LEG K: STATE ROUTE 165—THE MOWICH LAKE ROAD

by Patrick T. Pringle, Timothy J. Walsh, and David A. Knoblach*

This is the most direct access to Mount Rainier National Park from Seattle. The 27-mi (43 km) route begins in the Puget Lowland at Buckley (elev. ~720 ft or 220 m) in the White River drainage basin and, after crossing South Prairie Creek at Burnett and Wilkeson Creek at the historic mining town of Wilkeson, it winds south and east up the Carbon River valley via its spectacular gorge (Fig. K-1).

A short distance after you cross the Fairfax Bridge, you ascend outwash terraces, cross into the Voight Creek drainage basin, and then after about 11 mi (17.5 km) finally reach the Mowich River valley. As you enter Mount Rainier National Park, the road climbs to Mowich Lake, a beautiful tarn at 4929 ft (1502 m) elevation. The Mowich Lake area provides access to several main trails in the national park, including one to scenic Spray Park.

From the beginning of this leg to a short distance beyond its intersection with State Route (SR) 162, you travel along a glacial outwash channel of Pleistocene age, remaining on the Osceola Mudflow deposit and older lahars that underlie the flood plain for nearly the entire stretch. You then ascend a series of terraces in glacial deposits and enter the bedrock highlands of the Cascade Range. Once on the Cascade rocks, you pass folded, faulted, and intruded sedimentary rocks of the Eocene Puget Group, generally finding progressively younger rocks as you proceed up section through a tilted mass of layered rocks (Fig. K-2). You'll then drive past the overlying beds of the younger Ohanapecosh volcanic rocks and some sedimentary interbeds of Oligocene age and dikes and sills of an extensive intrusive complex of Miocene age before finally arriving at Mowich Lake.

This road is closed in winter (typically November to late June) near Milepost 0. Road and trail status 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* — Junction of SR 410 with SR 165. Take SR 165. This valley was carved by glacial meltwaters about 15,000 years ago. The bottom of the valley is underlain by lahars from Mount Rainier that flowed here through the White River valley.

0.2 *0.3* — Milepost (MP) 21.

0.4 *0.6* — On a clear day, there is a splendid view of Mount Rainier to the left.

1.2 *1.9* — MP 20.

1.6 *2.6* — Junction of SR 165 with SR 162. Stay on SR 165.

2.1 *3.4* — View of jagged peaks of Carbon Ridge ahead, about 9 mi (15 km) to the southeast, as you enter Burnett near MP 19. Carbon Ridge is composed of granodiorite of the Carbon River stock of Miocene age. This intrusion yielded K-Ar ages of 17.1 and 19.4 Ma (Tabor and others, 2000).

2.3 *3.7* — Bridge at Burnett.

3.2 *5.1* — MP 18.

Figure K-1. Geologic map for Leg K (three consecutive panels). The geology was adapted from 1:100,000- and 1:500,000-scale digital versions of 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.

