U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE MOUNT HOOD 30- BY 60-MINUTE QUADRANGLE, NORTHERN CASCADE RANGE, OREGON

By David R. Sherrod and William E. Scott[1]

OPEN-FILE REPORT 95-219

1995

[1]Both at Cascades Volcano Observatory, 5400 MacArthur Blvd., Vancouver, WA 98661

PRELIMINARY GEOLOGIC MAP OF THE MOUNT HOOD 30- BY 60-MINUTE QUADRANGLE, NORTHERN CASCADE RANGE, OREGON

By David R. Sherrod and William E. Scott

ABOUT THIS MAP

This map shows the geology of the central and eastern parts of the Cascade Range in northern Oregon. The Quaternary andesitic stratovolcano of Mount Hood dominates the northwest quarter of the quadrangle, but nearly the entire area is underlain by arc-related volcanic and volcaniclastic rocks of the Cascade Range. Most stratigraphic units were emplaced since middle Miocene time, and all are Oligocene or younger. Despite the proximity of the map area to the Portland metropolitan area, large parts remained virtually unstudied or known only from limited reconnaissance until the late 1970s. A notable exception is the area surrounding Mount Hood, where mapping and chemical analyses by Wise (1969) provided a framework for geologic interpretation.

Mapping since 1975 was conducted first to understand the stratigraphy and structure of the Columbia River Basalt Group (Anderson, 1978; Vogt, 1981; J.L. Anderson, in Swanson and others, 1981; Vandiver-Powell, 1978; Burck, 1986) and later to examine the geothermal potential of Mount Hood (Priest and others, 1982). Additional mapping was completed in 1985 for a geologic map of the Cascade Range in Oregon (Sherrod and Smith, 1989). From 1987 to 1990, detailed mapping was conducted in three 15-minute quadrangles on a limited basis (D.R. Sherrod, unpublished mapping) (see fig. 1 for index to mapping). An ongoing volcanic hazards study of Mount Hood by the U.S. Geological Survey (Scott and others, 1994) has provided the catalyst for completing the geologic map of the Mount Hood 30-minute by 60-minute quadrangle.

As of June 1994, only two broad areas still remain largely unmapped. One of these areas, labeled "unmapped" on the geologic map, lies in the Salmon River valley south of Zigzag along the west margin of the quadrangle. Although strata of the Columbia River Basalt Group in the Salmon River valley were mapped in detail by Burck (1986), the overlying middle and upper(?) Miocene lava flows, volcaniclastic strata, and intrusions have never been studied. The other poorly known area, the Mutton Mountains in the southeastern part of the map area, consists of Oligocene and lower Miocene volcanic and volcaniclastic rocks. Overlying lava flows of the Columbia River Basalt Group were mapped in some detail by Anderson (in Swanson and others, 1981).

AGE DETERMINATIONS

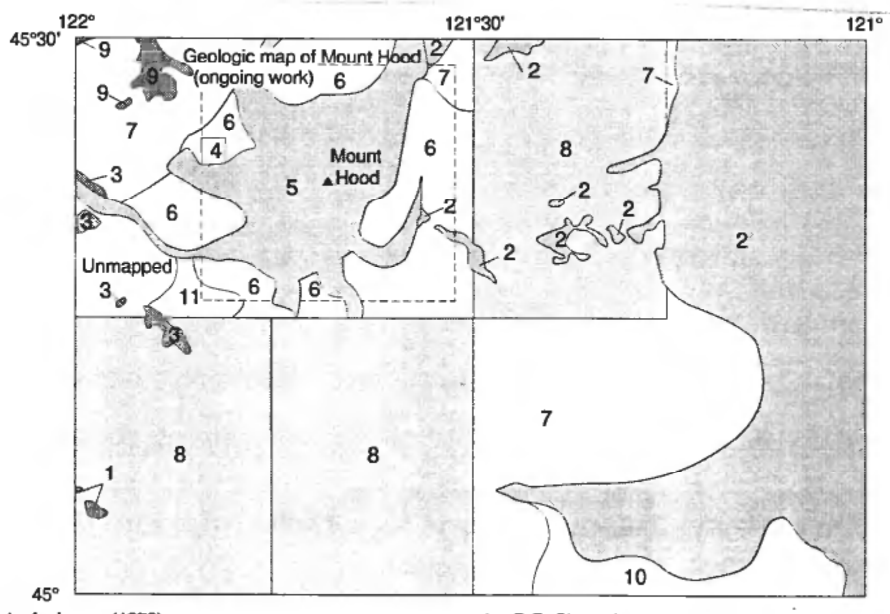
Ages for many units were determined by isotopic methods, chiefly potassium-argon (K-Ar). For many samples, fusion and gas extraction was conducted on sample splits, thereby improving the precision of the age determination. In these cases, a weighted mean age is reported (table 1), weighted by the inverse of the variance of individual runs (a standard statistical method; for example, Taylor, 1982). The age of young Mount Hood deposits is known from carbon-14 (^{14}C) dating of charcoal and wood.

