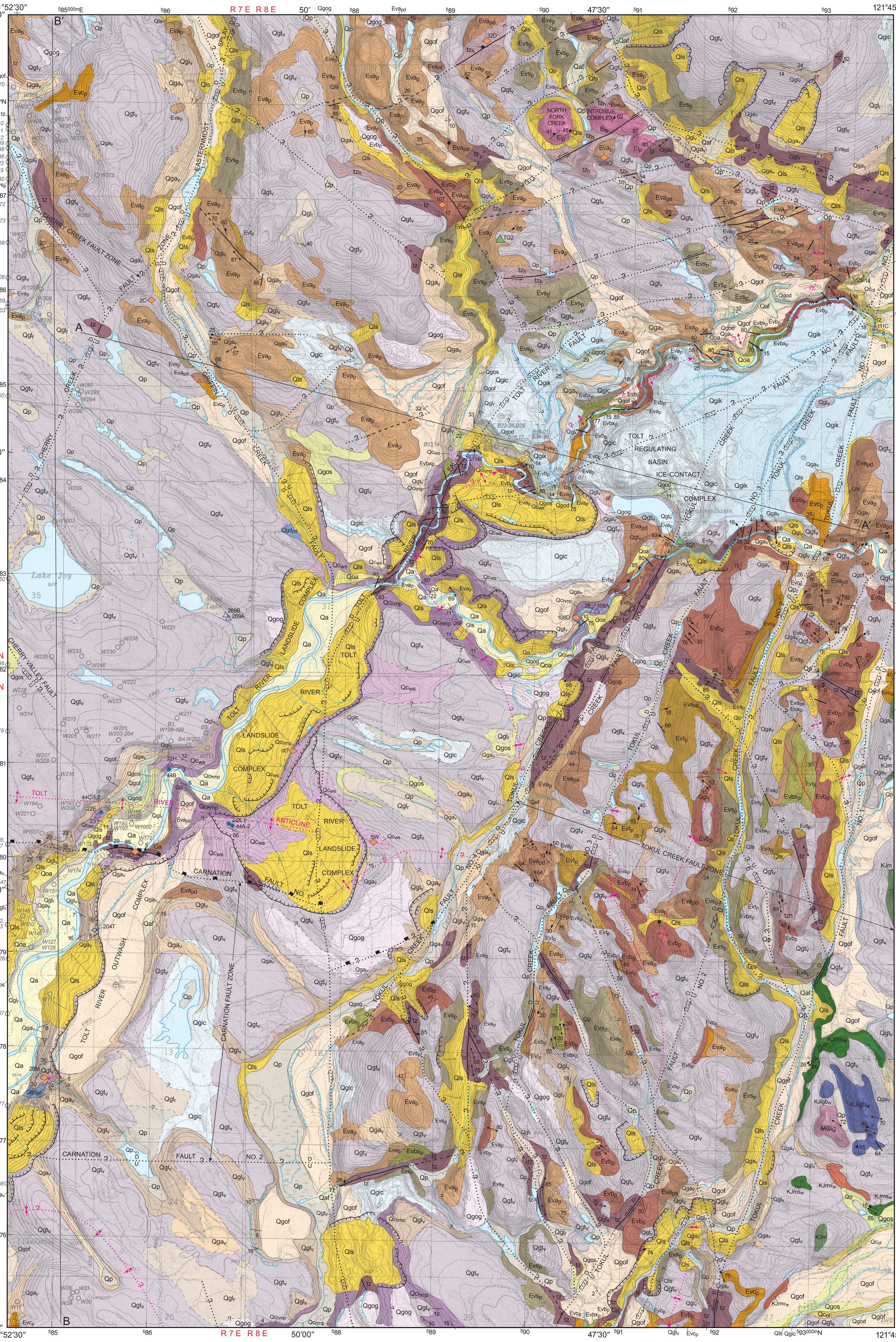
WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
Map Series 2012-01
Lake Joy 7.5-minute Quadrangle
October 2012
Plate 1 of 2
*Pamphlet accompanies map*

