LEG D: NORTHERN APPROACH

Sumner to Cayuse Pass on State Route 410

State Route (SR) 410 is the Chinook Pass Scenic Byway. This 56-mi (~90 km) leg follows the western portion of the byway, which begins by ascending from the flood plain of the Puyallup River (near Puyallup and Sumner) to cross part of the great Puget Lowland drift plain veneered by glacial sediments (Figs. 2 and D-1). The route enters the Cascade Range slightly east of Enumclaw and leads to the upper reaches of the rugged White River basin, which drains Mount Rainier's east face and the crest of the Cascade Range. The byway follows a part of the historic Naches Trail, traversed by both local tribes and early settlers, and eventually crosses the Cascade Range via Mount Baker–Snoqualmie and Wenatchee National Forests and Mount Rainier National Park to connect with the fertile Yakima River valley (see Leg F, p. 102). Stephen T. Mather, an early 20th century conservationist and first director of the National Park Service, recognized the scenic and recreational value of this area, and in 1928 he suggested special provisions to protect the scenery along this new state highway.

The broad Puyallup and Duwamish River valleys were in large part cut into the surface of the great Puget Lowland drift plain by rivers flowing under the mighty Puget lobe of the continental ice sheet as it surged south between the Olympic and Cascade mountains (see Fig. 6, p. 8). After you climb out of the flood plain of the Puyallup River and as the highway approaches Buckley and Enumclaw, you begin, almost imperceptibly, to traverse the deposits of the enormous Osceola Mudflow from Mount Rainier, which spilled onto the drift plain about 5600 years ago. As the road enters the Cascade Range, it ascends a staircase of Pleistocene-age terraces and crosses the broad glaciated valley of the White River. The valley is floored by a stack of postglacial Mount Rainier lahar deposits—evidence that enormous, sediment-charged slurries from Mount Rainier have sloshed by like swift rivers of flowing concrete.

Radiocarbon dating of recently excavated trees in downstream areas has revealed that during three periods in the past 2700 years, these lahars or lahar runouts

Figure D-1. Geologic map for Leg D (five consecutive panels). The geology was adapted from 1:100,000- and 1:500,000-scale digital versions of Schasse (1987b), Walsh (1987), Tabor and others (2000) 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.

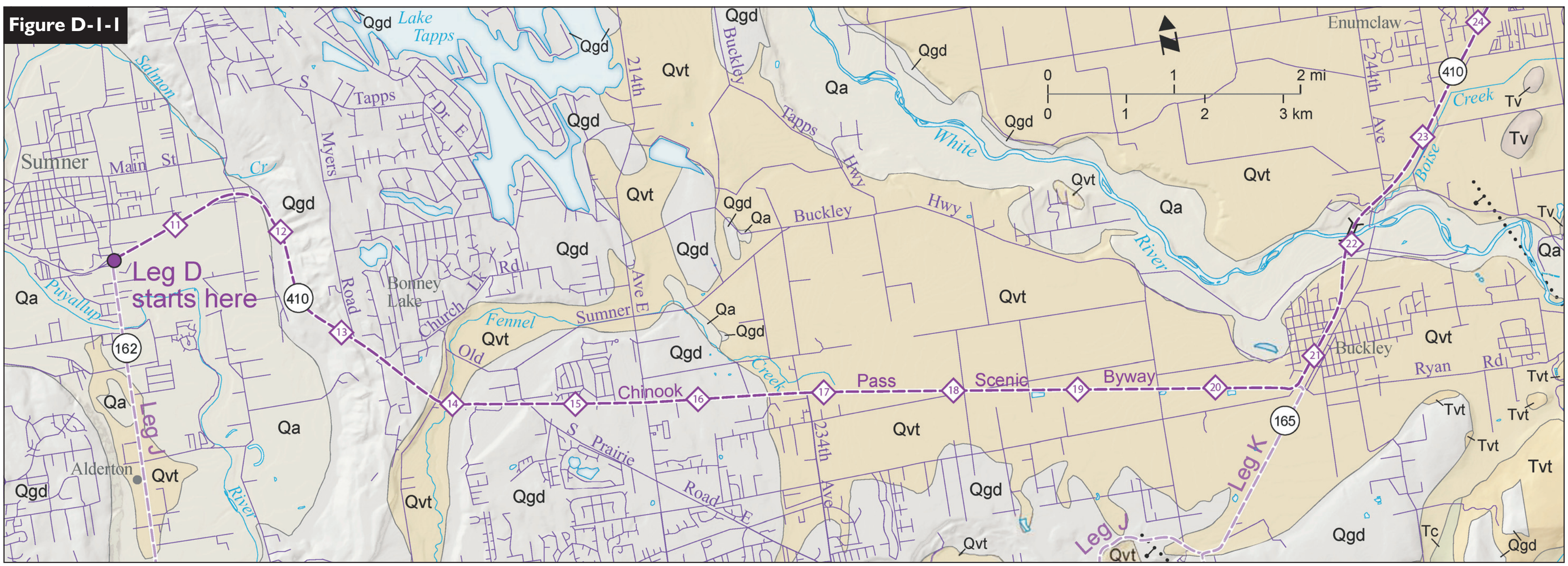


Figure D-1-1

caused catastrophic flooding and aggradation in the lowlands. Zehfuss (2005) and Zehfuss and others (2003a) note that deposits younger than the Osceola Mudflow define at least three episodes of clay-poor lahars in the White River drainage. Their inferred history is based on previous work by Crandell (1971), Scott and others (1995), and Pringle (2000) and on their own new results. The oldest of their three episodes of lahars in this area coincided with volcanism of Summerland age (~2,700–2,200 cal yr B.P.) when as many as five eruptions may have occurred (Vallance and Donoghue, 2000). Next came two episodes that correspond to the Deadman Flat assemblage of Scott and others (1995). The name 'Deadman Flat' is no longer used for this assemblage. Instead, the older of these is provisionally called the Twin Creek episode and the younger is provisionally called the Fryingpan Creek episode.

The Twin Creek lahars date at from about 1,700 to 1,350 cal yr B.P., on the basis of the range of three ages on detrital wood and charcoal from deposits along White River. Wiggle-matching of several radiocarbon ages from a single, bark-bearing log exhumed at Kent yielded an age of about 1,500 cal yr B.P. (Vallance and Pringle, this volume, p. 34). The Fryingpan Creek episode occurred about 1,100 yr B.P., as determined from buried stumps at Auburn and Fife (Pringle and others, 1997; Vallance and Pringle, this volume, p. 34). Similarities in the pattern of tree rings of some of the Fife and Auburn trees show they likely died at about the same time.

Here and there on the edges of the valley that you drive along as you head east from Enumclaw, 20- to 30-ft (6–9 m)-wide mounds of rock debris, most of which are made up of Mount Rainier rock, are testimony to the passage of one of the world's largest lahars, the Osceola Mudflow. At Federation Forest State Park, the road sits on top of terraces composed largely of the clay-poor, post-Osceola lahars from Mount Rainier noted above.

As you enter the forest lands past the town of Greenwater and drive toward Cayuse Pass, you will begin to see more exposures of bedded, pastel-colored volcanic rocks, welded tuffs, granodiorite, and landslide deposits—all providing evidence of a dynamic, and at times tumultuous, geologic past.

The highway is closed in winter (typically November to late June) past the Sunrise Road (Leg E) turnoff near milepost 62. 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.

