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**THE 1980 ERUPTION OF MOUNT ST. HELENS, WASHINGTON  
MARCH 20 - MAY 19, 1980**

BY  
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JAMES G. RIGBY, and  
KEITH L. STOFFEL

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COVER PHOTO taken of Mount St. Helens crater from the north-northeast on May 24, 1980  
by Keith L. Stoffel

# THE 1980 ERUPTION OF MOUNT ST. HELENS, WASHINGTON

## MARCH 20 - MAY 19, 1980

BY

MICHAEL A. KOROSSEC,  
JAMES G. RIGBY, and  
KEITH L. STOFFEL

### INTRODUCTION

This Information Circular consists of a compilation of events over the months before the major eruption of Mount St. Helens in 1980, an eyewitness report from above the volcano when it erupted, a description of the volcanic events on May 18, 1980, and a prediction of what might be expected from Mount St. Helens in the near future.

The geologic community, including the Division of Geology and Earth Resources, is continuing to study the volcanic eruption and geologic hazards which threaten large areas surrounding the mountain. During the summer of 1979, before the current eruptive activity had commenced, the Division conducted an exploration program designed to evaluate the geothermal potential of the stratovolcano and surrounding area. J. Eric Schuster and Mike Korosec coordinated the projects which included the drilling of three 500-foot holes for the meas-

urement of temperature gradients, the sampling and analysis of spring water, and a gravity survey (by Z. F. Danes, University of Puget Sound). No unusual conditions were observed that would have suggested geothermal resources or an impending volcanic eruption. The only thermal features noted or reported by others included a fumarole near the Boot, and warm ground areas about 2 miles east of McBride Lake, 1½ or 2 miles south of the Toutle River up Studebaker Creek, a few miles east of the crater near Pumice Butte on the southeast side of the Plains of Abraham, and on the upper south-southwest flank of the cone just below the summit. The Division had planned to continue the assessment efforts, including the drilling of two additional temperature gradient holes, but the eruption altered these plans. The information thus far collected during the program, however, will serve as a basis for comparative studies of the volcano in the future.

### GLOSSARY OF VOLCANIC TERMS

**Andesite** — A volcanic material of intermediate silica content and intermediate viscosity when in a molten state.

**Ash flow** — An avalanche consisting of volcanic ash and gases, highly heated, traveling down the flanks of a volcano.

**Caldera** — A large (generally, 1 mile or more in diameter) basin-shaped depression formed either by collapse or by explosion, usually at the summit of a volcano.

**Crater** — A smaller basinlike-rimmed depression formed by explosion or collapse, usually at the summit of a volcano.

**Dacite** — A volcanic material, intermediate between rhyolite and andesite, with a higher silica content than andesite and less than rhyolite.

**Detachment plane** — The surface along which a landslide disconnects from its original position.

**Dome** — A steep-sided mass of viscous lava, forming a more or less dome-shaped mass over the volcanic vent.

**Fumarole** — A volcanic vent from which fumes or vapors issue.

- Harmonic tremor** — A term derived from Hawaiian Island earthquakes that is used to describe a low amplitude, high constant sinusoidal wave thought to represent movement of magma.
- Hydrothermally altered rock** — Rock that has been decomposed or chemically changed by the prolonged action of hot steam and geothermal fluids.
- Lahar** — A torrential flow of water-saturated volcanic debris down the slope of a volcano in response to gravitative force; a type of mudflow.
- Landslide** — A descriptive term covering a broad variety of relatively rapid downslope movement of earth and rock material due to gravity.
- Mudflow** — A general term for a highly fluid, water-saturated, flowage of fine-grained earth materials due to gravity.
- Nuee ardente** — A French term applied to a highly heated mass of gas-charged ash which is expelled with explosive force down the mountainside with hurricane speed. Also known as a glowing avalanche, the incandescence is not always observed, especially during the daylight hours. Although most of the material moves laterally along the ground surface, great clouds of ash usually rise thousands of feet above it.
- Peleean eruption** — Volcanic activity characterized by large explosive events with nuees ardentes, pyroclastic flows, moderate to heavy ash expulsion, and dome formation.
- Pumice** — A high vesicular, frothy natural glass with a high silica content formed through volcanic activity.
- Pyroclastic** — A general term applied to volcanic material which has been explosively ejected from a volcanic vent.
- Pyroclastic flow** — A gravity flow of any type of pyroclastic material.
- Rhyolite** — A volcanic material of high silica content, equivalent to granite in composition, with a very high viscosity when in a molten state.
- Stratovolcano** — A volcanic cone, usually of large size, built of alternating layers of lava and pyroclastic material; also known as a composite cone.
- Tephra** — A general term for all pyroclastics of a volcano.
- Vulcanian eruption** — Volcanic activity characterized by strong explosions which produce pumice and large ash clouds, occasionally accompanied by crater or fissure lava flows. The term Vulcanian activity usually refers to the eruption of large ash clouds to great vertical heights.

EVENTS LEADING UP TO THE MAY 18, 1980,  
ERUPTION OF MOUNT ST. HELENS

by

James G. Rigby and Michael A. Korosec

The following summary of events leading to the major eruption of Mount St. Helens on May 18, 1980, has been compiled from U.S. Geological Survey and University of Washington daily updates of volcanic and seismic activity, and from notes and daily reports collected by Jim Rigby of the Division of Geology and Earth Resources while assisting the U.S. Geological Survey in Vancouver. In most cases, only the most important activity of the day is reported, ignoring minor activity which is usually emphasized on slower days. In addition, weekend reports are not as detailed as those of weekday events. This does not, of course, reflect the actual activity on the volcano. Some of the earthquake magnitudes are preliminary.

**March 20 - March 26** — A minor earthquake of 4.1 Richter magnitude was recorded in the vicinity of Mount St. Helens on March 20. This was the first sign that an eruptive phase had begun. Over the following week, swarms of microearthquakes were recorded, reaching magnitudes of up to 4.4 and triggering minor avalanching. The number and intensity grew, reaching a peak on March 26, although intensities were somewhat higher on March 25 than on the 26th.

