3D geologic map of the McMurray 7.5-minute quadrangle, Skagit and Snohomish Counties, Washington, with a discussion of the evidence for Holocene activity on the Darrington-Devils Mountain fault zone

Disclaimer

Citation and link

This 3D geologic map is derived from previously published geologic mapping and analysis. Some of the borehole data are considered preliminary and have not been examined for accuracy of either location or lithologic identification. While lithologic identification for all wells was made by the author of the published geologic map, not all of the wells shown in this 3D product were necessarily used to construct the geologic cross section. The map, cross section, and the borehole data within the 3D model are not intended for analytical use. Instead, the published map and (or) pamphlet should be consulted for original data and interpretation.

Click anywhere within this box to dismiss this disclaimer and continue.

Layer001

Layer002

No Separation | 5% | 50% | 100%

5

Probe

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

Web tutorial

PDF3D

WASHINGTON STATE DEPARTMENT OF **Natural Resources**

Peter Goldmark - Commissioner of Public Lands

3D PDF INSTRUCTIONS

NAVIGATION
(1 of 2)

- Click inside the window to manipulate the 3D view—the compass will rotate to point towards north
- Hold the left mouse button and move the mouse to tilt the view
- 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

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WASHINGTON STATE DEPARTMENT OF Natural Resources
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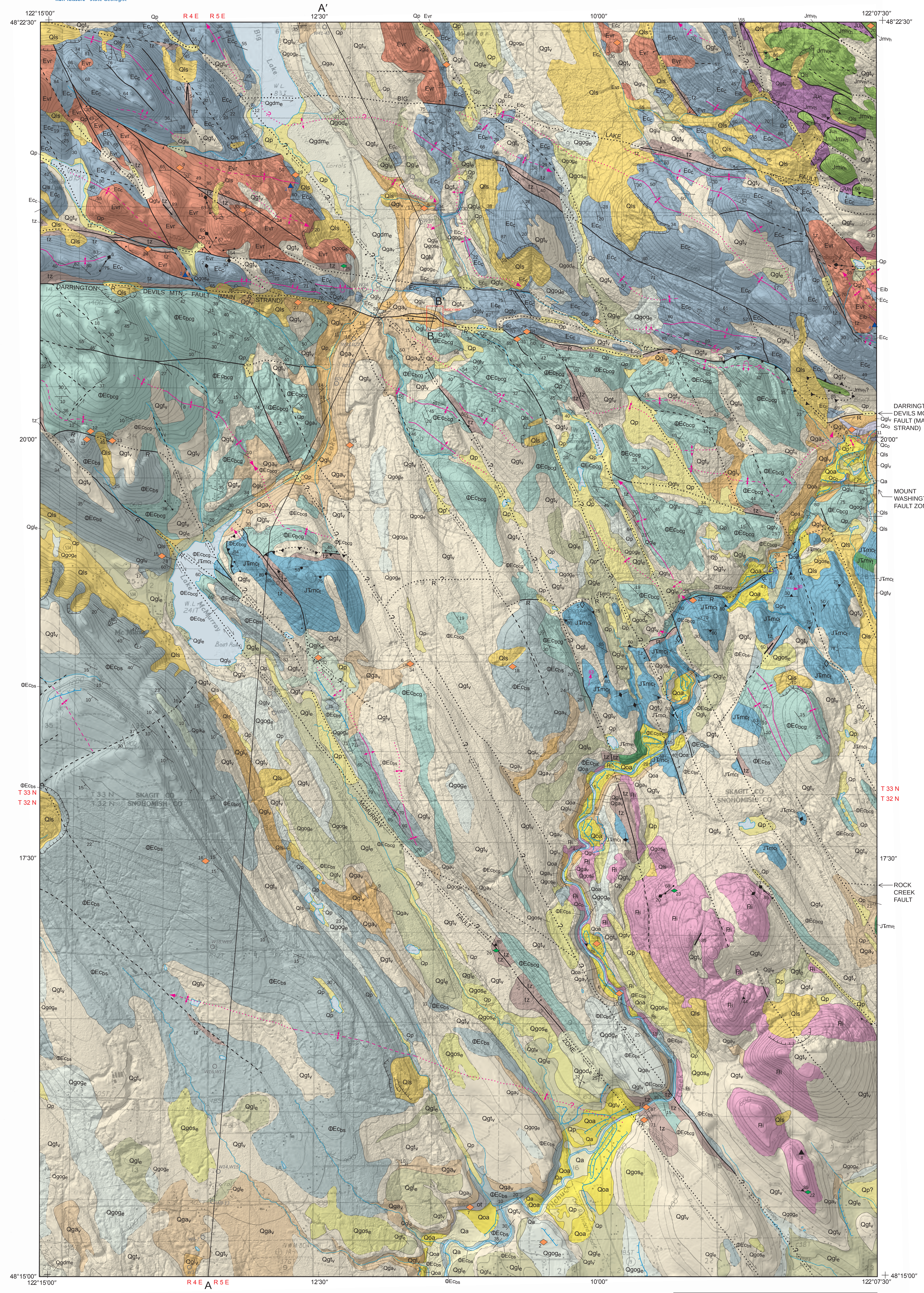
Geologic Map of the McMurray 7.5-minute Quadrangle, Skagit and Snohomish Counties, Washington, with a Discussion of the Evidence for Holocene Activity on the Darrington–Devils Mountain Fault Zone

