LEG C: SOUTHERN TRANSECT ALONG THE COWLITZ RIVER VALLEY

Interstate 5 to State Route 123 via U.S. Highway 12

by Patrick T. Pringle and Elizabeth S. Norman*

This approach, the western segment of the White Pass Scenic Byway, generally follows the Cowlitz River valley to the east (Fig. C-1), where it meets State Route (SR) 123 (see Leg G). Leg H is a continuation of this route that extends across the Cascades to SR 410, Naches, and Yakima.

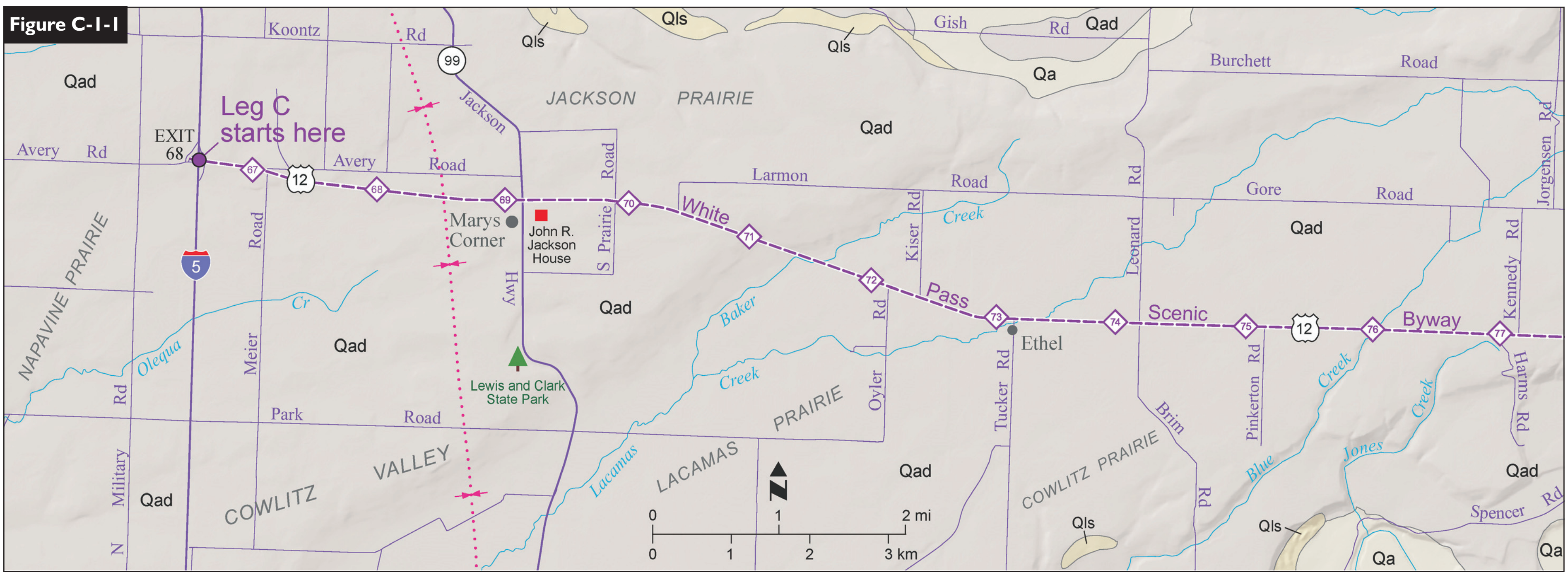
This 71-mi (115 km) route along U.S. Highway (US) 12 begins on Jackson Prairie (underlain by the Pleistocene Logan Hill Formation) and descends a series of progressively younger glacial terraces in stairstep fashion: Jackson, Lacamas, and Cowlitz Prairies or their physiographic equivalents. The older surfaces are at higher elevations and the younger ones are lower because erosion, possibly combined with a minor component of regional tectonic uplift, deepened the Cowlitz River valley before each succeeding episode of deposition. Dethier (1988) evaluated the soil formation on the terraces as related to their age; the deposits will be described en route. Dethier observed that during at least two glacial events, the Cowlitz glacier terminated more than 60 mi (100 km) from Mount Rainier, thus making it one of the longest valley glaciers in the conterminous United States.

About 4 mi (6.4 km) west of Morton, the road crosses a divide into the Tilton River drainage and remains in that watershed for about 9 mi (14.4 km) before descending back into the Cowlitz River valley near Fern Gap. East of Mayfield Lake, dark-colored rocks of the Hatchet Mountain Formation of Tertiary age crop out along the highway, indicating that you have entered the eroded and folded Cascade Range. Lava flows and fragmental volcanic rocks of this age crop out all along the route.

At Randle, this route accesses SR 131 and Forest Roads (FRs) 25 and 23, which lead to the east side of the Mount St. Helens area as well as to the Cispus River drainage and the north side of Mount Adams. (See Pringle, 2002.) Hummocky glacial deposits (end moraine and ice-marginal deposits) of Evans Creek age (~22,000–15,000 yr B.P.) near here suggest that this is

* See "Contributors", p. ii, for affiliation.

Figure C-1. Geologic map for Leg C (six consecutive panels). The geology was adapted from 1:100,000- and 1:500,000-scale digital versions of Schasse (1987a,b) 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.



the terminal position of the large valley glacier that occupied the Cowlitz River valley.

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* Mileage starts on US 12 at its junction with Interstate 5 (I-5). The road passes east over Jackson Prairie, a gently rolling terrace of the lower(?) Pleistocene Logan Hill Formation. This surface, which may be about a million years old, displays as much as 40 ft (12 m) of relief. Here, the Logan Hill Formation consists mainly of a compacted mixture of cobbles and pebbles in a sandy clay matrix. The sediment is outwash from an ancient glacier whose source was in the southern Washington Cascade mountains near Mount Rainier.

2.4 *3.8* Milepost (MP) 67.

2.5 *4.0* Marys Corner.

3.2 *5.1* Roadcuts expose the clayey, reddish, deeply weathered top of the Logan Hill Formation. Weathering reaches depths greater than 50 ft (15 m).

3.3 *5.3* MP 70.

4.1 *6.6* Good exposures of red soils of the Logan Hill Formation in a roadcut here.

