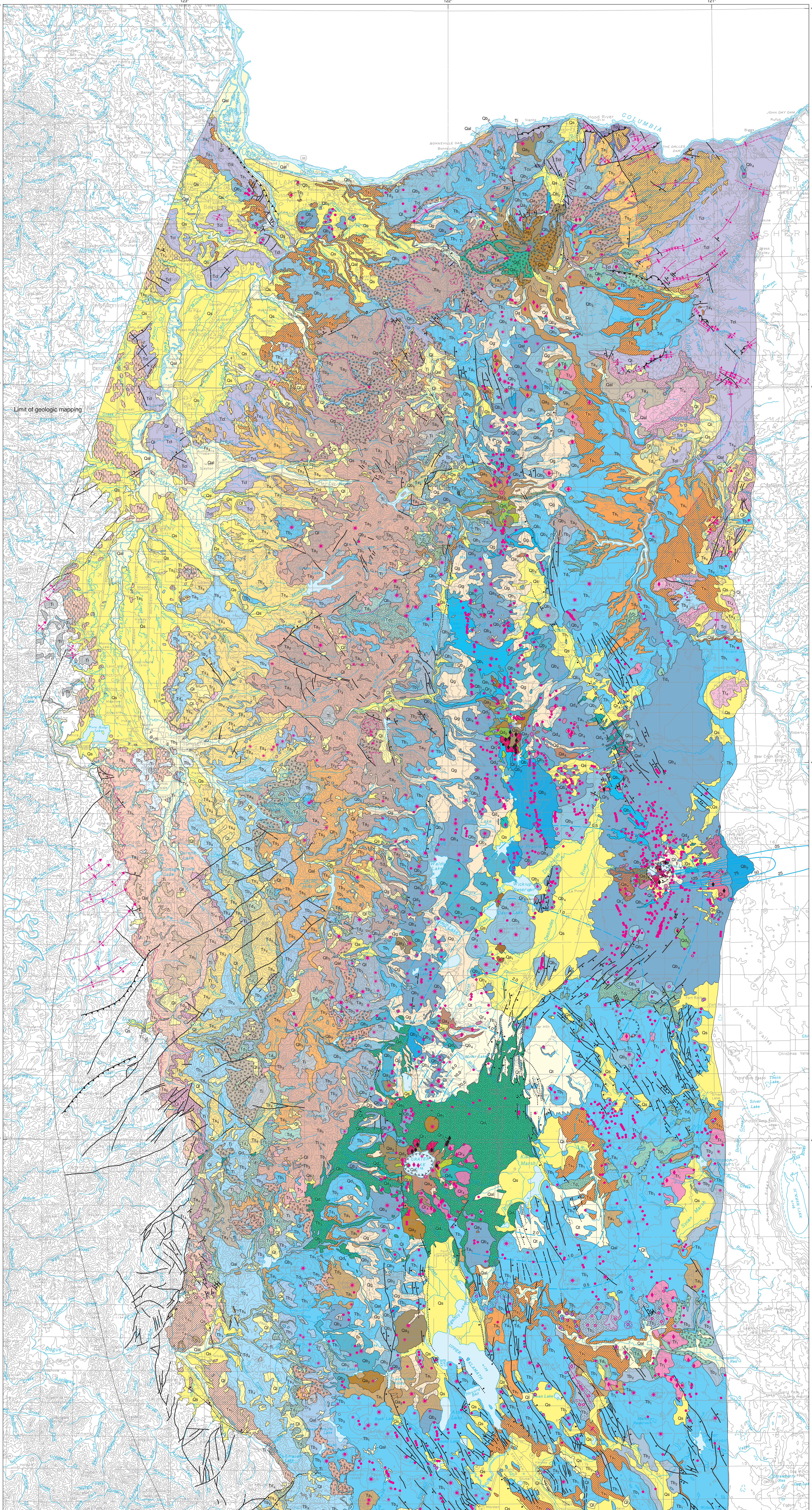