Magnetic polarity was determined for many samples to further characterize stratigraphic units. In some areas, a chronostratigraphic framework was developed by combining isotopic ages and sequential polarity changes; this framework allowed us to assign minimum ages for some undated stratigraphic units. We use 0.78 million years as the age of the most recent major chron boundary (base of Brunhes Normal-Polarity Chron) (Shackleton and others, 1990; Baksi and others, 1992). The correlation chart shows ages for other chron and subchron boundaries in Brunhes, Matuyama, and Gauss time (from Cande and Kent, 1992).

STRATIGRAPHIC SYNOPSIS

The Cascade Range volcanic arc has been active since about 40 million years (m.y.) ago (Duncan and Kulm, 1989), although the oldest arc-related rocks, if present in northern Oregon, are deeply buried. Only one canyon in the map area (the Clackamas River canyon in the southwest corner) has cut deep enough to expose lower Miocene volcaniclastic strata in the Cascade Range (unit Tos). East of the range, mildly alkaline volcanic rocks of Oligocene and early Miocene age are found in the Mutton Mountains. By middle Miocene time, much of the map area was flooded by tholeiitic basalt of the Columbia River Basalt Group. The Columbia River Basalt Group is not related to the volcanic arc but forms a useful stratigraphic marker. For informative summaries of the emplacement, distribution, and chemical evolution of the Columbia River Basalt Group, the interested reader is referred to studies by Beeson and others (1989), Nelson (1989), Tolan and others (1989), Wright and others (1989), or references cited therein.

Since the time of Columbia River Basalt, the locus and composition of Cascade Range volcanism in the map area have shifted sporadically. Andesitic eruptions were predominant in the western part from about 14 to 10 m.y. ago (Salmon and Sandy Rivers area), producing the Rhododendron Formation and overlying lava flows. From about 8 to 6.5 m.y. ago, lithic pyroclastic debris of the Dalles Formation was shed by chiefly andesitic volcanoes in the north-central part of the map area (Hood River valley escarpment). Andesitic to dacitic volcanism was again predominant about 5 to 3 m.y. ago, with known eruptive centers located from Lookout Mountain westward to Lolo Pass, probably including the area now occupied by Mount Hood. A major episode of mafic volcanism—basalt and basaltic andesite—began about 3-4 m.y. ago and lasted until about 2 m.y. ago. Since about 2 m.y. ago (Quaternary according to Harland and others, 1982), volcanism has been concentrated along the axis of the High Cascades. North and south of Mount Hood, Quaternary volcanic rocks are predominantly basaltic andesite lava flows; whereas at Mount Hood itself, andesite is volumetrically predominant, forming pyroclastic and debris flow deposits and lava flows.



1. Anderson (1978)
2. Anderson (in Swanson and others, 1981)
3. Burck (1986)
4. Priest and others (1982)
5. W.E. Scott, unpub. mapping, 1990-1993
6. D.R. Sherrod, unpub. mapping, 1990-1993
7. D.R. Sherrod, unpub. reconnaissance, 1985
8. D.R. Sherrod, unpub. mapping, intermittently 1985-1989
9. Vogt (1981)
10. Waters (1968a)
11. Wise (1969)

Figure 1. Index to mapping used on geologic map.