**March 27** — A thick black plume of ash and steam was exploded from the volcano's summit, rising to a level about 7,000 feet above the newly opened crater, which measured about 250 feet in diameter. Extensive long cracks were visible in the ice crossing the crater on the north and south, and running down the west and east sides of the volcano. One hundred and thirty-five earthquakes were recorded greater than magnitude 3, ranging up to 4.7.

**March 28** — Steam eruptions continued through the day, commonly to elevations of 14,000 to 16,000 feet. Small avalanches and mudflows moved down the upper flanks of the cone. One hundred and thirty earthquakes, greater than magnitude 3 were measured, ranging from 3.2 to 4.9.

**March 29** — A second crater was observed on the northeast side of the old crater which had apparently opened during the night before. The new opening measured about 75 feet wide and 30 to 60 feet deep. Eruptions observed during the day would begin as combinations of ash and steam, but would convert to steam only by the end of the eruption. One hundred and thirty-eight earthquakes greater than magnitude 3 were recorded, ranging up to 4.4. The "blue flame" was first observed during the night of the 29th, coming from the smaller, north-eastern crater.

**March 30** — Minor eruptions continued at a rate of about one every ½ to 1½ hours. The largest ash eruptions to date were noted, and the crater was slowly being enlarged. Seventy-nine earthquakes in the range of magnitude 3.2 to 4.6 were recorded. The blue flame was seen during the night again.

**March 31** — Explosive eruptions continued, and the two craters merged, with a low saddle between them. Seventy-five earthquakes were recorded, along with the first harmonic tremor reported.

**April 1** — Ash and steam eruptions reached elevations of 16,000 feet. Several small fumarole vents only a few feet in diameter opened up around the east crater on the northeast side. Avalanching and mudflows were observed, especially along the north flanks, and a thermal infrared survey detected a hot spot at about an elevation of 5,000 feet just west of the Timberline area. Seventy-six earthquakes over magnitude 3 were recorded.

**April 2** — Many small steam eruptions were intermingled with occasional larger steam and ash eruptions, reaching elevations of 14,000 to 15,000 feet, with one large eruption in the late afternoon to about 20,000 feet elevation. Eighty-eight earthquakes over magnitude 3 were recorded.



**April 3** — Ash and steam eruptions were accompanied by several earthquakes greater than magnitude 4, with the largest measuring 4.9. In addition, harmonic tremors were recorded again, as during the last 2 days.

**April 4 - April 14** — Earthquake activity continued at a moderate rate, with 2 to 5 events per day in the range of magnitude 4.0 to 4.7. A small eruption occurred on the 8th of April, but eruptive events were generally lacking during this period, and seismic activity decreased towards the end of the period. Harmonic tremors occurred on the 4th, 5th, 7th, 10th, and 12th.

**April 15 - April 22** — There was very little change in the frequency of eruptive activity, with a few small steam eruptions occurring daily. There was a slight decrease in seismic activity during the beginning of this period, but the level picked up on the 20th, with 57 earthquakes over magnitude 3, and with 7 earthquakes greater than magnitude 4. No harmonic tremors were recorded during this period.

**April 23 - May 6** — Over this period, there was virtually no eruptive activity. Steaming, while sometimes intense at the beginning of the period, was reduced to smaller fumarolic activity by the end of April. The formation of a bulge on the north-northeast flank was detected on April 23, and was suspected to have been growing since the eruptions in March. By the end of April, the area was defined as being 1 mile long and 0.6 mile wide. The axis of the elongated area trended northeasterly from the north side of the summit crater toward the Sugar Bowl. The maximum uplift had been 320 feet, and Goat Rocks was moving north-northwest at

about 5 feet a day. The area affected included the Forsyth, Leschi, and Loowit Glaciers. By May 1, it was determined that the bulge was moving out laterally faster than it was being uplifted. Seismic activity continued at a lightly reduced rate, with further decrease on April 30, but returned to former levels (about 31 per day) during the first week in May, with 5 to 8 events greater than magnitude 4 daily. No harmonic tremors were recorded.

**May 7 - May 14** — Eruptive activity increased dramatically with steam and ash eruptions reaching elevations of 13,000 feet with increased sulfur emission. Steam emissions were also detected at two sites on the Boot on the north flank, and from crevasses at the head of Shoestring Glacier on the southeast flank. The feature at Shoestring was enlarged somewhat by the end of the period. The lateral bulging continued on the north-northeast flanks, slowing down on May 10 to 11, but picking back up by the end of the period to about 5 feet per day. Large magnitude seismic activity increased during this period, with 6 to 11 events greater than magnitude 4 daily, although the number of earthquakes between magnitudes 3 and 4 decreased slightly. Two harmonic tremors occurred on May 8.

**May 15 - May 17** — Eruptive activity decreased, with only very few minor short-term steam eruptions. The bulge continued to grow at the same rate, and seismic activity over magnitude 3 decreased from 39 per day on May 15, to 33 on the 16th, to 18 on the 17th, with 8 earthquakes over magnitude 4 on the 15th, 10 on the 16th, and 6 on the 17th.

THE MAY 18, 1980, ERUPTION OF MOUNT ST. HELENS --  
A VIEW FROM THE TOP

by

Keith L. Stoffel\*

We took off from the Yakima airport with pilot Bruce Judson of Executive Aircraft at about 7:15 a.m. At about 7:50 a.m., we entered the restricted air space around Mount St. Helens from the northeast and began our first pass in a clockwise direction. Right off, we were impressed and surprised by the wet appearance of the north face. We circled above the base of the volcanic cone, at an elevation of about 11,000 feet, taking pictures. The mountain looked serene, with only very minor wisps of steam blowing toward the north and west. Striking features on the north side of the mountain included large wet areas glistening around the Goat Rocks and Sugar Bowl where small avalanches had kicked up rocks and snow. The reddish-brown debris flows surrounding the two domes contrasted sharply with the surrounding slopes. We wondered if these flows were very recent features and if they were hours or days old.

After we had completed the first pass, we began the second from the north-northeast, with a tight bank and a pass directly over the south side of the summit crater, at an elevation of about 11,000 feet. Again we were impressed by the serenity of the scene below. Activity included very minor steaming from a vent at the bottom of the main crater and from a small hole on the southeast side of the top surface of the raised southern lip of the crater. Numerous wet seeps were observed on the south-facing wall of the main crater, and a small lake had formed on the crater floor just below this area. As we continued westward across the crater's edge, we noted the immense fractures on the top of the south lip.

