

STOP 1: 0.50 miles (8.26 miles): Johnston Ridge. At the bench look west at the cliff face directly below the JRO. The cliff exposes Tertiary age basalt and andesite lava flows, which are also exposed in the foreground. These are part of a complex sequence of volcanic, intrusive, and sedimentary rocks that range in age from about 36 to 20 million years old. They are widely exposed throughout this region of the Cascades Mountains where they form the 'basement' on top of which modern volcanoes such as Mount St. Helens are constructed. In this locality the Tertiary rocks are faulted, tilted toward the east, altered, eroded, and mantled by May 18, 1980, deposits. This indicates a long (millions of years) and complex history of volcanism, mountain-building, and erosion in the region. Looking south-southwest to the plain below Johnston Ridge, note the transition from the smooth, gullied surface of the plain directly south to the hummocky terrain (small hills) to the west. Areas of hummocky terrain are a mixture of the lateral blast and debris avalanche deposits emplaced between 8:32 and 8:42 A.M. on May 18, 1980, while smooth areas are pyroclastic flow deposits emplaced later on May 18 and episodically through October, 1980. Due to the soft nature of these deposits, they are now extensively gullied by erosion from seasonal run-off and more episodic flood and debris flow events.

Trail Guide
Start (8.76 miles): The trailhead is at the southeast corner of the JRO parking lot. At 0.12 miles the paved path turns into an unpaved hiking trail.

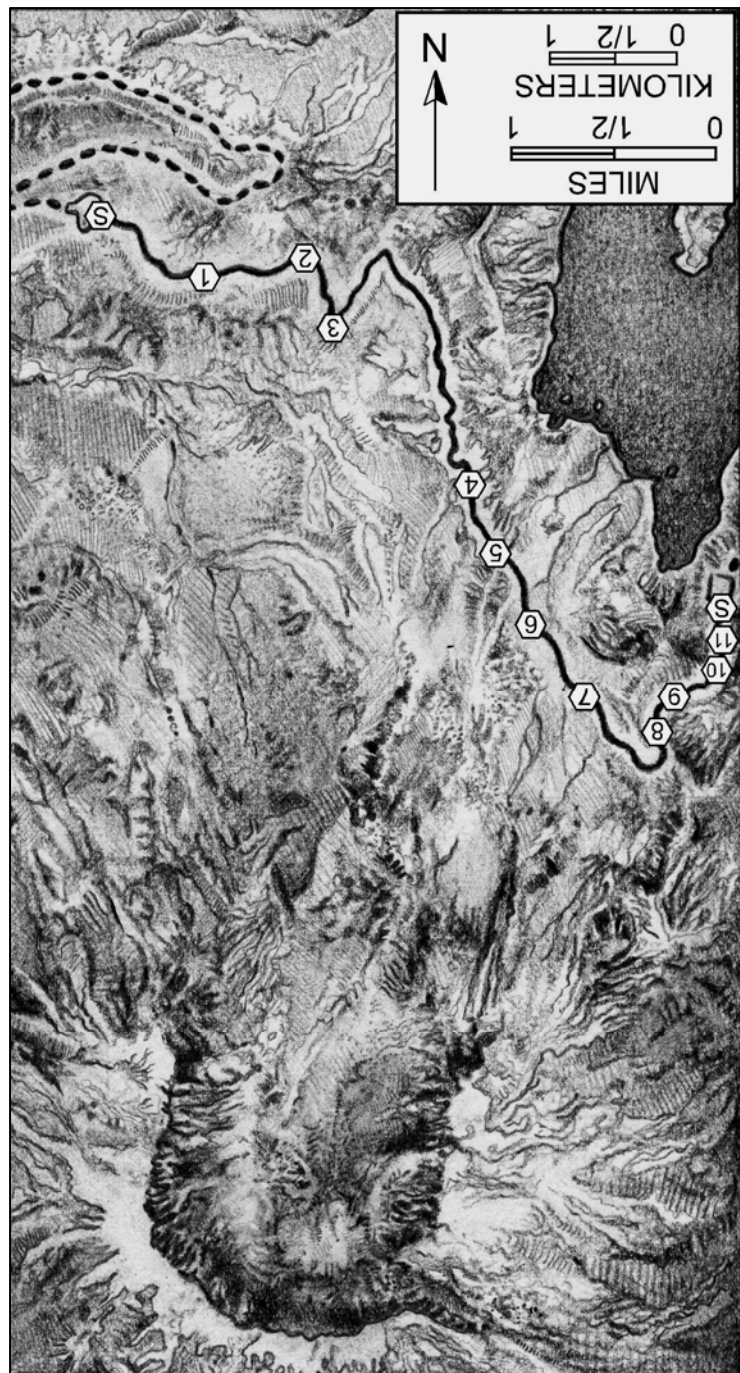
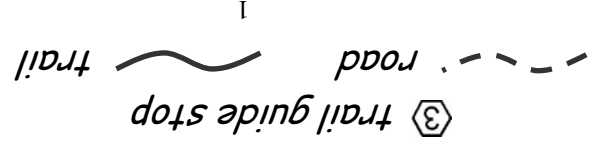
Because of National Monument regulations, no rock or plant collecting is allowed at any place along the trail. Also, plan your trip with care. Due to altitude, weather conditions, and lack of water along the trail, hikers should consider their physical condition. At the very least, bring water, snacks, sun screen, sunglasses, a hat, and a rain jacket. There are no restrooms past the starting points. Hikers must use designated trails and follow Monument regulations. Off trail hiking is strictly prohibited.

