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Geologic Map of the Eagle Gorge 7.5-minute Quadrangle

Geologic Map of the Eagle Gorge 7.5-minute Quadrangle, King County, Washington

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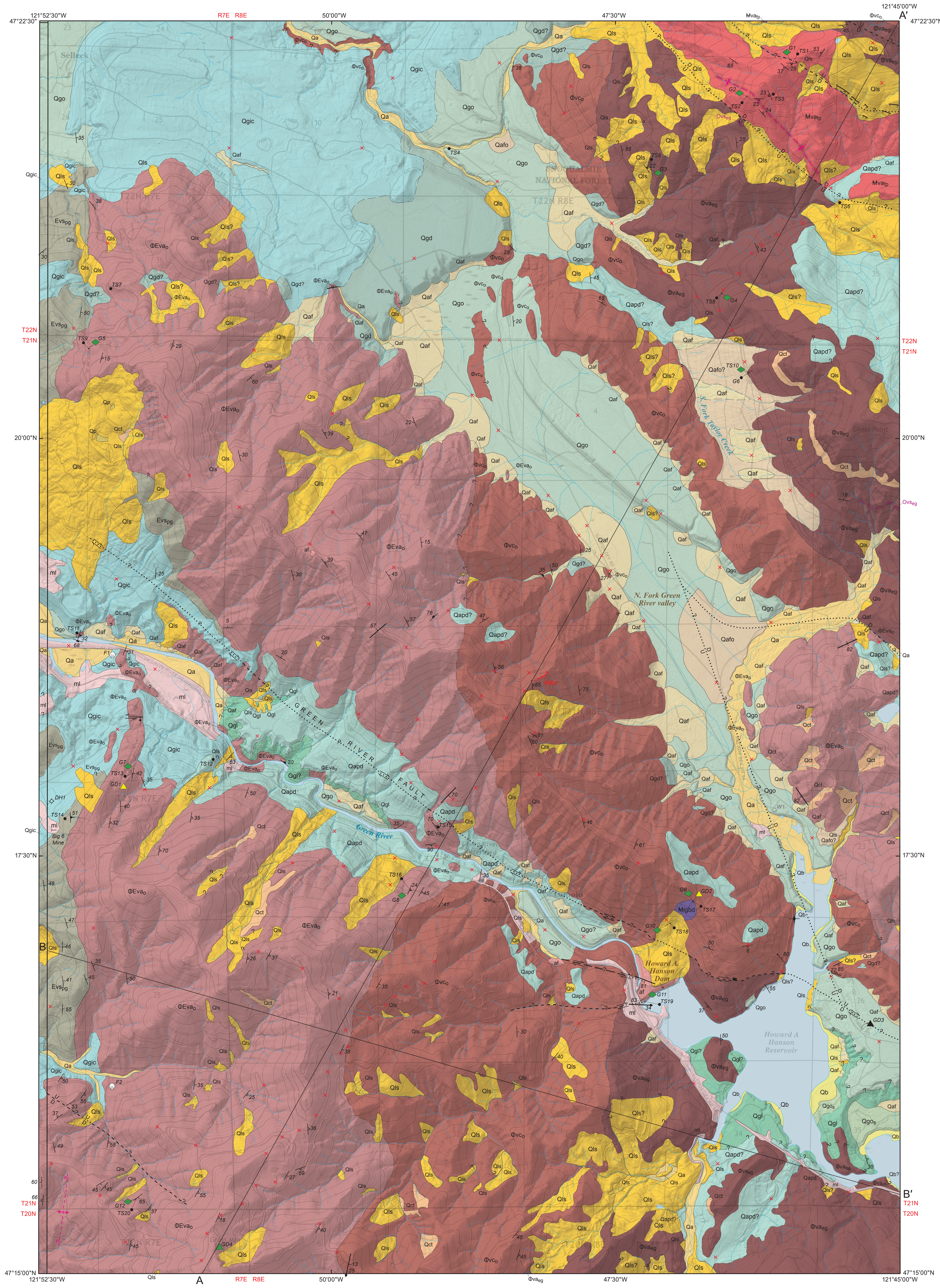


ABSTRACT

We present a geologic map of the Eagle Gorge quadrangle in Washington's Cascade foothills on the eastern edge of the southern Puget Lowland. We combine new geologic mapping and geophysical modeling to better understand the glacial history, local faulting, and resources in the map area.

Eocene to Miocene sedimentary and volcanic rocks are deformed throughout the map area and mostly dip east in the south and central portions of the map area. Older rocks have steeper dips, suggesting the strata were emplaced while deformation was ongoing.

