WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
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GEOLOGIC MAP OF THE VANCOUVER QUADRANGLE, WASHINGTON AND OREGON

Compiled by
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WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES

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This report has not been edited or reviewed for conformity with Division of Geology and Earth Resources standards and nomenclature.

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Brian Boyle · Commissioner of Public Lands
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GEOLOGIC MAP OF THE VANCOUVER QUADRANGLE, WASHINGTON AND OREGON

Compiled by
William M. Phillips

INTRODUCTION

This map is one of a series of 1:100,000-scale geologic maps compiled by staff geologists of the Division of Geology and Earth Resources (DGER) and used as source maps for the southwest quadrant of the geologic map of Washington (Walsh and others, in press). Geologic data for the southwest quadrant were compiled on 1:100,000-scale metric topographic maps, then reduced and simplified somewhat to construct the 1:250,000-scale state map.

As the 1:100,000-scale compilations contain details of structure and stratigraphy which could not be shown at the 1:250,000 scale of the state map, they have been released as DGER open file reports. Two exceptions are recently released maps prepared by the U.S. Geological Survey in the Snoqualmie Pass (Frizzell and others, 1984) and Wenatchee (Tabor and others, 1982) 1:100,000-scale quadrangles. The 1:100,000-scale geologic compilation maps used in the southwestern state map quadrant are shown in Figure 1 together with bibliographic data.

The DGER 1:100,000-scale compilations differ from the state map in depicting numerous formations and informally named units as well as generic time-lithology units. On the Vancouver 1:100,000-scale quadrangle, for example, the Troutdale Formation is symbolized and discussed as "QTtd" or "Quaternary-Tertiary Troutdale Formation." On the state map, the same unit is symbolized as "QPc" or "Quaternary-Pliocene continental sediments."

The geologic time scale for this map is basically that used for the "Correlation of Stratigraphic Units of North America (COSUNA)" project of the American Association of Petroleum Geologists (Salvador, 1985). Additions and modifications were made following Armentrout and others (1983), Montanari and others (1985), Prothero and Armentrout (1985), and Aquirre and Pasini (1985). These modifications entailed addition of regional floral and faunal zonations, placing the Eocene-Oligocene boundary at 35.7 m.y.B.P. and within the Refugian foraminiferal stage, and setting the Pliocene-Pleistocene boundary to 1.6 m.y.B.P.

Volcanic rocks are classified following Zannetin (1984) when chemical analyses are available. Otherwise, igneous rocks are classified after Travis (1955).

The 1:100,000-scale maps in this series are:

Korosec, M. A., compiler, 1987, Geologic map of the Mount Adams quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-5, 41 p., 1 pl., scale 1:100,000

Korosec, M. A., compiler, 1987, Geologic map of the Hood River quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-6, 42 p., 1 pl., scale 1:100,000

Logan, R. L., compiler, 1987, Geologic map of the Chehalis River and Westport quadrangles, Washington: Washington Division of Geology and Earth Resources Open File Report 87-8, 18 p., 1 pl., scale 1:100,000

Logan, R. L., compiler, 1987, Geologic map of the south half of the Shelton and the south half of the Copalis Beach quadrangles, Washington: Washington Division of Geology and Earth Resources Open File Report 87-9, 17 p., 1 pl., scale 1:100,000

Phillips, W. M., compiler, 1987, Geologic map of the Mount St. Helens quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-4, 63 p., 1 pl., scale 1:100,000

Phillips, W. M., compiler, 1987, Geologic map of the Vancouver quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-10, 32 p., 1 pl., scale 1:100,000

Phillips, W. M.; Walsh, T. J., compiler, 1987, Geologic map of the northwest part of the Goldendale quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-13, 9 p., 1 pl., scale 1:100,000

Schasse, H. W., compiler, 1987, Geologic map of the Centralia quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-11, 27 p., 1 pl., scale 1:100,000

Schasse, H. W., compiler, 1987, Geologic map of the Mount Rainier quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-16, 43 p., 1 pl., scale 1:100,000

Walsh, T. J., compiler, 1986, Geologic map of the west half of the Toppenish quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-3, 8 p., 1 pl., scale 1:100,000

Walsh, T. J., compiler 1986, Geologic map of the west half of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-4, 12 p., 1 pl., scale 1:100,000

Walsh, T. J., compiler, 1987, Geologic map of the Astoria and Ilwaco quadrangles, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-2, 30 p., 1 pl., scale 1:100,000

Walsh, T. J., compiler, 1987, Geologic map of the south half of the Tacoma quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-3, 12 p., 1 pl., scale 1:100,000

ACKNOWLEDGMENTS

Field work during the summer of 1985 was assisted by Matt McClincy, Keith Kaler, Mike Korosec, and Josh Logan. Keith Kaler supplied unpublished data on the volcaniclastic section near Martin Island.

Staff of the U.S. Forest Service Zone 2 Engineering office, Willard, Washington, provided access to unpublished geologic road logs and maps. Special thanks to Helga Christensen, Geometric Coordinator for the Gifford Pinchot National Forest, for supplying excellent road network maps at a scale of 1:24,000.

Reconnaissance mapping was conducted using these maps as base in much of the eastern map area.

Paul Hammond graciously permitted access to his unpublished maps and field guides. Without his enthusiastic support, this report would be much less. Important unpublished details of the geology of map area were contributed by Morris Mundorff, Bob Deacon, and Terry Childress-Lanchild. Marv Beeson and Terry Tolan led a valuable two day field trip and helped considerably with identification of Columbia River Basalt Group lithologies.

Early versions of this report were reviewed by Paul Hammond, Morris Mundorff, Terry Tolan, and Bob Deacon.

GEOCHEMICAL DATA

Major element geochemical data from XRF analyses of whole-rock samples are presented in Table 1.

K-AR AGE DETERMINATIONS

K-Ar age determinations for whole-rock samples of volcanic rock are presented in Table 2.

STRATIGRAPHIC CORRELATION CHART

A stratigraphic correlation chart for map unit in the Vancouver 1:100,000-scale quadrangle is shown in Figure 2.

EXPLANATION OF MAP SYMBOLS

Map symbols used on Plate 1 are shown in Figure 3.

SOURCES OF MAP DATA

Sources of map data are shown in Figure 4. Additional sources of data may be cited in the description for each geologic unit.

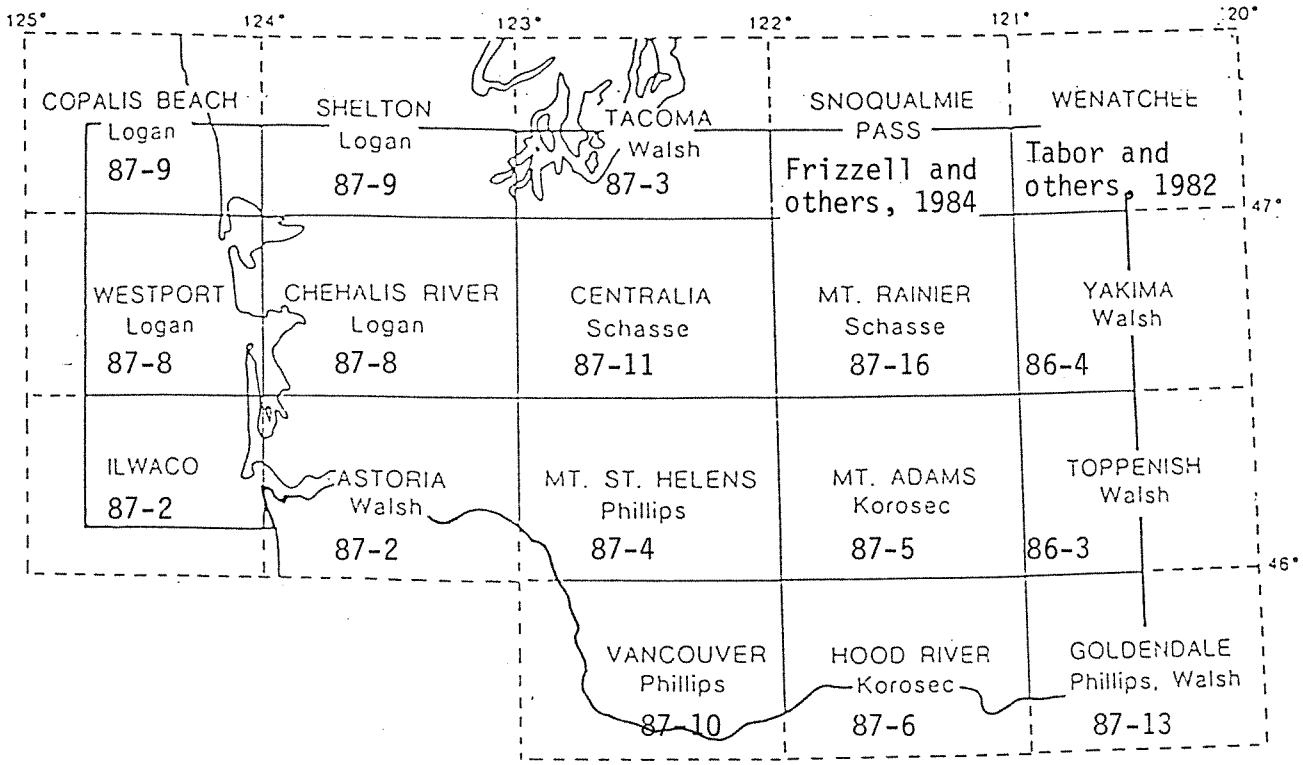

Figure 1: 1:100,000-scale geologic compilation maps used in the southwestern quadrant of the Washington State geologic map. The name of each 1:100,000 quadrangle is followed by the map compiler and an open file report number. See pages 1-3 for a list of the complete citations for the open file reports. Complete citations for Snoqualmie Pass and Wenatchee quadrangles are provided in References Cited at the end of this report.

