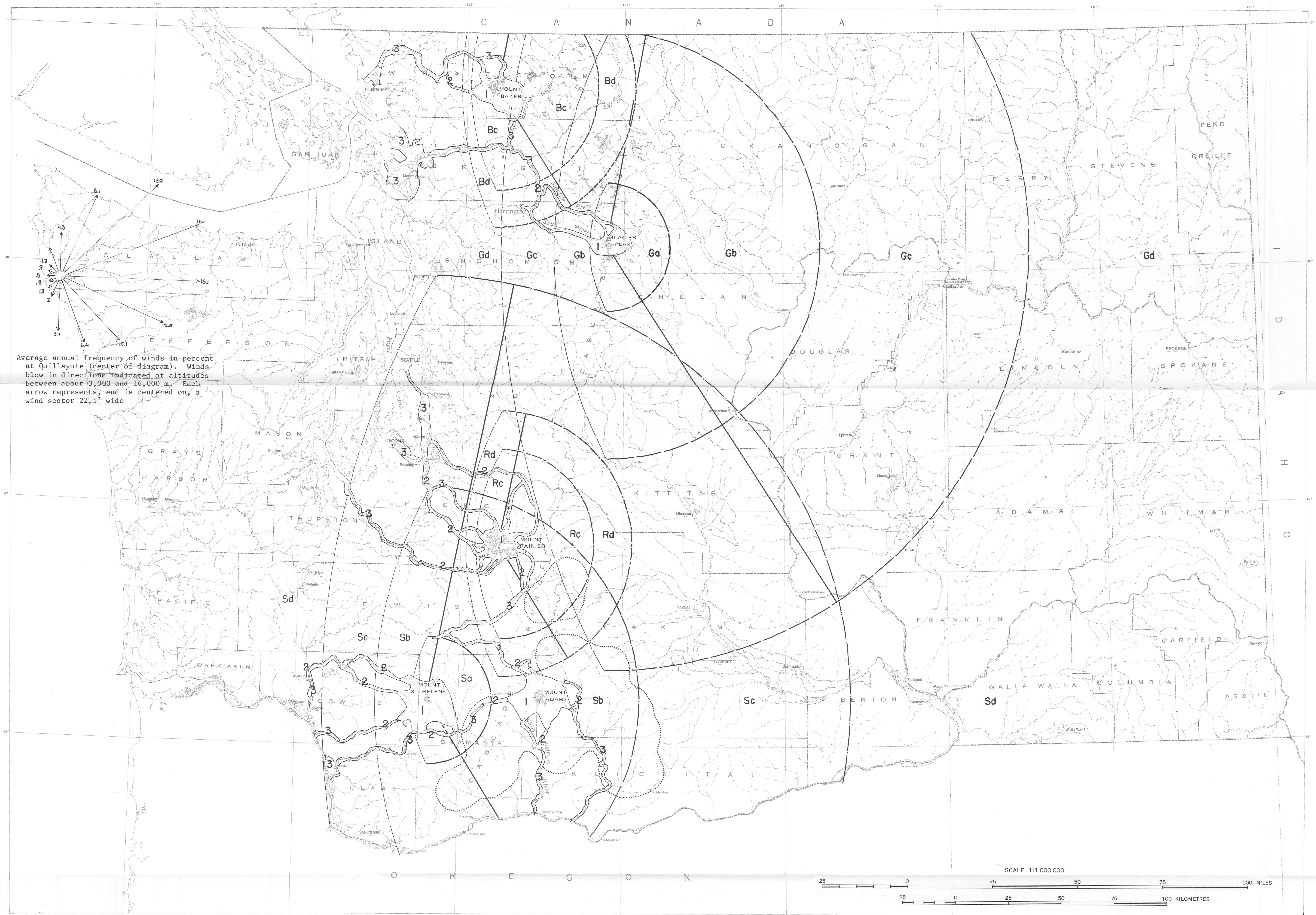
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-774
WASHINGTON




Base from U.S. Geological Survey, Washington, 1:500,000, 1962

Volcanic hazards assessment made in 1975

## MAP EXPLANATION

### ZONES OF LAVA FLOW, PYROCLASTIC FLOW, MUDFLOW, AND FLOOD HAZARDS

[Danger to property would be high in each zone, but potential danger to people could be averted by evacuation]

| Zone | Potentially hazardous events which could result from eruptions and affect areas shown |
|---|---|
| 1 | Lava flows, pyroclastic flows, mudflows, floods. |
| 2 | Mudflows, floods. |
| 3 | Floods. |

