



## Excursion guide 11: Mount St Helens

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*The 1980 eruption of the Mount St Helens volcano produced a huge crater, massive debris flows and truly remarkable blast effects. All the features are still very visible, and the site offers easy access for an unforgettable visit.*

Every geologist knows about Mount St Helens and its explosive eruption in 1980. Many may have planned a future visit to the slumbering volcano, without appreciating the importance of timing. The new road to Johnstone Ridge, opened this year, provides the first easy access to the west side of the mountain since before 1980. In another five or ten years, the growth of new forest will have dulled the visual impact of the enormous destruction in the blast zone. Now is the time to go – and St Helens is one of the world's truly awe-inspiring geological sites.

There are now three itinerary options for the visitor to St Helens, and each has its own merits (Fig. 1). The new road into the west side is the most convenient route for a quick visit. The back roads on the east side take more time but offer closer contact. The south side is away from the blast zone, but is the route in for the walk to the top. Time and energy dictate the choice.

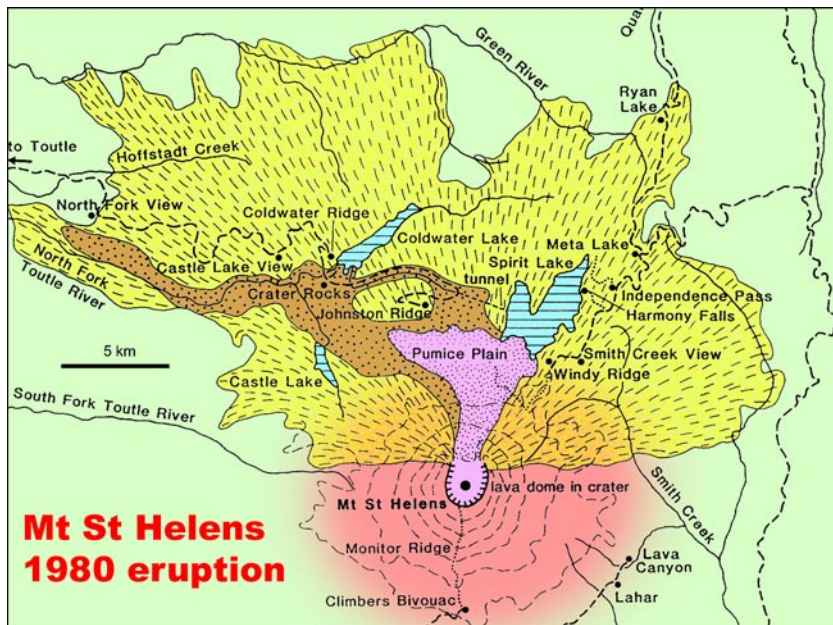
### **The background**

St Helens is one of the conical volcanoes forming the Cascades chain over the line where the remains of the Juan de Fuca plate are being subducted beneath the advancing North American plate. In typical convergent boundary style, St Helens and all the other Cascades volcanoes are acidic in composition and explosive in nature. The eruption of 1980 was very spectacular, very large (though overshadowed in size by other recent eruptions such as Krakatau, Katmai and Pinatubo), well documented and rather unusual in the nature of its massive, and very destructive, lateral blast. After its previous eruption in 1857, the volcano had been dormant until the spring of 1980.

On 20 March, a small earthquake (magnitude 4.2) heralded renewed activity; the next three weeks saw increasing numbers of earthquakes and a sequence of small summit eruptions, each producing vertical blasts and small amounts of airfall ash. Also, most significantly, there were notable periods of harmonic tremor – seismic vibrations of relatively constant amplitude, which are generated by moving magma at depth; they are quite distinct from sharp, fracture-generated shock waves, which start abruptly and then slowly fade.

This activity prompted a major monitoring exercise, for it was clear that a large eruption could be anticipated at some time in the near future. In late





**Fig. 1.** Map of Mount St Helens, showing the extent of the eruption blast and debris flows, and the routes now available for visitor access. The footpaths marked are only those described in the text. The lahar mudflows are not shown; they extended down all the creeks on the south side of the volcano, and also downstream of the debris avalanche in the Toutle North Fork valley.



sediments around many volcanoes have been re-interpreted, and these events are now seen as fairly normal eruption features.)