# Geologic Map of the Lake Joy 7.5-minute Quadrangle, King County, Washington

by Joe D. Dragovich, Megan L. Anderson, Shannon A. Mahan, James H. MacDonald Jr., Coire P. McCabe, Recep Cakir, Bruce A. Stoker, Nathan M. Villeneuve, Daniel T. Smith, and John P. Bethel

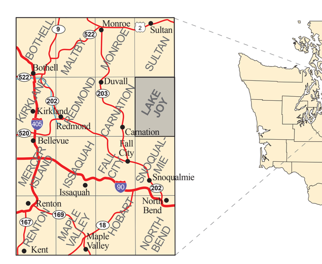
October 2012



Lambert conformal conic projection
North American Datum of 1927; to place on North American Datum of 1983, move the projection lines approximately 18 meters north and 93 meters east as shown by crosshair corner ticks
Base map from scanned and rectified U.S. Geological Survey Lake Joy 7.5-minute quadrangle, 1986
Shaded relief generated from a lidar bare-earth digital elevation model (available from Puget Sound Lidar Consortium, http://pugetsoundlidar.ess.washington.edu/); sun azimuth 5°; sun angle 54°
GIS by Coire P. McCabe and Joe D. Dragovich
Digital cartography and GIS by J. Eric Schuster and Anne C. Olson
Editing and production by Meredith C. Payne, Jaretta M. Roloff, and Katherine M. Reed

SCALE 1:24,000
contour interval 20 feet

*This geologic map was funded in part by the U.S. Geological Survey National Cooperative Geologic Mapping Program.*



APPROXIMATE MEAN DECLINATION, 2012

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## MAJOR FINDINGS

- On the basis of their distribution, composition, and stratigraphic style, Pleistocene Snoqualmie River or Tolt River nonglacial alluvium can be correlated with the Olympia beds, Whidbey Formation, or Hamm Creek unit and have been locally deformed and uplifted by ongoing tectonism.
- The Whidbey Formation is folded across the Tolt River anticline and likely uplifted along Carnation fault no. 1, which is potentially active.
- The northeast-trending left-lateral strike-slip Cherry Creek and Tokul Creek fault zones, conjugate to the northwest-trending southern Whidbey Island fault zone, are seismically active.
- The 1996 Duvall earthquakes (max. magnitude 5.3) may have resulted from shallow displacements along the trace of our Cherry Creek fault zone.
- Facies relations indicate that the volcanic rocks of Mount Persis emanated from center(s) in the map area (see unit Eīp) and to the north to northeast; flows and interbedded volcanic sediments were deposited more distally.

## DESCRIPTION OF MAP UNITS

*(See the pamphlet for detailed map unit descriptions.)*

### Quaternary Sedimentary Deposits

#### HOLOCENE NONGLACIAL DEPOSITS

af — **Artificial fill (Holocene)**—Mixed earth materials, including sand and gravel fill and may locally contain modified land.

Qp — **Peat (Holocene)**—Peat, muck, organic silt and clay, and local thin beds of tephra, including Mazama ash.

Qa — **Tolt River alluvium (Holocene)**—Boulder and cobble gravel, pebble gravel, and gravelly sand and lesser silt, peat, and organic sediments.

Qoa — **Older Tolt River Alluvium (Holocene to latest Pleistocene)**—Cobble to pebble gravel, sand, and silt in elevated terraces along the valley margins.

Qls — **Landslide deposits (Holocene to latest Pleistocene)**—Diamicton (unsorted mixture of clay, silt, sand, and gravel) or boulder gravel and local minor sand or gravel. Some landsliding may be the result of nearby active faulting.

Qaf — **Alluvial fan deposits (Holocene to latest Pleistocene)**—Debris-flow diamicton and alluvium.

#### PLEISTOCENE GLACIAL AND NONGLACIAL DEPOSITS

**Vashon Stade of the Fraser Glaciation**

*Vashon Recessional Deposits*

$Qgl_r$ — **Recessional glaciolacustrine (glacial lake) deposits**—Soft silt, clayey or sandy silt, and silty sand, typically with scattered dropstones; deposited in proglacial lakes.

Qgos — **Outwash sand**—Sand with some interbeds of silt or gravel; dark blue-gray; loose or soft; unstratified to weakly stratified to plane bedded, laminated, and crossbedded.