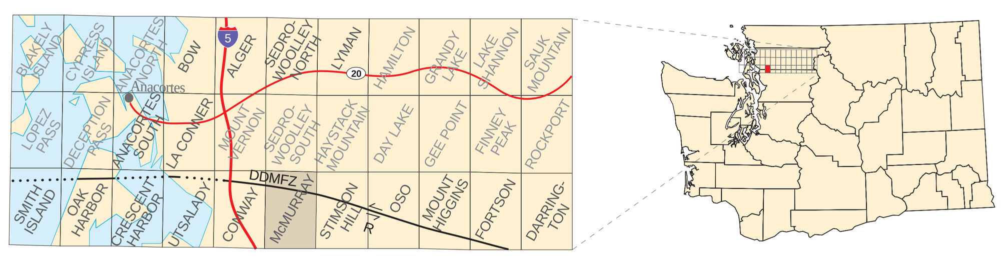
by Joe D. Dragovich and Alex J. DeOme

June 2006

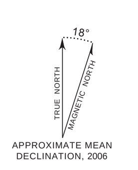


Lambert conformal conic projection
North American Datum of 1927; to place on North American Datum of 1983, move the projection lines 20 meters north and 95 meters east as shown by crosshair corner ticks
Base map from scanned and rectified U.S. Geological Survey 7.5-minute McMurray quadrangle, 1985
Shaded relief generated from a lidar bare-earth digital elevation model (available from the Puget Sound Lidar Consortium, http://pugetsoundlidar.ess.washington.edu/); SE corner, north half of west edge, and west third of north edge are U.S. Geological Survey 10-meter digital elevation model; vertical exaggeration 6x
Digital cartography by J. Eric Schuster and Anne C. Heinitz
Editing and production by Jaretta M. Roloff

SCALE 1:24,000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER
contour interval 40 feet



Map Index. 7.5-minute quadrangles around the McMurray 7.5-minute quadrangle, northwest Washington. Bold quadrangle names are 7.5-minute-scale geologic maps completed by Dragovich and others (see 'References Cited' in the pamphlet). The slight regional curvature of the main strand of the Darrington–Devils Mountain fault zone (DDMFZ) evident on this map is consistent with the assertion that the DDMFZ is a south-dipping structure that locally has thrust-type geometry.



DESCRIPTION OF MAP UNITS *(see pamphlet for more detailed unit descriptions)*

Quaternary Sedimentary Deposits

HOLOCENE NONGLACIAL DEPOSITS

Qa — **Alluvium of Pilchuck Creek (Holocene)**—(Boulder) gravel and sand; gray; subrounded to rounded clasts; loose, well stratified, and well sorted; plane-bedded sands common.

Qp — **Peat (Holocene)**—Peat, muck, and organic silt and clay, locally with thin beds of Mount Mazama tephra (~6,900 yr B.P.).

Qoa — **Older alluvium of Pilchuck Creek (Holocene to latest Pleistocene)**—Cobble gravel, gravel, and sand and minor silt.

Qls — **Landslide deposits (Holocene to latest Pleistocene)**—Diamicton with lesser (boulder) gravel; contains minor sand or gravel beds where locally modified by stream processes.