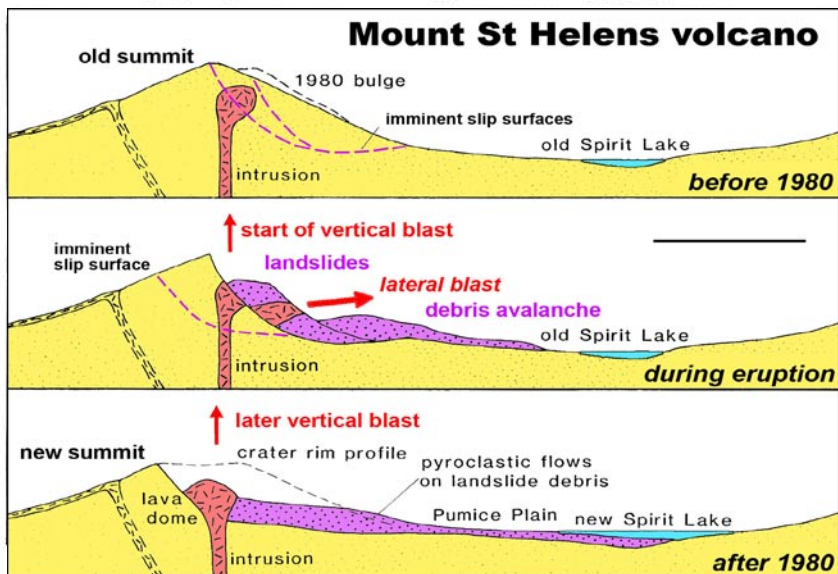
The main eruption occurred at 8.32 a.m. on 18 May 1980, with no immediately previous warning signs. An earthquake of magnitude 5.1, which may have been related to fracture destressing around the rising magma, triggered the eruption sequence. The earthquake caused the fractured rock of the bulged north slope to fail in a massive landslide. This was the largest landslide in recorded history, and produced a debris avalanche of about 7000 million tonnes of broken rock, which slid at 250 kph down into the Toutle valley; it moved fast enough to climb over a ridge 350 m high, it reached 20 km down the North Fork valley, it dammed and raised the level of Spirit Lake by 60 m and filled the valley with debris to an average depth of 50 m.

The removal of the landslide allowed the eruption to occur when the high-pressure volcanic gases lost their confining cover (Fig. 2). Because the landslide went only from the north side of the buried magma, the gases escaped sideways and produced the lateral blast towards the north. This reached velocities of up to 1000 kph and was hot (about 800 °C), but carried very little ash; it flattened fir trees over an area of 580 square kilometres and killed 60 people, mainly because it reached so much further than the anticipated vertical blast effects (Fig. 3).

April, the summit activity declined, but a large zone of the north slope started to rise steadily. This was correctly interpreted as being due to the viscous dacite/rhyolite magma rising within the core of the mountain. The north slope rocks were fractured by this doming and stretching, thereby reducing the stability of the slope. The potential for a landslide was recognized, but nobody foresaw the scale of this and the implications that it would have. (St Helens was the first large eruption with a landslide and lateral blast seen by geologists; since 1980 pyroclastic

**Fig. 3.** (right) Fir trees blown down by the eruption blast on the ridge north of Spirit Lake.

**Fig. 2.** (below) Sequence of cross-sections through Mount St Helens before, during and after the 1980 eruption.



All this took less than a minute, and was followed by a vertical blast which reached a height of 20 km and dumped airfall ash 1 cm to 1 m deep over much of Washington. The mountain was then 400 m shorter than it had been, and the summit cone had been replaced by a huge crater breached through its northern wall (Fig. 4). Pyroclastic flows subsequently covered part of the landslide debris (and included the extensive pumice deposit), and lahars, mudflows and floods swept for many kilometres down the surrounding valleys. Small pyroclastic flows recurred over the following few weeks. Growth



of the dacite dome in the centre of the crater continued intermittently until 1986. There have been minor explosions since then, and various small steam fumaroles have been active.

Since 1980, St Helens has been fitted with an enormous amount of monitoring equipment. Prediction techniques have improved with data on dome expansion, flank tilt, seismic activity and sulphur dioxide emission all showing increases before an eruption. A new observatory is planned on Johnston Ridge. Spirit Lake now drains through a tunnel to prevent erosion of the pumice plain, and a dam on the Toutle River will catch sediment for 45 years to minimize silting in the lowland rivers. The site is now protected as a US National Monument, and visitors benefit from two new visitor centres, 50 km of new highway and refurbished back roads. The volcano will probably erupt again inside the next 100 years; meanwhile, it is well worth a look.

### A short visit to the west side

The new road up the Toutle Valley puts the Johnston Ridge overlook just an hour's drive from the Interstate freeway from Seattle to Portland. This is the quick and easy way in for those without much time in the area; but, like all other roads on the mountain, it may be closed temporarily by snow between November and May.