<u>Mileage</u>

0.0 *0.0* This leg begins on SR 410 where it intersects with SR 162, just south of the town of Sumner. Set the trip odometer where the road goes under the SR 162 bridge. This arbitrary starting point is about 1.5 mi (2.4 km) east of where you access SR 410 from either SR 512 or SR 167. The broad Duwamish valley was carved during and after the Vashon glaciation. A detailed study of well logs in this valley bottom (Dragovich and others, 1994) confirms that before deposition of the great Osceola Mudflow about 5,600 years ago, an arm of Puget Sound extended from what is now the Port of Seattle to about 6 km (3.7 mi) north of Sumner (at present sea level). Similarly, in the Puyallup River valley, an arm of the sound would have extended southeast to near the west boundary of the city of Puyallup (see Fig. 36, p. 38). Apparently, more than 155 mi^2 (400 km^2) of new land was created by deposition of alluvium (mostly lahar derived) in the Puyallup and Duwamish valleys since before the Osceola Mudflow.

Sandy deposits from Mount Rainier tens of yards (meters) thick, as well as fluvial deposits, now underlie the valley floor, having been deposited mainly by lahars and lahar runouts from Mount Rainier or as a result of the volcanic flooding and aggradation that likely occurred for decades following each volcanic disturbance. One of these, the lahar of about 1,100 yr B.P., probably discharged from the White River canyon to the Duwamish valley at Auburn and branched: one lobe flowed north and sent a major flood of sediment as far as the Port of Seattle, while another flowed south into the present Puyallup Valley and buried forests near Fife. Probably not long after that lahar flooded the lower Duwamish River, the area was instantaneously jerked upward as much as 20 ft (6 m) when the Seattle Fault ruptured in the interval from A.D. 900 to 930 (Atwater, 1999; Zehfuss and others, 2003a).

0.5 *0.8* Milepost (MP) 11.

1.4 *2.3* Begin the climb up along the valley wall on SR 410.

1.6 *2.6* MP 12. Glacial outwash gravels crop out on the east side of the highway.

2.3 *3.7* More Pleistocene gravels crop out on the east side of the road. There is a good view of the valley to the west and southwest. The broad Puyallup River valley south of here and its northward extension, the Duwamish valley, were probably carved by meltwaters at the keel of the advancing Puget lobe of the Vashon glacier between 22 and 15 ka. Although vegetation covers most of the valley walls here, over the years geologists have examined outcrops to try to piece together the geologic history. Deposits of the Vashon glacier typically cap the plateau, and geologists used to think that, in layer cake fashion, the next layer of glacial deposits below the Vashon represented those of the penultimate glaciation. They were in for a surprise! Easterbrook and others (1981) and Westgate and others (1987) confirmed a revolutionary interpretation of the ages of many of the pre-Vashon layers when they dated a layer of coarse tephra near Sumner at about 1 Ma. That layer, the Lake Tapps tephra, sits atop the Salmon Springs deposits that had previously been considered to be only about 75 ka in age! Easterbrook and his coworkers had confirmed that the Salmon Springs deposits were more than one million years old. But why would the events of nearly 1 m.y. (between the Vashon Drift and Lake Tapps tephra) be "missing" from the record?

Recently geologists have begun to reassemble this puzzle. Not only has the Puget Lowland undergone a complicated erosional and depositional history and multiple glaciations, but faults in the upper 30 mi (50 km) of the Earth's crust have ruptured, lifting some areas and lowering others many meters at a time. Large parts of the 'record' have been removed, and much has been 'imported', creating a challenge for geologists. A later development in this fascinating story is that USGS geologist Wes Hildreth (1996) found that the Lake Tapps tephra had a geochemistry nearly identical to that of the pumice erupted from the

Kulshan caldera northeast of Mount Baker, some 110 mi (176 km) to the north!

3.0 4.8 City of Bonney Lake.

3.5 5.6 Fennel Creek. About 5600 years ago, a distributary lobe of the enormous Osceola Mudflow surged through this valley. After passing through the Fennel Creek valley, the road continues east across an area of glacial drift known locally as the Enumclaw plateau or plain.

4.2 6.6 South Prairie Road East.

7.8 12.6 Begin crossing the Osceola Mudflow deposit. As enormous as this mudflow was, by the time it reached here from Mount Rainier it did not have the volume to inundate the entire plateau area, so it spread out to a critical thinness, much like pancake batter on a griddle, and ponded locally. Where it was confined within valley walls, it continued to flow downstream.

9.2 14.8 City limits of Buckley.

9.6 15.4 MP 20.

10.2 16.4 Junction with SR 165. To access Leg K (p. 87), which describes the geology along SR 165 to Mowich Lake and the Carbon River area, you can turn south (right) here, then go about 0.25 mi (0.4 km) and make another right turn. (Remember to reset the odometer when starting Leg K.)

At the towns of Buckley and Enumclaw, the highway traverses a plain capped by the Osceola Mudflow. Scattered large boulders or mounds deposited by the mudflow are visible on the surface of the plain, but for the most part the terrain is smooth and lacks the mounds commonly visible in localities farther upstream. Within a few miles of this area, an archeological excavation unearthed more than 200 knives, projectile points, scrapers, and other artifacts beneath the Osceola Mudflow deposit (see Fig. 9, p. 12)—evidence of human occupation of the area before and possibly at the time of the mudflow (Williams, 1973; Hedlund, 1976). Hedlund also found artifacts on top of the Osceola Mudflow; these were made of obsidian and jasper not found on the west side of the Cascade Range, whereas the artifacts found under the Osceola Mudflow were made primarily of andesite and basaltic material obtained nearby.

11.0 17.7 Buckley urban center.

11.5 18.5 Cross the White River power canal. The graveyard on the east side of the road is probably underlain by lahar deposits of the past 1100 years.

11.7 18.8 Lahar deposits at the White River bridge at MP 22. The White River drains the east and northeast slopes of Mount Rainier. The upper White River valley was the main pathway for the Osceola Mudflow. Note the enormous 'Osceola' rocks in the river. Deposits of at least three lahars are exposed several hundred yards (meters) downstream of the bridge on the north side of the river.

The Osceola Mudflow here is a 9- to 16-ft (3–5 m)-thick cap on the glacial deposits of Vashon age that form the highest (~100 ft or 30 m) terraces near the river. Inset against the high Vashon-age terraces is a 20-ft (6 m) terrace that includes at least two layers of lahars. The lahar deposit that caps the terrace contains rounded grains of set C pumice from Mount Rainier (~2,200 yr B.P.); however, this lahar is likely to correlate with the lahar that buried trees in Auburn and Fife about 1100 years ago and left deposits as far north as the Port of Seattle. It probably picked up the older pumice as it flowed along the White River valley.

Continue east on SR 410 through Enumclaw.

14.0 22.5 Not far beyond MP 24 and before a curve to the right (if eastbound), notice that the bedrock beds in the mountains ahead seem to dip to the right (~southeast) (Fig. D-2). These are the folded volcanic rocks of the Huckleberry Mountain Formation of Oligocene age studied by Hammond (1963), Frizzell and others (1984), and Tabor and others (2000). The Huckleberry rocks are likely correlative with the Ohanapecosh Formation, whose age was bracketed by Vance and others (1987) by fission-track dating at 36.5 to 28.3 Ma.

14.5 23.3 Junction of SR 410 with SR 164 and Griffin Ave.

14.7 23.7 MP 25.