After we looped around to the north, we began a third pass along the same path followed

in the previous pass, crossing directly over the summit. We didn't notice anything different, but the pilot thought he noticed more extensive cracking.

The fourth pass began with a wide sweep to the northwest to get a better overview of the entire mountain. We circled clockwise at a distance of about 5 or 6 miles from the summit, passing over the northern end of Spirit Lake, and viewing each of the flanks as we continued the circular path. We turned sharply on the west side of the crater, intending to pass over the summit and continue east back to Yakima.

As we approached the summit, flying at an elevation of approximately 11,000 feet, everything was calm as before. Just as we passed above the western side of the summit crater, we noticed landsliding of rock and ice debris inward into the crater. The pilot tipped the wing towards the crater, giving us a better view of the landsliding. The south-facing wall of the north side of the main crater was especially active.

Within a matter of seconds, perhaps 15 seconds, the whole north side of the summit crater began to move instantaneously. As we were looking directly down on the summit crater, everything north of a line drawn east-west across the northern side of the summit crater began to move as one gigantic mass. The nature of movement was eerie, like nothing we had ever seen before. The entire mass began to ripple and churn up, without moving laterally. Then the entire north side of the summit began sliding to the north along a deep-seated slide plane. I was amazed and excited with the realization that we were watching this landslide of unbelievable proportions slide down the north side of the mountain toward Spirit Lake. We took pictures of this slide sequence occurring, but before we could snap off more than a few pictures, a huge explosion blasted out of the detachment plane. We neither felt nor heard a thing, even though we were just east of the summit at this time. Dorothy saw the southern portion of the summit crater begin to crumble and slide to the north just after the initial explosion.

From our viewpoint, the initial cloud

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\*NOTE: Keith Stoffel is a geologist with the Division of Geology and Earth Resources at the Cheney field office. He and his wife Dorothy, a geologist working for Century West Engineering Corp. in Spokane, drove to Yakima where Keith was going to represent the Division at the Yakima Gem and Mineral Show. On Sunday morning, May 18, with several hours to spend before the show, they decided to charter a private plane and fly to Mount St. Helens for pictures and observations. While nearly all Division geologists had flown the mountain at least once during the previous 2 months, this was to be Keith's and Dorothy's first trip.

appeared to mushroom laterally to the north and plunge down. Within seconds, the cloud had mushroomed enough to obscure our view. At about this time, the realization of the enormous size of the eruption hit us, and we focused our attention on getting out of there. The pilot opened full throttle and dove quickly to gain speed. He estimates that we were going 200 knots. The cloud behind us mushroomed to unbelievable dimensions and appeared to be catching up with us. Since the clouds were billowing primarily in a northerly direction, we turned south, heading straight toward Mount Hood.

After a couple minutes we felt sure we had outrun the clouds. Behind us, we could see the clouds continue to mushroom to the north and northwest. An ash cloud rolled across the summit and down the south face, completely enveloping

the cone and eventually obscuring all but the lower slopes. The pilot suggested turning west and flying around the west side of the cloud, but after we thought about it briefly, we realized that the billowing clouds were moving west faster than we could fly. To the east of the volcano, the ash cloud separated into billowing, mushroom-shaped clouds and a higher overhang of cirrus-type clouds. Ash fall from the mushroom-shaped clouds was heavy. Lightning bolts shooting through the clouds were tens of thousands of feet high. Soon, the ash cloud extended to elevations in excess of 50,000 feet.

We thought about flying back to Yakima and even turned to the east briefly, but again we decided against it, realizing we could never beat the ash cloud. Sometime between 9:00 and 9:15, we landed at a Portland airport.



## MOUNT ST. HELENS, MAY 18-19, 1980 —

## A SCENARIO

by

Michael A. Korosec

On Sunday morning, May 18, 1980, the climactic eruption of Mount St. Helens began. From U.S. Geological Survey news releases, media coverage, and eye-witness accounts, an attempt will be made to build a scenario of the events which took place in the vicinity of the volcano that day and the next. Relatively little information is available at this time, considering the magnitude of the explosive eruption and its devastation. As more facts and observations are collected and become available, it is likely that portions of this scenario will need to be changed.

At about 8:32 a.m. Sunday morning, a Richter magnitude 4.9 earthquake was recorded. Prior to the earthquake, the only visible activity on the mountain was very minor venting of steam from a fumarole at the bottom of the crater and from the small vent on the southeast rim of the crater. The earthquake triggered the collapse of ice blocks into the crater from glaciers on the south side. A few seconds later, a large portion of the north flank of the volcano began heaving and rippling, and slipped downslope towards the valley of the North Fork of the Toutle River along a fairly flat, steep detachment plane. Many steam vents opened at the top of this detachment plane almost immediately, and either dust or steam was pushed out in front of the slide. As the downward movement of the slide exposed a deep portion of the slide plane, perhaps 1,000 feet in elevation below the top of the detachment surface, a cloud of dark-colored ash arose nearly vertically at first, but quickly spread laterally to the north. As the landslide continued to move downslope, the ash cloud grew very quickly as it was blasted about 20° to 40° from vertical off toward the north. At the same time, a lateral blast was directed nearly due north through the upper portion of the slide block. Very shortly after, the summit crater erupted with a vertical blast of steam and ash. The vertical flank eruptive cloud was initially darker than the developing upper crater cloud, and the lateral blast which spread outward much more quickly than the others was the lightest in color.

The leading edge of the lateral blast raced ahead of the landslide, reaching the valley floor

and traveling up and over the north valley wall of the North Fork of the Toutle River. This portion of the eruption was a classic nuee Peleean d'explosion dirigee, or directed explosion cloud, similar to the event on Mount Pelee, May 8, 1902. As the cloud moved north from the volcano, it fanned out to the northeast and northwest.

As the summit eruption grew, portions of the south crater wall were progressively removed. A dense ash cloud rolled down the south flank of the volcano, but it is not clear from which eruptive center this ash cloud originated.

