COUNTY VOLCANO WARNING

To: **Broadcasters** (via EAS) Pre-scripted Message

Local jurisdictions

Citizens (via NOAA Weather Radio)

AHAB Sirens (Pierce County activates for Mount Rainier)

→ **State EOC** sends (via EAS) Pre-scripted Message

COUNTY EVACUATION

This message sent by **State EOC** at request of **County**

To: **Broadcasters** via EAS

Local jurisdictions

Citizens (via NOAA Weather Radio)

AHAB Sirens (Pierce County activates for Mount Rainier)

Washington Military Department

Emergency Management Division

USGS	US Geological Survey
State EOC:	State Emergency Operation Center
NWS:	National Weather Service
AHAB:	All Hazards Alert Broadcast
EAS:	Emergency Alert System
VAAC:	Volcano Ash Advisory Center
FAA:	Federal Aviation Administration

ISSUE UPDATE: JUNE 2010

Volcano Alert Notification System

The USGS and its partners keep watch over volcanoes within the US. The USGS is by law mandated to issue notifications regarding volcanic activity. In 2006, the USGS adopted a standardized volcano alert-notification system to describe the status of all volcanoes within the United States and its territories. The USGS volcano alert-notification system consists of two distinct types:

- **VOLCANO ALERT LEVEL** describes the current behavior of a volcano and potential for hazardous impacts to people on the ground. This 4-tiered system uses the terms Normal, Advisory, Watch, and Warning (from background to highest threat).
- **AVIATION COLOR CODE** provides ash-plume information for air traffic control, aircraft, and airlines. This 4-tiered system uses the terms Green, Yellow, Orange, and Red (from background to highest threat).

USGS communications during unrest and eruptions include both the Volcano Alert Level and the Aviation Color Code. During unrest (either escalating or de-escalating) and during most eruptions, the alert-level term and code color will change together (for example, Normal and Green; Advisory and Yellow; Watch and Orange; Warning and Red). However during some volcanic eruptions, the potential impacts to people on the ground and aviation differ substantially. In these cases, the Volcano Alert Level and Aviation Color Code will move independently.

For example, an eruption of a lava flow that threatens a community but produces no significant ash might warrant a Volcano Alert Level of Warning but an Aviation Color Code of Orange. On the other hand, an eruption that produces a huge cloud of volcanic ash that does not drift over inhabited areas might warrant a Volcano Alert Level of Watch and an Aviation Color Code of Red.

Volcano Alert Levels

These levels are intended to inform people on the ground and are issued in conjunction with the Aviation Color Code.

Volcano Alert Levels Used by USGS Volcano Observatories

Alert Levels are intended to inform people on the ground about a volcano's status and are issued in conjunction with the Aviation Color Code. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption and about potential or current hazards and likely outcomes.

Term	Description
Normal	Volcano is in typical background, noneruptive state **Or**, after a change from a higher level, Volcanic activity has ceased and volcano has returned to noneruptive background state.
Advisory	Volcano is exhibiting signs of elevated unrest above known background level **Or**, after a change from a higher level, Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
Watch	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **Or** Eruption is underway but poses limited hazards.
Warning	Hazardous eruption is imminent, underway, or suspected.

Know the alert level terms used by USGS volcano observatories

Normal

The typical background state of a volcano when not erupting. It includes periods of increased steaming, seismic events, deformation, thermal anomalies, or detectable levels of volcanic degassing, as long as that activity is within the background range seen during its monitoring history or at similar types of volcanoes. It is not an "alert" level per se, inasmuch as no concern of potentially hazardous activity is implied. In some cases, unrest that is initially seen as "anomalous," such as increased steaming or elevated seismic activity may after some time become considered normal background activity.

Advisory

Declared when one or more volcano monitoring parameters are outside the background range of activity. Progression towards an eruption is by no means certain, but the volcano is closely watched to see how unrest develops. After being downgraded from a higher level, Advisory means that volcanic unrest has decreased significantly but that the level of unrest has not yet reached background.

Know the alert level terms used by USGS volcano observatories

Watch

Declared for two different situations: (1) heightened or escalating unrest indicating a higher potential that an eruption is likely but still not certain or (2) an eruption that poses only limited hazard to people on the ground. In situation 2, it is implied that erupting volcanoes are inherently unstable and that conditions could change quickly. After downgrading from Warning to Watch, this level indicates that the potential for renewal of hazardous eruptive activity is high (situation 1) or that the volcano has settled into an eruptive style that poses only limited hazards (situation 2).

Warning

Declared when a highly hazardous eruption is underway, suspected, or believed to be imminent. Such events include large explosive eruptions that could destroy nearby communities and cause volcanic ash to fall on others downwind, eruptions of lava that are flowing towards nearby homes, and eruptions that could spawn powerful volcanic mudflows (lahars) that might inundate down-stream communities. During an eruption, information accompanying the alert levels and frequent updates will indicate in as much detail as possible the time of onset, intensity, ash-plume height, and types of hazardous phenomena. When an eruption ends or settles into milder, less hazardous activity the level is downgraded.

Aviation Color Code

The Aviation Color Code is in accordance with recommended International Civil Aviation Organization procedures. The color code places special emphasis on volcanic ash in the atmosphere, because ash can cause jet engines to fail in flight. Also, wind can carry ash clouds thousands of miles, creating a hazard to jet aircraft far distant from the erupting volcano.

Aviation Color Code Used by USGS Volcano Observatories

Color codes, which are in accordance with recommended International Civil Aviation Organization (ICAO) procedures, are intended to inform the aviation sector about a volcano's status and are issued in conjunction with an Alert Level. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption, especially in regard to ask-plume information and likely outcomes.

Color	Description
Green	Volcano is in typical background, noneruptive state **Or**, after a change from a higher level, Volcanic activity has ceased and volcano has returned to noneruptive background state.
Yellow	Volcano is exhibiting signs of elevated unrest above known background level **Or**, after a change from a high level, Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
Orange	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **Or** Eruption is underway with no or minor volcanic-ash emissions (ash-plume height specified, if possible)
Red	Eruption is imminent with significant emission of volcanic ash into the atmosphere likely, **Or** Eruption is underway or suspected with significant emission of volcanic ash into the atmosphere (ash-plume height specified, if possible).

Know the terms for the Aviation Color Code used by USGS volcano observatories

Aviation Color Code definitions are similar to those for Volcano Alert Levels and, like them, are based on a volcano's activity:

GREEN—Applies to the typical background state of a volcano when not erupting. At volcanoes that appear quiet but are not monitored with ground-based instruments, the absence of unrest cannot be confirmed; consequently, Green is not assigned to such volcanoes. It is not an "alert" level per se, inasmuch as no concern of potentially hazardous activity is implied.

YELLOW—Declared when one or more monitoring parameters at a volcano are outside the background range of activity. Progression towards an eruption is by no means certain, but the volcano is closely watched to see how unrest develops. After being downgraded from a higher level, Yellow means that volcanic unrest has decreased significantly but that the level of unrest has not yet reached background.

ORANGE—Used for two different situations: (1) heightened or escalating unrest indicating a higher potential that an eruption is likely but still not certain (the timeframe to eruption or cessation of unrest is variable) or (2) an eruption that poses only a minor hazard to aviation because of limited amounts of ash in the atmosphere or low ash-plume heights. After downgrading from Red to Orange, this level signifies that the potential renewal of hazardous eruptive activity is high (situation 1) or that the volcano has settled into an eruptive style that poses only limited hazards (situation 2).

RED—Declared when an explosive eruption is underway, suspected, or imminent that is releasing or likely to release a significant amount of ash into the atmosphere. During such events, accompanying information will indicate in as much detail as possible the time of onset, intensity, and ash-plume height. There will be frequent updates with detailed accompanying text to report on the progression of the eruption. When the eruption ends, or settles into milder activity with no or minor ash emissions, the level will be downgraded.