PLEISTOCENE GLACIAL AND NONGLACIAL DEPOSITS

Deposits of the Fraser Glaciation

EVERSON INTERSTADE RECESSIONAL DEPOSITS

$Qgdm_e$ — **Glaciomarine drift (Pleistocene)**—Silt, clay, and dropstone-bearing diamicton, locally with lenses of sand or gravel.

$Qgog_e$ — **Outwash gravel (Pleistocene)**—Gravelly sand and sandy (cobble) gravel, locally with lenses or beds of sand and silt and rare beds of poorly sorted gravels and diamicton.

$Qgik_e$ — **Ice-contact kame deposits (Pleistocene)**—Sandy gravel, sand, and pebbly sand.

$Qgod_e$ — **Deltaic outwash (Pleistocene)**—Sandy cobble gravel, gravel, pebbly sand, and sand.

$Qgos_e$ — **Outwash sand (Pleistocene)**—Sand and pebbly sand, locally with interbeds of silty fine sand or silt.

Qgl_e — **Glaciolacustrine deposits (Pleistocene)**—Clay, silt, sandy silt, silty sand, sand, and diamict with scattered dropstones.

VASHON STADE DEPOSITS

Qgt_v — **Lodgment till (Pleistocene)**—Nonstratified, unsorted mixture of clay, silt, sand, and gravel (diamicton) with disseminated cobbles and boulders.

Qga_v — **Advance outwash deposits (Pleistocene)**—Sand, pebbly sand, and sandy gravel with scattered beds of cobble gravel with local silt and clay interbeds.

Qgl_v — **Advance glaciolacustrine deposits (Pleistocene)**—Clay and silt with local scattered dropstones.

Deposits of the Olympia Nonglacial Interval

Qc_o — **Olympia beds (Pleistocene)**—Boulder gravel, cobbly gravel, gravel, sand, and silt, with minor clay, peat, and diamicton.

Deposits of the Possession Glaciation

ot — **Older till (Pleistocene)**—Diamicton.

oo — **Older outwash (Pleistocene)(Cross Section B only)**—Silty sand, locally with scattered gravel and occasional gravel interbeds.

Tertiary Volcanic, Intrusive, and Sedimentary Rocks

VOLCANIC AND HYPABYSSAL INTRUSIVE ROCKS

Eib — **Diabase (Eocene)**—Homogeneous, medium-grained, subophitic basaltic diabase dikes and sills.

Evr — **Rhyolite (Eocene)**—Rhyolite, andesite, and minor volcanolithic sandstone, conglomerate, and breccia.

SEDIMENTARY ROCKS

Rocks of Bulson Creek

$ΦEc_{bcg}$ — **Rocks of Bulson Creek, conglomerate facies (Oligocene to Eocene)**—Conglomerate with local interbeds and lenses of sandstone, lesser coal and siltstone, and rare paleosols and diamictite.

$ΦEc_{bs}$ — **Rocks of Bulson Creek, sandstone facies (Oligocene to Eocene)**—Sandstone with interbeds of siltstone, pebbly sandstone, coal, shale, and rare lenses of conglomerate.

Chuckanut Formation

Ec_c — **Coal Mountain unit (Eocene)**—Feldspathic sandstone, locally with pebbly sandstone, siltstone, mudstone, and coal.

Mesozoic to Paleozoic Low-Grade Metamorphic and Intrusive Rocks

HELENA–HAYSTACK MÉLANGE (Northwest Cascades System)

Jmv_h — **Greenstone (Jurassic)**—Metabasaltic greenstone with minor metagabbro, metadacite, metarhyolite, and minor slate, phyllite, and metasandstone.

Ju_h — **Ultramafite (Jurassic)**—Serpentinite with minor partially serpentinized dunite, peridotite, and pyroxenite.

TRAFTON SEQUENCE (Eastern Mélange Belt)

$J\overline{T}mc_t$ — **Metachert (Jurassic to Triassic)**—Metamorphosed chert and cherty argillite; locally includes minor argillite, siltstone, feldspatholithic sandstone or wacke, greenstone, tuff, and limestone.

$J\overline{T}mv_t$ — **Greenstone (Jurassic to Triassic)**—Metabasalt and green metatuff with minor thin interbeds of metachert locally.

Pzi — **Meta-intrusive (Paleozoic)**—Medium to coarse-grained hornblende metaquartz diorite, metadiorite with minor pyroxene metagabbro, and rare hornblendite.