Qgod — **Deltaic outwash and kame deltas**—Sandy cobble gravel, gravel, pebbly sand, and minor sand; loose; moderately to well-sorted; thin to very thickly bedded and well-stratified.

Qgof — **Fluvial outwash deposits**—Boulder and cobble gravel, gravel, and pebbly sand, with interbeds of sand and (rare) silt; loose; moderately to well-stratified; subhorizontal beds, local crossbedding, and rip-up clasts.

Qgic — **Ice-contact deposits, undivided**—Loose boulder and cobble gravel and gravel, locally with lesser diamicton, silty pebbly gravel, and sand, pebbly sand, and silt; moderately stratified and medium to very thickly bedded. Locally divided into:

Qgik — **Ice-contact kames**—Boulder and cobble gravel, gravel, sand and pebbly sand, and rare lenses of diamicton that is mostly flow till or melt-out till from buried sediment-laden ice blocks.

Qgog — **Outwash gravel deposits, undivided**—Poorly exposed bouldery pebble cobble gravel to pebbly sand; loose; massive to crudely bedded; largely ice-contact deposits.

*Vashon Advance Proglacial and Subglacial Deposits*

$Qgt_v$ — **Lodgment till**—Diamicton; grayish blue to very dark gray; dense; matrix-supported.

$Qga_v$ — **Advance outwash**—Sandy gravel, pebble gravel, sand, and cobble gravel; tan to dark green-gray; dense; well-sorted and stratified; thinly to thickly bedded; local silt interbeds, some laminated, and (or) rip-up clasts, deltaic and bar foreset beds, cut-and-fill structures.

$Qgl_v$ — **Advance glaciolacustrine deposits**—Clayey silt, silt, pebbly silt, diamicton; gray to grayish blue; locally contains very thin to thick beds of sand; contains scattered dropstones and iceberg melt-out till or flow till; stiff or dense; stratification and sorting varied.

**Pre-Fraser Pleistocene Glacial and Nonglacial Deposits**

$Qc_{ol}$ — **Sediments of the Olympia Nonglacial Interval, local facies**—Cobble and boulder gravel to pebble gravel sand, silt, and clayey silt; minor local peat and organic sediments; dense; very thickly to thinly bedded; well-stratified and well-sorted.

$Qc_{ws}$ — **Whidbey Formation, Snoqualmie River facies**—Sand, silt, and silty sand with lesser pebbly sand, clay, and organic sediments including peat; light yellowish brown to pale yellow to distinctive orange-gray to dark olive-brown; dense; well-sorted and well-stratified; laminated to thickly bedded; commonly plane bedded.

$Qc_{hmp}$ — **Hamm Creek unit of Troost and others (2005), Mount Persis volcanic facies**—Cobble gravel, boulder cobble gravel, pebble gravel, with lesser sand, silt, and peat interbeds; light gray, weathers light yellowish brown; ripple or bar crossbedding grading to scoured bedding; very dense or hard; moderately well-sorted and stratified; flattened organic fragments, logs, or sticks common.

$Qc_h?$ — **Hamm Creek unit of Troost and others (2005), Snoqualmie River facies (Cross Section B only)**—Sand, silt, and organic-rich beds found below gravel-dominated unit $Qc_{hmp}$.

$Qgt_{pd}$ — **Pre-Double Bluff glacial drift**—Poorly exposed, weathered, reddish brown till in two areas (NW¼ sec. 31, T26N R8E; SE¼ sec. 14, T25N R7E) in the western part of the map area.

$Qgl_{pf}$ — **Pre-Fraser glacial and nonglacial deposits, undivided (Pleistocene to Pliocene?) (Cross Section B only)**—Dense to very dense gravel, boulder gravel, sand, silt, clay, diamicton; local peat or organic sediments.

### Tertiary Volcanic, Sedimentary, and Intrusive Rocks

MOig — **Granite to granodiorite (Miocene to Oligocene)**—Medium-K calc-alkaline massive granite to granodiorite; dark- or light-gray; weathers yellowish brown. The felsic composition of this massive intrusion suggests correlation with the post-Eocene Snoqualmie, Grotto, or Index granite batholiths. We suspect that shallow intrusive bodies pervade the Tokul Creek fault zone area at depth (Cross Section A).

$Evs_p$ — **Volcanic rocks of Mount Persis of Tabor and others (1993), undivided (Eocene)**—Interbedded andesitic to basaltic flows, with lesser andesitic to rhyolitic tuff, tuff breccia, and breccia, volcanic to tuffaceous sandstone and siltstone, lahar deposits, volcanic conglomerate, shale, organic siltstone, and coal; flows range from basalt to andesite with some dacite; locally strongly altered. Locally divided into:

$Eva_p$ — **Volcanic rocks of Mount Persis, andesite flows**—Flows and rare flow breccia; bluish to greenish gray, dark green, gray or dark gray; weathered or altered to dark reddish gray or brown- or maroon-gray or yellow-brown-gray.

$Eva_{pd}$ — **Volcanic rocks of Mount Persis, dark basaltic andesite flows**—Basaltic andesite to andesite flows; dark or bluish gray to very dark gray; weathered or altered to reddish gray, reddish brown, or brownish yellow.

$Evb_p$ — **Volcanic rocks of Mount Persis, basalt flows**—Basalt to basaltic andesite; dark-gray to reddish or greenish gray; weathered or altered to very dark grayish brown or light olive-brown. Basalt occurs as flows but includes a few mapped basaltic dikes in SE¼ and NW¼ sec. 3, T25N R8E.

$Evt_p$ — **Volcanic rocks of Mount Persis, tuffs**—Crystal vitric and crystal vitric lithic to lithic andesitic to rhyolitic tuffs; light- to dark-gray to bluish gray to light yellowish brown; lithic tuff beds typically greenish.

$Evbx_p$ — **Volcanic rocks of Mount Persis, volcanic breccia**—Dacitic to andesitic lithic tuff breccia and lesser lithic or crystal-lithic lapilli tuff and agglomerate; red, green, and black, to gray volcanic clasts and matrix; commonly weathers to a dark greenish gray.

$Evc_p$ — **Volcanic rocks of Mount Persis, volcaniclastic rocks**—Lithic and feldspathilithic volcanic to tuffaceous sandstone, silty sandstone and siltstone; lesser volcanic conglomerate, tuff and lapilli tuff, shale, organic siltstone and coal; color varies, but mostly light yellowish brown, very pale brown to light bluish gray or greenish gray sandstone with some dark-red to reddish brown volcanic siltstone; well-sorted and well-stratified; massive to medium to thickly bedded, plane and ripple crossbedding typical.

$Ei_p$ — **Volcanic rocks of Mount Persis, North Fork Creek intrusive complex (Eocene)**—Gabbro and hypabyssal (subvolcanic) andesite, basaltic andesite, and basalt; greenish gray, light greenish gray; weathers or altered to pale or olive brown, dusky red or pale yellow.

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

KJm — **Western mélange belt of Tabor and others (1993), undivided (Cretaceous to Jurassic)**—Metamorphosed argillite, sandstone, greenstone, gabbro, and diabase with minor metachert, metatonalite, slate, phyllite, marble, and rare ultramafite, metaquartz diorite, hornblendite, amphibolite or banded amphibolite. Locally divided into:

$KJm_{vw}$ — **Western mélange belt metavolcanic rocks**—Greenstone from metamorphosed andesite tuff, flows, and rare volcanic breccia; greenish gray.

$KJm_{sw}$ — **Western mélange belt metasedimentary rocks**—Marine lithofeldspathic to feldspatholithic subquartzose metamorphosed sandstone, argillite and chert, and metaconglomerate; typically greenish gray to dark gray or green-gray; weathers brown.

$KJigb_w$ — **Western mélange belt metagabbro**—Metagabbro; greenish gray.

### Holocene to Tertiary Tectonic Zones

tz — **Tectonic zone**—Cataclasite, fault breccia, clay-rich fault gouge, mylonite, protomylonite, or moderately to strongly slickensided, fractured, and veined rocks in fault zones; yellowish to variously colored, mottled, and commonly altered. Unit $tz_a$ are mappable zones of hydrothermal alteration; typically along tectonic zones; principally propylitic alteration mineral assemblages but may locally include higher grades of hydrothermal alteration.

## GEOLOGIC SYMBOLS

- Contact—Solid where location accurate; dashed where inferred; queried where identity or existence questionable
- Fault, unknown offset—Solid where location accurate; dashed where inferred; dotted where concealed; queried where identity or existence questionable
- Reverse fault—Solid where location accurate; dashed where inferred; dotted where concealed; queried where identity or existence questionable; rectangles on upthrown block
- Right-lateral strike-slip fault—Solid where location accurate; dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrows show relative motion
- Left-lateral strike-slip fault—Solid where location accurate; dashed where inferred; dotted where concealed; queried where identity or existence questionable; arrows show relative motion
- High-angle right-lateral, oblique-slip fault—Location concealed; queried where identity or existence questionable; arrows show relative horizontal motion; U, upthrown block; D, downthrown block
- High-angle left-lateral, oblique-slip fault—Solid where location accurate; dotted where concealed; arrows show relative horizontal motion; U, upthrown block; D, downthrown block
- Anticline—Solid where location accurate; dashed where approximate; dotted where concealed; queried where identity or existence questionable
- Syncline—Solid where location accurate; dashed where approximate; dotted where concealed; queried where identity or existence questionable; arrowhead shows direction of plunge
- Dike—Identity and existence certain, location accurate
- Fluvial terrace scarp—Identity and existence certain, location accurate. Hachures point downscarp
- Landslide scarp—Identity and existence certain, location accurate. Hachures point down slope.
- A — A′ Cross section line
- Direction of downslope movement of landslide
- Bedding, including flow banding in volcanic rocks of Mount Persis—Showing strike and dip
- Horizontal bedding
- Vertical bedding—Showing strike
- Bedding in unconsolidated sedimentary deposits—Showing strike and dip
- Foreset bedding in unconsolidated sedimentary deposits—Showing strike and dip
- Joint—Showing strike and dip
- Vertical or near-vertical joint—Showing strike
- Foliation in metamorphic rock—Showing strike and dip
- Minor fault—Showing strike and dip
- Minor vertical or near-vertical fault—Showing strike
- Slickensided surface—Showing strike and dip
- Vertical slickensided surface—Showing strike
- Minor ice-shear folds in unit $Qgl_v$—Showing bearing and plunge
- Slip lineation or slickensides on a fault or shear surface—Showing bearing and plunge of offset
- Mylonitic foliation—Showing strike and dip
- Water well (W###) or geotechnical boring (B#)
- Significant site
- Age sample, °C, carbon-14
- Age sample, optically stimulated luminescence
- Age sample, tephra
- Earthquake epicenter (see Appendix G)

## AEROMAGNETIC AND GEOPHYSICAL MAP AND CROSS SECTIONS

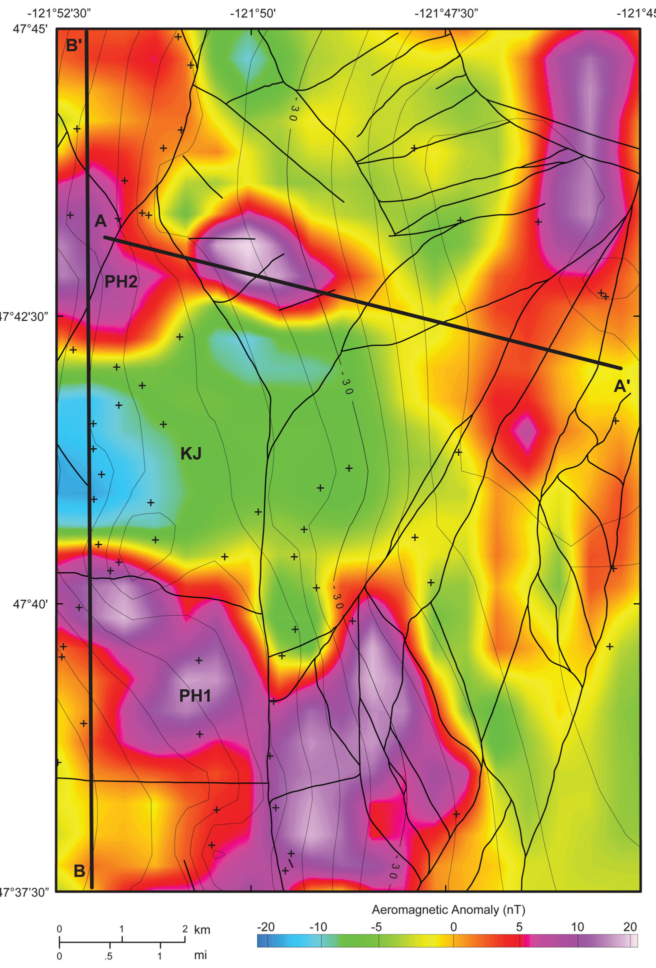
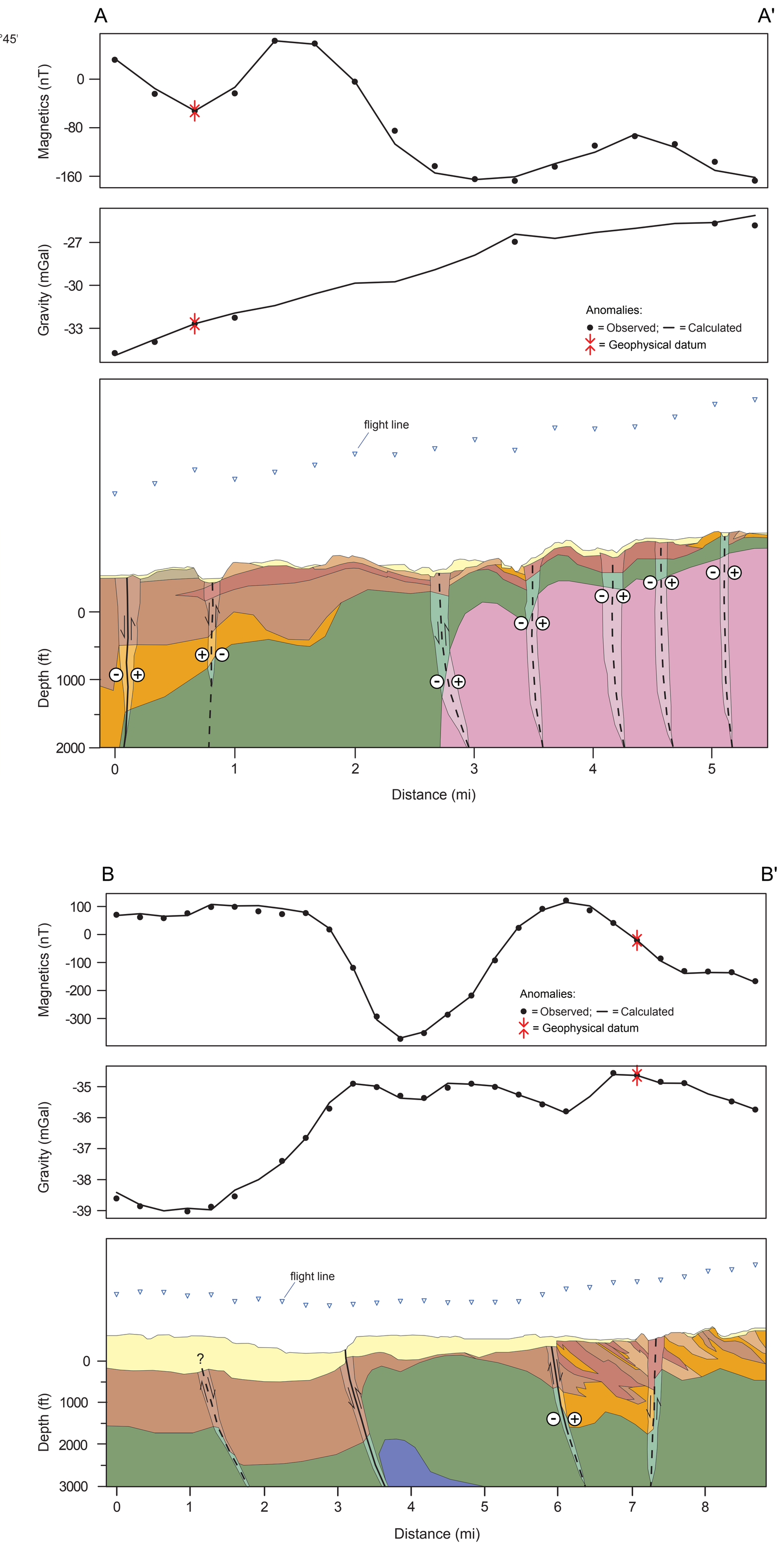


Figure 1. Aeromagnetic and gravity geophysical map of the Lake Joy quadrangle. Base map is the reduced-to- pole aeromagnetic anomaly map, filtered (upward continued and differenced with original grid) to bring out near-surface magnetic anomalies. Isostatic gravity contours (1 mGal interval) are labeled in mGals. Crosses indicate the location of gravity measurements controlling the isostatic gravity grid. Darker lines are faults from the geologic map. **KJ**, magnetic low due to Western mélange belt; **PH1** and **PH2**, magnetic highs likely due to either basalt or basaltic andesite.



| | | | |
|---|---|---|---|
| | Δρ = -650 to -620 | χ = 2.7 | Quaternary deposits |

**Volcanic Rocks of Mount Persis**

| | | | |
|---|---|---|---|
| | Δρ = -290 to -270 | χ = 3 | volcaniclastic, unit $Evc_p$ |
| | Δρ = -330 to -290 | χ = 1.2-2.7 | $Evc_p$ cataclasite, unit tz |
| | Δρ = -60 | χ = 11-80 | andesite, unit $Eva_p$ |
| | Δρ = -60 to 30 | χ = 80 | basaltic andesite, unit $Eva_{pd}$ |
| | Δρ = -330 to -70 | χ = 20-80 | $Eva_{pd}$ cataclasite, unit tz |
| | Δρ = 60 | χ = 80-90 | basalt, unit $Evb_p$ |
| | Δρ = -170 to -20 | χ = 50 | $Evb_p$ cataclasite, unit tz |
| | Δρ = -120 | χ = 8 | undifferentiated, unit $Evs_p$ |

**Tertiary Intrusive Rocks**

| | | | |
|---|---|---|---|
| | Δρ = 80 | χ = 0 | Index batholith, unit MOig |
| | Δρ = 30 | χ = 0 | cataclasite, such as unit tz |

**Western Mélange Belt**

| | | | |
|---|---|---|---|
| | Δρ = -10 | χ = 0-5 | Western mélange belt |
| | Δρ = -10 | χ = 0-1.2 | cataclasite, such as unit tz |
| | Δρ = 230 | χ = 0 | metagabbro, Western mélange belt, unit $KJigb_w$ |

Figure 2. Geophysical Cross Sections A and B. The geophysical cross sections coincide with lithologic Cross Sections A and B on the geologic map and match predicted gravity and aeromagnetic anomalies from the cross sections to data from the region (3x vertical exaggeration). Aeromagnetic data sampling distance is twice the flightline spacing. Gravity stations shown are within 1.5 km of the line. The model is assumed to extend to infinity in both directions perpendicular to the profile. The blue triangles in the lower panel indicate the height of the flight line above the ground for the aeromagnetic data. Δρ is the density contrast relative to normal crust (2670) in kg/m³; χ is magnetic susceptibility in SI units multiplied by 1000. Solid lines show fault locations that are well controlled by the geophysical data. Dashed lines show fault locations that are controlled by geologic mapping at the surface, but are less certain at depth. Unlike the map interpretation, where we focus on high-resolution magnetic anomalies that constrain within our models near-surface structures, for the geophysical modeling we use the total field magnetic anomaly. This enables us to constrain both the shallow and deep-seated structures that contribute to the magnetic anomalies of the region.

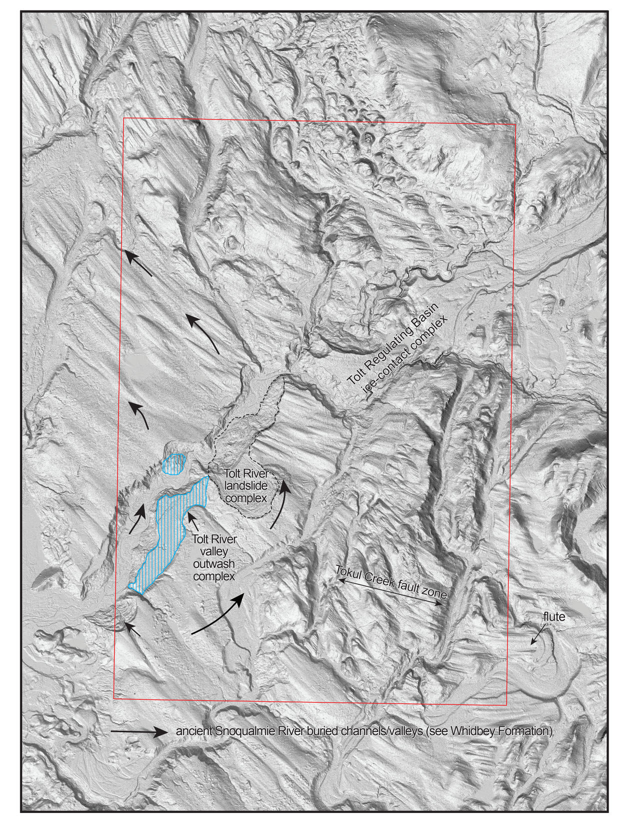
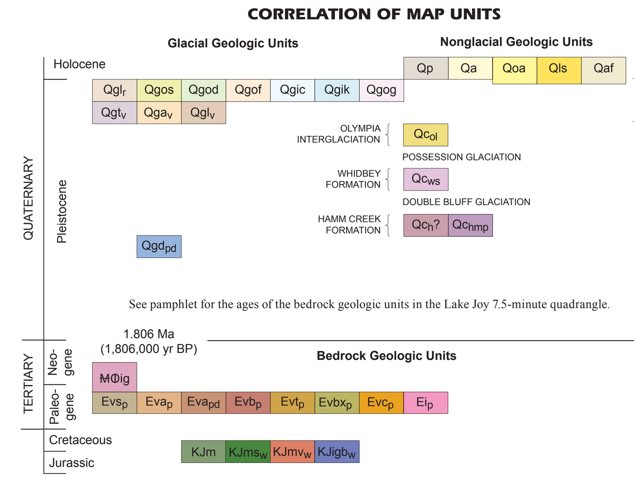
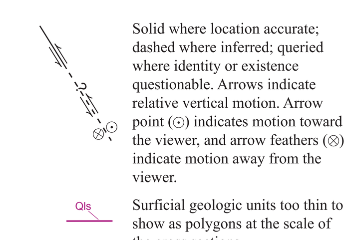



Figure 3. Shaded relief map of the Lake Joy 7.5-minute quadrangle (red rectangle) and surrounding area. The arrows show the general valley location and flow direction of the ancient Snoqualmie River valley(s) as indicated by the distribution of Whidbey Formation fluvial sediments (unit $Qc_{ws}$), as well as by the depths to bedrock and stratigraphic information. These ancient channels and floodplains have been modified by two subsequent continental glaciations, as well as by suspected active tectonism around Carnation fault no. 1.

## CORRELATION OF MAP UNITS





## FAULTS IN CROSS SECTIONS

Solid where location accurate; dashed where inferred; queried where identity or existence questionable. Arrows indicate relative vertical motion. Arrow point (⊙) indicates motion toward the viewer, and arrow feathers (⊗) indicate motion away from the viewer.

Surficial geologic units too thin to show as polygons at the scale of the cross sections.

**Lithologic Cross Sections A and B.** For our analyses of subsurface conditions, we obtained from various sources 426 stratigraphic logs for wells, geotechnical borings, and test pits. Most high-quality well and boring data are shown directly. We show composited information where wells and borings are closely spaced and (or) where subsurface geologic conditions are stratigraphically consistent over a short distance. Although other solutions are possible, our geophysical model of the map area is consistent with the stratigraphic arrangement we postulate here. (See Figs. 1 and 2 and Appendix D.) Appendix G provides information for the earthquake hypocenters near the cross sections, particularly those along the apparently active Carnation fault no. 1. Local folding of Pleistocene alluvial sediments, particularly the Whidbey Formation (unit $Qc_{ws}$) and the Hamm Creek unit (units $Qc_{hmp}$ and $Qc_h?$) on this section, is the result of probable ongoing tectonism.