Geologic mapping and geophysical modeling identify northwest-striking, nearly vertical faults and northwest-striking folds in the northeast corner and along the eastern boundary of the quadrangle. Our geophysical model supports the existence of a northwest-trending, synclinal basin that may have developed during the eruption of Eocene to Miocene volcanic rocks that fill the basin. These rocks are variably deformed, suggesting they experienced progressive deformation that may have continued into the Holocene. However, the evidence for active faulting in the Holocene remains unclear. Northwest-trending scarps in Holocene landslide deposits may be related to faulting or landslide movement in the northeast corner of the map area. Downstream of the Howard A. Hanson Dam, slip occurred on a fault prior to glacial drift being emplaced, as evidenced by alpine drift covering fault gouge that records fault movement.

DESCRIPTION OF MAP UNITS

Holocene to Pleistocene Nonglacial Deposits

af — **Artificial fill (Holocene)—**Mixed earth materials of varied grain size and sorting placed to elevate the land or modify topography.

ml — **Modified land (Holocene)—**Mixed earth materials of varied grain size and sorting; modified by humans.

Qa — **Alluvium (Holocene to Pleistocene)—**Unconsolidated gravel, sand, and silt in varied amounts; mapped in active river and stream channels and floodplains.

Qb — **Beach deposits and alluvium (Holocene)—**Sand, locally interbedded with varying amounts of silt, pebbles, cobbles, and boulders; mapped along the shores of Howard A. Hanson Reservoir in the eastern portion of the quadrangle; includes some alluvium where streams enter the reservoir and are modified by changes in water level and wave action.

Qp — **Peat (Holocene to Pleistocene)—**Organic and organic-rich sediment including peat, gyttja, muck, silt, clay, and sand; mapped where lidar reveals flat areas and closed depressions.

Qaf — **Alluvial fan (Holocene to Pleistocene)—**Varied amounts of pebble- to cobble-gravel, boulders, and sand with minor silt; generally unconsolidated and moderately to poorly sorted; thickness varies from a few meters on smaller fans to 25 meters on well-developed fans in the North Fork Green River valley; mapped throughout the area where stream channels become unconfined and transition into a characteristic fan-shaped landform that can be observed in lidar.

Qafo — **Alluvial fan older (Holocene to late Pleistocene)—**Mapped where lidar suggests that the source area may no longer be active because it has been disconnected by incision; Qafo is queried where indistinct in lidar.

Qls — **Landslide deposits (Holocene to Pleistocene)—**Sand, silt, clay, pebbles, cobbles, and boulders, in varied amounts, derived from rocks and deposits upslope; mostly loose, unsorted, and jumbled; mapped from landforms expressed in lidar. We query this unit where landslide forms were evident but questionable. Absence of a mapped landslide does not indicate the absence of landslide hazard.

Qct — **Colluvium and talus deposits (Holocene to Pleistocene)—**Loose soil, gravel, cobbles and boulders, sand, silt, and clay, all in varied amounts, deposited by shallow ravel and soil creep or rock fall.

Pleistocene Continental Glacial Sediment

The Puget lobe of the Cordilleran ice sheet advanced to its southern terminus, located approximately 100 km southwest of the map area (Bretz, 1913; Polenz and others, 2018), during the late Wisconsinan Vashon stade of the Fraser glaciation (Armstong and others, 1965). Based on the work of Porter and Swanson (1998), and recalibrated by Haugerud (2021), we estimate that Vashon ice and associated Vashon Drift entered the map area after about 17.6 to 17.7 ka based on samples from the Issaquah delta. The Puget lobe transported a diverse assortment of rock types from British Columbia and the North Cascades, including metamorphic and granitoid clasts sourced from north of the map area. We call this diverse assemblage of clasts 'exotic' or 'distally-sourced' because the rock types within them are uncommon or absent in the map area, and their clasts are commonly more rounded compared to locally derived clasts.

Field relationships indicate that an alpine glacial advance in the Cascade Range preceded the continental ice sheet advance. The Puget lobe and the alpine glaciers did not touch during the most recent maximum extent of the Puget lobe as inferred from cross-cutting relationships and dating of the deposits (Mackin, 1941; Crandell, 1963; Porter, 1976). Crandell (1963) mapped relatively fresh alpine drift, termed "Evans Creek drift" approximately 30 km south-southeast of the map area for deposits related to alpine valley glaciers that extended from the Mount Rainier area early in the Fraser glaciation. The Evans Creek drift preceded the Puget lobe's advance into the area based on mapping in nearby areas (Crandell, 1963; Porter, 1976). Within the map area we found alpine drift that was weathered and located in areas not associated with obvious cirques or moraines. It appeared more weathered than we would expect based on Crandell's descriptions of Evans Creek drift, and thus it is likely older. We've mapped this alpine drift as unit Qapd.