Sample Volcanic Activity Notice (VAN) for change from Normal/Green to Advisory/Yellow

CVO/USGS Volcanic Activity Notice

Volcano: **Rainier** (CAVW #1201-03-)

Current Volcano Alert Level: ADVISORY
Previous Volcano Alert Level: NORMAL

Current Aviation Color Code: **YELLOW**
Previous Aviation Color Code: **GREEN**

Issued: Thursday, November XX, 2009, XX:XX A.M. PDT (200911XX/XXXXZ)
Source: Cascades Volcano Observatory
Notice Number: 2009/Cx
Location: N 46 deg 21 min W 121 deg 45 min
Elevation: 14410 ft (4393 m)
Area: Cascade Range; West-Central Washington State

Volcanic Activity Summary: The swarm of small earthquakes that began three days ago has persisted and intensified to a level not observed during the past several decades of instrumental monitoring of Mount Rainier. It is uncertain whether or not this unrest will culminate in an eruption, but scientists at the USGS and the Pacific Northwest Seismic Network at the University of Washington are beginning continuous, 24-hour surveillance of monitoring data and are planning to install additional instruments on the volcano. Prehistoric eruptions of Mount Rainier have produced modest (less than one-half inch) ashfall in now populated areas of east-central Washington State and the southern Puget Sound region, as well as potentially destructive lahars (or volcanic mudflows) in the valleys that head on the volcano. Additional information will be released as warranted.

Recent Observations:
[Volcanic cloud height] Nil
[Other volcanic cloud information] Nil
[Lahar] Nil
[Ash fall] Nil

Contacts: CVO Scientist in Charge and Duty Scientist

Next Notice: A new VAN will be issued if conditions change significantly or alert levels are modified. While a VAN is in effect, regularly scheduled updates are posted at http://vulcan.wr.usgs.gov

Sample Volcanic Activity Notice (VAN) for change from Advisory/Yellow to Watch/Orange

CVO/USGS Volcanic Activity Notice

Volcano: **Rainier** (CAVW #1201-03-)

Current Volcano Alert Level: WATCH
Previous Volcano Alert Level: ADVISORY

Current Aviation Color Code: **ORANGE**
Previous Aviation Color Code: **YELLOW**

Issued: Thursday, December XX, 2009, XX:XX A.M. PDT (200912XX/XXXXZ)
Source: Cascades Volcano Observatory
Notice Number: 2009/Cx
Location: N 46 deg 21 min W 121 deg 45 min
Elevation: 14410 ft (4393 m)
Area: Cascade Range; West-Central Washington State

Volcanic Activity Summary: The ongoing unrest at Mount Rainier has evolved significantly during the past 12 hours prompting a rise in the alert level. Swarms of shallow (less than 2 miles below the summit) earthquakes have intensified in duration and in number of events per hour. Continuous GPS instruments on the volcano's flanks are now clearly recording a slow inflation. Both of these observations suggest that magma has risen into the volcano and that the probability of this unrest culminating in eruption has increased. Such eruptions will produce ash clouds and will also likely produce lahars in some or all valleys draining the volcano. Scientists at USGS and the Pacific Northwest Seismic Network at University of Washington continue to monitor the volcano 24 hours a day and will issue additional information as warranted.

Recent Observations:
[Volcanic cloud height] Nil
[Other volcanic cloud information] Nil
[Lahar] Nil
[Ash fall] Nil

Contacts: CVO Scientist in Charge and Duty Scientist

Next Notice: A new VAN will be issued if conditions change significantly or alert levels are modified. While a VAN is in effect, regularly scheduled updates are posted at http://vulcan.wr.usgs.gov

Sample Volcanic Activity Notice (VAN) for change from Watch/Orange to Warning/Red

CVO/USGS Volcanic Activity Notice

Volcano: **Rainier** (CAVW #1201-03-)

Current Volcano Alert Level: WARNING
Previous Volcano Alert Level: WATCH

Current Aviation Color Code: **RED**
Previous Aviation Color Code: **ORANGE**

Issued: Thursday, December XX, 2009, XX:XX A.M. PDT (200912XX/XXXXZ)
Source: Cascades Volcano Observatory
Notice Number: 2009/Cx
Location: N 46 deg 21 min W 121 deg 45 min
Elevation: 14410 ft (4393 m)
Area: Cascade Range; West-Central Washington State

Volcanic Activity Summary: An explosive eruption of Mount Rainier began at approximately XX:XX PST, December XX, 2009 (XXXX UTC). CVO is raising the aviation color code to Red and the alert level to Warning. Initial height of the eruption cloud is estimated at about 30,000 feet above sea level. The eruption cloud will carry ash northeastward. There is a high probability that lahars have been produced in some valleys that head on the volcano. Further reports will be issued as more information becomes available.

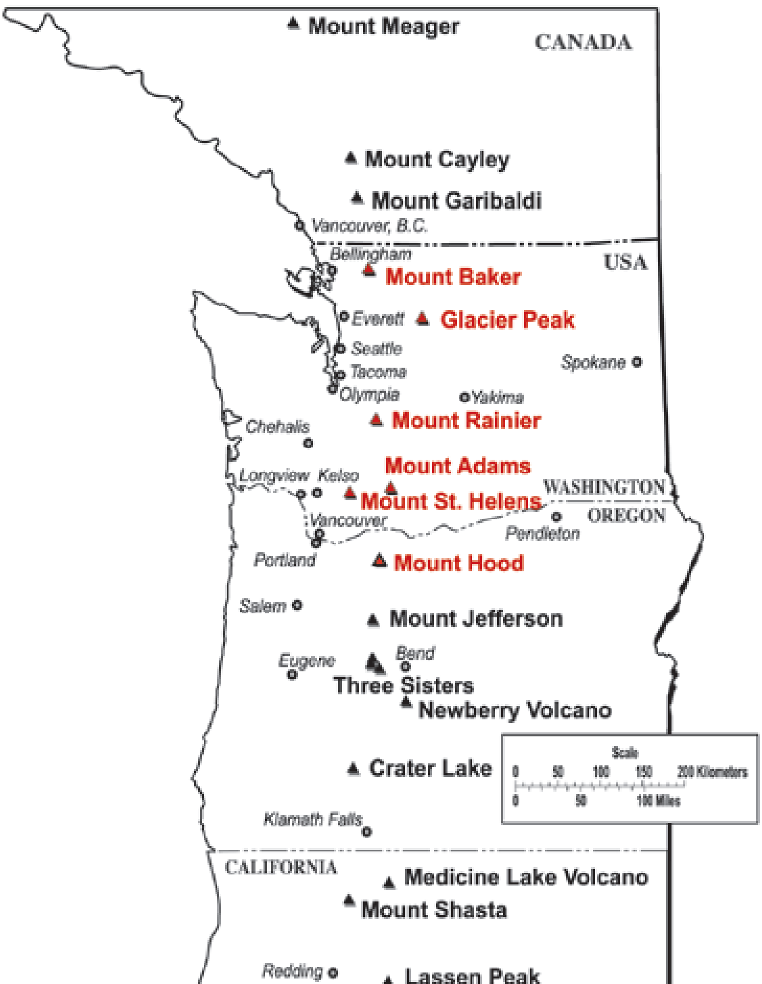
Recent Observations:
[Volcanic cloud height] Initial height of the eruption cloud is estimated at about 30,000 ft above sea level.
[Other volcanic cloud information] Nil
[Lahar] Lahars are possible on Puyallup, Carbon, White, Cowlitz, and Nisqually Rivers.
[Ash fall] Ashfall is likely in the vicinity of and downwind (northeast) from the volcano.

Contacts: CVO Scientist in Charge and Duty Scientist

Next Notice: A new VAN will be issued if conditions change significantly or alert levels are modified. While a VAN is in effect, regularly scheduled updates are posted at http://vulcan.wr.usgs.gov

Volcano Hazard Maps

Volcano hazard maps appear on the following pages for each of the five principal volcanoes in Washington as well as Mount Hood, Oregon, which also poses a threat to Washington. They have been simplified from more detailed maps in hazard assessments that are posted on the USGS-CVO web site *http://vulcan.wr.usgs.gov*. Hazard zones are based upon the extent of previous volcanic activity at each volcano and on the types and sizes of eruptions expected in the future.



Hazard Notes

These hazard maps show areas that could be affected by lahars, lava flows, and pyroclastic flows from the volcanoes if events similar in size to past events were to occur. Because small lahars are more common than large ones, most lahars would be less extensive than the hazard zones shown on the maps, but a few could be more extensive. Lahar hazard is not equal in all valleys. Hazard zone boundaries are approximate. Scientists continue to reevaluate the hazard zones as they learn more about these volcanoes.