4.5 *7.2* Descend from Jackson Prairie to Lacamas Prairie, the surface of an outwash plain of middle(?) Pleistocene Wingate Hill Drift. Notice that Lacamas Prairie is flatter than the older Jackson Prairie—it displays relief of only a few feet. Colman and Pierce (1981) estimated the age of Wingate Hill Drift to be about 600 to 300 ka.

7.3 *11.7* On a fine day, there is a good view of Mount St. Helens ahead and slightly to the right. Mount Adams volcano is also visible (east of Mount St. Helens), as is Goat Rocks, a mountainous remnant of an extinct Pleistocene volcano. (For more information on Goat Rocks, see Leg H, p. 124.)

9.3 *14.9* Wingate Hill outwash is exposed in a roadcut about 300 ft (90 m) west of MP 76. The reddish-brown weathering of this deposit extends to depths of 16 to 32 ft (5–10 m) and does not have the deep red hue of the older Logan Hill deposits.

11.3 *18.1* MP 78.

11.4 *18.3* Near Salkum, the road descends to a terrace underlain by outwash deposits of Hayden Creek age (~170–130 ka) and then crosses Mill Creek. This terrace is an equivalent of Cowlitz Prairie to the southwest. Till of Wingate Hill age is visible to the right just after you pass Mill Creek. The Wingate Hill terminal moraine is about a mile (1.6 km) west of here, whereas the maximum extent of the Hayden Creek glacier was about a mile (1.6 km) to the east. The hills and mountains of the Cascades come into view as you continue farther east.

15.2 *24.4* Cross Mayfield Lake (a reservoir). MP 82 is on the bridge. The concrete arch dam was completed in 1962. Glacial outwash deposits are visible north of the highway on both sides of the reservoir.

16.6 *26.7* The first outcrops of dark Cascade Range volcanic rocks (Oligocene–Eocene basaltic andesite) begin to appear in roadcuts near here.

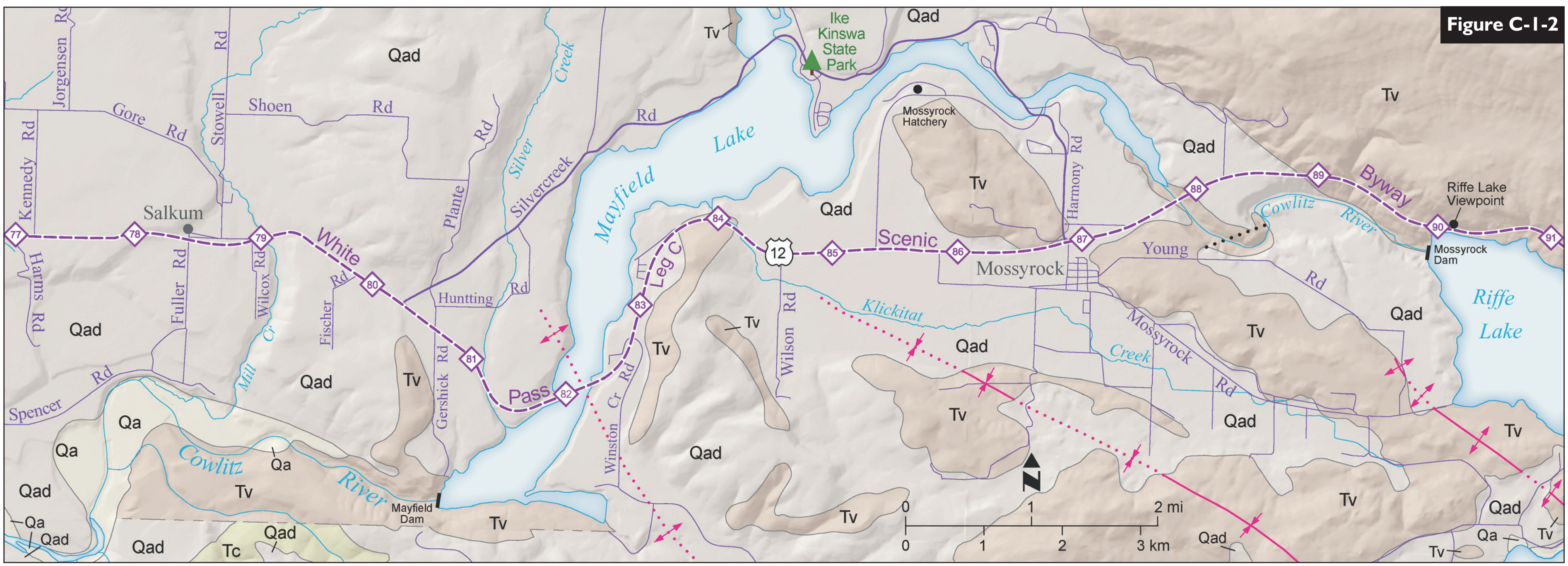


Figure C-1-2

photo by Beth Norman

Figure C-2. Goble Volcanics (Tertiary) visible in roadcuts on the north side of the highway; the layers dip to the east at the viewpoint. Beds of fragmental volcanic rocks crop out about 0.5 mi (0.8 km) farther to the east. The red soil (arrow) was baked by the lava flow that buried it. Note the steeply dipping hyaloclastite beds where lava flowed into water to trigger phreatomagmatic explosions.

17.3 *27.8* There is an outcrop of amygdaloidal basaltic andesite on the right (south) side of the highway, but no place to safely pull over and view it.

19.8 *31.8* Another outcrop of basaltic andesite on the left.

21.2 *34.1* Cross the Cowlitz River.

22.2 *35.7* The cliffs on the left (north of the highway) are more Oligocene–Eocene basaltic andesite.

22.9 *36.8* Landslide with riprap to prevent its moving onto the roadway.

