
PART III: USEFUL INFORMATION

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Many definitions herein are taken, with permission, from the Glossary of Geology, published by the American Geological Institute (Neuendorf and others, 2005).

- ablation** – the loss of snow and ice from a glacier's surface due to melting, erosion, evaporation, or sublimation.
- ablation till** – poorly consolidated rock debris that was on or in a glacier and that later accumulated as the glacial ice was removed by ablation.
- accretion** – the process by which one terrane is attached to another having a different history. Typically, accretion occurs during tectonic collision.
- accretionary lapilli** – a mass of cemented ash 1 to 10 mm (0.04–0.4 in.) in size.
- acoustic flow monitors** – instruments that can detect sound vibrations in a specified frequency range. For detecting lahars or debris flows, acoustic flow monitors sensitive to the frequency range of about 50 to 80 Hz are used. A properly located array of such instruments can be programmed to detect significant ground vibrations and to automatically send a signal to a central location for interpretation and possible use in early warning alert systems for potential evacuation of downstream communities.

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Mount Baker–Snoqualmie National Forest

<http://www.fs.fed.us/r6/mbs/recreation/>

Mount Rainier National Park

<http://www.nps.gov/archive/mora/home.htm>

Mount Rainier National Park road status

<http://www.nps.gov/mora/planyourvisit/road-status.htm>

Mount Rainier Volcano Hazard Response Plan

Pierce County—<http://www.co.pierce.wa.us/pc/Abtus/ourorg/dem/EMDiv/Mt%20Rainier%20VHRP.htm>

Washington Emergency Management Division—http://www.emd.wa.gov/plans/documents/mtrainier_volcanic_hazards_response_plan.pdf

Mount Rainier seismicity information

Pacific Northwest Seismic Network
<http://www.pnsn.org/RAINIER/welcome.html>

Washington Division of Geology and Earth Resources

<http://www.dnr.wa.gov/AboutDNR/Divisions/GER/Pages/home.aspx>

Washington Emergency Management Division

<http://www.emd.wa.gov/>

Washington State Parks campsite reservations

<http://www.parks.wa.gov/reserve.asp>
 888-226-7688

WSDOT Mountain Pass Conditions

Washington State Department of Transportation
 Phone: 1-800-695-7623; in Seattle 206-368-4499
<http://www.wsdot.wa.gov/traffic/passes/text.asp>

WSDOT State Route Web—Images along State Routes

Washington State Department of Transportation
<http://www.srvie.wsdot.wa.gov/>

WSDOT Statewide Traveler Information

Washington State Department of Transportation
<http://www.wsdot.wa.gov/traffic> ■

GLOSSARY

- aggradation** – the buildup of the Earth's surface by deposition, such as that performed by stream processes or volcanism.
- aggraded** – see *aggradation*.
- alluvial fan** – an outspread, gently sloping mass of alluvium deposited by a stream and/or debris flows.
- alluvium** – a general term for stream deposits.
- alpine glaciation** – the activity of a body of glacial ice whose source area is in a mountainous terrain in any latitude.
- alpine glacier** – a glacier in mountainous terrain. See *alpine glaciation*.
- alteration** – changes in the chemical and/or mineralogical composition of a rock, generally produced by weathering or hydrothermal activity. See *altered*; *hydrothermal alteration*.
- altered** – chemically or mineralogically changed, as via weathering or hydrothermal alteration.
- amphibole** – a group of dark, rock-forming ferromagnesian silicate minerals; for example, hornblende. Amphibolite is a rock consisting primarily of amphibole and plagioclase feldspar.
- amygdule** – a gas cavity in a lava that is filled with minerals (for example, opal, zeolites); *adj.*, amygdaloidal.

- andesite** – a fine-grained extrusive igneous rock generally containing abundant plagioclase, lesser amounts of hornblende and biotite, and little or no quartz; contains 54 to 62 percent silica; *adj.* andesitic.
- anticline** – a convex-upward fold having stratigraphically older rocks in its core.
- anticlinorium** – a composite anticlinal structure of regional extent comprising multiple folds.
- aragonite** – a carbonate mineral (CaCO₃) that is denser and harder than calcite.
- argillic** – alteration in which certain minerals in a rock are converted to clay-group minerals
- argillite** – a compact sedimentary rock derived from mudstone or shale; *adj.*, argillaceous.
- Ar/Ar, ⁴⁰Ar/³⁹Ar (Argon-40/Argon-39 age method)** – a variation of K-Ar (potassium-argon) age estimation. One reason ⁴⁰Ar/³⁹Ar dating offers a significant advantage over conventional K-Ar dating is that potassium and argon are measured on the same sample by using isotopic ratios of argon; thus, very small samples and single crystals may be used. A good reference is <http://www.diggles.com/bturrin/40Ar.html#aa2>.

arkose – a feldspar-rich sandstone, typically derived from the rapid disintegration of granite or granitic rocks; *adj.*, arkosic.

ash – see *volcanic ash*.

ash cloud – an eruption cloud of volcanic gas and fine particles.

augite – a dark mineral of the pyroxene group that is common in igneous rocks.

axis – a line passing through a body or fold of rock around which it is symmetrically arranged.

back-arc basin – a basin floored by oceanic crust, formed by sea-floor spreading on the opposite side of a volcanic arc from an oceanic trench.

back thrust – a thrust fault that is oriented so that the direction of displacement is generally opposite that of the predominant direction of folding or faulting.

bar and swale – undulating topography on a flood plain, formed by the migrating channel of a river or creek; the bars are composed of coarse particles (sand, gravel, or cobbles), and the swales are depressions that contain fine sand, silts, and clays.

basalt – a fine-grained volcanic rock, typically dark, that contains 45 to 54 percent silica; *adj.*, basaltic.

basaltic andesite – rocks that are intermediate in composition between andesite and basalt.

batholith – a mass of intrusive rock that has an area of at least 40 mi² (100 km²).

bed – an individual layer or stratum, ranging from less than 0.5 in. (~1 cm) to more than several yards (meters) in thickness; the floor or bottom of a lake or stream; *adj.*, bedded.

bedding – stratification; the arrangement of layers in a sedimentary rock or deposit.

bed load – sediment, such as cobbles, pebbles, and granules, that is transported along the bed of a river but is not in suspension.

bergschund – a large crevasse near the head of an alpine glacier.

biotite – black, brown, or dark green mica; a common mafic mineral.

bituminous coal – “soft coal”; coal that contains more than 14 percent volatile matter and has a calorific value of more than 11,500 BTU/lb. It is typically brown to black and burns with a smoky flame. The most abundant rank of coal.

block-and-ash flow – a pyroclastic flow containing blocks larger than 64 mm (2.6 in.); the slow cooling of these flows can cause the fragments to become welded.

bombs, breadcrust bombs – pyroclasts that are ejected while semi-molten and viscous and receive their shape during flight and/or impact. Shapes vary widely; many have a breadcrust-like texture (open cracks) on their outer surface caused by contraction during sudden cooling. (See Fig. A-11, p. 60.)

breadcrust – see *bombs*.

breccia – a rock composed of coarse, angular fragments in a matrix of finer particles.

calcite – a common mineral composed of calcium carbonate (CaCO₃).

caldera – a large, typically steep-sided volcanic basin produced by the collapse of an underlying magma chamber.

caliche – a light-colored, dominantly calcium carbonate or magnesium carbonate cement in soil layers that is precipitated from soil moisture in semi-arid regions, or the name given to a soil containing this material; hardpan.

carbonaceous – describes a rock unit or sediment rich in organic matter, coaly.

Cascade Range, Cascades – the north-trending volcanic arc near the western margin of North America.

Cascadia – the area of the Pacific Northwest whose physiography and geology has been directly influenced by the tectonic activity and history of the Cascadia subduction zone.

Cascadia subduction zone – the belt of subduction along the west coast of North America that extends from approximately the latitude of the middle of Vancouver Island, British Columbia, to Mendocino, California. (See Fig. 7, p. 9.)

Cenozoic – the geologic time encompassing the last 65 million years. (See Fig. 4, p. 5.)

chalcedony – a cryptocrystalline form of quartz, similar to chert, commonly found in vugs.

chert – a hard, dense rock consisting chiefly of microcrystalline quartz.

chlorite – a greenish clay mineral that is a common alteration product of ferromagnesian minerals.

cinder cone – a fairly small, cone-shaped volcanic vent consisting mainly of accumulated cinders and other pyroclastic fragments.

cirque – a glacially carved, horseshoe-shaped hollow at the head of a mountain valley. (See Fig. 24, p. 29.)

clast – a general term for any fragment or individual piece of rock.

clastic – made up of rock fragments.

clay-poor lahar – a lahar having less than 3 percent clay in the matrix; typically triggered when a pyroclastic flow or surge melts snow or ice or when a flood surge of any kind accumulates sediment on the flanks of a volcano.

clay-rich lahar – a lahar having greater than 3 percent clay in the matrix; typically triggered by transformation of a clay-rich landslide from collapse of a sector or flank of a volcano. See also *cohesive lahar*.

Clovis – a culture of early North Americans dating from roughly 13,500 to about 11,000 yr B.P.

coal – a black, combustible sedimentary rock formed by compaction of plant matter.

coeval – originating or existing during the same time or period.

cohesive lahar – a volcanic debris flow or mudflow that contains more than 3 percent clay minerals in its matrix.

coke – the solid residue of coal after removal of the volatiles.

collapse breccia – fragmental deposits and blocks that have fallen into a collapse structure, such as a caldera or cave.

colluvium – a general term for loose soil and rock debris that accumulates near the base of a slope.

colonnade – in lava flows, a lower zone that has thicker columns that are better developed than those in the upper entablature. (See Fig. F-12, p. 110.)

column – see *columnar joints*.

columnar joints – fractures bounding polygonal columns that form in lava or a welded tuff deposit because of contraction that occurs as the unit cools. The columns typically form perpendicular to the cooling surface. (See Fig. F-12, p. 110.)

composite volcano – a steep-sided volcano consisting of alternating layers of lava and pyroclastic debris, as well as abundant dikes and sills; a stratovolcano.

conformable – describes layers that are formed or deposited in uninterrupted sequence, one on top of the other.

conglomerate – a coarse-grained sedimentary rock consisting of rounded rocks in a finer matrix, commonly cemented.

contact metamorphism – a type of recrystallization or change in rocks that takes place adjacent to a magma body; also known as thermal metamorphism.

continental ice sheet – a thick glacial mass that is large enough to cover a significant part of a continent. (See Fig. 21, p. 27.)

country rock – the rock enclosing a mineral deposit or igneous intrusion.

creep – slow downhill movement of surficial materials (such as soil); also, the constantly increasing, slow deformation (strain) of rock that results from stress acting over a long time.