VASHON DRIFT

Qgo — **Recessional outwash, undivided (late Pleistocene)—**Pebble gravel and sand, less commonly includes cobble and boulder gravel; light tan-brown to light gray-brown, or variegated with iron and silica cement; loose; well rounded to subangular; poorly sorted to well sorted; gravel is clast-supported but locally it has a matrix of sand and silt, and interbeds of laminated silt and sand. Unit Qgo includes both locally derived and exotic clasts suggesting it is sourced from both continental glacial and local sources. Locally, the unit is subdivided into:

Qgo$_s$ — **Recessional outwash sand (late Pleistocene)—**Sand and silt; light brown; loose; subrounded fine sand; well sorted; at least 25 m thick and mapped on distinct terraces between 1,170 and 1,250 ft in elevation upstream of the Howard A. Hanson Dam in the Green River valley; younger than unit Qgl and formed while a glacial lake was draining.

Qgl — **Glaciolacustrine deposits (late Pleistocene)—**Sand and silt with minor clay and rare diamicton containing pebbles and cobbles; light brown to light gray; compact and stiff; subrounded clasts; well sorted to poorly sorted; planar-laminated beds of silt and structureless sand, locally includes diamicton and beds of silt, including subrounded exotic pebbles that we interpret as dropstones; deposited in glacial lakes when the valleys were blocked by the Cordilleran ice sheet; we infer the age of unit Qgl to be younger than about 17.7 ka and older than 15.5 ka (Porter and Swanson, 1998; Haugerud, 2021).

Qgd — **Glacial embankment (late Pleistocene)—**Sandy pebble to cobble gravel, with sparse pebble to boulder diamicton (till) and minor interbedded clayey silt; tan to light gray; sand and gravel are loose to dense and till and silt are very stiff; clasts are subrounded to rounded and exotic clasts are common; sorting varies from unsorted diamicton to well-sorted sand and gravel; Booth (1986) studied nearby drainages and suggested that these deposits are the result of subglacial deposition into a glacially impounded lake near the ice limit during glacial maximum. A few queried polygons, mapped remotely using lidar, are on benches just below 1,500 ft elevation that appear to be associated with a glacial lake or moraines in the North Fork Green River valley and their origin is unclear.

Qgic — **Ice contact deposits (late Pleistocene)—**Stagnant ice deposits, consisting of ablation till, kame deposits, subglacial outwash, and rare lodgment till; primarily loose to compact silty diamicton, with minor sandy pebble- to cobble-gravels; color is generally light gray to light brown-gray; grain size in the diamicton ranges from silt to boulder; clasts are generally subrounded but may include rare faceted and subangular clasts; typically a chaotic mixture of variably sorted and bedded sediment and diamicton; we interpret these deposits as being formed by the Puget lobe when it pushed into the Green River main stem and North Fork; clast lithologies are diverse and include rare distally sourced clasts (metamorphic and granitoid clasts), which suggest they were transported by the Puget lobe from elsewhere. The geomorphic character of unit Qgic includes drumlins and irregular hummocky landforms, such as kames and kettles, that suggest the unit was deposited as the ice sheet stagnated and melted.

PRE-VASHON DRIFT

Qapd — **Glacial drift, alpine (Pleistocene)—**Diamicton with boulders to pebbles in a matrix of sand to clay, and stratified drift of clay, silt, sand, pebble and cobble gravel, and ash altered to clay; tan to brown and red brown; soft to stiff and loose to dense; clasts subangular to subrounded and commonly more subangular; poorly to moderately sorted; commonly a thin veneer of unsorted oxidized diamicton in the uplands; varied clast weathering and degrees of soil development suggest that unit Qapd may include deposits from multiple alpine ice advances prior to the Fraser glaciation, similar to findings of Tabor and others (2000). Unit Qapd probably predates the Evans Creek drift of Crandell (1963) because of the presence of ash altered to clay and the more advanced state of weathering than would be expected for Evans Creek Drift based on its appearance in nearby areas. However, we lack direct age control.

Tertiary Bedrock Units

INTRUSIVE ROCKS

Migbd — **Gabbroic diorite (Miocene)—**Gray equigranular gabbroic diorite (geochemistry site G10, SiO_2 = 54.6%); phenocrysts of plagioclase, hornblende, and pyroxene; weathers pale yellow gray; well indurated; plagioclase crystals are anhedral to subhedral typically 2–3 mm and range to 4 mm; blocky planar joint. Mapped only in a small area of a landslide head-scarp 1 km northeast of the Howard Hanson dam where it intrudes unit Φvc$_o$. A zircon U-Pb age from this unit is 18.9 ±0.2 Ma (age site GD2) suggesting the diorite crystallized at that time

MΦii — **Andesite dikes (Miocene to Oligocene)(line unit only)—**Aphanitic to moderately porphyritic andesite; gray to black and green gray; weathers light tan and brown; well indurated; jointing is locally prominent and blocky, parallel and subperpendicular to the intrusive contact; most phenocrysts are 1–3 mm long; thin sections reveal phenocrysts are subhedral plagioclase with sparse subhedral to anhedral clinopyroxene. The groundmass is dark and cryptocrystalline and alteration minerals include clay (possibly smectite), iron oxides, calcite, and zeolites. Dike widths vary from 15 cm to 3 m and alteration of host rock is often less than 25 cm wide. This unit was only recognized in the central part of the map area along the ridge between the North Fork Green River Valley and the main stem of the Green River where it intrudes unit Φvc$_o$. This unit is depicted on the map plate as a red dike symbol. We interpret this unit as the feeder dikes for unit Mva$_{fp}$ and perhaps the earlier Oligocene volcanic flows of unit Φva$_{eg}$. If this is correct, then this unit is likely more widespread than currently mapped.

