STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

NEOTECTONIC MAP OF THE DALLES 1° BY 2° QUADRANGLE, OREGON AND WASHINGTON

GMS-27
Geologic and Neotectonic Evaluation of North-Central Oregon: The Dalles 1° x 2° Quadrangle

James L. Bela

Funded by U.S. Nuclear Regulatory Commission
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Base Map by U. S. Geological Survey
Control by USGS and NOS/NOAA

Field checked: J.L. Bela & S. Farooqui; 1982

Scale 1:250,000
CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

NEOTECTONIC MAP SYMBOLS

FAULTS

Fault, dashed where inferred; some faults may be inferred and approximate

High-angle fault; bar and ball on downthrown side

Thrust fault; sawteeth on upper plate

Strike-slip fault, showing relative horizontal movement

Strike-slip fault, sense of relative horizontal movement not determined

Oblique-slip fault, showing relative horizontal and vertical movement

FOLDS

Fold, showing direction of plunge if any; dashed where approximately inferred or concealed on geologic map

Crestline of upright anticline

Crestline of overturned anticline

Troughline of syncline

Doubly plunging anticline

MONOCLINES

Monocline, dashed where inferred

Abrupt decrease of dip in direction of arrows (foot of monocline)

Abrupt increase of dip in direction of arrows (top of monocline)

Prominent photo or topographic lineament, possibly a strike-slip fault (from Swanson and others, 1981)

Major structural lineament

Volcanic center

Youthful volcanic centers of Pliocene or Pleistocene age. For specific geologic information see accompanying geologic map

Earthquake epicenters to 1978

Magnitude < 3.7
Magnitude > 3.7 < 5.0

DISCUSSION

By John D. Beaulieu

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Map prepared by
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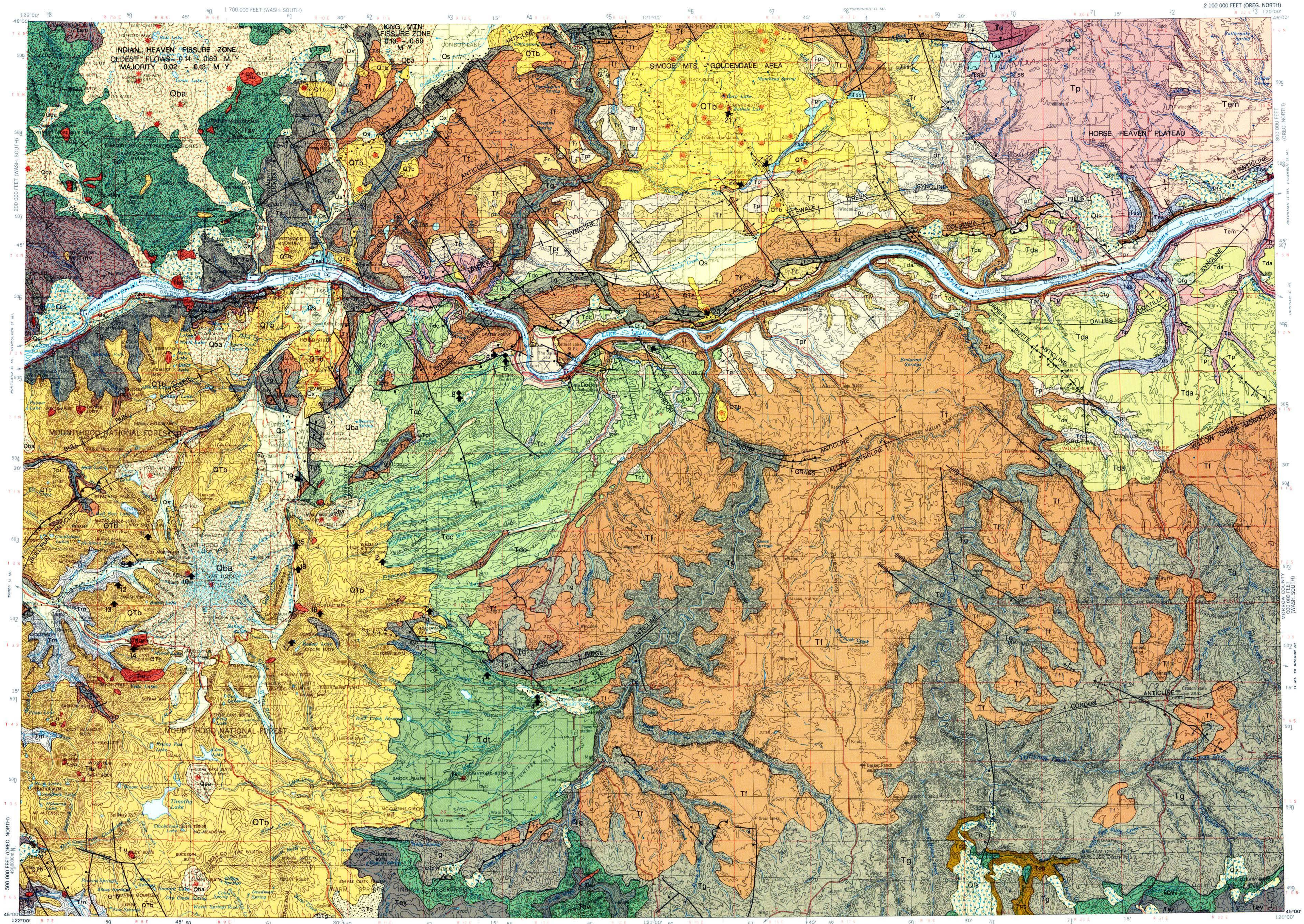
Geologic Compilation Map of The Dalles 1° by 2° Quadrangle, Oregon and Washington

