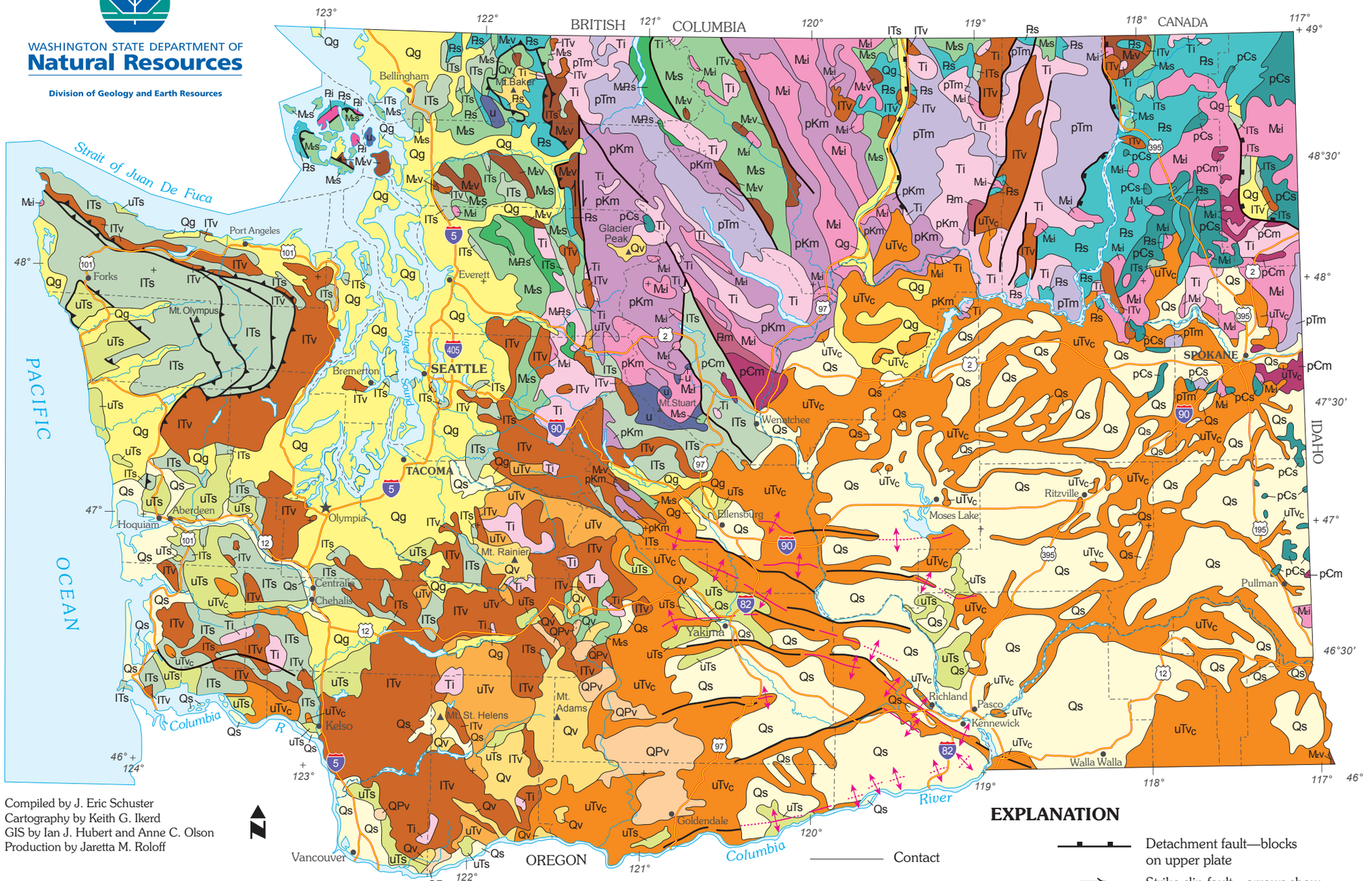
GEOLOGIC MAP OF WASHINGTON

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Division of Geology and Earth Resources