VOLCANIC AND SEDIMENTARY ROCKS

Mva$_{fp}$ — **Fifes Peak Formation (Miocene)—**Andesite to basalt and minor flow breccia; andesite to basaltic andesite is aphanitic and gray, dark gray, or dark red brown; basalt is porphyritic and dark gray to black; flow breccia is brown red; weathers to light gray, gray brown, brown, or red; flows are well indurated and breccia is variable and can be friable; jointing in lava flows is platy or occasionally produces wavy crude columns, vesicular flow tops are rare; flows include zeolite and clay alteration but lack the abundant prehnite observed in flows from older units (Hartman, 1973); individual flows are approximately 10–30 m thick; Hartman (1973) interpreted that the unit erupted from Miocene shield volcanoes; the lava was emplaced on top of andesite (unit Φva$_{eg}$) on an erosional unconformity according to Hammond (1963) and is faulted and deformed into a tight syncline.

Φva$_{eg}$ — **Andesite flows of Eagle Gorge (Oligocene?)—**Andesite, basaltic andesite, basalt, breccia flows, and minor tuff-breccia; typically gray, dark blue gray to black; weathers to a light brown and grayish red; flows are aphanitic to porphyritic and are 5–10 m thick, exhibit blocky and platy jointing, crude columnar jointing, and rarely have vesicular tops; according to Hammond (1963) unconformities exist both below and above this unit and this unit erupted onto the volcaniclastics of unit Φvc$_o$; andesite is fairly fresh in hand sample, but pyroxene is altered; overall the andesite is less altered than underlying flows in units ΦEva$_o$; included in this unit are rocks Hammond (1963) mapped as Eagle Gorge andesite, the Snow Creek formation, and Cougar Mountain formation. We assign this unit an Oligocene age based on three dates from overlying tuffs in the Cougar Mountain quadrangle that span approximately 23.6–20.8 Ma (Tabor and others, 2000; Hammond and Dragovich, 2008).

Φvs$_{eg}$ — **Sedimentary volcanic sandstone and conglomerate of Eagle Gorge (Oligocene?)(line unit only)—**Sandstone is gray to tan buff and consists of feldspar and pumice fragments; conglomerate is brown, consisting of andesite clasts; indurated to friable; sandstone contains local minor stringers of pebbles and is well sorted; conglomerate is poorly sorted; sandstone and conglomerate are well bedded; conglomerate consists of cobbles to boulders up to 1 m in diameter in a sandy matrix; likely thicker and more extensive to the east as mapped by Hammond (1963) as part of his volcanic sediments of Cougar Mountain formation; unit Φvs$_{eg}$ is mapped in two locations as a line unit: (1) near the eastern map boundary, southwest of Ghost Point, and (2) in the northeast corner of the map area near the contact with unit Mva$_{fp}$.

Late Eocene to Oligocene Ohanapecosh Formation

In the map area, the Eocene to Oligocene volcanic succession overlying the Puget Group has been called the Enumclaw volcanic series of Weaver (1916), Keechelus andesitic series of Smith and Calkins and mapped nearby by Warren and others (1945), unnamed volcanics of Gower and Wanek (1963), the Huckleberry and the Enumclaw formations of Hammond (1963), unnamed volcanics of Vine (1969), and unnamed rocks by Phillips (1984). Tabor and others (2000) grouped these rocks together in the Ohanapecosh Formation of Fiske and others (1963). We continue this use of Ohanapecosh Formation but due to the differences in map scale we divide the volcanic sequence into two units, a volcaniclastic-dominated unit Φvc$_o$ and a flow-dominated unit ΦEva$_o$. Due to changes in the definition of the Eocene–Oligocene boundary from 36.6 to 33.9 Ma based on Berggren and others (1985; 1995) our assignment of the Ohanapecosh includes in part late Eocene.

Φvc$_o$ — **Volcaniclastic rocks (Oligocene)—**Lithic tuff-breccia, lapilli tuff, pebbly diamictite, tuffaceous siltstone, and minor andesite flows; multicolored and include brown, blueish green, green, tan, purplish, blue, pink, and white rocks; moderately indurated to friable; the tuff, breccia, and diamictite typically contain angular clasts of pumice, andesite porphyry, dacite, minor basalt, and rare carbonized wood fragments; well-bedded to massive diamictons. and siltstone beds that are finely bedded to laminated; prominent spheroidal weathering in some volcaniclastic mudflows and tuffs; andesite is dark gray, largely aphanitic, and exists in isolated flows; Unit Φvc$_o$ was mapped by Tabor and others (2000) as Ohanapecosh Formation and correlates with the Huckleberry Mountain formation of Hammond (1963). This unit is considered Oligocene because the underlying unit is latest Eocene to early Oligocene.