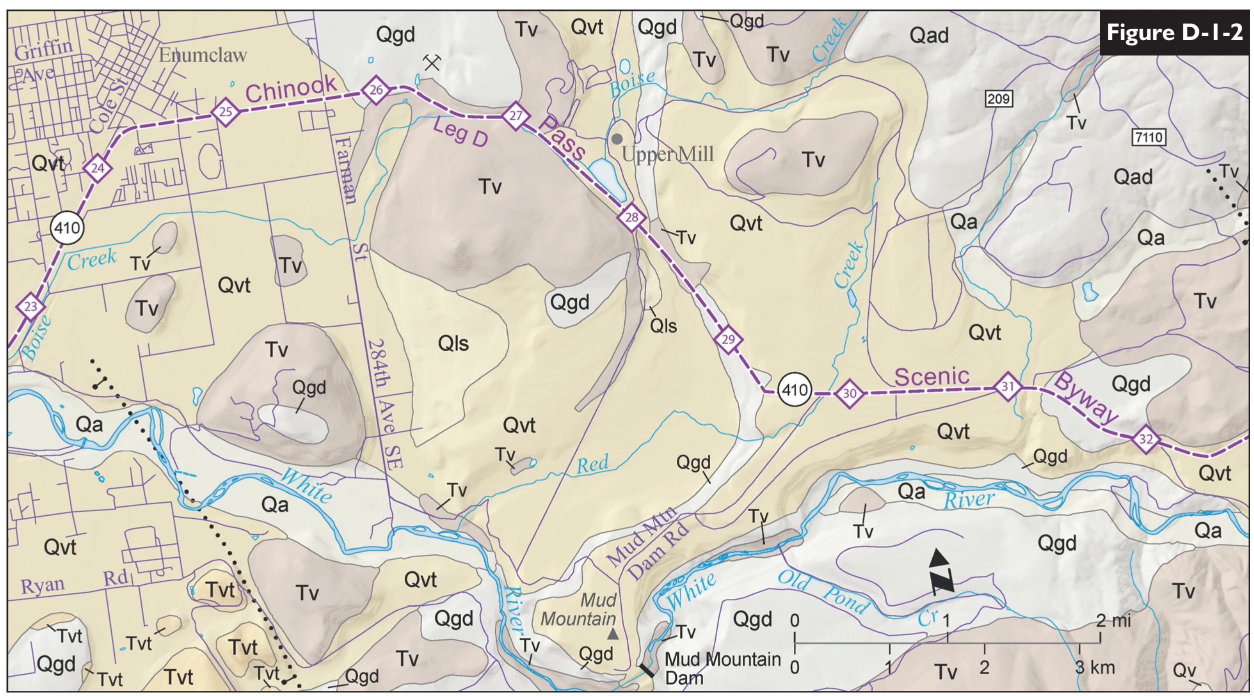


Figure D-1-2

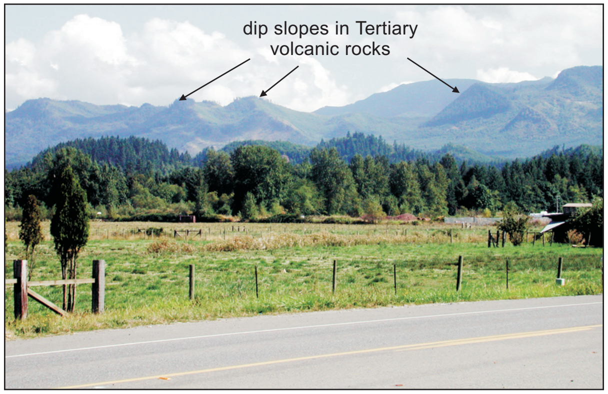


Figure D-2. View to the northeast from Enumclaw showing southwest-dipping beds of folded volcaniclastic rocks of the Huckleberry Mountain Formation (Oligocene) along the Cascade mountain front.

14.8 23.8 Small U.S. Forest Service and National Park Service offices are on the right side of the road.

15.3 24.6 Junction of SR 410 with 284th Ave SE (Farman St.). The Department of Natural Resources South Puget Sound Region office is on the right. Stay on SR 410. From here you begin to ascend three terraces situated where the White River valley meets the Puget Lowland. The Osceola Mudflow veneers all three terraces. (See the Mud Mountain Dam stop at mile 19.5.)

16.0 25.7 Begin ascending the second terrace. You'll see the first (westernmost) exposures of Cascade Range andesites and basaltic andesite of the Fifes Peak Formation along the highway at about mile 16.8 (slightly east of MP 27).

18.0 29.0 The 410 Quarry outcrop of Fifes Peak Formation andesite is probably about 24 to 23 Ma (Hammond, 1998).

19.5 31.4 **OPTIONAL SIDE TRIP:** Mud Mountain Dam (slightly west of MP 30) (restrooms and view with exhibit). From the junction of SR 410 and Southeast Mud Mountain Road (there is a large sign at the intersection for the Mud Mountain Dam Recreation Area), you can drive 2.4 mi (3.8 km) on the access road and then a short distance left to the dam viewpoint. A trail winds down to the lower viewpoint (20-minute round-trip walk); however, the upper viewpoint is impressive. A landslide in

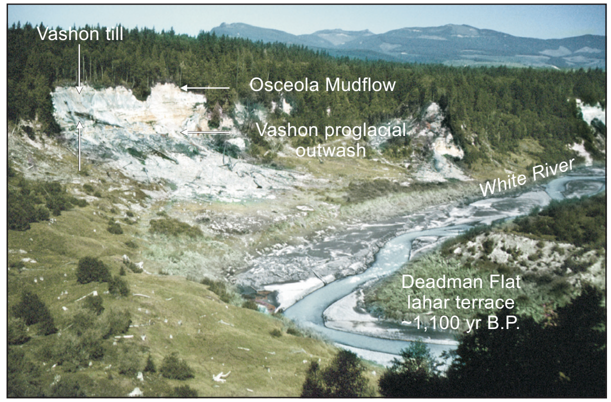


Figure D-3. View northeast from the Mud Mountain Dam overlook showing the Holocene and Pleistocene deposits exposed in the valley walls by a landslide that occurred during the flooding event of February 1996. From the top of the till to the river level is about 350 ft (110 m). The Vashon till was deposited by a re-entrant tongue of Puget lobe ice that pushed its way up the White River valley as much as 4.5 mi (7.2 km) from the east margin of the lowland. The steep canyon walls are quite unstable. This photo was taken in September 1996.

1996 exposed deposits on the valley wall to the north, including hummocky topography of the great Osceola Mudflow (Figs. D-3 and D-4). Vallance and Scott (1997) described the path of the Osceola Mudflow as it cascaded onto the Puget Lowland east of Enumclaw: "When it [the Osceola] encountered a narrow gorge of the White River at Mud Mountain that is only 300 m [984 ft] wide, the Osceola Mudflow spread out over glaciofluvial [and till] terraces of Vashon age that are up to 110 m [361 ft] above the White River...As it continued westward, the mudflow poured over terrace scarps to form a spectacular pair of falls...The upper fall would have formed an arc more than 6 km [3.7 mi] wide and more than 80 m [263 ft] high, and the second would have been more than 3 km [1.9 mi] wide and more than 110 m [361 ft] high."

Mud Mountain Dam was built by the U.S. Army Corps of Engineers solely for flood control in the lower White River basin (Fig. D-5). The earth-fill embankment dam was constructed between 1939 and 1942, although floodgates were not constructed until 1948. Additional information about the dam can be found in Galster (1989a,b).

photo by Beth Norman

Figure D-4. The area in Figure D-3 as it looked in September 2007. An assemblage of deposits comprising post-Osceola Mudflow lahars and lahar-derived sediments caps at least three terraces about 1 mi (1.6 km) upstream of the dam.

photo by Beth Norman

Figure D-5. Mud Mountain Dam. This earth-fill embankment dam was constructed for flood control in the lower White River basin.

The pointed peak sporting a radio antenna and visible to the southeast from the Mud Mountain Dam picnic parking area is the northern end of The Three Sisters, a northwest-trending ridge. The ridge's southeast flank was recently identified as a volcanic vent by USGS Geologist Tom Sisson (written commun., 1998), who noticed cemented spatter with possible feeder dikes and a "...1.5–2-m [2.4–3.2 ft] thick pumice fall that lies between the Tertiary basement and the lava, with pumice lumps to 20 cm [7.9 in.]". He dated the olivinebearing basaltic andesites there at about 360 ka (Sisson and Lanphere, 1999). Sisson observed that, although these rocks were erupted about 17.4 mi (28 km) north-northwest of Mount Rainier's summit, they are chemically similar to the basaltic andesites of the Echo and Observation Rocks vents on Mount Rainier's northwest flank.