EXPLANATION

- Contact
- Fault
- Thrust fault—sawteeth on upper plate
- Detachment fault—blocks on upper plate
- Strike-slip fault—arrows show relative movement
- Anticline—dotted where concealed

GEOLOGIC UNITS

Unconsolidated Deposits

- Qs — Quaternary sediments, dominantly nonglacial; includes alluvium and volcaniclastic, glacial outburst flood, eolian, landslide, and coastal deposits
- Qg — Quaternary sediments, dominantly glacial drift; includes alluvium

Sedimentary Rocks

- uTs — Upper Tertiary (Pliocene–Miocene)
- lTs — Lower Tertiary (Oligocene–Paleocene)
- Ms — Mesozoic
- MPzs — Mesozoic–Paleozoic
- Pzs — Paleozoic
- pCs — Precambrian

Volcanic Rocks

- Qv — Quaternary
- QPv — Quaternary–Pliocene
- uTv — Upper Tertiary (Pliocene–Miocene)
- uTvc — Columbia River Basalt Group
- lTv — Lower Tertiary (Oligocene–Paleocene)
- Mv — Mesozoic

Intrusive Igneous Rocks

- Ti — Tertiary
- Mi — Mesozoic
- Pi — Paleozoic

Metamorphic Rocks

- pTm — Pre-Tertiary
- pKm — Pre-Cretaceous
- Pm — Paleozoic
- pCm — Precambrian
- u — Ultramafic rocks

Note: Some pre-Tertiary sedimentary and volcanic rock units include low-grade metamorphic rocks. Ages assigned to metamorphic rocks are protolith ages.

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http://www.dnr.wa.gov/geology
http://www.dnr.wa.gov/geologyportal

The Geology of Washington State

Adapted by Lynn Moses from an article by Raymond Lasmanis

Washington's geology is highly diverse. Rocks of Precambrian age, as well as from every geologic period from Cambrian to Quaternary, are represented. The state has been subject to continental collisions, metamorphism, intrusion of igneous rocks, volcanism, mountain-building, erosion, and massive flooding. The easiest way to understand Washington's complex geology is to examine each of its physiographic provinces.

Okanogan Highlands

The Okanogan Highlands are characterized by rounded mountains (up to 8,000 feet) and deep, narrow valleys. The Columbia River divides the Okanogan Highlands in two. The eastern half contains the oldest rocks in the state. These Precambrian metasedimentary rocks are overlain by Paleozoic marine rocks that were deposited on an actively subsiding continental margin. The western half of the province was formed by deposition of sediments and volcanic rocks offshore to the west of the continental margin. Early Tertiary volcanic eruptions filled the western basins with volcanic debris, which was later covered by fluvial and lacustrine sediments. Fossil lake beds at Republic contain Eocene plants, insects, and fish. During the Quaternary, ice sheets covered the Okanogan Highlands, reshaping the landscape and forming lakes in the Columbia and Pend Oreille River valleys.

Columbia Basin

The Columbia Basin is characterized by loess hills and incised rivers overlying flows of the Miocene Columbia River Basalt Group, which issued from vents and fissures in southeastern Washington about 17 to 6 million years ago. These basalts cover 36 percent of the state and reach a maximum thickness of 16,000 feet. Between eruptions, lakes and forests developed on the cooled lava, only to be buried by the next flow. South of Spokane, steep-sided buttes called steptoes are the older rocks of the Okanogan Highlands exposed above the surrounding basalt. From the late Tertiary to the present, basalt flows in the western part of the Columbia Basin have been faulted and folded into a series of enormous, east–west trending anticlines and synclines called the Yakima Fold Belt. During the Pliocene and Pleistocene, large volumes of wind-blown silt called loess, derived from the continental ice sheet to the north, blanketed much of eastern Washington. As the ice sheet advanced into Idaho, it dammed the Clark Fork River and formed Lake Missoula. The ice dam broke repeatedly between 12,700 and 15,300 years ago, releasing massive floods that spread out over the Columbia Basin. The surface of the land was greatly modified by channels cut through the loess into the basalt, leaving a jumbled topography of coulees, buttes, mesas, dry waterfalls, hanging valleys, and giant ripples. These geomorphic features are known as the Channeled Scablands. The flooding events are called the Missoula or Spokane floods.