AREAS WITHIN 10 KM OF SCATTERED VOLCANIC VENTS OF QUATERNARY AGE--Products of future eruptions from such vents probably will be areally limited and consist only of lava flows and very small amounts of tephra. These hazards are in addition to those related to the principal volcanoes

### TEPHRA-HAZARD ZONES

[Symbols for source volcanoes are B, Mount Baker; G, Glacier Peak; R, Mount Rainier; S, Mount St. Helens. The combination on the map of capitals and small letters designates the source volcano and the tephra-hazard zones related to it]

| Zone | Anticipated maximum tephra thicknessess | Potential hazard to human life and health |
|---|---|---|
| a | >1 m | Very high. |
| b | 35 cm-1 m | High to very high. |
| c | 5-35 cm | Low to high. |
| d | 2-5 cm at Rainier and Baker, <5 cm elsewhere | Very low to low. |

Mount Baker
Glacier Peak
Mount Rainier
Mount St. Helens

Light and heavy lines show outer limits of tephra-hazard zones west and east, respectively, of volcanoes. Heavy straight north-northeast- and south-southeast-trending lines at each volcano show sector of most probable tephra fallout

### DISCUSSION OF TEPHRA-HAZARD ZONES

High-altitude winds, represented on the map at Quillayute, determine tephra distribution. They are based on 20-year records from the Winds Aloft Summary of the Air Weather Service, National Climatic Center, Asheville, N.C. The wind records at Quillayute closely resemble those from Salem in northwestern Oregon; this suggests that high-altitude winds are nearly uniform throughout western Washington.

The broad pie-shaped area east of each volcano, defined by heavy straight lines, shows the sector most susceptible to tephra fallout. Nearly 80 percent of the winds blow toward some part of that sector at altitudes between about 3,000 m and 16,000 m. Only a small part of that sector probably would be affected by any one tephra eruption.

The extents of tephra-hazard zones are based on the thicknesses of tephra which fell directly downwind from each volcano during the largest tephra eruption of the last 10,000 years, except for the zones related to Glacier Peak which are modeled on those of Mount St. Helens. The extents of the zones in the 180° sector east of each volcano are based on an assumption that a tephra deposit similar in size to the largest of the last 10,000 years is possible anywhere in tha. sector. Eruptions of smaller volume, which will result in lesser thicknesses than those shown, are more likely and will be more frequent than eruptions of large volume. The volume of tephra erupted by Glacier Peak 12,000-13,000 years ago may have been several times greater than that of Mount St. Helens which was used as a basis for the tephra-hazard zones shown, but the distribution and thickness of tephra from Glacier Peak are not yet adequately known.

A determination of the extents of tephra-hazard zones in the 180° sector west of each volcano is highly speculative. Winds from the east are typically of lower velocity and are less common than those from the west; furthermore, tephra blown toward the west while at high altitudes might, in falling, be carried back to the east by westerly winds at lower altitudes. No significant amount of tephra has fallen in the western sector beyond the base of the source volcano during the last 4,000 years at Mount St. Helens, or during the last 10,000 years at the other large volcanoes in Washington. The extents of the respective tephra-hazard zones west of each volcano are arbitrarily shown to be only 25 percent as great as those in the eastern sector, and zone boundaries at the junction of the two sectors are diagrammatic.

Small amounts of tephra erupted by volcanoes outside Washington could fall virtually anywhere in the State, however, the resulting deposits would probably be less than 5 cm thick. The nearest volcano in Oregon is Mount Hood, about 100 km south of Mount Adams. Mount Hood has erupted insignificant amounts of tephra during the last 10,000 years, but conceivably it could erupt larger volumes which might affect areas in south-central and southeastern Washington. This report does not consider the effects of a future eruption whose volume would be as great as that of an eruption of Mount Mazama volcano (Crater Lake) in Oregon between 6,000 and 7,000 years ago. Although such an eruption is possible in Washington, its likelihood cannot be accurately assessed.

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## DISCUSSION

### INTRODUCTION

Mount Baker and Mount Rainier each erupted at least once during the first half of the 19th century, and Mount St. Helens was frequently active until 1856. However, these volcanoes as well as Mount Adams and Glacier Peak have all been quiet for more than a hundred years. If these five large volcanoes in Washington are viewed in the perspective of the next few years, or even the next few decades, they surely present a lower degree of potential risk to lives and property than do some other kinds of natural phenomena such as earthquakes and major storms. Nevertheless, the potential danger from volcanoes is not so low that it should be disregarded, as it has been for the most part in the past. Sooner or later some volcano in Washington will erupt again, and the ever-expanding use of areas that could be affected will progressively increase the potential impact of an eruption on the State's economy and the health of its citizens. The relatively low frequency of volcanic eruptions in Washington during the last few centuries suggests that the degree of risk does not warrant changes in present land use in most places. However, decisions concerning acceptable degrees of risk should be based on such factors as the distance and direction of a site from the volcanoes, the eruptive behavior of those volcanoes, and the vulnerability of the development at that site to various kinds of volcanic phenomena. The purpose of this report and map is to provide information for making such decisions by describing the nature of potentially dangerous volcanic events and showing their possible geographic extents.

