3D geologic map of the Cliffdell and western two-thirds of the Manastash Lake 7.5-minute quadrangles, Yakima and Kittitas Counties, Washington

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Citation and link

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

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NAVIGATION
(1 of 2)

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- Use the mouse wheel to zoom
- Hold both the right and left mouse buttons to pan the view
- Toggle individual layers in the lower left corner
- Change the vertical scaling or layer separation in the lower toolbar
- Selecting an object will display its data below

OBJECT DATA

undefined

undefined

undefined

undefined

Layer001
Layer002

No Separation | 5% | 50% | 100%

5

Probe

1x Z-Scale | 10x Z-Scale | Default Scale | 10

Web tutorial

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PDF3D

3D model creation: Daniel W. Eungard

Editing and production: Alexander N. Steely

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands
Division of Geology and Earth Resources
David K. Norman - State Geologist

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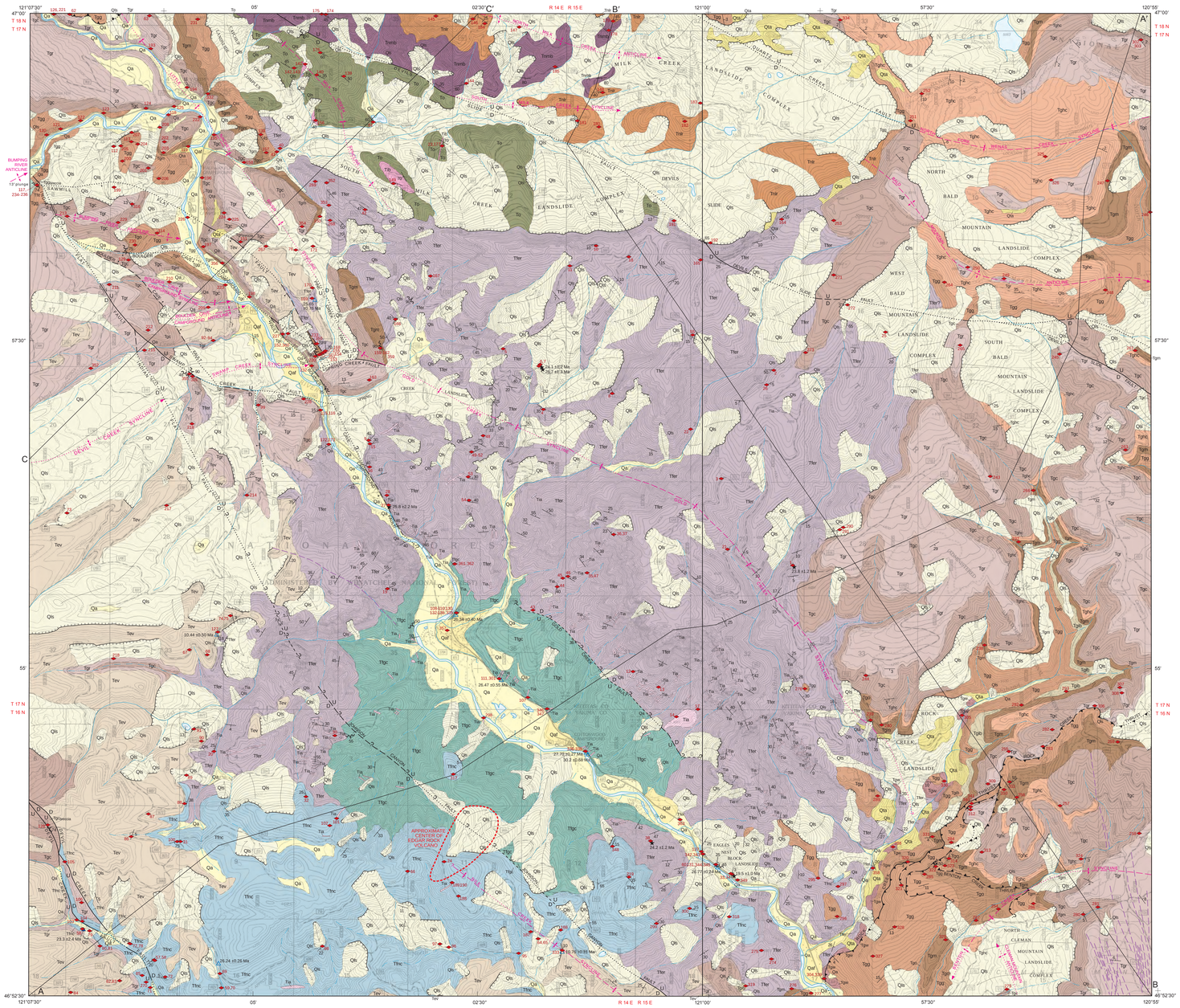
Forest Service