23.3 *37.5* Riffe Lake Viewpoint. Riffe Lake (a reservoir) is situated in the glacially carved valley of the Cowlitz River. In this area, the Goble Volcanics (Tertiary) are visible in roadcuts on the north side of the highway; the layers dip to the east at the viewpoint (Fig. C-2). The outcrop north of the highway is mapped as andesite (Schasse, 1987a); however, the rocks contain common ovoid-shaped oxidized remnants of olivine crystals that are more typical of basalt. Beds of fragmental volcanic rocks crop out about 0.5 mi (0.8 km) farther to the east. Note

Figure C-3. Riffe Lake (a reservoir) in the glacially carved valley of the Cowlitz River. Rugged peaks of the Mount Margaret wilderness in the distance (above and left of center) are the resistant granodiorites of the Spirit Lake pluton. View is to the south.

the reddish soils in some places that were baked by the lava or pyroclastic flows that buried them and also the steeply dipping hyaloclastite beds where lava flowed into water to trigger phreatomagmatic explosions. Vugs in the lava contain opal. Opal is composed of amorphous (noncrystalline) silica and commonly contains a small percentage of water. The opal was deposited by ground water that percolated into cavities in the rock. Vertical dikes of basaltic andesite are also visible locally.

South-southeast of Riffe Lake, Mount Margaret and other peaks in the Mount Margaret Wilderness north of Mount St. Helens are composed of granodiorite and granite of the Spirit Lake pluton, whose age has been estimated at 22 to 20 Ma by Evarts and others (1987)(Fig. C-3).

23.7 *38.1* There is a good exposure of hyaloclastite beds on the left (north), but no safe place to get out and examine them.

24.3 *39.1* MP 91.

25.5 *41.0* Viewpoint for Riffe Lake. The outcrop on the left (north) is basaltic andesite.

26.2 *42.1* The road climbs past glacial drift, out of the Cowlitz drainage, and then crosses a drainage divide into the Tilton River watershed.

27.2 *43.7* **OPTIONAL SIDE TRIP:** Short Road Crater View (1.3 mi [2 km] round trip). If the weather is good,

photo by Beth Norman

Figure C-4. Zone of reddish altered rocks. Slickensides are common on these sheared rocks, although no trace of a fault is visible.

this viewpoint near MP 94 affords a distant view of the Mount St. Helens crater, neighboring mountains, and the valley of the Cowlitz River. As you climb Short Road, you'll see Bellicum Peak, a mountain to the northwest that was not covered by glaciers during the Pleistocene Epoch. Imagine this lonely peak sticking up in the middle of a broad sheet of glacial ice during the extensive Hayden Creek glaciation.

Remember to compensate for mileage along the side trip.

28.2 *45.3* As the road descends into Morton, a zone of reddish altered rocks is exposed on the left (Fig. C-4). Slickensides are common on these rocks. Although no trace of a fault is visible, this may be a shear zone.

The smooth southwest-facing hillslope visible northwest of Morton is the dip slope of a limb of a northwest-trending anticline. Folding near Morton is more complex and tightly spaced than the gentle folding typically found in the region. Whereas the crest spacing (wavelength) of the folds in the younger rocks south of Rainey Creek ranges from about 6 to 18 mi (18–30 km), the spacing in the older rocks north of Rainey Creek ranges from about 2 to 6 mi (3–10 km). Because of this more intense folding, the rocks are generally more shattered and altered, and erosion has cut a window through the volcanic rocks into the older sedimentary rocks of the Eocene Puget Group. Landslides abound in this area, which lies between two active, north-northwest-trending seismic zones, the St. Helens zone and the West Rainier zone. The West Rainier zone is about 12 mi (20 km) north-northeast of the St. Helens zone (see Fig. 3, p. 4).

31.0 *49.9* Junction of US 12 with SR 7 at Morton. Continue east on US 12.

31.3 *50.3* MP 98.

33.3 *53.5* Slightly east of MP 100, sedimentary rocks of the Puget Group crop out on the south side of the highway (Fig. C-5). These rocks for the most part predate the Cascades, but they do interfinger with the earliest Cascade volcanic rocks. Clevinger (1968, 1969) provided details about the fossils and minerals associated with rocks in this area in his two useful guidebooks (Fig. C-6).

34.6 *55.7* There is an outcrop of volcaniclastic rocks of Tertiary age on the right (southwest), but no pullout.

34.8 *56.0* Junction with Davis Lake Road. This road extends to the north and then loops back to the northwest for a few miles at the base of the foothills before its junction with SR 7 in Morton. Davis Lake and Lake Creek sit in an extension of the same northwest-trending valley occupied by the Tilton River northwest of Morton (see Leg I, p. 77). The orientation of the valley seems influenced by the orientation of nearby folds and faults, many of which trend northwest.

Cathy Whitlock (Barnosky, 1981) developed an extensive record of paleoclimate and environmental change using pollen and plant fossils obtained by coring at Davis Lake and other sites, including Mineral Lake 12.7 mi (20 km) to the north-northeast. Her radiocarbon dates for the Davis Lake core spanned the last 26,000 years and cut through eight recognizable tephra layers. She concluded from the pollen evidence that tundra-parkland vegetation likely existed in this area from 26,000 to 16,000 yr B.P. These cold conditions were followed by warming from 16,000 to 15,000 yr B.P. and then a return to a colder climate until 12,000 yr B.P., when the pollen of several subal-