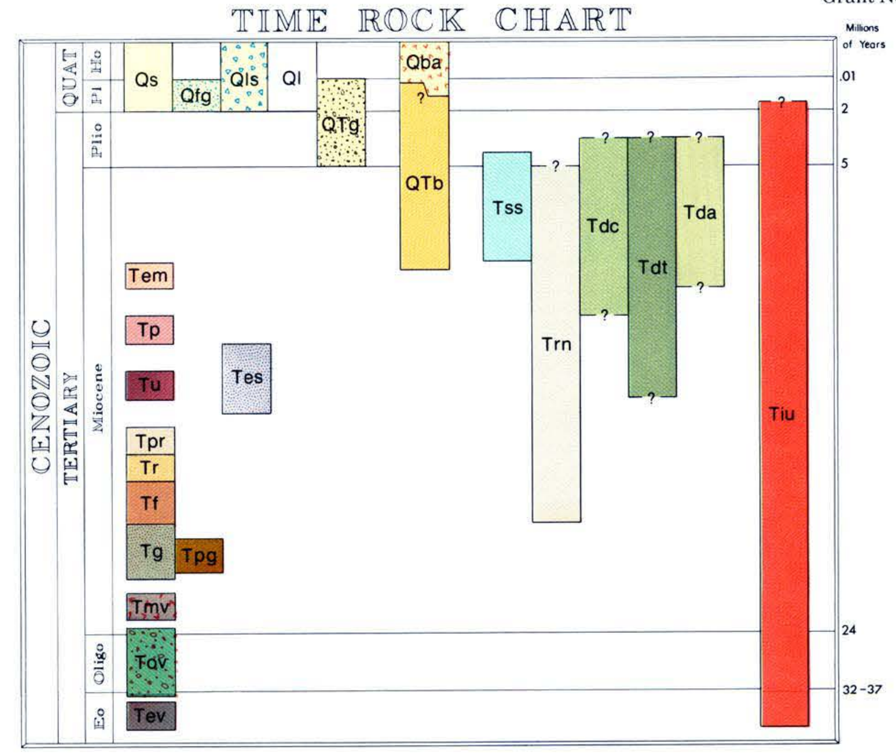
1982

GMS-27
Geologic and Neotectonic Evaluation of North-Central Oregon:
The Dalles 1° x 2° Quadrangle
Compiled by James L. Bela
Funded by U.S. Nuclear Regulatory Commission
Grant No. NRC-G-04-81-009



Compiled by James L. Bela. Geology modified from Wells and Peck (1961), Wise (1969), Meyer (1979), Rigby and Othberg (1979), Hammond (1980), Hammond and others (1980), Farooqui, Bunker and others (1981), Swanson and others (1981) and T.L. Tolan (personal communication, 1982)

Geologic structures compiled from Swanson and others (1981), Shannon and Wilson (1973, 1974, 1975, 1976), Newcomb (1969, 1970)



EXPLANATION

[modified after Swanson and others (1981) and Farooqui, Bunker, and others (1981)]

Qs — **Sedimentary deposits (Quaternary):** [illegible]

Qls — **Landslide deposits (Quaternary):** [illegible]

Ql — **Loess (Quaternary):** [illegible]

Qfg — **Catastrophic flood deposits (Pleistocene):** [illegible]

Qba — **Andesite and basalt (Quaternary):** [illegible]