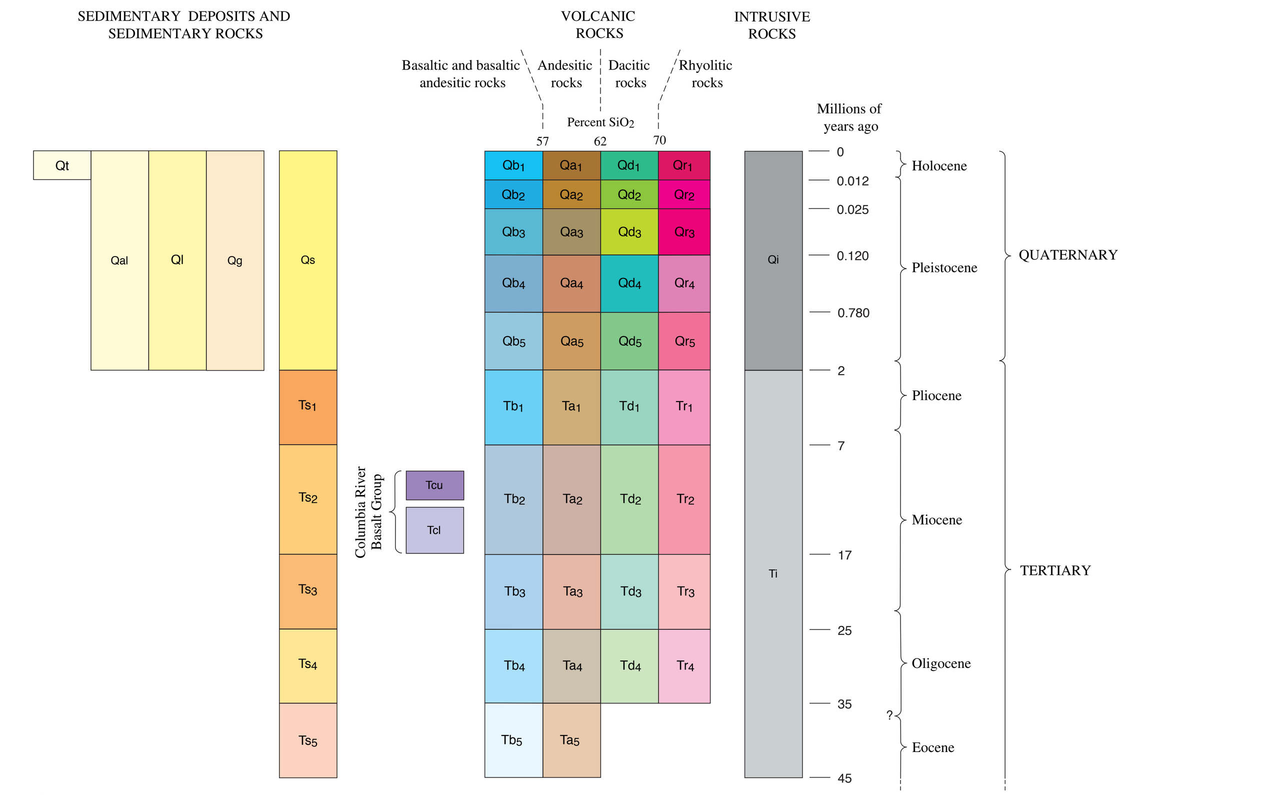