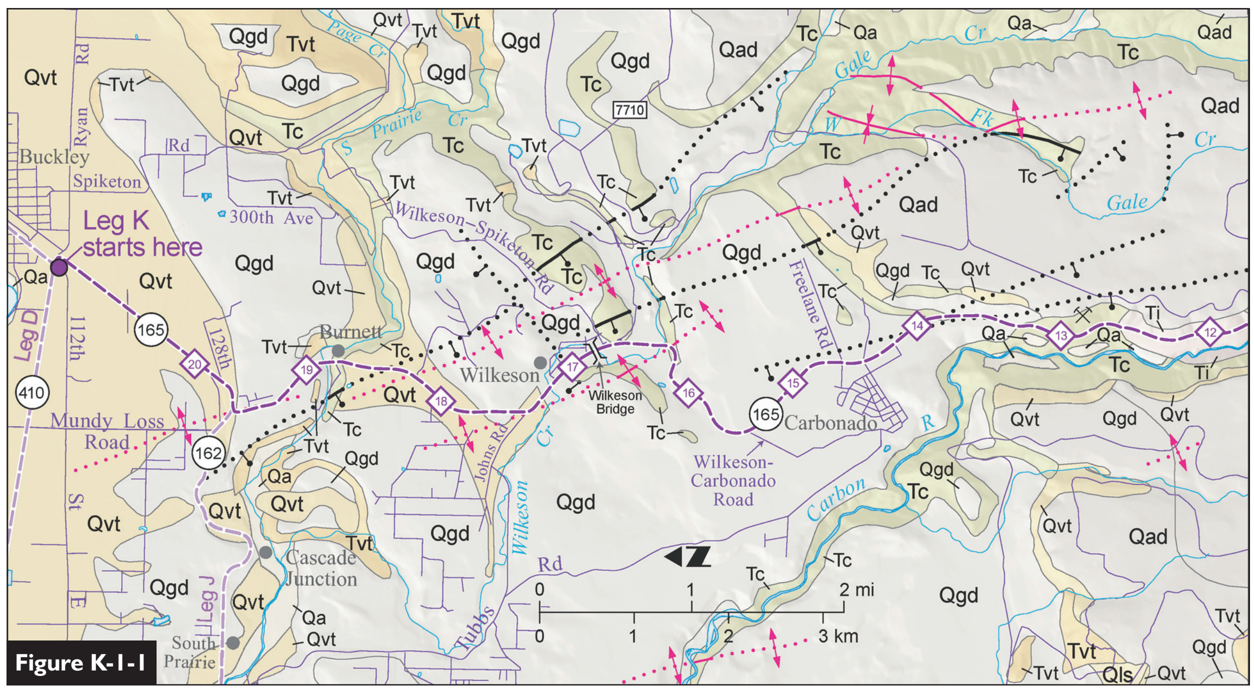


Figure K-1-1

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

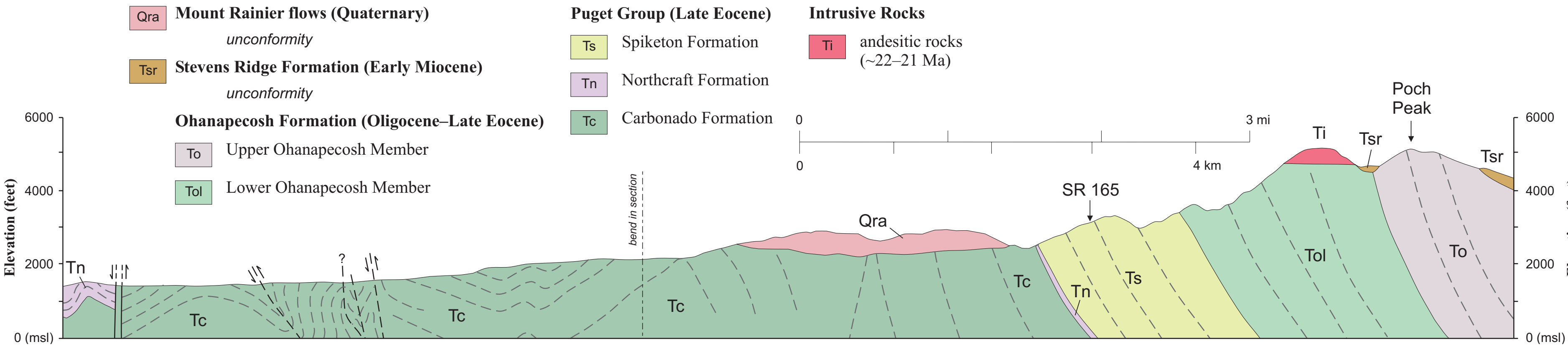


Figure K-2. The structure of faulted and folded bedrock of the Eocene Puget Group and Oligocene Ohanapecosh Formation and Stevens Ridge Formation west-northwest of Mount Rainier. Also shown are a Mount Rainier lava flow (unit Qra) and the recently identified Mowich Lake sill complex (unit Ti) of Hammond (1999) and Hammond and others (1999). Deposits of Quaternary glaciers and rivers are not shown. Modified from Buckovic (1974).

photo by Dave Knoblach

Figure K-3. The Wilkeson sandstone structure at Wilkeson before it was damaged by the 2001 Nisqually earthquake. The new structure was rebuilt in 2004 using the same sandstone blocks. View is to the north.

3.4 First of two turnoffs to Carbonado.
5.5

3.7 Ascend a terrace.
6.0

3.9 Wilkeson Cemetery on the left (east).
6.3

4.2 A sandstone monument marks the entrance to the
6.8 Town of Wilkeson (Fig. K-3). The original monument, built in 1925 for $2000, bore a sign reading "Wilkeson—Gateway to the Carbon Glacier" for those entering Wilkeson and "Remember Wilkeson" for those leaving (Hall, 1980). The original structure was damaged in the Feb. 28, 2001, Nisqually earthquake (magnitude 6.8). The earthquake shifted the sandstone blocks of one of the columns about 4 in. (10 cm) and tilted the structure slightly. Many of those blocks were used in constructing the new monument, which was completed in 2004.

4.6 Turnoff on the left (east) to Wilkeson School, con-
7.4 structed in 1913 of Wilkeson sandstone (Fig. K-4). Wilkeson sandstone was also used to construct the buildings on the Washington State Capitol Campus in Olympia, including the Capitol itself; construction there began in 1912. This sandstone is the uppermost member of the Carbonado Formation of the Puget Group of Eocene age. (See "A Sandstone Industry" sidebar on p. 147.)

The Wilkeson sandstone, part of the middle to upper middle Eocene Carbonado Formation, likely was deposited in a deltaic and flood-plain environment by streams that originated to the east (Fig. K-5). The Wilkeson sandstone also marks the stratigraphic top of the historically productive coal seams in the area. In this vicinity, lahars of the Northcraft volcano flowed into local drainages and thus are interbedded with Wilkeson deposits. Sedimentary rocks of the Spiketon Formation, in turn,

Figure K-4. Wilkeson School, constructed in 1913. The building stone, Eocene-age Wilkeson sandstone of the Carbonado Formation, was quarried and dressed nearby. It was also used to construct the Washington State Capitol buildings.

overlie and are interbedded with Northcraft laharic deposits. These sandstones, siltstones, and coal in the Spiketon are similar to those in the Carbonado Formation; however, the rank of the coal is lower. Collectively, these Eocene terrestrial sedimentary rocks are known as the Puget Group. The great thickness (>8,500 ft; ~2,600 m) of the Puget Group rocks suggests they were deposited in slowly subsiding tectonic basins (Gard, 1968).

Coal was discovered in this area in the 1870s, and a railroad reached the mines in the late 1870s. By 1885, the Tacoma Coke and Coal Company had constructed 160 coke ovens here (Kirk and Al-

Figure K-5. These well-preserved ripple marks on a *dip slope* of folded Carbonado Formation sandstone record wave movements on an Eocene beach. A rock hammer is shown for scale.

exander, 1995). The sixty that remain today can be seen near the road to the east of Wilkeson School and are on the National Register of Historic Places. There are more coke ovens at the bottom of the gorge near Carbonado and also near Crocker, located about 4.5 mi (7.2 km) west of Carbonado along SR 162 (Leg J). More than 500 were in use in this area in1921. Coke production here ended by about 1937.

