

# THE DARRINGTON–DEVILS MOUNTAIN FAULT—A PROBABLY ACTIVE REVERSE-OBLIQUE-SLIP FAULT ZONE IN SKAGIT AND ISLAND COUNTIES, WASHINGTON

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The Darrington–Devils Mountain fault zone (DDMFZ) has likely been locally active in the Holocene. This regional fault zone juxtaposes the Northwest Cascades System and the mélange belts and has a complex displacement history beginning in the mid-Eocene (or perhaps the mid-Cretaceous). Tertiary left-lateral strike-slip offset is well demonstrated for the DDMFZ main strand. New 7.5-minute scale mapping along most of the DDMFZ shows that antithetic right-lateral faults merge into the main strand and en echelon synthetic faults locally broaden the DDMFZ to 8 miles wide. The stratigraphy and provenance of Eocene and Oligocene sedimentary rocks indicate that the DDMFZ has a transpressional and transtensional strike-slip history with major sub-basin instability starting in the mid-Eocene.

Post-glacial DDMFZ activity has been concentrated along the main strand, with perhaps some additional offsets along nearby antithetic and synthetic segments. In the Cascade foothills, stratigraphic and geophysical data are most consistent with main strand reverse faulting, with perhaps some left-lateral strike-slip or oblique movement. Uplifted Pleistocene Olympia beds and latest Pleistocene Glacier Peak laharic deposits imply episodic, south-side-up offset in the Quaternary. An anomalously steep river gradient where Pilchuck Creek crosses the main strand also imply post-glacial offset. In the north fork Stillaguamish River valley, well located earthquake hypocenters with reverse slip focal mechanisms spatially correlate with the main strand. The down-dip hypocenter distribution suggests that the fault zone shallows into a regional décollement. On Whidbey Island, the occurrence of anomalously high ancient Skagit

River fluvial-deltaic sediments (Olympia beds) exposed in a growth fold directly south of the main strand appear to be the result of DDMFZ reverse or oblique faulting and uplift.

Reinterpretations of trench data combined with new lidar images near Lake McMurray provide evidence for Holocene main strand activity. Two east–west-trending scarps visible on lidar are interpreted as a Holocene graben formed in the hanging wall directly south of the DDMFZ main strand. The trench logs show a probable tectonic offset of the glacial and nonglacial deposits where the fault scarps cross the trenches.

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### Tertiary Intrusive, Volcanic, and Sedimentary Rocks

#### VOLCANIC AND HYPABYSSAL INTRUSIVE ROCKS

ØEiq	Stock at Granite Lakes (Oligocene–Eocene)—Porphyritic hornblende-clinopyroxene quartz diorite.
Eib	Diabase (Eocene)—Homogeneous, medium-grained, subophitic basaltic diabase dikes and sills.
Eian	Intrusive andesite (Eocene)—Porphyritic andesite dikes and sills.
Ev	Volcanic rocks, undivided (Eocene)—Non marine rhyolite, andesite, basaltic andesite, dacite, and rare basalt.
Eva	Andesite (Eocene)—Andesite with some basaltic andesite, minor interbedded basalt and tuff, and rare volcanic lithic sandstone and argillite.
Evb	Basalt (Eocene)—Basalt flows.
Evr	Rhyolite (Eocene)—Thick flows, breccias, dikes, and ash flows (vitric tuff ±lapilli) of high-silica rhyolite.

#### SEDIMENTARY ROCKS

##### *Rocks of Bulson Creek*

ØEc <sub>seg</sub>	Rocks of Bulson Creek, conglomerate facies (Oligocene to Eocene)—Chert and polycrystalline quartz conglomerate with interbeds of pebbly sandstone and sandstone
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ØEc <sub>seg</sub>	Rocks of Bulson Creek, sandstone facies (Oligocene to Eocene)—Sandstone with interbeds of siltstone, pebbly sandstone, coal, shale, and rare lenses of conglomerate.
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##### *Chuckanut Formation*

Ec <sub>n</sub>	Mount Higgins unit (Eocene)—Fluvial feldspathic to lithofeldspathic sandstone, siltstone, and mudstone with minor conglomerate, coal (anthracite), and altered tuff (bentonite).
Ec <sub>c</sub>	Coal Mountain unit (Eocene)—Fluvial feldspathic sandstone with conglomerate, mudstone, siltstone, and coal.
Ec <sub>b</sub>	Bellingham Bay member (Eocene)—Sandstone description

### Mesozoic Low-Grade Metamorphic Rocks (Prehnite-Pumpellyite to Blueschist Facies)

#### GOAT ISLAND TERRANE

KJmv <sub>g</sub>	Metavolcanic greenstone (Jurassic–Cretaceous)—Greenstone with interbeds of metachert.
KJms <sub>g</sub>	Metasedimentary rocks (Jurassic–Cretaceous)—Metasandstone with lesser metagraywacke, slaty or phyllitic metasilstone, and metaconglomerate.