QTg — **Gravel and conglomerate (Pliocene-Pleistocene):** [illegible]

QTb — **Olivine basalt and andesite (upper Miocene-Quaternary):** [illegible] Cascades range from about 1 to 4 m.y. (Hammond and others, 1980); rocks in upper Clackamas River area range in age from about 0.25 to 4.2 m.y. (Sutter, 1978; Hammond and others, 1980)

Western margin of Dalles Group sedimentary and volcanic rocks: Volcanic rocks here predominantly consist of andesite flows along eastern margin of Oregon Cascade Range; unconformable on Chenoweth Formation (**Tdc**) near The Dalles (Newcomb, 1969); elsewhere disconformable on Chenoweth Formation (**Tdc**) (near Tygh Ridge) and on Tygh Valley Formation (**Tdt**). Includes Qtv of Newcomb (1969); QTv of Beaulieu (1977); QTa of Robison and Laenen (1976); Ta of Waters (1968a,b); QTb of Hammond (1980); Qad of Waters (1968b); and Tpmv of Farooqui, Bunker, and others (1981). Available K/Ar dates of 5.1 ± 0.5 m.y. and 8.0 ± 0.8 m.y. (Farooqui, Bunker, and others, 1981) for this area, when compared to range of 3 to 7 m.y. in vicinity of Mount Hood (Wise, 1969), indicate an overlap in ages of Chenoweth Formation (**Tdc**) and these volcanic rocks, suggesting they could be contemporaneous

Tss — **Conglomerate of Snipes Mountain (upper Miocene-lower Pliocene):** Weakly consolidated river gravel and sand containing abundant quartzite and metavolcanic clasts. Interpreted as channel deposit of ancestral Columbia River in post-Elephant Mountain Member time (10.5 m.y. B.P.). Occurs on Horse Heaven Plateau in Goldendale area. Locally includes volcaniclastic detritus. Traces course of Columbia River from Snipes Mountain, Washington, through Goldendale, and White Salmon, Washington, and Hood River, Oregon, areas in probably late Miocene time; continues into Portland basin, where gravels of Columbia River source are known as Troutdale Formation (Buwalda and Moore, 1929, 1930; Trimble, 1963; Hammond, 1980; Swanson, Anderson, and others, 1981). Generally overlies units of Columbia River Basalt Group; overlain by unit **QTb** (Simcoe Lavas in Goldendale area) and lavas of Underwood Mountain in White Salmon, Washington

Dalles Group (previously named Dalles Formation. See Farooqui, Beaulieu, and others [1981] for more complete descriptions.) Includes:

Tda — **Alkali Canyon Formation (upper Miocene-lower Pliocene):** Poorly sorted, basaltic cobble gravel and minor interbedded tuffaceous sand and silt, with cobble imbrication indicating northern transport from Blue Mountains; commonly carbonate cemented. Unit varies in thickness from 32 to 130 ft. Locally includes 16-ft-thick light-gray vitric tuff at base of unit in Alkali Canyon. Overlies Columbia River Basalt Group rocks and associated sedimentary interbeds with slight angular unconformity. Includes Shutler formation of Hodge (1932, 1942) and Hodge and others (1941). Partially includes unit Tf of Hogenson (1964) and Dalles Formation of Newcomb (1966, 1971). Age is late Miocene to early Pliocene; **vertebrates** dated as Hemphillian (Shotwell, 1956). Generally overlain by loess (**Ql**)

Tdc — **Chenoweth Formation (upper Miocene-lower Pliocene):** Volcaniclastic and sedimentary rock consisting primarily of eastward-spreading laharic deposits of andesitic agglomerate and tuff breccia interbedded with conglomerate and sandstone rich in andesite clasts near foothills of Cascade Range. Grading laterally eastward and northward into more fluvial deposits (with proportion of lahars decreasing) of conglomerate and tuffaceous sandstone and siltstone; locally includes tuff and minor basalt flows. Maximum thickness is 1,800 ft; thins laterally to approximately 200 ft near Biggs and Rufus (Newcomb, 1966, 1969). Overlies Columbia River Basalt Group rocks and is of late Miocene to early Pliocene age. Previously named Dalles Formation by earlier workers (Condon, 1874; Cope, 1880; Piper, 1932; Newcomb, 1966, 1969). Vertebrates dated as late Miocene to early Pliocene (Buwalda and Moore, 1930); leaves dated as early Pliocene (Chaney, 1944). K/Ar dates are 5.1, 5.7, and 7.2 m.y. (Farooqui, Beaulieu, and others, 1981; Farooqui, Bunker, and others, 1981) and 10.6 and 15.2 m.y. (Newcomb, 1966). Locally overlain by nonindurated loess near Columbia River