Geologic Map of the Cliffdell and Western Two-thirds of the Manastash Lake 7.5-minute Quadrangles, Yakima and Kittitas Counties, Washington

by Paul E. Hammond

2010



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DESCRIPTION OF MAP UNITS

Quaternary Surficial Deposits

Qa — **Alluvium**—Gravel, sand, and mud deposited in stream flow, sheet flood, overbank, and lake deposits; includes wind-blown silt (loess) and colluvium (mixed soil and weathered rock in downslope creep); gray to pale brown; subangular to rounded clasts with boulders as much as 1 m (3 ft) in diameter; consists of diverse volcanic and plutonic rocks and some pre-Tertiary metamorphic rocks; poorly stratified and sorted in coarser deposits, well stratified and sorted in finer deposits, locally crossbedded; generally poorly consolidated, with the exception of loess and colluvium; covers all stream valley bottoms and underlies narrow benches, terraces, and ridge crests where dissected by streams, as much as 120 m (400 ft) above present stream levels; includes locally remnant gravel deposits adhering to steep valley walls; 0.1 to 75 m (3–250 ft) thick; loess and colluvium, 0.1 to 5.0 m (3–15 ft) thick. Includes boulders of Edgar Rock lava breccia, up to 10 m (30 ft) in diameter, in all stream valleys draining into the Naches River between Gold Creek and Pinecliff. Boulders were probably deposited by a flash flood during torrential rain and rapid snow melt between 200 and 1000 years ago.

Qaf — **Alluvial fan**—Rock and sand; gray; clasts consist of diverse volcanic and plutonic rocks; contains angular boulders more than 1 m (3 ft) in diameter; unsorted and chaotic; includes some channel and cut-and-fill deposits; poorly consolidated; restricted lateral extent at or near mouth of tributary streams at marked change in gradient; not common in most small streams, better developed at mouth of Gold and Rock Creeks; thickness is 1 to 20 m (3–65 ft).

Qta — **Talus**—Rock, generally monolithologic; brown to gray to white, depending on color of composing rock; clasts are angular and pebble to boulder size, some larger than 1 m (3 ft) in diameter; lacks fine-grained matrix; unsorted or poorly sorted, generally coarser downslope; most surface blocks unstable; restricted extent at base of cliff or steep, rocky slope; common at steep heads of landslides; commonly partly overgrown; thickness ranges from 1 to >30 m (3–>100 ft), thicker at base.

Qls — **Landslide**—Boulders and cobbles, commonly as intact rock masses, in a matrix of sand, clay, and silt; brown to dark gray; consists of rock avalanche, slump, or earthflow deposits composed of locally derived rock and soil, commonly with woody debris; angular to rounded clasts; chaotic to poorly sorted and unstratified; generally forms hummocky topography; commonly in a complex of coalescing and nested landslides; some slides in the complex have distinct margins and others have poorly defined margins or margins that thin out along the length of the slide; 0.1 to 10 km² (0.04–3.9 mi²) in area, as much as 7 km (4.4 mi) in length and 6 km (3.7 mi) in width, and 1 to 100 m (3–330 ft) estimated thickness at toe (Table 1 in pamphlet).

Middle to Upper Miocene Volcanic Deposits

Tev — **Ellensburg Formation, volcanic facies**—Interstratified conglomerate, tuff-breccia, sandstone, siltstone, and tuff; gray to white, yellowish to very pale brown where weathered; includes debris avalanche, laharic (mud) flow, stream flow, airfall, and a few pyroclastic flow deposits; well stratified but poorly sorted; in beds 1 cm to 45 m (0.03–150 ft) thick; contains rounded to subrounded clasts of about 50% dacite–silicic andesite and about 25% each basalt and pyroxene andesite (Hammond, 2010; Humphrey, 1996); dacite-silicic andesite with phenocrysts of plagioclase (11.0–35.9%), hornblende (0.7–4.7%), clinopyroxene (0.7–4.1%), orthopyroxene (0.9–3.7%), and ilmenite-magnetite (0.2–1.7%) in a generally poorly consolidated fine-grained dacite-silicic andesite tuff containing phenocrysts of plagioclase (11.9–31.9%), hornblende (2.7–4.2%), clinopyroxene (1.2%), biotite (0.7%), ilmenite-magnetite (0.5–1.7%), pumice (0.4–23.0%), and lithic particles (11.7–15.9%); where lower part of formation contains abundant clasts of Nile Creek andesite, strata are light brown; forms steep, smooth to cliff-forming ribbed slopes; unconformably overlies with sharp contact Grande Ronde Basalt (units Tgr and Tgc) and andesite of Nile Creek (unit Tfnc) in southwest part of map and andesite of Edgar Rock (unit Tfer) in south central part of map. Conglomerate and breccia rest upon scoured surface of basalt, and finer-grained beds overlie 1 m (3 ft) thick, brown, pebbly clay paleosol. Thickness is 30 cm to 150 m (1–500 ft) in Cross Section A–A'. Age ranges from 9.1 to 16.3 Ma (upper Miocene) based on dates in Smith (1988), Hammond (2005, 2010, unpub. data).