On the north side, the landslide had probably reached the valley bottom. While the slide moved most of the vertical distance as a nearly complete block, this mass probably began breaking up at about the time the lateral blast passed over it, and spread out throughout the valley. The continuation of the lateral blast probably hurled more material from the volcano's flanks, filling the valley below with a debris deposit from Spirit Lake to at least Castle Creek, measuring 4 miles north to south and 5 miles east to west. The super-heated ash-laden gas cloud (nuee ardente) from the lateral blast passed Coldwater Creek and continued to spread across several ridges to the Green River valley north and northwest. The nuee ardente was guided by topography beyond the Toutle Valley. The valley of the North Fork of the Toutle River was devastated 18 miles westward to about Deer Creek, just east of Camp Baker. The westward limit of destruction on the Green River was due northeast of Camp Baker, about 17 miles from the crater. To the north-northeast, the nuee reached Goat Mountain, Ryan Lake, and Strawberry Lookout, about 12 to 13 miles from the crater. In addition, the destructive wave extended down the Quartz Creek drainage an additional mile or two to the north from the Ryan Lake area.

Within the devastated area, several degrees of destruction had occurred. A large portion towards the proximal end was completely stripped of all vegetation and covered by ash and rock fragments to depths of several feet. Trees were uprooted and vehicles overturned. Beyond this, trees were snapped off at their bases and completely stripped

of their needles. Stumps were left standing but again were partially buried by heavy ash fall. In the fringe areas, pine needles were either stripped from standing trees or singed orange in a zone about 100 to 300 meters beyond the fallen trees. The ash cover ranged from several feet to several inches out from the crater. A rapid transition from 4 inches to less than an inch over a distance of about  $\frac{1}{4}$  mile occurred just beyond the zone of fallen trees on the far northwest corner of the devastated area.

Temperatures within the zone of devastation must have been quite high, estimated to have reached 500°C or more. Plastic on a blown-over truck camper 13 miles north-northeast of the volcano in the Ryan Lake area was melted. Similar occurrences have been reported for Spud Mountain and Elk Rock northwest of the volcano. Fishermen along the Green River in section 3, township 10 north, range 3 east, on the periphery of the affected area were burned badly, surviving only because they jumped into the river when it happened. The burns occurred as they came up for air and after they left the water. The heat evidently came upon them in a series of waves over a period of about 10 to 15 minutes.

After the lateral blast lost its hurricane force and high temperatures, the ash cloud slowed considerably, but continued to move to the northwest and northeast, reaching Silverlake about 1.5 hours after the eruption. The cloud moved along the surface topography at an altitude of less than 1,000 feet, traveling about 20 to 30 miles per hour. It was this cloud which deposited significant amounts of the ash in the Mossyrock and Riffe Lake area, and much of the Morton ash.

The nuee ardente or ash cloud which rolled down the south side of the volcano was much smaller than the north side activity, descending not far beyond the slope break. No obvious destruction resulted from this nuee, though it probably did deposit at least a thin layer of hot ash on the south flank.

At the crater, dark ash clouds were shooting upward very rapidly, reaching elevations of 50 to 60 thousand feet within several minutes of the initial eruption. Rock fragments and pumice were carried upward along with the ash, raining out in a large area to the north and east, extending at least to the Blue Lake and Horseshoe Lake area, 25 to 30 miles away. The ash, of course, was carried well beyond this point.

Pyroclastic flows periodically poured out of the crater and down the north flank into the

valley below. These flows probably occurred throughout the day, with a few reported to have occurred the next day. The early pyroclastic flows, along with the hot ash and debris began melting the snow and ice that remained on the flanks of the mountain and the broken glacial ice blocks within the valley. This water, along with ground water, possibly torrential rains from the eruption cloud, and water displaced from Spirit Lake, mixed with the ash and debris in the valley, creating small to very large mudflows which combined and began moving down the Toutle River valley very shortly after the eruption began. This process continued, to varying degrees, throughout the day. At some point, a large mudflow developed in the upper reaches of the South Fork of the Toutle River valley from the Toutle and Talus Glaciers. In addition, waters from the vicinity of and Shoestring Glaciers mixed with ash and debris, creating a mudflow which moved down the southeast flank and out the Pine Creek drainage, reaching the Swift Reservoir. Hot ash and pyroclastic flows, which poured down the northeast flank and across the Plains of Abraham, melted the ice fields between the Nelson Glacier and Dogs Head. This created a very large mudflow which moved down the western drainages of Smith Creek, continuing southeast along the main course of Smith Creek into the Muddy River and reaching the Swift Reservoir. These two east and southeast mudflows raised the level of Swift Reservoir by 2 feet.

During the course of the day, a large volume of material was removed from the south wall and the area between the central and lateral vents. At times, two distinct plumes could be seen rising from the crater, one directly over the central vent, the other centered nearly a mile due north, just south of the pre-eruption location of Goat Rocks. A large portion of this material may have been removed during the initial blast. There is no way of knowing how many individual pyroclastic flows and nuees ardentes descended the slopes of Mount St. Helens during the day and night. Some flows are reported to have traveled at speeds in excess of 70 miles per hour.

The vertical ash eruption had maintained levels of 50,000 to 60,000 feet for several hours after the initial eruption, but decreased by early afternoon to levels at times under 40,000 feet. By 4:30 p.m., the ash cloud had built back up to its highest level, about 63,000 feet, lasting for about an hour. This large vertical blast may have been accompanied by a lateral event on the north side, such as a large nuee ardente, because

another low altitude ground-hugging ash cloud passed just east of Silver Creek, at about 6:00 p.m., moving north at about 20 to 30 miles per hour. By evening, the height of the vertical eruption was only 15,000 feet, but occasionally reached 20,000 feet during short blasts. By Monday, eruptions consisted of ash erupting to only a couple thousand feet above the crater.

Seismic activity consisted of an almost continuous series of low to moderate strength events during the initial phase of the eruption. Harmonic tremors were recorded throughout the day, starting out at shallow depths of 2 to 3 km and getting progressively deeper to about 10 km by day's end. Just before noon, seismic activity increased. This seems to correspond with a color change for the ash, from dark to light. The activity climaxed between 3:00 and 5:00 p.m., roughly corresponding to the second large vertical ash eruptions. After this period, however, activity dropped off considerably.