Cascade Range

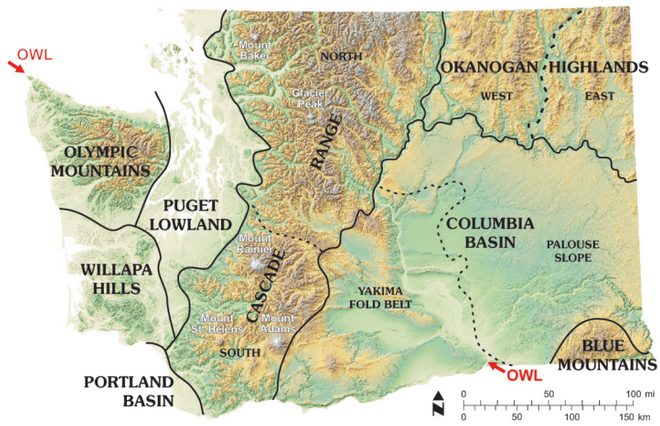
The Cascade Range consists of an active volcanic arc superimposed upon bedrock of Paleozoic to Tertiary age. Pliocene to recent uplift has created high topographic relief. As a result, the Cascades are an effective barrier to moisture carried eastward by prevailing Pacific winds, creating dry conditions in much of eastern Washington. A major east–west geologic break, tracing generally along Interstate 90 between Ellensburg and Seattle, separates the Cascades into northern and southern portions.

The North Cascades are composed of faulted and folded Mesozoic and Paleozoic crystalline and metamorphic rocks and Tertiary intrusive, volcanic, and sedimentary rocks. On the east side, the Methow Valley contains the thickest stratigraphic section of Cretaceous marine sedimentary rocks in the state. To the west, Paleozoic and Mesozoic marine sedimentary and volcanic rocks were deformed by complex thrust faulting during late Cretaceous subduction. Lower Tertiary sedimentary rocks, such as the Chuckanut Formation, were deposited in rapidly subsiding, fault-bounded basins. The Chuckanut Formation is one of the thickest nonmarine sequences in North America and is known for fossil palm fronds. Tertiary plutons cut and altered older rock throughout the North Cascades. Two Quaternary stratovolcanoes dominate the North Cascades—Mount Baker and Glacier Peak—both less than 1 million years old. The rugged topography of the North Cascades is a result of Pleistocene and Holocene glaciation. This region is second only to Alaska for the greatest concentration of alpine glaciers in the U.S.

The South Cascades consist of Tertiary volcanic and sedimentary rocks. At the beginning of the Tertiary, an erosional plain occupied the area. Cascade-arc volcanism began in the early Tertiary, and sediments derived from those eruptions interfingered with sediments being deposited on the platform. The paleocanyon of the Columbia River was filled first with fluvial channel deposits and then by intracanyon flows of Columbia River basalt. During the Quaternary, the gorge was the site of large landslides. It was also an outlet for the cataclysmic Missoula floods. Mount Rainier, Mount Adams, and Mount St. Helens, all active volcanoes less than a million years old, are current examples of Cascade-arc volcanism.