Introduction
 This guide describes the spectacular volcanic geology on the north side of Mount St. Helens while hiking the 8.76 mile trail (one-way) from the Johnston Ridge Observatory (JRO) to Windy Ridge. Most geologic features visible from the trail were created during the 1980 eruptive activity, although many features that are younger and much older are also visible. Mileage for the guide begins at the JRO, with reverse mileage in parentheses for hikers departing from Windy Ridge. Distances were determined with a hand-held GPS device, which hikers should consider carrying, if available.

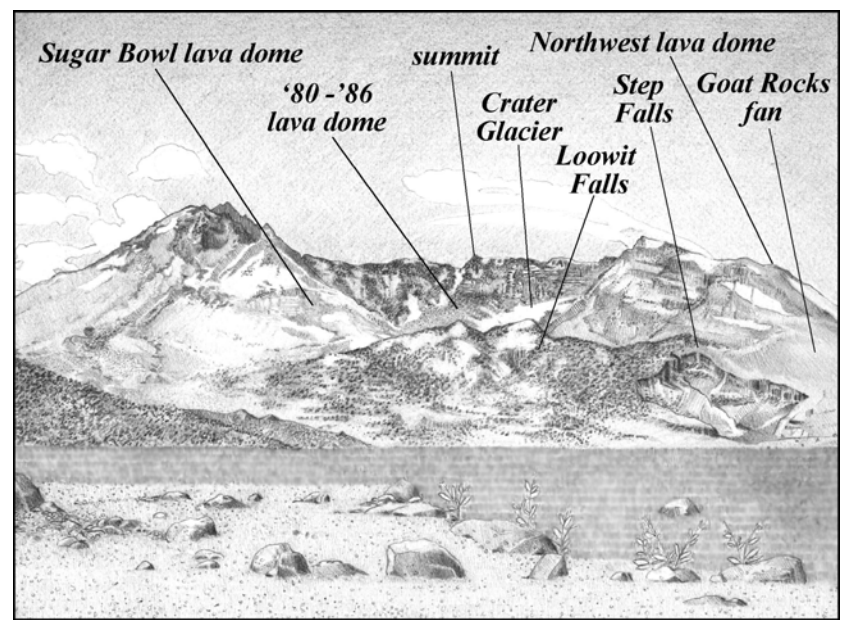
Due to space limitations, this guide does not describe in detail all geologic features visible from the trail, nor does it describe specific volcanic processes. Thus, some background knowledge on the 1980-86 eruptive activity is advised. Good sources of information may be found at the JRO exhibits. The following book, published by the Northwest Interpretive Association and sold at the JRO is also useful: *Roadside Geology of Mt. St. Helens National Volcanic Monument, by Patrick Pringle, Washington Department of Natural Resources, Information Circular 88.*

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JOHNSTON RIDGE TO WINDY RIDGE: A SELF-LED GEOLOGIC TRAIL GUIDE



A View from the Pumice Plain

lateral blast deposit. This is all that remains in this area of what was once a temperate rain forest. Underlying the lateral blast deposit are pumice layers from ancient eruptions of Mount St. Helens. Overlying the deposit is a pumice layer that rained out of the vertical eruption column that formed following the lateral blast on May 18, 1980. On a clear day, Mt. Adams is visible to the east.