Cretaceous – the geological period from about 144 to 65 Ma. (See Fig. 4, p. 5.)

crevasse – a deep fissure in the surface of a glacier. (See Fig. 24, p. 29.)

cross beds – strata thicker than 0.4 in. (1 cm) that are inclined at an angle to the main strata. The nature of the cross beds can provide clues to the currents or winds that deposited them.

cross dating – a method of matching tree rings using their known patterns or characteristics in an area to precisely date wood or trees such as those buried in volcanic deposits or injured by volcanic activity.

cuesta – an asymmetrical ridge with a long dip slope on one side and an abrupt cliff on the other.

cumulate – the rock material consisting of the crystals that settled to the bottom of a magma chamber.

cut-and-fill channel structures – typically bedded deposits, visible in cross-sectional view, left as fill in a stream channel that has been cut into older strata.

dacite – a fine-grained extrusive igneous rock typically having 62 to 69 percent silica; *adj.*, dacitic.

deep-seated – said of landslides whose failure plane is deep below the ground surface.

debris avalanche – a flow of unsorted rock debris that typically moves at high velocity.

debris flow – a moving mass of debris, typically water-saturated. True debris flows commonly have sediment concentrations greater than 80 percent by weight (60 percent by volume).

debris slide – a shallow mass movement of the soil layer or other geologic material.

dendrochronology – the scientific study of annual growth rings in trees for determining climatic or environmental information or the age of wood.

diamicton – a descriptive term for any poorly sorted deposit, such as a till, a debris flow, or a debris avalanche. Also diamict.

dike – a tabular intrusive rock body that forms where magma cuts across the bedding planes or foliation of other rock bodies.

diorite – a coarse-grained intrusive rock having roughly the same chemical composition as andesite (54–62% silica); *adj.*, dioritic.

dip – the angle of inclination of a layer of rock measured from the horizontal.

dip slope – a hillside whose slope is similar to the dip of the rock strata.

discharge – the rate of stream flow at a given time in units of volume per unit of time (ft³/s or m³/s).

dish structure – a thin, typically concave upward lamina of mud that may form in a clay-poor lahar and lahar-derived deposits as they dewater immediately after deposition.

dome – see *volcanic dome*.

drift – a general term for any glacial deposit.

drumlin, drumlinoid – a low, elongate, rounded hill typically composed of compact glacial drift that is built and/or shaped under flowing glacial ice and whose axis is parallel with the direction of ice movement. Drumlinoids are a less distinct form of drumlin.

earthflow – a type of mass movement that typically takes place along well-defined failure planes and may involve more than one failure process, such as slumping and plastic flow.

effective stress – intergranular pressure; the average normal force per unit area transmitted directly from particle to particle within a soil or rock mass.

effusion – the emission of moderately fluid lava onto the Earth's surface; the eruptive product thereof.

end moraine – see *terminal moraine*.

entablature – in lava flows, a zone that has thinner, less well developed columns; typically above the colonnade. (See Fig. F-12, p. 110.)

Eocene – the geologic epoch covering the time interval between about 54 and 34 Ma; it followed the Paleocene and preceded the Oligocene Epochs of the Tertiary Period. (See Fig. 4, p. 5.)

epiclastic – related to the fragmentation of rock by mechanical weathering or the accumulation or lithification of these fragments.

erratic – a large rock that has been transported far from its place of origin, typically by a glacier or cataclysmic flood event.

eruption column – the columnar eruption cloud from a volcano that results from the initial jet of volcanic material rising from the vent

extrusive – said of a rock that is erupted onto the Earth's surface.

facies – the characteristics (grain size, color, etc.) of a rock or sedimentary unit that distinguish it from another unit.

fan – a fan-shaped, gently sloping mass of debris or lava; see *alluvial fan*.

fault – a fracture along which one rock mass has slid past another.

fault breccia – angular rock fragments produced by fracturing and frictional slip along a fault.

feeder – the conduit through which lava passes from a magma chamber to some localized intrusion; for example, a feeder dike.

feldspar – a common rock-forming mineral group consisting of silicates of aluminum, sodium, potassium, and calcium.

felsic – referring to igneous rocks that have abundant light-colored minerals or less than 50 percent ferromagnesian minerals.

ferromagnesian minerals – silicate minerals such as olivine, pyroxenes, and amphiboles that contain considerable amounts of iron and magnesium.

fiamme – dark, glassy, flattened fragments in welded tuffs, possibly collapsed pumice; may reach several inches (centimeters) in length.

firm – material that is transitional between snow and glacier ice.

fission-track dating – a method for determining the age of a rock based on the number of tracks created by the emission of subatomic particles during radioactive decay.

flank collapse – a landslide in which part of a volcano's flank fails and slides and/or flows downslope and outward from the volcano. Compare with sector collapse.

flaser bedding – incomplete or interrupted mud laminae found in coarse sediment and sedimentary rocks.

flood basalt – the lava produced by enormous fissure eruptions, such as the Columbia River Basalt Group flows; also plateau basalt.

flow banding – stripes, lenses, or streaks in volcanic rocks of different colors, minerals, and/or textures that originate during flow of a lava; such

banding may indicate mixing of different magmas or zones of greater and lesser gas content.

flow breccia – a deposit of angular rock fragments, some of which are welded together, that is produced in association with a lava flow.

flow units – a group of sheets or beds of lava or pyroclastic rocks that were formed a single eruption or outpouring.

fluidal glass – small globular glass particles included in pyroclastic deposits; represents juvenile eruptive products.

fluvial – of or related to rivers or river processes.

fold – a bend in a rock stratum or layer.

footwall – the mass of rock that is beneath, on the lower side of a dipping fault or sloping ore body or vein.

fore arc – the region between a subduction-related trench and a volcanic arc.

formation – a distinctive body of sedimentary rock that can be mapped or traced from one place to another.

forward looking infrared thermography (FLIR) – a technique that uses cameras (sensors) that can detect radiant energy in the infrared spectral range (heat energy).

Fraser Glaciation – a series of glacial advances that occurred in the Pacific Northwest between about 29 and 10 ka. This glaciation coincided with oxygen isotope stage 2.

fumarole – a volcanic vent that emits gases.

gabbro – a coarse-grained intrusive rock consisting mainly of calcium-bearing plagioclase and pyroxene minerals and having roughly the same chemical composition as basalt (45–54% silica).

geode – a hollow or partly filled globular body in which the crystals (quartz, calcite, or zeolites) have grown toward the interior of the cavity.

geodesy – the science concerned with the precise shape, size, and physical aspects of the Earth.

geomagnetic – pertaining to the magnetic field of the Earth.

geomagnetic polarity – the orientation of the natural remanent magnetization of a rock. A rock having "normal" polarity has a natural remanent magnetization roughly parallel to the present ambient geomagnetic polarity, showing the magnetic negative pole to be near the geographic north pole at the time the rock was formed; a rock having "reversed" polarity has a natural remanent magnetization that shows the magnetic positive pole was near the present geographic north pole at the time the rock was formed. (See "Paleomagnetism" sidebar, p. 104.)

geomorphology – the science that treats the general configuration of the Earth's surface, its landforms, and their causes and history.

geophone – a seismic device that acts as a pickup and can detect ground vibrations within a certain range of frequencies.

glacier – a mass of ice, mainly recrystallized snow, that is heavy enough to move under its own weight; *adj.*, glacial.

glaciofluvial – pertaining to the meltwater streams that drain glaciers and the landforms and deposits left by these streams.

gneiss – a foliated or banded rock formed by regional metamorphism.

gouge – pulverized, commonly clayey, rock material found along faults and formed by the grinding action of rocks during faulting.

graded beds – layers of sediment that display a change in grain size, typically from coarser to finer upwards.

granite – a coarse-grained intrusive rock composed of potassium feldspar, plagioclase, quartz, and minor amounts of mafic minerals; more than 69 percent silica.

granodiorite – a coarse-grained intrusive rock, similar to granite, in which plagioclase minerals are more common than potassium feldspar, 62 to 69 percent silica.

graywacke – an obsolete (but convenient!) term for a coarse-grained sandstone that contains poorly sorted, angular to subangular fragments of quartz and feldspar embedded in a clayey matrix and that contains common dark (ferromagnesian) minerals; graywackes are commonly interpreted to have been deposited by turbidity currents.

greenstone – a field term for any dark-green altered or metamorphosed mafic igneous rock that owes its color to the minerals chlorite, actinolite, or epidote.

groundmass – the matrix of a porphyritic igneous rock.

ground moraine – an extensive area of till having little or no relief. (See Fig. 24, p. 29.)

grus – an accumulation of angular crystals and rock grains formed in situ by the disintegration of crystalline rocks.

hackly – a result of jagged fracturing.

half-life – the time required for half of the atoms in a sample of a radioactive isotope to decay.

hanging wall – the mass of rock that lies above a dipping fault or sloping ore body or vein.

hanging valley – any tributary valley whose mouth is high above the floor of the main valley. (See Fig. 24, p. 29.)

headscarp – the steep wall from which a landslide has detached.

headwall – the steep slope at the head of a valley or cirque. (See Fig. 24, p. 29.)

heavy mineral – slang for ferromagnesian or mafic minerals that have a specific gravity greater than about 2.85.

historic – having importance in, or influence on history; the Washington Office of Archaeology and Historic Preservation has issued guidelines for designation of historic features or structures (see <http://www.dahp.wa.gov/>).

hogback – a ridge having a narrow summit and steeply dipping flanks. Hogbacks are typically formed by the sharp edges of steeply inclined bedded rocks that are resistant to erosion.

Holocene – the geologic epoch of the Quaternary Period that followed the Pleistocene Epoch and comprises the last 12,000 years.

hornblende – a dark mineral commonly found in igneous rocks.

hornfels – a fine-grained rock formed by recrystallization during contact metamorphism.

hyaloclastite – a deposit formed by the flow or intrusion of lava or magma into water, ice, or water-saturated sediments and its consequent shattering into small angular fragments.

hydrothermal activity – the migration of hot, typically mineral-rich fluids produced by magma or by reactions of magma with adjacent rocks and (or) ground water.

hydrothermal alteration – the chemical or physical alteration of rocks or minerals owing to contact with hydrothermal waters.

hydrous – a term referring to minerals containing water as part of their crystalline structure.

hyperconcentrated flow – a type of gravity-driven sediment-rich slurry that has sediment concentrations in the range of 40 to 80 percent solids by weight (20–60 percent by volume) and that commonly forms when a lahar or debris flow undergoes dilution.

hypersthene – a dark mineral of the orthopyroxene group that is common in igneous rocks.

ice-marginal – referring to features or environments adjacent to glacial ice, for example, ice-marginal lakes.

igneous rock – a rock formed by the cooling of magma.

imbricated – overlapping; arranged like shingles or fish scales.

inclusion – a fragment of older rock within an igneous rock.

inholding – a plot of privately held land that is within the boundaries of land owned by the government.

inlier – an area or group of rocks that is surrounded by rocks of a younger age.

interferometric synthetic aperture radar (InSAR) – a technique for measuring small changes in deformation of the Earth's surface.

interbed – a bed, typically thin, of one type of rock material between, or alternating with, beds of another kind. In volcanic terrain, interbeds are commonly lake or stream deposits.

intermediate – said of an intrusive rock that is transitional between mafic and felsic.

intrusive rock – an igneous rock that solidifies under the surface of the Earth.

invasive flow – a lava flow that sinks into sediments or material having a lower density.

isotope – one of two or more forms of an element that have different atomic weights.

jasper – a variety of chert, typically red.

joint – a fracture in a rock along which movement has not occurred. (See Fig. A-11, p. 60.)

jökulhlaup – an Icelandic term for glacial outburst flood.