ΦEva$_o$ — **Andesite flows (late Eocene to Oligocene)—**Andesite flows, flow-breccia, minor tuff-breccia, rhyodacite tuff, and basalt, locally includes minor volcaniclastic sandstone and carbonaceous siltstone near the base; andesite is dark green gray, weathering to light brown gray; well-indurated; aphanitic to porphyritic; flows are blocky, platy, and have crude to well-developed columnar jointing; poor to moderately developed flow banding; rare vesicles; basalt is dark gray, weathering to brown gray; ground-mass is dark, deeply stained by iron oxides and includes smectite and other clay minerals; flow-breccia is mono-lithologic; basal sedimentary interbeds contain abundant feldspar grains, volcanic-derived clasts, and some carbonized plant fossils; the flows at the base of unit ΦEva$_o$ appear to interfinger with the underlying Puget Group. These rocks were mapped by Tabor and others (2000) as Ohanapecosh Formation and Hammond (1963) as Enumclaw formation.

Early to Middle Eocene Sedimentary Rocks of the Puget Group

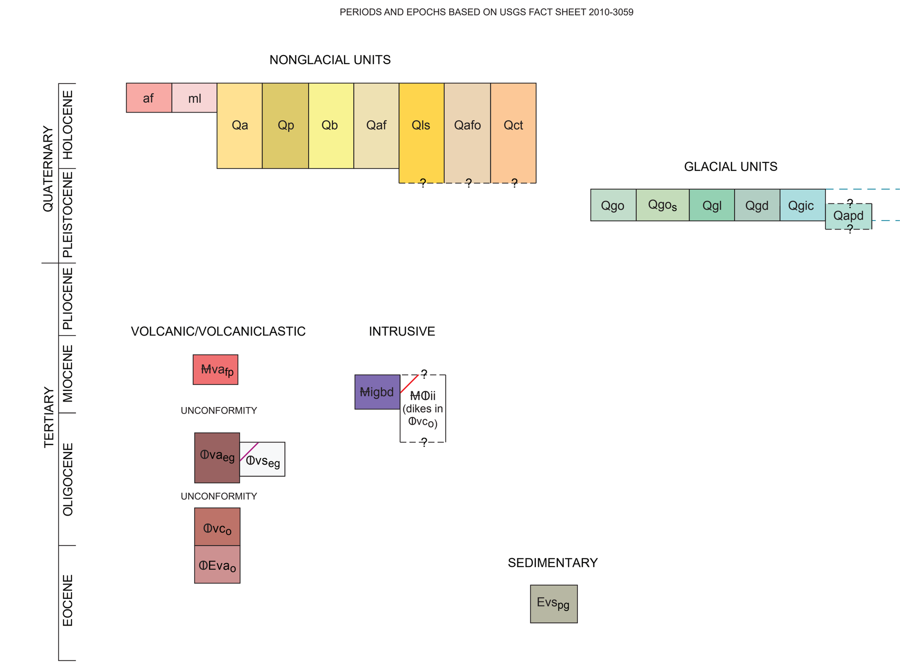
Evs$_{pg}$ — **Puget Group, undivided (Eocene)—**Coal-bearing sedimentary rocks including feldspathic micaceous sandstone, carbonaceous siltstone, coal, tuff, and pebble conglomerate; gray to light brown and black, weathering to orange white; sandstone is fine to coarse; clasts subangular to subrounded; moderately to poorly sorted; sandstone is in tabular beds that are structureless to cross-bedded and siltstone is planar laminated. The depositional environment of the rocks of the Puget Group represents a terrestrial delta plain upsection of shallow marine strata of the Raging River Formation (Buckovic, 1979; Johnson, 1985; Johnson and O'Conner, 1994). Vine (1969) suggested the unit is derived from the erosion of granitic or metamorphic rocks with the exception of the upper 90 m of section that includes locally derived volcaniclastic sedimentary rock. These volcaniclastic rocks likely represent the onset of volcanism from an ancestral Cascade Range based on ages from Tepper and Clark (2024).