The McKay coal seam lies immediately below the Wilkeson sandstone. In the late 1800s, coal miners believed that the stratigraphy at Wilkeson was similar to that of other coal regions in western Washington, such as along the Green River and at Black Diamond in King County to the north. However, because coal beds are folded and faulted throughout this area, it was (and still is) impossible to correlate coal seams between King County and Pierce County. Nonetheless, the uppermost significant coal seam found anywhere in either King County or Pierce County was commonly, but incorrectly, called the McKay seam.

Local lore states that at one time a person could walk the nearly 9 mi (14 km) between the towns of Burnett and Fairfax entirely underground through the system of mine tunnels. This story is untrue because of the folding and faulting noted above, but it does suggest the abundance of mined tunnels in this area.

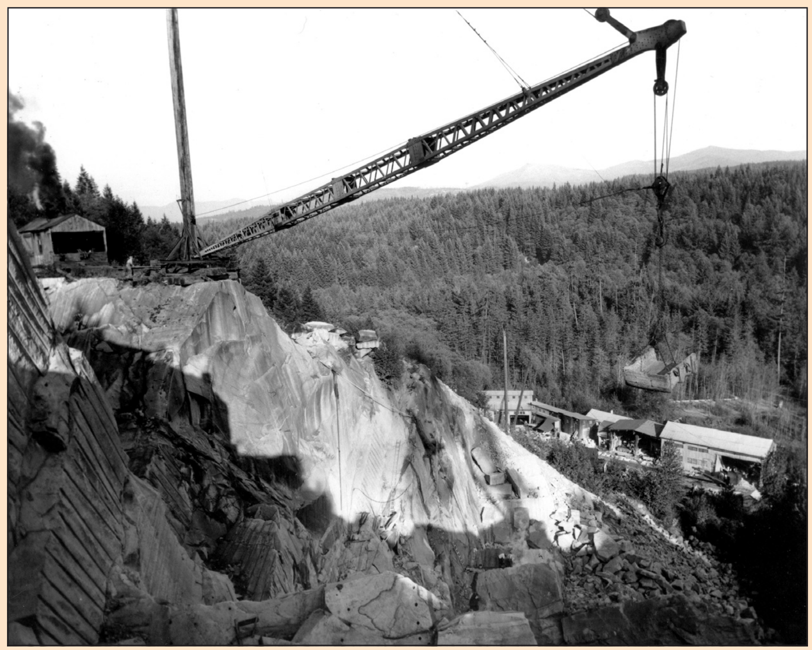
A Sandstone Industry

by David A. Knoblach and Rebecca A. Christie

Part of the Carbonado Formation of the Puget Group, the Wilkeson sandstone is a thick, buff to tan, medium-grained sandstone (Moen, 1967; Knoblach, 1994). The stone has about 10 percent porosity and needs no waterproofing, making it a high-quality building stone. A 1917 newspaper article quotes a building stone expert: “The sandstone from the Wilkeson quarry...is the best in the entire country. It has great strength, stands heat, and is nearer waterproof than any other sandstone I know. It is so hard that if the Germans had the Wilkeson stone they would be using it for bullets” (*Tacoma Daily Ledger*, 1917).

During the 1870s, the Northern Pacific Railroad removed material from outcrops of this stone for ballast in the construction of its railroad lines along the Pacific coast. In 1883, the builders of St. Luke’s Episcopal Church in Tacoma were the first to use Wilkeson sandstone for construction (Knoblach, 1993). Demand for stone for commercial buildings and homes increased in the 1890s following several devastating fires in large cities in Washington and around the nation. The early railroad quarry opened officially in 1886 (Hall, 1980). In time, several quarries worked in the stone, prominent among them, the Walker-Wilkeson quarry. Another quarry in this formation was worked near the town of Burnett (about 4 mi [7 km] north of Carbonado).

Many civic, business, and residential buildings in Washington and Oregon are faced with this sandstone. About 15,400 tons (~15,000 metric tons) of Wilkeson sandstone went into the dome of the current Washington State Legislature building, completed in 1928. It is one of only two solid stone domes in the nation (*The Northwest*, 1968), probably the last dome of its kind constructed anywhere in the world. Dressed and carved stone from this quarry went into the Cathedral of St. John the Evangelist in Spokane, built between 1926 and 1954. Stone cutting was a well-paid, men-only profession.



Walker-Wilkeson quarry in the late 1920s. A derrick that can move both equipment and rock rubble in the quarry lifts a container. The gang saws were in the shop buildings at the base of the slope. View is to the northeast. Photo courtesy of Tacoma Public Library.

With the development of concrete as a building material and improved bricks, stone use declined. Most major quarries had folded after the Depression. Bucking this trend, the Walker-Wilkeson quarry was in continuous production from 1904 until bankruptcy closed it in 1982. Total stone output from the Walker-Wilkeson quarry from 1911 to 1969 was estimated at 353,265 tons (~320,000 metric tons) (Knoblach, 1994). Orders totaling at least $250,000 were left unfilled at its closure (*The Olympian*, 1982). Products from the quarry, once the largest cut-stone plant west of the Mississippi River, included ashlar (hewn or squared stone), hearths, sills and coping, patio stone, special cut pieces, and sculpted stone (*Tacoma Daily Ledger*, 1932). Knoblach (1993) reported that the quarry (under another ownership) sold rock for pilings and rockeries, as well as architectural miniatures; today, as the Wilkeson Sandstone Quarry, it once again offers cut stone. The sandstone is still occasionally used to repair historic buildings and for preservation purposes. ■

Although perhaps not aesthetically pleasing in design, the subsurface coal mines in Washington are some of the most significant construction projects in the history of the Pacific Northwest. For example, in the 1890s, a mining inspector noted that more than 1000 pieces of timber were used for every 400 tons of coal mined—more than anywhere else in the world. The main reason local mines were so complex, and the extraction of coal so difficult, was that many coal seams were in places steeply dipping to vertical. Coal mining in the Fairfax area upstream of here was abandoned because the density of faults increased as mines approached Mount Rainier, making the coal extraction uneconomic, even though the rank increases closer to the mountain.

Many Wilkeson area coal mines now pose hazards to construction and recreation in the area. Some collapsed tunnels are visible from the air, appearing like parallel grooves or scratches upon the local topography.

The last active coal mine in the Wilkeson area closed in 1968, mainly because underground bituminous to subbituminous coal mining was no longer profitable. Open-pit mining could be considered here in the future here; however, environmental concerns such as acid mine drainage and habitat disruption would have to be addressed. Some of the local sedimentary rocks have been drilled for their coal-derived natural gas reservoirs, although no economically feasible deposits have been found.

Geologist Bailey Willis, who had mapped the coal seams in the Wilkeson–Carbonado area in the 1880s, was the one of the first Europeans to hike to the Carbon Glacier area along the north side of the Carbon River through the Fairfax Bridge area. The route was known for many years as the Bailey Willis trail. Coal miners recognized Willis by naming a coal town in the Wilkeson area South Willis. The town no longer exists, but it was about 1 mi (1.6 km) east of Wilkeson. The Willis Wall on Mount Rainier also is named after him. Willis later worked for the U.S. Geological Survey in California and recognized the earthquake potential of that region. He was one of the first to push to improve local building codes there because of the earthquake risks. (See the “Bailey Willis” sidebar on p. 149.)

4.8 *7.7* Cross Wilkeson Creek and ascend several terraces of glacial drift. About 16 ka, the Puget lobe of the continental ice sheet reached the mountainous terrain of the Cascade Mountains near here. It blocked rivers and creeks draining the Cascades, forming ice-marginal lakes. As the glacial ice receded, lakes would empty and subsequently become dammed by ice at successively lower elevations. When the Puget lobe had melted back and streams established channels, great kame deltas that had been deposited in the ice-marginal lakes remained perched along the former location of the ice margin as ghostly reminders of the ice dams and lakes. (See Fig. A-3, p. 55, and Figs. N-3 and N-4, p. 161.)

Figure K-6. Geologist Tim Walsh examines a thick hydrothermally altered andesite sill near MP 13 along SR 165. View is to the south.

5.3 *8.5* MP 16.

6.4 *10.3* The gravel pit on the left exposes stream-laid glacial deposits that are probably of Evans Creek age (~22–15 ka) and represent the outwash of the most recent Pleistocene alpine glacier in the Carbon River valley.

6.7 *10.8* Main Carbonado turnoff. Remain on SR 165.

8.3 *13.4* Gorge of the Carbon River. One result of a clearcut operation here was the discovery of a thrust fault (unmapped) and fold visible to the north-northwest in the gorge (toward Carbonado). The trees have since grown back, and the fault is not visible now. The outcrop to the left is intrusive andesite of Oligocene or Miocene age.

8.5 *13.7* Outcrops of folded Carbonado Formation sandstone and shale of the Eocene Puget Group with bituminous coal interbeds here dip to the east-northeast. Visible in these outcrops is a shear zone with thrust offset in a thin coal layer.

8.6 *13.8* Outcrops of folded Carbonado Formation sandstone

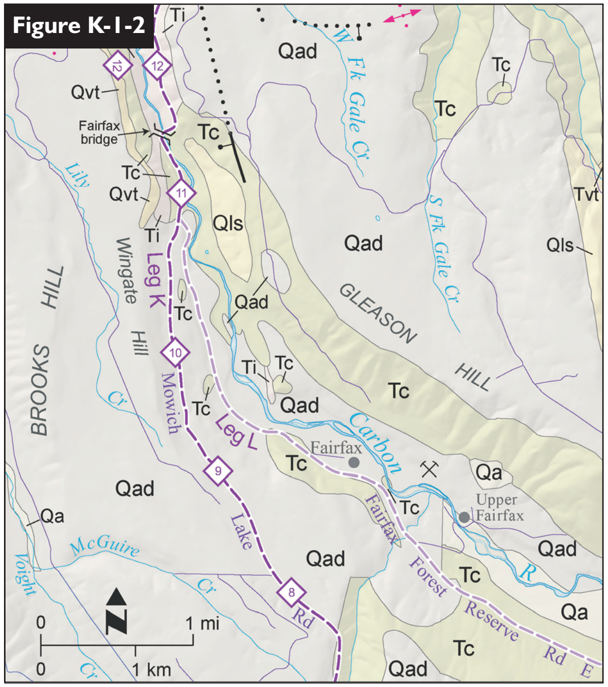
8.8 *14.2* The complexly jointed rock on the left (east) is intrusive andesite of Oligocene or Miocene age.

9.1 *14.6* The blocky outcrops in this stretch were originally mapped by Gard (1968) as quartz diabase, an intrusive rock similar to diorite, but they might more appropriately be described as hydrothermally altered or propylitized andesite sills (Fig. K-6). This rock has been sheared, and there are quartz veins visible in a pull-apart or extensional structure. The sill intrudes the Puget Group, which locally dips at steep angles. Geologists have not yet determined an age for this andesite, which is compositionally similar to Miocene intrusive rocks found in the Puyallup and Nisqually River basins 9 mi (14.4 km) and 21 mi (33.6 km) to the southeast respectively. It intrudes rocks ranging in age from Eocene through lower Oligocene, hence it is younger than those rocks.

The sill made this location a potential dam site. However, the area contains many significant underground coal mines, located both within the valley and below the river. The dam project was abandoned because unknown mine tunnels could become conduits for water after the reservoir was filled. Although the significant mines are mapped, others that were worked before the 1890s and during the depression of the 1930s have no record. This sill also has been considered as a potential quarry for crushed rock.

9.4 *15.1* Joints in the intrusive rocks likely contribute to minor slope instabilities near here by providing both failure planes and pathways for moisture. Notice that many joints have a nearly vertical orientation.

9.7 *15.6* Fairfax Bridge spanning the Carbon River gorge. Heat from the intrusions that fueled Cascade volcanoes affected coal seams both regionally and lo-



cally. In general, the rank of Eocene coal increases from lignite and subbituminous at shallow depths west of the Cascade Range nearer the Puget Lowland to anthracite (hard coal) closer to the volcanic centers and intrusive bodies and Mount Rainier (Walsh and Lingley, 1991).

It is widely accepted that Eocene coal seams in the Roslyn area north of Interstate 90 on the east side of the Cascade Range are the upstream equivalents of those in the Wilkeson–Carbonado area. However, Roslyn lies on the north side of the Olympic–Wallowa lineament, and rocks in that area are separated by faults from the rocks of this area. A similar increasing rank with proximity to volcanoes and intrusive centers applies there.

10.2 *16.4* Siltstone, mudstone, and sandstone with coal are exposed here. Beds dip to the west.

10.3 *16.6* Junction of SR 165 (Mowich Lake Road) with Carbon River Road (Fairfax Forest Reserve Road). To visit the Ipsut Creek Campground area and Carbon Glacier, bear left on Carbon River Road to follow Leg L. Bear right to stay on SR 165 to continue on this leg.

10.7 *17.2* On a clear day, there is a nice view of Mount Rainier and the Carbon River valley here.

11.0 *17.7* A large mound to the left (east) of the road could be morainal debris. However, similar mounds have been identified in volcanic debris avalanche deposits (see below).

12.0 *19.3* End of pavement.

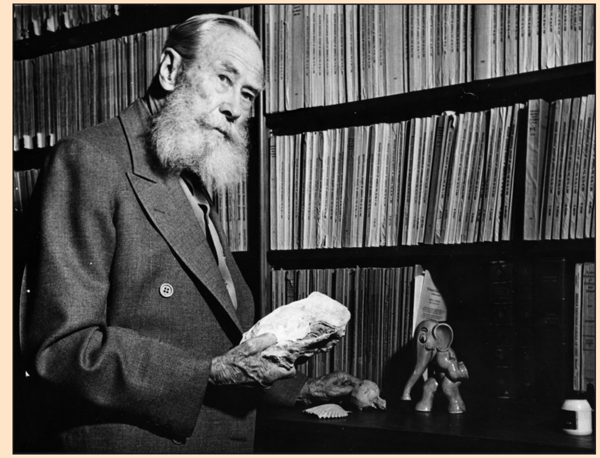
12.2 *19.5* MP 9.

12.4 *20.0* A clearcut here in 2002 revealed abundant subangular boulders of andesite scattered on the landscape in this vicinity. Although this area was mapped by Crandell and Miller (1974) as glacial drift, these subangular andesite boulders are more indicative of a lahar or volcanic debris avalanche deposit. The boulders might not be obvious because trees have reestablished on the site.

13.6 *21.9* A poorly sorted, matrix-supported deposit exposed on the right (west) here contains subangular ande-

Bailey Willis (1857–1949)

by David A. Knoblach, Katherine M. Reed, and Rebecca A. Christie



Geologist Bailey Willis (1857–1949) conducted pioneering investigations in the Mount Rainier area in the late 1880s. His lengthy career as a geologist included stints as the President of Seismological Society of America, as the head of two divisions of the U.S. Geological Survey, and as Chairman of the Geology Department at Stanford University. Willis was also an influential advocate for the establishment of Mount Rainier National Park. Photo courtesy of Stanford University Archives.

Bailey Willis, working as a survey geologist for the Northern Pacific Railway, mapped the coal seams in the Wilkeson–Carbonado area in the early 1880s. He was the first European to hike to the Carbon Glacier along the north side of the Carbon River through the Fairfax Bridge area. The route from Ashford to Fairfax, whose construction he supervised in 1883, was known for many years as the Bailey Willis (or Grindstone) trail. The trail enabled tourists to visit the north side of Mount Rainier. Willis worked with many others to have the mountain area set aside as a park (in 1899); he named Mountain Meadows, Spray Falls, Tolmie Peak, and Liberty Cap. The Willis Wall at the head of the Carbon Glacier is named after him. Coal miners recognized Willis by naming a coal town in the Wilkeson area South Willis; that town sent much of its coal production to California but faded away in about 1920 when California's oil and gas prices became lower than the cost of the 'imported' coal.

Willis joined the U.S. Geological Survey in 1884. His interest in the Puget Group continued, however; he published papers on the subject in 1897 and 1898. His career led him to study geologic structures worldwide. Oreskes (1999, p. 305) noted: "Those who thought [continental] drift plausible faced the criticism of Bailey Willis, who argued that the [continental] fits were *too* good, because faulting during breakup and subsequent coastal erosion would surely have modified the continental outlines!" He was later generally known as the 'father of structural geology'.

During his California years, he recognized the earthquake potential of that region. "It will be well for architects to respect His Majesty, the Earthquake, in making their designs" (Geschwind, 2001, p. 79). He was one of the first to push to improve local building codes there because of the earthquake risks. His efforts were not welcomed at the time. "[If scientists don't] stop their talk about the earthquake problem [in California] I for one am going to see what I can do about stopping the whole seismological games" said a real estate promoter in the early 1900s, who later organized a builders association to halt efforts to improve building codes in California, and to publicly humiliate and discredit Bailey Willis and other geologists (Geschwind, 2001, p. 89). Today the West Coast benefits from his work in having the Universal Building Code seismic zonation to guide construction.

Willis became the head of the Stanford University Geology Department in 1915. During his lifetime he presided over several professional societies and received numerous awards, including the gold medal of the Société Géographique de France (1910) and the Penrose Medal of the Geological Society of America (1944). He died in Palo Alto, California. ■

Figure K-7. Cross beds and some ripple marks exposed in rocks of the Puget Group on the north side of SR 165 between MPs 2 and 3. Marker pen (5.5 in. or 14 cm) is for scale (lower right center in circle). The cross-bedded rocks are tilted nearly vertically owing to extreme folding of the Puget Group rocks. These cross beds probably indicate sand movement in transverse bars of a braided stream, possibly at the onset of Ohanapecosh volcanism. A similar sort of sediment transport has occurred downstream of Mount St. Helens in ash-choked rivers.

site boulders and may be correlative with the similar boulders mentioned above. This deposit appears to postdate the Hayden Creek drift of about 170 to 130 ka.

13.5 *21.7* The roadcut on right exposes a glacial deposit with rounded boulders and cobbles.

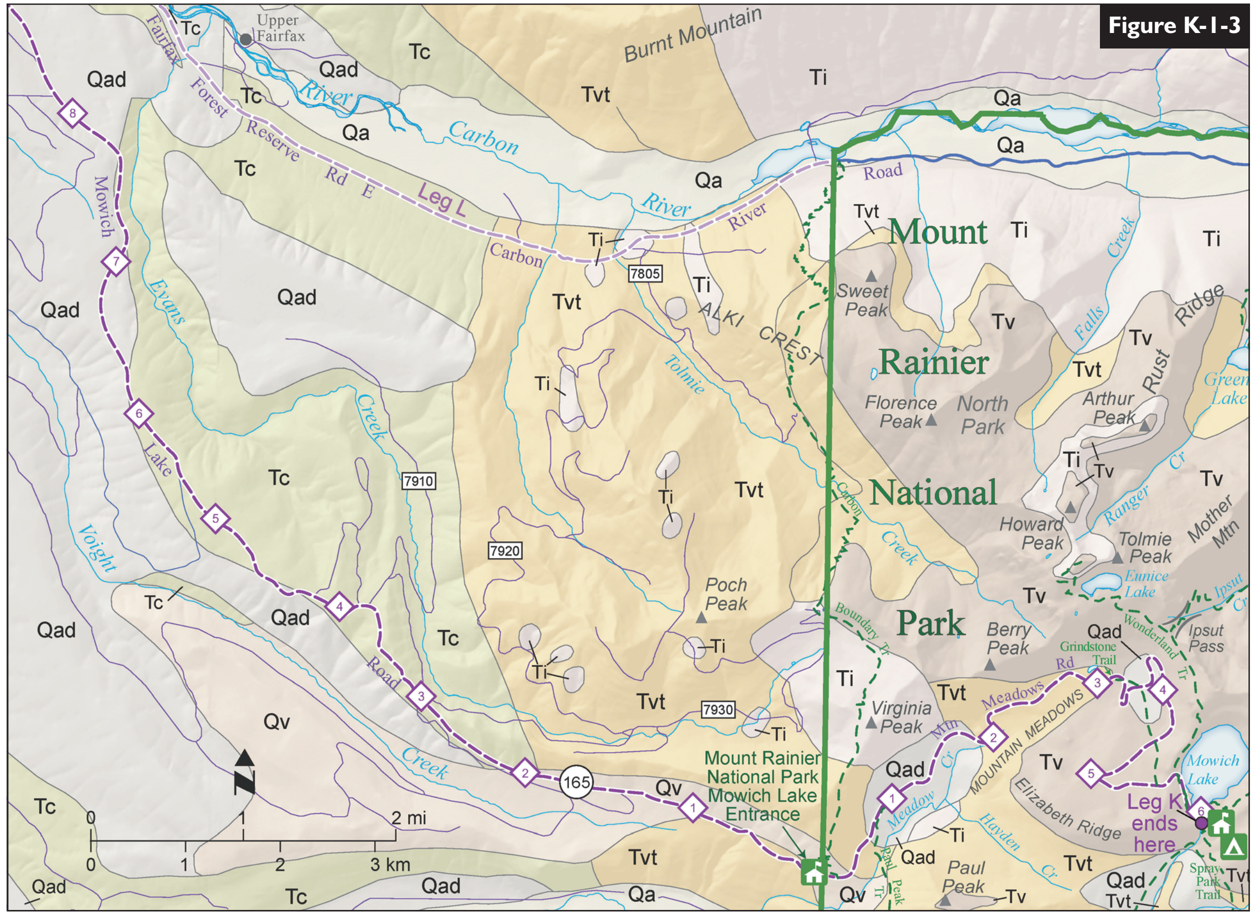
14.7 *23.6* A panoramic view to the southwest across the Mowich and Puyallup River valleys through a clearcut; it will soon be blocked by a young forest.

16.6 *26.7* Pullout to the right. Altered massive Puget Group sandstone crops out here.

16.9 *27.2* Sandstones on the east side of the road are interbedded with carbonaceous shales.

17.3 *27.8* More Puget Group sandstones are visible here, as are views of Mount Rainier through the foliage.

18.2 *29.3* MP 3. Evans Creek ORV (off-road vehicle) area. Carbonaceous siltstones with plant fragments are interbedded with sandstones. On a fine day, a spectacular view of Mount Rainier is nearly straight ahead.



18.6 *29.9* Note the cross beds (and possible ripple marks?) in sandstones of the Puget Group. The bedding of the rocks is oriented nearly vertically and strikes about north-northwest. If the beds were unfolded, the dip of the cross beds would indicate a generally westerly streamflow (Fig. K-7). For the next 0.5 mi (0.8 km) there are good outcrops of sandstone.

19.1 *31.7* More thin-bedded sandstone with local interbeds of carbonaceous material. These dipping beds contain fragments of volcanic debris and may have been deposited near the onset of Oligocene Ohanapecosh volcanism.

19.7 *31.7* If the weather is good, there is a fine view of the west face of Mount Rainier here.

20.2 *32.5* MP 1.

20.3 *32.6* Till from an advance of an alpine valley glacier overlies bedrock exposed in the quarry on the left (north). This quarry is overgrown with alder and behind a dirt berm, so it is difficult to see.

20.7 *33.3* A rainstorm during the winter of 1995/96 triggered a landslide in glacial drift and underlying colluvium that took out the road at this curve. Geologists from the Washington State Department of Transportation designed an engineered structure called a 'geosynthetic wall' to secure the repaired road from future failures (Moses and Jenkins, 1998). The concrete barriers along the south edge of the roadway mark the top of the wall.

Figure K-8. A thick sill of the Mowich Lake sill complex, a talus slope, and autumn foliage along SR 165 about 2 mi (3.2 km) west from the end of the road at Mowich Lake. Hammond (2000) noted that this sill complex covers an area of about 21 mi^2 (60 km^2) and has exposed thicknesses as great as 0.6 mi (1 km). View is to the north.

21.0 *33.8* A large outcrop of Ohanapecosh volcaniclastic rocks here includes a massive lapilli tuff. This is the first appearance of these greenish volcaniclastic rocks along this road. These rocks are significant because they are one of the older layers to show evidence of Cascade volcanism.

21.1 *33.9* This former quarry exposes a nexus of near-vent dikes that is part of the sill complex described below at mile 21.6. If you pull off on the south side of the road, you'll have a nice view of the northwest face of Mount Rainier, the North and South Mowich and Edmunds Glaciers, and the upper Mowich River valley.

21.2 *34.1* MP 0. SR 165 ends here and the National Park Service road begins. The road is gated here in winter.

21.5 *34.6* Mount Rainier National Park (sign). Rocks here strike N35°W and dip about 55 degrees to the northeast. One of the units is a poorly sorted volcaniclastic bed that might be a lahar deposit.

21.6 *34.8* Just inside the national park boundary, thin-bedded Ohanapecosh rocks are cut by dark, fine-grained intrusions. The beds of the Ohanapecosh strike about N50°W and dip about 70 degrees to the northeast, whereas the dikes strike about N30°W and dip nearly vertically. These intrusions are part of the Mowich Lake sill complex previously designated as Fifes Peak Formation (Hammond, 1999). According to Hammond, the dikes have yielded $^{40}Ar/^{39}Ar$ ages of about 22 to 21 Ma and are distinctly different in composition from the rocks of the older Fifes Peak Formation farther to the east. This sill complex covers an area of some 21 mi^2 (60 km^2) and is predominantly porphyritic augite-hypersthene andesite and microdiorite in composition. Hammond and his colleagues speculate that these intrusive bodies fed lava flows along the White River that have a similar petrologic composition.

Figure K-9. Mowich Lake and Mother Mountain. Castle Peak, on the left skyline, is composed of the dikes and many sills of the Mowich Lake andesite sill complex (Hammond, 1999). View is to the northeast.

21.7 *34.9* More alpine till is exposed here and at scattered outcrops between here and Mowich Lake.

21.8 *35.0* A sill crops out on the right

22.1 *35.5* Trailhead for the Paul Peak Trail. Intrusive rocks of the Mowich Lake sill complex crop out on the north side of the road, and a massive lapilli tuff of the Ohanapecosh Formation is not far to the west. The Paul Peak Trail accesses the Wonderland Trail, which circumnavigates the volcano.

Figure K-10. Mount Rainier and the two flank vents, Echo Rock and Observation Rock. These vents, both of Pleistocene age, produced the basaltic-andesite flows that underlie Spray Park. View is to the southeast from near the Wonderland Trail at Spray Park.

22.5 *36.2* Outcrop of intrusive andesite on the left.

22.6 *36.4* Outcrops of fragmental rock to the left here are hydrothermally altered and (or) sheared Ohanapecosh rocks. The alteration likely is related to the nearby Miocene intrusions noted above.

22.9 *36.8* Ohanapecosh volcanic breccia is exposed here.

23.5 *37.8* "Diorite porphyry" with crude columnar jointing mapped here by Fiske and others (1963) probably represents another exposure of the above-mentioned Mowich Lake sill complex described by Hammond (1999) and Hammond and others (1999). Till nearby is overlain by Mount St. Helens Yn tephra (3.5 ka).

24.2 *38.9* Greenish rocks exposed on both sides of the stream crossing are Stevens Ridge Formation volcaniclastic rocks (~25–21 Ma).

24.5 *39.4* Grindstone trailhead is to the right after a hairpin curve. This trail extends south from the Mountain Meadows area to the north flank of Elizabeth Ridge and does not connect to the Wonderland Trail.

25.0 *40.2* A prominent sill of the Mowich Lake sill complex is visible in a big cliff to the east at Ipsut Pass (Fig. K-8).

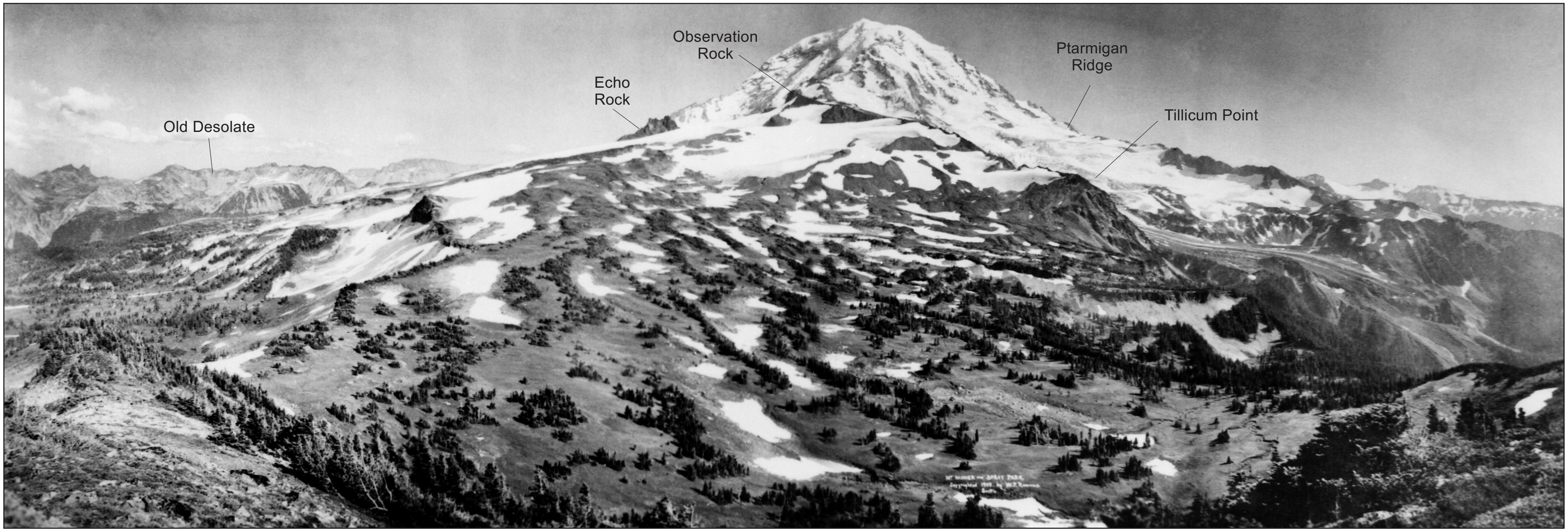


Figure K-10. "Mt. Rainier and Spray Park", a 1903 photo by W. P. Romans. This broad view is to the southeast and may have been taken from Mount Pleasant or another ridge-top location northwest of Spray Park. The smooth, partially snow-covered landform in the upper left center is the basaltic-andesite 'mini-shield' produced by Pleistocene eruptions at Observation and Echo Rocks. Old Desolate is made up of Miocene intrusive rocks and Mt. Rainier andesite. Photo copyrighted 1903, used with permission of the Washington State Historical Society; annotation added by the authors.

25.1 *40.4* Yellowish Stevens Ridge Formation(?) volcaniclastic rocks are exposed here.

25.3 *40.7* Outcrops of Stevens Ridge volcaniclastics and Fifes Peak andesites for next 1.3 mi (2.1 km).

25.9 *41.7* There can be a good view of Tolmie Peak to the north at a hairpin turn to the left at 4800 ft (1464 m) along the north flank of Elizabeth Ridge. Tolmie Peak and its adjoining ridge consist of Mowich Lake sill complex rocks with local granodiorite intrusions of early Miocene age.

27.0 *43.4* Parking area for Mowich Lake (Fig. K-9). Mowich Lake is a tarn and the largest lake in Mount Rainier National Park at 122.6 acres (~50 hectares); its measured depth is 190 ft (58 m)(Wolcott, 1961). The Spray Park Trail, accessible from the parking area, leads to beautiful Spray Park and views of Mount Rainier and two basaltic-andesite satellite vents—Observation and Echo Rocks—both of Pleistocene age (Figs. K-10 and K-11).

You will have to retrace this route to access other legs. ■