STOP 9: 7.32 miles (1.44 miles): The trail turns abruptly east. This point is the approximate northeast boundary of the 'tree removal zone,' an area in which virtually everything, natural or artificial, was obliterated or carried away by the May 18, 1980, lateral blast. Beyond this point is the 'tree down zone.' The tree down zone extends out to distances as far as 15 miles from the volcano. It is an area in which the lateral blast flattened nearly everything in its path and was channeled to some extent by topography. Along the trail the force and direction of the lateral blast are strikingly demonstrated by the parallel alignment of toppled large trees, broken off near the base of the trunk. Along this section of the trail layers of pumice that rained out of ancient Mount St. Helens eruption clouds can be seen mantling the Tertiary rocks. The most distinctive is a yellowish-colored pumice layer known as the 'Yn tephra.' This pumice layer was deposited about 3,500 years ago.

STOP 10: 7.95 miles (0.81 miles): East Flank of Mount St. Helens. On a clear day this point offers excellent views of the northeast and east flanks of Mount St. Helens. High on the mountain from west to east are the east wall of the crater, the Sugar Bowl lava dome, the Forsyth Glacier (mostly covered by rock debris), the Nelson Glacier, and the Ape Glacier. The small bulge protruding just above the east slope is the top of a lava dome known as the 'East Dome,' which erupted during the Sugar Bowl Eruptive Period about 1,200 years ago. The saddle in front of East Dome and extending further east is the 'Plains of Abraham.' This saddle is covered by small mudflow deposits that formed on the morning of May 18, 1980 and which subsequently flowed down Ape Canyon (out of view) and into the Smith Creek/Muddy River drainage system to the east and southeast.

STOP 11: 8.59 miles (0.17 miles): The hillside on the north side of the trail is covered with fallen trees aligned like compass needles, showing a preferred orientation to the northeast, indicating the direction the May 18, 1980, lateral blast was moving at this location. To the east the broad U-shaped profile of Smith Creek Valley was created by glaciers that incised the valley 22,000 to 11,000 years ago. The hills on the skyline far to the southeast are vents of the Indian Heaven volcanic field, which is a broad shield-like volcano. This volcanic field is probably less than 700,000 years old.

8.76 miles: Trail ends at the southeast corner of the Windy Ridge parking lot.

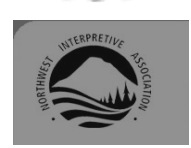
For more information:
 Visit the Monument website at: <http://www.fs.fed.us/gpnf/mshnm/>
 Visit the USGS website at: <http://volcan.wr.usgs.gov/>
 Visit the MSU Earth Sciences website: <http://www.montana.edu/wwwes/>



U.S. Department of Agriculture
 Forest Service, Gifford Pinchot National Forest



The National Science Foundation



The Northwest Interpretive Association



STOP 2 : 1.50 miles (7.26 miles). Directly east-southeast is 'Devil's Elbow', a north trending segment of Johnston Ridge formed by ~25° east dipping Tertiary rocks. A contact between May 18, 1980, debris avalanche rocks and underlying Tertiary rocks is exposed near the crestline of the ridge. This contact is marked by a change in color from tan, fairly well-layered Tertiary rocks to chocolate-brown colored, poorly consolidated debris avalanche rocks (this is most easily seen in the late afternoon). The Tertiary rocks on Devil's Elbow are well exposed because the cliff face was scoured bare by abrasion from the rapidly passing lateral blast. To the far north the prominent peak is Coldwater Peak, also composed of Tertiary rocks. Note the fallen trees on the hillside, which were blown down and aligned in the direction of the May 18, 1980, lateral blast. The trees on the lee side of the peaks facing away from the blast remain standing, however. Directly below the trail to the north is the drainage area for South Coldwater Creek, where portions of the debris avalanche flowed over Johnston Ridge and slid into the South Coldwater Valley (see next stop). In 0.1 miles the trail crosses a fault and turns south.

STOP 3 : 1.94 miles (6.82 miles). The trail is at a hairpin turn on the southern tip of Devil's Elbow. Beyond this point the trail passes over the May 18, 1980, debris avalanche deposit. On a clear day, Mt. Adams, another potentially active Cascade volcano, is visible far to the east. In the mid-foreground are two north-trending, east-tilted ridges of Tertiary rocks similar to Devil's Elbow: Harry's Ridge in the foreground and Windy Ridge further east. Between Windy Ridge and Harry's Ridge is the southern shore of Spirit Lake. The embayment between Devil's Elbow and Harry's Ridge is known as the 'Spillover'. In this area the debris avalanche overtopped Johnston Ridge, traveling into the South Coldwater Creek Valley. Portions of the debris avalanche were also deposited in the Spillover forming the distinctive hummocky topography. The debris avalanche deposit in this area is covered with fine-grained, white ash that rained out of tall ash-clouds produced by air rushing over the tops of rapidly moving pyroclastic flows on the afternoon of May 18, 1980.