Tertiary to Recent Tectonic Zones

tz — **Tectonic zones (Tertiary to Recent)**—Protomylonite, mylonite, cataclasite, fault breccia, and slickensided and fractured rocks in fault zones.

GEOLOGIC SYMBOLS

Age-date sample site, fossil
Age-date sample site, zircon fission-track
Age-date sample site, U-Th-Pb
Age-date sample site, radiocarbon
(called 'age sites' in the pamphlet)

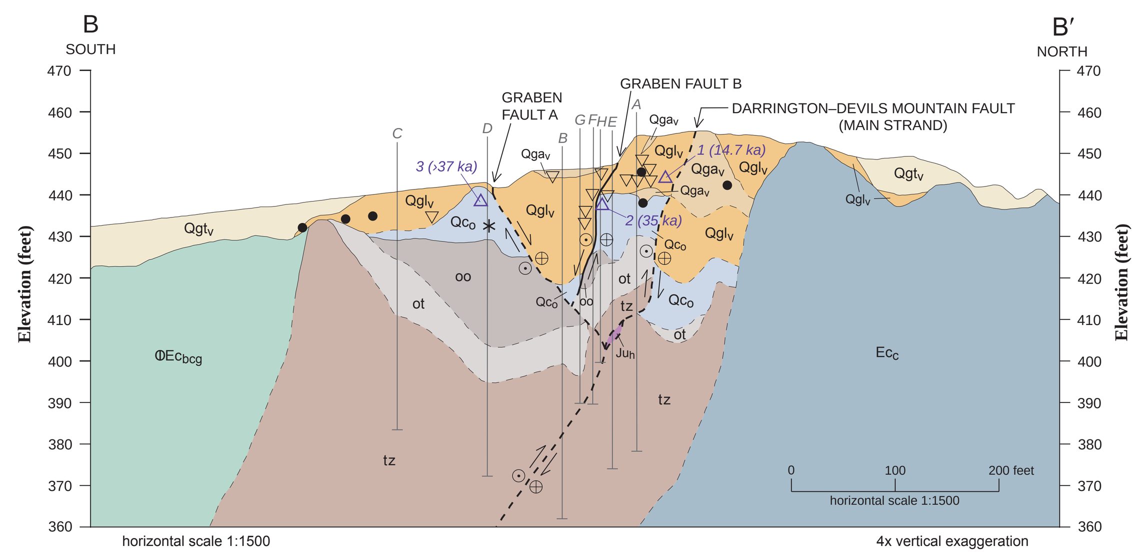
Geochemistry sample site
Critical site
(called 'sites' in the pamphlet)

Water well
Terrace—hachures on downslope side
Landslide scarp—hachures on downslope side
Bedding—showing strike and dip
Overturned bedding—showing strike and dip
Vertical bedding—showing strike
Bedding in Quaternary sedimentary deposits—showing strike and dip
Foreset bedding in Quaternary sedimentary deposits—showing strike and dip
Foliation in low-grade metamorphic rock—showing strike and dip
Vertical or near-vertical foliation in metamorphic rock—showing strike
Mylonitic foliation—showing strike and dip
Slickensided surface—showing strike and dip
Vertical slickensided surface—showing strike
Minor fault—showing strike and dip
Minor fold—showing bearing and plunge
Slip lineation or slickensides on a fault or shear surface—showing bearing and plunge of offset
Contact—dashed where inferred
Fault, unknown offset—dashed where inferred; dotted where concealed; queried where uncertain
Normal fault, bar and ball on downthrown side—dashed where inferred; dotted where concealed
Thrust fault, sawteeth on upper plate—dotted where concealed; queried where uncertain
Reverse fault, R on upthrown side—dashed where inferred; dotted where concealed; queried where uncertain
Right-lateral strike-slip fault—dashed where inferred; dotted where concealed
Left-lateral strike-slip fault—dashed where inferred
Normal right-lateral strike-slip fault, bar and ball on downthrown side—dotted where concealed; queried where uncertain
Normal left-lateral strike-slip fault, bar and ball on downthrown side—dashed where inferred; dotted where concealed
Reverse right-lateral strike-slip fault, R on upthrown side—dotted where concealed
Reverse left-lateral strike-slip fault, R on upthrown side—dotted where concealed
Anticline—dashed where inferred; dotted where concealed; queried where uncertain
Overturned anticline—dashed where inferred; dotted where concealed; queried where uncertain
Syncline—dashed where inferred; dotted where concealed; queried where uncertain
Overturned syncline—dashed where inferred; dotted where concealed; queried where uncertain