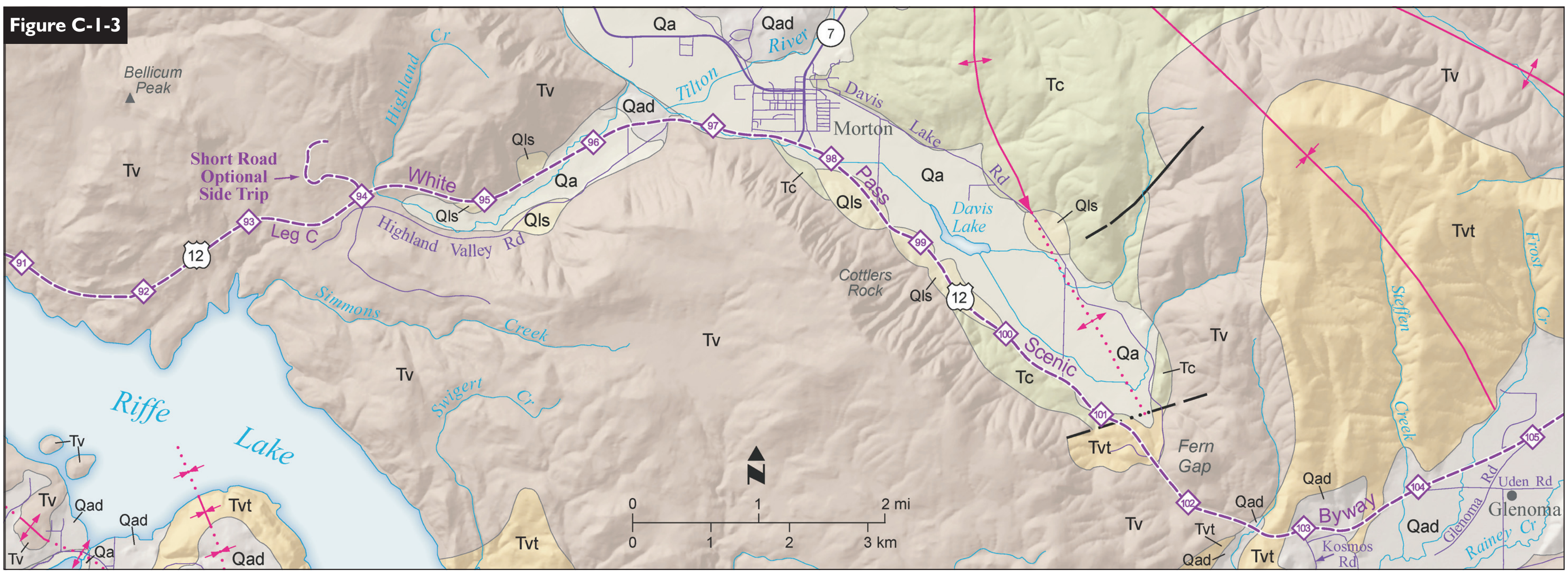
photo by Dave Norman

Figure C-5. Geologist Beth Norman examines sedimentary rocks of the Puget Group.

pine lowland tree species appeared, representing a shift to warmer, interglacial environment.

35.2 *56.8* About 4.2 mi (6.7 km) past the SR 7 junction, just past MP 101, the road crosses a northeast-

Figure C-1-3



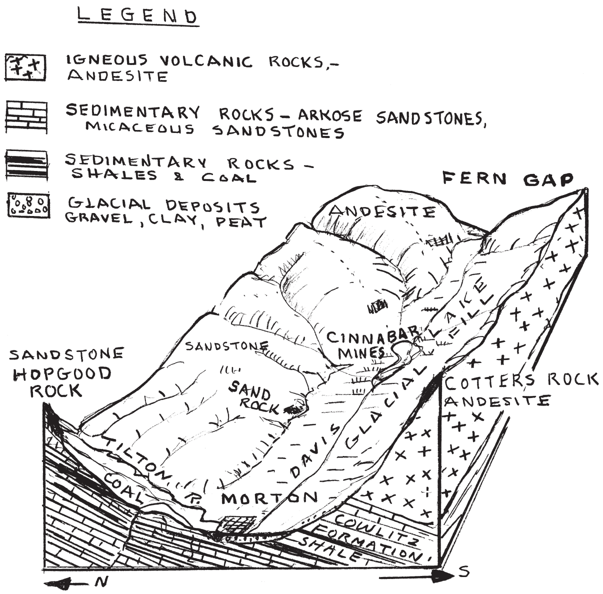


Figure C-6. A block diagram of the geology at Morton, Wash. View is to the east and shows the apparent dip of sedimentary rocks of the Puget Group in the southwest limb of a northwest-trending anticline. The anticline plunges to the southeast. Also shown are the cinnabar mines and selected physiographic features. Volcanic rocks overlie the sediments to the south of Morton. The U-shaped valley was carved during the Hayden Creek glaciation. Modified from Clevinger (1969).

trending normal fault, and you are back in the Goble Volcanics. The fault is not visible in outcrop. Although the fault motion has been interpreted as down-to-the-southeast, the topography appears inverted because the down-dropped rocks now stand higher than those rocks across the fault. If the interpretation of the fault is correct, this situation perhaps resulted because Goble Volcanics are more resistant to erosion than sedimentary rocks of the Puget Group.

The highway starts to climb once it reaches the volcanic rocks, passes again into the Cowlitz River drainage and the valley of Rainey Creek at Fern Gap, and then descends to Glenoma.

36.4 *58.5* Light tan to brown volcaniclastic rocks of Tertiary age crop out in the cliff on the left (northeast) side of the highway about 260 yd (240 m) east of Kosmos Road (Fig. C-7).

photo by Beth Norman

Figure C-7. Light tan to brown upper Eocene to Oligocene volcaniclastic rocks east of Kosmos Road. Outcrop is about 30 ft (10 m) high.

36.6 *58.9* A Tertiary lava flow crops out on the inside of a curve on the left (north) side of the road (Fig. C-8).

36.9 *59.4* Basalt flows of Tertiary age are exposed here.

37.3 *60.0* MP 104, Uden Road. Glacial drift exposed here is of Hayden Creek age (~170–130 ka)(Fig. C-9).

37.9 *60.9* Glenoma. The south valley wall along Rainey Creek (the elongated ridge south of Glenoma) is composed of upper Oligocene basaltic rocks, mostly lava flows. These rocks were derived from a volcanic center south of Riffe Lake.

41.0 *65.9* Rainy Creek Road on the south.

41.4 *66.6* Although not readily visible from the highway, deposits of yellowish tephra are common in roadcuts and stream banks near where the road crosses Rainey Creek. This pebble-size pumice is the Yn tephra layer from Mount St. Helens, erupted about 3,600 yr B.P. The deposit of pumice and ash from this eruption extends to the northeast to Alberta, Canada. It was probably the largest volcanic eruption in this region in the past 4000 years. Scientists studying the settlement sites and patterns near this area found that the native peoples moved far away from Mount St. Helens area at about this time and probably stayed away for nearly 2000 years (McClure, 1992).