Grande Ronde Basalt—Six single basalt lava flows (Hammond, 2010); dark gray to grayish black to black; some flows consist of multiple injections of lava or inflated invasive lava, especially the Cohassett (unit Tgc) and Grouse Creek (locally referred to as the Meeks Table, unit Tgg; Swanson, 1967). All flows contain fine-grained plagioclase (23.9–26.1%) and clinopyroxene (15.6–23.3%) in a very fine grained groundmass of tightly interwoven crystallites of plagioclase, clinopyroxene, and granular ilmenite-magnetite; in addition, Swanson (1967) reported small amounts of olivine. All flows are compositionally basaltic andesite (Hammond, 2010) rather than truly basalt. Individual flows vary in internal structure; in number, position, and thickness of tiers; in stubby to splintery to radiating columnar jointing, blocky jointing, or most commonly hackly jointing; and in vesicular to nonvesicular bases and tops to vesicular pillow lavas. Where flows terminated against gently rising topography, they grade into scoria; against steep topography, flows developed blocky to columnar jointing normal to the contact. All flows generally form steep benched slopes, rims, or cliffs. Thick beds of pillow lavas generally underlie smooth, uniformly graded slopes.

Although rarely exposed, interbeds (unit Tgb) commonly separate flows. They are 1 to 85 m (3–260 ft) thick and consist of whitish fine-grained tuff, generally of rhyolite composition, containing phenocrysts of plagioclase (8.9%), hornblende (5.3%), quartz (0.3%), biotite (0.3%), ilmenite-magnetite (0.7%), pumice (0.3%), and lithics (8.3%); yellowish to brownish fine-grained micaceous sandstone containing quartz (16.1–17.8%), biotite (5.1–7.5%), K-feldspar (4.6–7.4 %), muscovite (2.6–5.0%), plagioclase (2.2–4.1%), hornblende (0.6–0.9%), ilmenite-magnetite (1.0–2.2 %), lithics (1.6–2.3%), and siltstone; or dark gray to yellowish brown palagonitic hyaloclastite, the latter as much as 10 m (30 ft) thick. No interbeds have Ellensburg Formation lithology.

In the northeast part of the map, the Cohassett and McCoy Canyon flows (units Tgc and Tgm, respectively) merge entirely into hyaloclastite deposits (unit Tghc) where the flows advanced into either the ancestral Naches or Yakima Rivers or a lake marginal to the then-rising Manastash Ridge. The deposits vary in color from brown to orange, generally weathering to a yellowish white, are well consolidated, and contain abundant palagonite, black glassy particles, and many angular basalt fragments, most with glassy pillow rims. The lava flows consist of pillow lavas marginal to the hyaloclastite deposits. The combined deposits are as much as 200 m (650 ft) thick (Cross Section A–A'). Locally, bedding is uniformly stratified or crossbedded, but generally massive.

The top three flows, Rocky Coulee, Cohassett, and McCoy Canyon (units Tgr, Tgc, and Tgm, respectively) are part of the Sentinel Bluffs Member, N, (Reidel and others, 1989; Reidel, 2005), containing more than 4.2% MgO (Hammond, 2010) and having normal magnetic polarity. They advanced the farthest onto the flanks of Edgar Rock volcano; however, only the Rocky Coulee flow (unit Tgr) completely surrounded the volcano. The Ortley flow (unit Tgo), identified by its high TiO₂ and low MgO content (Hammond, 2010), is lower in the N₂ sequence. The lower two flows, Grouse Creek (Meeks Table; unit Tgg) and Wapshilla Ridge (unit Tgw) are R₂ sequence (Reidel and others, 1989), having reversed magnetic polarity. The Grande Ronde Basalt is divided into:

Tgr/Tgrbreccia — **Rocky Coulee lava flow**—Thickness is 1 to 45 m (3–145 ft), averaging 35 m (115 ft).

Tgc/Tgcbreccia — **Cohassett lava flow**—Thickness is 1 to 135 m (3–445 ft), averaging 110 m (360 ft).

Tghc — **Hyaloclastite deposits**—Thickness is 1 to 200 m (3–650 ft).

Tgm — **McCoy Canyon lava flow**—Thickness 1 to 90 m (3–295 ft), averaging 55 m (175 ft).

Tgo — **Ortley lava flow**—Thickness is 1 to 75 m (3–245 ft), averaging 50 m (165 ft).

Tgg/Tggbreccia — **Grouse Creek lava flow**—Locally referred to as the Meeks Table lava flow; thickness is 1 to 335 m (3–1100 ft), averaging 185 m (610 ft).

Tgw — **Wapshilla Ridge lava flow**—Thickness is 1 to 45 m (3–150 ft), averaging 30 m (100 ft).

Tgb — **Interbed deposits**—Thickness is 1 to 85 m (3–280 ft).

