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DESCRIPTION OF MAP UNITS

SEDIMENTS AND SEDIMENTARY ROCKS

QUATERNARY SEDIMENTS

Nonglacial

Qa **Alluvium**—Silt, sand, and gravel deposited in streambeds and fans; surface relatively undissected

Qoa **Older alluvium**—Silt, sand, and gravel deposited in stream beds and fans; may form low terraces; surface commonly dissected; commonly iron-oxide stained and, east of the Cascade Range, commonly contains caliche layers. Includes Skokomish Gravel

Qb **Beach deposits**—Fine to coarse sand forming beaches and associated active and stabilized back-beach dune fields, and minor estuarine deposits

Qd **Holocene dune sand**—Eolian sand and silt forming active dunes; dominant source is beaches along the Columbia River

Qp **Peat deposits**—Peat, muck, and lacustrine silt and clay rich in organic matter; deposited mostly in closed depressions

Qls **Landslide debris**—Clay, silt, sand, gravel, and larger blocks; unstratified and poorly sorted; surface commonly hummocky. Includes the 1980 debris avalanche of Mount St. Helens (Lipman and Mullineaux, 1981), talus, and all other mass-wasting deposits

Qc **Pleistocene continental sediments**—Stratified clay, silt, sand, gravel, and peat of lacustrine, estuarine, and fluvial origin; near Mount Rainier contains deposits of volcanic mudflows. Includes Kitsap, Alderton, and Puyallup Formations, and the Damon silt (Moore, 1965)

Periglacial

Loess

Ql **Loess**—Pale orange to brown eolian silt and fine sand; locally contains caliche and tephra

Upper Pleistocene Outburst Deposits of Glacial Lake Missoula

Qfs **Flood sand and silt**—Silt, sand, and clay, commonly grading into unit Qfg; contains slackwater deposits and crossbedded fine-grained surge deposits, and some interbedded gravels

Qfg **Flood gravel**—Boulder to cobble gravel with sandy matrix and minor silt interbeds; generally crossbedded with foreset beds dipping downvalley

Terraced Sediments

Qt **Terraced sediments**—Silt, sand, and gravel of diverse compositions and origins, such as proglacial outwash, glacial outburst deposits, older alluvium, lahars, and uplifted coastal marine and estuarine deposits. Includes parts of the Lakedale and Kittitas Drifts

Glacial

Deposits of Continental Glaciers—Puget Lobe of the Cordilleran Ice Sheet

Vashon Stade of the Upper Pleistocene Fraser Glaciation

Qgd **Undifferentiated glacial drift**—Clay, silt, sand, and gravel; contains moraines and mixtures of till and outwash not separately mappable. Consists of part of the Vashon Drift

Qga **Advance outwash**—Outwash sand and gravel and lacustrine clay, silt, and sand deposited during advance of glaciers; sands commonly thick, well sorted and fine grained, with lenses of coarser sand and gravel; locally contains nonglacial sediments. Consists of Colvos Sand and part of the Vashon Drift

Qgt **Till**—Unsorted, unstratified, highly compacted mixture of clay, silt, sand, gravel, and boulders deposited directly by glacial ice; locally contains outwash sand and gravel both within and overlying till. Consists of part of the Vashon Drift

Qgo **Undifferentiated outwash deposits**—Recessional and proglacial stratified sand and gravel; locally contains silt and clay. Consists of part of the Vashon drift

Qgos **Outwash sand**—Recessional and proglacial stratified sand; locally contains silt, clay, and gravel. Consists of part of the Vashon Drift

Qgog **Outwash gravel**—Recessional and proglacial, stratified pebble, cobble, and boulder gravel deposited in meltwater streams and their deltas; locally contains ice-contact deposits. Includes Steilacoom Gravel and part of the Vashon Drift.

Pre-Fraser Glacial Deposits

Qgp **Undifferentiated drift**—Till and outwash sand and gravel; commonly oxidized. Includes Salmon Springs, Orting, and Stuck Drifts, and Helm Creek drift of Carson (1970)

Deposits of Alpine Glaciers

Fraser Glaciation and Younger Deposits

Qad **Undifferentiated drift**—Till and outwash sand and gravel. Includes Burroughs Mountain, Garda, and McNeely Drifts, parts of Evans Creek and Lakedale Drifts, and McDonald Ridge drift (Hopkins, 1976)

Qao **Outwash deposits**—Stratified sand and gravel; locally contains silt and clay. Includes parts of Evans Creek and Lakedale Drifts and Chow Chow drift (Moore, 1965)

Pre-Fraser Glacial Deposits

Qap **Undifferentiated drift**—Till and outwash sand and gravel. Includes Lookout Mountain Ranch Drift, parts of Wingate Hill, Hayden Creek, and Kittitas Drifts, White Salmon drift (Hopkins, 1976), Mobray drift (Carson, 1970), and parts of the Humptulips drift (Moore, 1965) and Amboy drift (Mundorff, 1964, 1984)

Qapo **Outwash deposits**—Outwash sand and gravel with minor silt and clay. Includes Logan Hill Formation, part of Hayden Creek, Kittitas, and Wingate Hill Drifts, part of the Humptulips drift (Moore, 1965), part of the Amboy drift (Mundorff, 1964, 1984), and the Weatherwax and Wedekind Creek formations (Carson, 1970)

PLEISTOCENE-PLIOCENE SEDIMENTS

Continental

QPc **Continental sediments**—Gravel, sand, silt, and clay; deposits of the ancestral Columbia River contain distinctive orange quartzite clasts thought to be derived from northeast Washington; in the southern foothills of the Olympic mountains, moderately to intensely deformed alluvial sand and gravel; at Swale Creek valley, consists of material eroded from adjacent basaltic terrane and is overlain by loess. Includes the Troutdale Formation, and the Swale Creek valley sedimentary deposits (Newcomb, 1969)

PLIOCENE SEDIMENTS

Continental

Pc **Continental sediments**—Weakly cemented, moderately sorted cobble to pebble gravel with thin sand, silt, clay, and tephra interbeds; deposited by ancestral Yakima River and by smaller streams mainly in the Columbia Basin. Includes Thorp Gravel