Cross the drainage divide between Rainey and Kiona Creeks, located on coalescing alluvial fans from those two creeks.

photo by Beth Norman

Figure C-8. Lava flow of Tertiary age.

photo by Beth Norman

Figure C-9. Glacial drift of Hayden Creek age.

photo by Beth Norman

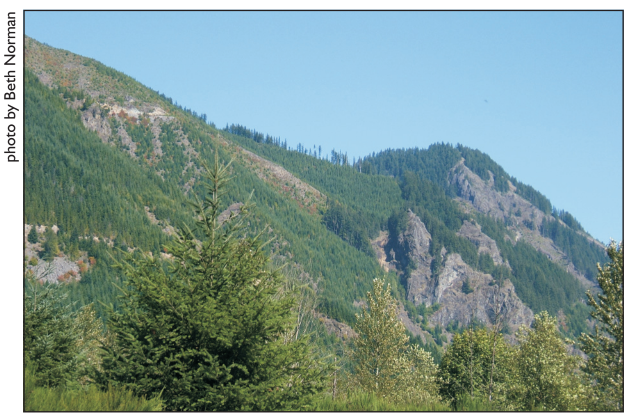


Figure C-10. These cliffs on the north side of US 12 near Kiona Creek are Oligocene andesite flows.

photo by Beth Norman

Figure C-11. Glacial drift of Hayden Creek age (~170–130 ka) exposed on the left (north) side of the highway slightly east of MP 12.

43.0 68.8 The cliffs on the north side of road are Oligocene andesite flows (Fig. C-10).

43.8 70.4 Kiona Creek.

44.3 71.3 MP 111. Junction of US 12 with Savio Road. Continue ahead on US 12. Lake Scanewa (610 acres; 2.47 km²), a reservoir impounded in 1994 by Cowlitz Falls Dam, lies several miles to the south. It is closed to fishing from March 1 to May 31 to allow out-migration of juvenile steelhead.

45.4 73.0 Glacial drift of Hayden Creek age is exposed on the left (north) side of the highway (Fig. C-11).

46.6 75.0 Slightly east of here the highway passes through a terminal moraine constructed by the large valley glacier that occupied the Cowlitz River during the Evans Creek alpine glaciation. South-dipping dip slopes in andesite flows are visible to the north (Fig. C-12).

47.2 75.9 MP 114. A significant landslide (not shown on map) more than 197 ft (60 m) wide blocked the highway here at about 6:00 p.m. on Nov. 22, 1995, narrowly missing a vehicle (Fig. C-13). During heavy rains, a large mass of rock toppled onto the clay-rich slope to the north, overloading it and causing rock debris and soil to move rapidly downslope some 985 ft (300 m). Inspection of the rock units above revealed a north-trending fault and an associated zone of gouge in the altered rock material along the fault zone—a zone of slippery, clay-rich, and mechanically weak rock debris. The rocks are sandstones and conglomerates of Oligocene age. The landslide deposit is 3.3 to 30 ft (7.5–9 m) thick, and its volume is 150,000 to 200,000 yd³ (115,000–150,000 m³). The Washington State

photo by Beth Norman

Figure C-12. South-dipping andesite flows visible north of US 12 about 0.5 mi (0.8 km) west of MP 114. The surface of the flow may have been smoothed by glacial ice in the mid-Pleistocene.

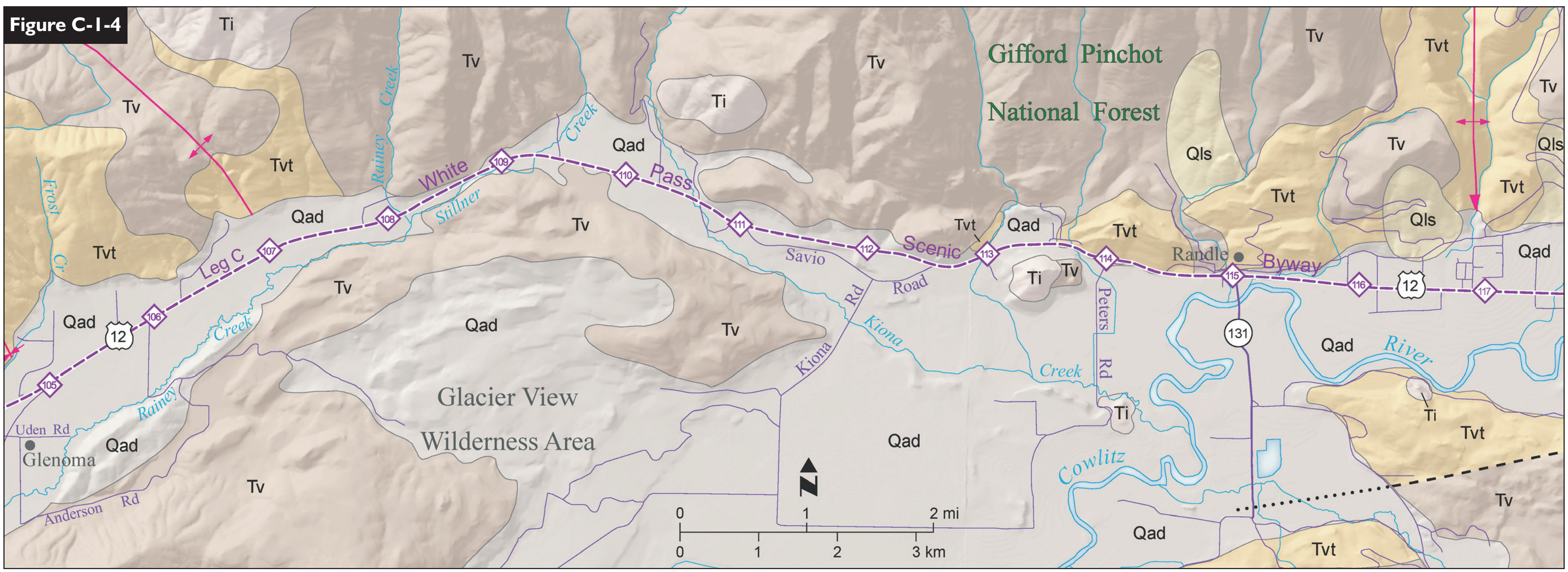


Figure C-13. A landslide complex north of US 12 about 1 mi (1.6 km) west of Randle at Peters Road. The failure occurred in stages at about 6:00 pm on Nov. 22, 1995. One landslide nearly hit a vehicle. This photo was taken in April 1996. During a period when the hillside was saturated, a zone of clayey gouge associated with a north-trending fault here failed when bedrock blocks from the cliff toppled onto upper slopes and overloaded the slippery material. The vertical distance from the topple to the road is about 800 ft (250 m). US 12 now goes around the toe of this slide.