### PRODUCTS AND EFFECTS OF ERUPTIONS

Lava flows are generally erupted quietly, although they are often preceded by explosive activity. Lava from volcanoes like the five large ones in Washington typically appears only after an eruption has been in progress for hours, days, or a few weeks, rather than at the outset of the eruption. However, flows from small volcanoes like those in the area around Mount Adams often occur soon after an eruption begins. The fronts of lava flows usually advance at rates ranging from those barely perceptible to about as fast as a person can walk. Lava flows are of virtually no direct danger to human life; those that extend into areas of snow, however, may melt it and cause potentially dangerous and destructive floods and mudflows. Lava flows generally result in total destruction in areas they cover. In addition, lava that moves into vegetated areas could start fires.

Pyroclastic flows are masses of hot, dry rock debris that move like a fluid, but they owe their mobility to hot air and other gases mixed with the rock debris rather than to a liquid. Such flows are often formed when large masses of hot rock fragments are suddenly erupted onto a volcano's flanks. Some flows are caused by an eruption of a volcanic dome, a mass of solid rock formed when stiff pasty lava pushes out of a volcanic vent and is too viscous to flow sideways. The sides of domes are typically steep and unstable, and pyroclastic flows may be formed when masses of hot rock slide outward and downward, shattering into countless fragments. Flows of hot rock fragments can move downslope at speeds of 55-120 km/hr owing to the force of gravity and possibly to the force of the eruption. Pyroclastic flows move along and bury valley floors. Accompanying clouds of hot dust may blanket adjacent areas, especially those downwind from the pyroclastic flow. Because of their mobility pyroclastic flows can affect areas at least as far as 20 km from a volcano. The principal dangers from pyroclastic flows result from (1) the swiftly moving basal flow of hot rock debris, which can bury and incinerate all living things in its path; and (2) the cloud of hot dust and gases, which may cause asphyxiation and burning of the lungs and skin. Vegetation and manmade structures in the path of a pyroclastic flow can be buried or set afire.

Mudflows are masses of water-saturated rock debris which move down slopes in a manner resembling the flowage of wet concrete. Explosive eruptions commonly form masses of loose, unstable rock debris on the flanks of a volcano and water may be provided by rain, melting snow, or the overflow of a crater lake. Mudflows might also be started by lava or a hot pyroclastic flow moving across and melting snow. These mudflows can be either hot or cold, depending on the presence or absence of hot rock debris in them. Other mudflows from volcanoes are caused by massive slides of rock which has been altered to clay and weakened by hot vapors. Mudflows have been known to move for many tens of kilometres down valley floors at speeds of 35 km/hr or more. The speed of mudflows depends mostly on their fluidity and the slope over which they move; the size of the area affected depends mainly on the volume of the mudflow. Constrictions which impede flowage in a valley may cause mudflows to pond temporarily and deepen. The chief threat to human life is that of burial. Structures can be buried, or swept away by the vast carrying power of the mudflows.

Floods caused by volcanism can carry large amounts of rock debris, and deposits of sand and gravel many metres thick may accumulate on valley floors for distances of tens of kilometres from a volcano. Eruptions at times of otherwise high stream discharge may result in unusually high floods.

Tephra is used in this report to describe rock fragments which are erupted into the air above a volcano. Large fragments generally fall back onto or near the volcano. Fine material is carried away by wind and falls to the ground at a distance determined by grain size and density, the height to which the material is erupted, and wind strength. The eruption of a large volume of tephra will cause a distinct layer to accumulate in the fallout area. Such a layer will form a lobe which is thickest directly downwind from the volcano, and which becomes thinner with increasing distance from the volcano and toward its sides. Tephra can endanger lives and property at considerable distances from a volcano by contaminating air, by carrying acids, and by forming a blanket at the ground surface. People can be injured by breathing tephra-laden air, by collapse of roofs under the weight of rain-soaked tephra, and by fires started by hot fragments. Tephra can block roads and isolate people, cause darkness during daylight hours, increase turbidity and temporary acidity in drinking water, and interrupt telephone and electrical services. Damage to property results mostly from the weight of tephra and its smothering and abrasive effects. Machinery is especially susceptible to abrasion and the corrosive effect of acidic gases and acids carried by tephra. The health and economic welfare of people in the fallout area can also be affected by the destruction or damage of crops. Long-term exposure to relatively minor effects of tephra can add up to severe problems. A volcano can emit toxic gases with or without an accompanying eruption of tephra; such gases are quickly diluted and dissipated by winds and rarely occur in lethal concentrations beyond the flanks of a volcano.