The smooth and, in places, gullied region directly to the south of the Spillover is the 'Pumice Plain'. The Pumice Plain is a gently north sloping, light-tan surface consisting of overlapping sheets of pyroclastic flow deposits erupted from Mount St. Helens. It formed when the pre-eruption channel of the North Fork of the Toutle River was buried by the debris avalanche and then by pyroclastic flows deposited between May and October, 1980, with the largest occurring on May 18. Beginning at about 9:00 A.M. and increasing in intensity until about 6:00 P.M., pyroclastic flows swept down the north face of Mount St. Helens and filled low spots between freshly deposited hummocks of the debris avalanche deposit to depths greater than 100 feet. The pyroclastic flows, which are composed of pumice and ash, developed when the vertical eruption column above the volcano partially collapsed, forming fast-moving, hot avalanches driven by volcanic gases and gravity. The trail described in this guide traverses pyroclastic flows emplaced between 3:00 and 4:25 P.M. on May 18, 1980.

On a clear day this vantage point offers excellent views of several features on the north flank of Mount St. Helens (see front illustration). The prominent shoulder on the upper northwest flank is the Northwest lava dome erupted during the 'Castle Creek Eruptive Period' of Mount St. Helens about 2,200 to 1,700 years ago. At a slightly lower elevation on the northeast flank is the Sugar Bowl lava dome, which was emplaced during the 'Sugar Bowl Eruptive Period' about 1,200 years ago. The beautiful waterfall cascading off the crater ledge is Step Falls. The brink of Step Falls is supported by erosionally resistant basalt lava flows erupted during the Castle Creek Eruptive Period. West of Step Falls is the smooth slope of the 'Goat Rocks fan'. The fan is an apron of pyroclastic rocks shed from the Goat Rocks lava dome, which was emplaced on the northwest flank of Mount St. Helens during the 'Goat Rocks Eruptive Period' about 150 years ago. The Goat Rocks dome was destroyed by the May 18, 1980, eruption, although the pyroclastic fan is preserved. East of Step Falls is Loowit Creek. On the upper slopes of the volcano between Step and Loowit Creeks is a region known as the 'Sasquatch Steps'. In this area the 1980 eruptions produced new volcanic deposits and exposed pre-1980 deposits. The older deposits were exposed by excavation of the crater by the 1980 landslides and lateral blast as well as by subsequent erosion by northerly flow of Step and Loowit Creeks out of the horseshoe-shaped crater. The Pumice Plain defines the northern and lowermost boundary of the Steps. Above the Sasquatch Steps is the modern crater formed by the climatic eruption on the morning of May 18, 1980. This crater is now partially filled by two dacite lava domes. The older dome grew episodically from 1980 to 1986. The younger dome began erupting in October, 2004. This dome is visible behind the 1980-86 dome. Dust rising from the crater is primarily due to avalanching of over steepened crater walls. Through time, this process has enlarged the diameter of the crater and reduced the slope of the crater walls. Surrounding both domes on their western and eastern sides is the Crater Glacier, which has formed only during the last two decades.

2.42 miles (6.34 miles): Junction with Trail 207 (Truman Trail). Turn south and head down slope through the debris avalanche deposit in the Spillover. While hiking through this region note the fine-grained, thinly layered white ash-cloud deposits mantling the hummocky, brown colored debris avalanche deposit.

STOP 4 : 4.32 miles (4.44 miles): Loowit Creek. About 0.2 miles prior to this stop the trail descended off the ash-covered debris avalanche deposit of the Spillover and onto the Pumice Plain, described at Stop 3. At this stop, the Pumice Plain is dissected by the modern fluvial plain of Loowit Creek. Stream cut exposures southwest and east of the trail show excellent cross sections of soft, easily erodable, light-colored pyroclastic flow deposits emplaced during the afternoon on May 18, 1980.

To the northeast is a fine view of Spirit Lake. At the beginning of the May 18, 1980, eruption, part of the debris avalanche slammed into Spirit Lake, raising its level about 200 feet and damming its natural outlet to a higher level. Water displaced by the avalanche formed a giant wave that surged 600 feet up the surrounding hillslopes, washing timber blow-down moments earlier by the lateral blast into the lake. This created an extensive mat of logs, many of which are still floating on the lake surface today. On a clear day, the trimline on hillsides surrounding Spirit Lake, below which the wave or debris avalanche carried the downed trees off the slopes into the lake, can be seen. Above the trimline trees are still present although they have been toppled by the force of the lateral blast. Directly north-northwest is an excellent view of Harry's Ridge, the Spillover, and Devil's Elbow. Looking northeast to Windy Ridge on the east shore of Spirit Lake, one can see two small U-shaped valleys carved into Tertiary basement rocks. The smaller southern valley is Cedar Creek Pass and the northern is Independence Pass. The U-shaped profiles of the valleys are evidence of incision by the erosive activity of glaciers, which were widely present in this region between 22,000 to 11,000 years ago. Directly south is perhaps the most spectacular view into Mount St. Helens's crater.