Department of Transportation (WSDOT) removed about 70,000 yd³ (52,000 m³) of landslide debris. Several days after the initial slide, the landslide began to flow 20 to 30 ft/day (6–9 m/day). The area had received 16.82 in. (42.7 cm) of rainfall in the previous 42 days, 8.68 in. (22.1 cm) in the previous 22 days, and 1.96 in. (5 cm) in an intense storm two days before the event. WSDOT has stabilized this slide and moved the road away from the base of the slope.

Figure C-14. Flood deposits capping the Cowlitz River flood plain near Randle. These sandy deposits show that since A.D. 1479 more than 13 great floods have inundated this part of the Cowlitz River valley from valley wall to valley wall. The light-colored layer slightly above the trenching tool is a tephra unit known as Wn, which was erupted during a major eruption of Mount St. Helens, probably in late A.D. 1479. The handle of the trenching tool is about 18 in. (45 cm) long.

On a clear day, Mount Adams volcano is visible 33 mi (53 km) to the southeast.

48.3 *77.7* Randle and the intersection of US 12 with SR 131. *Note if you are heading south:* There are no service stations between here and the town of Cougar (~100 mi or 160 km), so make sure you have plenty of fuel.

photo by Dave Norman

Figure C-15. An outcrop of granodiorite near MP 120. View is to the north.

SR 131 accesses the east side of Mount St. Helens National Volcanic Monument. The road crosses the Cowlitz River, the main fork of which originates on Mount Rainier. The greenish gray color of the water is caused by 'rock flour', the silt and clay carried in suspension by the river. Rock flour is created by the grinding action of rocks at the bed of a glacier.

49.4 *79.5* Cowlitz Valley Ranger Station.

50.0 *80.5* The broad flood plain of the Cowlitz River contains numerous layers of flood silts and sands. USGS geologist Norm Banks located a stack of flood deposits near here that overlie the white pumice layer Wn, erupted from Mount St. Helens in late A.D. 1479 or early 1480 (Fig. C-14). At least 13 flood layers lie on top of the Wn pumice, and the 1996 flood, which was a rain-on-snow event and inundated the valley floor from wall to wall, left the uppermost layer.

51.2 *82.3* MP 118. Cliffs to the left (north) are Miocene diorite and granodiorite intrusions.

54.0 *86.9* Pullout to the right (south). The outcrop on the left is granodiorite with inclusions of andesite (Fig. C-15).

55.1 *88.7* MP 121. The road curves to the left. Note the big scarp visible to the southeast on the face of Castle

Butte (Fig. C-16). Strata of upper Oligocene volcaniclastic rocks are visible in the scarp.

58.8 94.6 Near MP 125 there are some large boulders near the mouth of the canyon to the south. They might have been carried down by debris flows.

59.1 95.1 MP 126. Rest area. The hummocky terrain and large, angular to subangular boulders are typical of a landslide deposit, although Swanson and his USGS colleagues Norm Banks and Richard Moore (1997) have mapped this area as 'alluvial fan'. The source area of the debris is Goat Dike, a rock promontory to the south composed of volcaniclastic rocks. Light-gray granules of Mount St. Helens Wn tephra (A.D. 1479) lie atop the debris; however, there is no trace of the 3,500 yr B.P. Yn tephra from Mount St. Helens whose fallout was heavy in this area. Therefore, the age of this hummocky deposit is bracketed by the ages of these two layers.

Studies by Swanson and his colleagues revealed that the area is underlain by bedded volcaniclastic rocks of late Eocene and Oligocene age, mostly laharic units, that interbed with andesite

photo by Beth Norman

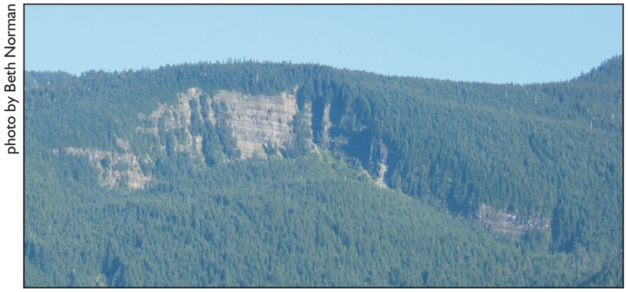


Figure C-16. The big scarp visible in the distance on the face of Castle Butte is strata of upper Oligocene volcaniclastic rocks.

and basaltic andesite lava flows on the south side of the Cowlitz River valley between Smith and Johnson Creeks. Those flows were part of a large shield volcano that was located near Angry Mountain, about 8.7 mi (14 km) to the east-southeast.

60.7 97.7 FR 20. More large rocks south of the highway may also be part of the same landslide noted at the rest area.

61.1 98.3 MP 128.

61.2 97.4 More large rocks, these at the mouth of Johnson Creek, were probably deposited by debris flows.

61.5 98.9 Chambers Lake turnoff and FR 21 to Glacier Lake. For a good view of Mount Rainier on a fine day, you can drive about 1.5 to 2 mi (2.4–3.2 km) up this forest road. Glacier Lake, accessible about 6 mi (10 km) up the Johnson Creek valley and via a vigorous hike, is dammed by a large rock slide–debris avalanche deposit. Bob Schuster dated a subfossil tree exposed in the lakebed upstream of the blockage at about 600 yr B.P., and a provisional tree-ring analysis of one subfossil snag drowned behind the landslide dam indicates that its outermost ring is about A.D. 1453. However, the bark was missing from the tree, so the precise year of its demise is uncertain—it is unclear if there are missing outer rings. The Glacier Lake rock slide may record a significant earthquake, owing to its proximity to two other landslide-dammed lakes and because it is not uncommon for landslides of this type and size to be triggered by seismic shaking. Curiously, Packwood Lake, only about 2.5 mi (4 km) to the northwest of Glacier Lake, is also impounded by a large landslide (Pringle and others, 1998), and

