LEG B: PARADISE TO OHANAPECOSH VIA STEVENS CANYON

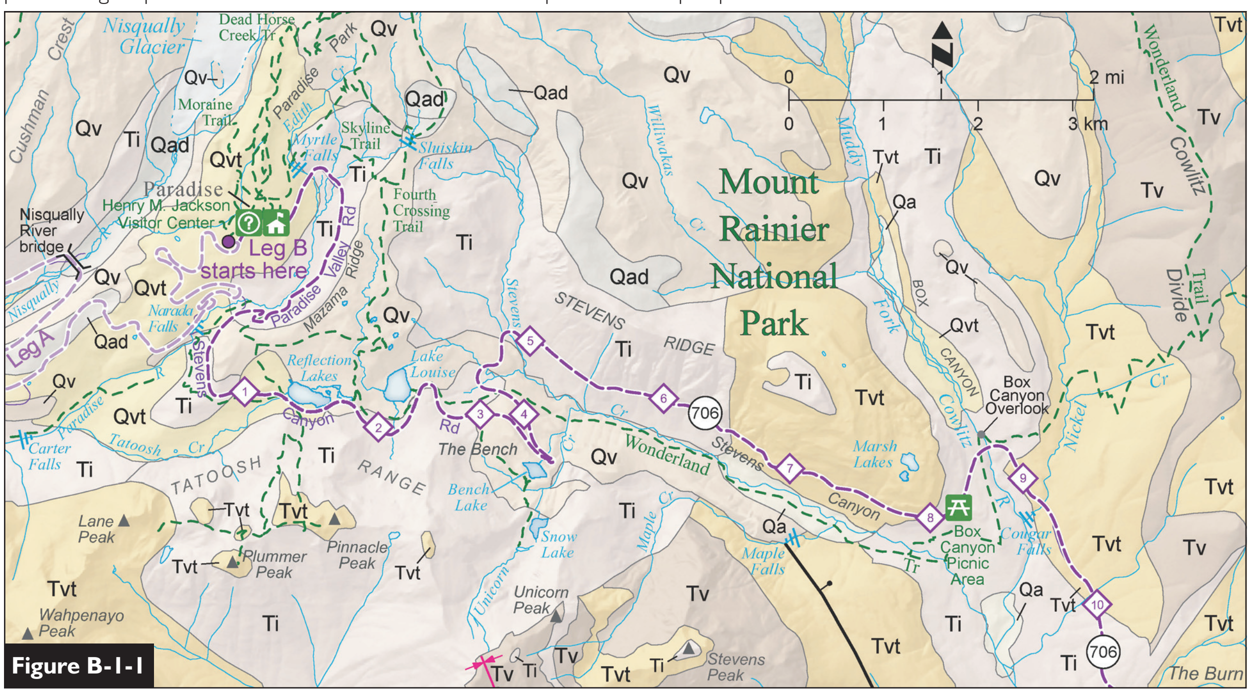
This 21-mi (34 km)-long leg begins in the timberline environment of Paradise in the Nisqually River watershed and descends the Paradise River valley before crossing over into Stevens Canyon and the Cowlitz River watershed (**Fig. B-1**). This route is one of the youngest in Mount Rainier National Park, having been dedicated on Sept. 4, 1957.

Starting at Paradise, the route crosses the Paradise River and passes lava columns, ash deposits, and the scenic Reflection Lakes nested on the deposits of a lahar that plowed over Mazama Ridge more than 6000 years ago. The road then descends into Stevens Canyon and a drier vegetation zone. The sparser vegetation in this eastern area of the park allows better rock exposures, and you will see plenty—Mount Rainier lava flows, granodiorite of the Tatoosh pluton, welded tuffs of the Stevens Ridge Formation, and the contact between the Stevens Ridge Formation and the underlying Ohanapecosh Formation.

Autumn is a particularly good season to examine the geology in upper Stevens Canyon—the crimson leaves of the vine maples can be spectacular that time of year. The Paradise Valley Road and the Stevens Canyon Road are typically closed from the first snowfalls in October until they can be opened in June. In the winter, when the road is closed to automobiles, this area is a favorite spot for alpine skiing. Although it has now been repaired, the Stevens Canyon Road was severely damaged by landslides in three places by the flood of November 2006, when a storm dumped 18 in. (~46 cm) of rain on the park in 36 hours. The status of roads and trails can be checked at the Mount Rainier National Park website or by contacting the park by phone. (See "Websites and Phone Numbers", p. 176.)