DESCRIPTION OF MAP UNITS

[Volcanic rocks are named according to chemical classification, in terms of weight percent SiO_2, as follows: basalt, <52 percent; basaltic andesite, ≥52 and <57 percent; andesite, ≥57 and <63 percent ; dacite, ≥63 and <68 percent; rhyodacite, ≥68 and <72 percent; rhyolite, ≥72 percent. This scheme follows the recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks (Le Bas and Streckeisen, 1991) but is modified slightly to include a field for rhyodacite]

SURFICIAL DEPOSITS FOUND IN ALL PARTS OF MAP AREA

Qal **Alluvium (Holocene and Pleistocene)**—Unconsolidated gravel, sand, and silt. Includes sandy and gravelly deposits along valley floors and sandy and muddy to peaty deposits of marshes and meadows. Near Mount Hood, this unit originates in several ways: much in the upper forks of Hood River and the Muddy Fork of the Sandy River is glacial outwash and debris-flow deposits of neoglacial age (past 3,000 yr), but in the White, upper Salmon, and Zigzag Rivers much consists of debris-flow deposits and fluvial sediments related to erosion and reworking of the thick debris-flow and pyroclastic-flow deposits that were emplaced in these valleys during Holocene time

Qca **Colluvial and alluvial slope deposits (Holocene and Pleistocene)**—Poorly sorted deposits that form sheets and fans on lower parts of valley walls; deposited by small streams and various slope processes. Grades downslope into alluvium of valley floors (Qal) and pinches out upslope against bedrock. May include till and outwash locally

Qt **Talus (Holocene and Pleistocene)**—Blocky to platy, coarse-grained detritus; typically forms aprons below steep cliffs. Characterized by open-work, unvegetated talus deposits, especially near timberline or on south- or west-facing slopes

Qls **Landslide deposits (Holocene and Pleistocene)**—Poorly sorted deposits of slumps and earthflows. Generally poorly exposed; mapped on basis of morphology. Commonly found at the base of steep slopes where incompetent rocks underlie thick, more competent sequences of lava flows. Map-unit symbol shown queried along West Fork Hood River where a large mass of material is of uncertain origin

Qg **Glacial deposits (Holocene and Pleistocene)**—Very poorly sorted pebbles, cobbles, and boulders in fine-grained (silty sand) matrix. Chiefly till; occurs as ground and lateral moraines in map area. Includes minor alluvium where reworked by streams. Grades upslope into talus and colluvium. Circles indicate morainal crests. Divided in Mount Hood area into following units:

Qgnt **Till of neoglacial age (Holocene)**—Forms steep, sharp-crested, unvegetated to forested moraines that lie within 1.5 km of present glaciers. Locally includes small areas of till of Evans Creek age (Qget)

Qget **Till of Evans Creek age (Pleistocene)**—Forms moraines that, in many areas, mark the maximum extent of glaciers about 20,000 yr ago during the Fraser glaciation. Also includes deposits near neoglacial till (Qgnt) that were deposited about 12,000 yr ago near end of Fraser glaciation

Qo **Outwash (Pleistocene)**—Well-rounded pebbles and cobbles that form thick terrace deposits along Shellrock Creek and Oak Grove Fork of Clackamas River (southwestern part of map area). Elsewhere, much outwash is included in alluvium (Qal). Divided near Mount Hood into:

Qoe **Outwash of Evans Creek age**—Only one locality, on northeast slope of basaltic andesite of Cloud Cap (Qbac). Deposited about 12,000 yr ago near end of Fraser glaciation

VENT DEPOSITS AND INTRUSIVE ROCKS FOUND IN ALL PARTS OF MAP AREA

Qv **Cinder cone or small volcano (Quaternary)**—Cinders, scoria, and agglutinate of vent deposits. Composition chiefly basalt or basaltic andesite

Qiba **Intrusive basalt and basaltic andesite (Pleistocene)**—Very fine grained to medium-grained massive lava. Forms plugs in southwestern part of map area that presumably were feeders (volcanic necks) for surrounding lava flows

Tv **Cinder cone or small volcano (Tertiary)**—Cinders, scoria, and agglutinate of vent deposits. Composition chiefly basalt or basaltic andesite

