WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
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GEOLOGIC MAP OF THE MOUNT RAINIER QUADRANGLE, WASHINGTON

Compiled by
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WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES

OPEN FILE REPORT 87-16

1987
(Revised Dec. 1987)

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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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. Other maps in the series are available for all 1:100,000-scale quadrangles within the south- west quadrant, that is, south of 47°15' north latitude and west of 120°30' west longitude, except for the Wenatchee and Snoqualmie Pass quadrangles which are available as U.S. Geological Survey Maps.

The 1:100,000-scale maps in this series that have been released to date 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

Igneous rocks are classified according to Travis (1955). If geochemical data are available, volcanic rocks are classified according to the current classification of the International Union of Geological Sciences (Zanettin, 1984).

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 Aguirre and Giancario (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.

Acknowledgments

Field work during the summer of 1985 was assisted by C. Cushman. T. J. Walsh provided mapping support in the south part of the Darland Mountain 7.5-minute quadrangle. M. A. Korosec provided mapping and sampling support in the Randle 15-minute quadrangle and locally in the Packwood 15-minute quadrangle, and supplied many insights into numerous aspects of the geology of the quadrangle. G. A. Clayton, (University of Washington) provided geologic details used in compiling the geology in the American Ridge, Nelson Ridge, Timberwolf Mountain, and Discovery Creek areas. Rick Wooten (U.S. Forest Service, Packwood Ranger District) provided unpublished geologic data and the use of air-photos for the Randle-Packwood area. D. L. Gusey (USFS) Naches Ranger District, provided an unpublished map and report of the geology of the district. Reviews and helpful comments were received from G. A. Clayton and J. A. Vance (University of Washington; D. A. Swanson and J. G. Smith (U.S. Geological Survey, Vancouver and Menlo Park respectively), Rick Wooten (USFS), N. P. Campbell (Yakima Valley College), and particularly P. E. Hammond (Portland State University) who provided a comprehensive review and details used to compile important aspects of the geology in the Bumping River-American Ridge area and area north of the American River.

DESCRIPTION OF MAP UNITS
MOUNT RAINIER QUADRANGLE, WASHINGTON

Quaternary Unconsolidated Deposits

Holocene Deposits

Nonglacial Deposits

af

Artificial fill--Tieton Reservoir Dam

Qal

Alluvium--Silt, sand, and gravel deposited in streambeds and fans; surface relatively undissected; includes some low-level terraces and some lacustrine deposits; may include some glacial deposits and some volcanic mudflow deposits

Qaf

Alluvial fan deposits--Poorly sorted boulder gravel to gravelly sand; forms fans of distinctly steeper gradient than floor of sidestream or trunk-stream valleys

Qls

Landslide debris--Rock fragments, colluvium, soil, and, locally, organic matter deposited by mass wasting; unstratified and poorly sorted; surface commonly hummocky

Qta

Talus deposits--Loose rubble accumulations on steep slopes and beneath cliffs; shown in the Bumping Lake area and surrounding areas (Simmons and others, 1983); not shown in the Mount Rainier area in the interest of showing bedrock detail on this map

Qme

Electron Mudflow--Unsorted mixture of andesite rock fragments in a clayey sand matrix; rock fragments chiefly of Mount Rainier provenance; radiocarbon age of contained wood is 530 +/- 200 yr (Crandell, 1963); confined to Puyallup River valley

Qmr

Round Pass Mudflow--Mudflow of Mount Rainier provenance on valley sides and some ridgetops in and adjacent to the valleys of Tahoma Creek and the North and South Puyallup Rivers; consists of an unsorted mixture of boulders in a yellowish-orange matrix of sand, silt, and clay; radiocarbon age of contained wood is about 2,800 yr (Crandell, 1971)

Qmo

Osceola Mudflow--Mudflow of Mount Rainier provenance consisting of an unsorted mixture of andesite rock fragments in a clayey sand matrix; forms terraces along the White River; radiocarbon age of contained wood is about 5,700 yr (Crandell, 1971)

Qmg

Greenwater lahar--Lahar of Mount Rainier provenance consisting of gray to yellowish-brown sand to angular and subangular blocks up to 10 m diameter; topographic surface characteristically dotted with mounds 1-10 m high; forms terraces at several places in the White River Valley; age between 5,700 and 6,600 yr (Crandell, 1971)

Qmp

Paradise lahar--Mudflow originating on the south flank of Mount Rainier and now mantles bedrock ridges, knobs, and depressions in the Paradise area; age between 5,800 and 6,600 yr (Crandell, 1971)

Qmu

Undifferentiated mudflows and interbedded mudflows and alluvium--Only larger deposits are shown; mudflows mostly resulted from floods caused by eruptions on Mount Rainier volcano, but some probably originated during periods of unusually heavy rainfall; mudflows are interbedded with alluvium in terraces or benches in the Pyramid Creek-Kautz Creek drainage and upper Nisqually River valley and the upper reaches of the Ohanapecosh River valley; mudflows are generally younger than 6,600 yr (Crandell, 1969, 1971)

Glacial Deposits

Qdg

Garda Drift--Deposits of till and outwash material forming well-preserved morainal ridges of alpine drift below the bases of glacial ice on Mount Rainier; till is gray, unweathered; outwash consists of poorly sorted and stratified boulder gravels extending down valley from moraines; younger than 2,040 +/- 200 yr (Crandell, 1969; Crandell and Miller, 1974)

Qdb

Burroughs Mountain Drift--Moraines of alpine drift found only short distances beyond Garda moraines; exposed in the valley of the West Fork of the White River on the west flank of Burroughs Mountain; younger than 2,980 +/- 250 yr (Crandell and Miller, 1974)

Qdm

McNeely Drift--Consists of till in moraines formed during the latest part of the most recent major glaciation on the slopes of Mount Rainier; weathering extends to 40-70 cm depth; forms sharp-crested moraines which are little modified by erosion; stones near surface lack weathered rinds; older than 8,750 yr B.P., probably about 11,000 yr (Crandell, 1969; Crandell and Miller, 1974)

Pleistocene Deposits

Glacial Deposits

Qtr

Undifferentiated terrace deposits--Well-rounded, unconsolidated terrace gravels near the mouth of Gold Creek on the Naches River, 2 miles southeast of Cliffdell; probable Pleistocene age (Carkin, 1985)

Qde
Qdet

Evans Creek Drift--Undifferentiated alpine glacial drift consisting of till, moraine, and outwash deposits (Hammond, 1980); till (Qdet) is bouldery, loosely compacted, and complexly interbedded with poorly sorted silt, sand, and gravel; oxidized yellowish-brown 0.6 to 0.9 m deep; cobbles near the surface generally lack weathered rinds; moraines retain much original constructional topography; outwash deposits are loosely consolidated, stratified, poorly to well-sorted silts, sands, and gravels and commonly underlie terraces graded to moraines; occurs in most valleys, deposited by Cascade ice cap; includes younger till in Tieton River Valley of Long (1951); age between 12,500 and 20,000 yr (Crandell and Miller, 1974)

Qdh

Hayden Creek Drift--Undifferentiated yellowish-brown stony till and boulder-gravel outwash deposits of extensive ice cap in the Cascade Range but exposed in valleys only at elevations above those reached by younger glaciation (Hammond, 1980); stones near top of the till have weathering rinds which range in thickness from 0.5 to 2.5 mm; original topography considerably modified but many large moraines still recognizable; age older than 38,000 yr (Crandell and Miller, 1974); probably as old as 130,000 to 140,000 yr (Porter, 1976; Waitt, 1977)

Qdht

Hayden Creek Drift, till deposits--Till and moraine deposits distributed along the Clear Fork of the Cowlitz River, Tieton River valley northeast of Goose Egg Mountain and northwest of Westfall Rock; Clayton (1983) provides evidence that the till exposed along the Clear Fork is possibly older than Hayden Creek; includes older moraine of Tieton River Valley of Long (1951)

Qdum

Undifferentiated alpine glacial moraine deposit--Alpine moraine deposit of undertermined age on slopes above South Fork of Tieton River

Quaternary Volcanic Rocks

Qvmo

Andesite of Observation and Echo Rocks at Mount Rainier volcano (late Pleistocene)--Dark-colored olivine andesite flows forming dissected remnants of two satellite cones on northwestern flank of Mount Rainier; flows from vents at Observation and Echo Rocks are as old as the Fraser glacial period (late Pleistocene) (Fiske and others, 1963)

Qvmr

Andesite of Mount Rainier volcano (middle and late Pleistocene)--Chiefly gray porphyritic hypersthene-augite and minor olivine andesite in thick intracanyon lava flows and associated mudflows near the base of the volcano; thinner flows and interbedded breccia on upper slopes (Fiske and others, 1963); most lava flows predate Hayden Creek Stade; older flows in the Yakima Park (Sunrise) area dated at 600,000 yr B.P. (K-Ar, plagioclase) and 320,000 yr B.P. (K-Ar whole rock) (Crandell and Miller, 1974); the most recent flows which make up the summit cone are probably no more than 2,000 years old (Crandell, 1971)

Qvsp

Dacite of Spiral Butte (late Pleistocene)--Cylindrical to conical plug dome of very fine grained, light-gray, platy, flow-banded hypersthene-hornblende dacite, east of White Pass; oldest flows younger than 0.73 m.y.B.P. and are probably late Pleistocene (Clayton, 1983)

Qvcf

Dacite of Clear Fork--Very fine grained quartz-hornblende-hypersthene dacite intracanyon lava flow along Clear Fork of the upper Cowlitz River; platy to columnar jointing with well-developed downward tapering and subdividing columns over 60 m tall; erupted from vent on east side of Coal Creek Mountain; overlain by Evans Creek Drift; abrupt steep termination and jointing characteristic of ponded lavas suggest lava flow was blocked by Cowlitz glacier, possibly during Hayden Creek Stade, about 130,000-140,000 yr B.P. (Hammond 1980); younger than 0.73 m.y.B.P. and probably late Pleistocene (Clayton, 1983)

Qvdl

Andesite of Deer Lake Mountain (late Pleistocene)--Hornblende andesite flow and lava-dome, contiguous to the White Pass Highway; age is younger than 0.73 m.y.B.P. and is probably late Pleistocene (Clayton, 1983)

Qvpe

Andesite of Pear Lake (Late-middle Pleistocene)--Hornblende andesite flow(s) bordering the east and northeast perimeter of the Tumac plateau; flow contains olivine, quartz, hornblende, and plagioclase-phyric lava that has anomalous chemistry (mixed magma); age is younger than 0.73 m.y. and is probably late-middle Pleistocene (Clayton, 1983)

Qvjl

Andesite of the Jess Lake complex (middle to late Pleistocene)--Hornblende andesite lava (including unusual highly vesicular glassy lava) and vent breccia almost completely overwhelmed by Tumac basaltic andesite (unit Qvtm); estimated age based on association with other Quaternary hornblende andesites in the White Pass area (Clayton, 1983)