An assemblage of deposits comprising post-Osceola Mudflow lahars and lahar runouts caps at least three terraces about 1 mi (1.6 km) upstream of the dam (Fig. D-4). One of these flows left a gravelly layer whose top is at about 1200 ft (366 m) elevation, more than 200 ft (61 m) above the river (Fig. D-6).

Remember to compensate for mileage along the side trip.

21.5 *34.6* Not far west of MP 32, the road cuts a mound in the Osceola deposit; its remnant is south of the road.

21.7 *34.9* MP 32.

22.1 *35.5* The roadcut on the north side of the road exposes hydrothermally altered Tertiary andesite estimated to be of early Miocene age by Hammond (1980). McCulla (1986) noted two circular areas between the White River valley and Mount Rainier that he interpreted to be shallow intrusive complexes. Zones of alteration that surround these circular features and that bound nearby faults have been dated at 19.0 to 20.3 Ma (Blakely and others, 2007). Several mining districts are associated with these areas of altered rock. (See the "Mining in Mount Rainier National Park" sidebar on p. 90 and the "Mineralization and Mining Northwest of Mount Rainier" sidebar on p. 91.) Along the White River, the altered rock is locally rich in alunite ($KAl_3(SO_4)_2(OH)_6$), a mineral commonly formed in volcanic areas where rocks are altered by solutions containing sulfuric acid. The altered rock serves as a silica resource for the Superior quarry, one of Washington's three silica mines. The silica being

Figure D-6. *(right)* Andy Roth examines a megaclast-bearing lahar runout deposit in the canyon of the White River valley upstream of Mud Mountain Dam. The large boulder is floating in the matrix of the deposit. The reddish-brown blob to its right is a large, fragile chunk of sandy fragmental debris that was picked by the lahar as it flowed downstream—note the bedding within it that dips to the left. Another sandy megaclast is visible behind Andy's left shoulder. These delicate clasts, which probably originated as chunks of alluvium that fell into the moving lahar, suggest that lahars can flow as a plug of sediment moving as a mass. This lahar runout layer extends roughly from Andy's knees to about 3 ft (1 m) over his head. The preservation of graffiti and 'pictographs' on the outcrop made by previous visitors attests to the compact nature of the lahar runout deposit.

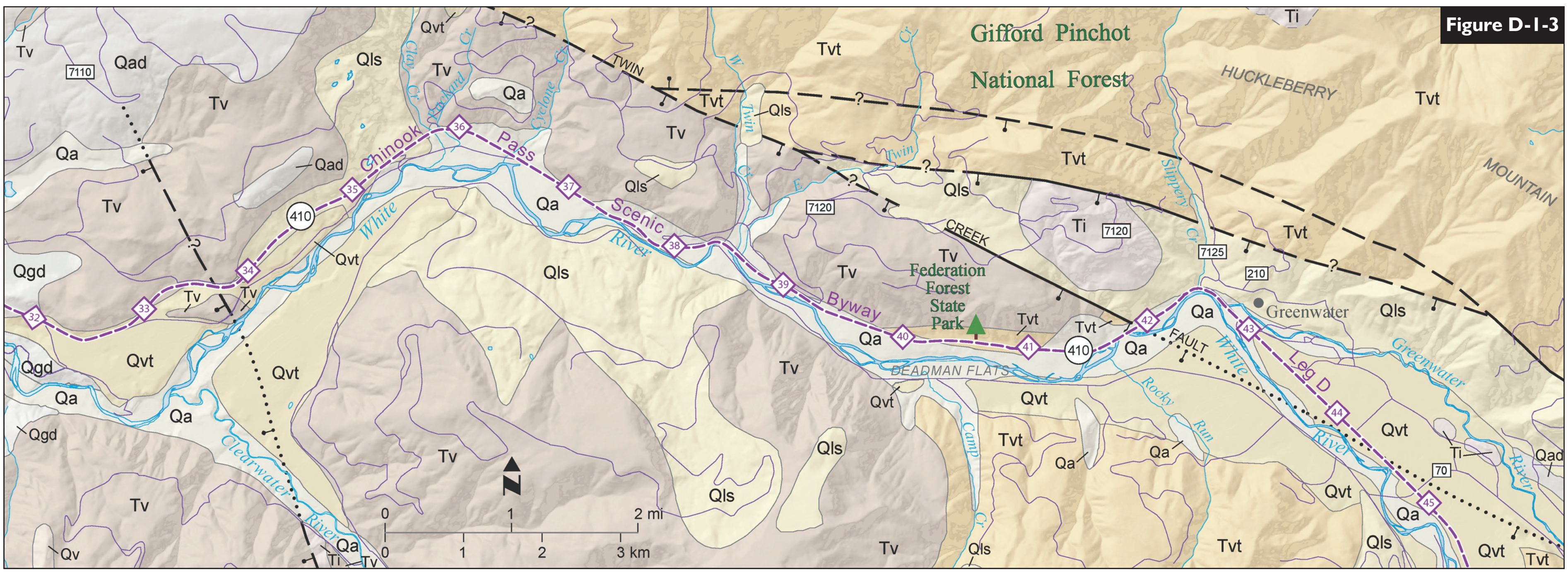


Figure D-1-3

Mining in Mount Rainier National Park

by Rebecca A. Christie and Katherine M. Reed

In 1897, the 18th annual report of the U.S. Geological Survey noted that the park boundaries "have been so drawn as to exclude from its area all lands upon which coal, gold, or other valuable minerals are supposed to occur, and they conform to the purpose that the park shall include all features of peculiar scenic beauty without encroaching on the interests of miners and settlers" (Russell, 1898, p. 413). However, Section 5 of the 1899 legislative act that established Mount Rainier National Park extended the federal mineral laws, the Mining Law of 1872 in particular, to lands within the park, perhaps because the act was copied from that for Yellowstone (Catton, 1995). Secretary of the Interior Cornelius N. Bliss asked that Section 5 be repealed because it seemed inconsistent with the purpose of parks. Acting Park Superintendent G. F. Allen was aware that prospecting activity was increasing rapidly—to as many as 165 mineral seekers in 1906. Claim staking then was an informal action, with many locations too vague for proper recording. Claimants were probably hunting illegally in the park and were cutting trails and building crude cabins. A further concern of park officials was how to proceed with permitting timber cutting and road building for developing claims, as well as the effects of water diversions and mills, and of patented mine inholdings. As a result of Allen's concerns and those of a park engineer, by the Sundry Civil Appropriations Act of Congress approved May 27, 1908, staking mining claims was no longer allowed in the park, although existing claims were not affected.

Before 1908, hundreds of claims had been filed, although nearly all were quickly abandoned or invalidated. For example, 41 claims had been filed for land in Glacier Basin on the northeast shoulder of Mount Rainier. (See the "Mining in Glacier Basin" sidebar on p. 98.) The number of active claims declined to about 30 by 1912. Park Ranger T. O. Farrell, who had considerable contact with the miners from 1908 to 1924, alone succeeded in getting 90 of those claims declared invalid.

Thompson (1981) provides a thorough history of these and other mining activities in the park. On the whole, mining was not profitable in the park and beyond its boundaries.