#### METAMORPHIC ROCKS OF ROCKY POINT

KJhmt <sub>g</sub>	Mixed metasedimentary and metavolcanic rocks (Jurassic?–Cretaceous)—Phyllitic meta-argillite, metaconglomerate, and metasandstone
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#### EASTON METAMORPHIC SUITE

Darrington Phyllite and (or) semischist of Mount Josephine (Jurassic)—Darrington Phyllite is sericite-graphite-albite-quartz phyllite to graphitic quartz phyllite (metashale) with rare interbeds of micaceous quartzite (metachert), metatuff, and albite. Semischist of Mount Josephine is semischistose feldspathic to lithofeldspathic metasandstone or metawacke; rare metaconglomerate schist. Divided into three map units on the basis of the percentage of interbedded phyllite and semischist:

Jph <sub>h</sub>	unit Jph <sub>h</sub> (90–100% Darrington Phyllite, 0–10% semischist of Mount Josephine).
Jph <sub>a</sub>	unit Jph <sub>a</sub> (50–90% Darrington Phyllite, 10–50% semischist of Mount Josephine).
Jph <sub>d</sub>	unit Jph <sub>d</sub> (0–50% Darrington Phyllite, 50–100% semischist of Mount Josephine).
Jsh <sub>h</sub>	Shuksan Greenschist (Jurassic)—Mostly well-recrystallized and strongly S1-foliated metabasaltic greenschist or blueschist.

#### HELENA–HAYSTACK MÉLANGE (NORTHWEST CASCADES SYSTEM)

Jmv <sub>h</sub>	Greenstone (Jurassic)—Metamorphosed basalt, andesite, dacite, and rare rhyolite occurring as mafic to intermediate flows and intermediate to felsic tuff and lapilli tuff
Jigb <sub>h</sub>	Metagabbro (Jurassic)—Medium-grained to rarely coarse-grained and uraltitic greenstone.
Ju <sub>h</sub>	Ultramafite (Jurassic)—Mostly serpentinite with rare nonserpentinized or partially serpentinized dunite, peridotite, and pyroxenite and minor metasomatic silica-carbonate rock (unit Ju <sub>h</sub> ), rodingite, or talc-tremolite rock.
Ju <sub>h</sub>	Silica-carbonate rocks (Jurassic)—Silica-carbonate mineralization products (listwaenites) resulting from metasomatism of ultramafites.
Jhmc <sub>h</sub>	Heterogeneous metamorphic rocks, chert bearing (Jurassic)—Graphite-bearing, medium gray meta-argillite, bluish gray metasandstone to metawacke, and minor metachert.
Jam <sub>h</sub>	Amphibolite (Jurassic)—Fine-grained amphibolite with well-crystallized green hornblende and plagioclase; other metamorphic minerals include chlorite, epidote, and pumpellyite.

#### EASTERN MÉLANGE BELT

Jar <sub>e</sub>	Meta-argillite (Jurassic)—Black; locally foliate with carbonate concretions and minor fine-grained metasandstone interbeds
Jtmt <sub>e</sub>	Mixed metavolcanic and metasedimentary rocks (Jurassic–Triassic)—Greenstone with volcanic subquartzose metasandstone, metawacke, meta-argillite, phyllitic argillite, metachert, and minor marble or marl pods; rocks structureless to locally moderately foliated.
Jtmv <sub>e</sub>	Greenstone (Jurassic–Triassic)—Metamorphosed plagioclase- and augite-phyric basaltic andesite, basalt, andesite, and dacite with minor diabase and gabbro.
Jtms <sub>e</sub>	Metasedimentary rocks (Jurassic–Triassic)—Metamorphosed argillite, sandstone, wacke, siltstone with subordinate chert pebble conglomerate, chert, marl, and rare marble.
Jtmc <sub>e</sub>	Metachert (Jurassic–Triassic)—Metachert locally with greenstone, metawacke, and meta-argillite.
Jtu <sub>e</sub>	Ultramafite (Jurassic–Triassic)—Serpentinite, talc-tremolite rock, metaperidotite, and metaclinopyroxenite.
Tmb <sub>e</sub>	Marble (Triassic)—Mostly coarsely crystalline gray to white marble.