Upper Oligocene Intrusions

Tia — **Andesite intrusions**—Many radial dikes and one plug in the southeast flank of Edgar Rock volcano and two dikes of andesite of Nile Creek; chiefly pyroxene andesite and a few basalt and dacite; dark to medium gray, weathering brownish gray; medium- to fine-grained phenocrysts of plagioclase (4.8–39.1%), clinopyroxene (0.1–2.3%), orthopyroxene (0.7–2.8%), ilmenite-magnetite (0.1–5.2%), and clots of phenocrystic minerals as much as 5 mm (0.2 in.) in length, in a propylitized, very fine grained aphanitic groundmass. Dikes are 1 to 10 m (3–30 ft) wide; plug measures 245 x 490 m (800 x 1600 ft). Age of Edgar Rock intrusions is 26.5 to 25.6 Ma; age of dikes of andesite of Nile Creek is 26.8 to 24.6 Ma (Hammond, 2010).

Oligocene Volcanic Deposits

Fifes Peak Formation—Consists of interstratified lava flows, breccia, and tuff of basalt to rhyolite composition in excess of 1065 m (3500 ft) thick. Divided into:

Tft — **Tuff of Indian Flat**—Lithic- and pumice-lapilli crystal-vitric andesitic to rhyolitic tuff; medium gray, pale brown, yellow to white; diverse sequence of tuffs, some containing abundant lithic lapilli of andesite (lapillistone), others with phenocrysts of plagioclase (15%) and clinopyroxene (5%), most containing combinations of plagioclase (10%), quartz (10%), biotite (5%), orthopyroxene (2%), clinopyroxene (1%), and hornblende (1%), and varied amounts of pumice and lithic lapilli in a vitroclastic matrix; in beds 1 cm to 20 m (0.03–65 ft) thick; major beds of uniform composition are as much as 75 m (250 ft) thick. Most beds are of pyroclastic flow origin; less abundant are ashfall tuff and thin volcanic sedimentary beds. Unit conformably overlies andesite lava flows of Fifes Peaks volcano (unit Tfpa) and is unconformably overlain by upper Grande Ronde Basalt flows. Source is unknown but interpreted to be part of the late eruptive phase of Fifes Peaks volcano, possibly in formation of its caldera, although no intrusive rocks of comparable composition are found in the core of the volcano. Shown only in a very small area in the northwest corner of the map adjacent to Indian Flat fault and in Cross Section C–C'. Thickness is 215 m (700 ft). Age is 25 Ma, upper Oligocene (Hammond, 2010).

Tfpa — **Andesite of Fifes Peaks volcano apron (Cross Section C–C')**—Chiefly andesite, but includes basalt and dacite lava flows and lava breccia; dark gray, weathering to brown; thin interbeds of andesite and dacite tuff, white to pale yellowish brown, and local deposits of basaltic tephra, reddish brown to black. Ranges in thickness from 260 to 480 m (850–1675 ft). Radiometrically age-dated at 24.6 to 26.6 Ma (upper Oligocene) with samples taken in adjacent quadrangles of Goose Prairie, Old Scab Mountain, Mount Clifty, and Raven Roost (Hammond, unpub. data).

Tfnc — **Andesite of Nile Creek**—Chiefly porphyritic andesite and dacite and a few basaltic andesite and rhyodacite lava flows (Hammond, 2010); dark to medium gray where fresh, brown to reddish brown where weathered; contains abundant fine- to coarse-grained phenocrysts of plagioclase (7.6–37.8%), orthopyroxene (1.2–6.6%), clinopyroxene (0.1–6.3%), and ilmenite-magnetite (0.1–2.8%) in a very fine grained to glassy groundmass (Carkin, 1988); distinguished from other lava flows of Fifes Peak Formation by prominent orthopyroxene phenocrysts; forms blocky lava flows with brecciated base, dense flow-layering, platy to blocky jointed interior, and brecciated to scoriaceous top; 5 to 60 m (15–200 ft) thick; contains interbeds as much as 10 m (30 ft) thick of whitish to yellowish tuff with phenocrysts of plagioclase (3.9–4.9%), quartz (1.3–1.6%), ilmenite-magnetite (0.4%), pumice (5.5–16.8%), and lithics (10.3–17.9%) and lithic-pumice lapilli tuff to tuff-breccia of andesite-rhyolite composition (Hammond, 2010). Most deposits in the map consist of thick sequences of laharic lithic tuff-breccia, 5 to 60 m (15–200 ft) thick, with subrounded boulders of lava as much as 10 m (30 ft) in diameter and interbedded tuff and lava flows. Flows and tuffs erupted from the andesite intrusive complex of North Fork Rattlesnake Creek, the erosional remnant of the North Fork Rattlesnake Creek volcano in the Timberwolf Mountain 7.5-minute quadrangle to the southwest (unit Tira, Hammond, 2005). Unit forms steep, benched slopes and unconformably overlies deposits of Edgar Rock volcano with a sharp contact on a surface of moderate to high relief, 5 to 50 m (15–165 ft). Unit thickness is 150 to 300 m (500–1000 ft). Age is 24.6 to 27.3 Ma, upper Oligocene (Hammond, 2010).