By Monday, with the eruptive activity on Mount St. Helens beginning to slacken, the topographic changes to the area around the volcano could be assessed. The once symmetrical 9,671-foot peak had been transformed into a U-shaped basin nearly 2 miles long from north to south and about 1 mile wide east to west. The rim reached a reported maximum elevation of about 8,400 feet, but portions of the rim were several hundred feet lower. The north flank opening to the crater is at about the 4,400-foot elevation. The Sugar Bowl and Dogs Head domes were preserved on the northeast side. Most of the glaciers are gone, but a few remained, at least in part, under a cover of ash. They possibly include Swift, Dryer, Talus, Toutle, Ape, and Shoestring Glaciers.

Within the crater, steam issued from numerous vents and fumaroles, concentrated on the south side over the central vent, with a few in the area of the exposed core of the Goat Rocks dome in the northern part of the crater basin. The crater bottom is about 300 feet below the north rim, and several thousand feet below the south rim.

The Swift Reservoir south of the volcano

had its water level raised by about 2 feet, representing an influx of 13,000 acre-feet of debris from Pine Creek, Smith Creek, and Muddy River.

The North Fork Valley of the Toutle River had been filled to a relatively flat surface, about 200 feet above the old valley floor. The material was a combination of ash flow, landslide material, large blocks explosively ejected from the volcano, and pyroclastic material. This valley filling extended down the valley to about Camp Baker and up some of the drainages such as Coldwater Canyon. Spirit Lake, which had been 185 feet deep, had its shoreline and drainage outlet raised by about 200 feet, and its shoreline extended about  $\frac{3}{4}$  of a mile to the south. The depth had been reduced to about 80 to 100 feet, requiring a filling of 250 to 300 feet of debris.

Secondary activity within the valley resulting from cool waters contacting hot pyroclastic debris produced numerous steam eruptions and continuous fumarolic activity. A few large steam vents and many hundred fumaroles were still active 2 weeks after the eruption, and may continue to be active for years and possibly decades. Other features occurring in the debris-filled valley include kettle holes, where small to very large blocks of ice melted out, leaving depressions measuring up to 50 feet in diameter; explosion craters, where buried ice and water were converted to steam in contact with hot pyroclastic debris and exploded upward through the sediment cover; "badland" and "scabland" topography, where water had eroded channels, sometimes 20 to 30 feet deep, and interconnected by a maze of smaller channels; small ripple and dune features, where water and(or) wind had piled or scoured ash; and large blocks of hydrothermally altered rock from the volcano's flanks, some over 50 feet high, looking like islands in a sea of mud and ash.

The May 18, 1980, eruption of Mount St. Helens was only one day in the history of a mountain that is thousands of years old, but that one day has left an important impact on the volcano and its surrounding area, and a lasting impression on all those who were a part of it.



## MOUNT ST. HELENS — WHAT CAN BE EXPECTED?

by

Michael A. Korosec

In the wake of the major eruption of Mount St. Helens on May 18, 1980, many "volcanologists" are predicting what can be expected of the volcano in the near future. Such statements as "the worst is over," and "activity can be expected to decrease now" have been heard, but what, if anything, can accurately be said about the volcano's future? An examination of historic eruptions of volcanoes similar to Mount St. Helens may provide some idea of volcanic activity to come.

The present volcanic activity of Mount St. Helens is a Peleean eruption, characterized by extreme explosive phases, and represented by several volcanoes in Central America and the West Indies.

The Mount Pelee eruption of 1902, in which the city of St. Pierre was destroyed and 30,000 lives were lost, is the most famous of these explosive events. The volcano is located on the Island of Martinique, of the Lesser Antilles in the Caribbean Sea. Prior to 1902, two minor eruptions were historically recorded, consisting of the venting of columns of ash which drifted only a few miles from the mountain.

On April 2, 1902, steam fumaroles were observed in the upper reaches of a river valley on the flanks of Mount Pelee. A slight ash fall and a strong odor of sulfur accompanied minor earthquakes detected on April 23 in the city of St. Pierre. On April 25, explosions occurred in the basin atop the mountain, sending ash clouds and rocks flying. A small cinder cone formed and continued to send ash into the air, dusting the city below for over a week. On May 5, a boiling mudflow destroyed a sugar mill, and activity began to intensify the following day. Violent explosions threw out dense clouds of ash on the 6th and 7th of May. On the 8th, activity slowed, with only a column of steam rising from the crater. Suddenly, with four consecutive explosions, a blast of super-heated steam and hot dust particles descended the slopes as an avalanche, destroying the town in a matter of seconds. This event, called a *nuee Peleean d'explosion dirigee*, or directed explosion cloud, is thought to have reached temperatures of 1200°C at its source and 600°C to 800°C miles down the valleys. Nondirected explosions later created hot steam and ash avalanches, termed *nuees ardentes*,

or glowing clouds. The incandescence is due to super-heated gas particles within the cloud. During both these types of eruptions, all of the magma is expelled as pumice and ash, with no liquid lava flows developing. When the ash is expelled vertically, with no *nuee* formation, it is termed Vulcanian activity.

Mount Pelee continued intermittent explosive eruptions with *nuees ardentes* and Vulcanian activity for several months following the May 8 disaster, including events on May 20 and 26, June 6, July 9, August 30, and December 16.

During mid-October of that year, several months after the initial eruptions, the gas-free portion of the magma began accumulating in the crater, forming a lava dome or tholoid. Early dome formation may be disrupted and rebuilt by succeeding eruptions, but these post-dome phase eruptions are usually fewer and of smaller magnitude. This dome formation is therefore often considered to signify the temporary end of that historic eruptive phase, but the Pelee dome continued to grow until October 1905.

Mount Pelee began erupting again in 1929. Activity was similar to the previous eruptions of 1902, complete with *nuees ardentes*, and continued for 3 years, ending with the formation of a summit dome.

The volcano La Soufriere on neighboring St. Vincent Island, about 90 miles south of Martinique, experienced a violent eruption less than 24 hours before Mount Pelee. During April 1902, minor earthquakes shook the island. Inhabitants on the leeward side of the island left the area, fearing the worst. On May 5, steam was emitted from the crater lake at the summit, with increased intensity over the next day. By May 7, the steam emissions were continuous, reaching heights of 30,000 feet. Later that day, a *nuee ardente* roared down the side of the volcano, accompanied by the release of great amounts of ash. The ash eruption was continuous until the 9th of May. Similar eruptions occurred on May 18 and September 1 and 3, which are reported to have been just as devastating. Between eruptions, the only visible sign of activity was the steam column which rose from the boiling water of the crater lake.