#### WESTERN MÉLANGE BELT

KJhmc <sub>g</sub>	Heterogeneous metamorphic rocks, chert-bearing (Cretaceous–Jurassic)—Semischistose metasandstone, slate, and phyllite; also contains greenstone derived from mafic volcanic breccia, tuff, and flows locally with well-developed pillows.
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#### TRAFTON SEQUENCE

JTmc <sub>s</sub>	Metachert (Jurassic–Triassic)—Metamorphosed chert and cherty argillite interbedded locally with argillite, siltstone, and minor thin beds of carbonaceous shale, wacke, and tuff.
JTms <sub>s</sub>	Metasedimentary rocks (Jurassic–Triassic)—Metamorphosed argillite, siltstone, fine-grained feldspatholithic sandstone, chert, cherty argillite, and tuff.
JTmv <sub>s</sub>	Greenstone (Jurassic–Triassic)—Metabasalt.
JMmb <sub>s</sub>	Marble (Jurassic–Mississippian)—Marble and limestone; locally contains interbeds of metamorphosed ribbon chert and argillite; calcite extensional veins pervasive.
Ri	Meta-intrusive (Paleozoic)—Medium to coarse-grained hornblende metag quartz diorite, metadiorite, with minor pyroxene metagabbro, and rare hornblendite.

### DESCRIPTION OF MAP UNITS

#### Quaternary Sedimentary and Volcanic Deposits

##### Holocene nonglacial deposits

Qaf	Artificial fill and modified land (Recent)—Fill at major construction sites.
Qs	Surficial deposits, undivided (Quaternary) (cross sections only)—Surficial units that are too thin to delineate separately in cross section.
Qa	Alluvium (Holocene)—Channel alluvial deposits include sand, gravel, and cobbly gravel with rare boulders.
Qb	Beach deposits (Holocene)—Sand, gravel, pebbly sand, and boulder gravel.
Qn	Nearshore deposits (Holocene)—Estuarine mud and fine-sand tidal flat deposits.
Qm	Saltwater marsh deposits (Holocene)—Organic-rich silt and mud, commonly with lenses and layers of peat.
Qp	Peat (Holocene)—Peat, muck, organic sediment, and clay, locally with thin beds of Mount Mazama tephrs (~6,900 yr BP).
Qd	Dune deposits (Holocene)—Wind-deposited, well-sorted, and well-rounded sand and silty sand.
Qoa	Older alluvium (Holocene)—Cobble gravel, sand, gravel with minor silt and clay interbeds and peat locally with abundant wood and organic matter.
Qaf	Alluvial fan deposits (Holocene)—Debris-flow diamicton and alluvial sand and gravel.
Qls	Landslide complexes (Holocene)—Diamicton with soft sand, silt, and (or) clay matrix.
Qt	Talus deposits (Holocene)—Nonsorted angular gravel and sandy boulder gravel to diamicton.
Ql	Lake deposits (Holocene)—Sand, silt, and fine sand deposited in Lake Cavanaugh; overlies glaciolacustrine deposits.

##### Holocene glacial deposits

Qad	Alpine till (Holocene?)—Gravelly clayey sand or sandy pebbly diamicton with localized clasts (may be Vashon till with abundant locally derived clasts).
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#### Late Pleistocene and Holocene Glacier Peak Volcanic and Sedimentary Deposits

Qvl	Lahar deposits, undivided (Holocene)—Description
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##### *Kennedy Creek Assemblage*

Qvs <sub>k</sub>	Volcanic sediments, undivided (Holocene)—Dacite-rich hyperconcentrated flood deposits and volcanic alluvium including pumiceous silt flood deposits.
Qvl <sub>k</sub>	Non-cohesive lahar (cross sections only)—Silty sandy gravel to gravelly sand locally with cobbles and rare boulders.

##### *Whitechuck Assemblage*

Qvs <sub>w</sub>	Volcanic sediments, undivided (late Pleistocene)—Dacite-rich hyperconcentrated flood deposits and volcanic alluvium.
Qvl <sub>w</sub>	Non-cohesive lahar—Cobbly to locally bouldery gravelly sand commonly with a trace of ash and minor pumiceous alluvium.

#### Pleistocene glacial and nonglacial deposits

##### Deposits of the Fraser Glaciation

###### *EVERSON INTERSTADE*

Qgdm <sub>e</sub>	Glaciomarine drift (Pleistocene)—Silt, clay, and dropstone-bearing diamicton, locally with lenses of sand or gravel.
Qgdm	Glaciomarine drift (Pleistocene)—Clay and clast-rich diamicton (unit Qgdm <sub>ed</sub> ) and mud (unit Qgdm <sub>ec</sub> ).
Qgom <sub>es</sub>	Emergence (beach) deposits (Pleistocene)—Pebbly sand or sand and gravel, locally with boulders.
Qgl <sub>e</sub>	Diamicton (Pleistocene)—Sandy, silty pebble gravel to bouldery, gravelly sandy silt.
Qgim <sub>e</sub>	Moraine deposits (Pleistocene)—Bouldery cobble gravel with interbeds of sand and minor diamicton.
Qgic <sub>e</sub>	Stratified ice-contact deposits (Pleistocene)—Bouldery cobbly gravel, diamicton, pebbly sand, and sand.
Qgo <sub>e</sub>	Recessional outwash (Pleistocene)—Sand, gravel, and sandy cobble gravel with rare boulders.
Qgot <sub>e</sub>	Fluvial deposits (Pleistocene)—Cobble and sandy pebble gravel, pebbly sand, and rare silt.
Qgog <sub>e</sub>	Gravel (Pleistocene)—Sandy gravel and cobble gravel.
Qgos <sub>e</sub>	Sand (Pleistocene)—Sand or pebbly sand.

Qgik <sub>e</sub>	Qgik <sub>e1</sub>	Qgik <sub>e2</sub>	Qgik <sub>e3</sub>	Qgik <sub>es4</sub>	Ice-contact kame deposits (Pleistocene)—Sandy gravel, sand, and pebbly sand, locally with silt pods and lenses of diamict.
Qgod <sub>e</sub>					Deltaic outwash (Pleistocene)—Sandy gravel and cobbly sandy gravel.
Qgl <sub>e</sub>					Recessional glaciolacustrine deposits (Pleistocene)—Clay, silt, sandy silt, and sand with local dropstones.

###### *VASHON STADE*

Qgt <sub>v</sub>	Ice contact deposits (Pleistocene)—Sandy gravel, gravelly sand, and bouldery cobbly gravel, locally with interlayered beds of silty sand or sand;
Qgt <sub>v</sub>	Till (Pleistocene)—Nonstratified, matrix-supported mixture of clay, silt, sand, and gravel in various proportions with disseminated cobbles and boulders.
Qga <sub>v</sub>	Advance outwash (Pleistocene)—Medium to coarse sand, pebbly sand, and sandy gravel with scattered lenses and layers of pebble-cobble gravel.
Qgl <sub>v</sub>	Advance glaciolacustrine deposits (Pleistocene)—Clay, silt, silty clay, and silty fine sand with local dropstones.

##### Deposits of the Olympia Nonglacial Interval

Qc <sub>e</sub>	Deposits of the Olympia nonglacial interval (Pleistocene)—Boulder-gravel, cobble-gravel, pebble-gravel, sand, silt, clay, peat, and rare diamicton.
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##### Deposits of the Possession Glaciation

Qgdm <sub>p</sub>	Glaciomarine drift (Pleistocene)—Silty clay and clay with scattered gravel dropstones.
Qgt <sub>p</sub>	Till (Pleistocene)—Diamicton consisting of clay, silt, sand, and gravel in varied proportions.
Qga <sub>p</sub>	Advance outwash (Pleistocene)—Sandy gravel, sand, pebbly sand, and scattered lenses of cobbly gravel.
ot	Older till (Pleistocene) (cross sections only)—Clay, silt, sand, and gravel in various proportions, with scattered cobbles and boulders.
oo	Older outwash (Pleistocene) (cross sections only)—Sand, gravel, silt, clay, and diamicton.

##### Whidbey Formation

Qc <sub>w</sub>	Whidbey Formation (Pleistocene)—Fluvial flood-plain facies (unit Qc <sub>wf</sub> ) and channel facies (unit Qc <sub>wc</sub> ); locally mapped as undivided (unit Qc <sub>wet</sub> ).
Qc <sub>wv</sub>	Lahar runoff of Oak Harbor (Pleistocene)—Pebbly sand and sand, locally overlain by water-laid ashy silt.

##### Deposits of the Double Bluff Glaciation

Qgt <sub>b</sub>	Till (Pleistocene)—Diamicton with rare lenses of sand and gravel.
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