MIOCENE SEDIMENTARY ROCKS

Marine

Mm2 **Middle to upper Miocene marine sedimentary rocks**—Coarse- to fine-grained, silty, friable lithofeldspathic and feldspatholithic sandstone, locally dominated by conglomerate, siltstone, and mudstone; blue-gray when fresh, orange-brown when weathered; locally tuffaceous; most commonly massive, but bedding locally enhanced by conglomerate lenses and beds, carbonized wood, mica flakes, and concretionary beds; mudstone and siltstone beds are common. Contains foraminiferal faunas referable to the Mohnian and Delmontian Stages. Consists of Montesano Formation

Mm1 **Lower to middle Miocene marine sedimentary rocks**—Fine-grained, silty feldspathic sandstone; friable, micaceous, gray when fresh, weathers to olive brown or creamy orange; massive to thin bedded; locally tuffaceous; abundant siltstone that contains macerated carbonaceous material; local basaltic sandstone, pebble conglomerate, and poorly sorted basal conglomerate. Contains foraminiferal faunas referable to the Saucesian, Relizian, and Luisian (?) Stages. Consists of the Astoria Formation

Continental

Mc **Continental sedimentary rocks**—Poorly consolidated to semiconsolidated sandstone, siltstone, and conglomerate, commonly tuffaceous; includes some tuff breccias, lahars, volcanic arenites, and peat; primarily the products of fluvial systems draining Tertiary volcanic terranes. Includes Mashel, Wilkes, and Dalles Formations and part of the Ellensburg Formation

Mcg **Continental sedimentary rocks, conglomerate**—Conglomerate with abundant dark-colored porphyritic andesite clasts, debris flow breccia, pebbly volcaniclastic sandstone, siltstone, and minor airfall tuff; commonly thick bedded. Consists of Eagle Creek Formation

OLIGOCENE-EOCENE SEDIMENTARY ROCKS

Marine

OEm **Oligocene to upper Eocene marine sedimentary rocks**—Indistinctly bedded to massive, commonly concretionary, light-gray tuffaceous siltstone and fine-grained tuffaceous sandstone; lower strata contain discontinuous beds of basaltic and glauconitic sandstone; dominantly offshore marine but grades into nonmarine volcaniclastic rocks east of Chehalis. Contains foraminiferal faunas referable to the Refugian and Zemmorian Stages. Consists of the Lincoln Creek Formation and part of Unit B of Wolfe and McKee (1972)

Nearshore

OEn **Oligocene to upper Eocene nearshore sedimentary rocks**—Basaltic conglomerate, sandstone, tuffaceous siltstone, pumice-lithic lapilli tuff, claystone, and lignite; locally interbedded with basaltic andesite flows; depositional environments range from nearshore marine to nonmarine; contains foraminiferal fauna referable to the Refugian Stage. Consists of the Toutle Formation

EOCENE SEDIMENTARY ROCKS

Marine

Em2 **Middle to upper Eocene marine sedimentary rocks**—Laminated to massive, tuffaceous siltstone, claystone, shale, and massive to crossbedded micaceous feldspathic sandstone in lower part, interbeds of basaltic sandstone; locally interbedded with basalt flows, tuffs, tuff breccias, and conglomerates. Contains foraminiferal faunas referable to the Narizian Stage. Includes part of the McIntosh Formation, Stillwater Creek Member of the Cowlitz Formation (Henriksen, 1956), Humptulips Formation (Rau, 1984, 1986), siltstone of Skamokawa Creek (Wells, 1981), siltstone of Cliff Point (Wells, 1979), siltstone and sandstone at Omeara Point (Wells, in press), siltstone at Shoalwater Bay (Wells, in press), and part of Unit B of Wolfe and McKee (1972)

Em1 **Lower? to middle Eocene marine sedimentary rocks**—Siltstone and massive to planar-laminated micaceous feldspathic sandstone, locally with graded bedding. Contains foraminiferal faunas referable to the Ulatisian Stage. Includes Unit A of Wolfe and McKee (1972), part of the McIntosh Formation (Wagner, 1967a), sandstone of Megler (Wells, 1979), part of the Crescent Formation (Rau, 1966), and the Hoh Assemblage (Rau, 1986)

Nearshore

En **Middle to upper Eocene nearshore sedimentary rocks**—Nearshore marine to nonmarine micaceous feldspathic sandstone, siltstone, shale, carbonaceous siltstone, claystone, and thick coal seams; locally interbedded with basalt flows and volcaniclastic rocks. Contains foraminiferal faunas referable to the Narizian Stage. Includes Skookumchuck Formation, Olequa Creek Member of the Cowlitz Formation (Henriksen, 1956), Cowlitz Formation (Wells, 1981), and rocks mapped as upper McIntosh by Pease and Hoover (1957) [See Logan, 1987a]

Continental

Ec2 **Middle to upper Eocene continental sedimentary rocks**—Micaceous feldspathic sandstone and lithofeldspathic sandstone interbedded with siltstone, shale, claystone, and coal; locally, interbedded with lava flows, tuffs, volcaniclastic breccias, and pebble conglomerates, and brackish-water deposits. Includes Puget Group undivided, Carbonado, Spiketon, and Roslyn Formations, parts of the Naches Formation, the Summit Creek sandstone (Ellingson, 1959), the Lookout Creek sandstone (Schreiber, 1981) and the beds of Chambers Creek (Winters, 1984)

Ec1 **Lower to middle Eocene continental sedimentary rocks**—Micaceous feldspathic sandstone and lithofeldspathic sandstone with lesser amounts of carbonaceous siltstone and shale, pebbly sandstone, conglomerate, and coal; locally interbedded with tuffs and volcaniclastic breccias. Consists of Swauk and Manastash Formations