Just a short way up Highway 504 from the Interstate, the Silver Lake Visitor Center is an essential stop. Each visitor centre has its own theme, and this is the one with the geological story – told superbly. Then it's on up the road, over the Toutle River bridge, which was destroyed by the 1980 lahars, and along the valley with glimpses of the lahar debris now retreating under new vegetation. Beside the road the half-buried A-frame house (signposted) shows how a metre of ash and mud was dumped by the lahar. There is little to see at the sediment retention dam off to the right.

Climbing the north flank of the valley, the roadcuts expose various Tertiary tuffs, agglomerates, ignimbrites, maroon weathered andesites and columnar basalts. The 1980 blast zone is entered, 20 km from the volcano, after crossing the high bridge over Hoffstadt Creek, but the first areas of forest have been logged and replanted. The North Fork Viewpoint and sundry other turnouts offer views to the valley floor, where the floodplain now lies on the lahar deposits and herds of elk often gather on the open land. Elk Rock Viewpoint overlooks some excellent blown-down forest on the ridges to the east; all the stripped tree trunks lie parallel, aligned by the blast from the volcano visible far ahead.

Stop at Castle Lake Viewpoint for an excellent view up to the volcano, the crater and the landslide debris, all seen in profile. Down below, the debris avalanche is over 100 m deep and has a very uneven surface; some hummocks are single blocks of rock carried down from the landslide, and many of the hollows are pseudocraters formed by escaping steam where groundwater was boiled beneath the hot debris. Across the Toutle Valley, Castle Lake was dammed in a side valley by the debris avalanche; it is 30 m deep, and its level is controlled by a channel



artificially cut through the debris levee. Further up the road, a large roadcut exposes ignimbrite flows above and below a bedded pumice tuff.

The Coldwater Ridge Visitor Center tells the story of ecological recovery in the blast area; it also offers views of Coldwater Lake with its deltaic fan built since 1985 by the outflow from the Spirit Lake tunnel eroding the new ash deposits. An excellent stop is at the Crater Rocks Trail, down at the foot of the next hill on the road to Johnston Ridge; this winds its way into the debris avalanche deposits, with huge blocks of various lavas, half-buried tree trunks and degraded pseudocraters (also called rootless steam craters). The Boundary Trail, just along the road, also leads to the debris avalanche and passes some well-exposed Tertiary dykes.

At the end of the road, the Crater Overlook on Johnston Ridge provides the single best view of Mount St Helens. It looks straight into the crater, through the breach formed by the landslide. The dacite lava dome appears black. Dust clouds rise from frequent rockfalls on the crater walls; they look like steam vents (which are now barely active). In front of the crater, the Pumice Plain has a surface smoothed by the deposits from the many pyroclastic flows which followed the main eruption. Stream channels and terraces cut through the pumice and into the underlying landslide debris. Broken tree stumps on the slopes around the viewpoint are witness to the volcano's lateral blast; this was the site where geologist David Johnston died while monitoring the mountain's dilation to identify precursors to the anticipated vertical blast.

Spirit Lake is just visible to the left below Windy Ridge, with Mt Adams in the distance. The flow from the lake now passes through a tunnel, to emerge by the road north of the ridge, which was cut to prevent the lake overtopping and eroding its natural dam provided by the landslide debris. This would have caused massive flooding and destructive sedimentation downstream. It would also have destroyed the Pumice Plain, which now survives to provide the perfect foreground in this splendid view into the crater.

**Fig. 4.** Air view from the west of the crater of Mount St Helens, with the landslide breach out to the left and the new lava dome just rising from the rim shadow (Photo: S. Monk).



**Fig. 5.** (far right) Mount St Helens seen from the north, with the breached crater rising above Spirit Lake, whose surface is thick with floating logs.