In 1951, Mount Lamington, a volcano on Papua, New Guinea, erupted violently, with only

a short period of preceeding activity. Landslides and earthquakes began on January 15, 1951, accompanied by a thin column of vapor rising from the summit crater. Emissions increased by January 18, with ash-laden volcanic gases reaching heights of several thousand feet. On January 20, an ash eruption reached a height of 25,000 feet or more. A day later, the initial catastrophic explosion produced a mushroom-shaped cloud, which rose to 50,000 feet. The explosion was preceded by a continuous roar, heard over 200 miles away. The nuee ardente spread out in all directions from the mountain, destroying over 90 square miles and taking nearly 3,000 lives. The volcano was quiet for 3 days following the eruptions, but commenced activity again on January 25. Explosive outbursts continued sporadically, including events on February 6, 18, 22, and 24, and March 5, with several milder events until June of that year. The high explosive phase lasted 2 months, with a 2-week cycle of activity. Mount Lamington's dome phase began a few days after the first climactic eruption. Between February 3 and 9, the dome rose at a rate of over 100 feet a day. The eruption on March 5 destroyed most of this dome, but growth continued, building the dome for nearly a year after that.

Mount Katmai on the Alaska Peninsula violently erupted in 1912. On June 4 and 5 of that year, earthquake activity shook the area. A large explosion occurred on June 6 along with two other explosions; ash and fragmented material were discharged, and pyroclastic flows of pumice and ash were discharged from fissures, forming ignimbrites. The explosive activity ended on June 8, and minor eruptions continued for only a few months beyond the initial events.

One of the greatest historic Peleean eruptions was that of Bezymianny in Kamchatka, U.S.S.R. On September 29, 1955, earthquake activity began and continued at an increasing rate through October 22. On that day a moderate eruption of ash clouds filled the skies around the volcano. Moderate ash eruptions continued through the last week in March, 1956. On March 30, a catastrophic explosion destroyed the top 500 feet of the cone and a significant portion of its southeast flank. The initial eruption was a laterally directed blast, about 30° from the horizon toward the east, which quickly convected upward to elevations in excess of 25 miles into the atmosphere. The lateral blast destroyed vegetation to a distance of 15 miles and singed trees 18 miles beyond the crater. Hot ash melted the heavy snow cover,

creating torrential mudflows. Nuees ardentes and ash flows raced down the flanks and continued 10 miles down the valley. Soon after the climactic eruption, a dome began building in the new crater. As it grew to a height of over 1,000 feet during the following 4 months, small portions of the dome were blown off by small to moderate explosions, creating nuees ardentes. After a quiet period of about a month, a second dome began building in October and reached a height of about 850 feet by December, marking the end of the eruptive period. One of the most remarkable statistics for this incredibly destructive eruption is that not a single life was lost.

The period of eruptions for other Peleean volcanoes include 3½ years for Hibokhibok on Camiguin Island, Philippines (September 1, 1948 to June, 1952), and about 1 year for the Mayon Volcano in the Philippines (April 21, 1968 to mid-1969).

The Mayon volcanic eruption should be further mentioned, since it is one of the few historic volcanic events in which the Peleean eruption was accompanied by a viscous lava flow. Mount Mayon, like pre-eruption Mount St. Helens, is a very symmetrical composite cone, despite the fact that the upper portion has been destroyed several times by explosive eruptions. The central vent has remained in a relatively fixed position over time, and explosively destroyed portions of the peak are rebuilt by later ash fall, ash flows, pyroclastic flows, and lava eruptions.

The 1914 eruption of Lassen Peak Volcano is not usually categorized as a Peleean eruption, but rather as a Vulcanian type. Eruptions were explosive and nuees ardentes devastated broad areas, but the bulk of the activity was the venting of large volumes of ash to great heights with no dome formation. About a year of high frequency moderate eruptive events led up to a two-phase climactic eruption in May 1915. On May 19, very large eruptions of ash were accompanied by the oozing of very thick lava of dacitic composition from the summit crater, traveling only 1,000 feet down the flanks of the volcano. On May 22, the largest vertical blast sent large volumes of ash and steam into the atmosphere and a nuee ardente down the northeast flank, which created mudflows beyond. Moderate ash eruptions continued for about 6 months, with periodic minor events ending by mid-1917.

In light of these observations of historic eruptions, a definitive prediction of what Mount St. Helens will do next is impossible, but a general scenario of possibilities can be presented. Activity