CORRELATION OF MAP UNITS[1]



[1]Time scale of Harland and others (1982) and Cande and Kent (1995)

DESCRIPTION OF MAP UNITS

SEDIMENTARY DEPOSITS AND SEDIMENTARY ROCKS

Qt — **Young tephra (Holocene)**—Fallout lapilli and ash. Mapped only where large areas of bedrock are completely blanketed. Unit consists of Mazama ash bed (Powers and Wilcox, 1964), which is a rhyolitic air-fall tephra (SiO_2 = 70-71 percent) erupted about 6,850 ^{14}C years ago (Bacon, 1983) from Crater Lake caldera. Mazama ash thickly veneers areas as distant as 50 km north, northeast, and east of caldera. Mazama ash has been identified as far away as Alberta, British Columbia and Utah; in British Columbia it is thicker than 1 cm (Powers and Wilcox, 1964). Thickest known deposits (20 m) lie just beyond caldera rim (Bacon, 1983) and east of Mount Thielsen (Sherrod, 1991). Isopachs shown in blue on map. Unit also includes undifferentiated Holocene pumice and ash on upper flanks of Newberry volcano that accumulated during several eruptions from intracaldera vents; youngest eruption occurred about 1,300 ^{14}C years ago (MacLeod and others, 1995)

Qal — **Alluvium (Holocene and Pleistocene)**—Poorly to moderately sorted sand, gravel, and silt deposited in valleys of active major streams. Many small areas omitted for clarity. Locally includes glacial and alluvial fan deposits

Ql — **Landslide deposits (Holocene and Pleistocene)**—Debris from mass-wasting processes, including slumps, earth flows, block glides, and rock falls. Landslides are most common where competent lava flows overlie weaker sediment or ash flows. Landslides that cover less than a few square kilometers are generally not shown

Qg — **Glacial deposits (Holocene and Pleistocene)**—Unconsolidated to moderately indurated, slightly to deeply weathered till that forms moraines and drift sheets mainly limited to middle elevations of High Cascades subprovince. Locally includes glacial outwash and related glaciofluvial and glaciolacustrine deposits. Many small areas omitted for clarity, especially moraines and till in mountain valleys and cirques. Chiefly younger than about 140,000 years (140 k.y.). Older tills, which in large part are unmapped and unstudied, crop out in lower elevations of major canyons in Western Cascades subprovince but are included in unit Qs

Qs — **Quaternary sediment and sedimentary rocks, undivided**—Mostly unconsolidated sand, gravel, and lacustrine deposits. Commonly includes deposits mapped by original authors as older alluvium, terrace deposits, upland gravel, basin-filling sediment, or undifferentiated Quaternary sediment. Along Columbia River, includes flood deposits resulting from numerous catastrophic emptyings of glacial Lake Missoula approximately 13,000 years ago (13 k.y.). In Willamette Valley, includes Willamette Silt (Allison, 1953; Hampton, 1972). Along west margin of Cascade Range, includes high-standing terraces that probably developed during Pleistocene glaciations. Along east side of Cascade Range, includes extensive distal outwash fans. In parts of La Pine valley and in Upper and Lower Klamath Lake basins, includes graben-filling sediment at least 400 m thick derived from Cascade Range and Newberry volcano (Sammel and Peterson, 1976; Veen, 1982; Couch and Foote, 1985)

Ts1, Ts2, Ts3, Ts4, Ts5 — **Tertiary sedimentary rocks**—Rocks ranging in age from 2 to approximately 45 millon years (m.y.). Ts_1, 2 to 7 m.y.; Ts_2, 7 to 17 m.y.; Ts_3, 17 to 25 m.y.; Ts_4, 25 to 35 m.y.; Ts_5, 35 to 45 m.y.

Patterns—In addition to primary age designation shown by color, patterns may be used to indicate different kinds of Tertiary sedimentary rocks:

No pattern — **Dominantly volcaniclastic sandstone, siltstone, granule conglomerate, and mudstone closely related to volcanic processes in time and location**—Sedimentary units shown without pattern correspond to fine alluvial facies and distal part of coarse alluvial facies of Smedes and Prostka (1972) and to distal volcaniclastic facies and outer part of medial volcaniclastic facies of Vessell and Davies (1981). Sandstone, siltstone, granule conglomerate, and mudstone dominate. Most sequences include beds interpreted as debris-flow deposits, hyperconcentrated stream-flow deposits, and ash-flow tuff. Excluded are sedimentary sequences whose origin and mode of formation are not closely related to active volcanism, even where individual beds contain substantial volcanic detritus. Beds are generally a few centimeters to 1 m thick. Unit grades laterally and vertically into other sedimentary or volcanic rock units as proportion of other rock types increases.

Sedimentary units shown without pattern formed predominantly by reworking of penecontemporaneous primary volcanic deposits or, less commonly, directly from volcanic processes. Most beds formed as a result of erosion and redeposition of primary volcanic or volcaniclastic deposits that were presumedly mostly unconsolidated and probably gravitationally unstable. Tops, distal parts, and aquagene parts of mass-flow deposits are particularly susceptible to reworking into better sorted and finer grained beds. Large volumes of volcaniclastic material may be quickly transported and redeposited to form these sequences.