## A day out on the east side

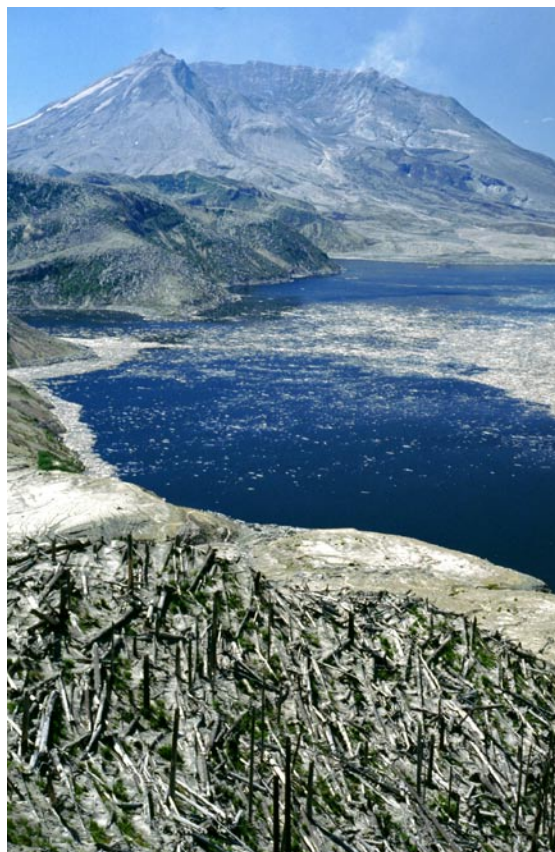
The east side is quieter, as fewer visitors make the long haul over the back roads, which stay closed through most of the winter. It is well worth a whole day, and requires a little planning as there is little accommodation at the two nearest end points, Packwood and Cougar; so book ahead in the summer. But the effort is rewarded. The best way in is from the north, on highway 25 south from Randle and then fork right onto 26.

This road enters the destruction zone near the top of the Quartz Creek valley, still 20 km from the volcano. The first signs are some roadside tree stumps charred black – a feature of the blast zone fringe where there was more time for oxygen mixing and burning. A little further on, Ryan Lake is in the midst of blown-down trees, and a short loop trail gives some excellent views. The valley floor is strewn with blown-down trees, while the old forest still stands on the higher ridges; this was the zone of channelled blast where the ash-laden gases just flowed along the valleys. The view north from the ridge is particularly stunning, and the road continues up the log-strewn wasteland of the Green River valley.

At Meta Lake, a short trail gives access to areas where shrubs survived the blast because they were buried under snowdrifts, even though the big trees fell around them. The wreck of a car caught in the blast remains at the roadside and makes a dramatic monument. The turnout at Independence Pass is an essential stop; just two minutes walk up onto the ridge gives the first full view of the volcano. Spirit Lake lies far below with its surface covered by a massive log jam, blown to this end of the lake by the south-west winds. Beyond it, the debris slopes rise into the yawning crater, and the valley sides are covered in fallen timber with all the straight spruce trunks aligned away from St Helens. For those with time and energy, the trail continues west, through the fallen timber, giving increasingly better views of the crater (Fig. 5). It rounds a bluff to overlook the northern tip of Spirit Lake where a zone is clear of trees and soil to over 150 m above the lake; this was washed by the wave pushed by the landslide tipping into the far end of Spirit Lake.

The best trail on this side of the mountain leaves the road just ahead and descends to Harmony Falls; it needs about 90 minutes. It descends through blown-down trees to the floor of a Devensian cirque which was swept by the landslide waves but is now gaining a new growth of colourful plants. The trail continues over a low moraine and past some ice-striated outcrops of coarse ignimbrite, to reach the shore of Spirit Lake. The log jam stretches into the distance, incredible to see but dangerous to walk on. To the south, the hillside is strewn with blown-down trees on its upper slope, was washed clear of trees by the landslide wave over the lower slope, and has a strandline of logs left when Spirit Lake was 6 m higher before the outlet tunnel was cut; the remains of the summit cone and the landslide apron lie beyond.

Back on the road, the Smith Creek Viewpoint on the left overlooks a landscape plastered in pale grey ash which came from pyroclastic flows and subsequent airfall. The floor of the valley is alluviated with lahar deposits capped by ash reworked from the hill-



sides by later rainfall. The road ends on Windy Ridge where 200 steps lead up to the best viewpoint, only 4 km from the volcano. The panoramic view is stunning – from Spirit Lake on the right, round across the whole landslide apron, and up into the crater. The black rubble pile of the dacite dome can be seen through the breach in the crater, whose remaining walls rise steeply beyond. The great fan of landslide debris slopes down to the edge of Spirit Lake and reaches across the deeply buried Toutle Valley to the foot of the bank rising to Johnston Ridge. Huge blocks of dark rock have been washed clean where they protrude through the veneer of white pumice, up to 30 m thick, from the later pyroclastic flows (Fig. 6). The Pumice Plain reaches up the ramp of debris rising to the spillover into the Coldwater valley.

From the Windy Ridge roadhead, a trail winds towards the landslide zone below the crater, although it needs about three hours to visit the Pumice Plain. It contours along the ridge to a fine viewpoint, and then descends to the debris sheet with its cover of pyroclastics. This area is an important and fragile study zone where plant recolonization is in its early stages, so walkers should not leave the marked trail. It is a dramatic landscape, and the crossings of a few ravines provide excellent sections through the pyroclastic flow and surge deposits.