Tdt — **Tygh Valley Formation (middle Miocene-lower Pliocene):** Volcanic, volcaniclastic, and sedimentary rocks, often interbedded, derived from source areas in Cascade Range. Basalt flows dominant in west, with sedimentary rocks more common in east near Tygh Valley. Complex area of volcanic centers at Graveyard Butte. Generally distinguished from Chenoweth Formation (**Tdc**) by relative paucity of lahars and location. Basalt flows generally form plateaus but may occur as intracanyon flows. Sedimentary and volcaniclastic rocks comprised of weakly cemented basaltic, andesitic, and pumiceous sandstone and conglomerate; tuffaceous siltstone and sandstone; tuff; pumice lapilli tuff; and laharic deposits of agglomerate and tuff breccia. Includes Ta, Tob, and Td of Waters (1968b). Overlies Columbia River Basalt Group rocks. K/Ar dated at 4.9 and 7.6 m.y. (Farooqui, Bunker, and others, 1981; Farooqui, Beaulieu, and others, 1981); age middle Miocene to early Pliocene

Trn — **Rhododendron Formation (middle to upper Miocene):** Predominantly pyroclastic and epiclastic tuff breccia and breccia, laharic (mudflow) breccia, volcanic agglomerate and conglomerate (including mudstones and sandstones), and volcanic ash (tuff) of distinctively local extents in northern Oregon Cascade Range; also includes some interbedded andesitic lava flows; rocks generally show low-grade zeolite-facies alteration (Wise, 1969; Beeson and others, 1980).

Type locality at Zigzag Mountain consists of lower 300-ft sequence of laharic (mudflow) breccias and conglomerates, central 900-ft section of tuffs and lapilli tuffs, and capping 200-ft-thick section of interbedded tuff and olivine basalt (Wise, 1969). West of map area, unit northwest of Zigzag Mountain in Bull Run Watershed consists of lower 200-ft-thick section of laharic breccia, minor 30- to 60-ft-thick tuffaceous interbeds between coarser pyroclastic units, and predominant (approximately 500-ft-thick) assortment of lapilli tuffs and breccias of ashflow origins occurring generally higher in section than laharic breccias and fine-grained tuffs (Schultz, 1980). Southwest of Clackamas River (just west of southwest map area), unit consists predominantly of volcanic agglomerates and breccias (Barnes and Butler, 1930); at Trout Creek north of Zigzag Mountain, unit comprises predominantly tuffaceous conglomerates and agglomerates (Barnes and Butler, 1930). Regionally, western margin of Rhododendron Formation near the Willamette Valley consists of about 600 ft of coalescing mudflow breccias; abundance of mudflows decreases and abundance of lava flows increases toward east until near Cascades, where lava flows predominate (Trimble, 1963).

Thickness varies in different localities, but generally ranges between 500 to 1,500 ft thick in northern Oregon Cascades. In Mount Hood area, unit is 1,400 ft thick at type section on Zigzag Mountain (Wise, 1969), thinning to zero southward (Salmon River canyon), to north (Bull Run canyon), and probably to east (Barlow Creek) (Wise, 1969).

Age is middle to late Miocene; hornblende sample from hornblende andesite boulder in lower part of formation K/Ar dated at 7 ± 2 m.y.; rock overlying Rhododendron near Lolo Pass (southeast of Bull Run Lake) K/Ar dated (whole rock) at 5.8 m.y. (Wise, 1969). K/Ar dates reported in Old Maid Flat area by Priest and others (1982) indicate Rhododendron may be generally older than about 10 m.y. in this area

Tes — **Selah member of Ellensburg Formation (middle Miocene):** Prominent, poorly indurated, massive, greenish-white, yellow- and buff-colored tuff occurring in Arlington, Oregon, and Roosevelt, Washington, area; occurs as thick interbed overlying Priest Rapids Member of Wanapum Basalt and underlying Pomona Member of Saddle Mountains Basalt. Mapped by Schmincke (1964), Newcomb (1971), Shannon and Wilson (1972, 1974, 1975, 1976), Kent (1978), Farooqui and Kent (1978). Here divided into three lithologic and petrographic units, similar to type Selah of central Washington (Kent, 1978, p. 1-2): (1) basal air-fall tuff, accretionary lapilli tuff, pumicite, with minor volcanic sandstone and siltstone; (2) middle unit subdivided into northern tectonic facies consisting of volcanic sandstones and basaltic conglomerate and southern lacustrine facies of dominantly claystone and siltstone; (3) uppermost unit of water-laid siltstone, sandstone, and minor pumicite. Fused tuff is commonly present at contact between Selah and overlying Pomona Member. Deposited in Arlington-Roosevelt basin, an east-west-trending structure about 50 mi long and 25 mi wide paralleling axis of Dalles-Umatilla syncline; thickness ranges from 30 to 350 ft, with thickest part lying in north-south area centered on Arlington. Relatively uniform thickness of Pomona flows here indicate that this basin was filled prior to Pomona time (approximately 12 m.y.) (Farooqui and Kienle, 1976; Farooqui and Kent, 1978). Generally concealed by earth slump and block slide landslide deposits (**Qls**) in Arlington area, as indicated