Distances along the route are given in miles, followed by kilometers in italics. If you take any side trips, you'll have to keep track of and add those miles to all the remaining mileages in the leg. Having a pencil and paper handy, and even a calculator will be helpful.

Figure B-1. Geologic map for Leg B (two consecutive panels). The geology was adapted from 1:100,000- and 1:500,000-scale digital versions of Schasse (1987b) and Schuster (2005) and has been draped over a shaded relief image generated from 10-m elevation data. The leg maps were constructed using source-map data whose scale is smaller than the leg map scale, thus minor exposures may not appear on leg maps. The numbers in diamonds indicate mileposts. The map explanation is on the inside back cover.



Mileage

0.0 *0.0* Leave the north end of the Paradise parking lot near Paradise Inn and drive down through the beautiful valley of the Paradise River. (This is a one-way road.) An outcrop of andesite with flow banding and breccia is on the left (Fig. B-2).

0.2 *0.3* Outcrop of platy andesite.

0.3 *0.5* Outcrop of columnar andesite.

0.4 *0.6* Edith Creek and Myrtle Falls are contained in a narrow chasm cut in Tatoosh granodiorite of Miocene age.

0.7 *1.1* Paradise River and Fourth Crossing Trail parking area. Tatoosh granodiorite (Fig. B-3) with veining is on the left with the Paradise lahar on top. (See Optional Side Trip, p. 58, for a description of the Paradise lahar.) Geologists such as Donal Mullineaux (1974) and Jim Vallance (2000) of the U.S. Geological Survey have used ash layers preserved in this area and other eastside locations to help interpret the history of eruptions and lahars at Mount Rainier (Fig. B-4).

1.6 *2.5* Glacially smoothed Tatoosh granodiorite is visible slightly before a curve to left. Glacial till crops out upstream. The Paradise lahar deposit near here is draped by about 9 in. (23 cm) of Yn tephra from Mount St. Helens, erupted about 3,500 yr B.P.

1.7 *2.7* Multicolored layers of ash are exposed to the east of the road on top of an unsorted deposit, probably that of the Paradise lahar or of an older one observed by Scott and others (1995) near Sluiskin Falls to the northeast.

1.8 *2.9* Outcrop of Tatoosh granodiorite on the left.

photo by Beth Norman

Figure B-2. Andesite with flow banding and breccia near Paradise. This is the same andesite flow that is exposed at Ricksecker Point.

1.9 *3.1* Turnout for the Lakes Trail just before a sharp turn to the right. This 4.8-mi (7.5 km) trail connects with several other trails, including Skyline Trail.

2.2 *3.5* An outcrop of Mount Rainier Andesite is on the left (east). Notice the columnar jointing (Fig. B-5).

2.3 *3.7* Turn left on Stevens Canyon Road to go to Stevens Canyon and Ohanapecosh. Andesite columns are on the left.

2.5 *4.0* More lava columns. The orientation of the columns indicates the flow probably cooled next to a large body of glacial ice.

2.7 *4.3* Inspiration Point. This vista point on the right (south) side of the road provides spectacular views of the upper Paradise River valley and Ricksecker Point lava flow to the southwest (Fig. B-6), as well as of Mount Rainier. Across the road to the northeast, a tan tephra deposit contains hornblende, a mineral that is fairly uncommon in Mount Rainier tephras (Fig. B-7). This tephra is overlain by a poorly sorted deposit (lahar or pyroclastic flow?) that is itself overlain by a lava flow older than the overlying Mazama Ridge flow. Sisson and Lanphere (1999) dated the Mazama flow at about 90 ka, and they showed that the age and chemistry of this flow are similar to those of the Bench and

photo by Beth Norman

Figure B-3. A marmot makes its home among boulders of Tatoosh granodiorite.

Stevens Canyon flows of Fiske and others (1963) and, further, that these flows are actually all part of the same flow (see mile 8.8 below.)

3.1 *5.0* North of the road are outcrops of the Tatoosh granodiorite.