## A hard day's walk to the top

Because the blast went north, there is little to see on the south side of St Helens. Tall timber coats most of the hills, and the paths of the 1980 lahars are now largely revegetated. It's an alternative route out from Windy Ridge but, except for a couple of lodges in





Cougar, there is nowhere to stay before Woodland on the freeway.

But the south side is the only way up to the top – for those with the time and energy! A road heads uphill from Swift Reservoir and has three branches. Left (west) leads to Ape Cave. This is a long lava tube formed in a basalt flow about 2000 years old, and it has some typical lava cave features with pahoehoe floors, glassy walls and small lava stalactites. Part of it is easily accessible (bring strong torches or rent at the entrance), but it's much the same as any other lava cave. Just down the road, the signposted Trail of Two Forests is much more special. The same basalt lavas overwhelmed a forest of Douglas Firs, creating magnificent tree moulds, upright and laid down. Bring a small torch to crawl through some of the moulds, which are ribbed with the bark pattern cast in basalt – a geological site not to be missed.

The right (east) road leads to Lahar Viewpoint on a great fan of 1980 lahar deposits. Just above the road, Stratigraphy Viewpoint has a stream-cut bank 6 m high exposing a splendid sequence of lahar, pyroclastic surge and airfall deposits, capped by a thin 1980 lahar. At the end of the road, a short trail passes columnar andesite 1900 years old in Lava Canyon.

The middle road ends at the car park known as Climbers' Bivouac. This is best reached very early to start up the trail soon after dawn; it's a climb of 1400 m and takes a full day. To protect the environment, the number of hikers to the summit is limited to 100 per day; so a permit is needed (write to, Mount St Helens National Volcanic Monument, 42218 NE Yale Bridge Road, Amboy, WA 98601). Permits are free, but summer weekends are booked up by Easter, and it's bad luck if the weather clouds in on your day.

The trail starts easily through delightful forest, until it emerges into the open on the lava flows of Monitor Ridge. These andesites are about 400 years old and present an incredibly rough, rocky surface which is still totally devoid of vegetation. Tumbled blocks of lava, each 1–5 m across, create a chaotic terrain where the viscous lava ground to a halt on a slope of nearly 30°. It is a textbook example of an

**Fig. 6.** The Pumice Plain, seen from Windy Ridge. The pale grey pyroclastics lie on the landslide debris which has come down from the summit (off to the left).

acid lava, with magnificent levees of chilled blocks falling as screes into the forest on their outer sides. Unfortunately, the lava provides awful walking conditions, only eased where 1980 ash has accumulated to form a path up some of the troughs; it's a continuous scramble going up and even worse coming down. The lava steepens as it rises to a small apex over the choked, subsidiary vent from which it emerged. A welcome excuse to rest is the splendid view of the leveed flows where they bite into the forest far below and round to the east.

The last 400 m to the summit climbs a slope of tephra thrown out by the 1980 eruption. Most of it is loose pumice, and lower layers of indurated material are exposed only in a few ribs. It lies at close to its angle of rest, and there is no trail. The ascent is mind-bendingly awful, perhaps best described as character-building, although the descent is almost a glissade, or an uncontrolled slide down the snow gullies. The reward is at the summit, 2549 m high where the crater is broken into the pre-1980 cone.

The crater rim is a knife edge (Fig. 7). On one side the pumice slope is graded just enough to rest on. On the other, the crater wall drops away with frightening steepness. This is still a youthful feature, and rocks and debris fall away continuously as the fresh rock face retreats in order to gain a stable profile. Every few minutes the sound of a debris slide or rockfall breaks the silence. Rocks fall to the screes which now bank against the chaotic pile of broken, crusted dacite forming the new lava dome. Exposed in the crater walls are layered lavas and pyroclastics of older cone-building phases. Beyond the new dome, the tongue of landslide debris reaches out through the crater breach to the shore of Spirit Lake, nestled in the grey ash wilderness of the blast area. Far to the north, Mt Rainier rises as a great white cone, matching the other conical volcanoes of Adams to the east and Hood to the south.

There is something magical about the summit of any high mountain, and St Helens is no exception. But the special features of St Helens are the effects of the massive eruption of 1980, and these spread right to the lower and more accessible slopes. A visit to any part is utterly fascinating. This must rate as one of the world's most amazing mountains.

**Fig. 7.** The new lava dome sits in the crater left by the landslide and eruption. The pumice plain and Spirit Lake lie beyond, and Mt Rainier rises from the horizon.