Tiba **Intrusive basalt and basaltic andesite (Pliocene)**—Very fine grained to medium-grained massive lava. Plugs and thick dikes in the Oak Grove Fork area commonly found surrounded by cinders, scoria, and agglutinate of vent deposits (mapped separately)

Tia **Intrusive andesite (Pliocene and Miocene)**—Platy to blocky, very fine grained to medium-grained, aphyric to porphyritic lava. Forms sills and plugs. Plug at Shellrock Mountain in northeastern part of map area contains 60.0 percent SiO_2 (Wise, 1969, his No. 38). Large mass on north side of Old Maid Flat in northwestern part of map area contains 58.4 percent SiO_2 (Gannett, 1982, his sample locality No. 7-2-9)

STRATIGRAPHIC UNITS EXPOSED IN NORTHWESTERN PART OF MAP AREA

Products of Old Maid eruptive period (Holocene)—Rock-avalanche and pyroclastic-flow deposits originally containing hot and cold dome rock, ash, and hot gases. Deposits formed during eruptions dominated by extrusion of lava dome and repeated destruction of dome by gravitational collapse and(or) explosive disruption. Melting of snow and ice by such events generated debris flows and floods. Also includes minor avalanche deposits of hydrothermally altered debris from upper flanks of Mount Hood volcano. Valleys draining the west and south flanks of the volcano accumulated thick sequences of volcaniclastic sediment. Subsequent incision by streams resulted in transport of sediment that is included in unit Qal. Radiocarbon and tree-ring dating suggest the Old Maid eruptive period occurred between A.D. 1760 and 1810 (Cameron and Pringle, 1987). Divided into:

Qhol **Lava**—Dacite dome forming Crater Rock, near summit of Mount Hood. Contains 62-64 percent SiO_2 (Wise, 1969; White, 1980a; Crandell, 1980)

Qhoc **Pyroclastic-flow and debris-flow deposits**—Poorly sorted dacite pebbles, cobbles, and boulders in chiefly gray sandy matrix; minor interbeds of silt and sand. Forms thick fills in upper White and Sandy river valleys. Pyroclastic-flow deposits are found as far as 8 km from vent; debris-flow and related alluvial deposits extend down Sandy River to the Columbia River and down White River through Tygh Valley (included in unit Qal) to the Deschutes River

Products of Timberline eruptive period (Holocene)—Similar in origin to products of Old Maid eruptive period, but more extensive and voluminous. Forms thick fills on southwest and west flanks of Mpunt Hood. Radiocarbon ages range from about 1,400 to 1,800 yr B.P. (Crandell, 1980; Cameron and Pringle, 1987). Consists of:

Qhtc **Pyroclastic-flow and debris-flow deposits**—Poorly sorted pebbles, cobbles, and boulders in chiefly reddish-gray sandy matrix. Juvenile blocks are andesite and dacite containing 61-63 percent SiO_2 (Wise, 1969; White, 1980a; Crandell, 1980). Pyroclastic-flow deposits extend as far as 12 km from the vent down Zigzag River, and debris-flow deposits extend down Sandy River to the Columbia River

Qhdl **Debris-avalanche deposit of Ladd Creek (Holocene)**—Poorly sorted boulders to pebbles of chiefly white to reddish-brown hydrothermally altered lava in matrix of sand, silt, and clay; clasts dominantly subangular. Forms sheet-like deposit that originated by debris avalanche from upper north flank of Mount Hood. Surface of deposit marked by fractured megablocks and boulder concentrations. Maximum-limiting radiocarbon age of about 4,000 yr B.P. (Meyer Rubin, USGS, written commun., 1993), but may date from start of Timberline eruptive period. (Sample Nos. and ages are CAMS-6328, 3,880±80 ^{14}C yr B.P.; CAMS-6329, 4,010±80 ^{14}C yr B.P.) Related debris-flow deposit that travelled down the West Fork of Hood River is included in alluvium (Qal).