3.4 *5.5* Reflection Lakes (see cover photo). The lakes occupy shallow depressions in a clay-rich deposit that was previously thought to be the Paradise lahar. However, Jim Vallance (USGS, written commun., 2002) believes this to be the older lahar mentioned above and described by Scott and others (1995) at Sluiskin Falls to the north. He determined the date of this lahar to be between 6,400 and 6,200 yr B.P. In order to reach the Reflection Lakes area, the lahar had to spill through a saddle in Mazama Ridge and down Stevens Canyon into the Cowlitz River watershed. Crandell (1971, p. 33) discussed the conditions under which lahar deposits could be left here: "…the lahar moved across Paradise Park and down the Paradise River valley in a single massive transient wave with a height of as much as 800 feet [244 m]. Such a wave must have been generated by a large avalanche of wet, clayey, rock debris from an area high on the south flank of the volcano, or perhaps its summit. Because of momentum, the avalanche-generated wave swept across Paradise Park…the great momentum of the wave, created by a vertical drop of 8000 feet [2438 m], carried it up over the east valley wall [Mazama Ridge]…the bulk of the material

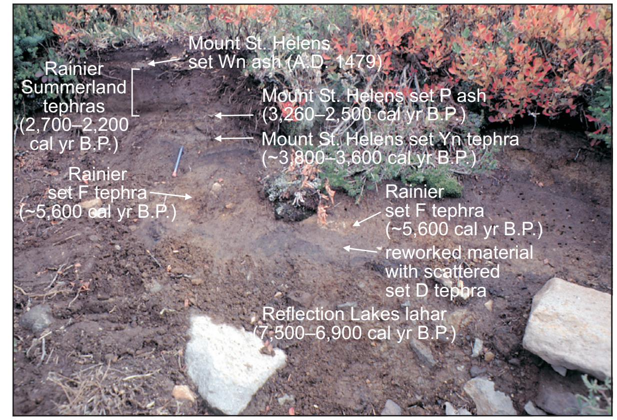


Figure B-4. Ash layers and buried soils overlying a lahar in Paradise Valley near the Fourth Crossing Trail parking area. USGS geologist Jim Vallance suggests that this lahar, which is likely the same one that underlies Reflection Lakes, dates to between 7,500 and 6,900 cal yr B.P., based on the ages of constraining tephra layers (written commun., 2002). Vallance also contributed the interpretations of the various tephra layers shown. He identified four 'exotic' (that is, not from Mount Rainier) tephra layers including Yn (3,800–3,600 cal yr B.P.), Wn (A.D. 1479), and set P (3,260–2,500 cal yr B.P.) tephras from Mount St. Helens. Mount St. Helens X tephra (~A.D. 1500) is present atop the Wn but is not visible in the photo. The blue pencil provides scale.

however, was deflected by Mazama Ridge to the southwest and down the Paradise Valley."

Continue east on Stevens Canyon Road toward Ohanapecosh.

4.2 *6.8* MP 2. Sunbeam Creek and waterfall. The creek flows over the Tatoosh quartz monzonite on the south side of the road and into Lake Louise to the north, which sits on a moraine of Evans Creek age (22–15 ka). About 0.5 mi (0.8 km) after the curve past Lake Louise, the road passes an outcrop of the Mazama Ridge lava flow on the right before descending into the canyon of Stevens Creek. The canyon can be spectacular in autumn when leaves of the vine maples turn bright colors (Fig. B-8).

4.5 *7.2* Lake Louise parking area. Just past the parking area is an outcrop of platy andesite on both sides of the road at the curve.

4.8 *7.7* Pullout on the left with an outcrop of Tatoosh quartz monzonite on the right.

photo by Beth Norman

Figure B-5. An outcrop of Mount Rainier Andesite. The subhorizontal columnar jointing indicates that it may have cooled next to glacial ice. The columns are about 1 ft (0.3 m) across.

5.0 *8.0* Snow Lake Trailhead. Snow Lake (elev. 4600 ft or 7360 m) is a tarn.

5.4 *8.6* Pullout with an outcrop of platy Mazama Ridge andesite on the right.

6.3 *10.1* The Wonderland Trail, which goes around the mountain, crosses the road here.

6.9 *11.0* Stevens Creek. Exposures of Tatoosh quartz monzonite are visible in Stevens Creek and on Stevens Ridge above to the north-northeast. Mazama Ridge to the northwest, capped by a lava flow, is a major drainage divide. Stevens Creek, which drains the last vestiges of Paradise Glacier, flows into the Pacific Ocean by way of the Cowlitz and Columbia Rivers. The Paradise River, on the other side of Mazama Ridge, drains to Puget Sound via the Nisqually River. Ironically, because of glacial retreat, the Paradise River no longer drains the Paradise Glacier.

7.1 *11.4* MP 5. Tatoosh quartz monzonite is exposed from MP 5 to MP 6.