Yakima Basalt Subgroup of Columbia River Basalt Group (middle-upper Miocene): See Swanson, Anderson, and others (1979) and Swanson, Wright, and others (1979) for more complete descriptions. Formations present in study area include Saddle Mountains, Wanapum, and Grande Ronde Basalt.

Saddle Mountains Basalt (approximately 13.5-6 m.y.):

Tem — **Elephant Mountain Member:** Nearly aphyric basalt flows of Elephant Mountain chemical type (Wright and others, 1973); about 100 ft in thickness. Normal to transitional magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). K/Ar age about 10.5 m.y. (McKee and others, 1977). Occurs extensively on Horse Heaven Plateau, Washington, and between Arlington and Boardman, Oregon. Feeder dike occurs upriver from confluence of Wenaha and Grande Ronde Rivers in northeastern Oregon (Ross, 1978; 1980, fig. 3); covers much of south-central Washington, in many places overlying "volcaniclastic debris erupted in the Cascades, carried eastward by rivers, lahars and winds, and deposited on the Pomona Member" (Swanson and Wright, 1979, 1981)

Tp — **Pomona Member:** Slightly phyric basalt flow of Pomona chemical type (Wright and other, 1973). Contains small phenocrysts of plagioclase, clinopyroxene, and olivine; about 100 ft in thickness. Prominent and easily recognized flow, with distinctive chemical composition and petrography making it one of best markers on Columbia Plateau. Peperite commonly developed where lava ploughed into vitric ash and volcaniclastic sediments near flow margins. Reversed magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). K/Ar age about 12 m.y. (McKee and others, 1977). Occurs extensively on Horse Heaven Plateau and in northern Oregon along Columbia River. Apparently flowed into Mosier, Oregon, and Columbia Gorge via river channel in south-central Washington that was in different location from present Columbia River; locally occurs as intracanyon flow west of Klickitat River (Anderson, personal communication, 1982) and in Columbia Gorge west of Hood River (Anderson, 1980)

Tu — **Umatilla Member:** Fine-grained basalt flow or flows of Umatilla chemical type (Wright and others, 1980) and older variant, Sopher Ridge chemical type (P.R. Hooper, unpublished data, 1979; Wright and others, 1980). Typified by very even grain size and near lack of phenocrysts; in places exhibits almost porcellanite appearance. Normal magnetic polarity (Rietman, 1966); age is approximately 13.5 m.y. Includes Bear Creek flow of Ross (1978), probably equivalent to flow of Sopher Ridge type; about 300 ft thick at type locality near McNary Dam, Washington (Pendleton 1° x 2° quadrangle). Occurs on Horse Heaven Plateau, Washington; along Columbia River east of Umatilla, Oregon; at scattered localities on northwest flank of Blue Mountains uplift east of Adams, Oregon; and extensively between crest of uplift and Joseph Creek. Underlies much of Pomona and Elephant Mountain Members in northeast (Horse Heaven Plateau) map area, but exposures in canyons are not shown due to map scale

Wanapum Basalt (approximately 15-14.5 m.y.):

Tpr — **Priest Rapids Member:** Fine- to coarse-grained basalt flows of Rosalia and Lolo chemical types (Wright and others, 1980) with reversed magnetic polarity (Rietman, 1966). Flows of Rosalia chemical type (lower MgO) are nearly aphyric and contain groundmass olivine visible with hand lens in fine-grained samples. Flows of Lolo chemical type (higher MgO) generally contain phenocrysts of olivine and commonly plagioclase. Flows of Lolo chemical type consistently overlie flows of Rosalia chemical type on Horse Heaven Plateau and farther west. Consists of only one to two flows in western and northern Oregon, about 100 ft in thickness; thins noticeably at flow margins in western Oregon near Mosier, where onlapping relationship with underlying Frenchman Springs Member occurs. Occurs as intracanyon flow that overfilled canyon at least 600 ft deep in Hood River Valley (Timm, 1979; Anderson, unpublished data, 1980) and in Bull Run Watershed (Vogt, 1979, 1981). In Old Maid Flat drill hole OMF-1, on basis of geochemistry, a 30-ft-thick Priest Rapids flow has been identified overlying 400-ft-thick pile of volcaniclastic debris believed to be part of Rhododendron Formation (**Trn**), which in turn overlies youngest Frenchman Springs flow (Beeson, personal communication, 1982; Priest and others, 1982). Commonly separated from overlying Umatilla Member of Saddle Mountains Basalt in south-central Washington (Horse Heaven Hills) by interbed (the Mabton bed of Laval, 1956) belonging to Ellensburg Formation