THE DARRINGTON–DEVILS MOUNTAIN FAULT ZONE

The Darrington–Devils Mountain fault zone (DDMFZ) is a major regional fault zone that has likely been locally active in the Holocene. (See 'Darrington–Devils Mountain Fault Zone' in pamphlet for more detailed information.) The fault zone divides rocks of the Northwest Cascades System from the Eastern and Western mélange belts on the south and has a complex displacement history beginning in the mid-Eocene (or perhaps the mid-Cretaceous) and continuing to the Recent. Tertiary left-lateral strike-slip offset is well demonstrated for the DDMFZ by thin-section and outcrop scale structures and by the geometry of antithetic and synthetic faults and en echelon fold axes. The Eocene and Oligocene stratigraphic record indicates that the broad DDMFZ has a complex Tertiary transpressional and transtensional strike-slip history. The Mount Washington and McMurray fault zones in the McMurray quadrangle are subparallel to the generally northwest-trending en echelon fold axes; they are major antithetic right-lateral faults within the DDMFZ.

Recent activity along the DDMFZ has been concentrated along the main strand of the fault, with perhaps some additional offsets along nearby antithetic and synthetic segments. Available stratigraphic and geophysical evidence is most consistent with reverse-fault offset of the main strand, with perhaps some transpressional left-lateral strike-slip or oblique movement. Lower Quaternary strata, such as the Olympia beds, have apparently been uplifted along and south of the main strand, implying episodic, south-side-up DDMFZ faulting in the Quaternary. Holocene offset is also suggested by uplifted older alluvium, subtle truncations of glacial fluting, an anomalously steep river gradient where Pilchuck Creek crosses the DDMFZ main strand, and spatial correspondence of earthquake hypocenters with the main strand. Reinterpretation of trench data acquired by Puget Power (1974) at two locations (Cross Section B and site 29) provides direct evidence for Holocene offset of the main strand. We reinterpreted the more easterly trench stratum (site 29) as tectonically mixed fault gouge, glacial till, organic-rich fault colluvium or paleosol of Olympia nonglacial age, and Tertiary sedimentary-rock fault gouge. Puget Power (1974) also dug several trenches and bored eight exploratory drill holes across the DDMFZ main strand in the north-central part of the study area (red box on geologic map). Cross Section B is our interpretation of this information. Recent lidar images of the area show two east–west-trending scarps subparallel to the main strand that we interpret as fault scarps. The trench logs show a prominent offset of the glacial and nonglacial deposits where the most prominent scarp meets the trenches. We interpret these features as Holocene fault (graben) scarps formed in the hanging wall of the DDMFZ active main strand.



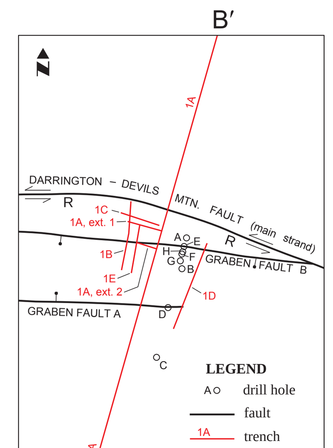
Cross Section B. Puget Sound Power and Light Company (1974) dug seven tightly spaced, north–south and east–west trenches and bored eight exploratory drill holes (A–H; 55–89 ft depth) across the main strand of the Darrington–Devils Mountain fault zone (DDMFZ)(see index map right). Cross Section B–B′ was constructed using this trench and drill hole log information, as well as our local geologic mapping and observations. This information was projected onto the plane of the cross section, which follows Puget Power's trench 1A (index map). The profile for the section was constructed using a combination of trench and current topographic and lidar elevation data. Because these trenches were dug on a pipeline egress, some of the land surfaces were noted as "graded and disturbed" by Puget Power (1974). Stratigraphic relations suggest a combination of Holocene reverse main-strand faulting with an uncertain amount of strike-slip displacement. Fractures and sand dikes were noted in the trench logs. Graben fault B occurs along a lidar-defined scarp (Fig. 5, pamphlet). This scarp is associated with distinct stratigraphic displacement noted by Puget Power in their trench logs. They previously attributed this displacement to "slumping" (see 'Darrington–Devils Mountain Fault Zone' in the pamphlet). Graben fault A occurs along the easternmost end of a lidar-defined scarp. Areas of fracturing, shown schematically with point symbols on the cross section, were commonly noted as having little or no stratigraphic displacement by Puget Power. This may be suggestive of a component of Holocene strike-slip displacement perpendicular to the plane of the main north–south trenches. Note the "uplift" of older Quaternary deposits along the main strand, particularly the apparent uplift and erosion of advance outwash (unit Qga_v) south of the main strand reverse fault. We have generalized the contact relations between units Qgl_v, Qga_v, Ec_c, and $ΦEc_{bcg}$ on the map plate from the more detailed geologic contact relations on Cross Section B–B′. Unit tz in the cross section is a broad zone of fault gouge and highly fractured rocks formed along the main strand here. The top of unit tz defines a paleovalley that was buried during the last glaciation. The tectonic lens of serpentinite noted in drill hole E is likely in-sheared Helena–Haystack mélange basement. The broad zone of gouge, occurrence of the exotic pre-Tertiary serpentinite, and tectonic juxtaposition of units Ec_c and $ΦEc_{bcg}$ are some of the characteristics that constrain this gouge zone to be the DDMFZ main strand. See 'Darrington–Devils Mountain Fault Zone' and information provided in unit descriptions (units Qgl_v, Qga_v, Qc_o) in the pamphlet for further information, particularly concerning the radiocarbon ages (ages 1, 2, and 3).