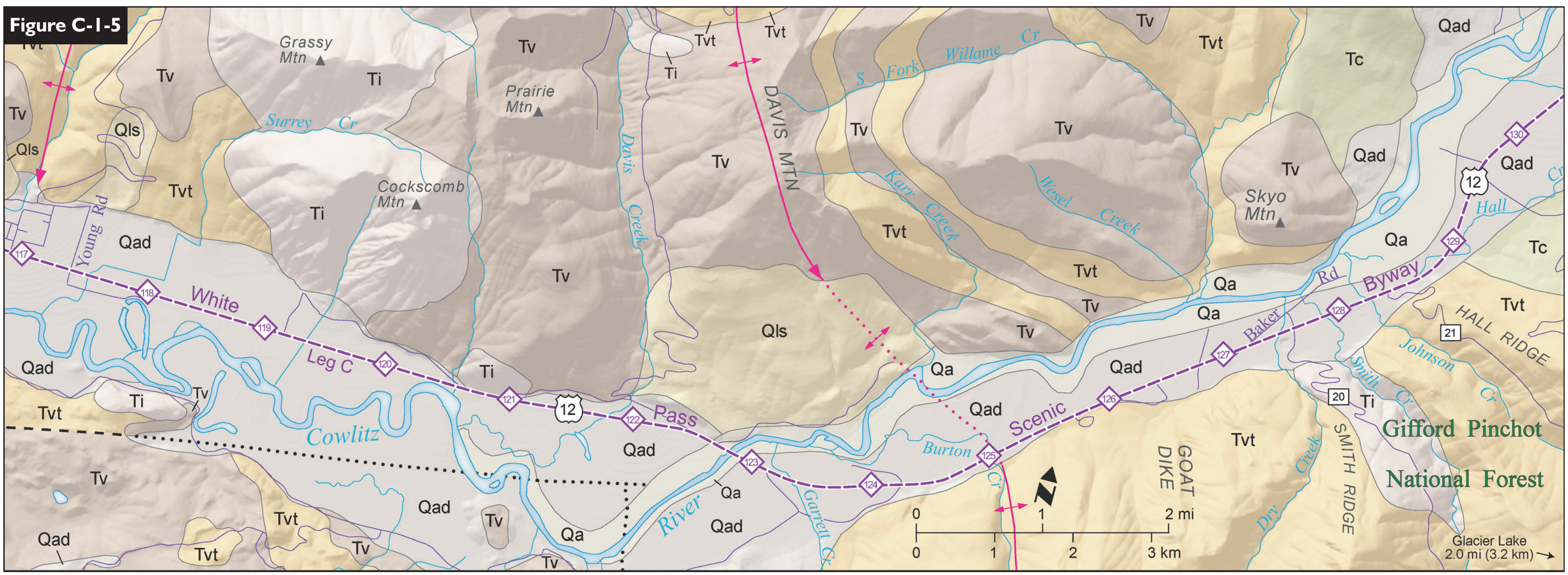


Figure C-17. Private landowner Greg Arkle takes a core sample of a half-submerged tree along the Cowlitz River near Packwood. The trees shown here were preserved by burial, perhaps for centuries, and then exposed when erosion during floods removed part of the bank. View to the southwest (downstream).

Hager Lake, mentioned below, is only about 3 mi (4.8 km) from the others.

Swanson (1995) found no significant evidence of active faulting in this area, although he did identify many small, mostly north-northwest-trending shear zones that cut Tertiary rocks. He constrained the age of most folding in this area to "between 18 Ma (possibly 15.6 Ma) and 12 Ma" based on paleomagnetic data, several K-Ar ages, and field observations.

Remember to compensate for mileage if you take the side trip.

61.6 99.1 Mount Rainier is visible to the left on a clear day.

62.0 99.7 The terrace or bench on the south side of the highway near the curve, slightly after Hall and Johnson Creeks, is supported in part by southwest-trending andesitic dikes. Hager Creek is a 'disappearing stream' that drains into the coarse rocky debris of a large alluvial fan. What could be the source of all this rocky debris? Hager Lake, which lies some 2.4 mi (3.8 km) southeast of the highway up Hager