Tr — **Roza Member:** Basalt flows of Roza chemical type (Wright and others, 1973) that consistently contain several percent single, in places clotted, plagioclase phenocrysts that average nearly 10 mm across and are evenly distributed throughout most flows. Transitional or reversed magnetic polarity (Rietman, 1966; Choiniere and Swanson, 1979). Very extensive unit elsewhere on Columbia Plateau (Swanson, Wright, and others, 1979; Swanson and others, 1980) but in mapped area occurs only in south-central Washington and in north-central Oregon along Columbia River. Generally no more than two flows; maximum thickness 100 ft, commonly 40 to 50 ft; observed to thin to only 5 ft where onlapping relationships occur. Mapped extent exaggerated in canyons (underlying Frenchman Springs Member basalt flows are not shown) to reflect regional extent of flows. "The general distribution of the Roza . . . suggests that the central part of the Columbia Plateau had begun to subside relative to its margins (absolute subsidence is not implied) before Roza time, as the member pinches out toward the west and northwest margins of the plateau as well as toward the east margin" (Swanson and Wright, 1979, p. 7)

Tf — **Frenchman Springs Member:** Basalt flows of Frenchman Springs chemical type (Wright and others, 1973). Many flows contain irregularly distributed plagioclase glomerocrysts as much as 50 mm across, but some flows, particularly younger ones, are virtually aphyric; generally fine to medium grained. Normal magnetic polarity (Rietman, 1966). K/Ar age approximately 14.5 m.y. (Swanson and Wright, 1979, p. 36; 1981, p. 25). Most extensive member of Wanapum Basalt; forms majority of basalt exposed at surface of map area. Overlies thin saprolite developed on top of Grande Ronde Basalt locally in Blue Mountains, and farther west commonly rests on prominent, thin, tuffaceous or sub-arkosic sandstone and siltstone unit known as Vantage Member of Ellensburg Formation in western part of plateau in Washington and informally called "Vantage horizon" in north-central and western Oregon. Thin, discontinuous subarkosic and tuffaceous interbeds occur between some flows in central and western part of Columbia Plateau, as, for example, at Maupin, Oregon. Basal flow is pillowed in many places. Unit can be subdivided into several recognizable flows throughout much of Columbia Plateau; these flows have not been mapped separately, but their identification helps to define structural relations. Very extensive in western part of Columbia Plateau and in Blue Mountains north of Umatilla River. Generally thins away from central Columbia Plateau; approximately 300 to 500 ft thick across much of plateau; about 200 ft thick in drill holes (OMF-1 and 7A) at Old Maid Flat, west of Mount Hood (Priest and others, 1982). In OMF-1 there are two sequences (flows?) 40 ft (upper) and 30 ft (lower) thick, separated by 500 ft of locally derived Cascade lavas; in OMF-7A there is one 200-ft-thick sequence. Unit is about 200 to 300 ft thick in Clackamas River area, immediately west of map area (Anderson, 1978; Hammond and others, 1980) and apparently underlies most or all of younger northern Oregon Cascades in southwest map area, as indicated by outcrop pattern

Tg — **Grande Ronde Basalt:** Basalt flows, aphyric to very sparsely plagioclase-phyric, comprising thickest and most voluminous formation in Columbia River Basalt Group. Generally fine grained and petrographically nondistinctive. Chemical composition varies within broad field now termed Grande Ronde chemical type (Yakima chemical type of Wright and others, 1973). K/Ar age 14 to 16.5 m.y. (Swanson, Wright, and others, 1979). In western part of Columbia Plateau, flows of high-Mg Grande Ronde chemical type generally overlie somewhat finer grained, hackly flows of low-Mg type in upper normally magnetized (N_2) part of section. Flows range in thickness from less than 3 ft to more than 160 ft but are generally between 50 ft and 80 ft. Total thickness unknown, estimated exposures are greater than 2,000 ft thick in Blue Mountains and greater than 1,500 ft thick in north-central Oregon along lower John Day River; recent interpretations suggest more than 10,000 ft of Grande Ronde Basalt may lie beneath Columbia Plateau in Pasco Basin (Reidel and others, 1981).