Qbp **Basaltic andesite of Parkdale (Holocene)**—Small agglutinate and cinder cone (about 2 km below Laurance Lake) and 6.5-km-long lava flow. Contains 55 percent SiO_2 (Wise, 1969). Radiocarbon age of charcoal from below lava flow is 6,890±130 yr B.P. (Harris, 1973)

Products of Polallie eruptive period (Pleistocene)—Similar in origin to deposits of Old Maid and Timberline eruptive periods. Includes lava flows and fragmental deposits from several vents on upper flanks; deposits occur widely around volcano but are found chiefly on south and east flanks. Erupted episodically over a time period of at least several thousand years during the Fraser glaciation (Crandell, 1980), which in the Oregon Cascade Range probably peaked about 20,000 yr ago and persisted until about 12,000 yr ago. Consists of:

Qhpl **Lava**—Andesite and dacite flows and domes (60-63 percent SiO_2; Wise, 1969; White, 1980a; Crandell, 1980) that extend as far as 3 km from Mount Hood's summit

Qhpc **Pyroclastic-flow and debris-flow deposits**—Poorly sorted boulders, cobbles, and pebbles in a chiefly gray sandy matrix. Includes minor debris-avalanche deposits of hydrothermally altered material. Three sequentially younger deposits occur adjacent to Newton Creek; contact between them labeled to show relative age: Y, younger; O, older. The youngest forms the valley floor, contains no evidence of units emplaced at high temperature, and probably originated largely from stream reworking of older Polallie deposits. Deposits preserved on ridgetops of upper East Fork Hood River valley were probably emplaced close to the time of maximum extent of glaciers of Evans Creek advance of Fraser glaciation (about 20,000 yr ago). Till of this age (unit Qget) that forms moraines in the valley of the East Fork near Pocket Creek contains abundant clasts derived from Polallie deposits

Pre-Polallie andesitic and dacitic rocks of Mount Hood (Pleistocene)—

Qhc **Pyroclastic-flow and debris-flow deposits**—Poorly sorted boulders, cobbles, and pebbles in a chiefly gray sandy matrix. Forms thick dissected fill between Muddy Fork of Sandy River and McGee Creek, and below lava flows of unit Qha south of Muddy Fork. Similar deposits are interbedded with lava flows of unit Qha elsewhere, but are not mappable at the scale of this map. Map-unit symbol shown queried 8 km west-northwest of Mount Hood where age of unit is uncertain

Qha **Andesite and dacite lava**—Cone-building flows and domes (57-64 percent SiO_2; Wise, 1969; White, 1980a). Forms much of upper flanks of Mount Hood and radial ridges that extend as far as 12 km from summit

Qbaa **Basaltic andesite of Aschoff Buttes (Pleistocene)**—Lava flows erupted from cinder cone (Aschoff Buttes) at west edge of map. Normal-polarity magnetization

Qbal **Basaltic andesite of Lost Lake Butte (Pleistocene)**—Lava flows that form small shield volcano at Lost Lake Butte at north edge of map area. Olivine phenocrysts 1-3 mm (5-7 percent) and clinopyroxene phenocrysts 1-3 mm (1-3 percent); thin-section descriptions by Wise (1969) also indicate microphenocrysts of orthopyroxene. Contains ~54.8 percent SiO_2 (two analyses, Wise

[1969], his Nos. 157 and 158). Normal-polarity magnetization; younger than 0.78 million years (m.y.) on basis of well-preserved landform. A small cirque with floor at elevation of 3,800-4,000 ft is carved in the north slope (north of map area); thus unit is probably older than about 20,000 yr (maximum of most recent glaciation)

Qbas **Basaltic andesite of Stump Creek (Pleistocene)**—Lava flows on distal northwest flank of Mount Hood; vent location unknown

Qbap **Basaltic andesite of The Pinnacle (Pleistocene)**—Olivine-bearing, slightly porphyritic lava flows. Contains 55-57 percent SiO_2 (Wise, 1969, his No. 145; Bargar and others, 1993, No. 41). Erupted from The Pinnacle, a glacially eroded scoria and agglutinate cone and feeder dikes on north slope of Mount Hood. Normal-polarity magnetization; K-Ar age of 0.14±0.02 m.y. (table 1, No. 1)

Qbac **Basaltic andesite of Cloud Cap (Pleistocene)**—Lava flows generally containing less olivine than lava from The Pinnacle (Qbap). Contains 55-58 percent SiO_2 (Wise, 1969, his Nos. 142, 143, and 144 from two flows; and Bargar and others, 1993). Forms small volcano whose lava overlies pre-Polallie andesitic lava from Mount Hood (Qha) and is surrounded by fragmental products of the Polallie eruptive episode (Qhpc). Normal-polarity magnetization. Potassium-argon age is 0.59±0.03 m.y. (table 1, No. 6)