Tfer — **Andesite of Edgar Rock volcano**—Chiefly blocky lava flows and breccia of basalt, andesite, and dacite (Hammond, 2010); black to gray, weathering brown; interbedded laharic breccia and small amount of brown and orange to yellow tuff and volcaniclastic sedimentary rocks (Carkin, 1988); most rubbly of the Fifes Peak Formation lava flows; basalt and basaltic andesite compose about 75%, andesite about 20%, and dacite about 5% of the flows; all flows contain abundant fine- to coarse-grained phenocrysts. Basalt and basaltic andesite contain plagioclase (1.0–39.1%), olivine (0.1–13.1%), clinopyroxene and orthopyroxene (0.1–2.3% each), and ilmenite-magnetite (0.1–9.2%); andesite contains plagioclase (0.3–25.4%), clinopyroxene and orthopyroxene (0.2–1.8% each), and ilmenite-magnetite (0.3–4.9%); and dacite contains plagioclase (3.1–18.7%), clinopyroxene and orthopyroxene (0.1–1.8% each), and ilmenite-magnetite (0.6–1.4%) in a fine- to very fine grained intergranular groundmass. Lava flows are blocky to platy jointed to totally brecciated and 2 to 40 m (7–13 ft) thick. Laharic breccia is 1 to 10 m (3–30 ft) thick, tuff is 5 cm to 35 m (0.2–120 ft) thick, and volcaniclastic sedimentary rock is 1 to 4 m (3–13 ft) thick. Unit forms steep slopes with irregular benches and cliffs. Base of unit, generally breccia, is locally exposed, unconformably overlying rocks of Gold Creek (unit Ttgc). A 35-m (120 ft)-thick brown lithic claystone (altered tuff) forms the base exposed west of the Devils Slide. Unit is overlain unconformably by Ellensburg Formation, Grande Ronde Basalt, and andesite of Nile Creek. Maximum thickness is 1800 m (5900 ft)(Cross Section A–A'). Age is 25.7 to 26.4 Ma, upper Oligocene (Hammond, 2010).

Ttgc — **Rocks of Gold Creek**—Massive lithic breccia intruded by many pyroxene andesite to basalt dikes (Hammond, 2010); deeply weathered, mottled brown, orange, and gray with greenish gray dikes; breccia forms about 75% of deposit, dikes 25%; breccia composed of 5 cm to 1 m (0.2–3 ft) angular to subrounded clasts of basaltic and andesitic lava and intrusive rock in a fine- to medium-grained comminuted rock matrix; dikes are aphyric to porphyritic, with fine- to medium-grained phenocrysts of plagioclase (5.8–26.0%), near totally altered clinopyroxene (0.7%), hornblende (0.5–7.1%), and ilmenite-magnetite (0.1–1.5%) in an intergranular groundmass; dikes are 1 to 15 m (3–45 ft) thick, commonly in clusters; extensively altered and well fractured. In the west-central part of the map, along SR 410 (secs. NE¼ 35, NW¼ 36, and SW¼ 29, T17N R14E), the upper-most part of the unit is a debris-avalanche megabreccia, 600 m (2000 ft) long and 50 m (165 ft) thick. Gold Creek rocks form the core of either Edgar Rock volcano or a similar older volcano that was deeply eroded before formation of Edgar Rock volcano, based on similar age and composition of breccia and dikes. Unit Ttgc is overlain unconformably by the andesite of Edgar Rock (unit Tfer) and the andesite of Nile Creek (unit Tfnc). Base of the unit is unexposed, but its thickness is in excess of 900 m (3000 ft)(Cross Section A–A'). Age of the unit is 26.3 to 30.3 Ma, lower to upper Oligocene (Hammond, 2010).

Lower Oligocene Intrusions

Tib — **Basaltic andesite dike, sill, or plug**—Sill and three dikes intruded into Ohanapecosh Formation (unit To); dark brown to greenish gray; basaltic andesite in composition (Hammond, 2010); aphanitic to porphyritic; fine- to medium-grained phenocrysts of plagioclase (13%), olivine (trace), clinopyroxene (1%), and ilmenite-magnetite (3%) in a fine-grained intergranular or inserted groundmass; generally altered and weathered; sill is 150 m (500 ft) wide and 45 m (160 ft) thick with vesicular margins; dikes are 1 to 35 m (3–115 ft) wide. Age is indefinite, younger than underlying Naches Formation (unit Tn), about 31 Ma, lower Oligocene.

Middle Eocene to Lower Oligocene Volcanic and Sedimentary Deposits

To — **Ohanapecosh Formation**—Interstratified tuff, laharic tuff-breccia, volcanic sedimentary rock, and two lava flows with associated tuff; pale brown to grayish green, grayish white lava flow and tuff; lava flows of basaltic andesite and rhyolite compositions, tuff chiefly rhyodacite-rhyolite in composition (Hammond, 2010). Bed of gray tuff of basaltic andesite lies adjacent to Devils Slide fault; altered and weathered; only recognizable minerals in tuff are plagioclase (10–15%) and quartz (5–10%); in addition tuff contains pumice and lithic lapilli; some tuff contains abundant carbonaceous fragments. Sandstone and siltstone are fine grained; bedding ranges from about 15 cm to 10 m (0.5–35 ft) thick. Both lava flows are aphanitic and are 10 m (35 ft) thick. Formation is in contact with Naches Formation along Devils Slide fault and overlain unconformably by deposits of Edgar Rock volcano and lava flows of upper Grande Ronde Basalt; base of formation not exposed. Thickness is at least 1900 m (6500 ft)(Cross Sections A–A', B–B', and C–C'). Age is about 28 to 32 Ma (lower Oligocene) based on age determinations northwest and west of map in quadrangles of Goose Prairie, Mount Clifty, Noble Knob, Norse Peak, Old Scab Mountain, Raven Roost (Hammond, unpub. data), and Timberwolf Mountain (Hammond, 2005). Unit is cut out to northeast in Cross Section A–A' by faults in the Manastash Ridge area.

Naches Formation—Consists of conformable interstratified sedimentary rock, basalt lava flows and tuff, and rhyolite lava flows and tuff, in excess of 1830 m (6000 ft) in map area. Divided into:

Tnr — **Rhyolite of Lily Pond Lake**—Interstratified lava flows and tuff; greenish gray, gray to grayish white, commonly iron and manganese stained; all lava flows and tuff composed of rhyolite (Hammond, 2010); lava flows are chiefly devitrified, varying from black perlitic flow-layered glass to a white amorphous mass; devitrified rock commonly contains spherulites and lithophysae; crystals are rare, less than 10% total, consisting only of plagioclase and quartz; tuff is fine grained, containing devitrified pumice and lithic lapilli and rare crystals; rock is well fractured, consequently slopes below are mantled with angular blocks; forms steep knobby slopes and jagged ridges with cliffs; tuff occurs in beds 2 to 15 m (5–50 ft) thick, lava flows are as much as 100 m (330 ft) thick; thickness of unit is 400 m (1300 ft; Cross Section B–B'); unit conformably overlies basalt north of Milk Creek (unit Tnmb); top of unit in map area is overlain conformably by a thin sequence, less than 5 m (15 ft) thick, of fine-grained sedimentary rock; age is 44.7 Ma, determined in one sample from the Quartz Mountain quadrangle to the north (Hammond, 2010).

Tnmb — **Basalt north of Milk Creek**—Chiefly scoriaceous lava flows and minor tuff; brown weathering, gray-green in fresh exposure; altered; all flows basalt in composition (Hammond, 2010); aphyric to generally porphyritic, containing fine- to medium-grained phenocrysts of plagioclase (13–35.8%), clinopyroxene (1.5–4.3%), olivine (~1%), and ilmenite-magnetite (0.4–3.6%) in an ophitic, intergranular to intersertal groundmass; vesicular to scoriaceous, with brecciated flow tops and bases, commonly amygdaloidal at top and bottom of flow; blocky to platy jointed, rarely columnar jointed; underlies steep slopes with thin, discontinuous rims; lava flows are 3 to 15 m (10–50 ft) thick; tuff deposits are generally of tuff-breccia with abundant angular basalt clasts, as much as 30 m (100 ft) thick; thickness of unit is 400 m (1300 ft) (Cross Section B–B'); conformable contacts with enclosing sedimentary and rhyolitic volcanic rocks; saprolitic palesol separates overlying rhyolite from basalt; age is 43.5 Ma, middle Eocene (Hammond, 2010).

Tnu — **Naches Formation, undifferentiated (cross sections only)**—Unknown volcanic and sedimentary deposits at depth.

Pre-Tertiary Rocks of Manastash Ridge

pTz — **Unknown pre-Tertiary rocks (cross sections only)**—At least two possibilities exist: (1) biotite-hornblende amphibolite with lenses of chloritized hornblende quartz-diorite gneiss of Goetsch (1978), cropping out 6.5 km (4 mi) north-northwest in the Frost Mountain 7.5-minute quadrangle, and (2) Lookout Mountain biotite schist of Stout (1964), located 16 km (10 mi) to the northwest in the Quartz Mountain 7.5-minute quadrangle. Both units are briefly described in Tabor and others (2000, p. 41). They lie along the southern margin of the Taneum Lake fault zone, mapped by Goetsch (1978).