Legend Cross Section B

Drill hole showing depth
^{14}C age-date sample showing site number and age in parentheses; ages from Puget Power (1974)
Soft-sediment deformation noted in trench by Puget Power (1974)
Sand dike noted in trench by Puget Power (1974)
Fracture noted by in trench Puget Power (1974)

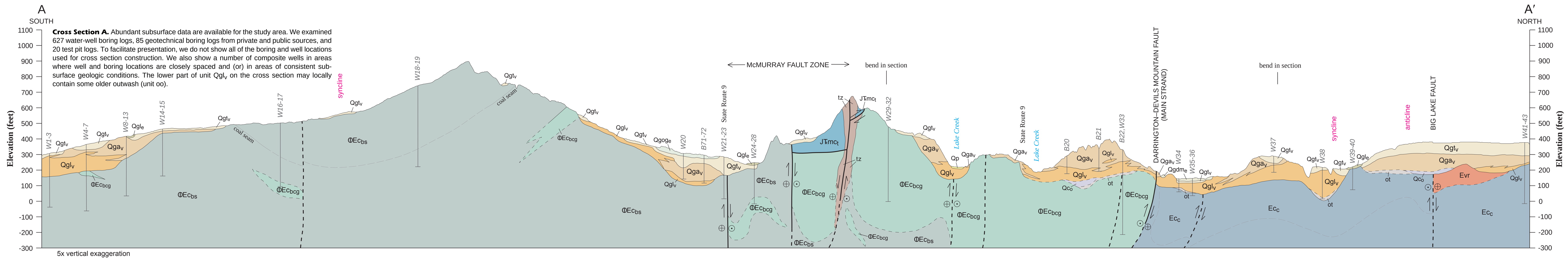
Fault movement indicators:

Strike-slip movement away from viewer
Strike-slip movement toward viewer
Arrows show relative dip-slip movement



B–B′ Index Map. Data presented in Cross Section B–B′ were projected into the line of the cross section from nearby trenches and drill holes, located as shown in this map. This map represents a small area (outlined in red) in the north-central part of the quadrangle. See Figure 5 in the pamphlet for a lidar image of the fault scarps in and around the index map area.

Cross Section A. Abundant subsurface data are available for the study area. We examined 627 water-well boring logs, 85 geotechnical boring logs from private and public sources, and 20 test pit logs. To facilitate presentation, we do not show all of the boring and well locations used for cross section construction. We also show a number of composite wells in areas where well and boring locations are closely spaced and (or) in areas of consistent subsurface geologic conditions. The lower part of unit Qgl_v on the cross section may locally contain some older outwash (unit oo).



Legend Cross Section A

Bedding, dashed where inferred
Well or composite well showing depth

Fault movement indicators:

Strike-slip movement away from viewer
Strike-slip movement toward viewer
Arrows show relative dip-slip movement