CRETACEOUS AND JURASSIC SEDIMENTARY ROCKS

Marine

KJm **Marine sedimentary rocks**—Lithofeldspathic sandstone and mudstone, with lesser conglomerate and greenstone, minor chert, and very rare green tuff. Radiolarian faunas indicate an age of Triassic(?), Jurassic, and Early Cretaceous; limestone clasts in a conglomerate have yielded fusulinids of probable Permian age. Consists of part of the Russell Ranch Formation

KJmct **Chert-rich marine sedimentary rocks**—Lithofeldspathic sandstone, mudstone, radiolarian chert, greenstone, green tuff, and red shale; characterized by thin stringers of altered green tuff and red shale within chert-rich horizons; contains radiolarian faunas referable to the Tithonian and Valanginian or Hauterivian Stages. Consists of part of the Russell Ranch Formation

VOLCANIC ROCKS AND DEPOSITS

QUATERNARY VOLCANIC ROCKS AND DEPOSITS

Lava Flows

Qvd **Pleistocene dacite flows**—Porphyritic dacite; northwest of Mount Adams, two-pyroxene, glassy intracanyon flow; at Spiral Butte, very fine grained, light-gray, platy, flow-banded hypersthene-hornblende dacite flows; along Clear Fork of the upper Cowlitz River, very fine grained quartz-hornblende-hypersthene dacite intracanyon flow

Qva **Andesite flows**—Porphyritic to aphyric, hypersthene-augite andesite, olivine-pyroxene andesite, and hornblende andesite with minor dacite; blocky to platy flows, commonly vesicular, commonly with breccia bases; form the stratovolcanoes at Mount Rainier, Mount Adams, and Mount St. Helens, voluminous valley-filling flows, monogenetic volcanic piles, plug domes; lesser amounts of basaltic andesite associated with basaltic volcanic fields (unit Qvb). Includes the Tieton Andesite and andesite flows of Mount Rainier (Fiske and others, 1963), Mount Adams (Hammond, 1980; Hildreth and others, 1983), and Mount St. Helens (Hopson, 1980)

Qvb **Basalt flows**—Light-gray to black, microphyric to coarsely phyric olivine basalt and olivine-clinopyroxene basalt; forms aa flows and pahoehoe flows with lava tubes, vent areas typically marked by cinder and scoria cones and accumulations of tephra and bombs; flows form volcanic fields at Indian Heaven, King Mountain, Tumac Mountain, Marble Mountain, and Soda Peaks. Includes Cave Basalt and other basalt flows at Mount St. Helens (Hopson, 1980)

Volcaniclastic Deposits

Qvc **Volcaniclastic deposits, undivided**—Ash- to block-sized lithic and pumice-rich pyroclastic deposits, debris flows, laharic deposits, pumice lapilli, and ash tephra, and fluvial gravels, sand, and silt; deposited by pyroclastic flows, lahars, and debris avalanches on or near Quaternary stratovolcanoes; at Mount St. Helens, lithic clasts consist of gray to pink hornblende-hypersthene dacite and andesite and lesser black andesite and basalt, locally interbedded with glacial till (Hopson, 1980); at Mount Adams, primarily andesitic debris

Qvp **Holocene pyroclastic flows**—Dacitic to andesitic, pumiceous pyroclastic-flow deposits of 1980 Mount St. Helens eruptions (Lipman and Mullineaux, 1981); mostly poorly sorted, ash-sized, crudely graded deposits of glass shards, pumice, broken phenocrysts, and lithic fragments and lesser lapilli- to block-sized pumice and lithic fragments

Qvl **Lahars**—Unsorted to poorly sorted, generally unstratified mixtures of cobbles and boulders supported by a matrix of sand or mud; also contains lesser stratified fluvial deposits; primarily late Pleistocene to Holocene deposits originating on Quaternary stratovolcanoes. Includes Osceola and Electron Mudflows, the Lily Creek Formation, the Greenwater lahar (Crandell, 1971), Paradise debris flow (Crandell, 1969), Trout Lake mudflow (Hopkins, 1976), lahars from 1980 Mount St. Helens eruptions (Lipman and Mullineaux, 1981) in the Toutle River, Muddy River, and Pine Creek drainages and pre-1980 Mount St. Helens lahars (Scott, 1986)

PLEISTOCENE-PLIOCENE VOLCANIC ROCKS

Lava Flows

QPvd **Dacite flows**—Light-gray to purplish-gray porphyritic oxyhornblende-pyroxene dacite; forms ridge-capping flows at Johnson Creek and Snyder Mountain and sheet flows east of the White Salmon River

QPva **Andesite flows**—Gray olivine-hypersthene andesite, pyroxene andesite, hornblende andesite, and hypersthene-hornblende andesite flows and associated breccias; erupted from vents in the Goat Rocks area, northwest of Mount Rainier, and in the Vancouver area. Includes andesite of Bee Flat (Fiske and others, 1963) and some flows of the Boring Lava

QPvb **Basalt flows**—Gray to gray-black, aphyric and plagioclase-olivine-phyric and pyroxene-olivine-phyric basalt; commonly trachytic; platy, blocky, and columnar jointed; commonly scoriaceous; erupted from multiple vents distinguished by cinder cones; at Hogback Mountain, olivine basalt and basaltic andesite form a shield volcano. Includes part of the Boring Lava, volcanic rocks of Simcoe Mountains (Sheppard 1967), mafic rocks of Hogback Mountain (Clayton, 1983), basalt porphyry of Balch Lake (Newcomb, 1969), and basalt of the Lincoln Plateau (Sheppard, 1967)

PLIOCENE VOLCANIC ROCKS

Lava Flows

Pvr **Rhyolite**—Flow-banded flows and domes, obsidian, breccias, lahars, and tuffs; at Devils Horns, tuffs are pumiceous and vitric. Includes Devils Horns rhyolite (Clayton, 1983) and volcanic rocks of Simcoe Mountains (Sheppard, 1960)

Pvd **Dacite flows**—Light- to medium-gray porphyritic dacite flows and flow breccia with phenocrysts of plagioclase, hornblende, quartz, and biotite; occurs as scattered remnants; also contains tuffs, lava domes, and hypabyssal intrusions

Pvb **Basalt flows**—Olivine basalt, olivine-augite basalt, and basaltic andesite flows, agglomerates, pyroclastic rocks, and dikes; the pyroclastic rocks contain welded basaltic bombs, blocks, scoria, and spatter. Includes the Devils Washbasin basalt (Clayton, 1983) and the olivine basalt of Bethel Ridge (Swanson, 1978)

Volcaniclastic Rocks

Pvt **Tuff**—Poorly consolidated pyroclastic debris to welded, dacitic lithic-crystal-vitric tuff and tuff breccia; crystals are augite and plagioclase. Includes the tuff at Midway (Hammond, 1980)

MIOCENE VOLCANIC ROCKS

Lava Flows

Mvr **Rhyolite**—Gray to white, banded, devitrified rhyolite interpreted as rheoignimbrite, with rare black welded vitrophyre and local basal unwelded pumice-perlite tuff; interbedded with rare rhyolitic sandstone, siltstone, and coal. Includes White River rheoignimbrite (Fischer, 1970)

Mvd **Dacite flows**—Porphyritic dacite flows and flow breccia; northeast of Mount St. Helens white to light-greenish-gray, plagioclase- and pyroxene-phyric, rarely with biotite and hornblende; forms flow-dome complexes and persists as scattered flow remnants; south of the Cispus River, black, glassy, plagioclase-augite-phyric, columnar flows and flow breccia

Mva **Andesite flows**—Pyroxene andesite and two-pyroxene andesite and basaltic andesite flows and flow breccia; also contains minor hornblende-pyroxene andesite and clinopyroxene basalt flows interbedded with volcaniclastic breccia, tuff, and volcanic sandstone; lavas commonly porphyritic; shield volcanoes of this unit are recognized at Fifes Peak, Cliffdell, and south of Bethel Ridge. Includes the Fifes Peak Formation, part of the volcanic rocks of Eagle Gorge (Frizzell and others, 1984), lava flows of Council Bluff (Hammond, 1980), lava flows of Three Corner Rock (Hammond, 1980), and Stevenson Ridge lavas (Berri and Korosec, 1983)

Mvb **Basalt flows**—Black to medium-gray and green, aphyric to sparsely plagioclase-, olivine-, and augite-phyric basalt flows and flow breccia, with minor interbedded mafic tuff, laharic breccia, and volcanic sedimentary rock

Volcaniclastic Rocks

Mvc **Volcaniclastic rocks**—Massive to well-bedded volcaniclastic breccias and conglomerates, tuffs, tuff breccias, and volcanic sandstones and siltstones; northeast of Mount St. Helens, andesitic to rhyolitic, pumice-lithic tuff and tuff breccia, volcanic siltstone, sandstone, conglomerate, and minor coal beds, locally associated with plugs and flows of dacite and rhyolite; south and west of Naches Pass, well-bedded andesitic breccia, tuff, and volcanic sandstone with rare white pumice tuff locally containing graded beds; west of Randle, poorly sorted, massive breccia and conglomerate that has sand- to boulder-sized clasts of augite andesite; near Burnett in Pierce County, poorly sorted, unstratified, matrix-supported breccia and conglomerate that has clasts of andesite and hornblende dacite, and crossbedded, pumiceous sandstone, lapillistone, and thin tuff; in the Kittitas Valley, mostly volcaniclastic sandstone and siltstone, and minor conglomerate and feldspathic sandstone interbedded with or stratigraphically above flows of Grande Ronde Basalt (unit Mvg). Includes the Randle laharic breccia-conglomerate (Fisher, 1960) and, east of the Cascades, part of the Ellensburg Formation

Mvt **Tuff**—Welded to nonwelded, vitric to crystalline, lithic and pumiceous dacite and rhyolite tuffs and tuff breccias; commonly quartz phyric; contains pyroclastic flows and airfall tuff with minor silicic lava flows and volcaniclastic sedimentary rocks. Includes part of the volcanic rocks of Eagle Gorge (Frizzell and others, 1984), welded tuff of The Palisades (Fiske and others, 1963), and Stevens Ridge Formation north of Mount Rainier

Flows of Miocene Columbia River Basalt Group

Yakima Basalt Subgroup

(Erupted from fissure vents in southeast Washington and adjacent Oregon and Idaho)

Mvs **Middle to upper Miocene Saddle Mountains Basalt**—Fine-grained, sparsely phyric tholeiitic and olivine flood basalt; generally 5 to 35 m thick; as much as 100 m thick west of Kelso; forms sheet flows and intracanyon flows, with sedimentary interbeds of tuffaceous sandstone, siltstone, and pumiceous conglomerate. K-Ar ages for flows shown range from approximately 13.5 to 10.5 m.y.; contains Umatilla, Wilbur Creek, Asotin, Pomona, and Elephant Mountain Members in the Columbia Basin; west of the Cascade Mountains, consists only of Pomona Member, which includes flows mapped as basalt of Pack Sack Lookout (Snavely and others, 1973; Magill and others, 1982)

Mvis **Middle Miocene Saddle Mountains Basalt, invasive flows**—Sills and dikes of olivine basalt and peperites thought to be formed by the invasion of the Pomona Member of the Saddle Mountains Basalt (Mvs) into poorly consolidated sediments. Consists of basalt mapped as intrusive basalt of Pack Sack Lookout (Snavely and others, 1973)

Mvw **Middle Miocene Wanapum Basalt**—Fine- to coarse-grained, sparsely phyric to abundantly phyric tholeiitic basalts, forming sheet flows that have thin sedimentary interbeds and a few intracanyon flows. K-Ar ages range from approximately 15.6 to 14.5 m.y.; contains Frenchman Springs, Roza, and Priest Rapids Members in the Columbia Basin; west of the Cascade Mountains, consists only of Frenchman Springs Member; includes flows mapped as Cape Foulweather Basalt

Mvg **Middle Miocene Grande Ronde Basalt**—Fine-grained, aphyric to very sparsely phyric flood basalt with basaltic andesite chemistry, forms broad sheet flows with sedimentary interbeds of tuffaceous sandstone, siltstone, and conglomerate. K-Ar ages for basalt range from approximately 16.5 to 15.6 m.y. Consists of magnetostratigraphic units Rl, Nl, R2, and N2 (Swanson and others, 1979b) in the Columbia Gorge and eastern Washington; west of the Cascade Mountains probably contains only R2 and N2; includes flows mapped as Depoe Bay Basalt

Mvig **Middle Miocene Grande Ronde Basalt, invasive flows**—Sills and dikes of basaltic andesite and peperites thought to be formed by the invasion of Grande Ronde Basalt (Mvg) into poorly consolidated sediments. Consists of basalt mapped as intrusive Depoe Bay Basalt

MIOCENE-OLIGOCENE VOLCANIC ROCKS

Undivided

MOv **Volcanic rocks**—Undifferentiated volcanic rocks of uncertain age, probably early Oligocene through early Miocene

Lava Flows

MOva **Andesite flows**—Porphyritic pyroxene andesite flows and flow breccia and lesser interbedded volcaniclastic rock

Volcaniclastic Rocks

MOvc **Volcaniclastic rocks**—Massive to well-bedded breccias, conglomerates, tuffs, tuff breccias, and volcanic sandstones produced by debris flows, mudflows, pyroclastic flows, and fluvial reworking of volcanic deposits. Includes rocks mapped earlier as Ohanepecosh Formation by Wise (1970), but now known to be mostly younger than the Ohanepecosh Formation

MOvt **Tuff**—Welded to nonwelded, vitric to crystalline, lithic to pumiceous dacite tuffs and tuff breccias; commonly quartz phyric; products of pyroclastic flows and air fall; contains minor silicic lava flows and volcanic sedimentary rocks. Includes Stevens Ridge Formation south of Mount Rainier, Bumping River tuff (Hammond, 1980), Rattlesnake Creek tuff (Schreiber, 1981), and the tuff of Burnt Mountain (Swanson, 1978)

OLIGOCENE VOLCANIC ROCKS

Lava Flows

Ovr **Rhyolite flows**—Light-buff rhyolite east of Mount Rainier, forming an 80-m-thick, 4-km-long lens within the upper Ohanapecosh Formation (unit Ovc); has contorted flow banding and spherulites; contains a flow-banded plug at South Cowlitz Chimney east of Mount Rainier

Ovd **Dacite flows**—Massive to flow-banded, aphyric to porphyritic, dacite and minor rhyolite flows, flow breccia, domes, and plugs; phenocrysts consist of euhedral quartz, plagioclase altered to microcrystalline quartz and feldspar, and altered mafic minerals; interbedded with silicic lapilli tuff

Ova **Andesite flows**—Aphyric to porphyritic andesite flows and flow breccia; in the Toutle Mountain Range, platy porphyritic two-pyroxene andesite interbedded with pumice-lithic tuff, volcaniclastic sandstone, conglomerate, and minor dacite and basalt flows; in the Mount Rainier area, porphyritic pyroxene andesite interbedded with lithic lapilli tuff and locally thick volcaniclastic breccia and conglomerate; in southwest Skamania County, thick flows of clinopyroxene basaltic andesite. Includes part of the Ohanapecosh Formation and the Skamania volcanic rocks (Trimble, 1963)

Ovb **Basalt flows**—Aphyric to porphyritic pyroxene and olivine-pyroxene basalt and basaltic andesite flows, and flow breccia; interbedded with mafic tuff and volcaniclastic breccia hornfelsed in the contact aureole of the Spirit Lake pluton. Includes olivine basalt of Milk Creek (Swanson, 1978)

Volcaniclastic Rocks

Ovc **Volcaniclastic rocks**—Greenish to brown and maroon, andesitic to basaltic lithic breccia, tuff, and tuff breccia, and volcanic siltstone, sandstone, and conglomerate; interbedded with basalt and andesite flows and rare dacite to rhyolite flows and tuffs; breccias typically unstratified, crudely graded, or very thickly bedded, poorly sorted, with clasts of pyroclastic rock, porphyritic basaltic andesite to dacite, and aphyric to glassy lava, in a matrix of altered plagioclase, devitrified glass shards and clay; sandstone and ash to lapilli tuff commonly form well-bedded, graded, parallel-laminated, poorly to well-sorted sequences; fossil leaf impressions common in siltstone; at Wildcat Creek, contains vertebrate fossils; unit is commonly altered to zeolites and clay. Includes part of the Ohanapecosh Formation, volcanic rocks of Huckleberry Mountain (Frizzell and others, 1984), tuffaceous rocks of Wildcat Creek (Swanson, 1978), and sandstone of Spencer Creek (Swanson, 1978)

Ovt **Tuff**—Crystal-lithic and pumice-lithic tuff and tuff breccia; in the Mount St. Helens area, dominantly pyroxene- and plagioclase-phyric with lesser quartz-phyric, block to lapilli tuffs, commonly unstratified and poorly sorted; interbedded with volcanic sedimentary rocks and dacitic to andesitic flows or plugs; in the Rimrock Lake area, consists of red and violet tuff and tuffaceous sandstone and siltstone thoroughly altered to clay and interbedded with olivine basalt. Includes the tuff of Milk Creek (Swanson, 1978)

OLIGOCENE-EOCENE VOLCANIC ROCKS

Lava Flows

OEva **Lower Oligocene to upper Eocene andesite flows**—Platy to massive, vesicular to dense, porphyritic basaltic andesite flows and flow breccia, with lesser andesite, basalt, and dacite; flows commonly have oxidized, wavy bases and thin interbeds of shale, tuff, or volcanic sandstone and conglomerate; forms complexes of numerous, thin, irregularly shaped flows of limited areal extent; most flows are plagioclase-clinopyroxene phyric; two-pyroxene or olivine-phyric flows also present; zeolites and calcite common in amygdules and fractures. Includes part of the Hatchet Mountain Formation, part of the Goble Volcanics (Wilkinson and others, 1946), and part of the Northcraft Formation (Hammond, 1980)

Volcaniclastic Rocks

OEvc **Lower Oligocene to upper Eocene volcaniclastic rocks**—Massive to well-bedded, lapilli and ash pumice-lithic tuff, volcanic sandstone, and poorly sorted, unstratified, matrix-supported conglomerate or breccia with abundant wood fragments; interbedded with thin basaltic andesite flows and, at base of unit, with feldspathic sandstone, shale, and coal. Includes part of the Hatchet Mountain Formation, part of the Goble Volcanics (Wilkinson and others, 1946), and part of the Northcraft Formation (Hammond, 1980)

OEvt **Oligocene to upper Eocene tuff**—Welded and nonwelded, moderately to highly altered tuffs and tuff breccias of dacitic(?) composition. Includes part of the Northcraft Formation (Hammond, 1980)

EOCENE VOLCANIC ROCKS

Undivided

Ev **Volcanic rocks, undivided**—Basalt, basaltic andesite, and rhyolite flows and volcaniclastic rocks, with interbeds of feldspathic sandstone, siltstone, and rare coal. Includes part of the Naches Formation

Lava Flows

Evr **Rhyolite flows**—Rhyolite flows, and tuffs and associated flow breccia; flows are banded and have platy jointing; tuffs are welded crystal-lithic ash flows containing some pumice lapilli and are interbedded with minor thin feldspathic sandstones and shales; contains associated plugs and dikes on Teanaway Ridge. Includes parts of the Naches Formation

Eva **Andesite flows**—Porphyritic and minor aphyric andesite flows and flow breccia; in the Centralia-Chehalis area, massive to platy clinopyroxene basaltic andesite with lesser basalt and andesite, interbedded with pyroclastic rocks and feldspathic sandstones, especially at the base; becomes olivine-bearing and more flow dominated eastward toward Morton; south of Cliffdell along the Naches River, altered green to brownish-green plagioclase-clinopyroxene andesite, rarely with hornblende, and lesser volcanic breccia and tuff; in the Taneum Ridge area, altered pyroxene andesite, dacite and rhyolite flows interbedded with commonly welded rhyolitic tuffs, volcaniclastic breccia, and minor coal-bearing sedimentary rock. Includes the Taneum Formation and part of the Northcraft Formation

Evb **Basalt flows**—Aphyric to sparsely phyric basalt flows and flow breccia; in the Willapa Hills, subaerial clinopyroxene-phyric basalt with minor pillow basalt, interbedded with subaqueous mafic tuff, volcaniclastic breccia, basaltic sandstone and conglomerate, and marine micaceous feldspathic sandstone and siltstone; in the Summit Creek area southeast of Mount Rainier, dense, sparsely phyric clinopyroxene basalt interbedded with silicic tuff, argillite, and feldspathic and volcaniclastic fluvial sedimentary rocks; on Teanaway Ridge, dense to glassy pyroxene and rare olivine basalt and basaltic andesite with mafic tuff and minor intermediate volcanic rocks, rhyolite tuffs, and feldspathic sandstone and siltstone; north of Manastash Ridge, microporphyritic olivine basalt with interbedded mafic tuff; north of the Little Naches River, altered aphyric to porphyritic pyroxene basalt, olivine-clinopyroxene basalt and pyroxene basaltic andesite, feldspathic sandstone and siltstone. Includes basalt of Summit Creek (Vance and others, in press), Teanaway Formation, basalt of Frost Mountain (Tabor and others, 1982), part of the Naches Formation, and volcanic rocks of Grays River [The Grays River unit includes rocks previously mapped as the Goble Volcanics Member of the Cowlitz Formation by Henriksen (1956), Goble Volcanics by Livingston (1966), volcanic rocks within the Cowlitz Formation by Livingston (1966), and volcanic rocks of Unit B by Wolfe and McKee (1972); see Phillips, 1987a, and Walsh, 1987a]

Volcaniclastic Rocks

Evc **Volcaniclastic rocks**—Andesitic volcaniclastic breccia, conglomerate, lithic tuff, volcanic sandstone, and siltstone; commonly interbedded with feldspathic sandstones and andesite flows; north of the Puyallup River, breccias and conglomerate of probable mudflow origin dominate; between the Puyallup and Nisqually Rivers and north of the Skookumchuck River, dominantly volcanic sandstones and siltstones, with lesser interbedded breccia and conglomerate. Includes part of the Northcraft Formation (Gard, 1968; Buckovic, 1974; Hagen, 1987)

Evt **Tuff**—Mafic and silicic tuff; in the Willapa Hills area, subaqueous, massive to well-bedded, palagonitic basaltic lapilli tuff and tuff breccia, basaltic sandstone, siltstone, and conglomerate; in the Cascade Range, the tuffs are silicic crystal lithic and pumiceous. Includes Pe Ell Volcanics Member of the Cowlitz Formation (Henriksen, 1956) and welded tuff at Spencer Creek (Swanson, 1964)

Crescent Formation Lava Flows and Volcaniclastic Rocks

EvC **Lower to middle Eocene Crescent Formation**—Fine-grained, dominantly submarine tholeiitic basalt flows and flow breccia, typically with zeolitic or chloritic alteration; pillows and altered palagonite common; locally contains thin interbeds of basaltic tuff and siltstone with foraminiferal faunas referable to the Ulatisian Stage; probably originated as mid-ocean ridge basalt and as seamounts; accreted to continent by middle Eocene time (about 48 m.y. ago); forms basement in the Coast Range

PRE-TERTIARY VOLCANIC ROCKS

Lava Flows

pTvr **Rhyolite**—Altered silicic volcanic rocks that have foliation well defined by aligned muscovite that wraps around relict quartz phenocrysts; locally deformed into sharp-hinged folds; originally may have been rhyolitic flows. May be part of the Russell Ranch Formation

CRETACEOUS-JURASSIC VOLCANIC ROCKS

Lava Flows

KJv **Basalt flows**—Fault-bounded greenstone unit consisting of pillowed lavas and minor shale interbeds. May be part of the Russell Ranch Formation

KJmv **Metavolcanic rocks**—Tectonic blocks of pillowed green-stone in metasedimentary units of the Russell Ranch Formation; original mineralogy was augite and calcic plagioclase; metamorphosed to greenschist facies. Consists of part of the Russell Ranch Formation

INTRUSIVE ROCKS AND LAVA DOMES

See pamphlet for intrusive rock classification.

QUATERNARY INTRUSIVE ROCKS

Intermediate

Qida **Intrusive dacite**—Hornblende-hypersthene and hypersthene dacite, and andesite, forming Holocene domes on Mount St. Helens (Hopson, 1980) and Pleistocene domes at Butte Camp (Hopson, 1980), Tumtum Mountain (Mundorff and Eggers, in press), and near the headwaters of the Kalama River (Hopson, 1980)

Qian **Intrusive andesite**—Olivine andesite and light-gray to yellow, deeply altered andesite that forms plugs, dikes, and small vent complexes on Mount Rainier

PLEISTOCENE-PLIOCENE INTRUSIVE ROCKS

Intermediate

QPida **Intrusive dacite**—Dacite domes and plugs; at Goat Mountain, southwest of Mount St. Helens, light-gray biotite-hornblende-quartz dacite porphyry plug; at Gross Mountain east of the Little White Salmon River, light-gray porphyritic hypersthene dacite. Includes Goat Mountain plug (Hammond, 1980) and dacite dome of Gross Mountain (Sheppard, 1964)

QPian **Intrusive andesite**—Plugs and dikes of pyroxene andesite, basaltic andesite, and hornblende andesite of the Goat Rocks area

PLIOCENE INTRUSIVE ROCKS

Intermediate

Pida **Intrusive dacite**—Porphyritic dacite domes, plugs, and stocks; northeast of the Goat Rocks, consists of several small stocks and plugs of pale brown to gray, fine- to medium-grained biotite-hornblende dacite; between the Wind and Little White Salmon Rivers, dacite forms a hypabyssal stock at Hauk Butte and a hornblende dacite to porphyritic diorite stock north of Wind Mountain; in the Simcoe Mountains, light- to dark-gray olivine-hypersthene-clinopyroxene dacite domes

Piq **Quartz diorite**—Light-gray to brownish-gray, porphyritic hypersthene-biotite-quartz diorite, and hornblende-quartz diorite forming a composite plug, and hornblende diorite; contains xenoliths of Grande Ronde Basalt (unit Mvg). Consists of the Wind Mountain quartz diorite (Wise, 1970)

Pian **Intrusive andesite**—Shallow stocks and plugs of hornblende andesite; may be of late Miocene age

MIOCENE INTRUSIVE ROCKS

Acidic

Mir **Intrusive rhyolite**—Rhyolite dikes, sills, plugs, domes, and shallow stocks; commonly white to tan, fine-grained felsite; may contain welded tuffs; in the Bumping Lake area, coarsely porphyritic rhyolite with phenocrysts of biotite, hornblende, and quartz; at Clear West Peak, mostly gray to purple, highly altered, sparsely plagioclase-phyric, devitrified rhyolite with vertical banding (suggesting intrusive origin); at Mann Butte, grayish-yellow aphanitic rhyolite forming a pervasively brecciated plug or dome; at Spud Hill, white to gray, unaltered, aphyric, microcrystalline biotite-quartz rhyolite plug. Includes Clear West complex (Fischer, 1970) and rhyolite of Mann Butte (Hammond, 1980)

Mia **Acidic intrusive rocks**—Sills, dikes, plugs, and stocks of acidic composition, including granite, granodiorite, and quartz monzonite; at Mount Rainier, light-colored hypabyssal intrusive rock gradational from diorite to quartz monzonite, dominantly granodiorite and quartz monzonite. Includes the Bumping Lake pluton (Simmons and others, 1983), part of the Tatoosh pluton (Fiske and others, 1963), and argillically altered parts of the Spirit Lake pluton (Evarts and Ashley, 1984)

Mig **Granite**—Medium-grained equigranular and porphyritic granite. Consists of part of the Tatoosh pluton (Fiske and others, 1963)

Miqm **Quartz monzonite**—Fine- to medium-grained quartz monzonite; north of Mount St. Helens, fine- to medium-grained, commonly deuterically altered, sparsely porphyritic and miarolitic pyroxene-hornblende quartz monzonite, granite, and aplite; in Mount Rainier area, fine-grained biotite-hornblende quartz monzonite; locally porphyritic. Includes part of the Spirit Lake pluton (Evarts and Ashley, 1984) and part of the Tatoosh pluton (Fiske and others, 1963)

Migc **Granodiorite**—Porphyritic to equigranular, fine- to medium-grained, hornblende-biotite or pyroxene granodiorite and lesser quartz monzonite and quartz diorite; north of Spirit Lake, consists of complex dike swarms of deuterically altered granodiorite and quartz diorite with numerous screens of hornfelsed country rock. Includes the White River pluton (Hammond, 1980), the Carbon River stock (Fischer, 1970), and part of the Silver Star pluton (Felts, 1939), part of the Tatoosh pluton (Fiske and others, 1963), and part of the Spirit Lake pluton (Evarts and Ashley, 1984)

Intermediate

Mida **Intrusive dacite**—Gray porphyritic hornblende and pyroxene dacite sills, dikes, domes, and small or shallow stocks; commonly altered

Miq **Quartz diorite**—Equigranular to porphyritic quartz diorite; at Silver Star Mountain, uralitized pyroxene quartz diorite; north of Spirit Lake, pyroxene quartz diorite to quartz monzonite bodies that have subtle, gradational contacts and pervasive deuteric alteration; forms smaller quartz diorite bodies in the Cascades. Includes McCoy Creek quartz diorite (Link, 1985), part of the Silver Star pluton (Felts, 1939), part of the Spirit Lake pluton (Evarts and Ashley, 1984), and part of the Tatoosh pluton (Fiske and others, 1963)

Mian **Intrusive andesite**—Dark- to medium-gray, aphanitic to porphyritic pyroxene and hornblende andesite and basaltic andesite; forms numerous dikes, sills, small plugs, and stocks throughout the Cascades

Mid **Diorite**—Fine- to medium-grained and commonly porphyritic pyroxene diorite, pyroxene-hornblende diorite, and hornblende diorite; occurs as sills, dikes, small stocks, and cupolas of major plutons; contains lesser quartz diorite. Includes Saturday Rock pluton (Hammond, 1980) and part of the Silver Star pluton (Felts, 1939)

Basic

Mib **Basic intrusive rocks**—Fine-grained to aphanitic basalt and basaltic andesite sills and dikes

Migb **Gabbro**—Diabase and gabbro sills, dikes and stocks; at Box Canyon near Mount Rainier, forms a large sill complex of dark-colored glomeroporphyritic augite diabase and minor basalt; north of Wind Mountain, forms a dark gray to black porphyritic plagioclase-hypersthene gabbro plug; at Bunker Hill in the Wind River valley, forms a black, coarse-grained augite gabbro plug that has a deuterically altered margin

Intrusive-Volcanic Complex

Miv **Intrusive-volcanic complex**—Intrusive and extrusive dacitic vitrophyres and breccias; breccias are highly altered and partially recrystallized; vitrophyres include glassy flows and probable welded tuffs; these rocks are cut by a silicic sill swarm that may not be related to the original complex activity. Consists of Skyscraper Mountain complex (Thompson, 1983)

MIOCENE-OLIGOCENE INTRUSIVE ROCKS

Intermediate

MOida **Intrusive dacite**—White to light-gray, aphyric to plagioclase-hornblende-phyric, commonly altered dacite sills, dikes, domes, and small stocks

MOian **Intrusive andesite**—Aphyric to porphyritic hornblende-, pyroxene-, and hornblende-pyroxene andesite stocks, sills, dikes, and dike swarms; commonly altered

MOid **Diorite**—Porphyritic pyroxene- and hornblende-diorite dikes and stocks; commonly altered

Basic

MOib **Basic intrusive rocks**—Aphanitic and plagioclase-phyric basalt, augite, and hypersthene-augite diabase and porphyritic pyroxene gabbro dikes and sills

Intrusive-Volcanic Complex

MOiv **Intrusive-volcanic complex**—Thick, heterogeneous, and disrupted assemblage of volcanic rocks, including andesite porphyry flows, interbedded volcaniclastic rocks, and dacitic tuffs and breccias with both extrusive and intrusive characteristics. Consists of the Mount Aix volcanic complex (Schreiber, 1981)

EOCENE INTRUSIVE ROCKS

Acidic

Eiqm **Quartz monzonite**—Two-phase stock consisting of blocky jointed granophyric, porphyritic quartz monzonite and granodiorite. Consists of the Ordway Creek stock (Livingston, 1966)

Intermediate

Eida **Intrusive dacite**—Fine-grained, granular, glomeroporphyritic, hornblende hypersthene dacite porphyry. Consists of andesite of Peoh Point (Tabor and others, 1982)

Basic

Eib **Basic intrusive rocks**—Gabbro, diabase, and basalt dikes and sills; in the Willapa Hills, flow-banded and vesicular sill complex whose interiors are coarse-grained to pegmatitic gabbro and margins are columnar-jointed basalt; south of Cle Elum and on Teanaway Ridge, black, fine- to medium-grained clinopyroxene diabase and gabbro dikes; elsewhere, small gabbro, diabase, and basalt intrusions

JURASSIC INTRUSIVE ROCKS

Intermediate

Jiq **Upper Jurassic quartz diorite**—At Quartz Mountain medium-grained hornblende meta-quartz-diorite and metagranodiorite stock; near White Pass, minor diorite and gabbro intruded by voluminous quartz diorite, which is in turn intruded by trondhjemite dikes; some intrusions are weakly foliated. Consists of Quartz Mountain quartz diorite (Goetsch, 1978), parts of the Indian Creek complex (Miller, 1985), and the Peninsula tonalite (Swanson, 1964)

METAMORPHIC ROCKS

JURASSIC METAMORPHIC ROCKS

Jsh **Schist**—Very fine grained albite-epidote-chlorite greenschist and blueschist with minor intercalations of ironstone and ferruginous quartzite in the greenschist; commonly highly foliated and well recrystallized, but locally, relict textures suggest derivation from porphyritic volcanic rocks, tuffs, and rare mafic intrusive rocks; locally interbedded with phyllite. Probable Late Jurassic protolith age and Early Cretaceous metamorphic age. Includes parts of the Easton Schist

Jph **Phyllite**—Very fine grained, black to gray, graphitic chlorite-sericite-quartz phyllite; commonly highly crinkled; locally interbedded with greenschist and blueschist. Probable Late Jurassic protolith age and Early Cretaceous metamorphic age. Consists of parts of the Easton Schist

Jog **Orthogneiss**—Well foliated, metaplutonic rocks of intermediate composition, primarily quartz diorite gneiss, with minor local amphibolite at Indian Creek. Consists of the tonalite gneiss of Hicks Butte (Frizzell and others, 1984) and parts of the Indian Creek complex (Miller, 1985)

PRE-JURASSIC METAMORPHIC ROCKS

pJsc **Schist**—Very fine grained graphitic garnet biotite schist, locally with staurolite, andalusite, and rare cordierite; relict bedding common; intruded by a quartz diorite that has an age of about 157 m.y. (Frizzell and others, 1984); contains unmapped bodies of metatonalite and gabbro. Consists of the Lookout Mountain Formation

pJam **Amphibolite**—Very fine grained schistose epidote amphibolite with minor mica schist, metadiorite, metagabbro, and cataclastic hornblende tonalite gneiss

OTHER

tz **Tectonic zone**

Geologic Symbols

contact
concealed

fault
approximately located
concealed

thrust fault (teeth on upper plate)
approximately located
concealed

volcanic vent

Please refer to the published paper version of GM-34 for correlation of map units diagrams, REFERENCES CITED, sources of map data, and further discussion