Jurassic – the second period of the Mesozoic Era, spanning the time between about 200 and 145 Ma. (See Fig. 4, p. 5.)

juvenile material – volcanic rocks derived directly from magma that has reached the surface; see also *pyroclastic*.

K-Ar dating – see *potassium-argon dating*.

kame terrace – a terrace-like deposit of stratified sand and gravel formed between a melting glacier or stagnant ice lobe and a valley wall or moraine. (See Fig. 24, p. 29.)

kettle – a bowl-like depression formed by the melting of a detached mass of ice buried by sediment as a glacier recedes. (See Fig. 24, p. 29.)

kinematic wave – a wave that moves through a medium without regard to the mass of the medium or the applied force.

lacustrine – pertaining or related to lakes.

lahar – the general term for a volcanic debris flow, a moving mixture of pyroclastic material and water that originates at a volcano; *adj.*, laharc.

lahar runout – the muddy flood resulting from dilution of a lahar as it mixes with stream water. The deposits are typically sandy and have fewer large rocks than lahar deposits. Runouts have sediment concentrations of 40 to 80 percent solids by weight (hyperconcentrated).

lamina – the thinnest recognizable layer in a sediment or sedimentary rock, typically thinner than 1 mm; plural, laminae.

lapilli – volcanic particles in the range of 2 to 64 mm (0.07–2.52 in.).

lateral moraine – an accumulation of till along the sides of a glacier where it meets the valley wall.

latewood – the dark or higher density part of a tree's annual growth ring formed during the latter part of the growing season.

lava – magma that reaches the Earth's surface; also the rocks that result from its cooling.

levee – an area of deposits at the edges of a stream or lava flow that approximately records the maximum height of the flow.

lignite – a brownish-black coal that is intermediate between peat and subbituminous coal.

limb – the flank of a fold between two adjacent hinges.

lineament – a linear topographical feature of regional extent that is inferred to reflect crustal features or structures.

liquefaction – in a soil, the transformation from a solid to a liquid state as the result of increased pore pressure and reduced intragranular pressure.

lithic – of or related to rocks or their descriptive characteristics; lithologic.

lithic-rich pyroclastic flow – a pyroclastic flow that contains a significant percentage of fragments of previously formed rocks mixed in with the juvenile rocks.

lithification – the process(es) by which sediment is converted into solid rock.

lithologic – see *lithic*.

lithology – the description of rocks in outcrop or hand sample, or the physical characteristics of a rock.

lithosphere – the solid outer portion of the Earth.

Little Ice Age – a period of cold climate from about A.D. 1350 to A.D. 1850. During this time, alpine glaciers worldwide advanced, in places by as much as a mile (1–2 km) down their valleys.

loess – a blanket deposit of windblown silt, typically unstratified and homogeneous, considered to have originated as dust from glacial deposits.

long period – said of a cyclic interval of seismic activity that lasts longer than 6 seconds.

mafic – a term used to describe an igneous rock that contains mostly ferromagnesian minerals.

magma – molten rock; can contain liquids, gases, and crystals; *adj.*, magmatic.

magmatism – the formation, movement, and solidification of magma.

magnetite – a common, dark, iron-rich oxide mineral.

magnetostratigraphic – said of a geologic unit that can be differentiated on the basis of its magnetic polarity or other geomagnetic property.

magnitude – a scale for measuring the energy released by an earthquake.

marine isotope stage – a time period representing an episode of glacial maximum or minimum defined on the basis of the ratio of ¹⁶O and ¹⁸O, two stable isotopes of oxygen. The ratio of these two isotopes in water is temperature dependent and is commonly measured in fossil shells or in layers of ice within a glacier. (See Fig. 25, p. 29.)

mass movement – the movement of geologic materials downslope under the influence of gravity.

mass wasting – see *mass movement*.

matrix – the finer grained material that encloses either the coarser material in a sediment or sedimentary rock or the phenocrysts in a porphyritic igneous rock; in an igneous rock, the matrix is also called the groundmass.

matrix strength – the ability of a granular substance to support a weight, as when a debris flow carries large rocks.

matrix-supported – said of large rocks that are suspended in a finer grained matrix of a depositional unit.

megaclast – one of the larger fragments in a fragmental deposit or rock containing a variety of particle sizes.

megaripple – a ripple-like feature having a wavelength greater than 1 m (3.28 ft). Because they are commonly created or deposited during humongous flood events, such as the sudden emptying of a glacial lake,

megaripples can consist in large part of pebbles, cobbles, and even boulders.

mélange – a mappable body of rock that includes exotic and native rocks and fragments of all sizes within a fragmented and commonly sheared matrix.

Mesozoic – the period of geologic time following the Paleozoic and preceding the Tertiary or Cenozoic. (See Fig. 4, p. 5.)

metagabbro – a metamorphosed gabbro.

metamorphic rock – a rock whose composition and (or) texture has changed because of heat and (or) pressure.

metamorphism – mineralogical, chemical, and structural changes in a rock in response to physical and chemical conditions such as those caused by deep burial and (or) exposure to hot fluids.

mica – a group of silicate minerals that cleave into thin sheets; *adj.*, micaceous, containing mica.

microdiorite – a fine-grained diorite.

mineral – a naturally formed solid inorganic substance having a fixed crystal structure and consistent chemical composition.

Miocene – the geologic epoch that covered the time span between about 23 and 5 Ma during the Tertiary Period.

monolithologic – consisting mostly of one rock type.

monzonite – a group of coarse-grained, intrusive rocks typically having a content of sodium- or potassium-rich feldspars higher than that of diorite.

moraine – a mound or ridge of unstratified drift, mostly till, that is directly deposited by ice; *adj.*, morainal. (See Fig. 24, p. 29.)

mudline – the maximum level of inundation by a lahar or flood determined by the height of mud left on trees or rocks.

natural remanent magnetization – the permanent magnetization acquired by igneous rocks as they cool or by magnetic particles as they settle in sediments.

neoglacial – relating to readvances of mountain glaciers during the Little Ice Age and other late Holocene episodes of glaciation.

noncohesive lahar – see *clay-poor lahar*.

normal fault – a steeply dipping fault in which the hanging wall has moved downward relative to the footwall; typically a result of horizontal extension; compare with reverse fault.

North Cascades – the physiographic area of the Cascade Range that extends roughly from the Olympic Wallowa Lineament north to Mount Meager volcano in British Columbia, Canada. The North Cascades include a rugged, complex collage of accreted terranes that have been intruded by plutons and perforated by volcanoes of Quaternary age. (See Fig. 5, p. 7.)

obsidian – dark-colored volcanic glass, a result of very fast cooling of a gas-poor lava.

Oligocene – the geologic epoch that spanned the time between about 34 and 23 Ma during the Tertiary Period.

olivine – a greenish rock-forming mineral common to some mafic igneous rocks such as basalt and gabbro.

Olympic Mountains – the young and rugged range of coastal mountains north of the Chehalis River and south of the Strait of Juan de Fuca. (See Fig. 5, p. 7.)

orogeny – the tectonic process that results in the formation of mountains.

outburst floods – sudden releases of water stored in or adjacent to a glacier or in a glacial lake; see *jökulhlaup*.

outcrop – an exposure of rock or a deposit; verb, to crop out.

outwash – stratified deposits produced by glacial meltwater.

overbank deposit – silt, clay, and (or) fine sand deposited from suspension on a flood plain. Overbank deposition begins when floodwaters can no longer be contained within the channel.

palagonite – a yellowish or orange mineral formed by the alteration of basaltic glass and typically found in the matrix surrounding basaltic fragments created as lava suddenly quenched and fractured in water.

paleo- – a prefix meaning old or ancient.

paleoclimatologists – scientists who study the record of ancient climate.

paleomagnetism – the natural remanent magnetism that was recorded by a geologic material at the time it formed; *adj.*, paleomagnetic.

Paleozoic – the geologic time period following the Precambrian and preceding the Mesozoic. (See Fig. 4, p. 5).

patent – a grant conferred by a government that allows sole rights to minerals on a piece of land for a set amount of time.

patterned ground – a group of more or less symmetrical landforms, such as circles, mounds, and stripes, that occur in surficial deposits affected by the actions of frost.

pegmatite – an exceptionally coarse grained igneous rock of granitic composition commonly found as dikes or veins at the margins of larger intrusive bodies.

permineralization – a process of fossilization wherein minerals are deposited in the original pore spaces or hard parts of a plant or animal.

petrographic – related to petrography, the branch of geology associated with the examination, description, and classification of different types of rocks.

petrology – the branch of geology relating to studying the origin, structure, and history of rocks; *adj.*, petrologic.

phenocryst – a large individual crystal in a porphyritic igneous rock.

phreatic explosion or eruption – an eruption or explosion of a mixture of steam and fine rock debris produced when water contacts magma.

phreatomagmatic – an interaction of magma and water that produces an explosion of both steam and magmatic gases.

phyric – see *porphyritic*.

pillow lava – a name for any globular, pillow-shaped lava, typically formed under water.

plagioclase – a series of feldspar minerals that vary in sodium and calcium content.

plastic flow – change in the shape of a solid that takes place without rupture.

plate tectonics – the theory that describes the Earth's lithosphere as divided into a number of individual quasi-rigid plates whose horizontal and vertical movements and interactions with other plates give rise to seismicity and volcanism.

platy jointing – rock fractures that form thin tabular sheets. In lavas, these typically form near a flow margin. (See Fig. F-12, p. 110.)

Pleistocene – the geologic period lasting from about 1.8 Ma to 12 ka and that includes the recent great Ice Ages. (See Fig. 4, p. 5.)

Pliocene – the geologic period preceding the Pleistocene and lasting from about 5.3 Ma to 1.8 Ma. (See Fig. 4, p. 5.)

plug – a vertical, pipe-like body of magmatic rock that is the conduit of a former volcanic vent.

pluton – a large intrusive rock mass formed deep in the crust.

point bar – an arcuate mass of sand and gravel that accumulates on the inside of a stream meander.

porphyritic – a texture of igneous rock in which coarse mineral crystals are scattered among finer grains and (or) glass.

porphyry – an igneous intrusion of any rock type that contains phenocrysts.

porphyry copper deposit – a type of hydrothermal mineral deposit associated with plutons in which copper minerals are disseminated.

postglacial – referring to the time since the most recent major Ice Age.

potassium-argon dating – the radiometric age determination of a rock sample based on the ratio of argon-40 to potassium-40 and the decay rates of these isotopes; also referred to as K-Ar dating.

proglacial – immediately in front of or just beyond the limits of the glacier, especially its lower end.

progradation – the building water-ward of a beach, shoreline, or delta because of the delivery or accumulation of sediment.

propylitized (propylitic alteration) – low pressure and low temperature alteration of a fine-grained rock such as an andesite to secondary minerals such as chlorite.

Puget lobe – a large finger-like body of the continental ice sheet that flowed south into the Puget Lowland. (See Fig. 6, p. 8.)

Puget Lowland – the broad, glaciated lowland between the Olympic Mountains and the Cascade Range. (See Fig. 5, p. 7.)

pumice – solidified rock froth; a porous volcanic rock that floats; *adj.*, pumiceous, a term that describes a pyroclastic rock whose texture is finer than scoriaceous; also said of a pyroclastic deposit that consists largely of pumice.

pyrite – a common brass-colored iron-sulfide mineral, FeS₂.

pyroclastic – describing the clastic rock material ejected during a volcanic eruption; also pertaining to the texture of a rock thus formed. In the plural, the word is informally used as a noun, pyroclastics.

pyroclastic density current – a general name for any of the mixtures of volcanic gas and particles (including surges and flows) that move downslope on the flanks of a volcano under the influence of gravity.

pyroclastic flow – a mass of hot, dry, pyroclastic debris and gases that moves rapidly along the ground surface. It can be caused by an eruption or collapse of a volcanic dome.

pyroclastic surge – a turbulent mixture of gases and particles that flows above the ground surface at high velocities. It can develop from a pyroclastic flow and is highly mobile.

pyroxene – a group of mafic silicate minerals.

Quaternary – the geologic period lasting from about 1.8 Ma to the present. It consists of the Pleistocene Epoch (ending ~12 ka) and the Holocene Epoch (12 ka–present). (See Fig. 4, p. 5.)

quenched – rapidly cooled.

radiocarbon dating – the calculation of the age of carbonaceous material by measuring the concentration of remaining ¹⁴C.

radiocarbon years – years before A.D. 1950 (by convention) based on the ratio of the carbon-14 isotope to normal carbon, ¹²C. Typically, radiocarbon years differ from 'calendar years' because of variations of the carbon isotope content of atmospheric carbon dioxide through time. A calibration to adjust these ages on the basis of tree rings (for about the last 11,000 years) has been devised; however, for simplicity, raw (uncalibrated) radiocarbon ages are mostly used in this guide. (See "Radiocarbon dates", p. 6.) Calibrated dates are expressed as 'cal yr B.P.'

radiolarian chert – sometimes described as "ribbon chert"; generally well-bedded microcrystalline rock containing fossil radiolaria (a type of protozoan) and well cemented by silica. This type of chert is thought to have formed in deep-marine environments.

radiometric age – see *radiometric dating*.

radiometric dating – a method of estimating the age of a rock or mineral by measuring the proportion of radioactive elements to their decay products in a rock sample. See *Ar/Ar (argon-argon)* and *potassium-argon (K-Ar) dating*.

rank – the degree of metamorphism in coal; used to classify coal by grade from lignite (softest) to anthracite (hardest).

rain-on-snow event – a flood that is triggered when a moist warm front dumps a substantial amount of rain on snow-covered areas.

raveling – erosion involving the movement of individual rocks and grains down a slope.

recession (glacial) – the melting backward or 'retreat' of the snout of a glacier from its farthest downvalley location when the supply of ice to the glacier is not sufficient to cause it to flow.

reentrant – from reentering or directed inward; for example, a transverse or tributary valley or recess that intersects another valley or escarpment.

refugium – an area that contains biological remnants of a previous environment, typically one that has persisted with little change during some severe natural disturbance. *Plural*, refugia.

resistivity – the amount of resistance to electrical charge flow.

reverse fault – a high-angle (>45°) fault in which the hanging wall has moved upward relative to the footwall; typically caused by horizontal compression.

rhyodacite – an obsolete term for a group of porphyritic extrusive igneous rocks that have a composition between dacite and rhyolite. Rhyodacite is roughly the extrusive equivalent of granodiorite.

rhyolite – a group of porphyritic extrusive igneous rock typically having more than 69 percent silica. It is the extrusive, finer grained equivalent of granite.

right lateral – a type of faulting or movement in which the side across the fault from the observer moves to the right.

Rimrock Lake inlier – an assemblage of pre-Cascade rock units, mostly of Mesozoic age, that are exposed east and south of Mount Rainier.

riprap – piles or layers of durable stone blocks used for engineering purposes such as breakwalls, for stabilizing landslides, or for armoring beaches and river banks; also the rock used for such purposes.

rock flour – silt- and clay-size rock particles produced by glacial pulverization.

roof pendant – a downward projection of older rock above and (or) into an intrusion.

rootless explosion crater – a small, shallow crater produced by a phreatic explosion.

runup – the advance of water, a slurry, or mass of debris up a slope or obstacle owing to its momentum.

sackung (or sackungen) – a type of deep-seated rock mass movement in which a ridge face creeps downslope. One feature of this motion is a sackung, a ridge-top trench or depression perpendicular to the direction of the slope movements. From the German word Sackung, sagging, subsidence).

sag pond – a small pond or body of water that occupies a closed depression on a landslide or along a fault and that formed because of fault or landslide movement.

sand volcano – an mound-like accumulation of sand produced by expulsion of liquefied sand to the surface.

saprolite – an ancient soil or weathered rock material that preserves some of the textures of the parent rock.

scarp slope – the slope on the opposite side of a hogback ridge from the dip slope.

schist – a strongly foliated metamorphic rock that can be readily broken into flakes and slabs because of the large percentage of parallel and subparallel crystals composing it; *adj.*, schistose.

scoria – an igneous rock containing abundant cavities (vesicles) but that does not float, typically formed at the surface of a lava flow. (See Fig. F-12, p. 110.)

sector collapse – a volcanic landslide in which a major part of the volcano, typically its summit area, slides away. Compare with *flank collapse*.

secular variation – the drift of the Earth's geomagnetic field over the centuries. It can be used to date young rocks whose minerals record the location of the magnetic poles when the rocks are formed.

sedimentary rock – a layered rock that results from the consolidation of sediments.

sediment-gravity flow – a general term for movement of any sediment mixture downslope in response to gravity.

sediment yield – the amount of material eroded from the land surface within the drainage basin of a stream or river system and delivered to a stream system.

seismic activity – earth movements or vibrations caused by earthquakes, landslides, debris flows, or the activity of humans; also, seismicity, of or pertaining to seismic energy or seismic activity.

seismometer – a device that detects and records seismic activity.

sericite – a fine-grained potassium-rich mica that is an alteration product.

shale – a sedimentary rock whose component particles are predominantly silt size or smaller.

shear zone – a tabular zone of rock that has been crushed and brecciated, typically because of fault activity on both sides of the zone.

shield volcano – a large, broad volcano having fairly shallow slopes formed by the eruption of highly fluid basalt lava.

silicate – a mineral whose crystal structure contains silica (SiO₂).

silicic – an adjective referring to a silica-rich igneous rock or magma. Such rocks generally are at least 65 percent silica.

silicification – the introduction of, or replacement by silica, which results in formation of fine-grained quartz, chalcedony, or opal.

sill – a tabular intrusive rock body that forms where magma is injected between two layers of rock.

slickensides – grooves on, or a striated surface of a rock produced by abrasion along a fault.

slips – debris slides.

slosh line – see *trimline*, *mudline*.

slump – a type of mass wasting in which blocks of material fail with a backward rotational motion.

snag – the trunk of a dead tree.

sorting – the degree of similarity of particle sizes (or other quality) of a sediment. Well-sorted material consists mostly of particles similar in size, whereas poorly sorted material consists of a wide variety of grain sizes.

spatter – an accumulation of very fluid pyroclastic debris, commonly basaltic, near a volcanic vent.

spheroidal weathering – chemical weathering that causes thin concentric shells/layers of decomposed rock to separate from a block of rock; caused by water penetrating the bounding joints.

spiracle – a vent or tube at the base of a lava flow formed as steam rose from underlying wet sediment or soil. (See Fig. F-12, p. 110.)

stage – in glaciology, a term for a major subdivision within a glacial epoch.

stock – a body of intrusive rock that has an area less than 40 mi² (100 km²).

stone stripes – a type of patterned ground.

stratified – composed of layers of sediment.

stratigraphy – the study of geologic strata or layers, their succession, composition, fossils, and other characteristics, and what ancient environments they represent.

stratovolcano – see *composite volcano*.

striation – a scratch or groove on a rock produced by the passage of a glacier or other geologic agent.

strike – the bearing or azimuth along which a fault, fold, or other planar feature is oriented.

strike-slip fault – a fault along which displacement is parallel to the strike of the fault.

subaerial – formed on land.

subangular – said of rocks or particles that have been rounded somewhat but still retain part of their original shape.

subaqueous – formed under water.

subbituminous – a rank of coal intermediate between lignite (softest) and bituminous.

subduction – the process of one lithospheric plate descending under another.

subduction zone – a long narrow belt in which subduction takes place.

subfossil – biological remnants, such as dead trees, that are preserved but not permineralized.

surge – see *pyroclastic surge*.

suspended load – fine sediment carried in suspension by a stream.

syncline – a fold that is concave upward, like a trough, having stratigraphically younger rocks in its core.

tailings – the washed or milled ore regarded as too poor to be treated further.

talus – rock debris, typically coarse, that accumulates at the base of a cliff or steep slope.

tarn – a small mountain lake that occupies a cirque. (See Fig. 24, p. 29.)

tectonic – relating to the individual lithospheric plates, their movements and interactions with other plates. See *plate tectonics*.

tectonic suture – a boundary that separates two conjoined tectonic plates.

tephra – a general term for all sizes of rock and lava that are ejected into the air during an eruption.

terminal moraine – the outermost end moraine of an ice sheet or glacier that marks the maximum extent of the ice. (See Fig. 24, p. 29.)

terminus – the lower margin or extremity of a glacier. (See Fig. 24, p. 29.)

terrace – a long, narrow, nearly flat surface that forms a step-like bench in a slope.

terrane – a large block of the Earth's crust, bounded by faults, that can be distinguished from other blocks by its geologic character.

Tertiary – the geologic period lasting from about 65.5 Ma to 1.8 Ma. (See Fig. 4, p. 5.)

thrust fault – a low-angle reverse fault (<45°) in which the hanging wall has moved upward relative to the footwall; typically caused by horizontal compression.

thunder egg – the popular term for a geode-like mass of chalcedony, agate, or opal that has weathered out of a vug in a welded tuff.

till – a general term for unsorted glacial deposit produced directly under, within, or on top of a glacier.

transform fault – a strike-slip fault that separates geologic plates or plate segments.

transgression – the spreading of the sea over land.

travertine – a finely crystalline or massive deposit of calcium carbonate, commonly crudely layered and (or) having fibrous structures, that is chemically precipitated from solution in surface and ground waters.

trench – an elongate depression on the sea floor roughly parallel to the continental margin and located between the margin and the subducting oceanic lithosphere.

trimline – the boundary between the area affected by scour or scrape and undisturbed terrain that denotes the maximum height of runoff or inundation by an avalanche, debris flow, flood, wave, or glacier.

tufa – a spongy, porous variety of travertine that forms in deposits at springs, in stream beds, and locally in lakes.

tuff – a fine-grained rock composed mostly of volcanic ash; *adj.*, tuffaceous.

turbidite – the deposit of a turbidity current.

turbidity current – a sediment-charged flow (density current) that moves swiftly down a subaqueous slope.

type locality – the geographic locality that best typifies and commonly gives its name to a geologic formation. The type section is the unique sequence of layers that defines a given geologic formation within the type area.

unconformable – said of rocks that do not succeed the underlying rocks in immediate order of age, implying a break in deposition or a period of erosion.

U-Pb dating – see *uranium-lead dating*.

uranium-lead dating – methods used to determine the age of rocks on the basis of the radioactive decay rate of uranium-238 to lead-206 or uranium-235 to lead-207, whose half lives are about 4.5 and 0.7 billion years respectively. This former technique is useful for very old rocks, such as those of Precambrian age.

valley glacier – a glacier that heads in one or more cirques and then flows into, and is confined by a valley; an alpine glacier. (See Fig. 24, p. 29.)

Vashon Drift – glacial deposits (including till and outwash) left by the Puget lobe of the continental ice sheet that moved through the Puget Lowland between 22 and 15 ka.

Vashon Glaciation – the most recent major episode of continental glaciation, during which a major lobe of ice, the Puget lobe, moved into and out of the Fraser-Puget Lowland between 22 and 15 ka (Vashon Glacier).

vent – the opening through which volcanic rocks are extruded or conduit through which these rocks pass during eruption.

verge – to slope, incline.

vesicle – a small cavity in a rock formed by the expansion of gas during formation of a volcanic rock. A spiracle is a large vesicle.

viscosity – resistance to internal flow.

volcanic arc – a curved belt of volcanoes and volcanic rocks lying above a subduction zone.

volcanic ash – fine pyroclastic particles (<2 mm or <0.08 in. in diameter).

volcanic dome – a steep-sided bulbous mass of lava, such as the Lava Dome at Mount St. Helens, that is commonly formed by eruptions of highly viscous dacite or rhyolite lava.

volcanic earthquakes – the sudden release of strain energy under or in a volcano as magma or volcanic gas pushes its way to the surface.

volcaniclastic – a general term for all fragmental material produced by a volcano.

vug – a cavity in a vein or rock. Some vugs are lined with crystals.

welded tuffs – fragmental volcanic (volcaniclastic) deposits that originate as flows of ash and pumice and that, because of their weight and heat, become welded together after they come to rest. Owing to this welding, they

cool in a manner somewhat similar to a flow of lava, and thus many display crude columnar jointing.

wiggle-matching – finding the best fit of a series of radiocarbon ages for chronologically spaced samples with the calibration curve for radiocarbon.

The samples submitted must have a known spacing in years. This technique can yield reduced errors.

Younger Dryas – the term for a period of cooling during late-glacial time that lasted from about 12,900 to about 11,500 calendar years ago.

zeolites – generic name for a large group of hydrous minerals that commonly form in vugs in volcanic rocks.

zircon – a common but minor mineral in igneous and metamorphic rocks; $ZrSiO_4$. ■

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DESCRIPTION OF MAP UNITS

The expanded unit descriptions shown here list the named units included in each map unit at the end of its description. The list covers those units that occur within the area of Figure 2. That figure depicts geologic units by age and lithology, and therefore some named units may be listed with more than one unit. Fewer units are shown in the map panels along each leg of the road guide than in Figure 2. Furthermore, because of the map scale, small outcrops of some units are too small to show on the leg maps. The road log refers to the units that are passed or the formation or informally named units that have a place in the geologic history of the study area. For more information, see the source map, GM 53 (Schuster, 2005), and the products from which it was prepared.

Note: Lithologies are not listed in order of abundance.

Unconsolidated Sedimentary Deposits

Qa **Quaternary alluvium** — Unconsolidated or semi-consolidated alluvium, alluvial fans, artificial fill, beach deposits, gravel, peat, regolith, talus, and terraced deposits. *Includes named unit:* Skokomish Gravel.

Qls **Quaternary mass-wasting deposits** — Primarily landslide deposits, but locally includes talus, colluvium, protalus ramparts, and rock glaciers.

Ql **Quaternary loess** — Eolian silt and fine sand. *Includes named unit:* Palouse Formation.

Qf **Pleistocene outburst flood deposits** — Silt, sand, gravel, and boulder deposits deposited by outburst floods from glacial Lake Missoula. *Includes named unit:* glacial Lake Missoula flood deposits and Touchet beds.

Qgd **Pleistocene continental glacial drift** — Till and outwash clay, silt, sand, gravel, cobbles, and boulders. *Includes named units:* Orting Drift, Salmon Springs Drift, Steilacomm Gravel, Stuck Drift, and Vashon Drift.

Qad **Pleistocene alpine glacial drift** — Till, outwash, and glaciolacustrine sediments. *Includes named units:* Burroughs Mountain Drift, Evans Creek Drift, pre-Evans Creek–post-Hayden Creek deposits, Garda Drift, Hayden Creek Drift, Kittitas Drift (undivided), Kittitas Drift (Indian John and Swauk Prairie sub-

drifts), Lakedale Drift (Bullfrog, Domerie, Hyak, and Ronald subdrifts), Logan Hill Formation, Lookout Mountain Ranch Drift, drift of McDonald Ridge, McNeely Drift, Wingate Hill Drift.

Sedimentary Rocks and Deposits

QTc **Quaternary–Tertiary continental sedimentary rocks and deposits** — Clay, conglomerate, gravel, sand, and silt. *Includes named units:* Alderton Formation, Kitsap Formation, Olympia-age nonglacial sediments, Puyallup Formation, and Whidbey Formation.

Tc **Tertiary continental sedimentary rocks** — Clay, silt, sand, and gravel deposits; claystone, coal, conglomerate, debris-flow breccia, fanglomerate, mudstone, sandstone, carbonaceous shale, siltstone, tephra interbeds, tuff, volcanoclastic breccias; commonly fossiliferous. *Includes named units:* Barlow Pass Volcanics, Carbonado Formation, beds of Chambers Creek, Chumstick Formation (undivided), Chumstick Formation (Nahahum Canyon Member), Eagle Creek Formation, Ellensburg Formation (undivided), Ellensburg Formation (Vantage Member),

sandstone of Lookout Creek, Manastash Formation, Mashel Formation, rocks of Mount Daniel, Naches Formation (undivided), Naches Formation (Guye Sedimentary Member), Puget Group (undivided), Puget Group (Renton and Tiger Mountain Formations), Roslyn Formation (lower, middle, and upper members), Spiketon Formation, sandstone of Summit Creek, Swauk Formation (undivided), Swauk Formation (arkosic rocks, conglomerate facies, fanglomerate, unidentified subdivision of), Thorp Gravel, Troutdale Formation, Wenatchee Formation, and Wilkes Formation.

Tn Tertiary nearshore sedimentary rocks — Claystone, conglomerate, lignite, sandstone, siltstone, tuff, volcanoclastic rocks; commonly fossiliferous. *Includes named units:* Cowlitz Formation, Skookumchuck Formation, and Toutle Formation.

Tm Tertiary marine sedimentary rocks — Breccia, claystone, conglomerate, mudstone, sandstone, semischist, shale, siltstone, slate, phyllite; locally tuffaceous; locally metamorphosed to zeolite facies; local pillow basalt; local chert pebbles. *Includes named units:* Astoria Formation, Blakeley Formation, sedimentary rocks of the Crescent Formation, Lincoln Creek Formation (undivided), sandstone member of the Lincoln Creek Formation, McIntosh Formation (undivided), sandstone member of the McIntosh Formation, and Raging River Formation.

Mm Mesozoic marine sedimentary rocks — Argillite, chert, conglomerate, limestone, mudstone, pelite, shale, siltstone, and tuff. *Includes named unit:* clastic subunit of the Russell Ranch Formation.

Volcanic Rocks and Deposits

Qv Quaternary volcanic rocks — Andesite flows, basaltic andesite flows, basalt flows, dacite flows, and rhyodacite dikes, flow breccia, hypabyssal intrusives, cinder and scoria cones, tephra, bombs, tuff, scoria, breccia, pyroclastic flow deposits, and hyaloclastite. *Includes named units:* basalt of Badger Peak, basalt of Blue Lake, basalt of Canyon Creek, Clear Fork Dacite, andesite of Deep Creek, andesite of Deer Lake Mountain, basalt of East Canyon Creek, basalt of Glaciate Butte, basalt of Goat Butte, complex of Hellroaring and Big Muddy Creek, mafic rocks of Hogback Mountain, andesite of the Jess Lake complex, basalt of Kincaid Lake, basalt of Lakeview Mountain, basalt of Lava Creek, basaltic andesite of Little Mount Adams, basalt of The Loaf, andesite, ol-

ivine andesite, dacite, and rhyolite flows of Mount Adams, rocks and deposits of Mount St. Helens, andesite of Mount Rainier (undivided), andesite of Mt. Rainier (andesites of Observation and Echo Rocks), dacite of Olallie Lake, andesite of Old Snowy Mountain, basalt of Paradise Falls, andesite of Pear Lake, basaltic andesite of Potato Hill, basalt of Red Butte, basalt of Riley Creek, basalts of Rimrock Lake, andesite of Round Mountain, andesite of Russell Ridge, andesite of Signal Peak, dacite of Spiral Butte, basalt of Spring Creek, basalt of Spud Hill, andesite of Swampy Meadow, Tieton Andesite, basalt of Tumac Mountain, basalt of Two Lakes, and basalt of Walupt Lake.

QTV Quaternary-Tertiary volcanic rocks — Andesite flows and breccias, basalt and basaltic andesite flows, and dacite flows. *Includes named units:* andesite of Bee Flat, andesite of Goat Rocks, mafic rocks of Hogback Mountain, basalt of Lincoln Plateau, volcanic rocks of Simcoe Mountains, and dacite of Snyder Mountain.

TVcr Tertiary volcanic rocks, Columbia River Basalt Group — Fine-grained flood basalt flows and invasive flows and related volcanic products. *Consists of named units:* Grande Ronde Basalt (undivided), Grande Ronde Basalt (N₁, R₂, and N₂ magnetostratigraphic units undivided, and R₂ magnetostratigraphic unit [invasive flow of Hammond and invasive flow of Howard Creek]), Saddle Mountains Basalt (undivided), Saddle Mountains Basalt (Asotin, Elephant Mountain, Pomona, Umatilla, and Wilbur Creek Members), Wanapum Basalt (undivided), and Wanapum Basalt (Frenchman Springs, Priest Rapids, and Roza Members).

Tv Tertiary volcanic rocks — Andesite flows, basaltic andesite flows, basalt flows, breccia, volcanic conglomerate, dacite flows, diabase, obsidian, pyroclastic rocks, rhyolite flows, volcanic sandstone, tuff, welded tuff, dikes, sills, domes, plugs, and lahars; local hypabyssal intrusions, interbedded sedimentary rocks, coal. *Includes named units:* Barlow Pass Volcanics, olivine basalt of Bethel Ridge, andesite and dacite of Burch Mountain, basalt of the Chumstick Formation, volcanic rocks of Council Bluff, basalt of Dalles Ridge, rhyolite tuffs and flows of Devils Horns, basalt of Devils Washbasin, basalt of Discovery Creek, volcanic rocks of Eagle Gorge, Fifes Peak Formation (undivided), Fifes Peak Formation (andesite and basalt megabreccia), Fifes Peak Formation (tuff of Clear West Peak), Fifes Peak Formation (tuff of Clear West Peak), basalt of Frost Mountain, Goble Vol-

canics, volcanic rocks of Grays River, Howson Andesite, olivine basalt of Milk Creek, volcanic rocks of Mount Daniel, volcanic rocks of Mount Persis, Naches Formation (undivided), Naches Formation (basalt and glomeroporphyritic basalt), Northcraft Formation, Ohanapecosh Formation, andesite of Peoh Point, Swauk Formation (Silver Pass Member), andesite of Smith Creek Butte, basalt of Summit Creek, Taneum Andesite, Teanaway Basalt, and basalt of Tieton Pass.

Tvc Tertiary volcanic rocks, Crescent Formation — Dominantly submarine basalt flows and flow breccia, grades into flow-dominated, locally columnar-jointed, partially nonmarine rocks near the top. *Consists of named unit:* Crescent Formation.

Mzv Mesozoic volcanic rocks — Andesite flows, basalt flows, breccia, dacite flows, greenstone, metabasalt, rhyolite flows, tuff; minor argillite, chert, conglomerate, limestone, sandstone, and shale. *Includes named unit:* Russell Ranch Formation.

Qvt Quaternary fragmental volcanic rocks and deposits (includes lahars) — Ash, debris flows, lahars, pumice, pyroclastic deposits, tephra, and near-vent fragmental deposits; local rockfall breccia, caldera-collapse megablocks, cross-cutting andesite dikes, welded tuff, and irregular intrusions; minor lacustrine and fluvial deposits; rare dacite flows. *Includes named units:* Electron Mudflow; lahar of Greenwater; Lily Creek Formation; volcanoclastic rocks and debris flows of Mount Adams, rocks and deposits of Mount St. Helens, lahar of Muddy River; Osceola Mudflow; debris flow of Paradise; and mudflow of Round Pass.

Tvt Tertiary fragmental volcanic rocks — Ash-flow tuff, breccia, tuff breccia, mudflows, pyroclastic flows, welded and nonwelded tuff; local andesite, basalt, dacite, and rhyolite plugs and flows; local sandstone, shale, and siltstone; local volcanic conglomerate, sandstone, and siltstone; minor coal. *Includes named units:* tuff of Bumping River, tuff of Burnt Mountain, volcanoclastic rocks of Cooper Pass, Ellensburg Formation, Fifes Peak Formation (undivided), Fifes Peak Formation (tuff of Clear West Peak undivided), Fifes Peak Formation (tuff of Clear West Peak [Chenuis Ridge and Sun Top units]), Goble Volcanics, volcanic rocks of Mount Daniel, Naches Formation (Mount Catherine Rhyolite Member), Northcraft Formation, Ohanapecosh Formation (undivided), Ohanapecosh Formation (Lake Keechelus

tuff member), welded tuff of the Palisades, Puget Group (Tukwila Formation), tuff of Rattlesnake Creek, volcanic sandstone and conglomerate of Spencer Creek, welded tuff of Spencer Creek, Stevens Ridge Formation north of Mount Rainier, Stevens Ridge Formation south of Mount Rainier, and tuffaceous rocks of Wildcat Creek.

Intrusive Rocks

Qi **Quaternary intrusive rocks** — Intrusive andesite and dacite. *Consists of named units:* plugs and dikes of Mount Rainier, rocks and deposits of Mount St. Helens, and feeders for flows of Old Snowy Mountain.

QTi **Quaternary–Tertiary intrusive rocks** — Andesite, basaltic andesite, and dacite domes, plugs, and dikes. *Includes named unit:* dacite porphyry of Goat Mountain.

Ti **Tertiary intrusive rocks** — Acidic (felsic), intermediate, and basic (mafic) intrusive rocks; intrusive rocks (undivided), intrusive-volcanic complex, intrusive andesite, argillic alteration, intrusive basaltic andesite, intrusive breccia, intrusive dacite, diorite, gabbro, granite, granodiorite, pebble breccia, quartz diorite, quartz monzonite, intrusive rhyolite, tonalite plutons, stocks, plugs, domes, dikes, dike swarms, sills, flows, and intrusive breccia. *Includes named units:* intrusive diabase and basalt of Box Canyon, Bumping Lake pluton, associated stocks of Bumping Lake pluton, diabase of Camas Land, Carbon River stock, soda rhyolite of Clear West, Duncan Hill pluton, Fifes Peak Formation (rhyolite of Clear West Peak), Fuller Mountain plug, complex of Horse Lake Mountain, Index Batholith (Sunday Creek stock), sills of Jug Lake, quartz diorite of McCoy Creek, volcanic complex of Mount Aix, volcanic rocks of Mount Daniel, granodiorite and quartz diorite of Nisqually, complex of Skyscraper Mountain, Snoqualmie Batholith (undivided), Snoqualmie Batholith (granite of Mount Hinman), Spirit Lake pluton, Tatoosh pluton, rocks related to the Tatoosh pluton, and White River pluton.

Mi **Mesozoic intrusive rocks** — Basic (mafic) intrusive rocks, diorite, gabbro, granodiorite, mixed metamorphic and igneous rocks, quartz diorite, and tonalite plutons, stocks, plugs, domes, dikes, pods, veins, and sills. *Includes named units:* rocks of the Eastern mélange belt, complex of Indian Creek, Ingalls tectonic complex, Lookout Mountain Formation of

Stout (1964), Mount Stuart batholith, contact complex of the Mount Stuart batholith, eastern pluton of the Mount Stuart batholith, Harding Mountain tonalite of the Mount Stuart batholith, western pluton of the Mount Stuart batholith, Quartz Mountain stock of the Eastern mélange belt, and rocks of the Western mélange belt.

M&Pu **Mesozoic–Paleozoic ultramafic rocks** — Dunite, harzburgite, ophiolite, peridotite, pyroxenite, serpentinite, talc schist, and altered ultrabasic (ultramafic) rocks; local veins of chrysotile asbestos, layers of chromite, and intercalated greenstone and metatuff. *Includes named units:* Chelan Mountains terrane (Napeequa unit), Ingalls tectonic complex (undivided), Ingalls tectonic complex (serpentinite), Ingalls tectonic complex (silicate-carbonate rock), Tonga Formation, and rocks of the Western mélange belt.

Metasedimentary and Metavolcanic Rocks

M&ms **Mesozoic metasedimentary rocks** — Mesozoic argillite, marine metasedimentary rocks, cherty metasedimentary rocks, low-grade phyllite, and low-grade schist. *Includes named units:* Darrington Phyllite, rocks of the Eastern mélange belt, Easton Schist, Ingalls tectonic complex (undivided), Ingalls tectonic complex (Peshastin Formation), chert-tuff subunit of the Russell Ranch Formation, Shuksan Greenschist, Western mélange belt (undivided), and argillite, graywacke, and potassium-feldspar sandstone of the Western mélange belt.

M&mt **Mesozoic metasedimentary and metavolcanic rocks** — Amphibolite, breccia, conglomerate, dikes, flows, gabbro, greenschist, greenstone, keratophyre, marble, meta-argillite, metabasalt, metachert, metaconglomerate, metadacite, metasandstone, metavolcanic rocks, phyllite, quartzite, feldspathic sandstone, volcanic sandstone, schist, serpentinite, sills, siltstone, tuffaceous rocks, and ultramafic rocks; local metadolomite, shale, and limestone; includes pillow basalt, argillite, and volcanoclastic rocks; minor chert-pebble conglomerate and meta-diabase. *Consists of named unit:* rocks of the Eastern mélange belt.

M&mv **Mesozoic metavolcanic rocks** — Andesite, meta-andesite, argillite, chert, dacite, metadacite, flow breccia, gabbro, greenstone, metabasalt, metadiabase, quartz porphyry dikes, volcanic-lithic and tuffaceous sandstone, tuff; local greenschist, meta-argillite,

metaconglomerate, metalimestone, metaquartz-diorite, metasandstone, metasiltite, metawacke, pyroxenite, schist, serpentinite, siltstone, tuff breccia; rare amphibolite. *Consists of named units:* Ingalls tectonic complex (undivided), Ingalls tectonic complex (Hawkins Formation), Russell Ranch Formation, and rocks of the Western mélange belt.

Pmv **Paleozoic metavolcanic rocks** — Pillow basalt, breccia, chert, lava flows, greenschist, greenstone, metabasalt, phyllite, tuff breccia, tuff, volcanoclastic rocks, local meta-argillite, metaconglomerate, metawacke, quartzite (metachert), phyllite; minor metalimestone. *Consists of named unit:* metavolcanic rocks of North Peak.

Metamorphic Rocks (Amphibolite Facies and Higher)

M&hm **Mesozoic heterogeneous metamorphic rocks** — Heterogeneous metamorphic rocks, some chert-bearing, and high-grade schist. *Consists of named units:* Chiwaukum Schist (Nason terrane), Ingalls tectonic complex (undivided), Ingalls tectonic complex (Hawkins Formation), Lookout Mountain Formation of Stout (1964), tectonic complex of Stout (1964), and Tonga Formation.

M&Pmh **Mesozoic–Paleozoic heterogeneous metamorphic rocks** — Amphibolite, marble, and chert-bearing heterogeneous metamorphic rocks. *Consists of named units:* rocks of the Eastern mélange belt, Lookout Mountain Formation of Stout (1964), and Chelan Mountains terrane (hornblende-bearing Napeequa unit).

M&Pam **Mesozoic–Paleozoic amphibolite** — Amphibolite. *Consists of named units:* Ingalls tectonic complex, Lookout Mountain Formation of Stout (1964), and Swakane Biotite Gneiss.

M&gn **Mesozoic gneiss** — Gneiss and banded gneiss. *Consists of named unit:* Swakane Biotite Gneiss

M&og **Mesozoic orthogneiss** — Orthogneiss. *Consists of named units:* tonalite gneiss of Hicks Butte and complex of Indian Creek.

Tectonic Zones

tz **Tectonic zones** — Ultrabasic (ultramafic) rocks and low-grade schist in tectonically disrupted zones, age unknown.

LIST OF NAMED UNITS

Alderton Formation	QTc	Deep Creek, andesite of	Qv	Grande Ronde Basalt of the	
Asotin Member of the Saddle Mountains Basalt	Tv _{Cr}	Deer Lake Mountain, andesite of	Qv	Columbia River Basalt Group	Tv _{Cr}
Astoria Formation	Tm	Devils Horn, rhyolite of	Tv	Grays River, volcanic rocks of	Tv
Badger Peak, basalt of	Qv	Devils Horns, rhyolite tuffs and flows of	Tv	Greenwater, lahar of	Qvt
Barlow Pass Volcanics	Tc, Tv	Devils Washbasin, basalt of	Tv	Guye Sedimentary Member	
Bee Flat, andesite of	QTv	Discovery Creek basalt	Tv	of the Naches Formation	Tc
Bethel Ridge, olivine basalt of	Tv	Domerie subdrift of the Lakedale Drift	Qad	Hammond invasive flow of the R ₂ magneto- stratigraphic	
Blakeley Formation	Tm	Duncan Hill pluton	Ti	unit of the Grande Ronde Basalt	Tv _{Cr}
Blue Lake, basalt of	Qv	Eagle Creek Formation	Tc	Harding Mountain, tonalite of,	
Box Canyon, intrusive diabase and basalt of	Ti	Eagle Gorge, volcanic rocks of	Tv	of the Mount Stuart batholith	Mzi
Bullfrog subdrift of the Lakedale Drift	Qad	East Canyon Creek, basalt of	Qv	Hawkins Formation of the	
Bumping Lake pluton	Ti	Eastern mélange belt,		Ingalls Tectonic Complex	Mz _{hm} , Mz _{mv}
Bumping River, tuff of	Tvt	rocks of the	Mzi, Mz _{ms} , Mz _{mt} , Mz _{Ram}	Hayden Creek Drift	Qad
Burch Mountain, andesite and dacite of	Tv	Easton Schist	Mz _{ms}	Hellroaring and Big Muddy Creek complex	Qv
Burnt Mountain, tuff of	Tvt	Electron Mudflow	Qvt	Hicks Butte, tonalite gneiss of	Mz _{og}
Burroughs Mountain Drift	Qad	Elephant Mountain Member of the		Hogback Mountain, mafic rocks of	QTv, Qv
Camas Land, diabase of	Ti	Saddle Mountains Basalt	Tv _{Cr}	Horse Lake Mountain complex	Ti
Canyon Creek, basalt of	Qv	Ellensburg Formation	Tc, Tvt	Howard Creek invasive flow of the R ₂ magnetostrati-	
Carbon River stock	Ti	Evans Creek Drift	Qad	graphic unit of the Grande Ronde Basalt	Tv _{Cr}
Carbonado Formation	Tc	Fidalgo Complex	Mz _{Ru}	Howson Andesite	Tv
Chambers Creek, beds of	Tc	Fifes Peak Formation	Ti, Tv	Hyak subdrift of the Lakedale Drift	Qad
Chelan Mountains terrane, Napeequa unit of the	Mz _{Ru}	Fifes Peak Formation,		Index batholith, Sunday Creek stock of the	Ti
Chelan Mountains terrane, hornblende-bearing Napeequa	Mz _{Rhm}	andesite and basalt megabreccia of the	Tv	Indian Creek, complex of	Mzi, Mz _{og}
unit of the		Fifes Peak Formation, Chenuis Ridge unit		Indian John subdrift of the Kittitas Drift	Qad
Chenuis Ridge unit of the tuff of		of the tuff of Clear West Peak of the	Tvt	Ingalls Tectonic Complex	Mz _{hm} , Mzi, Mz _{ms}
Clear West Peak of the Fifes Peak Formation	Tvt	Fifes Peak Formation, rhyolite of the		Mz _{mv} , Mz _{Ram} , Mz _{Ru}	
Chiwaukum Schist of the Nason terrane	Mz _{hm}	tuff of Clear West Peak of the	Ti	Ingalls Tectonic Complex,	
Chumstick Formation	Tc	Fifes Peak Formation, Sun Top unit		Hawkins Formation of the	Mz _{hm} , Mz _{mv}
Chumstick Formation, basalt of the	Tv	of the tuff of Clear West Peak of the	Tvt	Ingalls Tectonic Complex,	
Chumstick Formation, redbed fanglomerate of the	Tc	Fifes Peak Formation, tuff of		Peshastin Formation of the	Mz _{ms}
Clear Fork Dacite	Qv	Clear West Peak of the	Tv, Tvt	Ingalls Tectonic Complex,	
Clear West, soda rhyolite of	Ti	Frenchman Springs Member		serpentinite of the	Mz _{Ru}
Clear West Peak, tuff of, of the		of the Wanapum Basalt	Tv _{Cr}	Ingalls Tectonic Complex,	
Fifes Peak Formation	Tvt	Frost Mountain, basalt of	Tv	silicate-carbonate rocks of the	Mz _{Ru}
Cooper Pass, volcanoclastic rocks of	Tvt	Fuller Mountain plug	Ti	Jess Lake complex, andesite of the	Qv
Columbia River Basalt Group	Tv _{Cr}	Garda Drift	Qad	Jug Lake, sills of	Ti
Council Bluff, lava flows of	Tv	Glaciate Butte, basalt of	Qv	Kincaid Lake, basalt of	Qv
Cowlitz Formation	Tn	Goat Butte, basalt of	Qv	Kitsap Formation	QTc
Crescent Formation	Tv _c	Goat Mountain, dacite porphyry of	QTi	Kittitas Drift	Qad
Dalles Ridge, basalt of	Tv	Goat Rocks, andesite of	QTv	Kittitas Drift, Indian John subdrift of the	Qad
Darrington Phyllite	Mz _{ms}	Goble Volcanics	Tv, Tvt	Kittitas Drift, Swauk Prairie subdrift of the	Qad

Lake Keechelus tuff member of the Ohanapecosh Formation	Tvt	Mount Stuart batholith	M _{ei}	Peshastin Formation of the Ingalls Tectonic Complex	M _{ms}
Lake Missoula, flood deposits of glacial Lakedale Drift	Qf Qa, Qad	Mount Stuart batholith, contact complex of Mount Stuart batholith, eastern pluton of the Mount Stuart batholith, tonalite of Harding Mountain of the	M _{ei} M _{ei}	Peoh Point, andesite of Pomona Member of the Saddle Mountains Basalt	Tv T _{vc}
Lakedale Drift, Bullfrog subdrift of the Lakedale Drift, Domerie subdrift of the Lakedale Drift, Hyak subdrift of the Lakedale Drift, Ronald subdrift of the	Qad Qad Qad Qad	Mount Stuart batholith, western pluton of the Muddy River lahar	M _{ei} M _{ei} Qvt	Potato Hill, basaltic andesite of pre-Evans Creek–post-Hayden Creek deposits Priest Rapids Member of the Wanapum Basalt	Qv Qad T _{vc}
Lava Creek, basalt of	Qv	N ₁ magnetostratigraphic unit of the Grande Ronde Basalt	T _{vc}	Puget Group Puyallup Formation	Tc Qa
Lily Creek Formation, mudflows of the Lincoln Creek Formation	Qvt Tm	N ₂ magnetostratigraphic unit of the Grande Ronde Basalt	T _{vc}	Quartz Mountain stock of the Eastern mélange belt R ₂ magnetostratigraphic unit of the Grande Ronde Basalt	M _{ei} T _{vc}
Lincoln Creek Formation, sandstone member of the	Tm	Naches Formation	Tc, Tv	Randle laharic breccia-conglomerate	Tvt
Lincoln Plateau, basalt of	QTV	Naches Formation, basalt of	Tv	Raging River Formation	Tm
Little Mount Adams, basaltic andesite of Loaf, basalt of The	Qv Qv	Naches Formation, glomeroporphyritic basalt of Naches Formation, Mount Catherine Rhyolite Member of the	Tv Tvt	Rattlesnake Creek, tuff of Red Butte, basalt of	Tvt Qv
Logan Hill Formation	Qad	Naches Formation, sandstone and volcanic rocks of	Tc	Renton Formation of the Puget Group	Tc
Lookout Creek, sandstone of Lookout Mountain Formation	Tc M _{zhm} , M _{ei} M _{zRam} , M _{zRhm}	Nahahum Canyon Member of the Chumstick Formation	Tc	Riley Creek, basalt of Rimrock Lake, basalts of	Qv Qv
Lookout Mountain Ranch Drift	Qad	Napeequa unit of the Chelan Mountains terrane	M _{zRu}	Ronald subdrift of the Lakedale Drift Roslyn Formation (lower, middle and upper members)	Qad Tc
Manastash Formation	Tc	Napeequa unit, hornblende-bearing, of the Chelan Mountains terrane	M _{zRhm}	Round Pass, mudflow of	Qvt
Mashel Formation	Tc	Nisqually, granodiorite of	Ti	Roza Member of the Wanapum Basalt	T _{vc}
McCoy Creek, quartz diorite of McDonald Ridge, drift of	Ti Qad	Nisqually, quartz diorite of North Creek Volcanics	Ti M _{zmt}	Russell Ranch Formation	M _{zmv} , M _{zv}
McIntosh Formation	Tm	Northcraft Formation	Tv, Tvt	Russell Ranch Formation, chert-tuff subunit of the	M _{zms}
McIntosh Formation, sandstone member of the McNeely Drift	Tm Qad	Observation and Echo Rocks andesites of the andesite of Mount Rainier	Qv	Russell Ranch Formation, clastic subunit of the	M _{zm}
Milk Creek, olivine basalt of Mount Adams, andesite and olivine andesite flows of	Tv Qv	Ohanapecosh Formation Ohanapecosh Formation, Lake Keechelus tuff member of the	Tv, Tvt Tvt	Russell Ridge, andesite of Saddle Mountains Basalt of the Columbia River Basalt Group	Qv T _{vc}
Mount Adams, dacite flows of Mount Adams, Holocene andesite of Mount Adams, rhyolite of	Qv Qv Qv	Olallie Lake, dacite of Old Snowy Mountain, andesite of Old Snowy Mountain, feeders for flows of	Qv Qv Qi	Saddle Mountains Basalt, Pomona Member of the Salmon Springs Drift	T _{vc} Qgd
Mount Adams, volcanoclastic rocks and debris flows of	Qvt	Olympia-age nonglacial sediments	QTc	Shuksan Greenschist	M _{zms}
Mount Aix, volcanic complex of	Ti	Orting Drift	Qgd	Signal Peak, andesite of	Qv
Mount Catherine Rhyolite Member of the Naches Formation	Tvt	Osceola Mudflow	Qvt	Silver Pass Member of the Swauk Formation	Tv
Mount Daniel, rocks of	Tc, Ti, Tv	Palisades, welded tuff of The	Tvt	Simcoe Mountains, volcanic rocks of	QTV, Tv
Mount Daniel, volcanic rocks of	Ti, Tv, Tvt	Palouse Formation	Ql	Skokomish Gravel	Qa
Mount Persis, volcanic rocks of	Tv	Paradise Falls, basalt of	Qv	Skookumchuck Formation	Tn
Mount Rainier, andesite of	Qv	Paradise, debris flow (lahar) of	Qvt	Skyscraper Mountain, complex of	Ti
Mount Rainier, plugs and dikes of	Qi	Pear Lake, andesite of	Qv	Smith Creek Butte, andesite of	Tv
Mount St. Helens, rocks and deposits of	Qi, Qv, Qvt	Peoh Point, andesite of	Ti	Snoqualmie batholith	Ti
				Mount Hinman, granite of, of the Snoqualmie Batholith	Ti

Snyder Mountain, dacite of	QTV	Swauk Formation, conglomerate facies of the	Tc	Umatilla Member of the	
Spencer Creek, volcanic sandstone and conglomerate of	Tvt	Swauk Formation, fanglomerate of the	Tc	Saddle Mountains Basalt	Tv _{cr}
Spencer Creek, volcanic sediments of	Tvt	Swauk Formation, unidentified subdivision of the	Tc	Vantage Member of the Ellensburg Formation	Tc
Spencer Creek, welded tuff of	Tvt	Taneum Andesite	Tv	Vashon Drift	Qgd
Spiketown Formation	Tc	Tatoosh pluton	Ti	Walupt Lake, basalt of	Qv
Spiral Butte, dacite of	Qv	Tatoosh pluton, rocks related to the	Ti	Wanapum Basalt of the	
Spirit Lake pluton	Ti	Teanaway Basalt	Tv	Columbia River Basalt Group	Tv _{cr}
Steilacoom Gravel	Qgd	tectonic complex of Stout (1964)	Mz _{hm}	Wenatchee Formation	Tc
Spring Creek, basalt of	Qv	Thorp Gravel	Tc	Western mélange belt,	
Spud Hill, basalt of	Qv	Tieton Andesite	Qv	argillite and graywacke of the	Mz _{ms}
Steilacoom Gravel	Qgd	Tieton Pass, basalt of	Tv	Western mélange belt,	
Stevens Ridge Formation north of Mount Rainier	Tvt	Tiger Mountain Formation of the Puget Group	Tc	potassium-feldspar sandstone of the	Mz _{ms}
Stevens Ridge Formation south of Mount Rainier	Tvt	Tonga Formation	Mz _{hm}	Western mélange belt, rocks of the	Mz _i , Mz _{ms}
Stuck Drift	Qgd	Touchet beds	Qf	White River pluton	Mz _{mv} , Mz _{ru}
Summit Creek, basalt of	Tv	Toutle Formation	Tn	Wilbur Creek Member of the	
Summit Creek, sandstone of	Tc	Toutle River lahars	Qvt	Saddle Mountains Basalt	Tv _{cr}
Sun Top unit of the tuff of Clear West Peak of the Fifes Peak Formation	Tvt	transitional beds of Menard (1985)	Qgd	Wildcat Creek, tuffaceous rocks of	Qvt
Swakane Biotite Gneiss	Mz _{gn} , Mz _{am}	Troutdale Formation	QTc	Wilkes Formation	Tc
Swauk Formation	Tc	Tukwila Formation of the Puget Group	Tvt	Wingate Hill Drift	Qad
Swauk Formation, arkosic rocks of the	Tc	Tumac Mountain, basalt of	Qv		
		Two Lakes, basalt of	Qv		

EXPLANATION OF LEG MAPS

Below are the geologic units and symbols used in the leg maps in this guidebook. Note that the colors here may be muted or altered by the shaded relief base for the leg maps. More detailed descriptions of the map units are given in the "Description of Map Units" on page 185. These descriptions cover all of the units shown on Figure 2; the units on this page are only those units shown






on the leg maps. Most map units contain or consist of one or more named units, and these are listed with the unit's description. The "List of Named Units" on page 188 links the formation or informal name to the map unit symbol, and thus to the unit description.

On all maps, geologic contacts are approximate because the source maps were prepared at a smaller scale






than the maps in this book (WDGER, 2005). Also, a rock type mentioned in the text may not appear on a leg map because the polygon for its location is too small to be shown at leg map scale. To save space, some of the maps have been rotated away from true north. Keep your eye on the north arrows to determine map orientation.

KEY TO GEOLOGIC UNITS







Unconsolidated Sediments

 Qa	Quaternary alluvium
 Qls	Quaternary mass-wasting deposits
 Ql	Quaternary loess
 Qgd	Pleistocene continental glacial drift
 Qad	Pleistocene alpine glacial drift



Sedimentary Rocks and Deposits

 QTc	Quaternary–Tertiary continental sedimentary rocks and deposits
 Tc	Tertiary continental sedimentary rocks
 Tn	Tertiary nearshore sedimentary rocks
 Tm	Tertiary marine sedimentary rocks
 Mm	Mesozoic marine sedimentary rocks


Volcanic Rocks and Deposits

 Qv	Quaternary volcanic rocks
 Tvcr	Tertiary volcanic rocks of the Columbia River Basalt Group
 Tv	Tertiary volcanic rocks
 Mv	Mesozoic volcanic rocks
 Qvt	Quaternary fragmental volcanic rocks
 Tvt	Tertiary fragmental volcanic rocks

Intrusive Rocks

 Ti	Tertiary intrusive rocks
 Mi	Mesozoic intrusive rocks

Metasedimentary and Metavolcanic Rocks

 Mmv	Mesozoic metavolcanic rocks
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Metamorphic Rocks

 Mog	Mesozoic orthogneiss
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Other Geologic Units

	Glaciers and ice fields
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ROADS AND OTHER FEATURES

	Interstate Highway
	U.S. Highway
	Washington State Highway
	U.S. Forest Service Road
	National Park Boundary
	National Forest Boundary
	Leg route with milepost
	Trail
	National Park entrance or ranger station
	Visitor center
	Picnic area
	Camping
	State Park

GEOLOGIC SYMBOLS

	Contact — Dashed where scratch boundary
	Anticline — Showing direction of plunge; dotted where concealed
	Syncline — Showing direction of plunge; dotted where concealed
	Monocline — Dotted where concealed
	Fault — Long-dashed where approximately located, short-dashed where inferred, dotted where concealed
	Thrust fault — Sawteeth on upper plate; long-dashed where approximately located, short-dashed where inferred, dotted where concealed
	Left-lateral strike-slip fault — Arrows show relative movement; short-dashed where inferred, dotted where concealed; arrows omitted in crowded areas
	Dip-slip fault — Bar and ball on down-thrown side; long-dashed where approximately located, short-dashed where inferred, dotted where concealed

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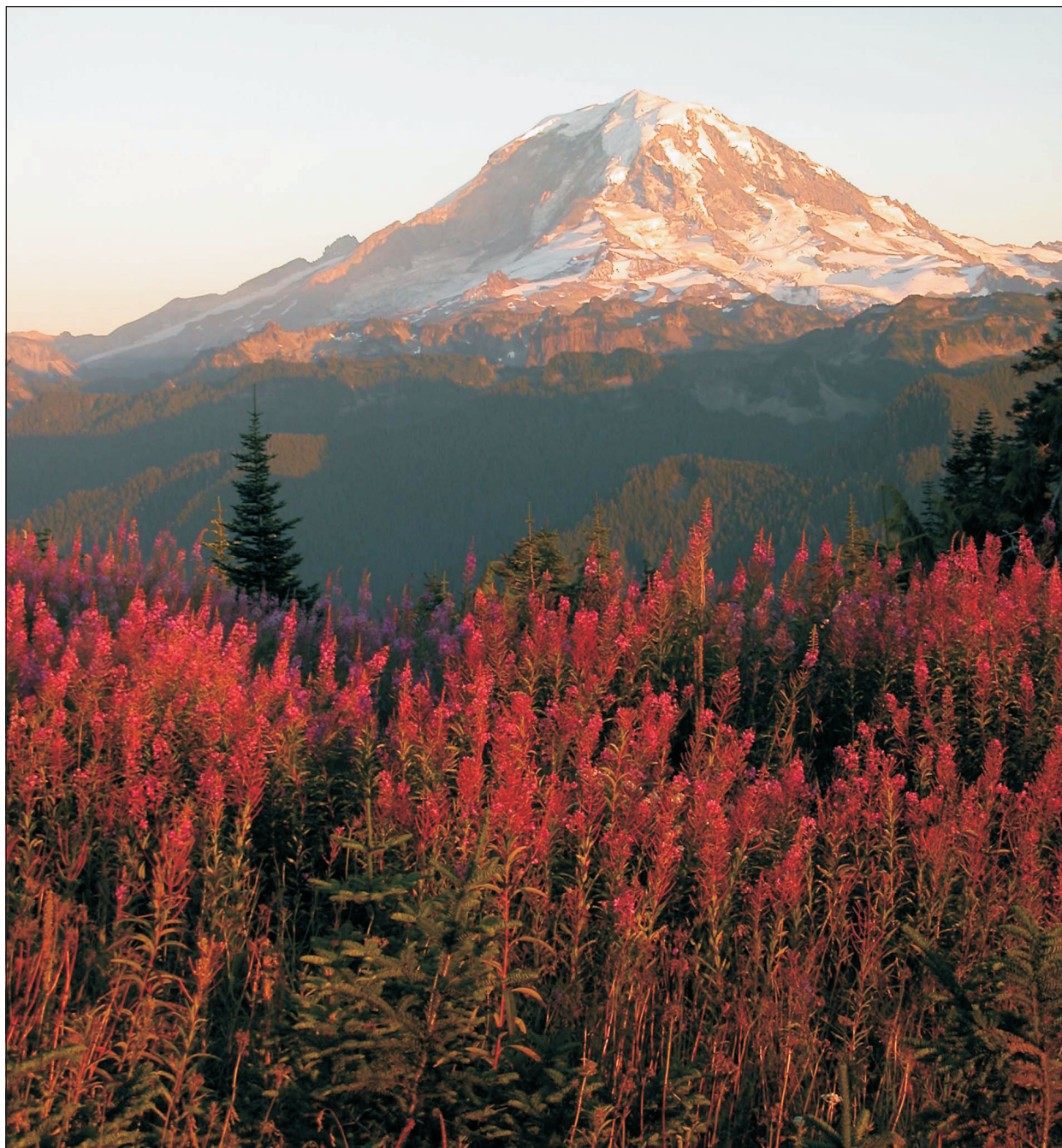
June 2008



WASHINGTON STATE DEPARTMENT OF
Natural Resources

Doug Sutherland - Commissioner of Public Lands

Division of Geology and Earth Resources
Ron Teissere - State Geologist



View of the northwest flank of Mount Rainier from an alpine meadow above the Carbon River Ranger Station about 8 mi from Mount Rainier. Photo by Elizabeth E. Thompson; taken in 2006.