Qvro

Andesite of Round Mountain (early to middle Pleistocene)--A 250-m-thick sequence of hornblende andesite lavas and tuff capping Round Mountain, situated at the interfluve of the Clear Fork of the Cowlitz and North Fork of the Tieton Rivers; K-Ar age dated (whole rock) at 0.79 +/- 0.13 m.y.B.P. [from a lava at Summit of Round Mountain (Clayton, 1983)]

Qvru

Andesite of Russell Ridge (Pleistocene)--Hornblende andesite dike (and flow?) occurring as several patches on Russell Ridge; Pleistocene age assigned on basis of association with other

Quaternary hornblende andesites in the White Pass area (Clayton, 1983)

Qvtm

Basalt of Tumac Mountain (middle and late Pleistocene)--Gray phyric olivine basalt; forms several vesicular, pahoehoe lava flows which underlie plateau beneath Tumac Mountain cinder cone (basaltic andesite geochemistry) of pre-neoglacial age (3,000 yr) and post-Evans Creek Stade (12,400 yr) (Hammond, 1980); recent tephra studies around the Tumac Plateau indicate the most recent eruption of Tumac Mountain occurred between 30,000 and 20,000 yr B.P. (Clayton, 1983)

Qva

Unnamed andesite flows (Pleistocene)--Several unnamed andesite flows which include hornblende andesite flows east and west of Spiral Butte, a basaltic andesite flow [possibly originating at Cramer Mountain northwest of Spiral Butte (Clayton, 1983)], and a basaltic andesite flow southwest of Spiral Butte (Clear Creek andesite of Hammond, 1980); a fourth unnamed (hornblende) andesite flow occurs in the Bumping River valley northeast of Bumping Lake and apparently has a vent on the southeast slope of American Ridge (G.A. Clayton, written commun., 1985)

Qvkl

Basalt of Kincaid Lake (middle to late Pleistocene)--Olivine basalt lava flow 8 km northwest of Tumac Mountain, which apparently ponded on the ridge crest to a depth of 40 m and then spilled down towards Carlton Pass (Clayton, 1983)

Qvlv

Basalt of Lava Creek (Pleistocene)--Hyaloclastic plagioclase-olivine phyric basalt, capping ridge between Lava and Little Lava Creeks in the north part of the Goat Rocks Wilderness; may be the product of a subglacial eruption, probably predating the valley-filling of the dacite of Clear Fork of the Cowlitz River (Swanson and Clayton, 1983)

Qvos

Andesite of Old Snowy Mountain (early Pleistocene?)--Light-gray, phyric hypersthene andesite (Hammond, 1980); very fine grained dense andesite; forms lava flows in the upper Lake Creek (southeast of Packwood Lake) and in the Cispus River valley to the south of the Mount Rainier quadrangle (Swanson and Clayton, 1983); erupted from vents near the top of Old Snowy Mountain; this vent area was also center of the Plio-Pleistocene Goat Rocks stratovolcano; may be related to Tieton Andesite (unit Qvti), which erupted about 1 m.y.B.P. (K-Ar age date) from vents just east of the Old Snowy vents (Clayton, 1983)

Qvdp

Andesite of Deep Creek (middle to late Pleistocene)--Light-bluish-gray to dark-gray phyric hypersthene-hornblende andesite (Hammond, 1980); forms several lava flows from at least two centers in the Bumping River drainage; dense, very fine grained, flow-layered, platy to blocky jointed; predates Evans Creek and possibly Hayden Creek(?) Stades; older than 140,000 yr but younger than 0.73 m.y. (Abbott, 1953; Simmons and others, 1983; Clayton, 1983)

Qvrr

Basalts of Rimrock Lake (middle Pleistocene?)--Two olivine basalts in the Rimrock Lake area: a younger, dark-gray nearly aphyric, diktytaxitic olivine basalt containing iddingsite; and an older dark-gray phyric olivine basalt with chiefly plagioclase phenocrysts; younger basalt locally fills gorges eroded into Tieton Andesite; both basalts have crudely columnar and platy jointing and extensive upper vesicular zones; unknown source probably lies to the west, perhaps at Hogback Mountain; older than 140,000 yr and younger than 990,000 yr, probably younger than 690,000 yr (Hammond, 1980; Swanson, 1978)

Qvti

Tieton Andesite (early Pleistocene)--Several flows of dark-gray hypersthene-augite phyric andesite and at least one flow of olivine andesite erupted from vents southwest of Pinegrass Ridge, which were the center of the Plio-Pleistocene Goat Rocks stratovolcano (Clayton, 1983); one of the least altered lavas of the Goat Rocks volcano; one flow, up to 120 m thick, extends down the Tieton River canyon to Naches, nearly 80 km from its probable source in the Goat Rocks area (Russell, 1893; Smith, 1903; Warren, 1941; Becraft, 1950); ages for the Tieton Andesite include K-Ar dates of 1.0 +/- 0.1 m.y.B.P. (Swanson, 1978) and 0.99 m.y.B.P. (Hammond, 1980); a 1.3 +/- 0.2 m.y.B.P. zircon fission-track date has come from a tuff directly underlying the Tieton Andesite (Clayton, 1983)

Qvhm

Mafic rocks of Hogback Mountain (early Pleistocene)--Upper part of the Hogback Mountain mafic magmas erupted from widely distributed vents in the White Pass area during the early Pleistocene; includes basalts and basaltic andesites which commonly bear olivine phenocrysts; lesser andesites and minor dacites also make up the Quaternary section; distal lavas, many of which originated at Hogback Mountain and were deposited in paleovalleys to the north, consist of several deposits which include: basaltic pillow palagonite breccias northwest of Twin include: basaltic pillow palagonite breccias northwest of Twin Sisters Lake; basaltic andesite and andesites forming the ridge north of Cartright Creek; and andesite and basaltic andesite vent facies at Cramer Mountain 4 km southwest of Tumac Mountain; a 50-m-thick hornblende andesite and dacite interrupt the monotonous sequence of basalts making up the bulk of Hogback Mountain lavas (the Plio-Pleistocene package, unit QThm; see Clayton, 1983, for details of the Hogback Mountain lavas); massive 4-m-thick basalt flow near stratigraphic top of Hogback Mountain Shield volcano gave a whole-rock K-Ar age of 1.53 +/- 0.18 m.y. (Clayton, 1983)

Qvb
Qvba

Unnamed basalt and basaltic andesite lava flows--Vesicular, plagioclase-clinopyroxene-olivine phyric basalt (unit Qvb) and basaltic andesite (unit Qvba) intracanyon lava flows with basaltic andesite, basalt, and andesite geochemistry (Table 1) in the Carlton Creek-Summit Creek area (M.A. Korosec, written commun., 1986)

Quaternary Intrusive Rocks

Qimr

Plugs and dikes of Mount Rainier volcano (middle to late Pleistocene)--Light-gray porphyritic andesite resembling andesite of lava flows of Mount Rainier; forms central plug and radiating dikes, and satellite plugs of olivine andesite at Echo Rock and Observation Rock; central plug altered and thoroughly opalized; age is younger than 600,000 yr (Fiske and others, 1963)

Pliocene-Pleistocene Volcanic Rocks

QThm

Mafic rocks of Hogback Mountain (late Pliocene to early Pleistocene)--Older Plio-Pleistocene package of Hogback Mountain Mafic rocks; mostly brown olivine-augite basalt erupted from vents along the Cascade crest south of White Pass and spread at least 16 km (Hammond, 1980); remnants of largest and oldest Hogback Mountain volcano exposed at Hogback Mountain consist of a 700-m-thick sequence of basalt flows which formed a shield volcano against the northern flank of the Goat Rocks stratovolcano; lavas erupted in the early history of the two volcanoes are complexely intercalated; age dates on the Plio-Pleistocene package include a fission-track date of 3.1 +/- 0.3 m.y.B.P. from a tuff in the lower part of the stratigraphic section; also more than 40 basalt flows with reversed magnetic polarity are inferred to be of early Matuyama chron age (1.88 to 2.47 m.y.; Clayton, 1983)

QTsy

Dacite of Snyder Mountain--Erupted west of Packwood Lake; "light-gray phyric olivine-hypersthene dacite (66% SiO_2); forms a series of short flows 3 to 7 m thick with slaggy tops and bases; dense, very fine grained; flow-layered, platy to blocky jointed; maximum thickness about 100 m, age unknown; remanent magnetic polarity undetermined; estimated age greater than 140,000 yr and possibly as old as 2 m.y.B.P." (Hammond, 1980)

QTbf

Andesite of Bee Flat (Pliocene or Pleistocene)--"Dark-colored intracanyon lava flows of hypersthene-oxyhornblende andesite (dacite?)" (Hammond, 1980); mapped in northwest part of Mount Rainier National Park. Thickness estimated at 90 m; age estimated to be Pliocene(?) by Fiske and others (1963)

QTvg

Andesite of Goat Rocks (Plio-Pleistocene)--Gray porphyritic pyroxene andesite, basaltic andesite, hornblende andesite, and minor dacite flows and flow breccia (Hammond, 1980; Swanson and Clayton, 1983); flows are generally fresh, with vesicular tops and massive, columnar-jointed centers, but locally are hydrothermally altered; flows and minor interbedded volcaniclastic rocks are remnants of the Goat Rocks stratovolcano whose center is located near the south boundary of the quadrangle along the Cascade crest; thick sequences of shallow-dipping valley-filling flows preserved as ridge-capping units due to inverted topography; lower part interstratified with pyroclastic rocks of the Devils Horns (unit Tvd); radiometric age dating and magnetostratigraphy of the Goat rocks flows show this unit to range from about 3 to 1 m.y.B.P.

QTvd

Unnamed dacite flows (Plio-Pleistocene)--Gray, porphyritic, hornblende-pyroxene dacite (Winters, 1984); phenocrysts of plagioclase, hypersthene, oxyhornblende, and augite; forms columnar-jointed flow interpreted to be an erosionally isolated intracanyon flow from the Goat Rocks volcano (unit QTvg) (Swanson and Clayton, 1983)

QTva

Unnamed andesite flows (Plio-Pleistocene)--Ridge-capping pyroxene andesites overlain by the basalt of Lava Creek (unit Qvlv) in the north part of the Goat Rocks Wilderness and small isolated patches of pyroxene andesite; little is known about this unit; may be part of the Goat Rocks volcano (unit QTvg) (Swanson and Clayton, 1983)

Pliocene-Pleistocene Intrusive Rocks

QTia

Andesite domes, plugs, and dikes (Plio-Pleistocene)--Hypabyssal intrusive pyroxene andesite; pyroxene basaltic andesite, and hornblende andesite in the Goat Rocks area; related to late Pliocene to early Pleistocene volcanism which produced the Goat Rocks stratovolcano (Swanson and Clayton, 1983)

Tertiary Stratified Rocks

Tvs_6

Pliocene volcaniclastic sediments, conglomerates, and tuffaceous sandstone--Unit is overlain by the pyroclastic rocks of the Devils Horns; contains carbonized organic material of lignite rank; may represent fluvial and volcaniclastic deposits of a major drainage near the Pliocene Goat Rocks volcano (G.A. Clayton, written commun., 1985)

Tvt_6

Pliocene tuff and tuff breccia--At South Fork Tieton River on north-facing slope below Klickton Divide; andesitic to dacitic ignimbrite; locally densely welded with 10 to 20-cm-long pumice fragments (G.A. Clayton, written commun., 1985)

Tvd_6

Pliocene dacite porphyry--Light- to medium-gray porphyritic dacite flows and flow breccia with phenocrysts of plagioclase, hornblende, quartz, and biotite set in a fine-grained to glassy, quartz-rich groundmass; contains tuffs, lava domes, and hypabyssal intrusions; occurs as scattered remnants of a formerly widespread system of hypabyssal intrusions and volcanoes in the White Pass and Nelson Butte areas; radiometric dating and remanent paleomagnetic polarity studies indicate that these rocks formed during the Pliocene (Clayton, 1983; Schreiber, 1981)

Tbt

Olivine basalt of Bethel Ridge (Pliocene?)--Includes 45-m-thick, crudely bedded deposit of reddish scoria and bombs capped by thin flow of light-gray olivine basalt on crest of Bethel Ridge; deposit occupies a channel eroded in unit Tvt_2? (Miocene-Oligocene tuffaceous rocks); remnant basalt flow occurs at west end of Bethel Ridge; also includes a poorly exposed, light-gray olivine basalt flow or plug on Russell Ridge 1.5 km southeast of Ironstone Mountain; most likely late Miocene or Pliocene because it rests on Bethel Ridge which was probably once covered by Grande Ronde basalt (middle Miocene) (Swanson, 1964, 1978)

Tdw

Devils Washbasin basalt (Pliocene)--"Thin flows, bedded pyroclastic rocks, and narrow dikes of olivine basalt erupted from a vent near Devils Washbasin and making up the spires of Devils Horns" (Swanson and Clayton, 1983); probably represents a short-lived parasitic vent that was subsequently overwhelmed by the major outpouring of andesite that built the Goat Rocks stratovolcano; interbedded with andesite flows of the Goat Rocks (unit QTvg) and overlies Devils Horns rhyolites; age is about 3 m.y. based on radiometric age dates and magnetostratigraphy (Clayton, 1983)

Tdv

Devils Horns Rhyolite (Pliocene)--High-silica rhyolite domes, ashflow tuffs, airfall tuff, and volcaniclastic breccia (Clayton, 1983; Swanson and Clayton, 1983); unit erupted from a caldera centered at Devils Horns near the south boundary of the quadrangle; unit consists of a near-vent sequence of mostly non-welded pyroclastic flows; basal portion is white, pumice-lapilli, vitric ash tuff and bedded vitric ash tuff; middle portion is characterized by surge deposits of cross-bedded vitric-lapilli and ash tuffs and graded obsidian-block breccias; upper portion consists of obsidian-lapilli ash tuff, obsidian-block tuff, thin-bedded pumice-lapilli tuffs, and vitric ash; zircon fission-track ages of 3.20 +/- 0.2 m.y. and 3.17 +/- 0.2 m.y. on rhyolite within (?) caldera mouth (Clayton, 1983); Pliocene tuff east of the area (unit Tvt_6) may be part of the Devils Horns rhyolites

Tel

Ellensburg Formation (middle to upper Miocene)--Exposures of this unit occur southwest of the Naches River in the northwest corner of the quadrangle, where it overlies the Grande Ronde Basalt and the Fifes Peak Formation (unit Tfp); consists chiefly of well-rounded gravels, bedded tuffaceous sediments, tuffs, and bouldery lahars; gravels are unconsolidated and consist of cobble- to boulder-sized clasts of porphyritic, gray, brown, and pink andesitic to dacitic lavas; gray to grayish-white sediments, tuff, and lahars contrast sharply with darker rocks of the Fifes Peak Formation; derived from volcanic centers in the Cascades; intertongues to the east of the quadrangle with flows of Yakima Basalt subgroup; upper part (?) dated at 10 m.y.B.P. (K-Ar, plagioclase; Laursen and Hammond, 1974)

Tgr
Tgn_2
Tgr_2
Tgn_1

Grande Ronde Basalt (middle Miocene)--Dark-gray to black, aphyric to sparsely plagioclase-phyric tholeiitic flood lavas, comprising the thickest, most voluminous member of the Columbia River Basalt Group; flows are generally fine grained and not petrographically distinctive; chemical composition varies within a broad field referred to as the Grande Ronde chemical type (basaltic andesite); age dates on flows and tuffaceous sediments between Grande Ronde (Vantage Member of Ellensburg Formation) and overlying Frenchman Springs Member of the Wanapum Basalt restrict age to between 15.6 and 16.5 m.y.B.P. (Watkins and Baksi, 1974; Long and Duncan, 1983, Lux, 1981); Grande Ronde flows can be divided into four magnetostratigraphic units, three of which occur within the map area: Tgn_2--upper flows with normal magnetic polarity occurring with unit Tgr_2 (upper flows with reversed magnetic polarity, underlying most, if not all of Tgn_2 over the western part of the quadrangle); Tgn_1--exposed along Divide Ridge and representing lower flows with normal magnetic polarity (Swanson and others, 1979)

Tvc_3

Lower Miocene volcaniclastic rocks--Multicolored volcaniclastic rocks including tuff, tuff breccias, lithic breccia, conglomerate, and volcanic sandstone; interbedded with lava flows, shown separately as Tva_3, and Tvb_3; shown as Tvt_3 where unit is primarily unworked tuff and tuff breccia; unit is similar to unit Toh (Ohanapecosh Formation), but is commonly thinner, less zeolitized, and stratigraphically bounded by units younger than the Oligocene volcaniclastic rocks; most of these rocks occur in the southwest corner of the quadrangle and continue into the Mount Adams quadrangle (Korosec, 1987); west of Randle, poorly sorted, massive breccia and conglomerate with sand- to boulder-sized clasts of augite andesite (Randle laharic breccia conglomerate of Fisher, 1960)

Tvt_3

Lower Miocene tuffs and tuff breccia--In southwest corner of quadrangle, light-gray to brown lithic tuff breccia and very light gray, pumiceous dacitic to rhyodacitic tuff, tuff breccia and interbedded volcaniclastic sandstone; north of the Skate Creek-Johnson Creek confluence on Lookout Mountain are felsic pyroclastic rocks which underlie andesitic and basaltic lavas (unit Tva_3) dated at 19.1 +/- 1.4 m.y.B.P. (K-Ar 1, Table 2; Phillips and others, 1986); north of the American River in the Miner Creek drainage west of Fifes Peaks; Hammond (1980) correlated a pale-orange to yellowish-brown lithic tuff with well-developed columnar and platy to slabby jointing and locally forming cliffs (which Abbott, 1953, included within the lower Miocene Fifes Peak Formation) with the tuffs at Bumping River (unit Tbr with a Miocene-Oligocene age)

Tfp

Fifes Peak Formation (lower Miocene)--Thick accumulations of basaltic andesite, andesite, rhyolite flows, tuffs, breccias, and laharic deposits; are remnants of at least four shield volcanoes which include the Fifes Peaks volcano (Warren, 1941; Abbott, 1953), an older and younger volcano recognized in the Tieton River area (Swanson, 1978), and an unnamed volcano has been recognized in the Gold Creek area along the Naches River (Carkin, 1985); the latter three have radial swarms of andesite and basaltic andesite dikes; in Mount Rainier National Park no Fifes Peak flow center has been identified; K-Ar ages range from about 17 to 25 m.y. (Hartman, 1973); fission-track ages on tuffs associated with Fifes Peak lavas range from about 22 to 26 m.y. (Vance and others, in press)

Tsr

Stevens Ridge Formation (upper Oligocene to lower Miocene)--Typically light gray or tan, locally light-green or reddish tan rhyodacite ash flow tuff and well-bedded volcaniclastic rocks including sandstone, siltstone and conglomerates; vitric to crystal-lithic tuff and interbedded volcanic sandstone, conglomerate, siltstone, and tuff; ash flow tuff is plagioclase, hornblende, clinopyroxene, hypersthene, biotite, quartz, pumice, and felsic to mafic volcanic-rock-fragment phyric in a matrix of devitrified shards; locally welded; gray to tan and greenish well-bedded volcanic sandstone, conglomerate, siltstone, and tuff which are locally cross-bedded; within the quadrangle, age of the unit is generally Miocene-Oligocene south of Mount Rainier; ages of the unit north of Mount Rainier are generally lower Miocene; south of Mount Rainier National Park, zircons from exposures of basal Stevens Ridge ash flows have yielded a U-Pb age of 24.8 m.y. and a fission-track age of about 26 m.y.; a 27 m.y. fission-track age comes from the type area within the National Park (Vance and others, in press); north of Mount Rainier in the Snoqualmie Pass quadrangle, K-Ar and fission-track ages range from 20 to 24 m.y. (Frizzell and others, 1984; Hartman, 1973)

Tpt

Welded tuff of the Palisades (lower Miocene)--In northeast part of Mount Rainier National Park, a black welded rhyodacitic pumiceous crystal-vitric tuff (crystals are augite, biotite, hornblende, and plagioclase) (Hammond, 1980); caps and grades downward into a plug of fluidal layered and spherulitic, brecciated rhyodacite (Fiske and others, 1963); U-Pb (zircon) age date of 25.1 m.y.B.P. (Mattinson, 1977)

Tvs_3

Lower Miocene volcanic sediments--In the Packwood area, gently dipping tuffaceous siltstone and sandstone, locally carbonaceous, and minor interbedded tuff, tuff breccia, and felsite unconformably overlie more steeply dipping Ohanapecosh strata; siltstone ranges from massive to shale-like; possibly represents basin-filling sediments in a structural trough; a fresh-water snail from a small quarry 0.7 miles north of Packwood suggests a late Oligocene or Miocene age (Fiske and others, 1963--who suggested that the sediments may be part of the Stevens Ridge Formation); a fission-track age date on zircons from a tuff bed exposed in the same quarry is 23.5 +/- 0.6 m.y. (G.A. Clayton, written commun., 1986; Table 2, sample location FZ 1)

Tva_3
$Tvba_3$

Lower Miocene andesite and basaltic andesite flows--South of the Cowlitz River in the southwest corner of the quadrangle, light- to dark-gray, hypersthene andesite, hypersthene basaltic andesite, and two-pyroxene basaltic andesite flows and flow breccia; at Lone Tree Mountain south of the quadrangle flows of this volcanic rock package were dated at 22.1 +/- 1.3 m.y.B.P. (K-Ar whole rock, Phillips and others, 1986; Korosec, 1987); at Lookout Mountain south of Mount Rainier National Park an olivine(?) basalt flow interbedded with andesitic flows and flow breccias yielded a K-Ar (whole rock) age of 19.1 +/- 1.4 m.y.B.P. (Table 2, sample location K-Ar 1; Phillips and others, 1986); west of Skyo Mountain unit Tva_3 is a vitric, aphanitic, black to very dark-gray basalt or andesite lithologically similar to the flows of Lookout Mountain; north of Randle a plagioclase-clinopyroxene phyric andesite flow yielded an age date of 16.1 +/- 1.8 m.y. B.P. (Table 2, sample location K-Ar 2; Phillips and others, 1986); near Klickton Divide southeast of the Goat Rocks (south of the quadrangle) the basaltic andesite is poorly studied, but it has been described as being similar to the Fifes Peak Formation (D. A. Swanson, oral communication, 1985)

Tvb_3

Lower Miocene basalt flows--Dark-gray, aphyric to porphyritic, clinopyroxene basalt flows at Huffaker Mountain; similar in appearance to unit $Tvba_3$ at Lone Tree Mountain, but chemical analyses reveal a slightly less silicic composition (49-53% SiO_2); basalt flows and flow breccias form a broad shield volcano, centered just south of Huffaker Mountain (south of the quadrangle) K-Ar age dated (plagioclase) at 23.2 +/- 0.7 m.y. B.P. (Russ Evarts and Roger Ashley, written commun., 1986; Korosec, 1987, Table 1)

Tbm

Tuff of Burnt Mountain (Miocene-Oligocene)--Interstratified yellowish to gray dacitic to rhyodacitic crystal-vitric ash-flow tuff with phenocrysts of augite, hypersthene and plagioclase (Hammond, 1980); locally platy jointed and interbedded with volcaniclastic rocks; commonly contains inclusions of granitic rocks and charred wood; occurs northeast of Rimrock Lake; volume of this 300-m-thick unit suggests eruption during a caldera collapse (Swanson, 1978); a 7-km-diameter complex eruptive and collapse structure (unit Timx) interpreted by Schreiber (1981) as a caldera has been suggested by Vance and others (in press) as a possible source of the tuff at Burnt Mountain; Vance and others (in press) report a zircon fission-track age of 24.6 +/- 2.4 m.y. for the unit

Trt

Rattlesnake Creek tuff (Miocene-Oligocene)--White to buff-colored pumiceous vitric ash flow tuff (vitric tuff of Rattlesnake Creek, Schreiber, 1981) occurring along Rattlesnake Creek; dated by zircon fission-track by Schreiber at 26.8 +/- 1.4 m.y.B.P.

Tbr

Tuff at Bumping River (Miocene-Oligocene)--Distinctive sequence of chiefly yellowish-gray to yellowish-brown lithic-pumice-vitric ash flow tuffs about 300 m thick which occur on American Ridge north of Bumping River (Hammond, 1980); interstratified with volcaniclastic beds, air-fall tuff, and olive-black to greenish-black porphyritic pyroxene andesite lava flows; in most places the unit overlies andesitic beds (unit Tva_2?) up to several hundred meters thick, but locally rests directly on Ohanapecosh Formation (unit Toh); the unit is overlain by andesitic lavas and pyroclastics and minor intermediate to silicic pumice flows, ash flows, and air fall tuffs, interpreted as distal deposits of Fifes Peak volcano; two samples of the tuff yielded zircon fission-track ages of 27.7 +/- 5 m.y. and 26.6 +/- 3.6 m.y. (Vance and others, in press)

Tva_2?

Oligocene or lower Miocene andesite flows--Querried nature of this unit indicates uncertain age of map packages which are predominantly andesite and basaltic andesite flows and flow breccia; in southwest corner of map units consists of gray, porphyritic pyroxene basaltic andesite and minor andesite; in the Skate Creek and Butter Creek area, greenish to brownish-gray andesitic lavas form massive cliffs; at Skyo Mountain the unit consists chiefly of gray to brownish-green andesite flows and flow breccia with subordinate amounts of laharic and tuff-breccia (U.S. Forest Service, Packwood Ranger District, written commun., 1984); in the southeast corner of the map area in the drainages of the North Fork Ahtanum Creek and South Fork Tieton River, poorly studied basaltic andesite lavas intercalated with well-bedded volcaniclastic rocks (unit Tvc_2?) were considered to be Oligocene by Swanson and others (1979); similar lavas south of the quadrangle have later been described by D.A. Swanson (oral commun., 1985) as being similar to Fifes Peak Formation lavas; at American Ridge the unit consists of rocks described as overlying and underlying the tuff at Bumping River (see description of unit Tbr); part of the unit has been referred to as Fifes Peak Formation at Union Creek (Hammond, 1980), which consists of interstratified brown to grayish-green pyroxene andesite porphyry lava flows interstratified with light-colored volcaniclastic rocks

Tvc_2?

Oligocene or lower Miocene volcaniclastics--Poorly studied packages of volcaniclastic rocks; at Dixon Mountain, north of Packwood, consists of grayish-green sandstones, siltsones, and conglomerates interbedded with light greenish-gray tuffs and tuff breccias (U.S. Forest Service, Packwood Ranger District, written commun., 1984); in the area of the North Fork Ahtanum and South Fork Tieton Rivers (southeast corner of quadrangle) poorly studied, well-bedded volcaniclastic rocks are interstratified with unit Tva_2? (Swanson and others, 1979; Clayton and others, written commun., 1985)

Tvt_2?

Upper Oligocene or lower Miocene tuffaceous rocks--Poorly studied package of rocks in the upper Rattlesnake Creek area (Timberwolf Mountain/northwest Bethel Ridge) consisting of light-tan to light brownish, gently dipping, poorly bedded pumice flows, tuffs and tuff breccias, which contrast markedly with underlying, greenish, well-bedded, altered volcaniclastic sediments that make up the volcaniclastic rocks of Wildcat Creek (unit Twc); rocks of this unit resemble the tuff at Rattlesnake Creek (unit Trt) and the tuff at Burnt Mountain (unit Tbm), and include pumice-flow deposits of rhyolite composition mapped in the Tieton River area by Swanson (1978) which have been dated at 23.3 +/- 2.0 m.y.B.P. (zircon fission-track, Vance and others, in press); the pumice-flow deposits are interbedded with the apron facies of the younger Tieton volcano (Fifes Peak Formation) of Swanson (1978); rocks of this unit may have had their source at Mount Aix

Toh

Ohanapecosh Formation (Oligocene)--Greenish to brown and maroon dacitic to basaltic-andesitic lithic breccia, tuff, tuff breccia, and volcaniclastic siltstone, sandstone, and conglomerate (Fiske and others, 1963; Winters, 1984; Vance and others, in press);

breccias typically are unstratified, crudely graded, or very thickly bedded and poorly sorted, with clasts of heterolithologic debris, including highly altered pyroclastic rock, porphyritic basaltic andesite to dacite, and aphyric to glassy lava in a matrix of altered plagioclase, devitrified glass shards, and clay; sandstone and ash to lapilli tuff commonly form well-bedded, graded, and parallel laminated sequences; most of the unit is extensively zeolitized and hydrothermally altered; local accumulations of lava; dominantly andesitic, are near vent facies; some of the larger lava accumulations represent volcanic centers from which the pyroclastic material may have been erupted; some of the lavas have been mapped as distinct units in the quadrangle; a correlation between the Ohanapecosh and similar rocks on the eastern side of the pre-Tertiary inlier (volcaniclastic rocks of Wildcat Creek, unit Twc) is strongly suggested by Vance and others (in press), based in part on concordant age dates for the two units; radiometric age dates from tuffs throughout the section of Ohanapecosh Formation range from as old as 36.4 +/- 3.6 m.y.B.P. to as young as 28.3 +/- 2.9 m.y.B.P.; the base of the unit has been demonstrated to interfinger with the underlying Eocene feldspathic sandstones of the Puget Group and its correlatives throughout the quadrangle (Buckovic, 1974; Winters, 1984; Abbott, 1953; Vance and others, in press; Ellingson, 1959); these data show that the Ohanapecosh spans the Oligocene and probably includes some upper Eocene strata

Tohl

Ohanapecosh Formation, lava flows (Oligocene)--Dark-brownish-gray, greenish-gray, or maroon plagioclase-augite-hypersthene phyric basaltic andesite and andesite flows and flow breccias interbedded with lithic-lapilli tuff and locally thick volcaniclastic breccia and conglomerate; occur in local thick accumulations that grade laterally into finer volcaniclastic rocks; all of the Ohanapecosh lavas have been pervasively altered; occur in and near Mount Rainier National Park (Fiske and others, 1963)

Tohr

Ohanapecosh Formation, rhyolite flows (upper Oligocene)--Light-buff rhyolite at Indian Bar, east side of Mount Rainier; forms an 80-m-thick, 4-km-long lens within the upper Ohanapecosh Formation; has contorted flow banding and spherulites; contains a flow-banded plug at South Cowlitz Chimney (Fiske and others, 1963); zircon fission-track age on the rhyolite at Indian Bar is 30.4 +/- 3.0 m.y.B.P. (Vance and others, in press)

Twc

Volcaniclastic rocks of Wildcat Creek (Oligocene)--In the Tieton River and Nelson Butte areas, green to violet, well-bedded, andesitic and dacitic volcaniclastic rocks, consisting chiefly of pumice-rich, lapilli-stone, lapilli tuff, and ash tuff, which commonly bear accretionary lapilli; locally interstratified with volcaniclastic sandstone, conglomerate, and thin coal seams (Swanson, 1978; Schrieber, 1981); tentatively extended north of Rattlesnake Creek, where it merges with strata mapped as Ohanapecosh Formation by Simmons and others (1983), to an area between Bald Mountain and the Bumping River; unit has not been examined in the field or traced laterally within the extended area except at Bald Mountain (P.E. Hammond, written commun., 1986); Vance and others (in press) have suggested a correlation with upper Ohanapecosh Formation on the basis of several zircon fission-track age dates and on the unit's resemblance to the Ohanapecosh Formation (although the Wildcat Creek rocks tend to be finer grained and lack interbedded lavas); two fission-track ages on the unit were 32.2 +/- 3.3 m.y. and 31.8 +/- 2.2 m.y. (Vance and others, in press); unit also includes red and violet tuff and tuffaceous sandstone and siltstone which Swanson (1978) called the tuff of Milk Creek

Twcb

Olivine basalt of Milk Creek (Oligocene)--Olivine basalt interbedded with the tuff of Milk Creek (unit Twc) in the headwaters of Milk Creek south of Kloochman Rock; exposure surrounded by landslide debris; age based on similarity of tuff of Milk Creek to the lower part of unit Twc and to the upper part of the sandstone of Spencer Creek (unit Tsns) (Swanson, 1978)

Tsns
Tsnc

Sediments of Spencer Creek (Oligocene)--Unit Tsns includes volcanic sandstone and subordinate conglomerate, tuff, and tuffaceous shale and sandstone; upper 65 m consists of interbedded volcanic sandstone and tuffaceous shales and sandstone; tuffs resemble tuff of Milk Creek (included in unit Twc); fission-track age date from air-fall tuff was 33.7 +/- 3.2 m.y.B.P., further supporting a correlation of these sediments with tuffaceous rocks of Wildcat Creek (unit Twc) (Vance and others, in press); current directions of rivers that deposited most of the unit were dominantly northward; abundant but poorly preserved plant remains, particularly along Spencer Creek (Swanson, 1978); unit Tsnc consists of more than 30 m of volcanic sandstone and less abundant conglomerate unconformably below unit Tsns along Spencer Creek; in contact with trondhjemite (unit Jid); contains clasts of pre-Tertiary Russell Ranch Formation and Indian Creek complex; lithologically similar to unit Tsns, except for lack of clasts of unit Tsnt (tuff at Spencer Creek) (Swanson, 1978)

Tva_2

Upper Oligocene andesite flows--Andesite and basaltic andesite flows and flow breccia believed to be equivalent to the Ohanapecosh lavas (unit Tohl) but not called Ohanapecosh because it remains to be demonstrated through detailed mapping that they are the same unit; north of Randle are dark-colored massive to platy, porphyritic two-pyroxene andesite flows and flow breccia with interbedded volcaniclastic breccia and conglomerate; age of this package of rock where it crops out to the west in the Centralia quadrangle was 27.0 +/- 1.8 m.y.B.P. (whole rock, Phillips and others, 1986; Schasse, 1987, Table 2, sample location K-Ar 6); in the Silver Creek Depression and on Dixon Mountain, unit is gray, brown, and green interbedded andesite flows and flow breccia with subordinate amounts of laharic and tuff breccia (U.S. Forest Service, Packwood Ranger District, written commun., 1984)

Tvc_2

Upper Oligocene volcaniclastic rocks--Rocks very similar to those of the Ohanapecosh Formation (unit Toh) but not called Ohanapecosh because they have not been demonstrated through detailed mapping to be the same units; interbedded with unit Tva_2 west of Randle; along axis of the Silver Creek Depression are interbedded volcanic sandstone and carbonaceous siltstones (U.S. Forest Service, Packwood Ranger District, written commun., 1984)

Tvr_1

Lower Oligocene(?) rhyolite--Unbedded breccia composed of rhyolite(?) clasts in depositional(?) contact with Jurassic foliated rocks of the Indian Creek plutonic complex (unit Jif); age uncertain, but probably early Oligocene (G.A. Clayton and others, written commun., 1985)

Tvc_1

Lower Oligocene(?) volcaniclastic rocks--Package of little-studied rocks consisting of "Tertiary volcanic cobbles" exposed in slopes on north side of the North Fork Ahtanum Creek near its headwaters in the southeast corner of the quadrangle (G.A. Clayton and others, written commun., 1985)

Tna

Naches Formation (middle to upper Eocene)--Feldspathic sandstone and volcanic rocks; in the Milk Creek valley (extreme northeast corner of the quadrangle), light-greenish-gray to pale-brown medium- to coarse-grained micaceous lithofeldspathic sandstone, argillaceous and carbonaceous shale, altered tuff, light-colored silicic rocks, and dark-brown spheroidally weathering porphyritic andesite; interbeds of coaly shale and rare volcanic-rich pebble conglomerate; leaf fossils locally common; fission-track age dates on rhyolites within this unit in the Snoqualmie Pass quadrangle to the north range from about 40 m.y.B.P. to 44 m.y. B.P. (Tabor and others, 1984)

Tpg

Rocks of the Puget Group (middle to upper Eocene)--Massive fluviatile micaceous feldspathic subquartzose sandstone, siltstone, claystone, and coal; rocks exposed along the Carbon River/Catt Creek anticline in the northwest part of the quadrangle have been referred to the Spiketon and Carbonado Formations by Gard (1968), Buckovic (1974), and Hammond (1980); rocks exposed north of Bumping Lake were described in detail by Abbott (1953) and are similar in appearance and stratigraphic position to the adjacent Summit Creek sandstone (unit Tss) (Ellingson 1959; Clayton, 1983); these strata are probably older than 36 m.y. based on fission-track ages for rocks just above the Summit Creek sandstone; sandstones in similar stratigraphic position exposed in the Johnson Creek area (unit Tcc) 25 to 30 km to the south have been dated at about 36 m.y.B.P. (Winters, 1984)

Tss

Summit Creek sandstone (middle to upper Eocene)--A fluviatile, light grayish-brown, micaceous, quartzose, feldspatholithic sandstone; commonly massive or crossbedded but also contains coal seams [with middle Eocene-age leaf fossils (Ellingson, 1959)], and rhyolitic tuffs and mudstones (Clayton, 1983); 750-m-thick section intertongues with overlying Ohanapecosh andesitic to dacitic volcaniclastic rocks; fission-track ages from three zircon samples from rhyolites in the lower part of the overlying Ohanapecosh Formation average about 36 m.y.; the unit overlies the basalts of Summit Creek (unit Tsb) with apparent conformity; south of Summit Creek, silicic ash flows on strike with the upper part of the basalt section yielded fission-track ages of about 44 and 46 m.y. (Vance and others, in press); these age dates bracket the age of the unit between 36 m.y. and 46 m.y.

Tcc

Chambers Creek beds (middle to upper Eocene)--Light-gray micaceous feldspathic sandstone and lithic feldspathic sandstone, dark-gray mudstone, and siltstone with sparse intercalations of coal, tuff, lapilli tuff, and tuffaceous sedimentary rock (Winters, 1984); upper beds are interstratified with and overlain by andesitic volcanic sandstones and coarser volcaniclastic rocks of the late Eocene to early Oligocene Ohanapecosh Formation; mostly exposed south of the quadrangle in a northwest-trending, northwest plunging faulted anticline at Johnson Creek; fission-track date of 35.9 +/- 0.7 m.y.B.P. on zircon from altered vitric tuff clay (Winters, 1984)

Tlo

Lookout Creek sandstone (middle to upper Eocene)--Thin-bedded commonly cross-laminated fluviatile lithofeldspathic sandstone in a sequence that is as much as 200 m thick near Lookout Creek; unconformably overlies plutonic rocks, turbidites, and pillowed greenstones along the eastern margin of the Tieton inlier; overlain disconformably by volcaniclastic sediments of Wildcat Creek (unit Twc) (Schreiber, 1981); correlated with similar sandstones, also directly overlying pre-Tertiary rocks near Rattlesnake Peak and upper McNiel Creek (Clayton, 1983)

Tvc_0

Eocene volcaniclastic rocks (middle to upper Eocene?)--North of the Nisqually River in northwest corner of the quadrangle, unit consists of interbedded volcanic breccia, sandstone, siltstone, tuff, conglomerate, thin beds of coaly material, and minor porphyritic andesite flows which intertongue with rocks of the Puget Group [Keechelus tongues (units 2 and 4) mapped by Fisher (1957, 1961)]; east of the South Fork Tieton River near its headwaters unit consists of a 50-m-thick section of felsic volcaniclastic fluvial sediments and tuffs which were deposited on pre-Tertiary basement and are conformably overlain by the basalt at Discovery Creek (unit Tdc) (Clayton, 1983)

Tsnt

Welded tuff at Spencer Creek (middle to upper Eocene)--Welded ash-flow tuff probably of dacitic or rhyodacitic composition (Swanson, 1978); conformably below sandstone of Spencer Creek (unit Tsns) and unconformably above or in fault contact with older rocks; more than 100 m thick at mouth of South Fork Tieton River; age dated (zircon fission-track) by Vance and others (in press) at 41.8 +/- 3.8 m.y.B.P.

Tva

Undifferentiated andesitic volcanic rocks (Eocene?)--In the core of a dome along the Naches River in the northeast corner of the quadrangle, deformed and propylitically altered green to brownish-green porphyritic clinopyroxene-andesite(?) lavas and lesser volcanic breccias and tuffs; flows contain vesicles filled or lined with carbonate and lesser zeolites (Carkin, 1985); age uncertain; mapped as "lower Keechelus" (Ohanapecosh) by Warren (1941), these rocks have more recently been referred to as the Naches Formation by Bentley (1977) and Hammond (1980)

Tsb

Basalt of Summit Creek (lower(?) to middle Eocene)--Basal andesite of Ellingson (1959); dense, sparsely phyric subaerial olivine-bearing basalt flows, which dominate a steeply west-dipping 2000-m-thick basal unit that unconformably overlies highly deformed Cretaceous-Jurassic turbidites; interbedded with silicic tuff, argillite, and feldspathic and volcaniclastic fluvial sediments; south of Summit Creek, silicic ash flows on strike with upper part of the section have fission-track ages of 44.0 +/- 3.0 and 46.1 +/- 2.7 m.y. (Vance and others, in press); zircon from an ash-flow tuff interbedded with conglomerates near the base of the section gave a U-Pb model age of 55 +/- 3 m.y. (Vance and others, in press); overlain with apparent conformity by the Summit Creek sandstone (unit Tss)

Ttp

Basalt at Tieton Pass (middle Eocene)--Altered, highly vesicular subaerial olivine basalt flows that crop out in upper North Fork of the Tieton River at the margin of the Tieton (pre-Tertiary) inlier; flows form a section about 200 m thick that overlies Mesozoic turbidites; fission-track age date of 42.4 +/- 3.7 m.y.B.P. from a thin quartz-phyric vitric tuff just above the basalt (Vance and others, in press)

Tdc

Basalt at Discovery Creek (middle Eocene?)--Dense, aphyric aphanitic subaerial basalt flows exposed in a tributary of the South Fork Tieton River (Clayton, 1983); this unit is not to be confused with nearby basalts intercalated with well-bedded volcaniclastic rocks of uncertain age assignment (unit Tva_2?) (Miocene or Oligocene)) (G.A. Clayton, written commun., 1985); the basalt at Discovery Creek overlies the clastic subunit of the Russell Ranch Formation in angular unconformity

Tertiary Intrusive-Volcanic Complexes

Tisx

Skyscraper Mountain complex (lower Miocene)--On northeast flank of Mount Rainier, intrusive and extrusive dacitic vitrophyres and breccias; breccias are highly altered and partially recrystallized; vitrophyres include glassy flows and probably welded tuffs; these rocks are cut by a silicic sill swarm that may not be related to the original complex activity (Thompson, 1983); possibly represents the lower portions of a volcanic plug or neck (Fiske and others, 1963)

Timx

Mount Aix volcanic complex (upper Oligocene to lower Miocene)--Thick heterogeneous and disrupted assemblage of volcanic rocks, including andesite porphyry flows, interbedded volcaniclastic rocks, and dacitic tuffs and breccias with both extrusive and intrusive characteristics; contained within a complex eruptive and collapse structure about 7 km in diameter which Schreiber (1981) interpreted as a caldera; has been suggested as a source of the tuffs at Burnt Mountain, Rattlesnake Creek, and Bumping River (Vance and others, in press); because some of these tuffs differ widely in lithology, several eruptive episodes must be represented; Schreiber (1981) obtained a date of 27.6 +/- 1.4 m.y.B.P., and Vance and others (in press) determined an age of 26.3 +/- 1.3 m.y. (both fission-track dates on zircons) on different ash-flow tuffs from the caldera fill complex

Tertiary Intrusive Rocks

Tia

Intrusive andesite (upper Oligocene to Pliocene)--Includes dark- to medium-gray, aphanitic to porphyritic hornblende andesite, pyroxene andesite, and pyroxene basaltic andesite; forms shallow stocks and plugs, numerous dikes, sills, plugs, and dike swarms throughout the quadrangle; mostly Miocene or late Oligocene to early Miocene; commonly altered

Tib

Intrusive basalt and diabase (upper Oligocene(?) and lower Miocene)--Basalt and diabase sills and dikes that invade the Ohanapecosh and Stevens Ridge Formations at many localities in the southern and western parts of Mount Rainier National Park; basalt and diabase sills crop out in the Longmire area; swarms of basalt dikes of the same composition as the sills crop out in the southern and western parts of the park; sills and related dikes are probably a hypabyssal phase or the Fifes Peak lavas (Fiske and others, 1963); in the Beljica Meadows area west of Mount Rainier National Park, augite and hypersthene augite diabase, quartz diabase, and diorite in a sill believed to be equivalent to other rocks of this unit (Evarts and others, 1983)

Tibx

Intrusive diabase and basalt of Box Canyon (lower Miocene)--Tabular intrusive complex of diabase sills in Box Canyon on southeast side of Mount Rainier; dark-colored porphyritic augite diabase that is propylitically altered; 8 km long by 300 m thick; major complex emplaced along contact between Stevens Ridge and Ohanapecosh Formations; swarms of basalt dikes (unit Tib) of the same composition as the sills crop out in the area (Fiske and others, 1963)

Tid

Intrusive dacite (Pliocene and Miocene)--Porphyritic dacite domes, plugs, and stocks northeast of the Goat Rocks and east of Deep Creek (south of Bumping Lake); consists of several small stocks and plugs of pale brown to gray, fine- to medium-grained biotitc-hornblende dacite of Pliocene age (Clayton, 1983); north of Bumping Lake dacite of probable Miocene age cuts a short section of Puget Group rocks at its base (P.E. Hammond, written commun., 1986); in the Silver Creek Park and Davis Creek areas west of Packwood two bodies of light gray to dark green-gray dacite of Miocene or possibly late Oligocene age (U.S. Forest Service, Packwood Ranger District, written commun., 1984; and Table 1, this report)

Tidi

Diorite intrusions (upper Oligocene(?) and Miocene)--Dikes, sills, and small stocks of light- to medium-gray pale-brown, fine- to coarse-grained, pyroxene (augite and/or hypersthene) diorite, commonly altered greenish-gray to olive-gray (Fisher, 1957; Simmons and others, 1983; Swanson, 1978; U.S. Forest Service, Packwood Ranger District, written communication, 1984)

Tigd

Unnamed granodiorite intrusions (Miocene)--In the Bumping Lake area on Nelson Ridge, propylitically altered diorite, quartz diorite, and granodiorite plugs and anastomosing veins, sills, and dikes (G.A. Clayton, written commun., 1985); mapped as dacite porphyry by Abbott (1953) and rhyodacite porphyry by Simmons and others (1983); west of Summit Creek-Carlton Creek area, granodiorite split out of Tatoosh hypabyssal rocks (unit Tit) (M.A. Korosec, oral commun., 1986); northeast of Randle, two granodiorite stocks have been mapped (M.A. Korosec, written commun., 1985)

Tir

Rhyodacite intrusions (upper Miocene)--Small stocks, plugs, dikes, and sills; especially common in association with Bumping Lake pluton (Hammond, 1980); light- to yellow-gray rhyodacite (rhyolite?), commonly porphyritic (quartz-biotite-plagioclase-hornblende-phenorcrysts), dense aphanitic groundmass (Abbott, 1953; Simmons and others, 1983); age uncertain; dated at 6.3 to 6.2 +/- 0.2 m.y.B.P. (K-Ar sericite; Armstrong and others, 1976) but may be older

Tibl

Quartz monzonite and granodiorite of Bumping Lake pluton (Miocene)--Greenish-gray, weathering pale reddish-brown, coarse-grained biotite quartz monzonite (granite), and yellowish-gray to gray, fine- to medium-grained biotite-hornblende granodiorite, locally containing abundant angular xenoliths (magmatic Granite Lake breccia of Abbott, 1953); sharp contacts and lack of gradation between parts of the pluton suggest multiple emplacements (Hammond, 1980); age of this pluton in controversy; cut by unit Tir, forming alteration dated at 6.3-6.2 +/- 0.2 m.y.B.P. (K-Ar, sericite, Armstrong and others, 1976); unit Tir is cut by andesite porphyry dikes considered to be feeders to the Fifes Peak Formation (unit Tfp) with ages ranging from 17 to 26 m.y.; Clayton (1983) reports a zircon fission-track age of 24.7 +/- 0.6 m.y. on the quartz monzonite

Tiblgd

Granodiorite stocks associated with Bumping Lake pluton (Miocene?)--"Light-gray, weathering yellowish-gray, medium- to coarse-grained biotite-hornblende granodiorite; finer grained towards margins of stocks; commonly contains xenoliths of country rock and possibly agmatites; rock is similar to the Nisqually granodiorite (unit Tins) of Mount Rainier National Park; age relationships between granodiorite and quartz monzonite of Bumping Lake pluton (unit Tibl) are unknown" (Hammond, 1980); (Abbott, 1953; Simmons and others, 1983)

Tijl

Jug Lake quartz diorite sills (middle to upper Miocene)--Many small plutons or sills of quartz diorite that intrude pre-Tertiary rocks of the Russell Ranch Formation (unit KJr) and the lower Tertiary basalts of Summit Creek (unit Tsb); pale brown to gray biotite-hornblende quartz diorite porphyry; locally altered Ellingson (1959, 1972) called these quartz diorites the Jug Lake pluton, but the intrusion he mapped around Jug Lake does not exist (Clayton, 1983); Clayton (1983) reports a fission-track age of 11.5 +/- 0.4 m.y. from one of the small plutons

Tiwr
Tiwrg

White River pluton (middle Miocene)--"Occurs in northeast part of Mount Rainier National Park, underlying part of Mount Rainier; may be part of Tatoosh pluton; very light-gray, altering to pale greenish-gray hornblende-biotite quartz diorite and hornblende granodiorite; locally saussuritized and altered to chlorite" (Hammond, 1980); dated at 13 +/- 1 m.y.B.P. (K-Ar, biotite; Fiske and others, 1963) and 14.1 m.y.B.P. (U-Pb, zircon; Mattinson, 1977); granitic phase of the White River pluton (unit Tiwrg) near

Antler Peak and Sunrise Ridge is greenish altered Porphyritic granite (Thompson, 1983)

Tins
Tinsq

Nisqually granodiorite (lower to middle Miocene)--"Core and western margin of Tatoosh pluton of Mount Rainier National Park; pinkish to light brownish-gray medium-grained equigranular hornblende-biotite granodiorite; dated at 17.5 m.y.B.P. (U-Pb, zircon; Mattinson, 1977) and 14.7 m.y.B.P. (K-Ar, biotite; Fiske and others, 1963"; Hammond, 1980; Wright, 1960); a coarse-grained amphibole-pyroxene quartz diorite (unit Tinsq) representing the quartz-diorite phase of the Nisqually granodiorite (Thompson, 1983)

Titg
Titgd
Titq
Titgm

Rocks of the Tatoosh pluton (lower to middle Miocene)--Unit Titg, Tatoosh quartz monzonite (granite), forms eastern margin and southern part of Tatoosh pluton in Mount Rainier National Park; light-gray equigranular fine-grained biotite-hornblende quartz monzonite, locally porphyritic [see Thompson (1983) for detailed subdivision of intrusive phases of the pluton]; gradational downward and laterally with the Nisqually granodiorite (unit Tins); age about the same as unit Tins (14.7 to 17.5 m.y.) (Hammond, 1980; Wright, 1960; Fiske and others, 1963); unit Titgd is a granodiorite phase defined by Thompson (1983) in the Reflection Lakes area, distinguished by a coarse texture and porphyritic nature with strikingly dark plagioclase phenocrysts; unit Titq represents small satellite tonalite masses also mapped by Frizzell and others (1984) north of the quadrangle; unit Titgm represents several satellite bodies of undifferentiated Tatoosh granodiorite and quartz monzonite (Fiske and others, 1963)

Tit

Undifferentiated acidic intrusive bodies related to Tatoosh pluton (early Miocene)--Undifferentiated diorite, quartz diorite, granodiorite, and quartz monzonite porphyries with subordinate amounts of microgranite, porphyritic granophyre, and felsite; occur as swarms of sills, dikes, and irregular small intrusive bodies clustered mainly near the borders of the Tatoosh pluton and associated stocks; also concentrated along contact between Ohanapecosh-Stevens Ridge Formations; unit consists dominantly of granodiorite and quartz monzonite, aphanitic to medium-grained, commonly porhyritic and granophyric; locally hydrothermally altered (Fiske and others, 1963); sill near Chinook Pass dated at 25.8 m.y. (U-Pb, ziron; Mattinson, 1977)

Ticr

Carbon River stock (lower Miocene)--Consists chiefly of pale greenish-gray uralitized equigranular to porphyritic biotite-hypershene-augite granodiorite; a border zone of pyroxene quartz diorite (tonalite), and an aureole of pyroxene andesite dikes (Fischer, 1970); a satellite of the Tatoosh pluton; two radiometric age dates by Frizzell and others (1984): 19.4 +/- 3.0 m.y.B.P. (K-Ar, hornblende); 17.1 +/- 0.4 m.y.B.P. (K-Ar, biotite) are well within the age range of the Tatoosh pluton (14 to 24 m.y.)

Ticw

Soda-rhyolite of Clear West intrusive complex (lower Miocene)--Chiefly gray to purple, sparsely plagioclase phyric devitrified soda-rhyolite with local glassy vitropheres, forms plug dome and adjacent sills; plug is flow-layered and contains remanent collapse blocks of pumice vitric tuff, interpreted as the White River rheoignimbrite; most of this unit occurs in the Snoqualmie Pass quadrangle to the north (Frizzell and others, 1984; Fischer, 1970); dated at 18.6 +/- 0.4 m.y.B.P. (intrusive rock, K-Ar, whole rock; Hartman, 1973) and 22.6 to 21.8 m.y.B.P. (tuff, U-Pb zircon; Mattinson, 1977)

Pre-Tertiary Rocks

Russell Ranch Unit

KJr

Clastic subunit of the Russell Ranch Unit (Cretaceous-Jurassic)--Formally referred to as the Russell Ranch Formation (see Miller, 1985) for details concerning nomenclature change; a voluminous, chaotically deformed supracrustal sequence of interbedded lithofeldspathic sandstone and mudstone, with lesser conglomerate and greenstone, minor chert, and very rare green tuff, showing turbidite characteristics of the flysch facies (Clayton, 1983; Miller, 1985); unit is tectonically deformed and broken; limestone cobbles occurring locally and prominent in an olistrohomal boulder breccia have yielded fusulinids of probable Permian age (Ellingson, 1972); contains radiolarian fauna referable to the Tithonian and Valaginian or Hauterivian Stages (Charles Blome, USGS, written commun., 1986); consists of part of the Russell Ranch Formation (Simmons, 1950; Ellingson, 1972; Swanson, 1978; Schreiber, 1981; Clayton, 1983; Miller, 1985)

KJrc

Chert-tuff subunit of the Russell Ranch unit (Cretaceous-Jurassic)--Mapped by Miller (1985) and distinguished from unit KJr by the abundance of chert; unit consists of lithofeldspathic sandstone, mudstone, radiolarian chert, greenstone, green tuff, and red shale; characterized by thin stringers of altered green tuff and red shale within chert-rich horizons; unit is tectonically deformed and broken; radiolarian fauna from three localities have been assigned Jurassic(?) and late Jurassic or early Cretaceous ages (Charles Blome, USGS, written commun., 1986); consists of part of the Russell Ranch Formation

KJrg

Tectonic blocks of pillowed greenstone in clastic subunit of Russell Ranch unit (Cretaceous-Jurassic)--Widespread in clastic subunit (unit KJr) of the Russell Ranch unit; most blocks are small, but larger (>100 m^2) lenses are concentrated in a 1.5-km-wide zone near the Indian Creek plutonic complex (units Jid, and Jif,) amygdaloidal rocks occur in less than half of the blocks; original mineralogy was augite and calcic plagioclase; metamorphosed to greenschist facies; age estimate based solely on association of greenstones with the clastic subunit in which they are enveloped (Miller, 1985); consists of part of the Russell Ranch Formation

pTgr

Eastern greenstone unit (Cretaceous-Jurassic?)--Narrow (1 km wide) fault-bounded block of pillowed greenstones with rare shale interbeds (fault slices?); strongly resemble greenstones (unit KJrg) within the Russell Ranch unit and may be correlative; unit occurs as a long continuous outcrop belt interrupted only by Cenozoic rocks, unlike the small discontinuous tectonic blocks within clastic rocks of unit KJr; sedimentary interbeds are rare in this unit but are common in unit KJrg; unit consists almost entirely of pillowed flows, whereas in unit KJrg both pillowed and massive flows are abundant; metamorphic grade of unit pTgr is slightly less than that of unit KJrg; age of Cretaceous-Jurassic(?) is tentatively assigned based on unit's weak association with unit KJrg (Miller, 1985); Miller states: "Taken as a whole, the Russell Ranch unit can perhaps best be described as a tectonic melange"; consists of part of the Russell Ranch Formation

pTvr

Silicic metavolcanic unit (pre-Tertiary)--Altered silicic (rhyolitic?) volcanic rocks that have foliation well defined by aligned muscovite that wraps around relict quartz phenocrysts; locally deformed into sharp-hinged folds; originally may have been rhyolitic flows; unit was originally assigned a Tertiary age by Clayton (1983) who now considers it to be pre-Tertiary (Miller, 1985)

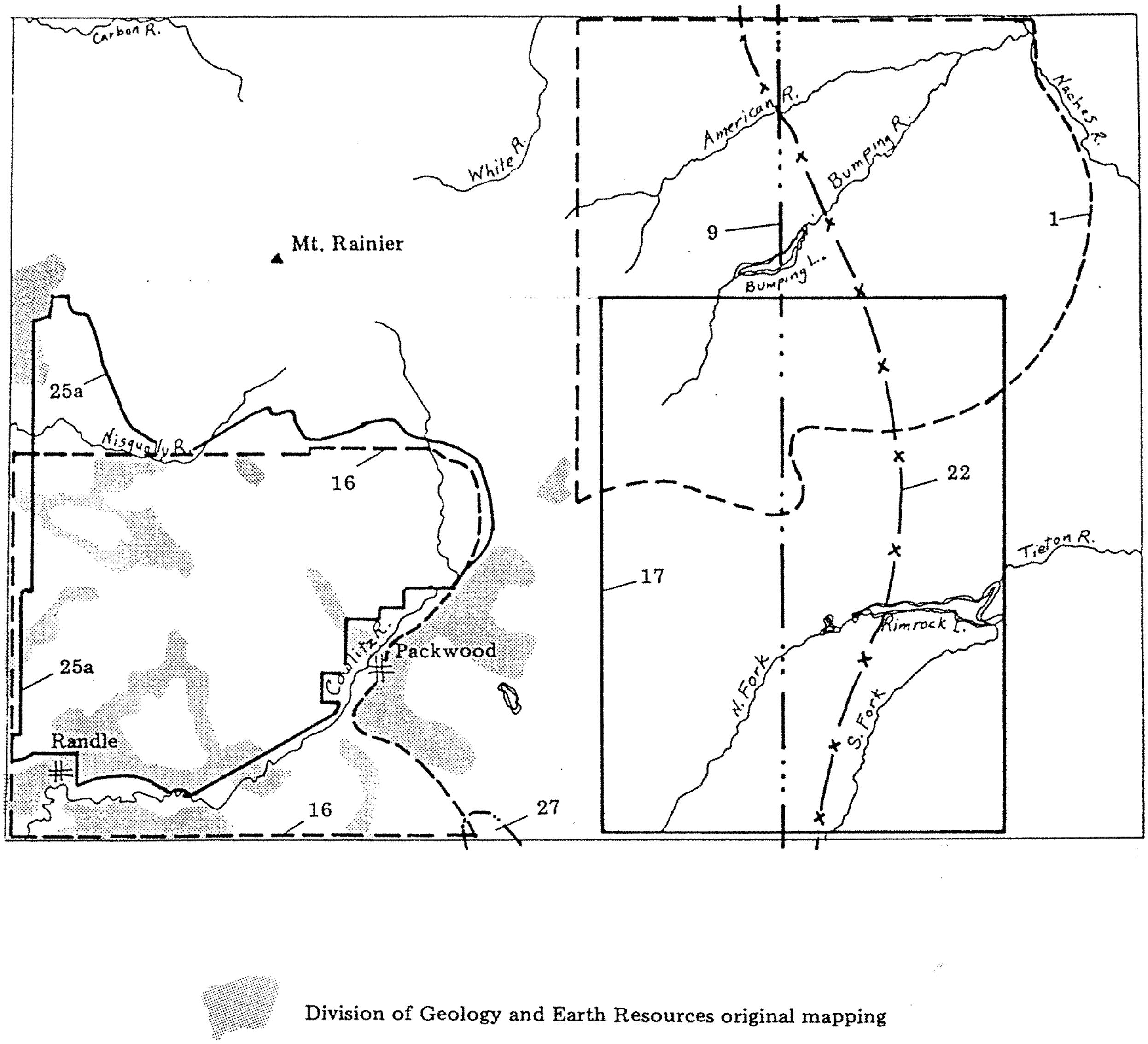
Indian Creek Plutonic Complex

Jid

Directionless to weakly foliated plutonic rocks (Upper Jurassic)--Directionless to weakly foliated minor diorite and gabbro intruded by voluminous quartz diorite (tonalite), which is in turn intruded by trondhjemite which Swanson (1964) named the Peninsula plagiogranite; later dated by Clayton (1983) at 132 +/-4 m.y.B.P./152.5 m.y.B.P. (zircon fission-track using two different techniques to arrive at a best fit line for age determination); Swanson (1978) suggested that the Peninsula plagiogranite together with the rocks of the Russell Ranch unit and eastern greenstone unit (units KJr and pTgr) may be part of a dismembered ophiolite complex

Jif

Well-foliated metaplutonic rocks (Upper Jurassic)--Consists mainly of gneisses metamorphosed to the epidote-amphibolite facies (Miller, 1985); Miller states: "It appears that the foliated rocks are more deformed and metamorphosed equivalents of the directionless rocks, rather than the directionless rocks being younger"; these gneisses locally preserve the sequence of early mafic rocks intruded by progressively more leucocratic rocks (Miller, 1985); tonalitic gneisses intrude dioritic gneisses and locally amphibolites, which are in turn intruded by rare dikes of pegmatitic trondhjemitic gneisses; zircons from the pegmatites, were dated (U-Pb method) at 155 m.y.B.P. by Mattinson (1972) who argued that the pegmatitic rocks were intruded during metamorphism; metamorphism and plutonism probably record a single Jurassic thermal event (Miller, 1985); unit includes the gneissose quartz diorite of Hindoo Creek (Schreiber, 1981) and the Indian Creek amphibolite (Ellingson, 1968, 1972)



Location

1. Abbott, 1953.
2a, b. Bentley, 1977.
3. Buckovic, 1974.
4a-f. Campbell, in press.
5. Carkin, 1985.
6. Clayton, 1983.
7. Clayton and others, 1985, written commun., scale 1:24,000.
8. Crandell, 1969.
9. Crandell and Miller, 1974.
10. Ellingson, 1959.
11. Evarts and others, 1983.
12. Fisher, 1957.
13. Fiske and others, 1963.
14. Hammond, 1960.
15. Hammond, 1980.

Location

16. Korosec, 1985, written commun., scale 1:100,000.
17. Miller, 1985.
18. Niesen and Gusey, 1983.
19. Schreiber, 1981.
20. Simmons and others, 1983.
21. Swanson, 1978.
22. Swanson and others, 1979.
23. Swanson and Clayton, 1983.
24a, b. Thompson, 1983.
25a-c. U.S. Forest Service Gifford Pinchot National Forest Packwood Ranger District, 1984, written commun., scales: a.) 1:100,000 b.) 1:62,500 c.) 1:62,500
26. Vance and others, in press.
27. Winters, 1984.

Figure 1a. - Map showing sources of map compilation data for Mount Rainier quadrangle.