### AVERAGE FREQUENCY OF PAST ERUPTIONS OF MAJOR VOLCANOES

The frequency is based on the period of years shown in parentheses. Tephra has been formed during virtually every eruptive episode at Mount St. Helens, Mount Rainier, and Glacier Peak, and perhaps also at Mount Baker. No tephra is known to have been erupted at Mount Adams during the last 10,000 years.

| | |
|---|---|
| Mount St. Helens (4,000 years) | 1 per 100-200 years |
| Mount Rainier (10,000 years) | 1 per 500-1,000 years |
| Mount Baker (10,000 years) | 1 per 1,000-3,000 years |
| Mount Adams (10,000 years?) | 1 per 5,000 years(?) |
| Glacier Peak (13,000 years) | 1 per 10,000-15,000 years(?) |

Summary of recent eruptive activity and probable greatest potential hazards at the five major volcanoes in Washington

[Principal sources of information: Mount Baker, Hyde and Crandell (1975); Glacier Peak, Tabor and Crowder (1969), and Crandell, unpub. data; Mount Rainier, Crandell (1971), and Mullineaux (1974); Mount St. Helens, Crandell and Mullineaux (1973), and Mullineaux and others (1975); Mount Adams, K. D. Hopkins, oral commun. (1975)]

| Volcano | Relative explosiveness of eruptions | Recognized products of eruptions of major volcanoes during the last 13,000 years | | | | | Most recent eruptions which resulted in an identifiable deposit | Probable greatest potential hazard |
|---|---|---|---|---|---|---|---|---|
| | | Lava flows | Domes | Tephra | Pyroclastic flows | Mudflows | | |
| Mount Baker | Low | Two about 8,700(?) yr ago; one or more between 10,400 and 6,600 yr ago from satellite vent. | None recognized. | Four eruptions of small volume; order of magnitude 0.001-0.1 km³. | At least 11 during an eruptive period about 8,700(?) yr ago. | Between 20 and 30 on east and southeast sides of volcano. | 1843(?). | Direct and indirect effects of mudflows or avalanches moving rapidly into reservoirs in Baker River valley. |
| Glacier Peak | High | Several between 12,000 and 13,000 yr ago?. | Two formed between 12,000 and 13,000 yr ago. | Large volume deposited downwind across eastern Washington between 12,000 and 13,000 yr ago; order of magnitude perhaps 10 km³. | Several between 12,000 and 13,000 yr ago. | Several extended down Suiattle and Sauk River valleys at least 20 km beyond Darrington. | None known since about 12,000 yr ago. | Deposition of tephra in central or north-central Washington from large-volume eruption. |
| Mount Rainier | Low | Eruptions of lava formed cone at summit of volcano about 2,000 yr ago. | None recognized. | Eleven eruptions of small volume; probable range in order of magnitude 0.001-0.1 km³. | One on west side of volcano about 2,500 yr ago. | At least 55; largest covered 330 km² in Puget Sound lowland about 5,500 yr ago. | Small volume of tephra erupted some time between 1820 and 1854. | Avalanching of large masses of hydrothermally altered rock to form mudflows which could extend tens of kilometres down valleys. |
| Mount St. Helens | High to low | Many during last 2,500 yr. | At least 6. | At least 7 large-volume eruptions; probable order of magnitude 1 km³. Many other small-volume eruptions; probable order of magnitude 0.001-0.1 km³. | Many down all sides of volcano, most recently about 450 yr ago. | Many down all valleys that head on volcano; some reached at least 65 km from volcano. | Eruption of tephra about 1800; formation of dome in 1840's. | Deposition of tephra in central or south-central Washington from large-volume eruption; formation of large pyroclastic flows and mudflows. |
| Mount Adams | Low | Probably several. | None recognized. | None recognized. | None recognized. | One extended at least 20 km down White Salmon River valley about 5,000 yr ago. | Not known. | Avalanching of large masses of hydrothermally altered rock to form mudflows which could extend tens of kilometres down valleys. |

# PRELIMINARY ASSESSMENT OF POTENTIAL HAZARDS FROM FUTURE VOLCANIC ERUPTIONS IN WASHINGTON

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1976

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1980

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