MINING IN THE UPPER NISQUALLY VALLEY

Eagle Peak Copper Mining Company

Mary Gehrett, later Mrs. Baiker Long, filed the Aldula lode claim at Eagle Peak in 1903 (Filley, 1996), and the adjacent Paradise lode claim was filed by her husband and her son, Roy H. Wheelock, in 1906. The Eagle Peak Copper Mining Company, encompassing all of these claims, formed in 1908 and mined copper 1.5 mi (2.4 km) upstream of Longmire on the south side of the confluence of the Paradise and Nisqually Rivers (see Fig. A-1-4, p. 61). Around 1909, they "...installed on the mill site...an oil flotation mill for reducing ores, [an] aerial tramway from the tunnels on the lodes across the river to the mill site, a pipe line to supply water for the mill and domestic use, a tool house, ore bunker, bunk house to house the workers" (U.S. Department of the Interior, 1933). Reaburn (1918) reported that during the winter, the ore was hauled out on sleds.

The claims covered 41.3 acres (16.5 hectares) and produced about 200 tons (~190 metric tons) of ore between 1919 and 1928 (Derkey and others, 1990, p. 148). Thompson (1981), however, noted that in about 1930 a mining inspector indicated that only 45 tons had been shipped in a decade, the total profit being only $455. Huntting (1956, p. 61) reported that the ore assayed at 8.05 percent copper, less than 0.1 ounce per ton silver, and some cobalt. In the 18-ton assay shipment, only 1.87 ounces of gold was found, and it was associated with arsenopyrite. There was also about 0.04 percent uranium (Martin, 1971). The mineralization was in joints in granite or granodiorite just north of an area underlain by the Stevens Ridge Formation.

Tomlinson (1930) quotes a letter: "the last car load taken out some three or four years ago and shipped to a smelter in Tacoma did not contain enough mineral to pay for the freight to the smelter. It was necessary for the company to borrow money to meet the freight bill". No mineral production was reported after 1930 (Martin, 1971).The company managed to do just enough work to keep the claims legal, but the park continued to maintain that use of the mill site could be by park permission only (E. L. Parsegan, Park Ranger, unpublished history, 1966). In a 1932 hearing, a Tacoma commissioner declared the mill site claim null and void, but the company won an appeal in 1933. Filley (1966) wrote "As late as 1955, the company was still proposing developmental plans and insisting that Eagle Rock was a valuable copper claim". Mr. Wheelock continued to seek more development of the Eagle Peak Company property until his death in 1966.

In his 1971 assessment, A. L. Martin, a mining engineer, found that the cost of mining greatly exceeded the average value of the rock. He concluded, "There are no mineral reserves nor indications that the land could ever be used for economic mineral production", recommending that the company be "served through adverse contest proceeding". Park officials bought this property in 1974.

Paradise Mining and Milling Company

Reaburn (1915) noted that tunnels were being developed on the Sherman and Ike Evans claims, adjacent to the Aldula and known as the Paradise Mining and Milling Company workings, also on the south side of the rivers. A 1931 assay showed no gold, a trace of silver, and 13.47 percent copper (Filley, 1996). Huntting (1956, p. 61) noted that 40 tons assayed at 10 percent copper and that the ore was in a "slip plane in andesite". However, little ore was shipped, possibly because the company did not have clear permission to take ore across the Nisqually River, despite having built a tramway. In 1948, the Rainier National Park Company offered to buy the claims from the aging Evans brothers, but the men could not produce a clear title (Thompson, 1981). The property was transferred to the government in 1950—for $6000 in condemnation. A. L. Martin, in the report cited above, commented that this sum may have been the only profit made by the unpatented mine.

A visitor looking at Eagle Peak from the west side of the Nisqually River can discern little evidence of mine tunnels, although the mining practices did cause some scarring of the steep mountainside.

Short Canyon Mining Company

In about 1902, the Hendricks family located several quartz-lode gold claims on the Paradise River above (east of) Longmire springs and the Eagle Peak and Paradise claims. Huntting (1956, p. 61), however, mentions only copper and molybdenum at this property. The claims were developed (shafts, a tunnel, at least two buildings) and worked until 1915, when some Seattle investors bought the claims. Assessment work was not done, and the claims were annulled in 1923 (Catton, 1995).

MINING OPERATIONS IN THE CARBON RIVER VALLEY

The Washington Mining and Milling Company received permission in 1907 to build a road from their 38 lode claims (ore minerals not identified) in the park 6 mi (~10 km) to an existing road near Fairfax; the road was to become federal property on completion. When the road was inspected in the fall of 1907, only the part in the park was complete, the rest being a trail (Thompson, 1981). Large quantities of park timber had been removed, far more than went into road construction. Although some development work was done during parts of the following two years, the company gave up 21 claims in 1909, likely out of fear of adverse proceedings. The remaining claims were relinquished several years later (Catton, 1995), and the company stopped operating in the park by 1913.

In 1908 and 1909, the Hephizibah Mining Company had six claims on Sweet Peak (see Fig. L-1-2, p. 153) and a 5-acre (~2 hectares) mill site claim below the mountain, and they had felled timber around this site. A logging railroad along the Carbon River had by now reached to within a few miles of the claims. Park officials concluded that the mining claims were really an attempt to harvest timber and that the mill site claim was invalid, partly because there was no road on which to haul out the ore. The company objected. Inspection by a General Land Office mineral expert led to the opinion that the claims were valid. However, the Secretary of the Interior Richard Ballinger was unconvinced and proposed further examination. Little further work was done at the mine thereafter, and in 1923 the claims were annulled (Catton, 1995). ■

photo by Beth Norman

Figure D-7. Hydrothermally altered andesite along the north side of SR 410 slightly east of MP 38.

mined was probably deposited along fracture systems in a hot-springs type environment during the late phases of alteration (John and others, 2003). Silica is used for making many products including glass, abrasives, and semiconductors.

22.5 *36.2* Hydrothermally altered andesite crops out on the north side of the highway along a curve.

23.9 *38.5* Emergency pullout on the south side of the road. The wide glacial valley of the Clearwater River, tributary to the White River, is visible to the southwest. Glaciers that carved the Clearwater valley probably headed in the high peaks of the Carbon River stock, a granodiorite intrusion of Miocene age that lies to the south.

24.8 *40.0* Near MP 35 the road reaches the west edge of a large Quaternary landslide that covers about 5.3 mi^2 (14 km^2). Note the irregularities in the roadbed over the next 0.7 mi (1 km) caused by occasional movement of this landslide. The landslide heads along the southeast-trending Twin Creeks fault. Hammond (1980) mapped the fault along the slope to the north of the highway.

Additional zones of altered rock occur along northside roadcuts for the next 5 mi (8 km).

26.8 *43.1* Near MP 37, gently west-dipping columnar-jointed andesite lava flows of Miocene age are visible on the north side of the road.

27.2 *43.7* More andesite crops outs north of the highway.

Mineralization and Mining Northwest of Mount Rainier

by Rebecca A. Christie, Katherine M. Reed, and Patrick T. Pringle

The rocks generally northwest of Mount Rainier in the informally named White River altered area are mostly hydrothermally altered Fifes Peak Formation. The alteration occurred near small plutons and other intrusive rocks and along nearby faults. The alteration in the White River area was dated at 20.3 to 19.0 Ma by Blakely and others (2007).

The White River area altered rocks are largely andesite, basaltic andesite, and dacite flows and breccias; polymetallic veins and epithermal deposits carry copper, silver, and gold. The minerals occur in zones of argillic and propyllitic alteration (John and others, 2003). The distribution of the silica-rich altered rocks was probably structurally controlled. Blakely and others (2007) note, "based on its similarities with Goldfield, [Nevada, the] White River [area] may have potential for concealed precious and/or base metal deposits at shallow depth… Gravity and magnetic anomalies provide evidence for a pluton beneath the White River altered area that may have provided heat and fluids to overlying volcanic rocks. East- to east-northeast-striking extensional faults and (or) fracture zones…may have tapped this intrusion and provided vertical and lateral transport of fluids to now silicified areas", perhaps validating the early 20th century mineral explorations.