Grande Ronde Basalt is divided into four magnetostratigraphic units on basis of dominant magnetic polarity (Swanson and others, 1981) but not differentiated here

Tpg — **Picture Gorge Basalt of the Columbia River Basalt Group (middle Miocene):** Flows of plagioclase-phyric and aphyric basalt of Picture Gorge chemical type (Wright and others, 1973). K/Ar age of 14.6 to 15.8 m.y. (Swanson, Wright, and others, 1979). Generally medium to coarse grained but commonly fine grained along Brown Creek (T. 6 S., R. 24 E., east of map area), where flows are hackly jointed, aphyric, and resemble Grande Ronde Basalt except for chemical composition. Columnar jointing generally poorly formed, except for Butte Creek invasive flow of Cockerham (1974) along Butte Creek (T. 6 S., Rs. 19-20 E.). Weathers to rounded outcrops in most places except along Brown Creek. Upper flow generally highly plagioclase-phyric. In map area, crops out along Butte Creek and nearby John Day River; east of map area crops out nearly continuously south of latitude 45°10' between longitude 118°45' and 120°00' and in headwaters of Grande Ronde River and tributaries such as Fly and Beaver Creeks (Tps. 4-5 S., Rs. 35-37 E.)

Tmv — **Miocene volcanic rocks (lower-middle Miocene):** Basaltic andesite, andesite, and lesser dacite and rhyolite flows and breccias, chiefly in Cascade Range. Underlies Grande Ronde Basalt with erosional and in places angular unconformity. Includes sandstone, conglomerate, and laharic breccia of Eagle Creek Formation, exposed along the Columbia River Gorge (Tme of Beaulieu, 1977; Tec of Hammond, 1980); lava flows of Council Bluff, northwest map margin (Hammond and others, 1976; Tcb of Hammond, 1980); lava flows of Three Corner Rock north of Columbia River Gorge (Ttcr of Hammond, 1980); and Nohorn andesite in Clackamas River area (Tn of Hammond and others, 1980). K/Ar and fission track ages indicate middle and early Miocene age (Hammond and others, 1977; Hammond, 1980). May include some volcanic rocks of Oligocene age

Tov — **Oligocene volcanic and sedimentary rocks (chiefly Oligocene; includes some middle Eocene-lower Miocene rocks):** Includes mostly andesitic and dacitic lava flows, tuffs, breccias and laharic breccias, and other volcaniclastic sedimentary rocks including claystone, sandstone, and conglomerate of John Day Formation (southern map boundary, Oregon) and Ohanapecosh and Stevens Ridge Formations (north of Columbia River) (Hammond, 1980). John Day Formation predominantly varicolored air-fall and water-deposited ash and tuff, welded tuff, and volcanic (rhyolite and rhyodacite) flows (Robinson, 1975; Robison and Laenen, 1976). Ohanapecosh and John Day Formations commonly zeolitized. Fission track ages for Ohanapecosh Formation indicate 45 and 31 m.y. (middle Eocene to early Oligocene) (Vance, personal communication, 1978, in Hammond, 1980). K/Ar and fission track ages for the Stevens Ridge Formation range from 26.8 to 19.5 m.y. (late Oligocene to early Miocene) (references cited *in* Hammond, 1980). On basis of K/Ar dates (Swanson and Robinson, 1968) and paleontologic evidence (Woodburne and Robinson, 1977), age of John Day Formation ranges from about 36 m.y. to 18 to 19 m.y.

Tev — **Eocene volcanic rocks (Eocene):** Clarno Formation, consisting chiefly of lava flows and breccias of altered, dark-greenish-gray andesite and basaltic andesite; upper part of unit marked regionally by prominent red-clay saprolite at contact with overlying John Day Formation (Robinson, 1975; Robison and Laenen, 1976). K/Ar age determinations generally older than 41 m.y. (Noblett, 1981). "The regional geologic setting and its relation to plate tectonic models of the Pacific Northwest suggest that the Clarno Formation was largely derived from subduction volcanism" (Noblett, 1981, p. 98)