Beds that have quite different mechanisms of sediment transport and deposition are interlayered in this unit. A typical stratigraphic section would be dominated by volcanic graywacke, sandstone, and siltstone but would contain interbeds of coarse volcanic diamicton and ashy tuff. Volcanic graywacke, sandstone, and siltstone beds are thin to medium bedded and fine grained. They typically show sedimentary structures indicating transport by normal stream flow and deposition by traction-dominated, grain-by-grain mechanisms. Diamictons are dominantly matrix supported and have planar bed forms. Beds are 0.5 to 3 m thick. Angular volcanic clasts are the dominant constituent of their coarse fraction. Beds of diamicton show features typical of transportation by debris flows or hyperconcentrated stream flows and deposition en masse (Janda and others, 1981; Smith, 1986; Pierson and Costa, 1987), although a few volcanic diamictons are ash-flow tuffs. Ashy tuffs, in contrast, are generally thin and average grain size is less than 0.5 mm; they are interpreted as having been deposited from ash falls because of their fine grain size and because they mantle preexisting topography.

All components of unit are believed to have been deposited at some distance from volcanic sources (5-10 km or more). Graywacke, sandstone, and siltstone are interpreted as channel and overbank deposits that accumulated on aggrading volcanic dispersal aprons with relatively low gradients. Volcanic diamictons probably moved off flanks of active volcanoes as channelized mass flows that choked existing streams and then spread over distal parts of aggrading volcanic aprons as thin sheets. Ash-flow tuffs also probably followed existing valleys off flanks of active volcanoes and spread out over aggrading volcanic aprons.

Some rocks included in unit, such as air-fall tuff, formed directly from volcanic processes

Continental sedimentary rocks not directly related to volcanic processes—Dominantly sandstone, conglomerate, and mudstone that lack primary volcanic detritus. Sediment interpreted as being deposited far from active volcanoes or deposited during periods of volcanic quiescence. Also includes volcaniclastic sediment that was transported by normal fluvial and eolian processes and not in direct response to penecontemporaneous volcanic activity. Commonly, sediment was deposited in alluvial fans, along river valleys, or in freshwater lakes. Includes deposits described in original sources as older alluvium, terrace deposits, stream deposits, some glacial outwash deposits, alluvial fans, lacustrine sediment, windblown deposits, conglomerate, sandstone, siltstone, shale, and coal

Marine, brackish-water, and deltaic sedimentary rocks—Mostly sandstone, siltstone, shale, and mudstone. Includes minor coal and conglomerate. Sediment interpreted as being deposited in open ocean, in estuaries, in brackish-water swamps, or in deltas. In many places, rocks formed in these different environments are interbedded. Includes deposits described in original sources as mostly sandstone, siltstone, mudstone, shale, coal, and conglomerate. Because of their fine grain size and abundant weathered component of uncertain provenance, it is difficult to determine if specific lithologic units were deposited in response to volcanic events. On this map, marine rocks are limited to Eocene and lower Oligocene strata at west edge of Cascade Range

VOLCANIC ROCKS

Basaltic and basaltic andesitic rocks

Columbia River Basalt Group (Miocene)—Comprises voluminous tholeiitic basalt flows of Miocene age. Most lava issued from dike swarms located 400 km east of Cascade Range, flowed west across area of present-day Columbia Plain, and lapped against older rocks of Cascade Range. Some lava flooded through low gaps in the range in northern Oregon and southern Washington. Although not part of Cascade-arc volcanism, the Columbia River Basalt Group forms an important stratigraphic horizon. Informally divided into:

Tcu — **Upper part**—The Saddle Mountains Basalt as defined by Swanson and others (1979). Unit forms about 2 percent of total volume of Columbia River Basalt Group (Tolan and others, 1989) and was erupted between 13.5±3 and 6 m.y. ago. All members of unit, except the Pomona Member, are restricted to Columbia Plain east of map area. The 12-m.y.-old Pomona Member followed approximate course of modern Columbia River through Cascade Range (Anderson, 1980; Tolan and Beeson, 1984). Potassium-argon ages (Swanson and others, 1979) indicate that the Pomona Member erupted between about 12 and 10.5 m.y. ago; preferred age of the Pomona is 12 m.y., according to D.A. Swanson (oral commun., 1987). A few outcrops of the Pomona in Columbia River Gorge (Anderson, 1980) are too small to show at map scale

Tcl — **Lower part**—The Wanapum and Grande Ronde Basalts as defined by Swanson and others (1979). The older Grande Ronde Basalt is the most widespread unit of the Columbia River Basalt Group in Cascade Range. In the overlying Wanapum Basalt, only the Frenchman Springs Member is widely distributed in Cascade Range. The Priest Rapids Member of the Wanapum defines a narrow intracanyon path along axis of Bull Run syncline in northern Oregon (Vogt, 1981); other members never crossed the range. Potassium-argon ages (Swanson and others, 1979; McKee and others, 1977; Tolan and others, 1989), as well as structural data (Reidel, 1984), suggest that the Wanapum and Grande Ronde Basalts were erupted between 14.5 and 17 m.y. ago

Qb1, Qb2, Qb3, Qb4, Qb5 — **Quaternary basaltic and basaltic andesitic rocks**—Dominantly lava flows but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 0 to 2 m.y. Qb_1, 0 to 12 k.y.; Qb_2, 12 to 25 k.y.; Qb_3, 25 to 120 k.y.; Qb_4, 120 to 780 k.y.; Qb_5, 780 k.y. to 2 m.y.

Tb1, Tb2, Tb3, Tb4, Tb5 — **Tertiary basaltic and basaltic andesitic rocks**—Dominantly lava flows but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 2 to approximately 45 m.y. Tb_1, 2 to 7 m.y.; Tb_2, 7 to 17 m.y.; Tb_3, 17 to 25 m.y.; Tb_4, 25 to 35 m.y.; Tb_5, 35 to 45 m.y.

Andesitic rocks

Qa1, Qa2, Qa3, Qa4, Qa5 — **Quaternary andesitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 0 to 2 m.y. Qa_1, 0 to 12 k.y.; Qa_2, 12 to 25 k.y.; Qa_3, 25 to 120 k.y.; Qa_4, 120 to 780 k.y.; Qa_5, 780 k.y. to 2 m.y.

Ta1, Ta2, Ta3, Ta4, Ta5 — **Tertiary andesitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 2 to approximately 45 m.y. Ta_1, 2 to 7 m.y.; Ta_2, 7 to 17 m.y.; Ta_3, 17 to 25 m.y.; Ta_4, 25 to 35 m.y.; Ta_5, 35 to 45 m.y.

Dacitic rocks

Qd1, Qd2, Qd3, Qd4, Qd5 — **Quaternary dacitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 0 to 2 m.y. Qd_1, 0 to 12 k.y.; Qd_2, 12 to 25 k.y.; Qd_3, 25 to 120 k.y.; Qd_4, 120 to 780 k.y.; Qd_5, 780 k.y. to 2 m.y.

Td1, Td2, Td3, Td4 — **Tertiary dacitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 2 to approximately 35 m.y. Td_1, 2 to 7 m.y.; Td_2, 7 to 17 m.y.; Td_3, 17 to 25 m.y.; Td_4, 25 to 35 m.y.

Rhyolitic rocks

Qr1, Qr2, Qr3, Qr4, Qr5 — **Quaternary rhyolitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 0 to 2 m.y. Qr_1, 0 to 12 k.y.; Qr_2, 12 to 25 k.y.; Qr_3, 25 to 120 k.y.; Qr_4, 120 to 780 k.y.; Qr_5, 780 k.y. to 2 m.y.

Tr1, Tr2, Tr3, Tr4 — **Tertiary rhyolitic rocks**—Dominantly lava flows and domes but includes some near-vent breccia and pyroclastic rocks. Rocks range in age from 2 to approximately 35 m.y. Tr_1, 2 to 7 m.y.; Tr_2, 7 to 17 m.y.; Tr_3, 17 to 25 m.y.; Tr_4, 25 to 35 m.y.

Patterns—In addition to primary age and composition of volcanic rocks shown by color, patterns may be used to indicate volcanic facies:

No pattern — **Volcanic rocks deposited mostly near vents**—Units shown without pattern are products of concurrent volcanism and deposition, and they generally correspond to vent facies of Smedes and Prostka (1972) or to core facies and proximal volcaniclastic facies of Vessell and Davies (1981). Also includes lava that flowed down valleys or spread over lowlands far removed from vents. Typical constructional volcanic features include composite volcanoes, shield volcanoes, domes, and smaller monogenetic volcanoes. Larger volcanic edifices commonly intertongue with each other and with rocks of other map units (see figure 2); most intertonguing relations are too detailed to show at map scale. Vent areas, particularly those of composite and shield volcanoes, contain lava flows, flow breccia, and near-vent pyroclastic deposits, which generally cannot be separated at scale of this map. Constructional volcanic edifices older than a few million years are generally poorly preserved and difficult to recognize

Volcanic diamicton—Unsorted to poorly sorted, poorly layered to well-layered deposits of direct volcanic origin that contain a wide range of clast sizes. Corresponds to more distal part of vent facies of Smedes and Prostka (1972) and medial volcaniclastic facies of Vessell and Davies (1981). Deposited from cold- or warm-fluid flows that moved rapidly downslope propelled by gravity. Commonly described by other authors as catastrophic. Includes mudflow deposits, some mass-flow deposits not further described in source reports, debris flows, landslides triggered by volcanic action, some block-and-ash flows, some deposits designated only as tuff breccia, and deposits mapped as volcanic diamicton but not more specifically identified. Also includes young mudflow deposits and debris-flow deposits downstream from major volcanoes. Lava flows are rare

Pyroclastic-flow deposits—Most are poorly sorted, thin, rich in lithic clasts, and nonwelded to partly welded. Pumice is common in ash-flow tuff but not in block-and-ash deposits. Plagioclase is most common phenocryst and may constitute as much as 20 percent of some deposits. Variable amounts of clinopyroxene, orthopyroxene, and amphibole are also present but rarely total more than 5 percent. Biotite or quartz present in only a few tuffs; sanidine found only in upper Eocene and Oligocene tuff east of Cascade Range. Deposited from hot dry flows of particulate volcanic rock, intermixed air, and volcanic gas that move rapidly downslope propelled by gravity. Pyroclastic-flow deposits generally make up a greater proportion of stratigraphic sequences near volcanoes' summits, but classification of these mixed sequences at this map scale is arbitrary. Volcaniclastic aprons generally grade downstream into sequences in which volcanic diamictons are dominant.

In strata older than 10 m.y., pyroclastic-flow deposits, which were emplaced hot, are commonly difficult to distinguish from mass-flowage deposits, which were emplaced cold. In many places, lithostatic loading compacted both kinds of deposits and flattened pumice clasts. Widespread, very low grade metamorphic recrystallization of unstable glass, devitrified glass, and vapor-phase alteration minerals created fine-grained aggregates of metamorphic minerals dominated by zeolites and smectitic phyllosilicates.

Determining original chemical composition is also difficult. Most pyroclastic-flow deposits contain extraneous lithic clasts—as much as 20 percent in some beds. Extensive low-grade metamorphic recrystallization may also have changed chemical composition of some deposits. Present-day temperate-humid climate favors thorough chemical weathering of these very low grade metamorphic rocks, further altering their original chemistry. Most pyroclastic-flow deposits are presumed to be andesite or dacite, although some are rhyolite

Subaerial and subaqueous deposits of basaltic ejecta—Palagonite tuff cones and rings. Shown in southeast corner of map where basalt (Tb_1) includes overlapping gently to steeply sloping pyroclastic cones of once-glassy but now altered detritus that resulted from interaction between magma and ground water or surface water. Individual vents interpreted from outwardly dipping beds and shown by separate symbol (maar, palagonite tuff ring, or tuff cone, explained below). Elsewhere on map, shown only by vent symbol, which encompasses areal extent of individual cones and rings

INTRUSIVE ROCKS

Qi — **Intrusive rocks (Quaternary)**—Includes rocks that have a wide variety of textures and compositions. Most common are small, fine-grained plugs with andesite or basaltic andesite composition. Dikes omitted for clarity

Ti — **Intrusive rocks (Tertiary)**—Sills, plugs, and stocks that have a wide variety of textures and compositions. Most common are sills, plugs, and stocks forming small, fine-grained to aphanitic intrusions with basaltic to andesitic composition. Dikes omitted for clarity

Rocks not related to Cascade arc

Contact—Dotted where concealed

Contact between individual coalesced volcanoes or areas with different overprint patterns within same map unit