Areas at risk from volcanic ash fall are not shown on the maps because the threat depends upon the size and type of the eruption and the speed and direction of winds. Winds blow towards the east much of the time, and thus, ash is more likely to be blown across the Cascade Range to eastern Washington and beyond, but ashfall can affect the more densely populated areas west of the Cascades. In addition, under certain wind conditions, ashfall from out-of-state volcanoes can affect Washington.

Hazard Map Explanation

Near-volcano hazard zone subject to:

- **Lava Flows-**Flows of molten rock.
- **Pyroclastic flows-**Flows of hot ash, pumice, rock fragments, and volcanic gas that rush down slope, commonly at speeds of 60 miles per hour.
- **Thick tephra fall-**Tephra is a term for fragments of rock blasted into the air during volcanic eruptions.
- **Lahar initiation-**Lahars are rapidly flowing mixtures of rock debris and water also referred to as mudflows or debris flows. They are caused by landslides, by intense precipitation, and by snow and ice melt during eruptions.
- **Rock avalanches and rock fall-**Events that occur commonly even in the absence of volcanic activity.

Downstream lahar hazard zone:

High

Low

Limited to valleys draining volcano flanks

Regional lava flow hazard zone:

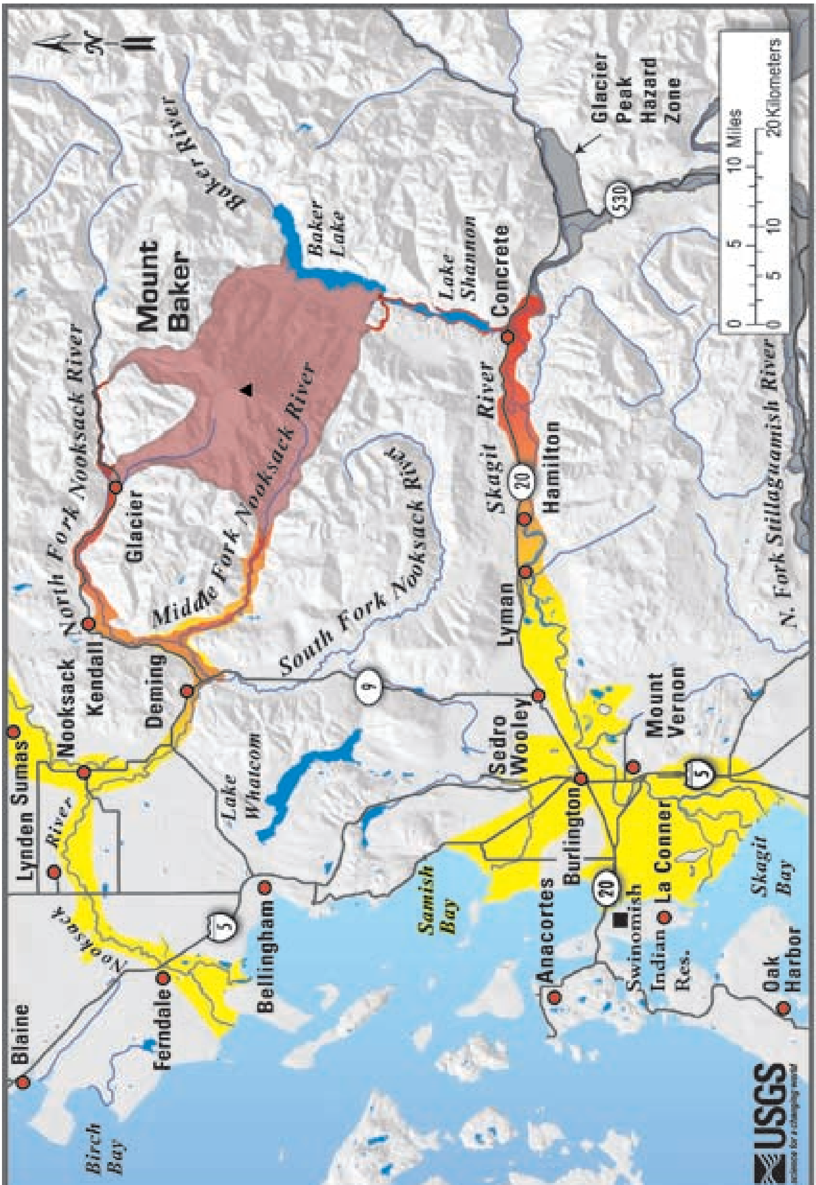
Lava flows can issue from dispersed vents between major volcanoes.

Volcanic ash hazard zone (not shown):

- Fine rock fragments (volcanic ash) from explosive eruptions and carried by wind sometimes for thousands of miles.

Whatcom / Skagit Counties, WA

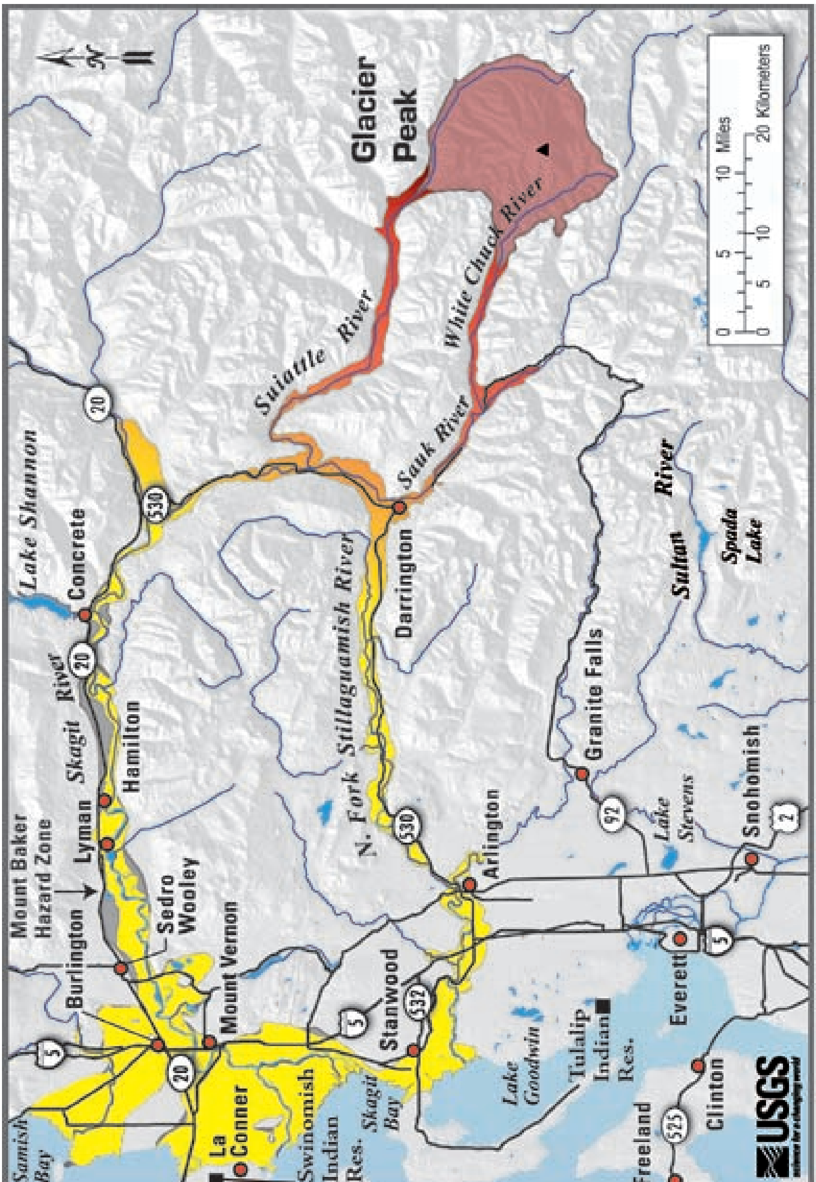
Mount Baker



Simplified from Gardner and others, 1995, Potential Volcanic Hazards form Future Activity at Mount Baker, Washington, USGS Open-File Report 95-498

Skagit / Snohomish Counties, WA

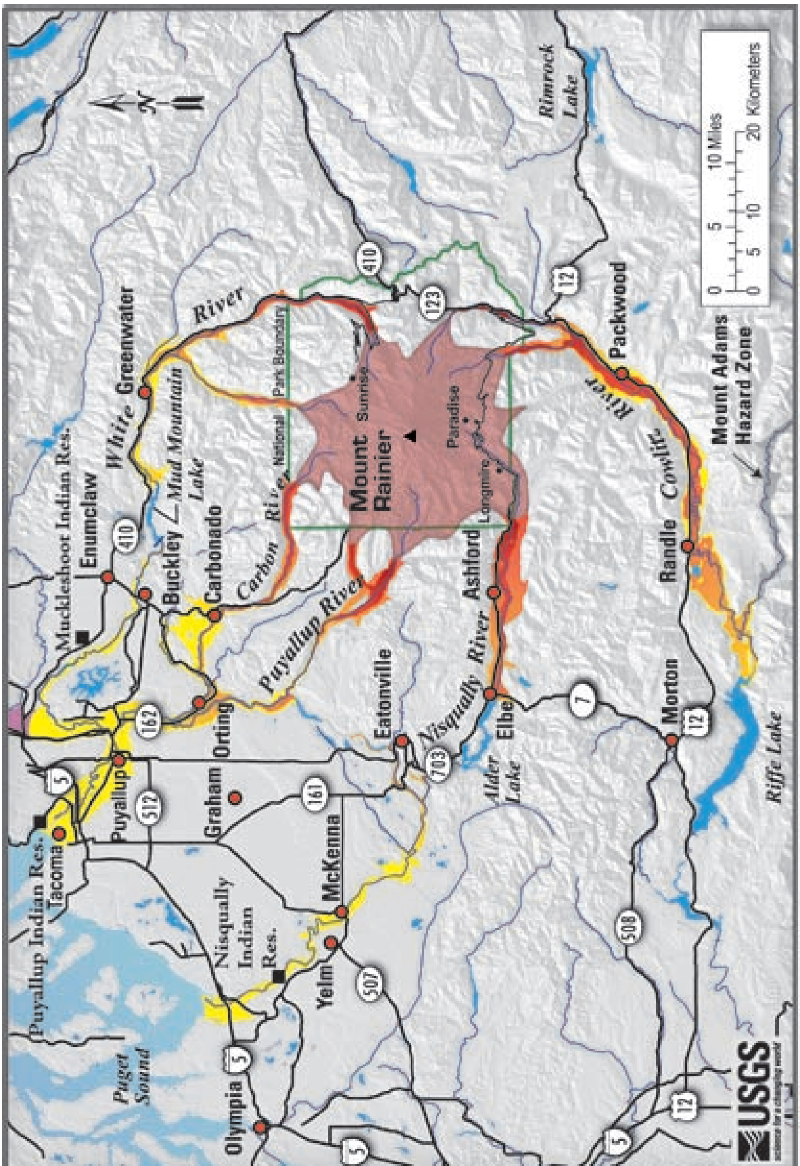
Glacier Peak



Simplified from Waitt and others, 1995, Volcanic-Hazard Zonation for Glacier Peak, Washington, USGS Open-File Report 95-499.

Pierce / King / Thurston / Lewis Counties, WA

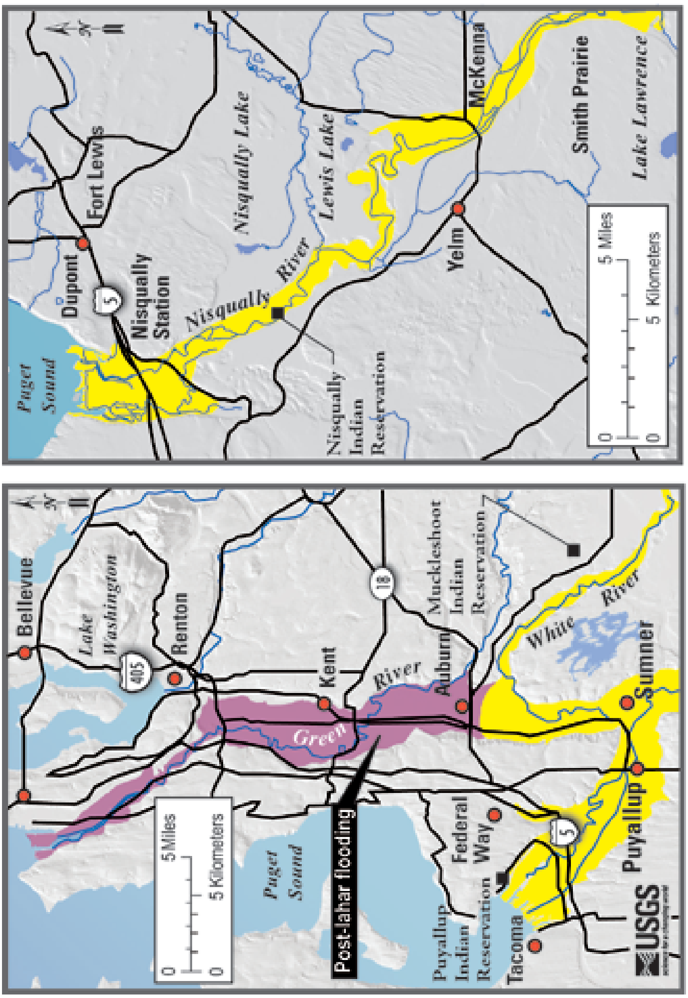
Mount Rainier



Simplified from Hoblitt and others, 1998, Volcano Hazards from Mount Rainier, Washington, USGS Open-File Report 98-428.

Pierce / King / Thurston / Lewis Counties, WA

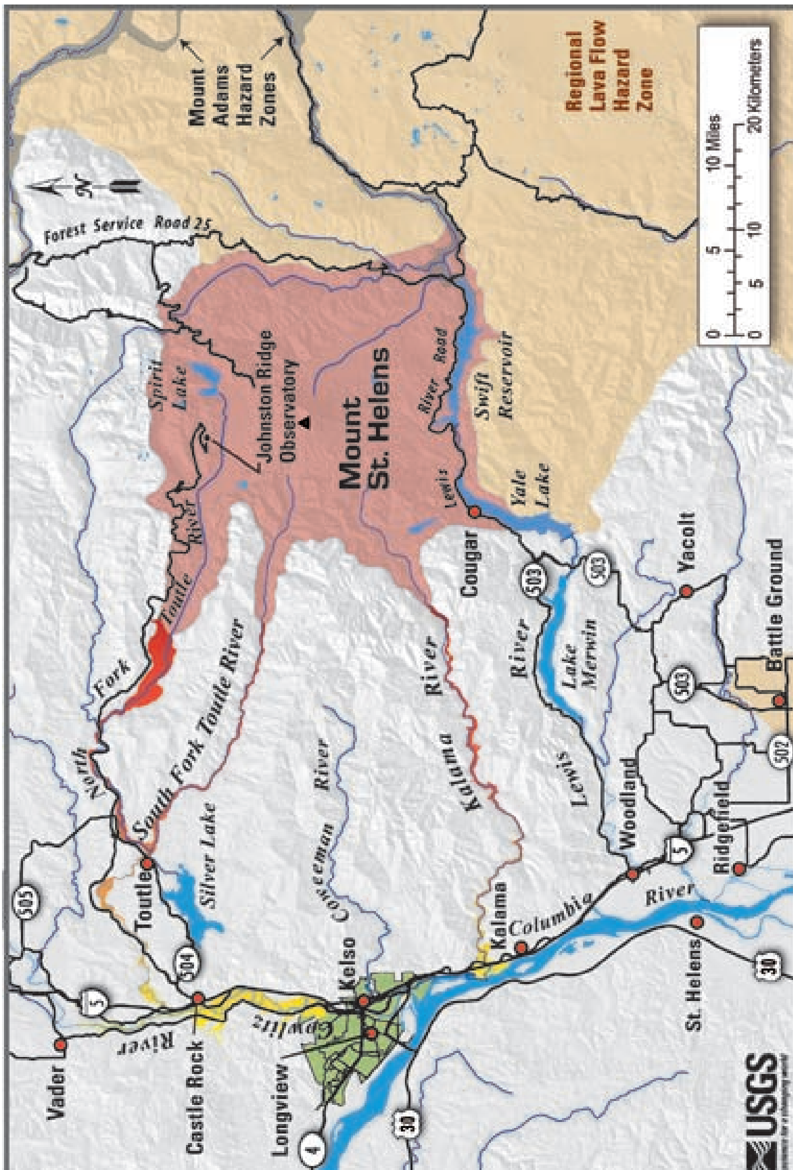
Mount Rainier (insert maps)



Simplified from Hoblitt and others, 1998, Volcano Hazards from Mount Rainier, Washington, USGS Open-File Report 98-428.

Cowlitz / Lewis / Skamania Counties, WA

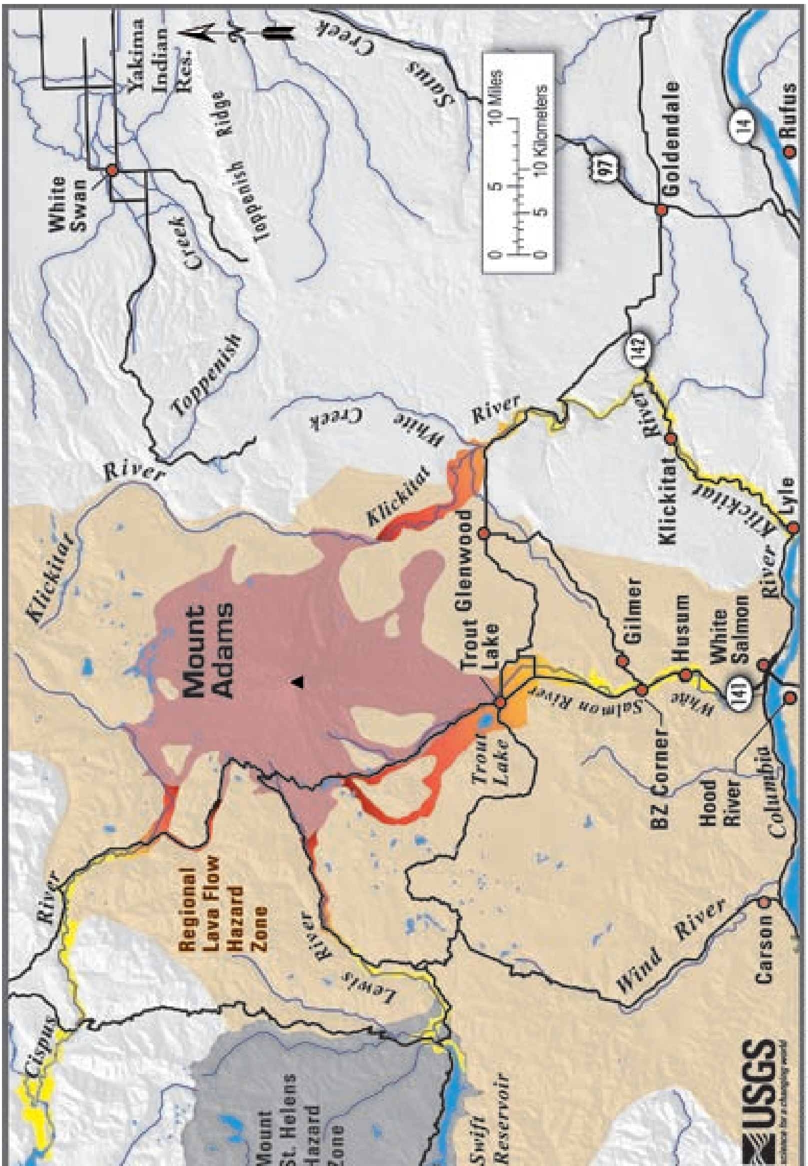
Mount St. Helens



Simplified from Wolfe and Pierson, 1995, Volcanic-Hazard Zonation for Mount St. Helens, Washington, USGS Open-File Report 95-497.

Klickitat / Yakima / Skamania Counties, WA

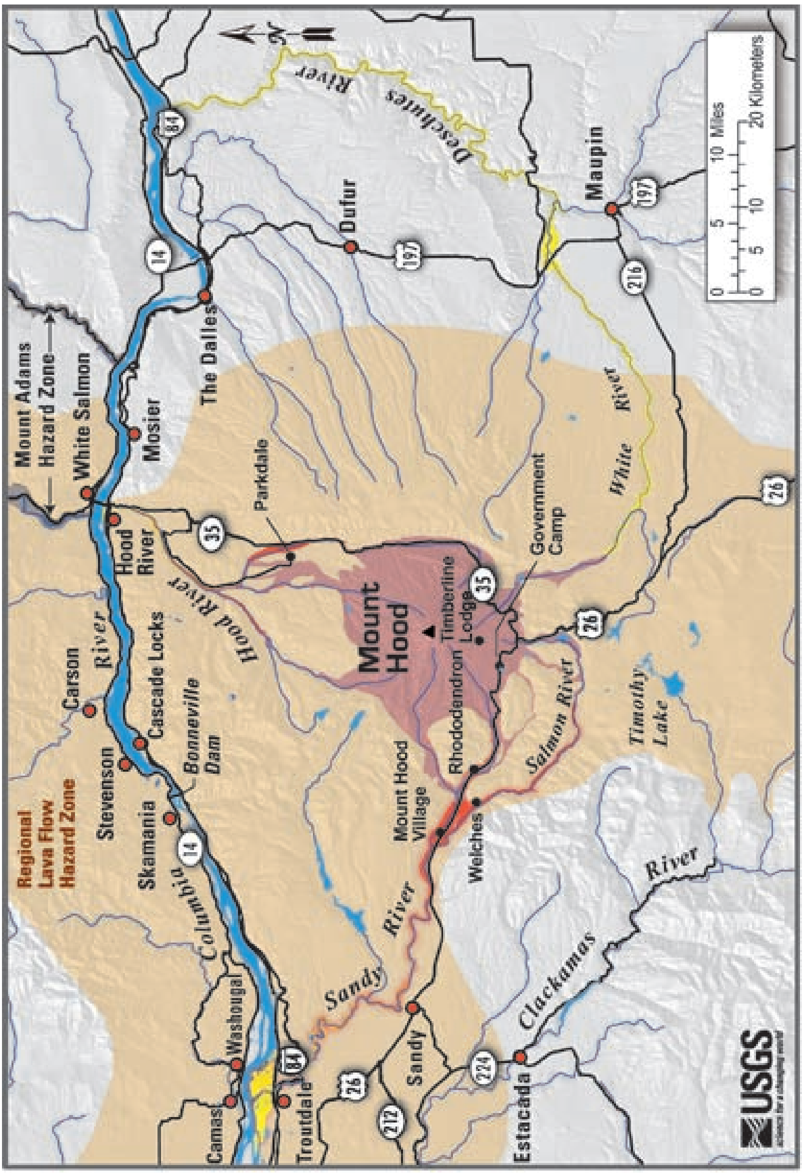
Mount Adams



Simplified from Scott and others, 1995, Volcano Hazards in the Mount Adams Region, Washington, USGS Open-File Report 95-492.

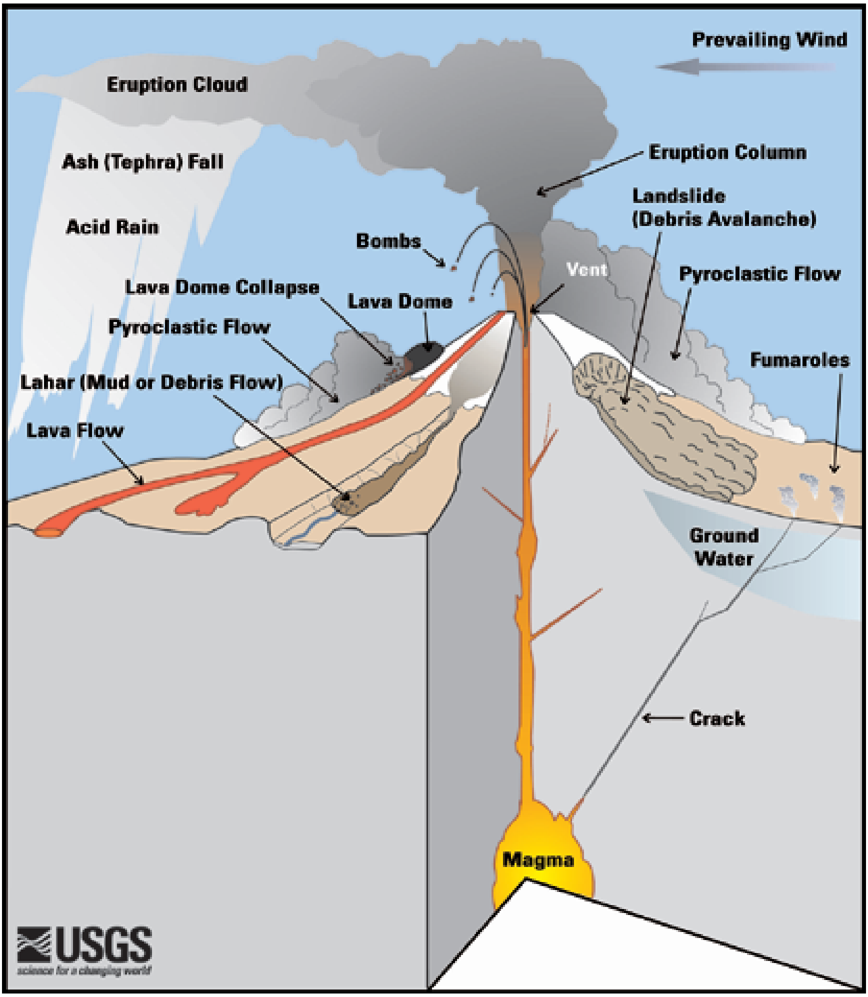
Hood River / Clackamas / Wasco / Multnomah Counties, OR

Mount Hood



Simplified from Scott and others, 1997, Volcano Hazards in the Mount Hood Region, Oregon, USGS Open-File Report 97-89

Volcanic Hazards



Tephra (includes volcanic ash)

A note about terminology: Scientists commonly use the term tephra to refer to fragments of volcanic rock and lava (regardless of size) that are blasted into the air by explosions or carried upward by hot gases in eruption columns or lava fountains and fall back to Earth's surface. Tephra includes large blocks and bombs (boulder size) to fine ash (dust size). Grains that are sand size or smaller are called ash.

What is volcanic ash? Is it hazardous?

The largest rock fragments expelled by eruptions usually fall back to the ground within two miles of the vent, but small fragments of volcanic ash rise high into the air and fall out far downwind. When ash falls in these downwind areas it has cooled to surrounding air temperature. Volcanic ash is normally not poisonous to people or pets, but fluorine-rich or very thick ash can be a hazard to grazing animals.

Volcanic ash can be a nuisance or a hazard, depending on the amount that falls and its grain size. Even a fraction of an inch can disrupt life for people many miles from the volcano for long periods of time and can make breathing difficult and irritate the eyes. It can reduce visibility and make driving difficult. Volcanic ash can damage machinery. Ash clogs filters, drains, and sewer systems. It can collapse roofs of some buildings when it exceeds about four inches in thickness and becomes wet. Ash from an erupting volcano can temporarily disrupt transportation and communication routes distant from the mountain. When wet, it can cause short circuits in power transmission lines.

On the morning of May 18, 1980, Mount St. Helens blasted an enormous column of volcanic ash and gas more than 80,000 feet into the air. By the end of the day, more than 500 million tons of ash had fallen onto parts of Washington, Idaho, and Montana. The ash disrupted travel because of poor visibility, slippery roads, and ash-damaged vehicles. At least 10,000 people became stranded, and many small communities became isolated because of this impact on transportation.

Volcanic ash — A hazard to aviation

Volcanic ash poses a significant hazard to aircraft as far as thousands of miles from an erupting volcano. When ash particles encounter aircraft traveling at speeds of several hundred knots, they cause abrasion to the windshield and other parts of the aircraft. The overall result of an aircraft's flying into an ash cloud can be degraded engine performance (including flame out), loss of visibility, and failure of critical navigational and operational instruments. There are no remote volcanoes when it comes to volcanic ash.

One of the first potentially life-threatening ash/aviation incidents recognized occurred during the eruption of Mount St. Helens in May 1980. On May 18, 1980, a McDonnell–Douglas DC-9-30 flying through the ash cloud suffered damage to engine parts, surface abrasion to the windshield, and a clogged hydraulic system; and a Boeing 747 sustained damage from ash while parked on the ground. A week later on May 25, 1980, a C-130 Hercules flew through the cloud of a smaller eruption while en route from Tacoma, Washington, to Portland, Oregon. The plane suffered temporary engine failure, permanent engine damage, and contamination to air handling systems, hydraulic lines, and pitot tubes. A day later, two Boeing 727 transport jets also encountered the ash cloud and suffered engine damage.

The May 25 incident was the first documented encounter resulting in jet power loss. The May 18 DC-9 incident was the first known to involve engine damage. These incidents and the significant failures of aircraft engines in Indonesia (1982) and Alaska (1989) prompted interagency cooperation between the USGS, National Oceanographic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), the International Civil Aviation Organization (ICAO) and representatives of the airline industry.

In 1995 nine regional Volcanic Ash Advisory Centers (VAACs) were established around the world under the auspices of the International Civil Aviation Organization to issue volcanic ash warnings to aircraft. The VAACs are tasked with the detection, tracking, and forecasting of the movement of eruption clouds within their respective areas of responsibility. Ash clouds in Washington and Oregon are the responsibility of the VAAC in Washington, D.C. The USGS and its partners work continuously with the VAACs, FAA, and US military and commercial airlines to advise them about volcanic events and to aid pilot training concerning volcanic hazards.

Although recent eruptions of Mount St. Helens did not damage many aircraft, along North Pacific air routes, some of the busiest in the world, at least 15 aircraft have been damaged since 1980 by flying through volcanic ash clouds. The 2010 eruption of ash from Eyjafjallajokull volcano in Iceland and its disruption to travel and business caused damages in the billions of dollars.

Volcanic gases

More than ninety percent of gas emitted by volcanoes is water vapor (steam). Other common volcanic gases are carbon dioxide and sulfur dioxide.

Volcanic gases floating freely in the atmosphere are not a hazard to people and animals unless they are in high concentrations, which typically is not an issue away from vents.

But odorless carbon dioxide is heavier than air and can become trapped in ice caves and topographic depressions on volcanoes where it displaces the air and can be deadly.

Since the 1980s, carbon dioxide release has been unusually high at Mammoth Mountain volcano in east-central California. In 2006, three members of the ski patrol there died and their four would-be rescuers were hospitalized after a thin snow bridge collapsed and plunged them into a carbon-dioxide-filled hole.

Sulfur dioxide gas can react with water in the atmosphere to create acid rain, which can cause corrosion and harm vegetation downwind.

Lava flows and lava domes

Molten rock that erupts onto the Earth's surface is called lava. The hottest, most fluid lava flows at Washington's volcanoes tend to travel only short distances from a vent, rarely moving beyond the base of a volcano. Once solidified, they typically form much of a volcano's cone. For example, most Cascade volcanoes consist of hundreds of overlapping layers of lava flows and rock rubble.

Slightly cooler or crystal-rich lava oozes to the surface in a semi-solid form and piles high in mounds called lava domes. During eruptions in 1980-86 and 2004-2008 at Mount St. Helens, lava extruded onto the crater floor to form lava domes. Substantial portions of Glacier Peak, Mount St. Helens, and Mount Hood are constructed of lava domes.

Lava flows and lava domes in themselves seldom are a direct hazard beyond the base of a volcano, but their collapse on the steep-sided slopes of a volcano can cause avalanches of hot rock and gas (pyroclastic flows) that can incinerate whatever lies in their path. On snow-covered volcanoes, pyroclastic flows melt snow and ice and produce lahars. These lahars can have disastrous effects tens of miles down valley from the volcano. The collapse of lava flows and domes are one of the greatest volcano threats worldwide.

Pyroclastic flows

Pyroclastic flows are high-speed avalanches of hot ash, rock fragments, and gas that can move down the sides of a volcano during explosive eruptions or when a growing lava dome or flow collapses and breaks apart. Pyroclastic flows can be as hot as 1,500°F and move at speeds of 40 to 80 miles per hour. Such flows tend to follow valleys and are capable of knocking down and burning everything in their paths.

In the recent geologic past, Glacier Peak and Mount Hood have generated hundreds of pyroclastic flows that have swept down the slopes of the volcano. Some resulted from large explosive eruptions that produced voluminous flows of pumice and ash near the volcano and substantial ashfall in eastern Washington and beyond. Other pyroclastic flows resulted from frequent collapses of growing lava domes. The flows buried valley floors tens to hundreds of feet deep and perhaps started forest fires. A modern example is the 1991-1995 eruption of Mount Unzen volcano in Japan. Portions of that lava dome collapsed and formed pyroclastic flows that traveled almost three miles from the crater where they destroyed about 2,000 houses and claimed the lives of 43 people.

Lava domes that grew in the crater of Mount St. Helens from 1980-86 and 2004-08 were nestled within the walls of the crater on a relatively flat floor and did not produce many collapses or pyroclastic flows. If lava eventually fills the crater, pyroclastic flows could sweep all the volcano's flanks.

At most Cascade volcanoes, pyroclastic flows seldom travel more than a few miles beyond the base of the volcano, but their potential to swiftly melt snow and ice and generate far-traveling volcanic mudflows, called lahars, makes them an even more hazardous process.

Debris avalanches, lahars (volcanic mudflows), and debris flows

A note about terminology: The terms debris flows, mudflows, and lahars are sometimes used interchangeably. Volcanologists prefer to use the term lahar for flows of water, rock, mud, and other debris that originate on a volcano. However, at Mount Rainier, where small such flows occur frequently, we use the term debris flow to distinguish them from large lahars, which can affect people catastrophically tens of miles from the mountain. The term debris avalanche describes a type of rapidly moving landslide that is common on some volcanoes.

Debris Avalanches

Debris avalanches are rapidly moving landslides that can range in size from small events affecting only a limited area to catastrophic movements, such as massive collapses of the entire summit or sides of a volcano. Some Cascade volcanoes are susceptible to debris avalanches because portions of them are built of weak materials or have been weakened by attack from acidic volcanic fluids, a process called hydrothermal alteration. Eruptions, intense rainfall, or large local earthquakes can trigger debris avalanches on volcanoes. Most large prehistoric debris avalanches from Cascade volcanoes happened during volcanic eruptions, but some debris avalanches occurred when a volcano was quiet.

Lahars

Lahars are flows of mud, rock, and water that can rush down valleys and stream channels at speeds of 20 to 40 miles per hour and can travel more than 50 miles. Some lahars resemble fast-moving rivers of wet concrete. Close to their source, these flows are powerful enough to rip up and carry trees, houses, and huge boulders for miles. Farther downstream they entomb everything in their path in mud. Lahars differ from floods in that they contain higher concentrations of mud and rocks.

Historically, lahars have been one of the deadliest volcano hazards because they can reach lowland areas quickly and bury them in mud and rock debris. Most lahars from

Cascade volcanoes originate by the rapid melting of snow and ice during eruptions. Other lahars are generated by debris avalanches that contain sufficient water to transform all or part of the avalanche into a lahar. Large lahars are a potential hazard to many communities downstream from glacier-clad volcanoes. During volcanic unrest or eruption, people in potentially hazardous areas should be prepared to move rapidly to high ground out of lahar hazard zones.

Lahars choke river channels and cover valley floors with large amounts of sediment. Such disruption of watersheds can initiate years or decades of high sediment production, shifting stream channels, increased flooding, and burial of downstream areas by sediment. Unlike areas affected by other natural hazards such as earthquakes or floods, the lingering consequences of a volcanic eruption can make areas unavailable for redevelopment long after an eruption ends.

A prehistoric debris avalanche at Mount Rainier and one in 1980 at Mount St. Helens are the best known examples in Washington. A debris avalanche 5,600 years ago (commonly called the Osceola Mudflow) removed almost one cubic mile of the northeast flank and summit of Mount Rainier before transforming into a lahar that swept more than 70 miles downstream through areas now densely populated and into Puget Sound. On May 18, 1980, a debris avalanche on Mount St. Helens removed about two-thirds of a cubic mile of the north flank and summit of the volcano, traveled 14 miles down valley in 10 minutes, and buried the valley to an average depth of 150 feet. Fortunately for downstream communities, the avalanche did not contain enough water to mobilize entirely into a lahar as did the Osceola. The Mount St. Helens event ranks as one of the largest terrestrial landslides in historical time.

Lahars and Debris flows at Mount Rainier

At Mount Rainier, lahar hazards are evaluated at two different scales: small flows that occur almost annually and threaten campgrounds, hiking trails, and roads within the National Park (referred to as debris flows in emergency management plans), and much more infrequent large flows that threaten river valleys all the way to Puget Sound (referred to as lahars in emergency management plans). The small (but still dangerous) debris flows are triggered primarily in summer and autumn, when glaciers are producing and storing large volumes of meltwater and when intense rainfall can erode sparsely vegetated ice-free areas of steep ground. Since 1992 dozens of debris flows at Mount Rainier have destroyed roads and buried trails and picnic areas, while similar flows at Mount Hood have caused millions of dollars of damage to roads and bridges.

Lahar detection system and evacuation signage near Mount Rainier

The risk from lahars is greater on the west slope of Mount Rainier than at other locations in the Cascades because of the existence of large amounts of weakened rock on the volcano's west side that is subject to landsliding, coupled with dense residential and commercial development in the valley below.

As a result, Pierce County Department of Emergency Management, in collaboration with the USGS and Washington State Emergency Management Division, maintains a lahar warning system in the Puyallup and Carbon River valleys. In the event of a lahar, automated signals will be sent to the Pierce County Law Enforcement Support Agency (LESA) and Washington State Emergency Operations Center at Camp Murray. The public will be notified through multiple channels including sirens, the emergency alert system, broadcasts on NOAA weather radios, and other forms of mass communication.

The USGS also operates a lahar detection system on the Toutle River at Mount St. Helens. The telemetered data go to the USGS-CVO, the National Weather Service Office in Portland, which will broadcast warnings.

Safety Precautions

Preparing for volcanic activity

Society cannot always abandon or prevent settlement of areas where volcanic hazards exist; what is important is to learn to live with them as safely as possible.

Learn

Determine whether you live, work, or go to school in a volcano hazard zone. Learn about all volcanic processes that could affect your community. Residents can obtain copies of USGS volcano-hazard reports to determine whether they live or work in areas at risk from volcanic activity. Everyone should plan how they and their families will respond to any natural disaster, including unrest or eruptive activity at nearby volcanoes.

Inquire

Ask local emergency management offices to advise you about how to respond during any emergency. Residents who live near a volcano should also find out what their local officials are doing to prepare their community for the possibility of renewed volcanic activity.

Plan

Develop an emergency plan with your family so that you are prepared for natural hazards and emergencies. Preparation might include knowing where to go when family members are separated, where to go for emergency housing, what emergency supplies to keep on hand, and how to be self sufficient for several days, as recommended by local emergency management agencies.

General safety principles

Hazards on volcanoes—Lava flows, pyroclastic flows, and volcanic gases

- Obey closures. Listen to advice from public safety agencies and land managers regarding access restrictions and safety recommendations before and during a volcano crisis.

Hazards on valley floors—Lahars and debris flows

- If you are on the floor of a valley that originates on a Cascade volcano, and you receive a warning that a lahar is in progress, follow the instructions of officials. You will probably be instructed to move to high ground 50 to 100 feet off the valley floor.

- When hiking in valleys on the slopes of Cascade volcanoes during late summer or during intense rainfall, be alert for the signs of an approaching debris flow—ground shaking and low roaring sound—and move quickly up the valley wall to higher ground. When you hear it, you may have only minutes to escape.

What to do during an ash fall

- Know in advance what to expect and how to deal with volcanic ash.
- Prepare to shelter in place with emergency supplies on hand, rather than evacuating from ash-affected areas.
- Keep ash out of buildings, machinery, air and water supplies, downspouts, storm drains, etc., as much as possible to reduce problems.
- Wet ash can cause electrical shorts and disruption of power systems and require the use of backup power sources.
- Stay indoors to reduce exposure—especially if you have respiratory ailments.
- Minimize travel—driving in ash is hazardous to you and your car.
- In ash-filled air, use dust masks and eye protection to reduce irritation. If you don't have a dust mask, use a wet handkerchief.
- Don't tie up phone lines with non-emergency calls.
- Use your radio to receive information about ash fall.
- Wind and human activity can resuspend volcanic ash long after an eruption.
- Be alert for signs of structural weakening of buildings when accumulations of wet ash exceed a thickness of about 4 inches.

How do I clean up?

- Minimize activities that resuspend ash by removing as much ash as possible from frequently used areas.
- Clean from the top down and wear a dust mask. Dampening the ash may ease removal, but be careful not to wash ash into drainpipes, sewers, storm drains, etc.
- Use water sparingly because widespread use of water for clean-up may deplete public water supplies and clog drainage systems.
- Caution: Fine ash is slippery when wet.

Volcano Histories

Histories of Washington volcanoes and Mount Hood, Oregon

MOUNT BAKER erupted in the mid-1800s for the first time in several thousand years. Activity at steam vents (fumaroles) in Sherman Crater, near the volcano's summit, increased in 1975 and is still vigorous, but there is no evidence that an eruption is imminent.

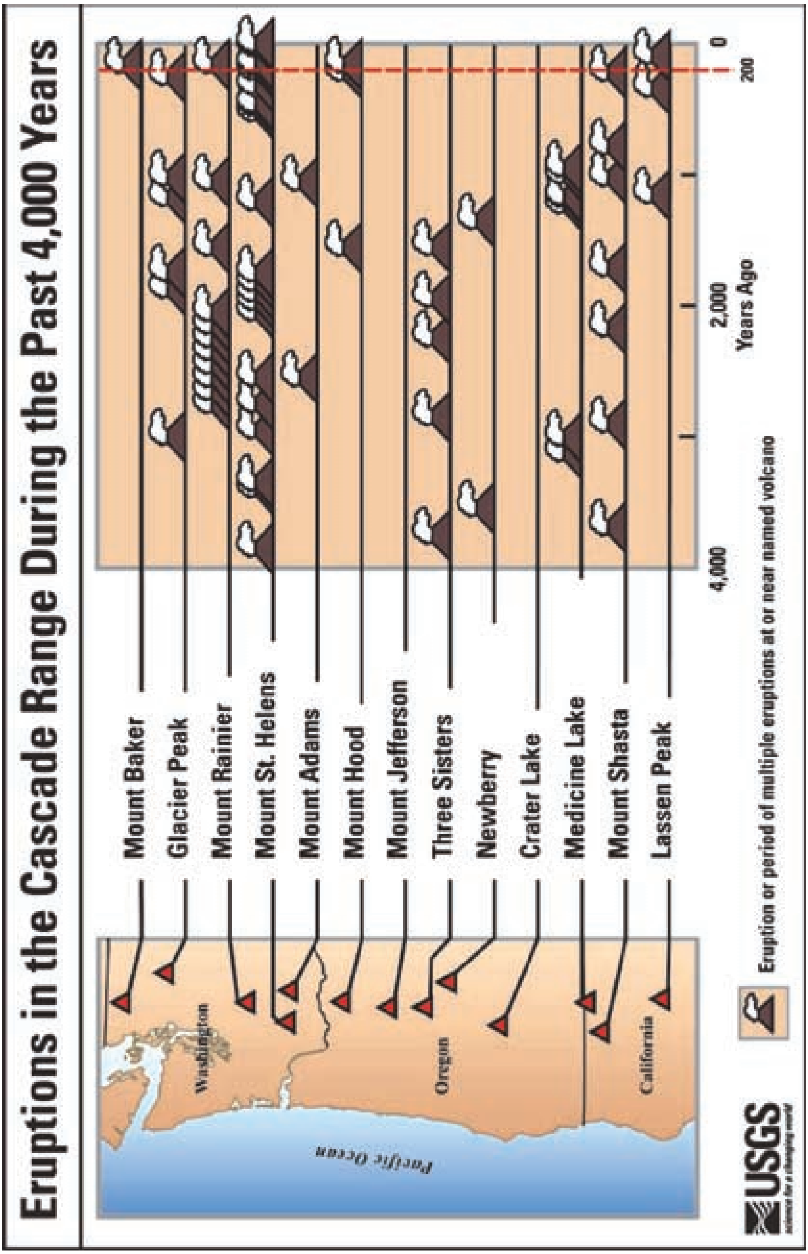
GLACIER PEAK has erupted at least six times in the past 4,000 years. About 13,000 years ago, an especially powerful series of eruptions deposited volcanic ash at least as far away as Wyoming.

MOUNT RAINIER has produced more than a dozen eruptions and numerous lahars in the past 4,000 years. The most recent lava flow happened about 1,000 years ago, though pioneers in 1894-95 watched steam explosions at the volcano's summit. It is capped by as much glacier ice as the rest of the Cascade volcanoes combined, and parts of Rainier's steep slopes have been weakened by hot, acidic volcanic fluids. These factors make this volcano especially prone to debris avalanches and lahars.

MOUNT ST. HELENS has been the most frequently active volcano in the Cascades during the past 4,000 years. It has produced many lahars and a wide variety of eruptive activity, from relatively quiet eruptions of lava (most recently in mid-1980 to 1986 and 2004 to 2008) to explosive eruptions much larger than that of May 18, 1980. Mount St. Helens has produced large plumes of volcanic ash throughout its recent history—more than any other Cascade volcano.

MOUNT ADAMS has produced few eruptions during the past several thousand years. This volcano's most recent activity was a series of small eruptions about 1,000 years ago. The upper slopes of Mount Adams have been weakened by long-term exposure to hot, acidic volcanic fluids, and this has made some areas especially prone to debris avalanches.

MOUNT HOOD has erupted several times during the past 2,000 years, most recently during the late 18th and the mid-19th centuries. Although not an explosive volcano, Mount Hood has generated large lahars from collapsed lava domes and pyroclastic flows. In 1805 explorers Lewis and Clark named the river now known as the Sandy River, the Quicksand because of the large amount of sand at its mouth. Today we recognize that multiple lahars from Mount Hood deposited the sand, the most recent in 1791.


Eruptions in the Cascade Range During the Past 4,000 Years
Pacific Ocean
Washington
Oregon
California
Mount Baker
Glacier Peak
Mount Rainier
Mount St. Helens
Mount Adams
Mount Hood
Mount Jefferson
Three Sisters
Newberry
Crater Lake
Medicine Lake
Mount Shasta
Lassen Peak
4,000
2,000
Years Ago
200
0
Eruption or period of multiple eruptions at or near named volcano
USGS

Frequently Asked Questions

What are the hazards from Washington's Cascade volcanoes?

Lahars are the principal hazards to life and property at Washington State's volcanoes; volcanic ash can be a widespread nuisance or threat, depending upon the amount of ash produced in the eruption and where and how thickly it falls.

Which Cascade volcano will erupt next?

No one knows for sure, but seven of them have erupted in just the past 300 years: Mount St. Helens (1800-1857, 1980-1986, and 2004-2008), Lassen Peak (1914-1917), Mount Baker (1843), Glacier Peak (1700s), Mount Rainier (1894-95), Mount Hood (1780-1793), and Mount Shasta (1786). Any of these could be the next to erupt, though the odds are highest at Mount St. Helens.

What kinds of unusual activity might be noticed before an eruption?

Common symptoms of volcanic unrest include an increase in the frequency or intensity of earthquakes beneath a volcano; the occurrence of volcanic tremor; swelling, subsidence, or cracking of the ground; increased steam emission or small steam explosions; melting snow or ice; changes in existing fumaroles or hot springs, or the appearance of new ones; and increased discharge of magmatic gases. Volcanologists assess the significance of volcanic unrest partly by monitoring the pace and intensity of such activity.

How many volcanoes exist in the United States and its territories?

The United States and its territories have about 170 volcanoes that have been active during the past 10,000 years, and most could erupt again in the future. In the past 500 years, 80 U.S. volcanoes have erupted one or more times.

How many potentially active volcanoes are there on Earth?

There are about 1500 potentially active volcanoes worldwide, aside from the continuous belt of volcanoes on the ocean floor. About 500 of these have erupted in historical time.

Resources

USGS Volcano Hazards Program . . . . http://volcanoes.usgs.gov

General information about volcanic processes (including extensive information about the effects of volcanic ash and recommendations for cleanup), alert system, hazard assessments, fact sheets, educational materials

USGS Cascades Volcano Observatory . . . . http://vulcan.wr.usgs.gov

General information about Cascade volcanoes

Pacific Northwest Seismic Network . . . . http://www.pnsn.org

Current and past earthquake data and maps

Washington Emergency Management Division . . http://www.emd.wa.gov

Inter-agency volcanic eruption response plans, preparedness recommendations

International Volcanic Health Hazard Network (IVHHN) . . . . www.ivhhn.org

Pamphlets: *Health hazards of volcanic ash—a guide for the public*, and *Guidelines on preparedness before, during and after an ashfall*

International Association for Volcanology and Chemistry of Earth's Interior (IAVCEI) DVD . . . http://www.iavcei.org

Understanding Volcanic Hazards; Reducing Volcanic Risk (both sections available in English and Spanish)