8.8 *14.1* Several small turnouts provide places to observe the Stevens Ridge Formation welded tuff on the north side of the valley and the dacite flow of Mazama Ridge in Stevens Canyon. Fiske and others (1963) inferred that the two lowest benches visible to the south were two separate flows (Fig. B-9). Dave Lescinsky and Tom Sisson (1998), however, showed that these were part of the same flow they mapped at Mazama Ridge. They noted that most of the ridge-capping lavas that Fiske and others proposed had gained their positions through reversed topography probably formed through confinement of a single lava flow to ridge sides and crests by thick valley ice during the Pleistocene (see Fig. 27, p. 30). Curved and chaotic fan-shaped lava columns suggest chilling against ice. Sisson explains (USGS, written commun., 1998): "...in Stevens Canyon, look across the valley and notice the benches in the lava. One lies just upstream of the valley of Unicorn Creek and one lies just upstream of the outlet of Maple Creek. Chemical compositions and four radiometric ages confirm that the Mazama Ridge [see below and at Inspiration Point above], Bench, and Stevens Canyon lavas are all the same flow and do not result from eruptions spaced widely in time and separated by long periods of erosion (previous interpretation). Apparently, lava flowed down Mazama Ridge, bounded on the sides by ice in the valleys of Paradise River and Stevens Canyon. When the lava reached the end of Mazama Ridge it was diverted to the east by running into the Tatoosh Range. The lava proceeded along the margin of the Stevens Canyon glacier (paleo-Paradise Glacier) until it ran into a tributary ice stream in the valley of Unicorn Creek. The lava temporarily stopped and thickened until it melted through the Unicorn glacier, and then it continued down the margin of the main Stevens Canyon glacier until it ran into the tributary glacier in the valley of Maple Creek. The lava was dammed again and thickened until it melted through that ice and continued down a meltwater channel that lay on the margin of the main Stevens Canyon glacier until the eruption ended."

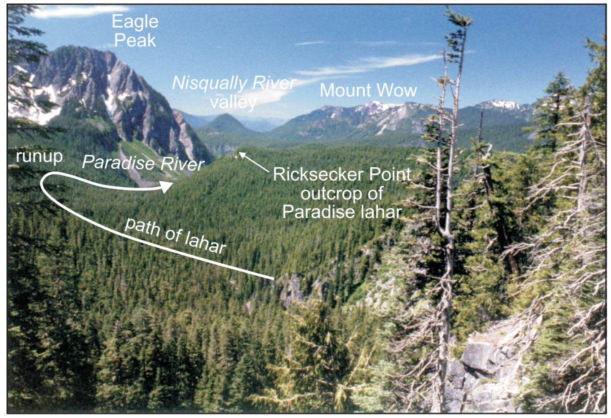


Figure B-6. The view west-southwest down Paradise Valley to Ricksecker Point from Inspiration Point. Ricksecker Point is the toe of a relatively young, fairly thick lava flow from Mount Rainier. That flow, whose age has been estimated at about 40 ka (Sisson and Lanphere, 1999), was probably ponded by glaciers that sat in the Paradise and Nisqually River valleys. The Paradise lahar sloshed through this valley about 5000 years ago, leaving a deposit at Ricksecker Point, some 800 ft (245 m) above the valley bottom (see Fig. A-23, p. 65). Eagle Peak and adjoining peaks of the Tatoosh Range to the west are cored by intrusive granodiorite of the Tatoosh pluton (25.8–14.1 Ma) and capped by older welded tuffs and breccias of the Stevens Ridge Formation.

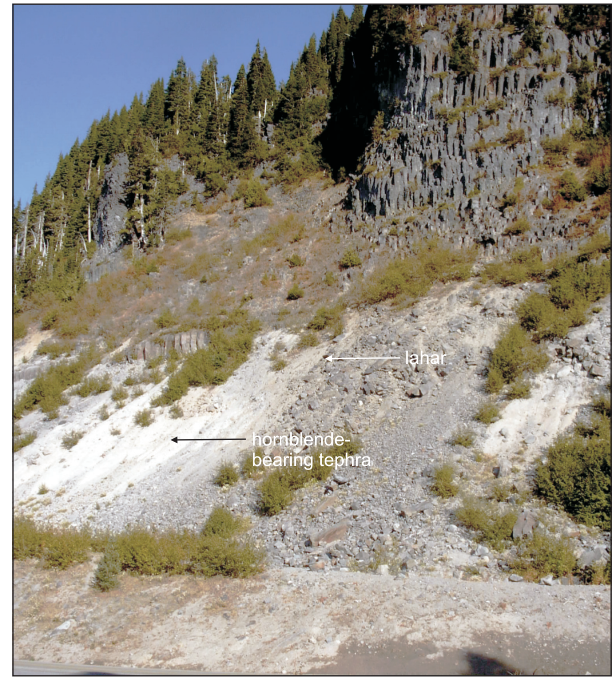


Figure B-7. The toe of Mazama Ridge where the Mazama Ridge lava flow (~99 ka; not shown) caps an older lava flow (columnar joints) over a lahar or pyroclastic flow over a hornblende-bearing tephra that is possibly correlative with the Sunset Amphitheater tephra (~190 ka). It is about 60 ft (18 m) to the base of the older lava flow. View is to the north.

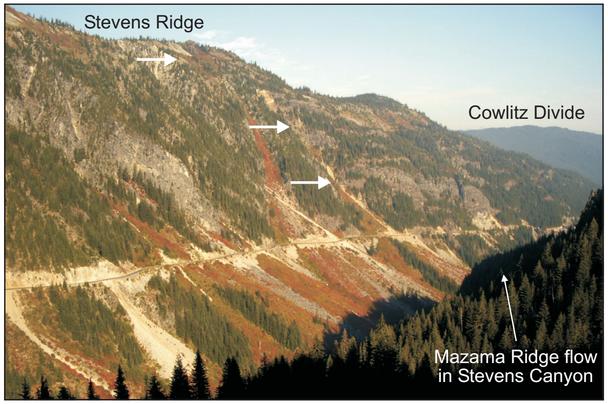


Figure B-8. Stevens Canyon and Stevens Ridge from about 1 mi (1.6 km) east of Lake Louise. Arrows at top and center show the approximate contact of Tatoosh granodiorite (left; 25.8–14.1 Ma) with the welded tuffs of the Stevens Ridge Formation. Notice the differences in the vegetation growing on the respective rock units; the horizontal stripes to the right suggest bedding. Cowlitz Divide is composed of the Ohanapecosh Formation (~37–27 Ma). The Mazama Ridge flow is about 90 ka. View is to the east.

The Mazama Ridge dacite flow in Stevens Canyon has been dated at about 90 ka by Sisson and Lanphere (1999).

9.0 *14.5* Tunnel through welded tuff. The Stevens Ridge rocks preserve an example of the scale and nature of some volcanic eruptions during the early Miocene in the southern Washington Cascades. The thick welded tuff layers were deposited by ash flows that originated in large eruptions of ash and lapilli. The flows moved as sheets yards (meters) or tens of yards thick flowing outward from the vent. These pumiceous flows were hot enough and thick enough in some places to weld together after they came to rest (Figs. B-10 and B-11). In such eruptions, several to many tens of cubic miles (2.4 $mi^3 = 10\ km^3$) of volcanic debris may be ejected from the magma chamber fueling the volcano—so much that part of the volcanic edifice falls into the void left behind, creating a caldera. The welded tuff is visible for the next mile (1.6 km).

10.3 *16.6* Stevens Creek Trailhead.

10.6 *17.0* Wonderland Trail. Note the dark-colored sill about 10 ft (3 m) thick at the top of the west portal of the highway tunnel west of Box Canyon. According to Fiske and others (1963), here a Tatoosh sill is cutting a Fifes Peak Formation sill (Fig. B-12).

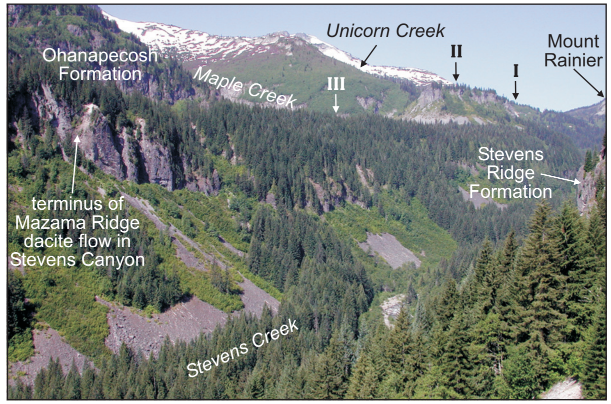


Figure B-9. Stevens Creek canyon from Stevens Canyon Road. The Mazama Ridge dacite flow of Stevens Canyon was dated by Sisson and Lanphere (1999) at about 90 ka. The direction of lava movement was upper right to lower left. Lescinsky and Sisson (1998) concluded that the flow was ponded at successively lower levels by tributary glaciers from the valleys of Unicorn Creek (bench level I, in the distance) and Maple Creek (bench level II) before being deflected and flowing downvalley at a lower elevation (bench level III in center and at left). The uppermost bench level is named 'The Bench'. View is to the west.

10.8 *17.3* Box Canyon Overlook. The Box Canyon area exhibits spectacular postglacial incision and glacial striations (Fig. B-13). Box Canyon was carved by the Muddy Fork Cowlitz River, which heads at the Cowlitz and Ingraham Glaciers. Although none of the lahars that originated in the Cowlitz River watershed are comparable in size to the largest in other Mount Rainier drainages, the broad flood plain of the Cowlitz River many miles downstream (known as Big Bottom) is underlain by distal phases of many lahars that occurred in the last several thousand years.

At Box Canyon, the Muddy Fork has cut deeply into the volcanic bedrock. The footbridge 0.1 mi (0.2 km) upstream is the best vantage point. The greenish cut stones that line the bridge, walkway, and parking area are blocks of mudflow breccias of the Oligocene Ohanapecosh Formation. The greenish color is due to low-temperature metamorphism.

Figure B-10. Michael Bennett stands at an outcrop of welded tuffs of the upper Miocene Stevens Ridge Formation along Stevens Canyon Road. Note the crude columnar structure of the welded tuff.

Figure B-11. Fiamme, or stretched and flattened pumice (dark, elongate blob on the lower left), in Stevens Ridge welded lapilli tuff along Stevens Canyon Road.

This site is an example of why stratigraphic studies of a volcano must include areas beyond the volcano's base to provide a complete picture of

Figure B-12. Dark-colored sill about 10 ft (3 m) thick at the top of the west portal of the highway tunnel west of Box Canyon. According to Fiske and others (1963), here a Tatoosh sill is cutting a Fifes Peak Formation sill.

lahar magnitude and frequency. Many lahars have passed this point, yet little evidence of them is preserved here. A complete flow record is revealed only in the depositional areas of downstream valleys. Deposits on the volcano itself can be thin and quickly eroded or might be covered by the deposits of later eruptions. Glacial erosion and deposition are added complications. At Mount St. Helens, a series of flood surges that were derived from breakouts of avalanche-dammed lakes did not incorporate enough sediment to form debris flows until they reached a point about 12 mi (19 km) from the base of the volcano. Nevertheless, about 30 km (18.6 mi) from the volcano, one of these debris flows had a peak discharge of 200,000 to 300,000 m³/s (261,600–392,400 yd³/s), comparable to the Amazon River at flood stage (Scott, 1988).

11.3 *18.1* Nickel Creek. As the road ascends from here to Backbone Ridge, cuts expose Ohanapecosh Formation breccias overlain by light-colored Stevens Ridge Formation pyroclastic flows for the last 2 mi (3.2 km).

12.2 *19.6* MP 10.

14.0 *22.4* Outcrop of crystal lithic tuff.

14.2 *22.8* MP 12.

photo by Beth Norman

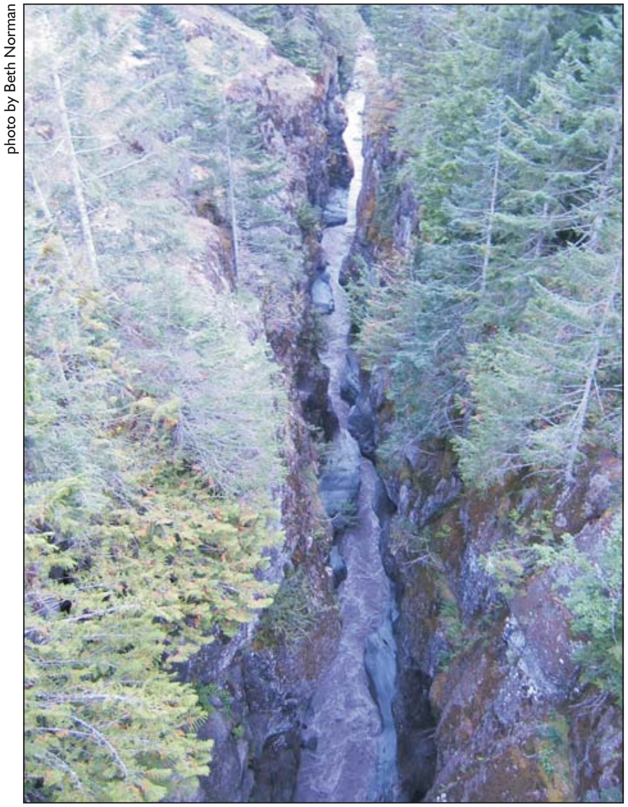


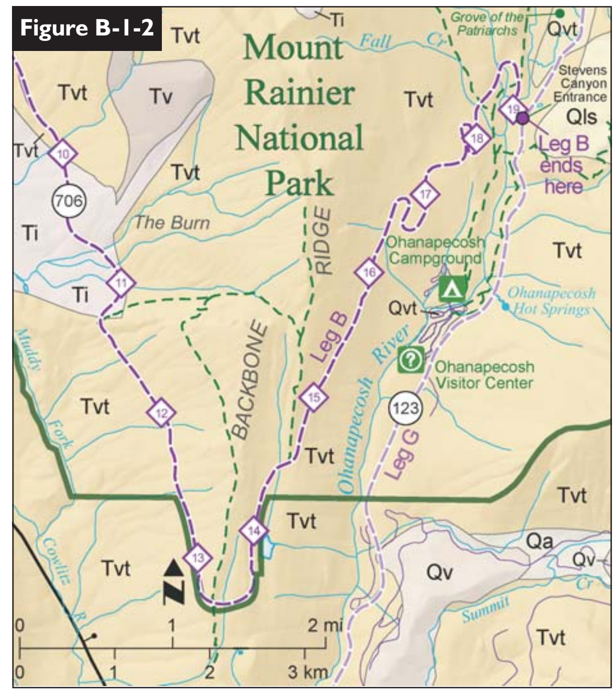
Figure B-13. Box Canyon Overlook. Box Canyon exhibits spectacular postglacial incision in bedrock of the Ohanapecosh Formation. The Muddy Fork Cowlitz River has cut a gorge about 180 ft (55 m) deep and 15 to 30 ft (5–9 m) wide.

14.9 *23.9* An andesite dike cuts the tuff east of the road.

15.2 *24.5* MP 13.

15.3 *24.6* A turnout on the west side of the road provides a magnificent view of the southeast slope of Mount Rainier with Little Tahoma Peak on the right skyline, Success Cleaver on the left skyline, and Cowlitz Glacier tumbling toward the viewer (Fig. B-14). Outcrops of Stevens Ridge welded tuff across the road to the east are cut by two andesite dikes (Fig. B-15). For the next 2 mi (3.2 km) you will see outcrops of tuffs.

Figure B-14. View of Mount Rainier from the Stevens Canyon Road pullout at Backbone Ridge. The late-afternoon lighting emphasizes the contrast between the volcano's rugged, glacially dissected pre-Holocene rocks and its smooth, youthful summit, Columbia Crest cone. View is to the northwest.



17.3 *27.7* For the next 2 mi (3.2 km), the road descends through Fiske and others' (1963) thickest identified section of the Ohanapecosh Formation. They estimated that the original thickness of the Ohanapecosh Formation sediments was as much as 15,000 ft (2.8 mi; 4.5 km). Drive carefully along this stretch of road, which is narrow and has no good places to pull off. Below here are moraines of Evans Creek age and the Pleistocene Clear Fork flow to the southeast (Fig. B-16).

Figure B-15. Dacitic(?) dikes of early Miocene age that cut the Stevens Ridge Formation tuffs exposed at the Backbone Ridge pullout. The left dike is about 4 ft (1.2 m) thick. View is to the east.

Near the top of the ridge within the first 600 ft (180 m) after the sharp turn to the north, scattered 1.6- to 6.6-ft (0.5–2 m) greenish and maroon pods in the rocks (Fig. B-17) are fragments of saprolites that were, along with rocks of the underlying Ohanapecosh Formation, ripped up and incorporated into basal ash flows of the overlying Stevens Ridge volcaniclastic rocks. "Fragments of bedrock, saprolite, stream-rounded pebbles, and bits of macerated wood were swirled upward as much as 50 ft [13 m] into ... the ash flow" (Fiske and others, 1963).

20.2 *32.5* MP 18.

20.4 *32.8* Cowlitz Divide Trail crosses the road.

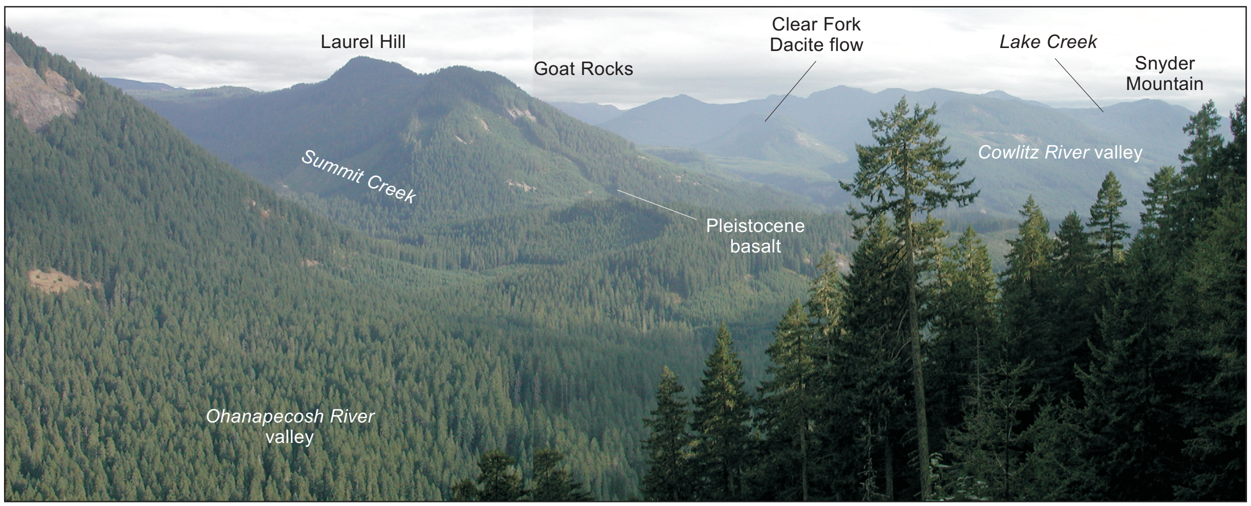


Figure B-16. View from Backbone Ridge to the southeast across the Ohanapecosh River valley at the Clear Fork Dacite flow and Goat Rocks (see Leg H, p. 124). Geoff Clayton (1983) obtained a radiometric age of about 0.65 ka on this flow. Hammond (1989) suggested that the Clear Fork flow may have been ponded by a lobe of ice in the upper Cowlitz River valley. The Pleistocene basalt shown might have been erupted from the Tumac Mountain volcano 10.5 mi (17 km) to the east or from a vent a few miles/kilometers west of Ohanapecosh valley along Summit Creek. Snyder Mountain is cored in large part by a thick pyroxene andesite lava flow erupted from Goat Rocks volcano between 0.78 and 0.14 Ma (Swanson and others, 1997). Swanson and his colleagues noted that the flows filled canyons incised as deep as 1150 ft (350 m) in upper Oligocene volcaniclastic rocks. A large debris avalanche from Snyder Mountain dammed upper Lake Creek to form Packwood Lake; the youngest radiocarbon age on a barkless snag in the lake is 970 yr B.P. (Pringle and others, 1998).

20.7 *33.1* Falls Creek. A tuff crops out on the left (if eastbound).

21.0 *33.8* Grove of the Patriarchs. From the trailhead, a short (50-minute round trip) walk leads to a magnificent old-growth forest of huge Douglas-firs and western redcedars that probably are at least 1000 years old. Their great age and low position on an island in the middle of the Ohanapecosh River indicate that no destructive lahars have originated in this drainage in at least 1000 years. The flood of November 2006, however, did serious damage, destroying the suspension bridge and part of the boardwalk along the trail and depositing as much as 4 ft (1.2 m) of fine sediment on the flood plain that supports the old trees.

21.1 *33.9* Ohanapecosh River bridge.

21.5 *34.6* Junction of Stevens Canyon Road with State Route 123 (see Leg G, mile 10.9). SR 123 passes through the rugged valley of the Ohanapecosh River, tributary of the Cowlitz River. You can turn left (north) here to go to Cayuse Pass and SR 410 or right (south) to go to US 12.

Remember to reset your odometer when you start another leg. ■

Figure B-17. Maroon and greenish pods, between 1 and 2 ft (0.3–0.6 m) across, in the Stevens Ridge pyroclastic flow on Backbone Ridge. These were interpreted by Fiske and others (1963) to be chunks of a soil layer that had developed on the underlying Ohanapecosh Formation. The soil was ripped up and incorporated into the Stevens Ridge flows.