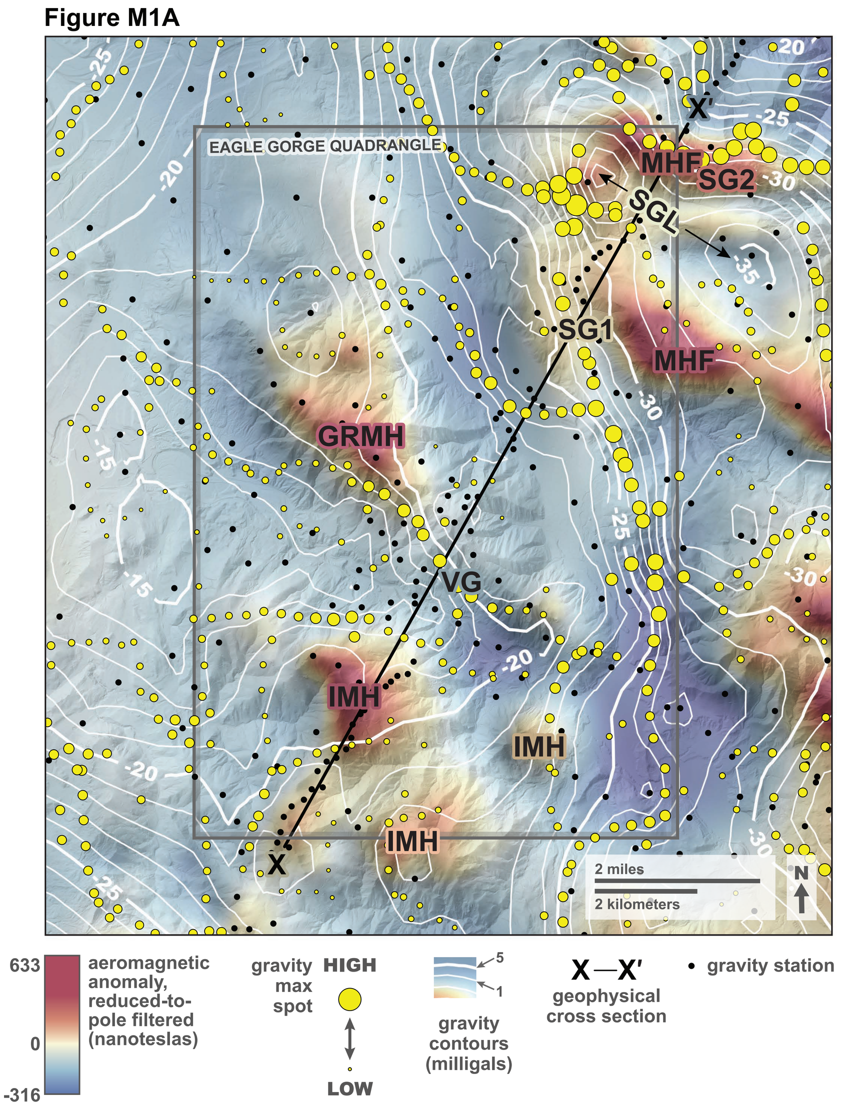
GEOLOGIC SYMBOLS

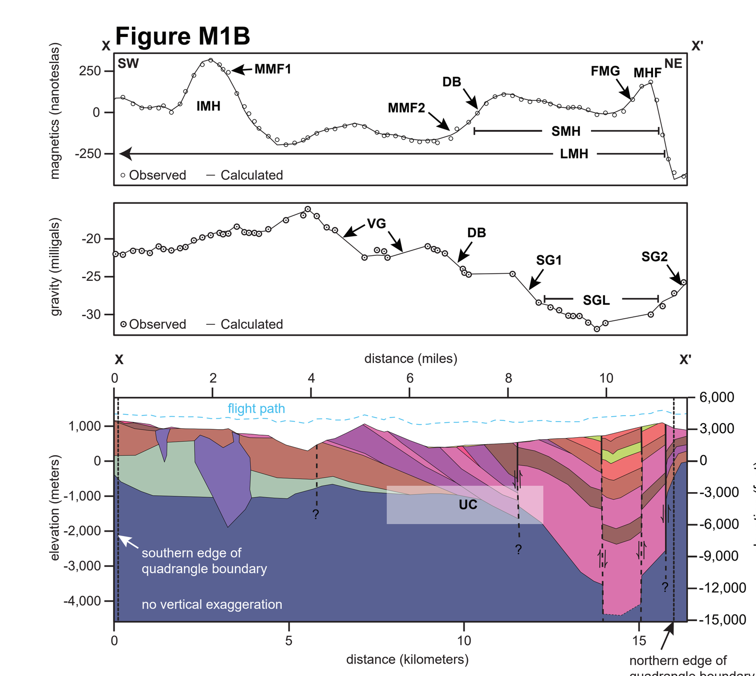
- Contact—Solid where location accurate; long-dashed where approximate; short-dashed where inferred; queried where identity or existence questionable
- Fault—Solid where location accurate; dotted where concealed; queried where identity or existence questionable
- Strike-slip fault, right lateral offset—Long-dashed where approximate; short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrows show relative motion
- Oblique-slip fault, reverse right-lateral offset—Inferred; queried where identity or existence questionable; arrows show relative motion; rectangles on upthrown block
- High-angle dip-slip fault—Short-dashed where inferred; dotted where concealed; queried where identity or existence questionable; relative motion shown by U and D
- Oblique-slip fault, normal left-lateral offset—Accurate; identity and existence certain; arrows show relative motion; bar and ball on downthrown block
- Oblique-slip fault, high-angle right-lateral offset—Concealed; identity or existence questionable; relative horizontal motion shown by arrows; relative vertical motion shown by U and D
- Anticline—Inferred; identity or existence questionable
- Syncline—Approximate; identity and existence certain
- Geologic unit too thin to show as a polygon—Approximate; identity and existence certain
- Scarp of unknown origin—Hachures point down slope
- Dike—Identity or existence questionable; location approximate
- A — A′ Cross section line
- Perennial stream
- Intermittent stream
- 45 Inclined bedding—showing strike and dip
- 81 Overturned bedding—showing strike and dip
- 80 Inclined bedding, where top direction of beds is known from local features—showing strike and dip
- 76 Small, minor inclined joint—showing strike and dip
- 35 Inclined cleavage—showing strike and dip
- 51 Inclined metamorphic or tectonic foliation parallel to bedding—showing strike and dip
- Vertical metamorphic or tectonic foliation parallel to bedding
- 57 Small, minor inclined fault—showing strike and dip
- 82 Small, minor vertical or near-vertical fault—showing strike
- 25 Inclined slickenline, groove, or striation on fault surface—showing bearing and plunge
- 57 Inclined flow banding, lamination, layering, or foliation in igneous rock—showing strike and dip
- GD1 Age site, U-Pb, uranium-lead
- GD4 Age site, $^{40}Ar/^{39}Ar$, argon-argon
- GD3 Age site, ^{14}C, carbon-14
- F2 Age site, fossil
- DH1 Drill hole or test pit
- G11 Geochemistry sample location
- Gravity station location
- Big 6 Mine Tunnel entrance
- TS12 Thin section location
- W1 Water well