Table 1: Major-element geochemical analyses

Sample	Unit	SiO2	Al2O3	TiO2	Fe2O3	FeO	MnO	CaO	MgO	K2O	Na2O	P2O5	1/4 1/4	Sec	Twp	Rge
BP0117851	TGO	57.47	15.83	1.64	4.56	5.23	0.15	7.21	3.41	0.90	3.34	0.27	CENTER	39	05N	01E
BP0117852	TGR	54.53	13.90	1.90	5.75	6.59	0.20	8.36	4.65	1.15	2.68	0.30	SW/4	43	05N	01E
BP0117853	TGO	60.57	15.93	1.42	3.79	4.34	0.15	6.62	2.65	0.84	3.44	0.26	SE CORNER	43	05N	01E
BP0317861	Tva2	57.43	16.82	1.72	2.00	7.42	0.17	6.79	3.27	1.14	2.96	0.26	CENTER	32	05N	01E
BP0403851	TGO	54.88	17.35	1.04	4.19	4.80	0.15	9.35	4.60	0.54	2.89	0.20	SW/4 NW/4	37	06N	01W
BP0713841	TGO	56.54	15.87	1.36	4.56	5.22	0.17	7.95	3.98	0.78	3.38	0.19	S/2	02	05N	01W
BP0725841A	TGR	56.53	15.73	2.16	2.00	6.93	0.21	7.39	3.86	1.83	3.02	0.34	CENTER	39	05N	01E
BP0726842A	TGR	55.33	14.39	1.75	5.31	6.08	0.19	8.42	4.36	1.22	2.60	0.35	CENTER S/2	30	05N	01E
BP0726842C	TGR	55.10	15.79	1.92	2.00	7.54	0.24	8.76	4.30	1.41	2.63	0.32	CENTER S/2	30	05N	01E
BP0802842	TGO	55.01	16.97	1.25	4.00	4.58	0.14	9.13	5.08	0.51	3.10	0.25	NW/4 SW/4	33	07N	01W
BP0816851	Tva2	51.88	17.31	1.07	4.72	5.41	0.17	10.39	5.89	0.30	2.74	0.14	SW/4 NW/4	07	05N	05E
BP0820851	TGRN2	53.66	15.29	2.05	2.00	9.90	0.21	8.52	4.90	0.94	2.23	0.30	E/2	12	04N	01W
KK0904855	Tva2	54.20	15.80	1.63	5.68	6.51	0.18	8.63	4.07	0.24	2.90	0.16	NE/4 SE/4	03	03N	04E
KKDI12	TGO	57.78	15.54	1.76	4.83	5.53	0.16	7.07	3.10	0.81	3.12	0.29	NW/4 NE/4	26	06N	01W
KKDI8	TGO	61.94	15.68	1.30	3.79	4.34	0.14	5.47	2.26	1.64	3.15	0.28	NE/4 SE/4	34	06N	01W
MKTT1	QVD	68.04	16.80	0.52	1.94	2.22	0.10	3.94	1.52	1.54	3.25	0.13	NE/4	08	05N	04E
MM0903851	Tva2	52.65	15.25	1.91	6.36	7.29	0.21	8.55	4.31	0.46	2.79	0.23	SW/4	28	02N	04E

Analyses by XRF, Department of Geology, Washington State University
All analyses normalized to 100% on a volatile-free basis.

Samples with Fe2O3 = 2.00% analyzed with Columbia River Basalt Group standards and a single-fusion sample preparation method.

All other samples analyzed with international standards and a double-fusion sample preparation method. Fe2O3/FeO set at 0.87 for these samples.

Table 2: K-Ar age determinations in the Vancouver quadrangle.

ID Number	Sample Number	Unit Dated	Rock Dated	Material Dated	Treatment	% K20	Radiogenic Ar (moles/gm * 10)	% Radiogenic Ar	K-Ar Date (my B.P.)	Standard Deviation	REF	LAB
K-AR 1	MM0903851	Tva2	basalt flow	whole rock	nit, hf	0.601, 0.605	2.563	32.9, 20.1	27.9	1.9	1	1
K-AR 2	KK0904855	Tva2	andesite flow	whole rock	nit, hf	0.346, 0.342	1.33	22.4, 13.1	28.1	2.7	1	1
K-AR 3	BP0816851	Tva2	basalt sill	whole rock	nit, hf	0.427, 0.424	1.65, 1.63	39.5, 35.8	26.6	2.3	1	1
K-AR 4	-----	Qvbe	basalt flow	whole rock	-----	-----	-----	-----	1.53	0.2	2	2
K-AR 5	-----	Tigd	granodiorite	whole rock	-----	1.90, 1.95	6.59	25.2	19.6	0.7	3	3
K-AR 6	-----	Tigd	alteration	whole rock	-----	4.62, 4.58	15.23	65.1	19.0	0.7	3	3
K-AR 7	-----	Tvt3	tuff	whole rock	-----	-----	-----	-----	32.8	0.8	4	4
K-AR 8	-----	Qvso	basalt flow	whole rock	-----	-----	-----	-----	0.36	0.01	5	---
K-AR 9	MM0904851	Tvb3	basalt flow	whole rock	hf	0.952, 0.952	3.258, 3.258	79.0, 73.3	23.6	1.2	1	5

References:
1. Phillips and others (1986)
2. Hammond and Korosec (1983)
3. Power and others (1981)
4. Hammond (1980)
5. Polivka (1984)

Labs:
1. Geochron
2. University of Utah
3. University of British Columbia
4. Mobil Research Laboratory

Treatments: nit=nitric acid
hf=hydrofluoric acid

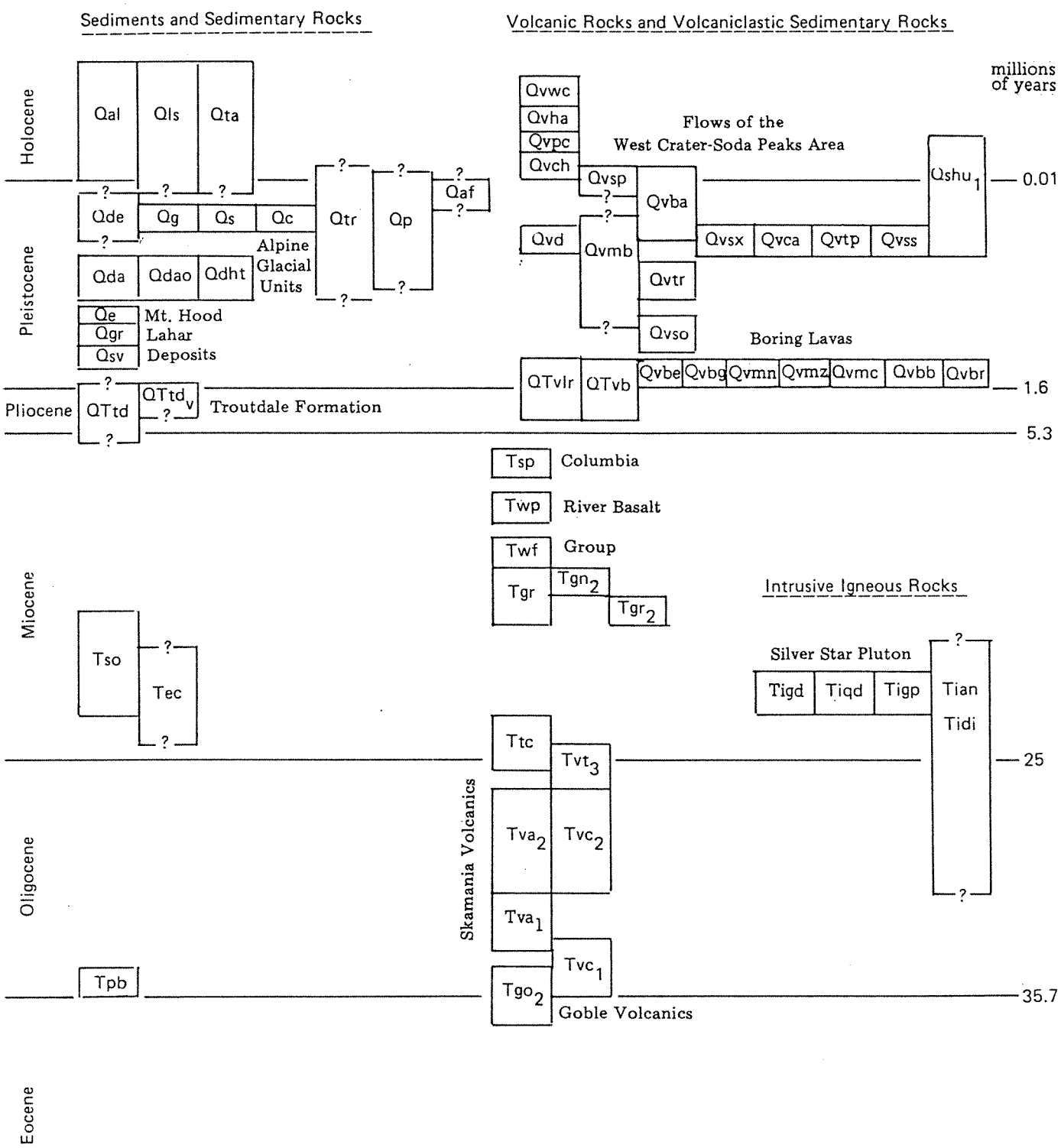

Figure 2: Stratigraphic correlation chart.

approximate strike and dip of bedding

strike and dip of bedding

anticline, long-dashed where approximately located; dotted where concealed; arrow shows direction of plunge

syncline, long-dashed where approximately located; dotted where concealed; arrow shows direction of plunge

fault, long-dashed where approximately located; dotted where concealed; ball on downthrown side

K-Ar 7
13.8±1.2

K-Ar sample locality with isotopic age determination in millions of years (my) before present (B.P.) +/- one standard deviation

volcanic vent

Figure 3: Explanation of map symbols.

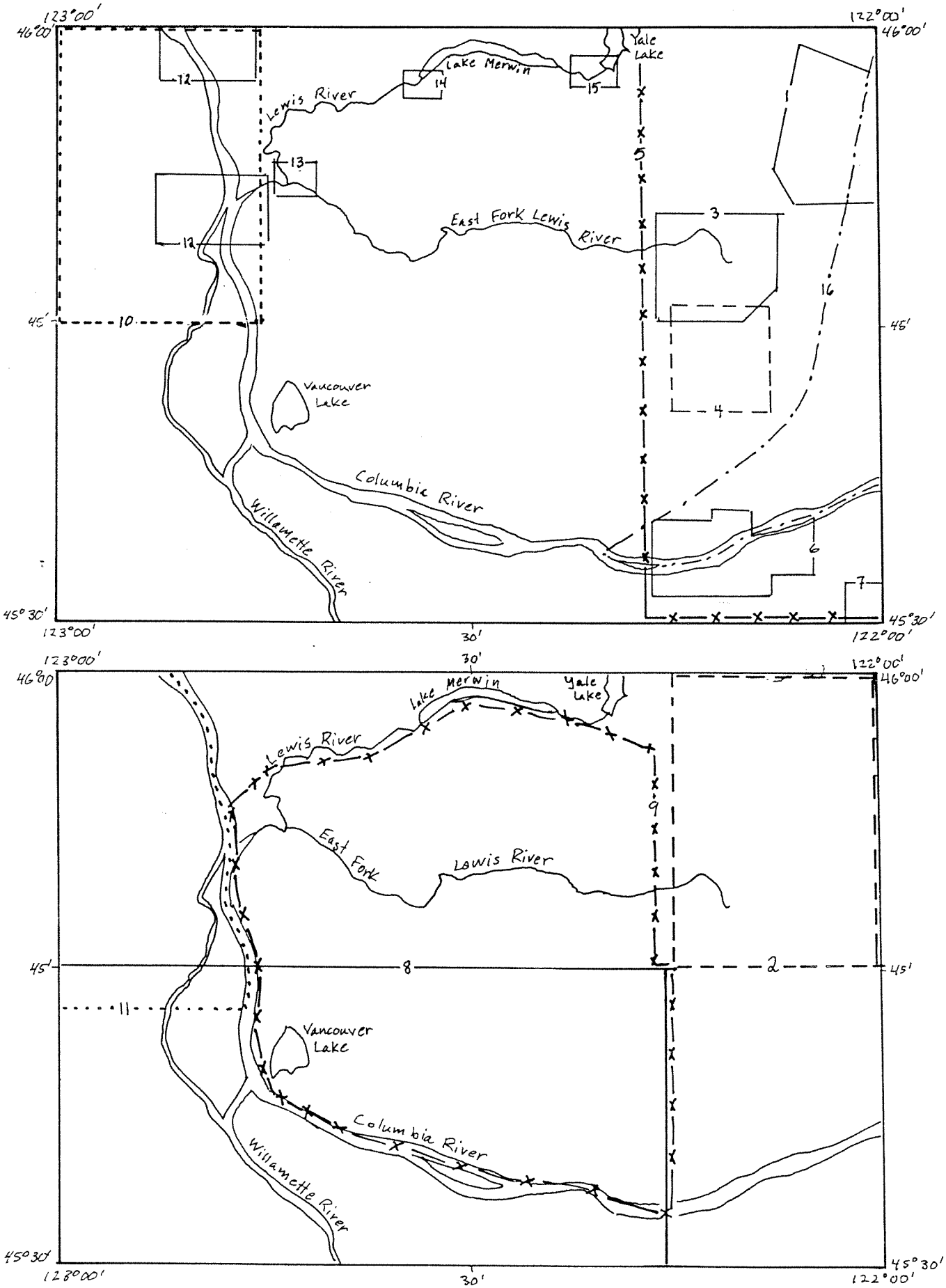

Figure 4: Sources of Map Data.

Sources of Map Data

1. Polivka (1984)
2. Hammond (1985)
3. Schriener (1978)
4. Shephard (1980)
5. Hammond (1980)
6. Tolan (1982)
7. Vogt (1981)
8. Trimble (1963)
9. Mundorff (1964)
10. Wilkinson and others (1946)
11. Wells and Peck (1961)
12. Shannon and Wilson (1968)
13. Bateman (1951)
14. Williams (1930)
15. Ebasco Services Incorporated (1974)
16. Swanson and others (1979)

Not Shown on Index Map

Allen (1975) [location of Boring Lavas vents]
Balsillie and Benson (1971) [Portland fault]
Hammond and Korosec (1983) [location of Boring Lavas vents]
Fiksdal (1975) [landslides]
Fiksdal (1978) [contact Tva_2 and Tvc_2]
Mundorff (1984) [Amboy drift and outwash; Canyon Creek drift]

DESCRIPTION OF MAP UNITS OF THE VANCOUVER QUADRANGLE, WASHINGTON

Quaternary Sedimentary Deposits

Nonglacial Deposits

Qal

Alluvium (Holocene to upper Pleistocene)--Medium to fine sand and silt on the floodplains of the Columbia and Willamette Rivers; sand and gravel on the floodplains of the Lewis and East Fork Lewis Rivers; forms bars, islands, and low, undissected terraced deposits; typically less than 15 m thick; locally up to 50 m thick (Mundorff, 1964; Trimble, 1963).

Qtr

Terraced deposits (Holocene to Pleistocene)--Poorly known deposits along the lower Washougal River; may consist of dissected lake sediments deposited when the Washougal River was dammed by landslides, or may consist of Missoula Flood deposits (units Qs or Qc) produced when floodwaters backed up into the Washougal drainage.

Qls

Landslide deposits (Holocene to Pleistocene)--Diverse slide and slump deposits; typically consist of thoroughly disarranged blocks in a matrix of finer material; most landslides are in areas where competent units such as Boring Lavas, Grande Ronde Basalt, or flows of Three Corner Rock are underlain by weaker sedimentary or volcaniclastic deposits; age of slides generally uncertain; large slides in southeast portion of map area probably date from the Pleistocene (Trimble, 1963).

Qta

Talus deposits (Holocene to Pleistocene)--Rubble deposits on steep slopes and below rockfalls; consists of Columbia River basalt clasts forming talus cones below cliffs (Hammond, 1980).

Qp

Marsh, bog and peat deposits (upper Pleistocene)--At Fargher Lake (secs. 23-26, 5N-2E) and near Orchards (secs. 13-15, 2N-3E, consists of 1.5 to 10 m of peat, muck (decomposed peat), greenish-gray clayey lake mud, diatomaceous soils, and thin layers of pumice tephra and diatomite (Rigg, 1958); at Fargher Lake, 7 layers of Mount St. Helens tephra are present and range in age from about 17,000 to about 32,000 yr B.P. (Heusser and Heusser, 1980).

Qaf

Alluvial fan deposits (Pleistocene)--Fine sand and silt with lesser gravel; forms fans, terraced deposits and basin fill along streams tributary to the Columbia River; toward the apexes of the fans, materials grade to coarse sand and gravel; important source of domestic water supplies (Mundorff, 1964, p. 55-56).

Periglacial Deposits from Glacial Outburst Floods of Glacial Lake Missoula (upper Pleistocene)

Lacustrine deposits of clay, silt, sand, and gravel were left in the Portland area by numerous glacial-outburst floods from glacial Lake Missoula between about 15,300 to 12,700 yr B.P. (Waitt, 1985, p. 1284). The floodwaters were hydraulically dammed by the highlands and relatively narrow Columbia River channel in the northeast portion of the map area and backed up well into the Willamette Valley (Trimble, 1963). Thickness of the deposits varies widely from about 9 m to more than 75 m (Trimble, 1963, p. 59).

Qc

Fine -grained flood deposits--Very fine sand, silt, and clay; locally more than 30 m thick; generally massive; sand and silt fraction consists mainly of quartz with lesser muscovite (Trimble, 1963); correlative with the Willamette silts of Allison (1953).

Qs

Sand-sized flood deposits--Very coarse to fine sand; horizontally stratified; grading from gravel along contact with unit Qs to silt at contact with unit Qc; as much as 15 m thick; consists of quartz and mafic lithic fragments (Trimble, 1963).

Qg

Gravel-sized flood deposits--Well-rounded, foreset-bedded, well-sorted and stratified pebble and cobble gravel with angular to subangular boulders typically 2.5 m or less in length; clast-supported with a sandy matrix; sandy matrix composed of mafic volcanic fragments, quartz, and muscovite; pebbles and cobbles consist of 60% Columbia River basalt, 30% other mafic volcanic rocks, and 10% quartzite, tuff, granitic rocks, and sandstone (Trimble, 1963).

Alpine Glacial Deposits

Qde

Evans Creek Drift (upper Pleistocene)--Compact, poorly sorted, cobble and boulder till with gray, sandy and clayey matrix (Hammond, 1980); largely limited to north-facing cirques; as much as 20 m thick near Soda Peaks (Polivka, 1984); includes the Canyon Creek drift of Mundorff (1984); age ranges from about 10,000 to 20,000 yr based upon correlation with the type-Evans Creek Drift in the Mount Rainier area (Crandell and Miller, 1974).

Qda

Amboy drift (upper Pleistocene)--Till, lacustrine and fluvial outwash deposits, ice-contact deposits, and boulder deposits; thickest in Lewis River and East Fork Lewis River valleys and in Yacolt and Chelatchie basins; overlain by C tephra set of Mount St. Helens (35,000-40,000 yr B.P.); cobble weathering rinds generally 1.10 to 1.15 mm; carbon-14 date of wood from the drift older than 60,000 yr B.P.; correlative with the pre-Fraser-age Hayden Creek Drift (Mundorff, 1984, 1964).

Qdao

Outwash deposits of Amboy drift (upper Pleistocene)--Cobble and sand outwash deposits forming dissected terraced deposits along the Lewis River valley (M. A. Mundorff, U.S. Geological Survey, retired, oral commun., 1985).

Qdht

Hayden Creek Drift (upper Pleistocene)--Brownish gray till and boulder gravel; 15 to 30 m thick; age older than 38,000 yr; probably as old as 130,000 to 140,000 yr (Hammond, 1980); correlative with the Amboy drift of Mundorff (1984, 1964).

Pleistocene Volcaniclastic Sediment Deposits

Mudflow (lahar) and/or pyroclastic-flow deposits that originated on Mount Hood are present in the Sandy River drainage. The deposits are of uncertain age but appear to be pre-Hayden Creek glaciation (Crandell, 1980). The following units consist of terraced deposits along the Sandy River that were divided by Trimble (1963) on the basis of weathering and topographic position.

Qe

Estacada Formation (upper ? Pleistocene)--Cobble gravel and boulder cobble gravel; forms terraced deposits along the Sandy River locally as much as 30 m thick; gravel overlain by persistent stratum of evenly bedded, loosely consolidated sand that is between 15 and 30 m thick; locally contains poorly stratified mudflow deposits (Trimble, 1963, p. 56-57).

Qgr

Gresham Formation (middle ? Pleistocene)--Cobble gravel and boulder cobble gravel, locally interstratified with mudflow deposits; 30 to 45 m thick; overlain locally with 7 to 8 m of clayey silty sand; gravels poorly sorted and poorly stratified; units Qgr and Qs are similar in composition but distinguished by terrace elevation and degree of weathering; Qgr decomposed to a depth of 8 to 11 m; forms red clay-rich material with larger pebbles, cobbles and boulders preserving solid cores.

Qsw

Springwater Formation (lower Pleistocene)--Poorly sorted, unstratified, moderately well-consolidated cobble gravel, boulder cobble gravel, and mudflow deposits; extensively weathered to saprolite or red clay-rich soil to depths of 8 to 23 m; clasts consist dominantly of Cascadian mafic volcanic rocks; thickness 30 m to 60 m (Trimble, 1963, p. 46-50).

Quaternary Volcanic Deposits

Qvd

Dacite dome of Tumtum Mountain (upper Pleistocene)--Massive, very fine grained, light gray to grayish orange dacite; forms steep cone-shaped dome mantled with talus blocks; consists of sparse, scattered, black acicular amphibole phenocrysts, microphenocrysts of andesine, and sparse dark xenoliths 3 to 4 cm in diameter; groundmass composed of fine -grained zeolite; dacite has normal remnent magnetic polarity and is overlain by Amboy Drift (unit Qda); erupted along a northeast-trending fault zone (M. J. Mundorff and A. A. Eggers, written commun., 1986).

$Qshu_1$

Pyroclastic flows and lahar deposits of Mount St. Helens (upper Pleistocene)--Unconsolidated pyroclastic flow and lahar deposits characterized by gray, pink, and red hornblende-hypersthene dacite and andesite clasts (Hopson, 1980), and absence or near-absence of mafic lithic clasts; consists of valley-filling deposits 15 m to as much as 65 m thick in the Lewis River valley

and along Speelyai Creek (Hyde, 1975); eruptive periods (Mullineaux and Crandell, 1981) represented by the deposits probably include Ape Canyon, Cougar, Swift Creek, and Pine Creek, with a possible age range of about 35-40,000 yr to about 2500 yr

Qvmb

Basalt of Mowich Butte(Pleistocene?)--Poorly known basalt or basaltic-andesite lava flow. Chemical analysis given in Hammond and Korosec (1983).

Flows of the West Crater-Soda Peaks Area

Holocene Units

Qvwc

Andesite flows of West Crater--Light to medium gray pyroxene-phyric andesite and hornblende andesite forming two flow lobes and a lava dome; 26 to 58 m thick; age less than 7,700 yr and possibly as young as 2,000 yr (Polivka, 1984).

Qvha

Scoria cone of Hackmore Creek--Reddish brown to brownish black olivine-pyroxene-plagioclase-phyric andesite scoria; forms cone 15 m in height; carbon-14 age of 8000 +/- 300 yr (Polivka, 1984).

Qvpc

Basaltic-andesite flows of Puny Creek--Light brownish gray to light gray pyroxene-olivine-phyric basaltic-andesite; forms short, thick intracanyon flows with platy jointing, smooth flow-tops, and steep talus-covered sides; average thickness 38 m; unglaciated; age estimated at less than 10,000 yr (Polivka, 1984).

Qvch

Basaltic-andesite flows of Chinook Creek--Medium light gray, microphyric olivine-plagioclase basaltic-andesite forming thick (55 m) intracanyon block lava flow; unglaciated; age estimated at less than 10,000 yr (Polivka, 1984).

Pleistocene Units

Qvsp

Basaltic-andesite flows of South Soda Peaks--Medium light gray olivine-phyric basaltic-andesite forming four moderately thick (1

to 5 m) overlapping lava flows with platy jointing; flow surfaces covered by 0.2 to 2.0 m of glacial till and colluvium; contains basaltic xenoliths up to 6 m in length; age estimated at greater than 10,000 yr (Polivka, 1984).

Qvba

Basaltic-andesite and basalt flows of Bare Mountain--Lightto medium-gray olivine-pyroxene-phyric basaltic-andesite to basalt forming multiple, thick, blocky-jointed lava flows; maximum thickness 83 m; unit has largest present volume of any Quaternary flow in the Soda Peaks-West Crater area; age estimated between 10,000 to 20,000 yr (Polivka, 1984).

Qvsx

Basaltic-andesite flows of Siouxon Creek--Light gray, porphyritic olivine basaltic-andesite forming two separate, thick (15 to 23 m) flows; flows glaciated and heavily forested; age estimated at greater than 10,000 yr; probably correlative with units Qvss, Qvtp, and Qvca (Polivka, 1984).

Qvca

Andesite flows of Calamity Creek--Lightto medium-gray andesite forming thick (20 to 22 m) glaciated and forested lava flows; age preglacial (older than about 10,000 yr); probably correlative with Qvss, Qvsx and Qvtp (Polivka, 1984).

Qvtp

Andesite flow of Timbered Peak--Medium gray porphyritic augite-olivine basaltic-andesite forming a thick (31 m) intracanyon flow which has been breached by glaciation and now lies opposite sides of a valley; age preglacial (older than about 10,000 yr); probably correlative with Qvss, Qvsx and Qvca (Polivka, 1984).

Qvss

Basalt of Sister Rocks--Basalt flow of Sister Rocks: light to medium gray, olivine-pyroxene-phyric basalt forming thickly forested lava flow; average thickness 14 m; age preglacial (older than about 10,000 yr); probably correlative with Qvtp, Qvca and Qvsx (Polivka, 1984).

Qvtr

Basalt of Trout Creek Hill--Dark gray, vesicular to dense, olivine-phyric basalt; forms series of intracanyon flows 1.5 to 10 m thick; total unit thickness 1.5 to 45 m; age estimated between 35,000 to 136,000 yr; overlies Hayden Creek-age glacial deposits (Hammond, 1980).

Qvso

Basalt of Soda Peaks--Light to medium gray, olivine-pyroxene phyric basalt; forms flows 9 to 33 m thick; platy- to blocky-jointed; locally vesicular; covered by well-developed glacial till, soil, and forest-cover; yielded K-Ar age of 360,000 +/- 10,000 yr (Polivka, 1984).

Pliocene-Pleistocene Volcanic Deposits

Flows of the Boring Lavas

QPvb

Boring Lavas, undivided--Light gray to yellowish gray aphyric olivine-hypersthene basalt and basaltic-andesite, and olivine-phyric basalt; dense to vesicular; commonly scoriaceous; platy to blocky jointed; groundmass of basalt commonly pilotaxitic to diktytaxitic; locally consists of mafic tuff breccia, ash, tuff, and cinders; maximum thickness about 150 m.

The unit forms numerous lava flows, cinder cones, and small shield volcanoes in the Portland-Vancouver area; includes High Cascade lava flows in the southeast corner of map area; erupted onto an erosional surface formed by the Troutdale Formation and older Tertiary bedrock; age range not known for certain but probably late Pliocene to early Pleistocene (Hammond, 1980; Trimble, 1963; Allen, 1975).

On the basis of geochemistry and geomorphic development, the unit is divided into the following flow or eruptive units (Hammond and Korosec, 1983):

Qvbe

Basalt of Bear Prairie--Reversely magnetized lava flows and two cinder cones; yielded K-Ar age of 1.53 +/- 0.2 m.y. (Hammond and Korosec, 1983).

Qvmn

Basalt of Mount Norway

Qvmz

Basalt of Mount Zion

Qvbg

Basalt of Battle Ground--Contains circular lake suggestive of a maar; sediments from the lake have maximum carbon-14 age of 20,200 +/- 400 yr (Barnoksy, 1985).

Qvmc

Basalt of McCloskey Creek

Qvbb

Basalt of Bobs Mountain

Qvbr

Basalt and basaltic-andesite of Beacon Rock

QTvlr

Basalt of Larch Mountain--Probably a High Cascade unit rather than a Boring Lava.

Pleistocene-Miocene Sedimentary Deposits

QTtd

Troutdale Formation--Vitric sand and quartzite-bearing gravel, fine -grained leaf-bearing sand, silt and clay, micaceous quartzose sand, and cobbly and bouldery vitric sand; well-indurated to weakly consolidated; bedding typically lenticular; well-sorted, coarseto very coarse vitric sand composed of basaltic glass (sideromelane); gravel contains characteristic white, yellow and red, smooth and well-rounded quartzite clasts in addition to dominant mafic volcanic cobbles and pebbles (Trimble, 1963); average thickness about 30 to 45 m (Mundorff, 1964).

In north-central portion of map area, the fine -grained "lower member" of the is Troutdale exposed (Mundorff, 1964); lower member consists of 6 to 12 m of laminated silty clay and micaceous sand; well records (Mundorff, 1964) indicate as much as 270 m of the lower member is present in the subsurface; the lower member may be correlative to the Sandy River Mudstone of Trimble (1963).

The age range of the Troutdale Formation is uncertain; within the map area it is overlain unconformably by 12-15,000-yr old deposits of glacial Lake Missoula; overlies unconformably the 17 to 15.3-m.y. old Grande Ronde Basalt; overlain and interbedded

with the Boring Lavas, one flow of which (unit Qvbe) yielded a K-Ar age of 1.53 +/- 0.20 m.y.; contains a fossil flora considered to be early Pliocene in age (Trimble, 1963, p. 35); in the Columbia River Gorge, Tolan and Beeson (1984) report Troutdale gravels beneath the 12-m.y. old Pomona member of the Saddle Mountain Basalt; therefore, the unit is assigned a middle Miocene to early Pleistocene age span though the actual range in the map area may be much less.

$QTtd_v$

Volcanic breccia subunit of the Troutdale Formation--Massive to thick-bedded, poorly sorted, dark gray to reddish-gray volcanic breccia; exposed in roadcuts along southbound lanes of Interstate 5 north of Woodland; consists of dark gray two-pyroxene basalt or basaltic-andesite clasts 5 cm to 30 cm in length, supported by light-colored tuffaceous matrix (Wilkinson and others, 1946); contains abundant wood fragments; underlain by micaceous fine -grained sand and overlain by gravel facies of the Troutdale Formation; contains a Pliocene flora (Wilkinson and others, 1946); similar in stratigraphic setting to the Rhododendron Formation of Oregon but probably represents lahars that originated on stratovolcanoes in the southern Washington Cascades.

Middle Miocene Columbia River Basalt Group Flows

Tsp

Pomona Member of the Saddle Mountains Basalt--Porphyritic olivine basalt; forms a single intracanyon lava flow 6 to 122 m thick; columnar to fan jointed; contains equant and tabular, clear plagioclase phenocrysts 0.3 to 1.3 cm in length, and scattered clots of olivine 0.3 to 1 cm long; groundmass generally medium to coarse grained in appearance; yielded K-Ar ages (outside of map area) of about 12 m.y. (Tolan, 1982).

Twp

Priest Rapids Member of the Wanapum Basalt--Black, glassy to fine -grained, microphyric olivine-plagioclase basalt, crudely-bedded hyaloclastite, and minor pillow lavas and invasive flow lobes; forms a single intracanyon flow with maximum thickness of 220 m; flows have reversed paleomagnetic polarity, rare plagioclase phenocrysts exceeding 1 cm in length, and hackly jointed entablature with a basal colonnade (Tolan, 1982).

Twf

Frenchmen Springs Member of the Wanapum Basalt--Black, generally plagioclase phyric basalt with a glassy to very fine -grained

groundmass and normal to excursional paleomagnetic polarity (Tolan, 1982); consists of five flows in the map area (Ginkgo, Sand Hollow, and Union Gap units of Beeson and others, 1985); dated outside of the map area at about 15.3 m.y.B.P. (Lux, 1981).

Tgr

Grande Ronde Basalt, undivided--Dark gray to black, aphyric to sparsely plagioclase-phyric basaltic-andesite; consists of as many as 15 flows in the Columbia River Gorge (Tolan, 1982); near Ridgefield and Woodland, consists of two or three thin, intracanyon flows which are plastered against Tertiary bedrock; includes both high-MgO and low-MgO subunits, and R_2 and N_2 magnetostratigraphic units.

Tgn_2

N_2 magnetostratigraphic subunit of the Grande Ronde Basalt--In the Columbia River Gorge area, uniform-textured, gray to black, fine to medium grained, sparsely plagioclase-phyric basaltic-andesite flows; forms three flows with relatively high-MgO contents; low-MgO N_2 flows consists of a distinct plagioclase glomerophyric flow (Winter Water flow of Powell, 1978), plus as many as five glassy to fine -grained aphyric to rarely phyric flows with hackly-jointed, thick entablatures (Tolan, 1982).

Tgr_2

R_2 magnetostratigraphic subunit of the Grande Ronde Basalt--In the Columbia River Gorge area, as many as five, fine -grained to glassy, aphyric to phyric basaltic-andesite lava flows; flows have hackly-jointed entablatures with blocky to columnar colonnade; locally contains thick (158 m) pillow-palagonite complexes (Tolan, 1982).

Lower and Middle Miocene Sedimentary Rocks

Tso

Scappoose Formation of Van Atta and Kelty (1985) (lower to middle Miocene)--Fluvial micaceous, lithofeldspathic sandstone, conglomerate, and carbonaceous to coal-bearing mudstone, intertongued with shallow neritic to estuarine siltstone, mudstone, and minor sandstone; conglomerate clasts derived from low-MgO Grande Ronde Basalt (see unit Tgr) which interfingers with and overlies the Scappoose; about 460 m thick. The Scappoose disconformably overlies the Keasey (late Eocene through early Oligocene) and Pittsburg Bluff (late Eocene through Oligocene) formations; the unit was previously assigned to the late Oligocene through early Miocene (Warren and others, 1945); as mapped, may include some strata of Pittsburg Bluff or Keasey formations.

Lower Miocene Volcanic Rocks

Tec

Eagle Creek Formation--"Interstratified light brown to gray clayey conglomerate with abundant dark-colored porphyritic andesite clasts, laharic breccia, pebbly volcaniclastic sandstone, siltstone, and a few beds of air-fall tuff; forms discontinuous lensoidal beds 3 to 6 m thick; total thickness of unit 150 to 365 m" (Hammond, 1980, p. 26).

Ttc

Andesite flows of Three Corner Rock--"Interstratified dusky red, brown to dark gray pyroxene andesite porphyry, hornblende-pyroxene andesite porphyry lava flows, gray to reddish brown laharic breccia, and minor volcaniclastic rocks; lava flows are platy to columnarly jointed, glassy to finely crystalline; 18 to 40 m thick; interbeds of breccias and volcaniclastic rock are 1 to 5 m thick; total unit thickness 1000 m" (Hammond, 1980); equivalent to flows of Stevenson Ridge (Berri and Korosec, 1983); the aphyric to microphyric flows of Sedem Point (Berri and Korosec, 1983) that cap the Ttc sequence yielded K-Ar age of 23.6 +/- 1.2 m.y. (Phillips and others, 1986).

Lower Miocene-Upper Oligocene Volcanic Rocks

Tvt_3

Tuff--Light gray to greenish-gray lithic-pumice-crystal tuff; contains crystals of augite, plagioclase, and rarely, quartz; interbedded with volcaniclastic sandstone and conglomerate (Hammond, 1980); age uncertain; underlies Ttc so older than about 24 m.y.; correlative (?) with the Stevens Ridge Formation found near Mount Rainier (Fiske and others, 1963; Hammond, 1980).

Oligocene Volcanic Rocks

Tvc_2

Volcaniclastic rocks (upper Oligocene through lower ? Miocene)--Light gray to greenish-gray lithic-pumice-crystal lapilli tuff, tuff breccia, and andesitic to dacitic sandstone, conglomerate and siltstone; commonly massive to thickly-bedded; contains numerous thin, discontinuous intrusive rocks (sills and dikes) or lava flows; at Gumboot Mountain (sec. 31, 5N-5E), contains flaggy-parting sandstone and siltstone with an Oligocene fossil flora (R. Burnham, written commun., 1985); age range uncertain; stratigraphically above flows of unit Tva_2 (K-Ar age of about 28 m.y.); lies stratigraphically below flows of Three Corner Rock

(minimum K-Ar age of about 24 m.y.; includes East Fork Formation of Schriener (1978) and part of the Skamania Volcanics of Trimble (1963).

Tva_2

Basaltic-andesite and basalt flows (upper Oligocene)--Dark gray, basaltic-andesite and basalt, aphyric to augite-plagioclase phyric; commonly contains fine -grained, holocrystalline groundmass; forms thick, dense, blocky- to platy-jointed flows or sills; locally contains interbeds of dark-colored mafic tuff or basaltic sandstone and conglomerate; relatively less altered, more mafic, and forms thicker flow or sill complexes than units Tva_1 or Tgo_2; yielded K-Ar ages of 27.9 +/- 1.9 and 28.1 +/- 2.7 m.y. (Phillips and others, 1986); includes part of the Skamania Volcanics of Trimble (1963).

Tva_1

Andesite and basaltic-andesite flows (lower Oligocene)--Aphyric to pyroxene-plagioclase-phyric andesite and basaltic-andesite with minor flow breccia, tuff, and volcaniclastic sandstone; typically forms massive, blocky- to platy-jointed flows similar in appearance to Tgo_2; distinction between the two units is largely based upon Tva_1 lying stratigraphically above the widespread volcaniclastic unit, Tvc_1; age uncertain, but probably correlative with units dated in the Mount St. Helens 1:100,000-scale quadrangle (Phillips, 1987) at about 33 m.y.B.P.

Eocene-Oligocene Volcanic and Sedimentary Rocks

Tpb

Pittsburg Bluff Formation (uppermost Eocene to Oligocene)--highly variable, massive, marine arkosic or tuffaceous sandstone, mudstone and conglomerate; maximum thickness 250 m; contains Galvinian Stage molluscan fauna and Refugian and Zemorrian Stage foraminifers (Armentrout and others, 1983; Beaulieu, 1971).

Tvc_1

Volcaniclastic sedimentary and volcanic rocks (uppermost Eocene through lower Oligocene)--Heterogeneous conglomerate, breccia, and tuff; typically thick bedded and poorly exposed; forms persistent horizon separating flows of unit Tgo_2 and Tva_1; well-exposed along Interstate 5 near Marten Island (6N-1W).

At Martin Island area, unit consists of matrix-supported bouldery pebble conglomerate about 12 m thick with angular to rounded mafic volcanic clasts; grades downward into purple and white, well-bedded tuffaceous sandstone and siltstone; a breccia is

exposed that consists of lapilli-sized, angular basalt clasts with glassy rims that suggest a hyaloclastic origin for the unit; well-bedded, dark colored lithic-crystal tuff about 12 m thick contains mafic volcanic lithic fragments in a plagioclase-rich matrix; greenish-gray reverse-graded lapilli tuff 15 to 20 m thick is also present; along railroad tracks, distinctive breccia with angular basaltic sandstone and basalt blocks up to 3 m in length is exposed; locally resembles block lava flow and is over 10 m thick.

At Yale Dam, the unit consists of pinkish to greenish, pervasively altered, ash to block tuff; coarser grained tuff locally silicified; finer tuff (possibly a paleosol) decomposed to mottled red and green clays; at Yale Dam, unit Tvc_1 is unconformably overlain by unit Tva_1 (Tilford and Sullivan, 1981).

Age of unit Tvc_1 is somewhat uncertain; in Mount St. Helens 1:100,000-scale quadrangle (Phillips, 1987), a plagioclase separate from correlative strata between Merrill Lake and Cinammon Peak yielded a $^{40}Ar/^{39}Ar$ date of about 36 m.y.B.P. (R. Evarts, written commun., 1987); these strata also contain a Goshen flora (Wolfe, 1961); underlying unit Tgo_2 probably spans 38 to about 35 m.y.; age span of overlying unit Tva_1 appears to be from about 33 to 34 m.y.; therefore, Tvc_1 probably spans the Eocene-Oligocene boundary, from about 37 to about 34 m.y.B.P.

Tgo_2

Basaltic-andesite lava flows of the Goble Volcanics (upper Eocene through lower Oligocene)--Porphyritic pyroxene basaltic-andesite lava flows and flow breccia with thin interbeds of red-brown siltstone, sandstone, conglomerate, and tuff; also contains lesser olivine basalt, pyroxene andesite, and platy to irregularly jointed dacite; flows are typically thin (1 to 4 m) and lenticular or lozenge-shaped, with wavy top and bottom contacts; thin (5-50 cm) siltstone or sandstone layers often separate flows; dense flow centers typically blocky jointed to platy; well-developed columnar-jointing or colonnade-entablature sets rare; locally, scoriaceous flow breccia forms bulk of unit, enveloping small,lenticular dense flow-centers in block rubble; vugs and fractures contain characteristic assemblage of calcite and complex suite of zeolite minerals (Tschernich, 1986); total unit thickness exceeds 1500 m in the type area between Woodland, Washington and Kelso (Wilkinson and others, 1946).

In thin section, the unit is most commonly plagioclase-augite phyric with trachytic groundmass of plagioclase microlites, clinopyroxene, opaque minerals, and murky, green to brown, microcrystalline mixtures of zeolite minerals, chlorite, and volcanic glass; olivine phenocrysts also present in a few flows. The Goble Volcanics were first described by Wilkinson and others

(1946) for flows and pyroclastic rocks exposed at Goble, Oregon (sec. 12, 6N-2W), and on the Washington side of the Columbia River between Woodland and Kelso.

The age of Tgo_2 ranges from about 38 to about 35 m.y.B.P. (latest Eocene to early Oligocene). The unit correlates with the Cole Mountain Volcanics of northwestern Oregon (Niem and Niem, 1985), the basal portions of the Ohanapecosh Formation (Fiske and others, 1963), and with basal portions of the volcanic rocks of Huckleberry Mountain (Frizzell and others, 1984) north of the White River. Portions of the Northcraft Formation of Hagen (1987) may be correlative with Tgo_2, but further mapping is required to demonstrate this.

Miocene Igneous Intrusive Rocks of the Silver Star Pluton

The Silver Star Pluton is a large pluton of intermediate to granitic composition named by Felts (1939). Numerous smaller plutons, stocks, and plugs of similar composition and texture are also present in the eastern one-third of the map area. Two named units, Saturday Rock Pluton and Deer Creek Pluton, are described in Hammond (1980).

Tigp

Granitic porphyry--Light bluish-gray vesicular quartz diorite porphyry; composed of 6 to 10% large plagioclase and chloritized hornblende phenocrysts, 3 to 5% subspherical vesicles or quartz-filled amygdules, and pilotaxitic groundmass of plagioclase, hornblende, chlorite, magnetite, pyrite, and interstitial quartz; forms 5% of Silver Star pluton and intrudes granodiorite (Tigd); associated with porphyry-copper-type mineralization (Shepard, 1980; Schriener, 1978)

Tigd

Granodiorite--Light gray, porphyritic to hypidiomorphic equigranular granodiorite; composed of anhedral, interstitial quartz and orthoclase, subhedral to euhedral plagioclase, twinned and subhedral hornblende, anhedral, ragged biotite, and anhedral magnetite; both hornblende and biotite variably altered to chlorite, fibrous amphibole (?) and Fe-Ti oxides; from 50 to 70% of the Silver Star pluton is composed of granodiorite; yielded K-Ar age (Power and others, 1981) of 19.6 +/- 0.7 m.y. (Shepard, 1980; Schriener, 1978).

Tiqd

Quartz diorite--Light brown to light gray porphyritic to equigranular quartz diorite; composed of phenocrysts of anhedral quartz, subhedral plagioclase, subhedral augite, altered

hypersthene, and interstitial quartz, augite, and trace orthoclase; pyroxene extensively altered and commonly replaced by anhedral masses of uralite (amphibole), chlorite, magnetite, and minor biotite; forms 25 to 30% of the Silver Star pluton (Shepard, 1980; Schriener, 1978).

Tidi

Diorite--Medium bluish-gray to medium dark gray, hypidiomorphic-porphyritic and hypidiomorphic-granular diorite; composed of phenocrysts of subhedral to euhedral plagioclase, stubby to elongate subhedral augite, and stubby subhedral hypersthene; opaque Fe-Ti-oxide phenocrysts and interstitial anhedra compose about 6% of the diorite; pyroxenes variably altered to chlorite, epidote, opaque, clay and fibrous amphibole (?); forms dominant lithology of cupolas and Saturday Rock Pluton (Shepard, 1980; Schriener, 1978).

Tian

Intrusive andesite--Light to medium gray pyroxene-plagioclase-phyric andesite; forms chilled border zone of Silver Star Pluton as well as numerous smaller intrusive bodies in eastern one-third of map area; consists of subhedral to euhedral phenocrysts of plagioclase, augite, and less commonly, pleochroic brown hornblende; groundmass aphyric to fine -grained and variably altered to dark brown clay; mafic phenocrysts also variably altered to chlorite, clay, and opaque Fe-Ti minerals (Shepard, 1980; Schriener, 1978).

STRUCTURE

The dominant structural feature of the map area is the Portland-Vancouver basin. The basin consists of an open, roughly elliptical, northwest-trending syncline 25 to 30 km wide. The floor of the basin slopes to the west-southwest so that greatest basin depth is reached in Portland. The Portland Hills structure forms the basin margin on the southwest and may be responsible for the basin slope. Deposition of the Troutdale Formation (Miocene to early Pleistocene) occurred simultaneously with development of the Portland-Vancouver basin (Mundorff, 1964, p. 28).

The Portland Hills structure, consisting of a northwest-trending anticline and fault, separates the Tulatin synclinal basin on the southwest from the Portland-Vancouver basin on the northeast. Location of the Portland Hills anticlinal axis is poorly constrained on the map; cross sections indicate that the axial region is broad and crenulated (Balsillie and Benson, 1971). The east limb of the anticline is cut by the Portland Hills fault. Balsillie and Benson (1971) concluded that the fault has normal

dip-slip displacement of about 225 m. Seismicity near the fault has been interpreted to indicate continuing displacement along the structure (Balsillie and Benson, 1971).

An important northeast-trending fault zone is present between Fargher Lake (sec. 25, 2E-5N) and Canyon Creek (sec. 3, 4E-5N). The fault zone, termed the Chelatchie Prairie faults by Mundorff and Eggers (written commun., 1985), truncates the major Lakeview Peak anticline and forms Chelatchie Prairie, a flat-bottomed, alluvium-filled, down-faulted basin. Tumtum Mountain, a Pleistocene dacite dome, was erupted along the Chelatchie Prairie fault zone (Mundorff and Eggers, written commun., 1985). The fault zone is well-exposed northeast of Tumtum Mountain along Canyon Creek in S/2 sec. 4 (5N-4E). The fault plane is vertical to near-vertical and forms a zone 13-18 m wide of yellow to orange-weathering fault gouge and purple to green very fine grained angular fault breccia (Mundorff and Eggers, written commun., 1985). Displacement along the fault zone is not known.

A northwest-trending fault zone formed the Yacolt basin in 3E-5N and 3E-4N. The fault zone may continue to the southeast through Dale along a prominent topographic linear (Mundorff, 1964, p. 30).

Structural details are unclear or imprecisely known in many other areas of the map area, especially in the eastern half. Thickly bedded to massive volcanic lithologies apparently lacking distinctive marker horizons that make structural data difficult to collect. Long-dashed fold axes and fault traces on the map need further study and should be regarded as unproved structures.

REFERENCES CITED

Aguirre, Emiliano; Pasini, Giancarlo, 1985, The Pliocene-Pleistocene boundary: Episodes, v. 8, no. 2, p. 116-120.

Allison, I. S., 1953, Geology of the Albany quadrangle, Oregon: Oregon Department of Geology and Mineral Industries bulletin 37.

Armentrout, J. M.; Hull, D. A.; Beaulieu, J. D.; Rau, W. W., 1983, Correlation of Cenozoic stratigraphic units of western Oregon and Washington: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 7, 90 p., 1 plate.

Allen, J. E., 1975, Volcanoes of the Portland area, Oregon: ORE BIN, v. 37, p. 145-157.

Balsillie, J. H.; Benson, G. T., 1971, Evidence for the Portland Hills fault: ORE BIN, v. 33, no. 6, p. 109-118.

Barnoksy, C., 1985, Late Quaternary vegetation near Battle Ground Lake, southern Puget Trough, Washington: Geological Society of America Bulletin v. 96, no. 2, p. 263-271.

Bateman, A. J., Jr., 1951, Geology of dam sites on Lewis River, Washington: U.S. Geological Survey Open-File Report, 11 p.

Beaulieu, J. D., 1971, Geologic formations of western Oregon (west of longitude 121°30'): Oregon Department of Geology and Mineral Industries Bulletin 70, p. 31-32.

Beeson, M. H.; Fecht, K. R.; Reidel, S. P.; Tolan, T. L., 1985, Regional correlations within the Frenchman Springs Member of the Columbia River Basalt Group--New insights into the middle Miocene tectonics of northwestern Oregon: Oregon Geology, v. 47, no. 8, p. 87-96.

Berri, D. A.; Korosec, M. A., 1983, Geological and geothermal investigation of the lower Wind River Valley, southwestern Washington Cascade Range: Washington Division of Geology and Earth Resources Open File Report 83-5, 48 p., 2 plates.

Crandell, D. R., 1980, Recent eruptive history of Mount Hood, Oregon, and potential hazards from future eruptions: U. S. Geological Survey Bulletin 1492, 81 p., 1 plate.

Crandell, D. R.; Miller, R. D., 1974, Quaternary stratigraphy and extent of glaciation in the Mount Rainier region, Washington: U.S. Geological Survey Professional Paper 847, 59 p., 2 plates.

Ebasco Services Incorporated, 1974, Report for selection of plant, Yale hydroelectric expansion: Pacific Power and Light Company, 1 vol.

Felts, W. M., 1939, A granodiorite stock in the Cascade Mountains of southwestern Washington: Ohio Journal of Science, v. 39, no. 6, p. 297-316.

Fiksdal, A. J., 1975, Slope stability of Clark County, Washington: Washington Division of Geology and Earth Resources Open-File Report 75-10, 4 p., 1 plate, scale 1:62,500.

Fiksdal, A. J., 1978, Geology of southern Skamania County: Washington Division of Geology and Earth Resources unpublished report, 1 sheet, scale 1:62,500.

Fiske, R. S.; Hopson, C. A.; Waters, A. C., 1963, Geology of Mount Rainier National Park, Washington: U. S. Geological Survey Professional Paper 444, 93 p.

Frizzell, V. A., Jr.; Tabor, R. W.; Booth, D. B.; Ort, K. M.; Wait, R. B., Jr., 1984, Preliminary geologic map of the Snoqualmie Pass 1:100,000 quadrangle, Washington: U. S. Geological Survey Open File Report 84-693, 43 p., 1 plate, scale 1:100,000.

Hagen, R. A., 1987, The geology and petrology of the Northcraft Formation, Lewis County, Washington: University of Oregon Master of Science thesis, 252 p., 1 plate.

Hammond, P. E., 1980, Reconnaissance geologic map and cross sections of southern Washington Cascade Range, latitude 45°30'N.-47°15' N., longitude 120°45'-122°22.5' W.: Portland State University Department of Earth Sciences, 31 p., 2 sheets, scale 1:125,000.

Hammond, P. E., 1985, Geologic map of the Lookout Mountain 15-minute quadrangle: unpublished map, 1 sheet, scale 1:62,500.

Hammond, P. E.; Korosec, M. A., 1983, Geochemical analyses, age dates and flow-volume estimates for Quaternary volcanic rocks, southern Cascade Mountains: Washington Division of Geology and Earth Resources Open File Report 83-13, 36 p., 1 plate.

Heusser, C. J.; Heusser, L. E., 1980, Sequence of pumiceous tephra layers and the late Quaternary environmental record near Mount St. Helens: Science, v. 210, no. 4473, p. 1007-1009.

Hopson, C. A., 1980, Geology of the Mount St. Helens area, Washington: unpublished report, 2 sheets, scale 1:32,250.

Hyde, J. H., 1975, Upper Pleistocene pyroclastic-flow deposits and lahars south of Mount St. Helens volcano, Washington: U. S. Geological Survey Bulletin 1383-B, 20 p.

Korosec, M. A., compiler, 1987, Geologic map of the Mount Adams quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-5, 39 p., 1 pl., scale 1:100,000

Korosec, M. A., compiler, 1987, Geologic map of the Hood River quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-6, 40 p., 1 pl., scale 1:100,000

Lux, D. R., 1981, Geochronology, geochemistry and petrogenesis of basaltic rocks from the western Cascades, Oregon: Ohio State University Ph.D dissertation, 171 p.

Montanari, Alessandro; Drake, Robert; Bice, D. M.; Alvarez, Walter; Curtis, G. H.; Turrin, B. D.; DePaolo, D. J., 1985, Radiometric time scale for the upper Eocene and Oligocene based on K/Ar and Rb/Sr dating of volcanic biotites from the pelagic sequence of Gubbio, Italy: Geology, v. 13, no. 9, p. 596-599.

Mundorff, M. J., 1964, Geology and ground-water conditions of Clark County, Washington, with a description of a major alluvial aquifer along the Columbia River: U. S. Geological Survey Water-Supply Paper 1600, 268 p., 1 plate.

Mundorff, M. J., 1984, Glaciation in the lower Lewis River Basin, southwestern Cascade Range, Washington: Northwest Science, v. 58, no. 4, p. 269-281.

Mullineaux and Crandell, 1981, The eruptive history of Mount St. Helens. In Lipman, P. W.; Mullineaux, D. R., editors, 1981, The 1980 eruptions of Mount St. Helens, Washington: U. S. Geological Survey Professional Paper 1250, p. 3-15.

Niem, A. R.; Niem, W. A., 1985, Geologic map of the Astoria Basin, Clatsop and northernmost Tillamook Counties, northwest Oregon: Oregon Department of Geology and Mineral Industries Oil and Gas Investigations 14, 2 sheets, scale 1:100,000, with 8 p. text.

Phillips, W. M., compiler, 1987, Geologic map of the Mount St. Helens quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-4, 59 p., 1 pl., scale 1:100,000

Phillips, W. M.; Korosec, M. A.; Schasse, H. W.; Anderson, J. L.; Hagen, R. A., 1986, K-Ar ages of volcanic rocks in southwest Washington: Isochron/West, v. 47, p. 18-24.

Polivka, D. R., 1984, Quaternary volcanology of the West Crater-Soda Peaks area, southern Washington Cascade Range: Portland State University Master of Science thesis, 78 p., 1 plate.

Powell, L. V., 1978, The structure, stratigraphy and correlation of the Grande Ronde Basalt on Tygh Ridge, Wasco County, Oregon: University of Idaho Master of Science thesis, 57 p.

Power, S. G.; Field, C. W.; Armstrong, R. L.; Harakal, J. E., 1981, K-Ar ages of plutonism and mineralization, western Cascades, Oregon and southern Washington: Isochron/West, no. 31, p. 27-29.

Prothero, D. R.; Armentrout, J. M., 1985, Magnetostratigraphic correlation of the Lincoln Creek Formation, Washington--Implications for the age of the Eocene/Oligocene boundary: Geology, v. 13, no. 3, p. 208-211.

Rigg, G. B., 1958, Peat Resources of Washington: Washington Division of Mines and Geology Bulletin 44, 272 p.

Salvador, Amos, 1985, Chronostratigraphic and geochronometric scales in COSUNA stratigraphic correlation charts of the United States: American Association of Petroleum Geologists Bulletin, v. 69, no. 2, p. 181-189.

Schriener, Alexander, Jr., 1978, Geology and mineralization of the north part of the Washougal mining district, Skamania County, Washington: Oregon State University Master of Science thesis, 135 p., 1 plate.

Shannon and Wilson, 1968, Report on preliminary subsurface investigations--Proposed nuclear power plan sites, Clark and Cowlitz Counties, Washington: Shannon and Wilson [Portland, Oregon] 0-67-306, report to Sargent and Lundy, 37 p., 2 plates.

Shepard, R. J., 1980, Geology and mineralization of the southern Silver Star Stock, Washougal mining district, Skamania County, Washington: Oregon State University Master of Science thesis, 113 p., 1 plate.

Swanson, D. A.; Anderson, J. L., Bentley, R. D.; Byerly, G. R.; Camp, V. E.; Gardner, J. N.; Wright, T. L., 1979, Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U. S. Geological Survey Open File Report 79-1363, 26 p., sheet 10 of 12, scale 1:250,000.

Tabor, R. W.; Waitt, R. B., Jr.; Frizzell, V. A., Jr.; Swanson, D. A.; Byerly, G. R.; Bentley, R. D., 1982, Geologic map of the Wenatchee 1:100,000 quadrangle, central Washington: U. S. Geological Survey Miscellaneous Investigation Series Map I-1311, 1 sheet, scale 1:100,00, 20 p.

Tilford, N. R.; Sullivan, J. G., 1981, Lewis River hydroelectric developments. In Association of Engineering Geologists, 1981, Field trip guidebook--Engineering geology in the Pacific Northwest: Association of Engineering Geology, p. 156-185.

Tolan, T. L., 1982, The stratigraphic relationship of the Columbia River Basalt Group in the lower Columbia River Gorge of Oregon and Washington: Portland State University Master of Science thesis, 151 p., 1 plate, scale 1:21,120.

Tolan, T. L.; Beeson, M. H., 1984, Intracanyon flows of the Columbia River Basalt Group in the lower Columbia River Gorge and their relationship to the Troutdale Formation: Geological Society of America Bulletin, v. 95, no. 4, p. 463-477.

Travis, R. B., 1955, Classification of rocks: Colorado School of Mines Quarterly, v. 50, no. 1, p. 98 p.

Trimble, D. E., 1963, Geology of Portland, Oregon, and adjacent areas: U.S. Geological Survey Bulletin 1119, 119 p., 1 plate, scale 1:62,500.

Tschernich, R. W., 1986, Zeolite collecting at Goble, Oregon--revisited: Micro Probe [Northwest Micro Mineral Study Group Newsletter], v. VI, no. 3, 6 p.

Van Atta, R. O.; Kelty, K. B., 1985, Scappoose Formation, Columbia County, Oregon--New evidence of age and relation to Columbia River Basalt Group: American Association of Petroleum Geologists Bulletin, v. 69, no. 5, p. 688-698.

Vogt, B. F., 1981, The stratigraphy and structure of the Columbia River Basalt Group in the Bull Run Watershed, Multnomah and Clackamas Counties, Oregon: Portland State University Master of Science thesis, 148 p.

Waitt, R. B., 1985, Case for periodic, colossal jokulhlaups from Pleistocene glacial Lake Missoula: Geological Society of America Bulletin v. 96, no. 10, p. 1271-1286.

Walsh, T. J., 1986, Geologic map of the west half of the Toppenish quadrangle, Washington: Washington Division of Geology and Earth Resources Open-File Report 86-3, 1 sheet, scale 1:100,000, 7 p.

Walsh, T. J., 1986, Geologic map of the west half of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-4, 1 sheet, scale 1:100,000, 9 p.

Walsh, T. J., 1987, Geologic map of the Astoria and Ilwaco quadrangles, Washington: Washington Division of Geology and Earth Resources Open File Report 87-2, 1 sheet, scale 1:100,000.

Walsh, T. J.; Korosec, M. A.; Phillips, W. M.; Logan, R. L.; Schasse, H. W., in press, Geologic map of Washington--southwest quadrant: Washington Division of Geology and Earth Resources GM-34, scale 1:250,000.

Warren, W. C.; Grivetii, R. M.; Norbisrath, Hans, 1945, Geology of northwestern Oregon, west of Willamette River and north of latitude 45°15': U. S. Geological Survey Oil and Gas Investigations Preliminary Map [OM 42], scale 1:145,728.

Wells, F. G.; Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geological Investigations Map I-325, scale 1:500,000.

Wilkinson, W. D.; Lowry, W.D.; Baldwin, E. M., 1946, Geology of the St. Helens quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 31, 39 p., 1 plate, scale 1:62,500.

Williams, I. A., 1930, Report on geologic conditions at Ariel dam site, north fork of Lewis River, Washington: prepared for Northwestern Electric Company, Portland, Oregon, 1 vol.

Wolfe, J. A., 1961, Age of the Keechelus andesitic series of the Cascade Range, Washington. In Short papers in the geologic and hydrologic sciences; Geological Survey Research 1961: U. S. Geological Survey Professional Paper 424-C, article 232, p. 228-230.

Zanettin, Bruno, 1984, Proposed new chemical classification of volcanic rocks: Episodes, v. 7, no. 4, p. 19-20.

ERRATA

Phillips, W. M., 1987, Geologic Map of the Vancouver Quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open File Report 87-10.

Plate (geologic map):

Under Explanation of Units, Quaternary Volcanic Deposits, Pleistocene Units, unit Qvso basaltic-andesite flows of Soda Peaks should read:

Qvsp basaltic-andesite flows of South Soda Peaks.

Map polygons labeled Qvso in sections 28, 33, 34, and 35, T. 5N., R. 6E. should be labeled Qvsp.

November 24, 1987
wmp