4.39 miles (4.37 miles): The trail leaves the fluvial plain of Loowit Creek and ascends back onto pyroclastic flows deposited during the afternoon on May 18, 1980.

STOP 5 : 4.82 miles (3.94 miles). About 0.07 miles back, the trail descended into a small valley cut into May 18, 1980, pyroclastic flow deposits and filled with a mudflow deposit probably produced on March 19, 1982. At this stop note the varying colors and sizes of rocks in the mudflow deposit. This is because mudflows often transport rocks from many eruptive episodes, while the more uniform color pyroclastic flow deposits typically represent a single eruptive event involving new magma. Look northwest and note several large boulders transported by the mudflows and left stranded on top of the pyroclastic flows. The small hill directly south of the trail is a hummock of the debris avalanche deposit.

5.00 miles (3.76 miles): The trail descends into another small valley filled with stream and mudflow deposits. The light colored cliffs across the creek are pyroclastic flow deposits emplaced between 3:00 and 4:25 P.M. on May 18, 1980.

5.09 miles (3.67 miles): The trail climbs back onto May 18, 1980, pyroclastic flow deposits.

STOP 6 : 5.32 miles (3.44 miles): Junction with Trail 207A. To the south is Loowit Falls, which drops about 250 feet from its brink. The brink of Loowit Falls, like Step Falls to the west, is supported by erosionally resistant Castle Creek Period basalt lava flows. From this vantage point the stratigraphy in the western wall of Step Canyon is well exposed (especially in the early morning). The lower white outcrops are part of a dacite lava dome erupted during the 'Pine Creek Eruptive Period' about 2,500 to 3,000 years ago. Overlying this dome are Castle Creek Period basalt lava flows. In turn, the basalt lava flows are overlain by pyroclastic rocks of the Goat Rocks fan, described at STOP 3. To the southeast, the hummocky brown hills are composed of Castle Creek Period basalt lava flows, some covered by May 18, 1980, lateral blast and debris avalanche deposits. To the north is an excellent view of Bear Cove at the northern shore of the western arm of Spirit Lake. Similar to the Spillover, Bear Cove is filled with May 18 debris avalanche deposit.

5.42 miles (3.34 miles): The trail crosses a densely vegetated creek bed filled with mudflow deposits. About 400 feet from this point the trail crosses Willow Spring and descends off the Pumice Plain and onto mixed May 18, 1980, lateral blast and debris avalanche deposits.

5.52 miles (3.24 miles): The trail begins ascending a gently north dipping slope of Castle Creek Period basalt lava flows.

Along the trail the lava flows are covered by May 18, 1980, lateral blast deposit, although they are well exposed in outcrops along the south side of the trail.

STOP 7 : 5.84 miles (2.92 miles): Castle Creek basalt lava flows. Outcrops on the south side of the trail show good exposures of basalt lava flows erupted from Mount St. Helens during the Castle Creek Eruptive Period about 1,700 years ago. At this stop, a channelized lava flow is exposed, with levees on either side of a deeper flow channel in the central portion of the outcrop. To the east, note the complex stratigraphy in the package of east-tilted Tertiary rocks on Windy Ridge, which are mantled by light-colored pumice layers that rained out of ancient and historic eruption clouds from Mount St. Helens.

6.07 miles (2.69 miles): South of the trail Castle Creek Period basalt lava flows are covered by May 18, 1980 lateral blast deposit. To the north the lateral blast deposit is also exposed, although it is incised by gullies from recent stream erosion.

6.73 miles (2.03 miles): Junction with Trail 216E. The trail turns north and ascends Windy Ridge, a north-trending, east-tilted ridge of Tertiary basement rocks mantled by pumice from ancient Mount St. Helens eruptions and May 18, 1980, lateral blast deposit and air fallout pumice.

STOP 8 : 7.07 miles (1.69 miles): Lateral blast deposit. The thin, gray clast-rich layer at the ridge crest on the west side of the trail is the lateral blast deposit produced on the morning of May 18, 1980. The large, dense rocks in the deposit are chunks of the magma body (the 'cryptodome') that rose to shallow levels in Mount St. Helens and created the 'bulge' on the north side of the volcano in the weeks leading up to the climatic eruption. Note the thin organic-rich layer at the base of the

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