Tiu — **Intrusive rocks, undivided:** Fine- to medium-grained, commonly porphyritic, generally mafic plugs, dikes, and irregular intrusive bodies. Mostly associated with early and middle Tertiary volcanism. In Cascade Range, includes plugs related to late Tertiary and perhaps Quaternary volcanism (Wells and Peck, 1961; Wise, 1969; Hammond, 1980; Hammond and others, 1980). Laurel Hill intrusion near Mount Hood K/Ar dated at 11.6 ± 1.2 m.y. (Wise, 1969) to 8.2 ± 0.2 m.y. (Bikerman, 1970); cuts Rhododendron Formation (**Trn**) and overlying porphyritic andesites (**QTb**) of Zigzag Mountain

For a listing of **REFERENCES CITED,** *see Neotectonic Map*

AGE REFERENCE TABLE

Sample Location Number	Age (m.y.)	Source
1	7.6 ± 0.8	Farooqui, Bunker and others, 1981
2	8.0 ± 0.8	Farooqui, Bunker and others, 1981
3	7.2 ± 0.7	Farooqui, Bunker and others, 1981
4	4.9 ± 0.5	Farooqui, Bunker and others, 1981
5	41.1 ± 2.8	Farooqui, Bunker and others, 1981
6	47.5 ± 5.7	Farooqui, Bunker and others, 1981
7	5.1 ± 0.5	Farooqui, Bunker and others, 1981
8	5.7 ± 0.6	Farooqui, Bunker and others, 1981
9	10.7 ± 0.4	Priest and others, 1982
10	3.2 ± 0.3	Wise, 1969
11	5.8 ± 0.8	Wise, 1969
12	7 ± 2	Wise, 1969
13	5.5 ± 0.7	Wise, 1969
14	11.6 ± 1.2	Wise, 1969
	8.2 ± 0.2	Bikerman, 1970
15	7.0 ± 0.8	Wise, 1969
16	3.0 ± 0.2	Wise, 1969
17	4.1 ± 0.6	Wise, 1969
18	2.7 ± 0.2	Priest and others, 1982
19	2.1 ± 0.2	Priest and others, 1982
		(Neil Woller, personal communication)
20	0.9 ± 0.1	Shannon and Wilson, 1973
21	3.5 ± 0.1	Shannon and Wilson, 1973
22	4.5 ± 0.1	Shannon and Wilson, 1973
23	2.0 ± 0.3	Shannon and Wilson, 1973

GEOLOGIC SYMBOLS

Contact

Fault, dotted where concealed; not all faults are shown on this map (see Neotectonic Map); faults shown here reflect major structural trends and geologic contacts. Some faults may be inferred and approximate; faults along Quaternary sediments and bedrock units do not necessarily indicate Quaternary faulting

High-angle fault; bar and ball on downthrown side

Thrust fault; sawteeth on upper plate

Strike-slip fault, showing relative horizontal movement

Strike-slip fault, sense of relative horizontal movement not determined

Oblique-slip fault, showing relative horizontal and vertical movement

Fold, showing direction of plunge if any; dashed where approximately located; dotted where concealed. Not all folds are shown on this map (See Neotectonic Map); folds shown here reflect generalized major structural folds and the regional structural systems discussed in the text

Crestline of upright anticline

Crestline of overturned anticline

Troughline of syncline

Monocline, dashed where approximately located; dotted where concealed

Abrupt decrease of dip in direction of arrows (foot of monocline)

Abrupt increase of dip in direction of arrows (top of monocline)

Volcanic center

23 — Age (m.y.) showing sample location; sample number references table indicating complete age and source of data. General age ranges for lavas associated with Indian Heaven fissure zone, King Mountain fissure zone, and Simcoe Mountains - Goldendale area are indicated directly on the map (Hammond, 1980)

Measured section (Farooqui, Bunker and others, 1981; Farooqui, Beaulieu, and others, 1981)

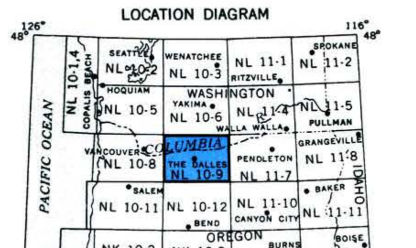
Base map by U. S. Army Map Service

Prepared by the U.S. Army Topographic Command (AMSK), Washington, D.C. Compiled in 1954 by photogrammetric methods. Planimetry revised from aerial photographs taken 1952. Photographs field annotated 1953. Revised in 1971 by the U.S. Geological Survey from aerial photographs taken 1970

100,000-foot grid based on Oregon coordinate system, north zone and Washington coordinate system, south zone

Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
Cartography by Paul E. Staub

LOCATION DIAGRAM



Scale 1:250,000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION