LEG E: SUNRISE ROAD

State Route 410 to Sunrise

Sunrise Road is one of the most spectacular and scenic drives in the Pacific Northwest (Fig. E-1). The ~15-mi (25 km) road ascends from about 5500 ft (1676 m) elevation to about 6400 ft (1951 m), passing outcrops of lavas and intrusive rocks, rubbly deposits of lahars and glacial tills, tephra layers, and banded layers of silt that were deposited in ice-marginal lakes when glaciers occupied the White River valley. As the road winds around the east end of Sunrise Ridge, spectacular tilted columns of lava attest to the interaction of 'fire and ice'. At the Sunrise Point viewing area, there are broad panoramas from Mount Baker and Glacier Peak volcanoes to the north to Mount Adams in the south. The road then continues west along the surface of the large Burroughs Mountain lava flow to Sunrise and a spectacular view of Mount Rainier volcano. Several trailheads there lead to a multitude of scenic destinations. Glaciers such as the Emmons, the largest in the contiguous 48 states, drape the mountain, their young, sparsely vegetated moraines marking their maximum extent during the Little Ice Age. The smooth, youthful Columbia Crest cone sits in a crater left after the volcano's summit slid away as the Osceola Mudflow, about 5,600 cal yr B.P.

Sunrise Road is typically closed by snow from late October until late June. 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.

Mileage

0.0
0.0 Sunrise Road is accessed from State Route (SR) 410, which skirts the eastern edge of Mount Rainier National Park. Sunrise Road turns off to the southwest. Please use care here—the intersection has an unusual acute angle. Oligocene Ohanapecosh volcanic rocks are exposed along the begin-

Figure E-1. Geologic map for Leg E. 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 inside back cover.

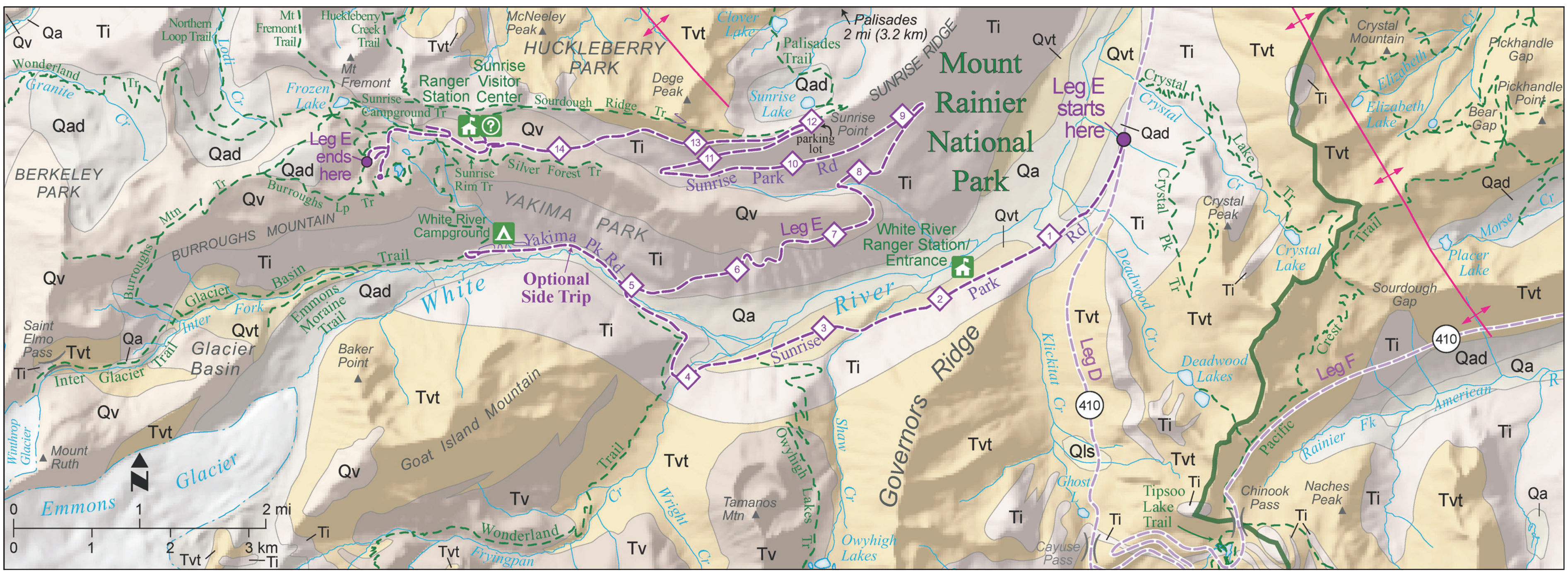


photo by Beth Norman

Figure E-2. Granodiorite containing inclusions of dark andesite. This outcrop is about 0.4 mi (0.6 km) west of MP 3.

photo by Beth Norman

Figure E-3. Osceola Mudflow deposit near Fryingpan Creek.

photo by Beth Norman

Figure E-4. Avalanche chute and debris fan near White River Campground. View is to the south.

ning of the road as it descends into the White River valley. The view en route is up the White River valley, which heads at Emmons Glacier and drains the east side of the volcano. The White River was a major pathway for the Osceola Mudflow and later lahars. Orange-tinted, poorly sorted diamicts in roadcuts along the valley floor are scattered remnants of the Osceola.

1.3 *2.1* White River Entrance. Here are information, restrooms, and water.

2.6 *4.2* The outcrop on the left (south) is intrusive Miocene White River granodiorite. Shaw Creek heads at Barrier Peak (due south), which is cored by intrusive rock. Slightly west of Shaw Creek, the Osceola Mudflow deposit is exposed on the right (north).

3.0 *4.8* Milepost (MP) 3. Pass an exposure of the Osceola Mudflow deposit here with a layer of cobbles at the top.

3.4 *5.4* On the left (south) across from a pullout, granodiorite contains inclusions of dark andesite (Fig. E-2).

3.5 *5.6* Trailhead to Owyhigh Lakes south via the east flank of Tamanos Mountain above Shaw Creek. Tamanos Mountain is cored by lava flows of the Ohanapecosh Formation (late Eocene–mid-Oligocene age).

4.2 *6.8* West of the bridge over Fryingpan Creek is a parking lot and the Wonderland Trailhead. The Osceola Mudflow deposit is exposed in an outcrop on the north side of the road slightly east of the bridge (Fig. E-3). Geologists found wood in a post–Osceola Mudflow lahar assemblage near here having a radiocarbon age of 1,120 yr B.P., and USGS geologist Rick Hoblitt reported a 1,080 yr B.P. age on charred wood from a lithic-rich tephra overlying that lahar deposit (Scott and others, 1995). While the eruption(s?) that likely produced the lahar and the tephra were probably moderate in size, the laharic floods of this age inundated valleys as far downstream as the Ports of Seattle and Tacoma. Both the Osceola Mudflow deposit and granodiorite of the White River pluton are visible along the road approaching MP 5.

5.3 *8.5* Granodiorite crops out near the junction of Sunrise Park Road and the Yakima Park Road to the White River Campground. On the north side of the river, slightly downstream of the bridge, mafic dikes are exposed in stream-polished outcrops of the White River pluton.

OPTIONAL SIDE TRIP: White River Campground and trailheads. The type locality for the quartz diorite of White River is found about 0.3 mi (0.5 km) up the road to the campground (Mattinson, 1977). Mattinson obtained U-Pb ages of 14.1 Ma on two populations of zircons in that pluton. Outcrops between 0.1 and 0.5 mi (0.16–0.6 km) are quartz diorite. The campground ranger station is at 1.0 mi (1.6 km). An avalanche chute and debris fan (Fig. E-4) are visible from loop D at 1.5 mi (2.4 km). Farther up the White River, the hornfels-grade contact between the White River pluton and the Ohanapecosh Formation is exposed. Details on the geology of this pluton can be found in Murphy and Marsh (1993).

For early-season hiking when other alpine areas are still snow covered, consider the Emmons Moraine Trail. This area is in a precipitation shadow, so it commonly gets less snow. Where the Moraine Trail turns south, the Inter Fork Trail continues west and ascends into beautiful Glacier Basin, where limited mining went on in the early 1900s. (See the "Mining in Glacier Basin" sidebar on p. 98.)

Depending on the season or weather conditions, Sunrise Road may be blocked beyond this point. If this is the case, you may still be able to access the Moraine Trail and Inter Fork Trail trailheads. To do this, turn left into the campground and drive to the parking area at the far west end, then walk west from the parking area.

Remember to compensate for mileage along the side trip.

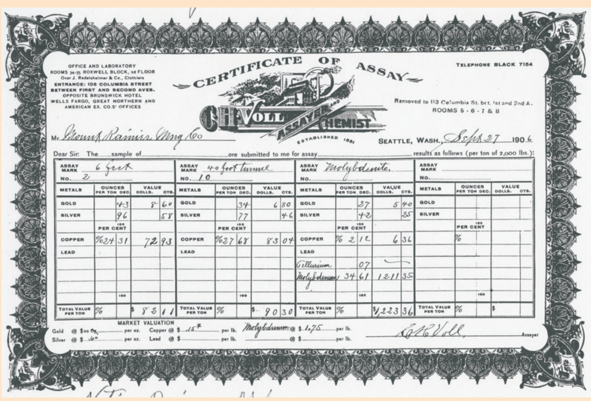
5.4 *8.6* The clay-rich Osceola Mudflow overlies debris flow deposits slightly past the road junction.

Mining in Glacier Basin

by Rebecca A. Christie and Katherine M. Reed

Glacier Basin, on the northeast side of Mount Rainier, is in the upper reaches of the White River. The park had an interest in making all sides of the park accessible to visitors, and mining offered a potential way to reach this goal. However, park managers later thought that mining was not in concert with the purpose of the park and gradually acquired mine properties. In the end, miners realized that the return for their efforts was not adequate, but they had prepared the roadways that take today's visitors to Glacier Basin. (See also the "Mining in Mount Rainier National Park" sidebar on p. 90.)

The Mount Rainier Mining Company in Glacier Basin had the most extensive copper and silver workings in the park. Peter Storbo and his associates made 41 claims in 1898 (Filley, 1996), forming their company in 1905. The *Tacoma Daily Ledger* reported that the ore's assayed value was as high as $458 per ton (Martinson, 1966; silver in 1898 dollars was worth about $0.43 per 0.77 ounce, and the average price of copper was 12.03 cents per pound [The Mineral Industry, 1899; Schrader, 1898]).


OFFICE AND LABORATORY
ROOMS 34-35 ROXWELL BLOCK, 3d FLOOR
Over J. Redelsheimer & Co., Clothiers
ENTRANCE: 106 COLUMBIA STREET
BETWEEN FIRST AND SECOND AVES.
OPPOSITE BRUNSWICK HOTEL
WELLS FARGO, GREAT NORTHERN AND
AMERICAN EX. CO.S' OFFICES

CERTIFICATE OF ASSAY

C. H. VOLL ASSAYER AND CHEMIST ESTABLISHED 1881

TELEPHONE BLACK 7154

Removed to 113 Columbia St. bet. 1st and 2nd A.
ROOMS 5 - 6 - 7 & 8

Mr. Mount Rainier Mng Co SEATTLE, WASH., Sept 27 1906

Dear Sir: The sample of ore submitted to me for assay results as follows (per ton of 2,000 lbs.):

Assay Mark	6 feet, No. 2		40 foot tunnel, No. 10		Molybdenite, No.		No.	
Metals	Ounces per ton	Value	Ounces per ton	Value	Ounces per ton	Value	Ounces per ton	Value
Gold	.43	8.60	.34	6.80	.27	5.40		
Silver	.96	.58	.77	.46	.42	.25		
	Per cent		Per cent		Per cent		Per cent	
Copper	% 24.31	72.93	% 27.68	83.04	% 2.12	6.36	%	
Lead								
Tellurium					.07	—		
Molybdenum					34.61	1211.35		
Total value per ton	%	$ 82.11	%	$ 90.30	%	$ 1,223.36	%	$

MARKET VALUATION
Gold @ $20.67 per oz. Copper @ $ .15 per lb. Molybdenum @ $ 1.75 per lb.
Silver @ $ .60 per oz. Lead @ $ per lb. @ $ per lb.

C. H. Voll, Assayer

Relations between park management and the company were never smooth. In 1911, the Secretary of the Interior concluded that the numerous irregularities (including the fact that no discovery of vein or lode had been made) were enough to start proceedings against the company. The company subsequently (possibly consequently) gave up 32 claims. Eight remaining claims covering about 165 acres (~66 hectares) were patented in 1924.

A 12 x 14 ft shack built in 1948 on the old hotel site. From a 1952 Mount Rainier Mining Company/Storbo report from Douglas B. Evans to the superintendent of Mount Rainier National Park. Photo courtesy of the National Park Service.

By 1930, miners had dug several tunnels and prospect pits, erected a water-powered sawmill, two cabins, a barn, a blacksmith shop (Thompson, 1981), and even a sewer system. Ore was taken out by wagon and pack horses to Enumclaw (at 40 cents per ton [in a November 1915 letter from the Park Supervisor to the Secretary of the Interior]), where it was forwarded to the Guggenheim smelter in Tacoma (Thompson, 1981).

In the interest of increasing tourism, the park allowed the mining company to build a 20-mi (38 km) road up the White River to Glacier Basin (Martinson, 1966). By 1916, a new hotel and boarding house to accommodate 40 people was under construction at the mining site; it apparently was never finished. In addition, the road proved to be too steep for most traffic, as well as of very rough construction (Thompson, 1981), and thus the "hotel" was essentially idle. Not only did the road to Glacier Basin extend across the slippery, clay-rich deposits of the Osceola Mudflow and glacial drift in most of its steep uppermost reaches, it was also adjacent to the Inter Fork of White River in that area. Therefore after rainstorms severely damaged the road in 1926, it would remain quite primitive even with repairs. At about this time, Park Superintendent Reaburn noted that the ore assayed at only $60 per ton, too low to make an interesting profit (if any). As the Park Service was beginning development in the Yakima Park area (1929–1931), it allowed the last three miles of the wagon road to Glacier Basin to revert to a trail (Catton, 1995).

Mill and mine site buildings. Generator building to the left. Safety breaker and ruins of water wheel are on the right. Photo courtesy of the National Park Service.

In the late 1920s, Storbo and his associates were accused of misrepresenting the company and cheating stockholders, and in November 1930, Storbo and another officer were found guilty of fraudulent use of the U.S. Mail to promote stock sales. The trial was widely reported in Seattle and Tacoma newspapers; see, for example, the *Tacoma Daily Ledger* of Nov. 29, 1930. The men served 18 months of hard labor at McNeil Island penitentiary and were fined $1,000 each.

The mine was revived briefly in the late 1940s under the management of Ole (or Tomine) and Thor Oakland; 47 tons of ore was sent to a smelter in Tacoma in 1948. However, costs again exceeded profit. After several years of company offers and government counteroffers, in 1984 the government bought the last remaining inholding of the mining company's land for $55,800, far less than the mine owners thought the claims were worth (Ripp, 1999).

The ruins of the stone cellar walls of the hotel at Camp Storbo, a rock foundation of a cabin, and mine tailings can still be seen in Glacier Basin. ■

Dwight "Rocky" Crandell estimated that the mudflow was at least 700 ft (~210 m) thick here (Schultz and Smith, 1965, p. 28). This would be impressive but for the fact that about 2.5 mi (4 km) upstream of here, USGS geologist Jim Vallance found a runup deposit of the Osceola Mudflow in a small cirque slightly downslope of Baker Point that was 1500 ft (457 m) above the current valley floor!

The Osceola Mudflow is visible in places as a layer less than 33 ft (10 m) thick for about the next mile (1.6 km), with Mount St. Helens tephra layers Yn, C, and Wn visible on top of it in some outcrops.

5.6 *9.0* Another outcrop of granodiorite.

6.3 *10.1* The Osceola Mudflow deposit is exposed at the top of a rock wall on the left near a gravel turnout on the right at a sharp bend to the left (north).

6.6 *10.6* Still more Osceola Mudflow exposed here; note the altered rocks in the poorly sorted layer.

Figure E-5. Geologist Yukio Hayakawa examines tephra layers of Pleistocene age exposed along Sunrise Road about 6.9 mi (11 km) from SR 410. These tilted beds might be part of a slump block. This photo was taken in 1996, and the layers are now covered by slopewash.

6.9 *11.1* Tephra layer about 60 ft (18.3 m) above the road. More tephra is exposed for the next 0.5 mi (0.8 km)(Fig. E-5). Some of these dipping bedded ash layers are likely reworked and are possibly deposited in a basin behind a lateral moraine.

7.0–7.4 *11.2–11.9* Spectacular columns of Mount Rainier Andesite, as well as till, a tephra of pre-Evans Creek age (>22 ka), and beds of fine material (glacial-lake deposits), are visible between miles 7.0 and 7.4.

7.7 *12.4* Exposures begin of the andesite of Burroughs Mountain lava flow.

photo by Beth Norman

Figure E-6. Nearly horizontal lava columns in the Burroughs Mountain flow. They are one of the clues that indicate it was emplaced against glacial ice (Lescinsky and Fink, 2000; see Fig. 27, p. 30). The bounding glacier, which headed on Mount Rainier, must have occupied the White River valley.

7.8 *12.5* Pullout with a sign explaining the formation of horizontal columns. The andesite in the outcrop here has abundant plagioclase crystals (Fig. E-6). This flow is one of the longer intracanyon flows that preceded the main cone-building stage of the volcano. Work by Stockstill and others (2002) shows that as the flow followed the course of the ancestral White River, it likely chilled against a glacier that at one time filled the valley to form the picturesque, nearly horizontal columnar joints exposed in the roadcut. Stockstill and her colleagues also found that the flow is rather large, at 0.8 mi^3 (3.4 km^3), and that the lava is compositionally stratified or zoned. This demonstrated to the researchers that, despite complex magmatic recharge events, Mount Rainier has been capable of developing shallow magma chambers that show compositional zonation, with the less dense, but more explosive felsic magma higher up in the magma chamber—a trait shared by volcanoes that produce explosive ash-flow tuffs.

8.0 *12.8* The layers of fine lacustrine sediments just around the bend from the lava columns are quite impermeable and thus almost always look moist because they are relatively impervious to ground water infiltrating above (Fig. E-7). These sediments likely accumulated in glacial lakes that were dammed up along the margin of a large valley glacier occupying the White River valley. At another turnout slightly farther along there is a diamict, possibly a lahar or pyroclastic flow deposit, overlain by thick tephra.

Figure E-7. Silty beds deposited in moraine-dammed lakes. This outcrop is along Sunrise Road slightly past (northwest of) the nearly horizontal columns of the Burroughs Mountain lava flow.

Figure E-8. Aerial oblique view of large landslides in Ohanapecosh Formation above SR 410. Arrows indicate the direction of flow; the slide in the center of this photo is about 0.3 mi (0.5 km) long and 0.2 mi (0.3 km) across. View is to the southeast from the Sunrise Point area.

11.6 *18.6* An andesite lava flow crops out at the switchback.

12.0 *19.2* MP 12.

12.9 *20.6* Sunrise Point switchback parking lot. This is the type locality of the quartz monzonite of Sunrise Point of Mattinson (1977). The rock is commonly altered. Mattinson (1977) used U-Pb dating of zircons to obtain an age of 24 Ma for these rocks, considerably older than the nearby White River pluton, described above at the optional side trip to White River Campground.

In fine weather, you can see a sweeping panorama of the North Cascades, as well as views of selected peaks in the southwest Washington Cascades and the enormous Mount Adams volcano to the east and south respectively. On the near west-facing ridge to the southeast, several large landslides in the Ohanapecosh Formation rocks move slowly from year to year, creating maintenance problems along SR 410 (Fig. E-8). Blocks of the Ohanapecosh rocks are moving along dip slopes that encourage the masses to slide to the west.

13.8 *22.2* An andesite flow can be seen in this outcrop.

13.9 *22.2* MP 14.

14.0 *22.5* A complex upper and lateral boundary between the Sunrise Point pluton and the Ohanapecosh Formation is exposed here.

14.6 *23.5* Roadcuts to the north (now mostly covered with grasses), across from a turnout on the left (south) side of the road, expose orange Mazama ash, which is overlain by the blocky rubble of layer S (the 'Sourdough rubble') and pumiceous layers from Mount Rainier (Fig. E-9; see also Fig. 34, p. 37). Mazama ash, known as layer O, was produced by the enormous eruption that created Crater Lake in Oregon (7,500 cal yr B.P.).

The tephra once known as the Sourdough rubble or layer S has been reinterpreted by Jim Vallance to be a basal layer of set F, which is associated with the Osceola Mudflow. This layer is visible in this area of Yakima Park as a 6-in. (15 cm)-thick train of sand and angular Mount Rainier rocks that lies about 3.3 ft (1 m) below the ground surface. Mazama ash is exposed immediately underneath the rubbly phase of layer F. The basal layer F rubble is found on Goat Island Mountain (there consisting of much larger blocks) and northward to Huckleberry Park. From the size and distribution of the ejected rocks, Mullineaux (1974) concluded that a laterally directed phreatic explosion deposited this layer. Rocks greater than 20 in. (50 cm) in diameter can be found about 6 mi (10 km) from the Rainier summit! These large rocks are not similar to the Tertiary-age rocks composing the ridge to the north, so it is not likely they rolled downslope to their present location from that ridge. Fresh Mount Rainier rocks exposed in gullies along the Silver Forest Trail (south from Sunrise) could also be part of layer F.

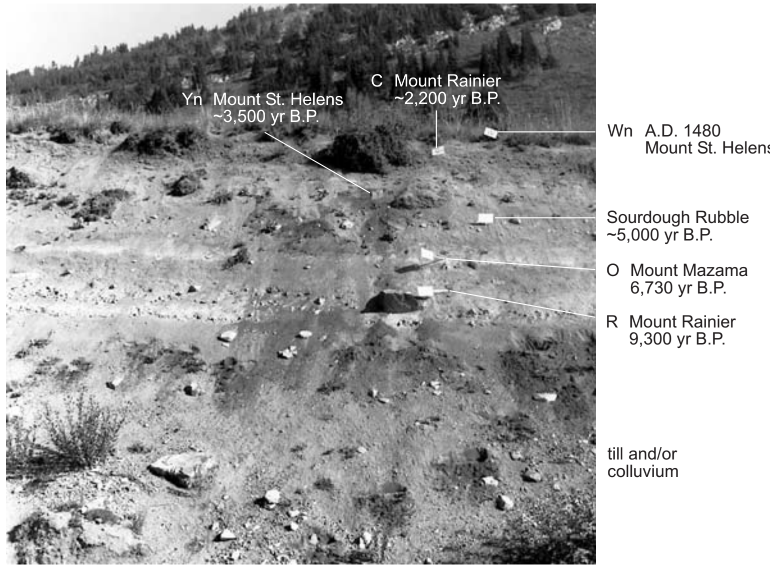


Figure E-9. Tephra layers along Sunrise Road at Yakima Park. The tephra deposits were labeled for the 1965 field trip of the International Association for Quaternary Research; vegetation now covers most of these layers. From the uppermost label to the lowest is about 6 ft (1.8 m). View is to the north, with Sourdough Mountain on the horizon. National Park Service photo.