Faults—Dashed where approximately located, dotted where concealed

Normal fault—Ball and bar on downthrown side, where known

Thrust or high-angle reverse fault—Sawteeth on upper plate. In map area, thrust or high-angle reverse faults occur on northeast flank of Tualatin Mountains ("Portland Hills" is common local usage), in Mount Hood area, on Columbia Plain from Columbia River south to Mutton Mountains, and in southern Coast Range

Folds—Dashed where approximately located, dotted where concealed. Showing crestline and direction of plunge, where known

Anticline

Syncline

Monocline—Shown only on Columbia Plain

Abrupt decrease of dip in direction of arrows

Abrupt increase of dip in direction of arrows

Vents—

• or • — **Cinder cone, spatter cone, small intraglacial vent, or other small cone**—Chiefly basaltic to andesitic, but a few are dacitic and one is rhyolitic (Central Pumice Cone in Newberry caldera). Except for the Newberry cone, symbol shown within areas mapped as rhyolite or dacite indicates isolated basaltic to andesitic vents that lack related lava flows. Shown in black where color indistinct from associated map unit

♦ or ♦ — **Dome**—In rocks older than a few million years, distinguishing individual domes is possible only locally, and for these rocks, symbol generally indicates presence of complex dome field instead of individual domes. Domes shown in Crater Lake are postcaldera constructional features sampled by dredging. Shown in black where color indistinct from associated map unit

Shield volcano, lava cone, andesitic cone, or large mafic volcano

Composite volcano

Maar, palagonite tuff ring, or tuff cone—Volcanoes whose grain size and cone shape result from interaction between magma and ground water or surface water. Includes intraglacial deposits of palagonite, palagonitized tuff, and pillow basalt (for example, möbergs and tuyas). All such vents shown on map are basalt or basaltic andesite in composition, although magma of any composition is capable of water-related explosive fragmentation. Where shown within areas mapped as rhyolite or dacite, symbol indicates mafic vents that lack related lava flows

Small volcano, undivided

Caldera margin, buried or flooded—Showing approximate outline of known or inferred lithologic or structural margin that in most places corresponds to ring faults. Hachures point toward center of caldera. Calderas are shown east of Cascade Range crest at Yamsay Mountain, Bald Mountain, and Newberry volcano; Crater Lake in High Cascades (shown flooded); and an inferred buried caldera in Western Cascades 30 km east of Medford

Pumice and ash isopachs—Showing thickness of fallout deposits. Data from MacLeod and others, 1995; MacLeod and Sherrod, 1992 (see sheet 2); Sherrod and Pickthorn, 1992 (see sheet 2); and Sherrod, 1991

Newberry pumice deposits (contours in centimeters)

75 — **Mazama ash deposits (contours in meters)**

0.2

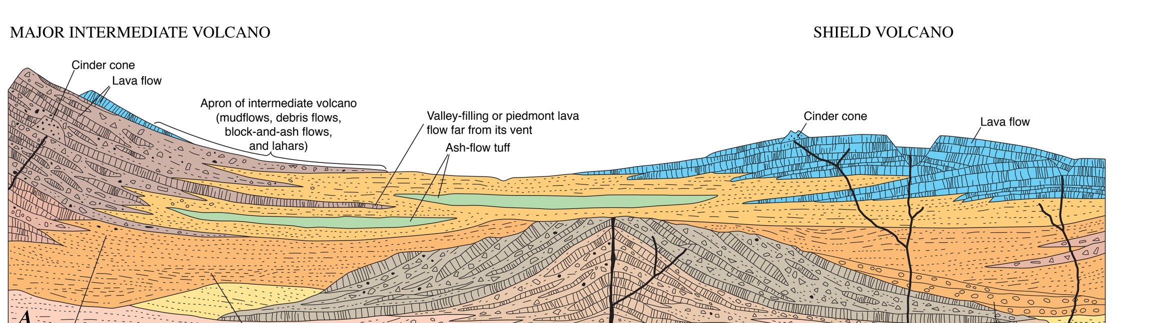
Base from U.S. Geological Survey, 1964-65 (revised 1982)
Lambert conformal conic projection
Standard parallels 33 and 45
Central meridian 122