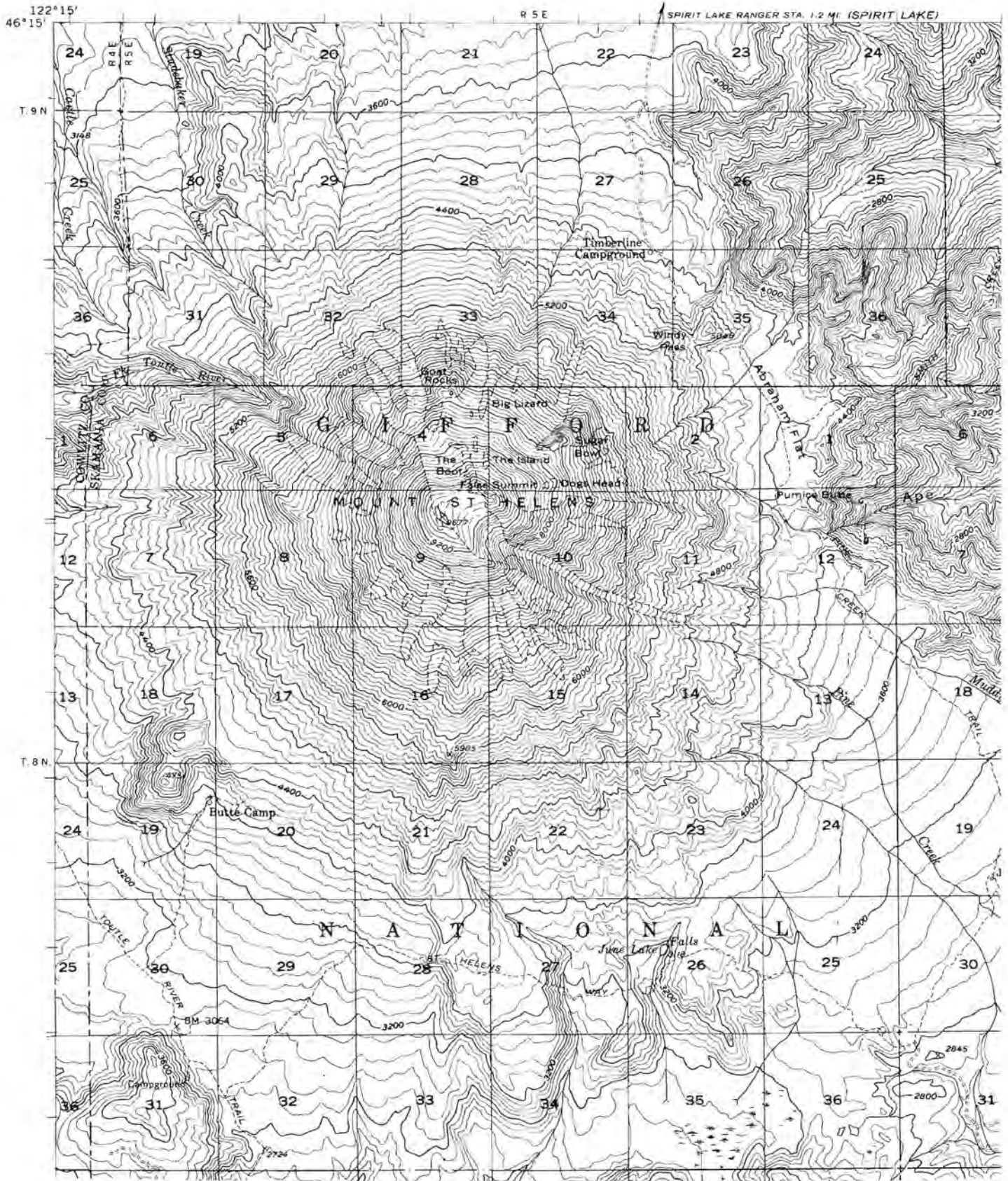


as a whole can be expected to continue over a period of a few weeks to a few years. During this time, an occasional explosive eruption may occur, along with ash flows and nuees ardentes. Periods of quiescence between eruptions will be characterized by small to moderate steam and ash eruptions or minor venting of steam. Dome building should begin a very short time after the explosive eruptions and continue for weeks or months as degassed viscous magma is pushed out of the vent. The dome may end the eruptive phase of the volcano, or may be destroyed by further explosive eruptions, which would create further nuees ardentes and pyroclastic flows into the valley below. Lava flows are unlikely to occur. Pyroclastic flows are much more likely and can be expected to occur anytime during the active period, especially in association with explosive events. The Vulcanian activity (venting of large volumes of ash high into the atmosphere) is usually restricted to the early pre-dome stage of eruption, but may occur long after the dome begins to build as part of a large explosive eruption.

The Peleean-type of eruption seems to be associated with the final phases of activity of a volcano. This final phase is measured on a scale of hundreds or thousands of years, so this eruption is probably not the last word from Mount St. Helens.

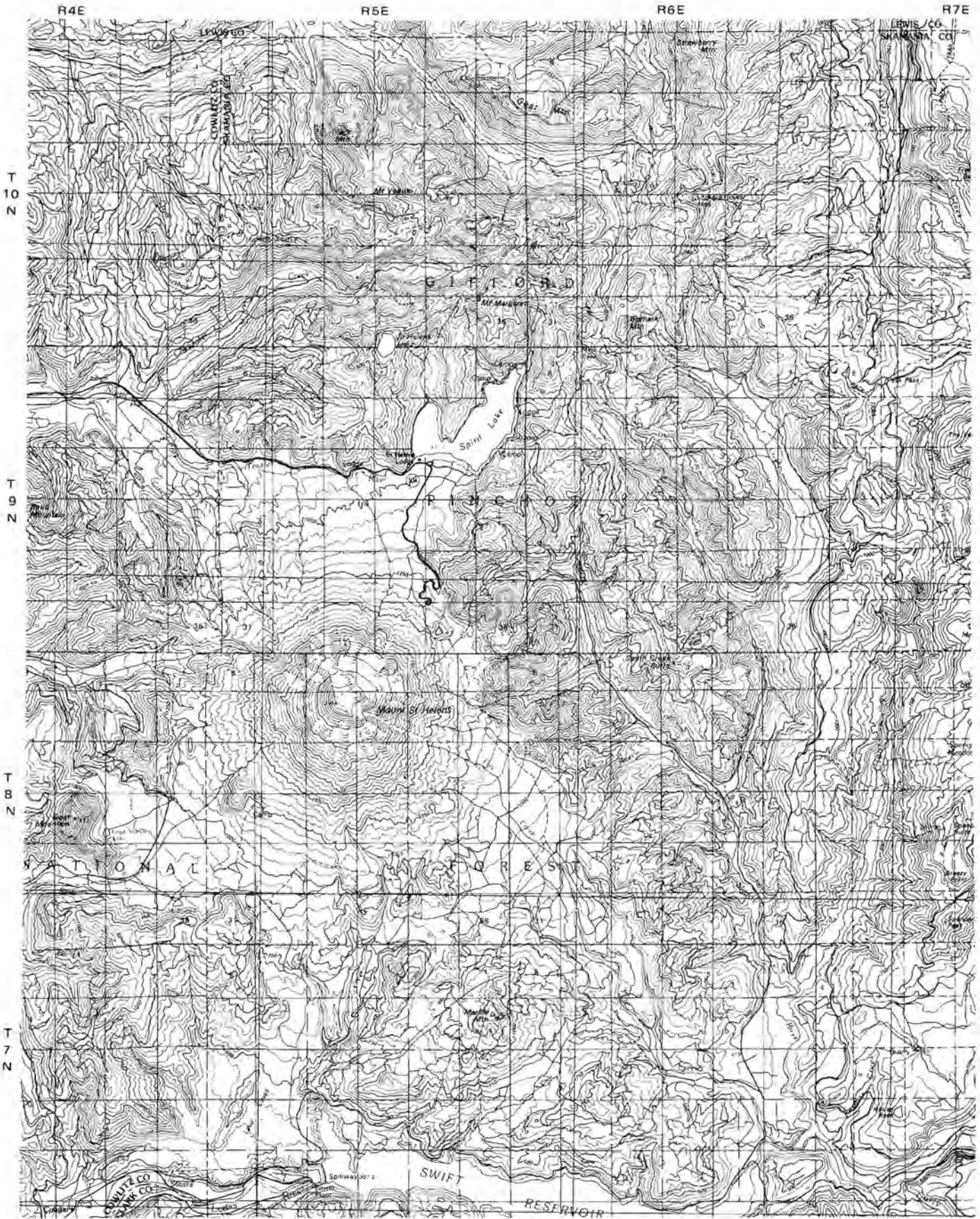
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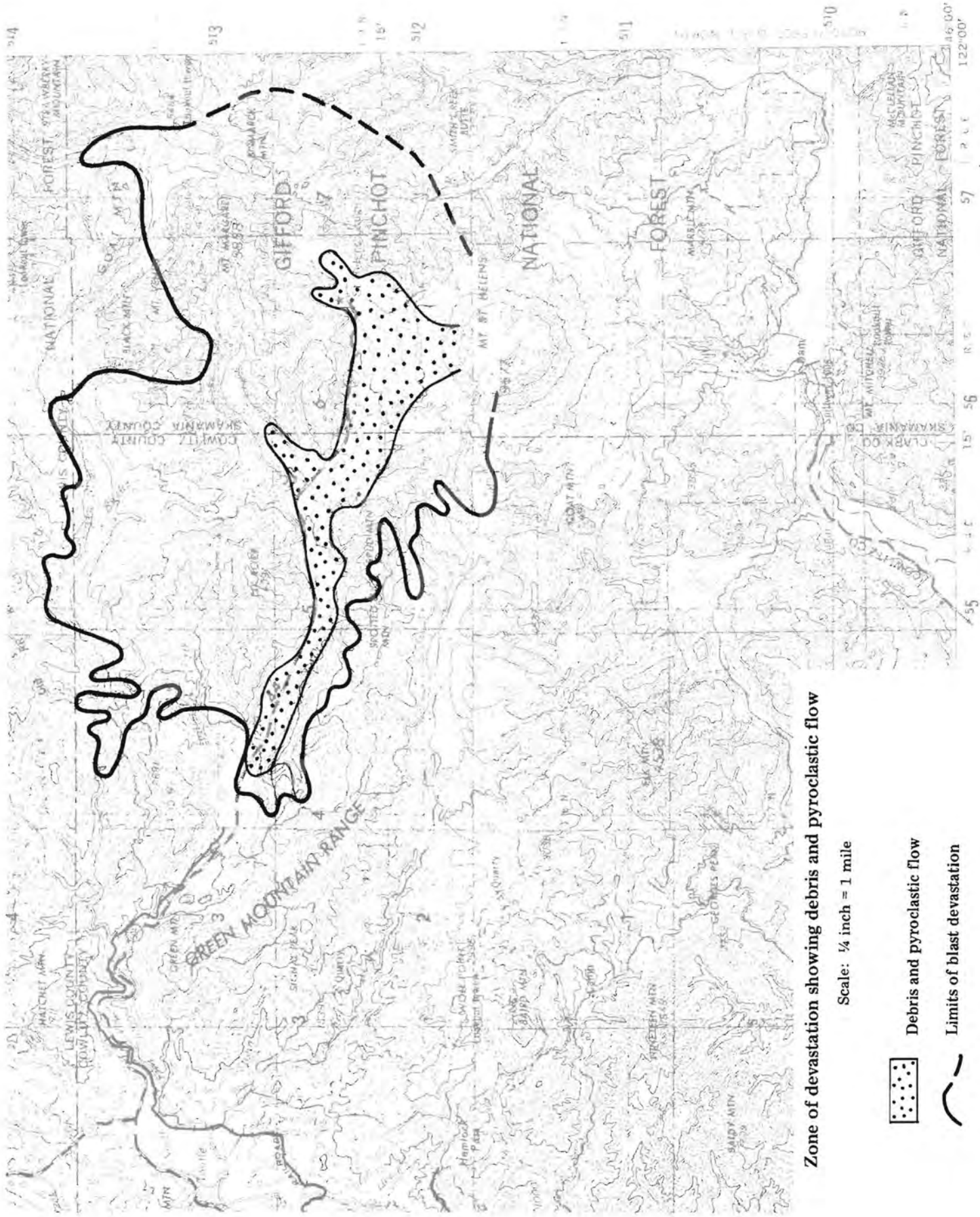
U.S. Geological Survey Mount St. Helens topographic quadrangle map







Scale: 3/8 inch = 1 mile

U.S. Forest Service location map



Zone of devastation showing debris and pyroclastic flow

Scale: 1/4 inch = 1 mile

-  Debris and pyroclastic flow
-  Limits of blast devastation

PRELIMINARY ASH THICKNESS DISTRIBUTION  
MAP OF THE MAY 18, 1980 ERUPTION OF  
MOUNT ST. HELENS

by

James G. Rigby

The following preliminary map shows the distribution of ash erupted from Mount St. Helens on May 18, 1980. It was compiled from approximately 40 data points only. As more data are gathered and made available, it will be possible to make refinements to the map. Thickness measurements, upon which the map was based, were supplied by various individuals, county agencies, local police departments, universities, and by the National Weather Bureau Service; their kind cooperation is heartily acknowledged.

In addition, this map was based primarily on ash thickness measurements taken within 72

hours of its accumulation. It has been noted that after setting on the ground for only a few days, the tephra settles and compacts up to approximately one-half of its original thickness. In addition, it is very susceptible to redistribution by subsequent local winds and rain. For these reasons, it is necessary to differentiate between thickness measurements conducted during, or soon after, fall-out of the ash, versus measurements taken at later dates. Individuals conducting measurements should keep this in mind, always noting the time and date of their thickness measurements.