GEOLOGIC SYMBOLS

Contact—dashed where approximately located

Bedding (cross sections only)—queried where uncertain

Normal fault—long-dashed where approximately located; dotted where concealed; queried where uncertain; bar and ball on downthrown side

Thrust fault—long-dashed where approximately located; short-dashed where inferred; dotted where concealed; sawteeth on upper plate

High-angle dip-slip fault—long-dashed where approximately located; short-dashed where inferred; dotted where concealed; queried where uncertain; relative motion shown by U and D

High-angle, right-lateral, oblique-slip fault—long-dashed where approximately located; short-dashed where inferred; dotted where concealed; queried where uncertain; relative horizontal motion shown by arrows, relative vertical motion shown by U and D

Fracture, approximately located

Anticline—long-dashed where approximately located; dotted where concealed; large arrow shows plunge direction

Syncline—long-dashed where approximately located; dotted where concealed; large arrow shows plunge direction

Arrow—showing direction of landslide movement

Landslide scarp—hachures on downslope side

20 — Bedding—showing strike and dip

25 — Flow layering in lava flow—showing strike and dip

45 55 — Shear—showing strike and dip

23.3 ±2.4 Ma — Age-date sample, zircon fission-track

26.77 ±0.24 Ma — Age-date, $^{40}Ar/^{39}Ar$

19.5 ±1.0 Ma — Age-date sample, whole-rock K/Ar

243 — Geochemistry sample location

Note: Age-date and geochemistry sample locations share the same numbers. Where an age-date sample and a geochemistry sample were collected at the same site, there is more than one symbol but only one number.

REFERENCES CITED

Bentley, R. D.; Powell, Jack; Jenvold, Steven; Campbell, N. P., 1988, Structural geology and stratigraphy of the Cleman Mountain area, "Cleman Mountain Report"; [unpublished report submitted to] Meridian Oil Company, Denver, Colorado, December 15, 1988, 103 pages, 5 plates, 2 tables.

Byrnes, M. E., 1985, Provenance study of late Eocene arkosic sandstones in southwest and central Washington; Portland State University Master of Science thesis, 65 p.

Campbell, N. P., 1975, A geologic road log over Chinook, White Pass, and Ellensburg to Yakima highways: Washington Division of Geology and Earth Resources Information Circular 54, 82 p.

Campbell, N. P., 1987, Geology of the Rattlesnake Creek mile 4 damsite, central Washington: Association of Engineering Geologists Bulletin, v. 24, no. 4, p. 549-555.

Campbell, N. P., 1988, Structural geology along the northwestern Columbia River Basalt margin, Washington: Washington Division of Geology and Earth Resources Open File Report 88-5, 108 p., 8 plates.

Campbell, N. P., 1989, Structural and stratigraphic interpretation of rocks under the Yakima fold belt, Columbia Basin, based on recent surface mapping and well data. *In* Reidel, S. P.; Hooper, P. R., editors, Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 209-222.

Carkin, B. A., 1988, The geology and petrology of the Fifes Peak Formation in the Cliffdell area, central Cascades, Washington: Western Washington University, Master of Science thesis, 157 p., 2 plates.

Fiske, R. S.; Hopson, C. A.; Waters, A. C., 1963, Geology of Mount Rainier National Park, Washington: U.S. Geological Survey Professional Paper 444, 93 p., 1 plate.

Goetsch, S. A., 1978, The metamorphic and structural history of the Quartz Mountain–Lookout Mountain area, Kittitas County, central Cascades, Washington: University of Washington Master of Science thesis, 86 p., 1 plate.

Hammond, P. E., 2005, Geologic map of the Timberwolf Mountain 7.5-minute quadrangle, Yakima County, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-60, 1 sheet, scale 1:24,000.

Hammond, P. E., 2009, Geologic map of the Meeks Table and western two-thirds of the Nile 7.5-minute quadrangles, Yakima County, Washington: Washington Division of Geology and Earth Resources Geologic Map GM-74, 1 sheet, scale 1:24,000.

Hammond, P. E., 2010, Supplement to GM-76, Geologic map of the Cliffdell and western two-thirds of the Manastash Lake 7.5-minute quadrangles, Yakima and Kittitas Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 2010-6, 1 Microsoft Excel file.

Humphrey, C. C., 1996, Correlation of the upper Ellensburg Formation with the Old Scab Mountain eruptive center, east-central Cascade Range, Washington: Portland State University Master of Science thesis, 201 p.

Kienle, C. F., Jr.; Bentley, R. D.; Anderson, J. L., 1977, Geologic reconnaissance of the Cle Elum–Wallula lineament and related structures: Shannon & Wilson [Portland, Ore.], 75 p.

Le Maitre, R. W., editor; and others, 1989, A classification of igneous rocks and glossary of terms—Recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks: Blackwell Scientific Publications, 193 p., 1 plate.

Luker, J. A., Jr., 1985, Sedimentology of the Ellensburg Formation northwest of Yakima, Washington: Eastern Washington University Master of Science thesis, 184 p.

Price, N. J.; Cosgrove, J. W., 1990, Analysis of geological structures: Cambridge University Press [Cambridge, UK], 502 p.

Ratzat, Erwin, 1945, The Olympic–Wallowa lineament: American Journal of Science, v. 243A [Daly volume], p. 479-485.

Reidel, S. P., 2005, A lava flow without a source—The Cohassett flow and its composition components, Sentinel Bluff Member, Columbia River Basalt Group: Journal of Geology, v. 113, no. 1, p. 1-21.