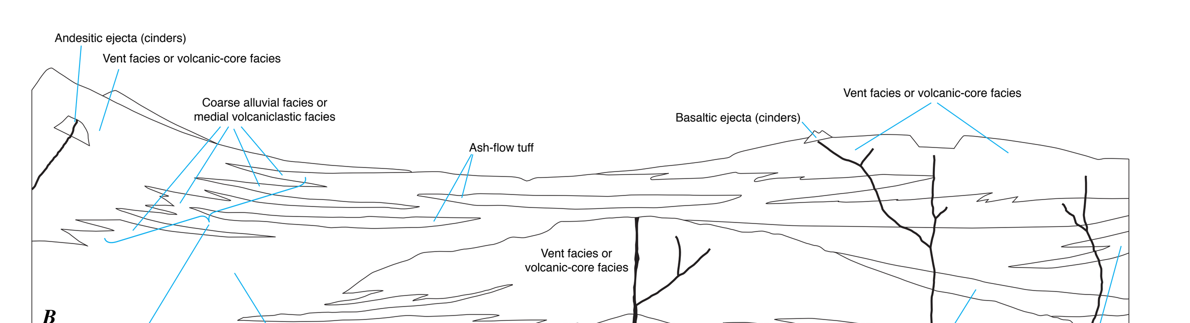
SCALE 1:500 000
CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

AREA OF MAP

Geology compiled by D.R. Sherrod from published and unpublished mapping listed in "Sources of mapping"
Edited by Julia Thomas
Digital cartography by Kathryn Nimz and Kevin A. Ghequiere
Manuscript approved for publication March 15, 1996

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—2000





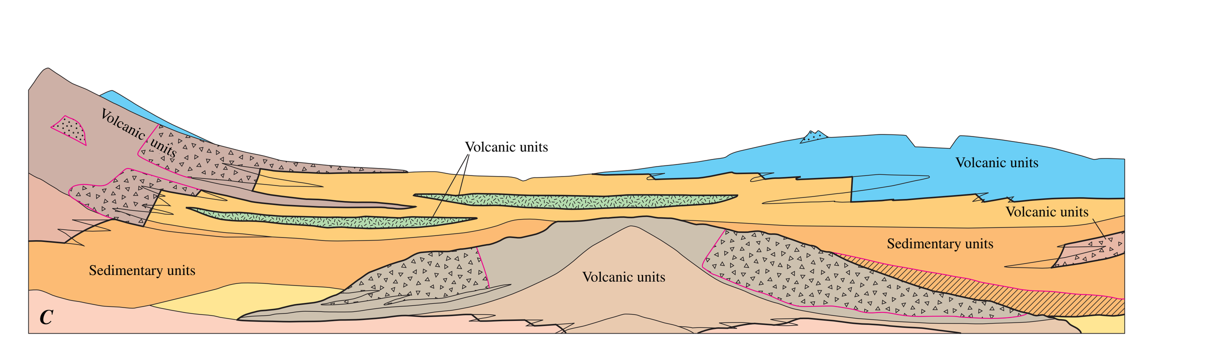


Figure 2. Hypothetical cross section through part of a continental arc illustrating conceptual model of volcanic and sedimentary processes and resulting deposits. *A*, typical volcanic and sedimentary features. *B*, facies relations (facies terminology is from Smedes and Prostka, 1972, and Vessell and Davies, 1981). *C*, patterns used show selected facies and rock types on map.

EXPLANATION

SEDIMENTARY UNITS
(Age indicated by general color on geologic map)

No Pattern — Volcaniclastic sandstone, siltstone, granule conglomerate and mudstone closely related to volcanic processes

Continental sedimentary rocks not directly related to volcanic processes

CONTACTS

Contacts as mapped in the field

Interpretative contacts between volcanic and sedimentary units

Interpretative contacts between different volcanic and sedimentary facies or genetic units within the same map unit

VOLCANIC UNITS
(Age and composition indicated by general color on geologic map)

No Pattern — Volcanic rocks deposited mostly near vents—Includes large valley-filling lava flows

Volcanic diamicton—Unsorted deposits of warm or cold fluid flows of direct volcanic origin. Includes debris flows, block-and-ash flows, and lahars

Subaerial deposits of andesitic and basaltic ejecta—Mostly cinder cones

Pyroclastic-flow deposits

GEOLOGIC MAP OF UPPER EOCENE TO HOLOCENE VOLCANIC AND RELATED ROCKS OF THE CASCADE RANGE, OREGON

By
David R. Sherrod and James G. Smith

2000

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