15.6 *25.1* Sunrise Visitor Center and Ranger Station. (This is a good place to get trail maps.) At the Sunrise parking lot, you can see the great splendor of Mount Rainier's east face. It is a sight that inspires many, as you can see from a photo by Asahel Curtis (see frontispiece). This is one of the best places to see the amphitheater-shaped crater created by the Osceola Mudflow. Remnants of the crater rim are seen at Point Success, Liberty Cap, the uppermost exposures of Willis Wall, and other headwalls. The dark ribs (lava flow levees) that protrude through Emmons Glacier (see Fig. 1, p. 1) were sampled by USGS geologists Tom Sisson and Jim Vallance for their paleomagnetic orientation. They found that these levees have a paleomagnetic orientation similar to that of the rocks of block-and-ash flow deposits in the upper Puyallup River valley that were erupted about 2,450 yr B.P. Thus, this lava flow was likely produced during the same eruptive episode.

Visitors may want to take the optional short hike up the Sourdough Ridge Trail to Sourdough Mountain (0.4 mi; 0.6 km) for additional views or take other trails. A popular and shorter option is to take the Emmons Vista Trail (0.3 mi [0.5 km] round trip; south of the parking area), which leads to several scenic overlooks. From Emmons Vista there are more glimpses of the magnificent east face of Mount Rainier (Fig. E-10).

The 1963 debris avalanche deposit is plainly visible on the surface of the Emmons Glacier, from which the White River can be seen emerging. The deposit, which is made up of at least seven distinct avalanches, originally extended about another mile (1.6 km) downstream to within 0.5 mi (0.8 km) of the White River Campground and had a volume of about 14.4 x 10^6 yd^3 (~11 x 10^6 m^3) (Crandell and Fahnestock, 1965; Fahnestock, 1978). Fortunately, the avalanches occurred in December when the area was deserted. Estimates of flow runup onto the back of a terminal moraine indicated a distal velocity of 80 to 90 mi/hr (35–40 m/sec). High velocities, almost certainly in excess of 70 mi/hr (30 m/sec), increase the risk with this type of event. The avalanches originated from the side of Little Tahoma Peak, possibly triggered by a steam explosion. The flow passed over an old stream gage house, leaving it undamaged, showing that the flow was likely riding on a cushion of trapped air in some places.

Figure E-10. The spectacular northeast face of Mount Rainier from the Emmons Vista overlook, about 100 m (~300 ft) south of the Sunrise parking area. Goat Island Mountain is the erosional remnant at left center on the skyline; it is composed of granodiorite of the White River pluton, as well as volcanic rocks of the older Stevens Ridge and Ohanapecosh Formations. Geologist Jim Vallance found a runup deposit of the Osceola Mudflow in the meadow visible downslope of Baker Point, 1500 ft (457 m) above the present valley floor. Note the amount of recession of the Emmons Glacier terminus from its advance position during the Little Ice Age, which is marked by the lateral and terminal moraine and trimline on Goat Island Mountain. The small lake in the center of the photo is moraine dammed; its volume changes from year to year.

In July 1974 and again on Aug. 16, 1989, similar but smaller avalanches fell from Russell Cliff and traveled 1.2 to 2.5 mi (2–4 km) down Winthrop Glacier. Although the 1989 avalanche was only about 10 percent of the size of the Little Tahoma Peak avalanches, seismic signals generated by it were recorded as far away as 124 mi (200 km) (Weaver and others, 1990). The size and nature of the seismic signal of the Russell Cliff avalanche led a curious USGS seismologist, Bob Norris, to re-check the records from December 1963. He discovered a large signal on December 6 that is tentatively thought to correlate with the avalanches from Little Tahoma Peak (which were previously thought to have occurred on Dec. 13 or 14, 1963) (Norris, 1994).

During his investigations of Mount Rainier in the mid-1990s, USGS geologist Tom Sisson observed localized faults on the flank of Mount Ruth and on the west side of Emmons Glacier that offset a talus slope, with the Emmons side downthrown. He noticed a similar fault that lies on the west slope of Disappointment Cleaver, also downthrown toward the Emmons. It appears that rock masses must periodically spall off these fracture surfaces and slide down the Emmons, and this was likely the cause of the 1963 rockslides.

You can retrace this leg to get back to SR 410 and Leg D, from which you can continue to explore the Mount Rainier area.

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