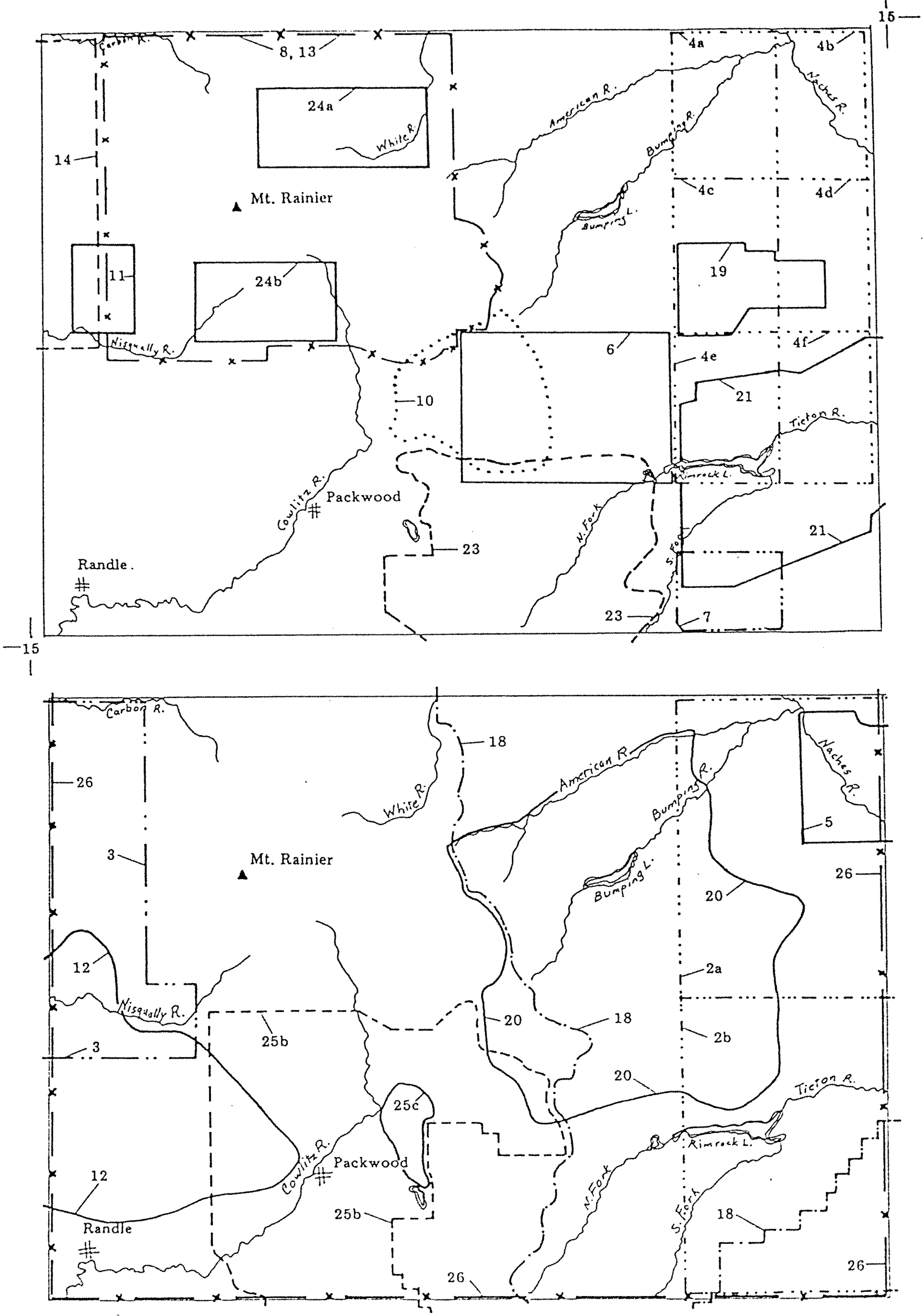


Figure 1b. - Map showing sources of map compilation data for Mount Rainier quadrangle.

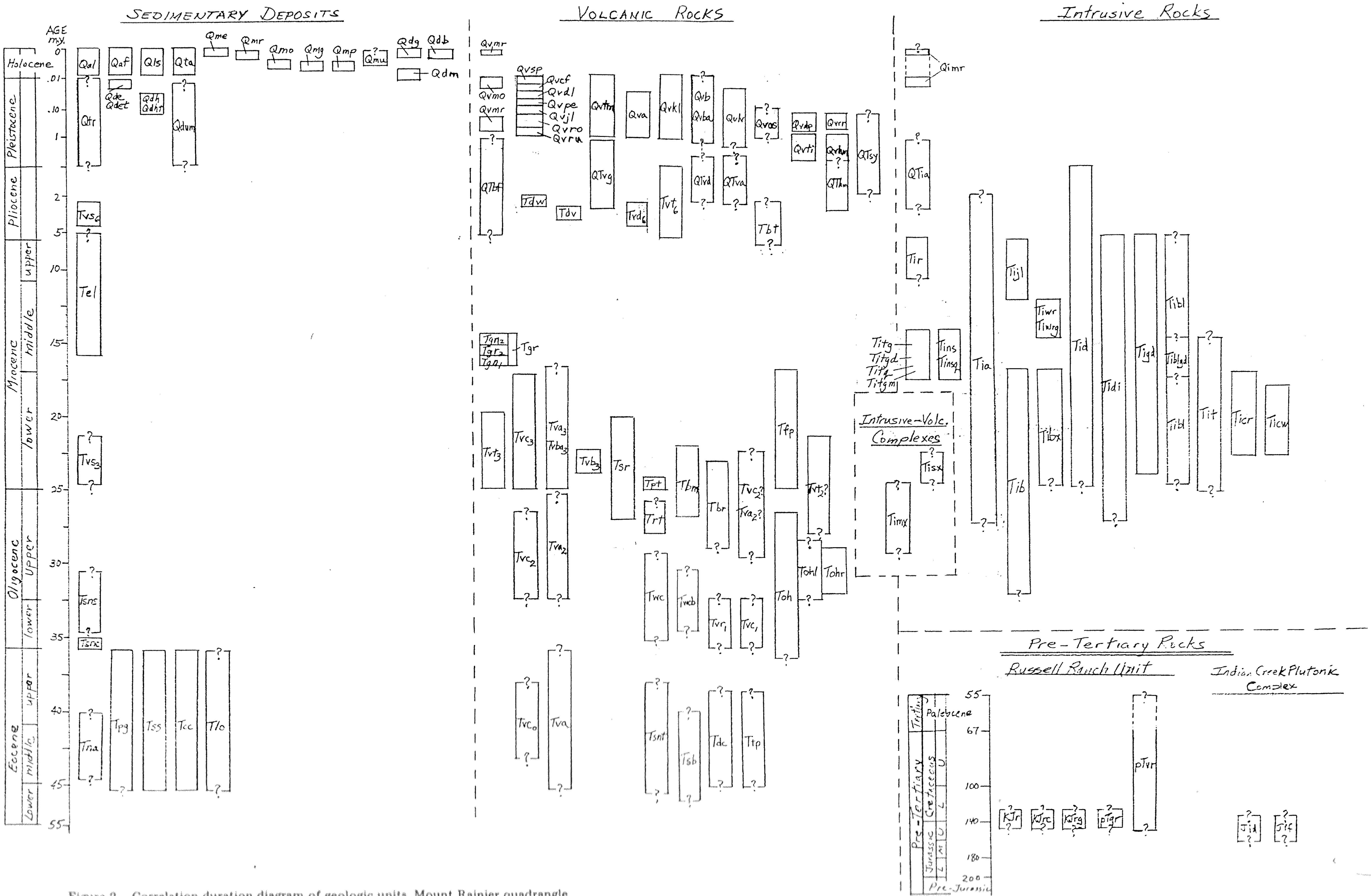


Figure 2. - Correlation-duration diagram of geologic units, Mount Rainier quadrangle.

Table 1. WHOLE-ROCK MAJOR ELEMENT ANALYSES FOR THE MOUNT RAINIER QUADRANGLE, WASHINGTON

Sample	Unit	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	QSec	Sec	Twp	Rge
MK8682	Qvba	54.95	17.58	1.33	9.04	0.14	7.46	4.94	0.89	3.35	0.32	SE/4 SW/4	10	14N	10E
MK8687	Qvba *	53.37	16.92	1.42	9.31	0.15	8.13	6.37	0.94	3.06	0.32	NW/4 NE/4	11	14N	10E
MK8688	Qva	58.99	17.79	1.19	7.92	0.12	6.06	2.92	1.06	3.67	0.27	NE/4 SW/4	11	14N	10E
MK86810	Qvb	51.19	16.81	1.33	10.36	0.15	9.25	7.39	0.60	2.71	0.21	NE/4 NE/4	17	14N	10E
MK85820	Tia	54.29	18.74	1.05	9.51	0.15	9.35	3.64	0.14	2.99	0.13	NW/4 NW/4	04	13N	07E
MK85612	Tia	56.13	16.79	1.75	10.72	0.17	7.51	2.83	0.70	3.17	0.22	SW/4 SW/4	15	12N	07E
MK85730	Tid	76.53	14.14	0.18	2.63	0.07	1.90	0.05	1.97	2.43	0.12	NE/4 NE/4	32	13N	08E
MK85731	Tidi	64.54	16.17	0.65	5.75	0.10	5.56	2.64	1.28	3.18	0.13	NW/4 SE/4	18	12N	08E
MK85728	Tigd	67.40	15.88	0.57	5.10	0.10	4.38	1.70	1.72	3.01	0.15	SE/4 SW/4	24	13N	07E
CC0827851	Tva3	51.49	16.58	1.25	10.60	0.17	10.85	5.50	0.67	2.66	0.24	NE/4 SE/4	04	14N	08E
MK85817	Tva3	58.22	15.67	1.08	9.04	0.16	8.13	4.16	0.40	2.97	0.16	SE/4 SW/4	08	12N	07E
MK85619	Tva3	57.29	16.94	1.39	10.31	0.17	7.50	2.59	0.77	2.81	0.23	NW/4 NW/4	25	12N	07E
MK85723	Tva2?	58.25	17.86	1.50	10.55	0.17	5.24	2.60	0.43	3.29	0.11	SW/4 NW/4	21	12N	08E

Analyses by XRF, Department of Geology, Washington State University
All analyses normalized to 100% on a volatile-free basis. Iron expressed as Fe_2O_3
All samples analyzed with international standards and a double-fusion sample preparation method
* Unit is too small to show on the map

TABLE 2. AGE DATES FOR THE MOUNT RAINIER QUADRANGLE

MAP NO.	MAP SYMBOL	MEAN % K2O	MEAN % 40Ar /TOTAL Ar	AGE (mybp)	LAB	REF	MATERIAL DATED	TWP	RGE	1/4 1/4 SEC
K-Ar 1	Tva3	0.488	16.3	16.1 +/- 1.8	1	a	Whole Rock	12N	07E	SE SW 08
K-Ar 2	Tva3	0.808	50.2	19.1 +/- 1.4	1	a	Whole Rock	14N	08E	NE SE 04
		NO. OF GRAIN	AGE PER GRAIN(mybp)							
FZ 1	Tvs3	1	15.3	23.5 +/- 0.6	2	b	Zircon	13N	09E	NE SW 15
		2	18.2							
		3	22.2							
		4	22.7							
		5	25.3							
		6	25.4							
		7	26.0							
		8	27.3							

Laboratories

1. Krueger Enterprises, Inc.,
   Geochron Laboratories Division, 1985
2. University of Washington
   (G. A. Clayton)

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b. Geoff. Clayton, written communication, 1986

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