CORRELATION OF MAP UNITS

PERIODS AND EPOCHS BASED ON USGS FACT SHEET 2010-3059







		Model properties ρ	Model properties χ	Average measured rock properties ρ	Average measured rock properties χ
	Quaternary (undifferentiated)	2,000	0	-	-
	sedimentary interbed	2,240	17	-	-
Miocene volcanics–Mv	andesite	2,620-2,630	27-35	2,630	20
	andesite/volcaniclastic mix	2,520-2,560	18-20	2,560	17
	basaltic flows	2,730	60	2,730	25
Eocene-Oligocene volcanics–ΦEv	basaltic andesite	2,670-2,700	36-45	2,710	24
	magnetic volcaniclastic	2,240-2,460	25-35	-	-
	predominantly volcaniclastic	2,240-2,460	0-19	2,480	11
	andesite flow/volcaniclastic mix	2,520-2,590	3-12	2,570	14
	predominantly andesitic flows	2,590-2,620	12-18	2,620	17
	Puget Group	2,480	0	2,480	7
	dioritic intrusion of unknown age	2,600-2,640	48-50	-	-
	western mélange belt	2,730	4	2,730	3

Figure M1—Geophysical interpretation for the map area.

A—Combined isostatic gravity and overlying hillshade topography aeromagnetic map (reduced-to-pole). Gravity contours are 1 mGal. Gravity stations are black dots. **X-X'** shows the end points of the geophysical model in **M1B**. Gray box marks the limits of the Eagle Gorge quadrangle.

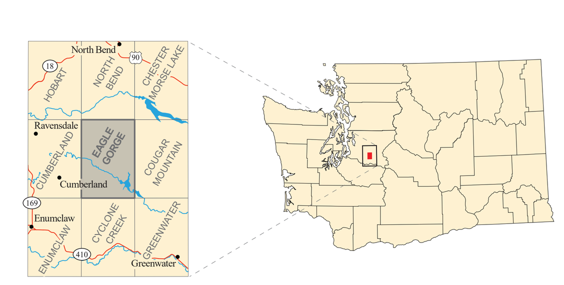
B—Two-dimensional potential-fields forward model of profile **X–X'**. Vertical dotted lines in the bottom panel show the location of the quadrangle boundaries. Units and properties shown in the bottom panel predict gravitational and magnetic anomalies shown in the top two panels (ρ–saturated bulk density; χ–magnetic susceptibility x 10^3). Measured rock properties summarize results from this map area (see Data Supplement), the Chester Morse quadrangle (Steely and others, 2022), and, for the Puget Group, Anderson and others (2024). Gravity data shown are no more than 500 m in map view from the model line. Diameter of the gravity data points (small dots inside gravity data point circles) is equal to the approximate data error, however errors for magnetic data points are too small to show. "Flight path" shows the elevation of the airplane that flew the aeromagnetic survey. Several sub-units of the Eocene–Miocene volcanics, though not separated on the geological map and cross section are geophysically distinct enough to model here; therefore we identify them primarily by their physical volcanology. We interpret all fault strands as having a sense of strike-slip displacement, though no evidence clearly documents sense of slip.