In the 1930s and 1940s, the mineralized rocks of the White River area were explored for alunite ($KAl_3(SO_4)_2(OH)_6$), particularly near Enumclaw (see map, inside front cover). Alunite is a source of potash (K_2CO_3), and before this time the United States had relied on German sources of potash that later were embargoed during World War II (Bates, 1969, p. 371). Drilling by Kalunite, Inc. in 1940 indicated nearly 590,000 tons of alunite, but that was likely not enough to pay for erecting a plant to process the ore (Valentine and Huntting, 1960, p. 5). No production was reported.

While exploration for silica in the altered rocks started about 80 years ago, the new understanding of its geology has sparked a renewed interest in this resource. The silica is concentrated as rocks are leached by hydrothermal alteration. At the Superior silica quarry north of SR 410 near Enumclaw, Ash Grove Cement Co. mined about 110,000 tons (~100,000 metric tons) of silica in 2001; the silica was used to make cement. At the Scatter Creek silica quarry, just northwest of the Superior quarry, the James Hardy Building Products Co. mined about 120,000 tons (~109,000 metric tons) of silica in 2001. The silica went to manufacture fiber cement for siding products (Derkey and Hamilton, 2002). Both quarries are still active (2007), but production figures are proprietary. ■

27.8 *44.7* MP 38.

28.0 *45.0* Pullout on the right. The outcrop north of the road is hydrothermally altered andesite (Fig. D-7). The White River is south of the highway.

28.2 *45.4* The road curves to the right. A quick view of the White River, adjacent to the highway, seasonally shows the high turbidity that results from glacial rock flour and other suspended sediments in this glacially fed stream. The road passes over West Twin and East Twin Creeks. Clay-poor lahars of the past 2700 years and the clay-rich Osceola Mudflow are exposed in the West Twin and East Twin Creeks area. USGS geologist Jim Vallance (written commun., 1994) found that the highest exposure of the Osceola Mudflow here is at least 75 m (246 ft) above the White River. To visualize how deep the Osceola must have been in this area, Crandell (1971) noted that 2 mi (3.2 km) farther east along the road, near the Federation Forest State Park campground and south of the highway, a water supply well penetrated the Osceola Mudflow at a depth of 200 ft (61 m)! Thus the actual flow depth of the Osceola in this reach was likely more than 135 m (443 ft)!

28.9 *46.5* Federation Forest State Park boundary.

30.8 *49.5* (~MP 41). The road here is on a terrace composed of sandy, clay-poor lahars of the past 2700 years. The most recent of these has been dated upstream of here at about 1,120 yr B.P. (Scott and others, 1995). The largest lahar in this assemblage was at least 60 ft (18 m) deep at this location.

30.9 *49.7* Entrance (right) to the Federation Forest State Park interpretive center is just south of SR 410.

31.1 *50.0* Scattered mounds or hummocks in the Osceola Mudflow deposit poke up through the fairly flat-topped, younger lahars.

31.4 *50.5* There is a good view of the White River (south) and an outcrop of platy andesite (north).

31.5 *50.7* Picnic area adjacent to the White River along the south side of the road (slightly west of MP 42).

photo by Beth Norman

Figure D-8. Platy andesite lava of the Huckleberry Mountain volcanic rocks is exposed along the road about 0.8 mi (1.3 km) west of Greenwater.

31.8 *51.2* MP 42.

32.0 *51.5* Pullout to the right. Platy andesite lava of the Huckleberry Mountain volcanic rocks is exposed along the road here (Fig. D-8). The age range of about 35 to 25 Ma, similar to that of the Ohanapecosh Formation, was determined by K-Ar and fission-track methods (Frizzell and others, 1984; Tabor and others, 2000).

32.3 *52.0* The rubbly, poorly sorted Osceola Mudflow deposit is exposed on the north side of the road about 0.1 mi (~0.2 km) before it crosses the Greenwater River.

32.5 *52.3* Platy andesite crops out on the north side of the road.

32.8 *52.8* Town of Greenwater (~MP 43). Lahars have left abundant deposits in this area, perhaps because downstream of here the valley is fairly constricted. Upon reaching the narrowed valley, the main pulse of a lahar would have hydraulically ponded somewhat to leave terrace-capping veneers and valley-filling deposits in upstream areas. As a lahar drained, its more watery recessional phase would have quickly downcut into the freshly laid sediments as the White River tried to reestablish equilibrium following each volcanic disturbance.

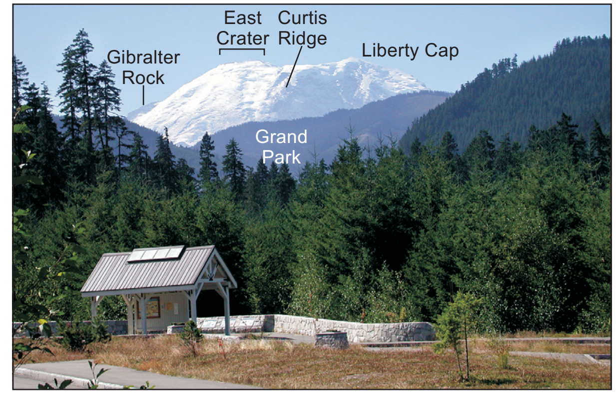


Figure D-9. View of Mount Rainier from the MP 49 viewpoint along Mather Memorial Parkway (SR 410). East Crater, the youngest feature on the volcano's summit cone, is about ~0.25 mi or 0.4 km wide. The summit is about 18 mi (29 km) distant. View is to the south-southwest.

The West Fork White River joins the White River about 2 mi (3.2 km) to the east. This fork drains the northeast slope of Mount Rainier, head-