Figure C-1-6

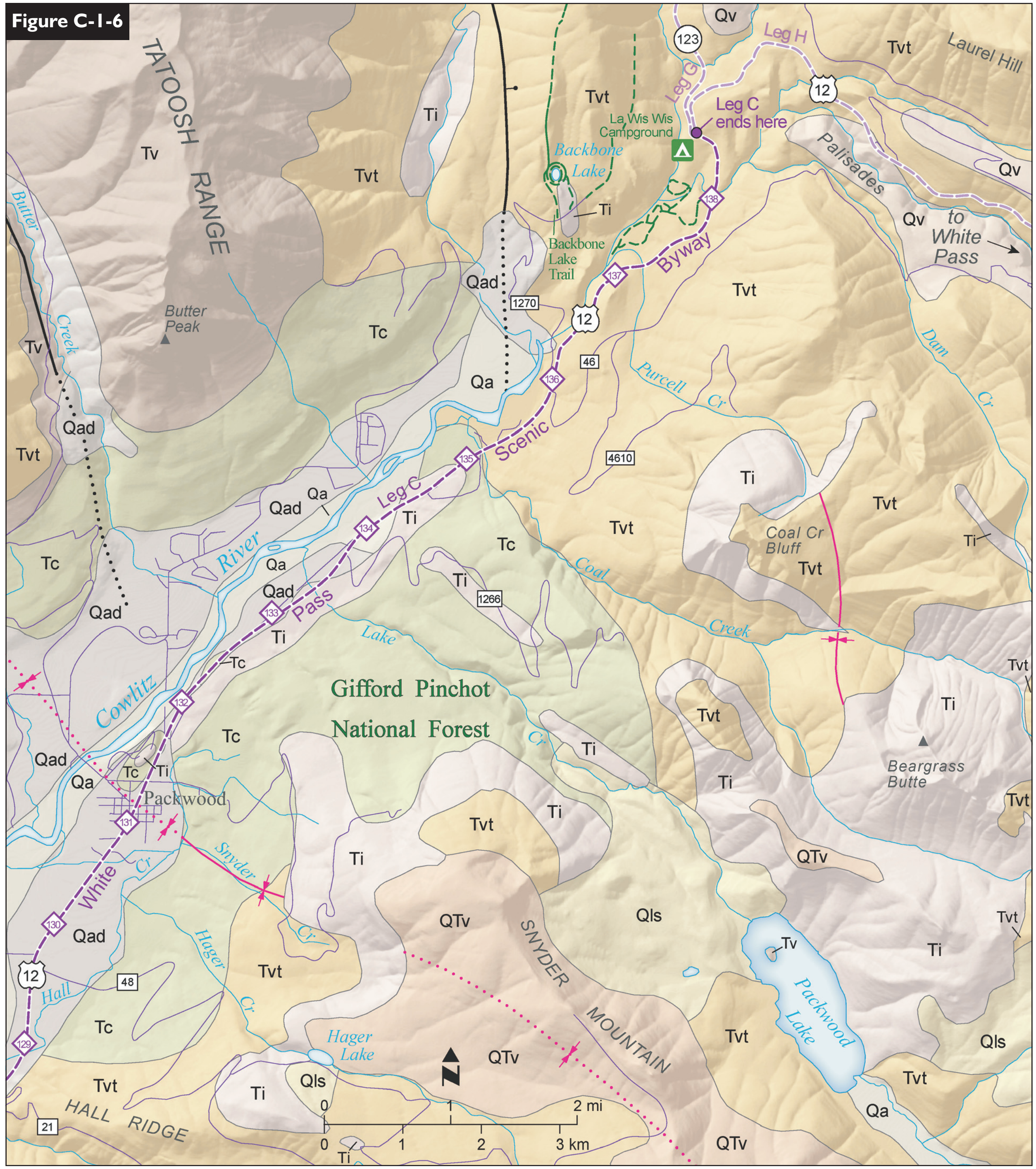


Figure C-18. A subfossil tree near Packwood is buried by about 3 ft (1 m) of sediment. Poorly exposed here near the base of the tree, the Wn tephra, 5 in. (13 cm) thick, was erupted from Mount St. Helens, probably in late A.D. 1479, so the sediments above it have been deposited since that time. The handle of trenching tool is about 18 in. (45 cm) long.

Creek, is dammed by a large landslide from Hall Ridge. USGS Geologist Bob Schuster found standing snags in the lake and suggested it formed within the last several centuries (Swanson and others, 1997). Perhaps partial breaching of the newly dammed lake deposited the bouldery debris of the alluvial fan at the base of the valley wall.

62.1 *99.9* MP 129.

64.1 *103.1* MP 131, downtown Packwood. This small town may be located closer to more volcanoes than any other town in Washington. This location provides easy access to Mounts Adams, St. Helens, and Rainier, as well as the Indian Heaven volcanic field to the south and the White Pass area.

Buried trees and gravel and sand layers rich in Mount Rainier Andesite fragments (Figs. C-17 and C-18) indicate that lahar runouts and volcanic floods from Mount Rainier eruptions have flowed along the valley bottom. The configuration of the

photo by Beth Norman

Figure C-19. An Oligocene or Miocene intrusive andesite sill slightly east of Packwood. View is to the north.

photo by Dave Norman

Figure C-20. Geologist Beth Norman examines black sedimentary rocks exposed on north side of US 12 slightly east of Packwood. They are lake deposits of Oligocene or Miocene age.

Cowlitz River's upper tributaries at Mount Rainier, however, suggests that other river systems face a higher probability of future lahars than the Cowlitz valley.

Glacial grooves and striations on rocks locally offer further evidence of the huge glaciers that have carved this broad valley during past ice ages.

64.3 *103.5* Depart Packwood heading east. Note landslides visible ahead and slightly to the left, on the south face of Butter Peak, the exposed rocky face to the north that is the southernmost peak of the Tatoosh Range. The Tatoosh pluton was named for the Tatoosh Range by Fiske and others (1963).

64.6 *103.9* The outcrop on left is an Oligocene or Miocene intrusive andesite sill (Fig. C-19).

Figure C-21. Crude columnar joints in an andesitic sill of Oligocene or Miocene age in an outcrop near MP 134 on US 12 east of Packwood. The top of the sill and overlying material has been removed by a glacier of Evans Creek age that filled this part of the Cowlitz valley. The underlying fine-grained sedimentary rocks were interpreted by Swanson and others (1997) as overbank deposits. Leaf fossils shown in Fig. C-22 were found near the hammer (white circle) at the bottom center of the photo.

64.9 *104.4* The black sedimentary rocks that crop out on north side of the road are lake deposits of Miocene age (Fig. C-20). On the south side of road is an andesite sill.

66.6 *107.2* Cross Lake Creek, which drains landslide-dammed Packwood Lake.

66.9 *107.6* MP 134. Columnar-jointed rock exposed south of the road is an andesitic sill of the Packwood complex of Oligocene or Miocene age (Fig. C-21) (Swanson and others, 1997).

67.2 *108.1* Thin shale laminae under the sill are lake deposits that contain some leaf fossils (Fig. C-22).

67.6 *108.8* Grizzly Road. The highway is cut through an andesite sill.

67.7 *108.9* Gray, intrusive andesite of Miocene or Oligocene age.

68.3 *109.9* Coal Creek and Coal Creek Road.

68.4 *110.1* Enter Gifford Pinchot National Forest.

68.7 *110.5* The small outcrop of tuffaceous sedimentary rocks on the right contains fossil wood.

69.0 *111.0* Near MP 136, FR 46 is on the southeast side of the road, and slightly past here, FR 1270 goes to Backbone Lake Trail #164.

69.4 *111.7* Gray tuff on the right (southeast) that overlies a resistant andesitic sill is probably the Purcell Creek tuff of Miocene age, identified by Swanson (1996) in this area.

69.6 *112.0* Green to light-gray tuffs crop out to the right (southeast) of the road.

69.8 *112.3* At a curve to the right slightly before MP 137, note a large cliff of greenish-brown volcaniclastic rocks, possibly Purcell Creek tuff.

70.4 *113.2* Fine-grained tuffs on the right here contain lapilli and larger clasts.

70.6 *113.6* Chain-up area.

71.1 *114.4* La Wis Wis Campground.

71.5 *115.0* Intersection of US 12 with SR 123. You can continue east on US 12 via Leg H or turn left here and follow Leg G (in reverse order) toward Chinook Pass (16.3 mi or 26.2 km). Alternatively, you can intersect the end of Leg B and the Ohanapecosh Entrance to Mount Rainier National Park by going north on SR 123 5.4 mi (8.6 km).

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

Figure C-22. *Metasequoia* leaf fossils in indurated lake beds of Oligocene or Miocene age. These were found under the sill along US 12, about 2.6 mi (4 km) east of Packwood (Fig. C-21). The fragment in the inset photo is about 4 in. (10 cm) long. (Fossil collecting on Washington Department of Transportation land requires permission.)