Geophysical feature acronyms referred to in the pamphlet—**DB**: Gradients due to dipping beds; **FMG**: Fault-related magnetic gradient; **GRMH**: Green river magnetic high; **IMH**: Magnetic high due to an interpreted intrusion; **LMH**: Long wavelength magnetic high due to a wide, deep magnetic material (diorite or gabbro); **MHF**: Magnetic high due to a flow; **MMF1** and **MMF2**: Magnetic misfit likely due to unknown structures smaller than the resolution of our mapping; **SG1**: Gradient one, bounding the southwestern edge of the synclinal basin; **SG2**: Gradient two, bounding the northeastern edge of the syncline, also the location of a major fault; **SGL**: Gravity low due to the synclinal basin; **SMH**: Magnetic high due to magnetic materials filling the synclinal basin; **UC**: Geometry of the basement contact unclear due to poorly-constrained model parameters; **VG**: Gravity gradients due to low density volcaniclastic material composing the bulk of a topographic feature.RTUXN

Lambert conformal conic projection
North American Datum of 1983
Base map from U.S. Geological Survey Eagle Gorge and Cumberland 7.5-minute quadrangles, 2020
Shaded relief generated from a lidar bare-earth digital elevation model (available from the Washington Geological Survey, https://lidarportal.dnr.wa.gov/)
GIS by Trevor Contreras
Digital cartography by Daniel E. Coe
Editing and production by Susan R. Schnur, Nikolas Midttun, and Joel H. Gombiner

SCALE 1:24,000

contour interval 20 feet



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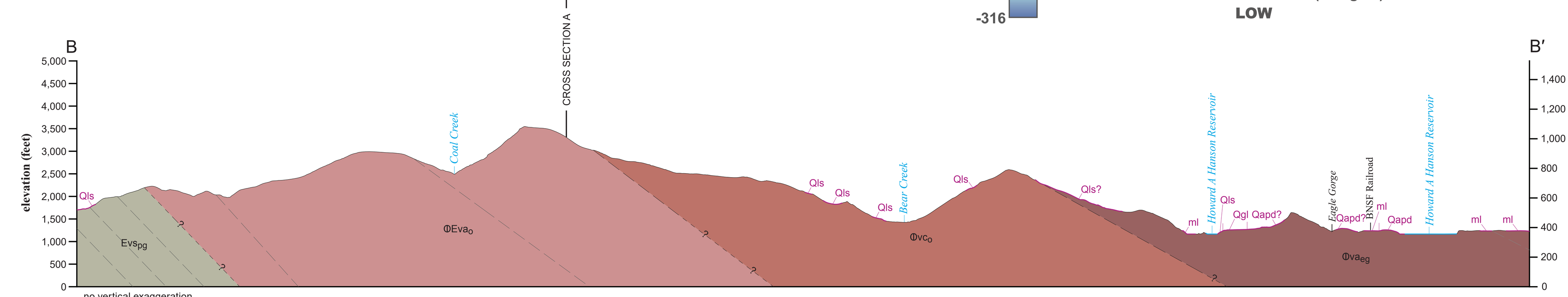

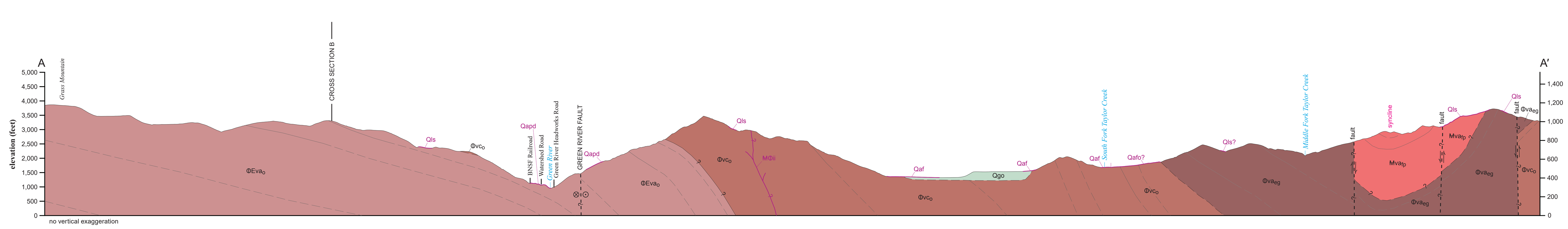

CROSS SECTION EXPLANATION

Qa / Qp — Geologic units too thin to show as polygons at the scale of the cross section; vertical tick mark separate units.

Arrows show component of relative fault movement in the plane of the cross section.

Arrow point shows fault movement toward the viewer; arrow feathers show fault movement away from the viewer.