Reidel, S. P.; Tolan, T. L.; Hooper, P. R.; Beeson, M. H.; Fecht, K. R.; Bentley, R. D.; Anderson, J. L., 1989, The Grande Ronde Basalt, Columbia River Basalt Group—Stratigraphic descriptions and correlations in Washington, Oregon, and Idaho. *In* Reidel, S. P.; Hooper, P. R., editors, Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 21-53.

Schmid, R., 1981, Descriptive nomenclature and classification of pyroclastic deposits and fragments—Recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks: Geology, v. 9, no. 1, p. 41-43.

Smith, G. A. 1988, Sedimentology of proximal to distal volcaniclastics dispersed across an active foldbelt—Ellensburg Formation (late Miocene), central Washington: Sedimentology, v. 35, no. 6, p. 953-977.

Stout, M. L., 1964, Geology of a part of the south-central Cascade mountains, Washington: Geological Society of America Bulletin, v. 75, no. 4, p. 317-334, 1 pl.

Swanson, D. A., 1966, Tieton volcano, a Miocene eruptive center in the southern Cascade mountains, Washington: Geological Society of America Bulletin, v. 77, no. 11, p. 1293-1314, 2 plates.

Swanson, D. A., 1967, Yakima Basalt of the Tieton River area, south-central Washington: Geological Society of America Bulletin, v. 78, no. 9, p. 1077-1109.

Swanson, D. A., 1989, Geologic maps of the French Butte and Greenhorn Buttes quadrangles, Washington: U.S. Geological Survey Open-File Report 89-309, 25 p., 2 plates, scale 1:24,000.

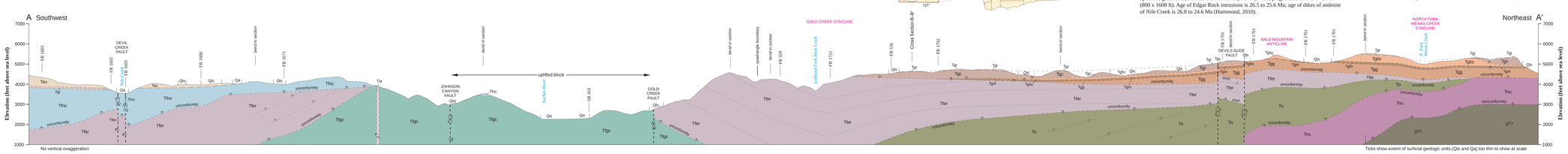
Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Waitt, R. B., 2000, Geologic map of the Snoqualmie Pass 30 x 60 minute quadrangle, Washington: U.S. Geological Survey Geologic Investigations Series Map I-2538, 1 sheet, scale 1:100,000, with 57 p. text.

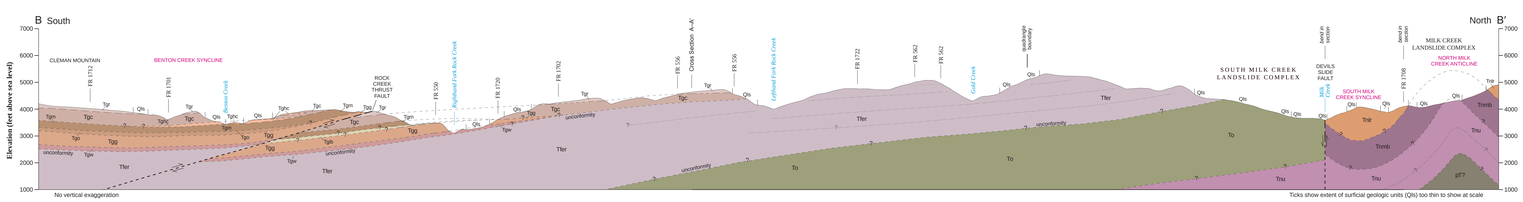
Walker, J. D.; Geissman, J. W., compilers, 2009, Geologic Time Scale: Geological Society of America, doi: 10.1130/2009.CTS004R2C.

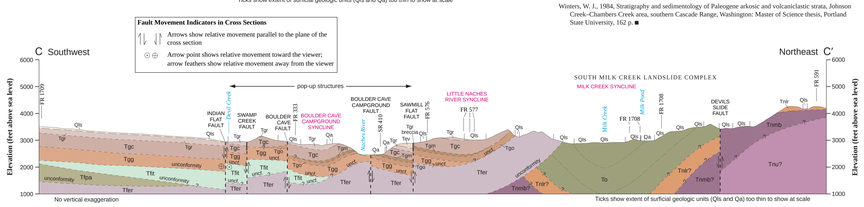
Warren, W. C., 1941, Relation of the Yakima basalt to the Keechelus andesitic series: Journal of Geology, v. 49, no. 8, p. 795-814.

Wilson, Marjorie, 1989, Igneous petrogenesis—A global tectonic approach: Unwin Hyman [London], 466 p.

Winters, W. J., 1984, Stratigraphy and sedimentology of Paleogene arkosic and volcaniclastic strata, Johnson Creek–Chambers Creek area, southern Cascade Range, Washington: Master of Science thesis, Portland State University, 162 p. ■







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