Figure D-1-4

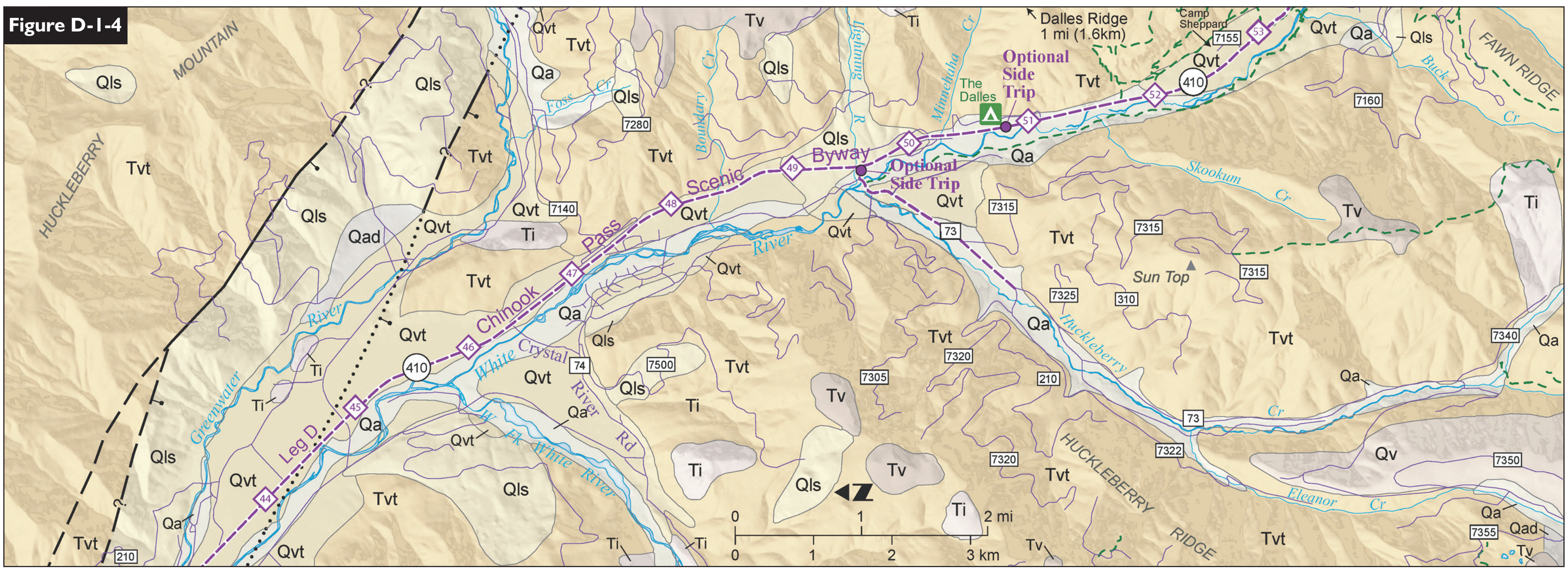


Figure D-10. Crude columnar jointing in a welded lapilli tuff of Miocene age near the Skookum Falls Viewpoint on SR 410. Paul Hammond (Portland State Univ., written commun., 2003) has mapped this tuff as the lowest three or four subunits in the lowest pyroclastic flow of the Sun Top tuff, which occurs along the west face of Dalles Ridge and along the ridge to the west of the White River. Hammond has obtained a radiometric age of about 22 Ma for the Sun Top tuff. This outcrop is about 20 ft (6 m) tall.

ing at Winthrop Glacier. The West Fork valley was one of the pathways of the great Osceola Mudflow.

34.7 Forest Road (FR) 70 on the north accesses the up-
55.8 per reaches of the Greenwater River and the Naches Pass area. Hiking trails accessible via this road include the trail to Greenwater Lakes, which are dammed by landslides. The easternmost lake contains a submerged forest that can provide clues to the age of the landslide damming it.

36.4 Pullout at the entrance to Mount Baker–
58.5 Snoqualmie National Forest. This stretch of road is named the "Mather Memorial Highway" after Stephen T. Mather, the first director of the National Park Service.

37.7 Mather Memorial Viewpoint at MP 49. From here
60.7 you can gaze south through the broad glacial valley of Huckleberry Creek to Mount Rainier. The east flank of the young Columbia Crest cone protrudes from the crater left by the great Osceola Mudflow (Fig. D-9).

39.2 **OPTIONAL SIDE TRIP:** Osceola Mudflow hum-
63.0 mocks via FR 73. The mounds of the Osceola Mudflow deposit are commonly obscured because they are tucked up against the sides of valley walls or back in the trees. SR 410 passes by several mounds, but they are difficult to see. To see them in better exposures, you can turn off on FR 73 (slightly east of MP 50) to the southwest up Huckleberry Creek and follow the gravel road across a bridge at 0.3 mi (0.5 km). At 0.8 mi (1.3 km) you will pass the entrance to the R. Nevan McCullough seed orchard. At 1.3 mi (2.1 km) there is a 'Y' in the road (intersection of FR 7315 and 73). Here bear right, staying on FR73 and continue for another 0.4 mi (0.6 km) to see several large tree-covered mounds (10–20 ft or 3–6 m in height) adjacent to the road. A forest road turn-around point is located 1.8 mi (2.9 km) from SR 410 at the intersection of FRs 73 and 7720.

While being interviewed for the 1996 documentary film "Perilous Beauty", retired geologist Dwight "Rocky" Crandell recounted his early thoughts about the nature and origin of the Osceola Mudflow: "…I came up with the idea that perhaps it had actually flowed into place, like a giant mudflow…and it was just like a light going on over my head, because everything I knew about the deposit fit this kind of origin—that it had…flowed into place, and it had not been formed by a glacier at all. But the question in my mind: if it was a mudflow, then how did it get started, and where did it come from? … I had no idea at all, even though I was standing there on the plain formed by this mudflow, and I could see Mount Rainier in the distance. And I didn't make the connection for a long time…We could hardly believe our eyes when we actually saw a remnant of the same deposit there at the tip of Steamboat Prow" (U.S. Geological Survey, 1996).

Crandell and Donal Mullineaux, another USGS geologist who studied the volcano in the 1960s and 1970s, originally interpreted the mounds as part of an older flow that they called the 'Greenwater lahar'. However, near The Dalles south of MP 50, USGS geologist Jim Vallance found only one lahar unit exposed in each of four test pits that were adjacent to or between hummocks and that were only 200 m (656 ft) west of a gravel pit exposure of Osceola Mudflow (Scott and others, 1995). The hummocks, mainly consisting of rock debris of only one rock type from Mount Rainier, were evidently grounded on the margins of the valley as the Osceola Mudflow ponded in backwater areas. About half the rocks in that Osceola outcrop were from Mount Rainier; others are 'exotic' or non-Mount Rainier rocks, such as intrusive rocks of Miocene age, that were picked up by the lahar as it flowed (Crandell, 1973).

Remember to compensate for mileage along the side trip.

39.3 MP 50.
63.2

40.2 **OPTIONAL SIDE TRIP:** The Dalles Camp-
64.7 ground. For those who have time to explore this campground, there are several features of interest. Geologists have identified many lahar deposits from Mount Rainier near here. Two terraces are not capped by Wn tephra from Mount St. Helens (late A.D. 1479), the white to light-gray, sand-size pumice that is commonly found in the soil layer in the northeast sector of Mount Rainier; hence the lahar deposits here are likely younger than this date. A higher and presumably older terrace is also underlain by Mount Rainier lahar runouts. The campground also has a yet-higher surface with lahars of post-Osceola age underlying it, and Osceola Mudflow deposits are exposed in several places along the river. To access the river, go through campsite 39.

One set of exposed stumps, some of whose tops have been sawed off, are visible near the river. These were buried by a debris flow from

Minnehaha Creek. Judging by the degree of decomposition of the trees, this flow occurred sometime in the last 150 years, but probably much more recently (see Fig. M-4, p. 157).

Fragmental deposits including glacial drift and lahar deposits crop out about 0.3 mi (0.5 km) south of The Dalles Campground.

Remember to compensate for mileage along the side trip.

41.3 66.4 Skookum Falls Viewpoint. An interpretive sign here discusses rock flour caused by the grinding of glaciers, as well as the Osceola Mudflow. Note the crude columnar jointing in the brownish bedrock across the road to the east (Fig. D-10). This outcrop was mapped by Hartman (1973) as Stevens Ridge Formation welded lapilli tuff. However, Paul Hammond interprets this exposure to be the lower three or four units of the welded Sun Top tuff (Miocene) that he had identified at Dalles Ridge and which Tabor and others (2000) had previously assigned to the Fifes Peak Formation. Hammond (Portland State Univ., written commun., 2003) has dated this tuff at about 22 Ma. The waterfall on Skookum Creek plummets over the same rock unit on the southwest side of the river.

41.9 67.4 MP 52.

42.7 68.7 Entrance to Camp Sheppard trailhead (FR 7155) and view of spectacular cliffs of Sun Top tuff up the road. To view the cliffs you must turn up FR 7155.

44.2 71.3 Buck Creek Recreation Area, FR 7160. For those who are westbound, the imposing cliff straight ahead on the skyline is Dalles Ridge, composed of Sun Top tuff.

45.5 73.2 FR 7172 and entrance to Alta Crystal Resort on the left.

45.8 73.3 The dark-colored bedrock outcrops east of the road are Ohanapecosh Formation volcaniclastic rocks of Oligocene age. Large blocks, as much as several feet across, sit above bedded silts.

46.0 74.0 MP 56.

46.5 75.0 Silver Springs Campground. A water-supply well for a U.S. Forest Service ranger station penetrated the Osceola Mudflow at a depth of about 15 m (48 ft) and was still in it when drilling stopped at 61 m (196 ft). Nearby, the mudflow veneers the valley sides 38 m (122 ft) above the river (Crandell, 1971).