Puget Lowland

The Puget Lowland is a broad, low-lying trough located between the Cascade Range to the east, and the Olympic Mountains and Willapa Hills to the west. Lower Tertiary sedimentary rocks unconformably overlie the Crescent Formation. The oldest of these sedimentary rocks consist of sandstones, shales, and coals deposited on a coastal plain fed by westward-flowing rivers. As the Cascade Range began to form, much of the sediment deposited on the coastal plain was derived from volcanic eruptions. During the Quaternary, the Puget Lowland was covered a number of times by continental ice sheets. The most recent (Fraser) glaciation reached its peak about 14,000 years ago. The Fraser ice sheet extended to Littlerock, south of Olympia. Maximum ice thickness during the Fraser Glaciation was approximately 1,000 feet at Olympia, 3,000 feet at Seattle, and over 5,000 feet at Bellingham. The Fraser ice retreated quickly, leaving behind a landscape sculpted by glacial erosion and covered by newly deposited glacial drift. The location of present-day waterways and river drainages was established by the pattern of Fraser glacial erosion and deposition.



Physiographic provinces of Washington State. Subprovinces are separated by dashed lines. OWL, Olympic–Wallowa lineament.

Olympic Mountains

The Olympic Mountains, part of the Coast Range, form the core of the Olympic Peninsula. The oldest bedrock of the Olympic Mountains is the lower Tertiary Crescent Formation, a thick sequence of submarine and subaerial basalt flows with some interbedded siltstone and limestone. During middle Tertiary subduction, lower Tertiary marine sediments were continually thrust beneath the Crescent Formation. Uplift of the Olympic Mountains began when the wedge of underplated sediments reached a critical thickness about 17 million years ago. Continental glacial deposits mantle the east and northwest side of the Olympic Peninsula, where the Fraser ice sheet split into the Juan de Fuca and Puget lobes. Alpine glaciation carved the rugged peaks of the Olympic Range and flooded much of the coastal lowland with meltwater carrying sand and gravel.

Willapa Hills

The Willapa Hills are part of the Coast Range and include the adjacent broad valleys that open up to the Pacific Ocean. Barrier beaches characterize the low-lying coastline, behind which are major estuaries at Grays Harbor and Willapa Bay. This province is underlain by Tertiary sedimentary and volcanic rocks deposited in nearshore embayments and shallow seas surrounding basalt islands. Flows of Columbia River basalt followed ancestral courses of the Columbia River until they reached the Pacific Ocean at Willapa Bay and Grays Harbor. As it flowed to the sea, meltwater from continental glaciers carved a wide valley along the present-day Black and Chehalis Rivers. However, most of the province was never glaciated, so ridges and hills have a rounded topography and deep weathering profile. Evidence for large earthquakes (magnitude 8 or greater) on the interface of the Juan de Fuca and North America plates is preserved in the coastal marshes of this province.

Blue Mountains

The Blue Mountains are characterized by a broad uplift reaching elevations of more than 6,000 feet above sea level. Windows of Paleozoic or Mesozoic metamorphic rocks are exposed at four locations where streams have incised deep canyons through overlying rocks of the Columbia River Basalt Group. In the Blue Mountains, Grande Ronde Basalt of the Columbia River Basalt Group was extruded from northwest-trending fissures. Dikes now show the locations of these vents. As thick sequences of basalt were erupted in the Blue Mountains during the middle Miocene, adjacent basins formed—for example in the vicinity of Troy, at the Oregon–Washington border. Ancestral valleys were blocked by basalt flows, causing the Troy Basin to be infilled with thick sequences of sediments and peat. Arching of the Blue Mountains was initiated between 12 to 10 Ma. Younger Miocene flows did not cover the emerging Blue Mountains. They only lapped up against the flanks of the uplift, finally folding and faulting.

Portland Basin

Portland Basin marks the northern terminus of the Willamette Lowland of Oregon. It is characterized by low topographic relief. At the edge of the basin are exposures of Columbia River basalt; within the basin itself, the basalt units lie more than 1,000 feet below the surface. Starting during the Miocene and continuing through the Pliocene, the basin was filled by sediments of the ancestral Columbia River. This was followed by a period of volcanism from 2.6 to 1.3 Ma. This volcanism was associated with faulting and structural deformation and further depression of the Portland Basin. Lastly, as the Missoula floods burst out of the Columbia River gorge 12,700 to 15,300 years ago, deposits of poorly sorted sand, clay, and gravel accumulated in the basin.