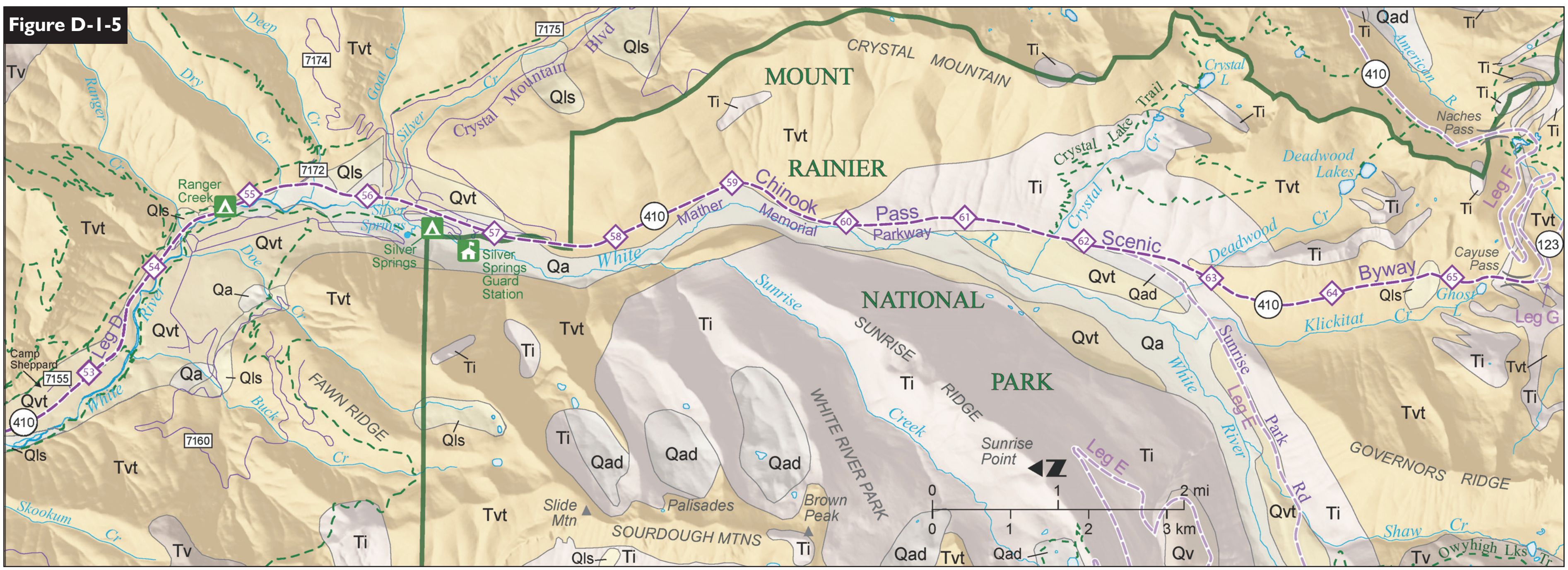
46.8 75.3 Silver Creek Guard Station and U.S. Forest Service information station (open spring through fall).

47.6 76.6 Turnoff to Crystal Mountain ski area.

47.7 76.7 Mount Rainier National Park boundary.

49.3 79.3 Vertical contact between the Ohanapecosh Formation and Sunrise Point pluton. This is the northern boundary of the Sunrise Point pluton. (See mile 12.9, p. 100.) Oligocene Ohanapecosh Formation lavas and breccias make up the country rocks. The contact slices across contours on either side of the White River, and the Ohanapecosh is only mildly altered, unlike the hornfelsed Ohanapecosh rock farther upstream. The Sunrise Point pluton is a quartz monzonite at this location. Fiske and others (1963), in their pioneering geologic map, showed the basic relations between the upper part of Crystal Mountain—mainly

Figure D-1-5



Ohanapecosh Formation—and the intrusive rocks below. Many sills and dikes cut the Ohanapecosh rocks. Downslope, near the highway, outcrops contain less alkali feldspar and consist of quartz diorite or granodiorite. This is geologically interesting because the dikes and sills are younger (Miocene) than the overlying Ohanapecosh (Oligocene)—the Ohanapecosh rocks are literally the roof of older rocks over the chambers of the magma that later intruded them and are now long solidified.

The west slopes of Crystal Mountain have proven to be of great interest as a location where climate and geologic materials have influenced vegetation. At about 5300 ft (1615 m) elevation, in the basin holding Lower Crystal Lake, naturalists Susan McDougal and David Biek (Tacoma Public Library, oral commun., 2003) have found an extraordinarily rich spot in which there are 13 species of conifers within a 100-m (328 ft) radius. This location may be so diverse because it has rich soils and has endured many climate fluctuations without undergoing a major disturbance. The site is just high enough above the valley bottom that for at least 130,000 years it escaped being overrun by any valley glacier occupying the White River valley (or the great Osceola Mudflow), and at the same time it is just low enough that it was not destroyed by a cirque glacier from the Crystal Lake basin.

51.7 *83.2* Crystal Lake Trailhead.

51.9 *83.5* Sunrise Road veers off to the southwest slightly past MP 62. This road provides access to the Sunrise area of Mount Rainier National Park via Yakima Park Road (see Leg E). It also leads to the White River Campground area and many trails. Stay on SR 410.

52.6 *84.6* About 0.5 mi (0.8 km) south of the Sunrise Road junction, a turnout on the west side of the road allows an excellent view of Mount Rainier and the upper White River valley (Fig. D-11). Be careful of traffic—this can be a busy viewpoint.

53.0 *85.2* Cross Deadwood Creek. Note the rock fragments exposed in a landslide on the north side of the bridge.

53.4 *85.9* At the pullout near here (eastbound), there is a good view into the valley. On the west side of the road, there is an outcrop of granodiorite sills and dikes that cut and alter Ohanapecosh rocks.

54.3 *87.4* Note the rough condition of the road over the next mile (1.6 km); the road is on a landslide (not shown on map) and is constantly being repaired. This large landslide and one slightly to the south are moving westward along west-dipping beds of Ohanapecosh Formation into Klickitat Creek (see Fig. E-8, p. 99).

54.8 *88.2* Cross a ravine that exposes rubble from the large landslide of Ohanapecosh rocks on the south side and bedrock on the north side.

55.1 *88.6* MP 65.

55.4 *89.1* Cross another ravine that exposes rubble from the large landslide of Ohanapecosh rocks on the south side and bedrock on the north side.

There is a small turnout near Ghost Lake and the second large landslide into Klickitat Creek. The parkway crosses the slide by curving around to the right along contour and crosses another ravine that contains large boulders of Ohanapecosh rocks. Ghost Lake is 100 ft (30 m) below the road. Ghost Lake may sit on the landslide—no tree snags are visible in the lake, as could be expected if the lake were upstream of an impoundment. The diameters of two individual lichens (*Rhizocarpon geographicum*) on rocks adjacent to the lake were in excess of 85 mm (3.4 in.). From a calibration curve established by Porter (1981), these measurements suggest an age of at least 180 years for the lichens, and probably more, considering climatic factors. A study of ash layers in the lake could provide a better idea of its age.

Figure D-11. Mount Rainier, Goat Island Mountain (slightly above center), and the glaciated White River valley from a pullout on SR 410 about 0.4 mi (0.64 km) south of the Sunrise Road junction. Note the cirques on the summit of Goat Island Mountain and its glacially faceted flanks.

55.8 *89.8* Cayuse Pass (elev. 4694 ft or 1431 m). Outcrops near the junction with SR 123 are volcanic breccias and andesites of the Ohanapecosh Formation.

At this point, you can choose to continue ahead to Chinook Pass (where you can follow Leg F in reverse) or turn right onto SR 123 to continue on Leg G south toward the Stevens Canyon Entrance to Mount Rainier National Park at Stevens Canyon Road (the end of Leg B) or to access US 12 (the end of Leg C and beginning of Leg H).

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