Qbc **Basalt of Crutcher Bench (Pleistocene)**—Porphyritic olivine basalt that forms sequence of at least four lava flows. Total thickness at least 30 and perhaps as much as 60 m. Normal-polarity magnetization; Sandy River has incised 120 m to form Crutcher Bench, indicating that unit was probably emplaced in early part of Brunhes Normal-Polarity Chron. Erupted from cinder vent on valley wall above Crutcher Bench (north of Zigzag)

Qbdc **Basaltic andesite of Devil Canyon (Pleistocene)**—Lava flows in Devil Canyon and 2 km southeast in Lady Creek. Devil Canyon flow, erupted from vent at head of canyon, is platy to blocky weathering, slightly porphyritic lava with phenocrysts of olivine, ~1 percent (≤1 mm), and plagioclase, 1-3 percent (≤1 mm). Contains ~54.6 percent SiO_2 (one analysis, Wise, 1969, his No. 74). Normal-polarity magnetization; position in canyon floor indicates age probably younger than 0.78 m.y. Potassium-argon age is 0.71±0.04 m.y. (table 1, No. 7). Flow in Lady Creek, undated but also of normal-polarity magnetization, is lithologically similar and occupies similar topographic setting in adjacent canyon floor. It was erupted from a vent in the canyon of Lady Creek

Qahr **Andesite of Horseshoe Ridge (Pleistocene)**—Fine-grained, nearly aphyric andesite lava. Vent marked by domal mass at highest elevation of outcrop area on northwest flank of Horseshoe Ridge, and distal lava forms topographic bench on southeast side of Zigzag River. Normal-polarity remanent magnetization; Zigzag River has incised 140 m below base of unit, indicating emplacement occurred in early part of Brunhes Normal-Polarity Chron

Qap **Andesite of Perry Lake (Pleistocene)**—Fine- to medium-grained, nearly aphyric andesite lava. Contains 59.1 percent SiO_2 (one analysis; Wise, 1969). Erupted from vent of uncertain location (but near Red Hill) and flowed northeast down Bear Creek. Cut by normal fault with about 20 m offset. Normal-polarity magnetization; age younger than 0.78 m.y. because it overlies the basaltic andesite of Blue Ridge (Qbr). Perry Lake, which is labeled on the Mount Hood North 7.5-minute quadrangle, is a small, shallow, mosquito-infested lake on the flow's surface

Qbr **Basaltic andesite of Blue Ridge (Pleistocene)**—Chiefly basaltic andesite and lesser basalt. Erupted from vents on Blue Ridge. Includes rocks with normal- and reversed-polarity magnetization; youngest parts are probably younger than 0.78 m.y. on basis of cinder cone preservation in Red Hill area. Potassium-argon ages of 1.12±0.03 and 1.27±0.03 m.y. (weighted mean ages, table 1, Nos. 8 and 10) for samples near base of unit

Qae **Andesite of Enola Hill (Pleistocene)**—Moderately porphyritic lava flow. Forms bench-capping lava east of Rhododendron. Contains ~58.7 percent SiO_2 (one analysis, Wise, 1969, his No. 78). Normal-polarity magnetization; Zigzag River has incised 200 m to form Enola Hill bench; thus unit was probably emplaced in early part of Brunhes Normal-Polarity Chron

QTb **Basalt (Pleistocene or Pliocene?)**—Remnants of olivine basalt southwest of Lost Lake, near Lolo Pass on northwest side of Mount Hood, and north of Tilly Jane Creek on northeast side of Mount Hood. Reversed-polarity magnetization. Potassium-argon age of 1.37±0.10 m.y. from sample in talus shed by unit near Lolo Pass (table 1, No. 11). Also includes moderately porphryritic basalt or basaltic andesite possessing normal-polarity polarization on ridge east of Lost Lake Butte

Qall **Andesite of Laurance Lake (Pleistocene)**—One or two lava flows of slightly porphyritic andesite that caps ridge north of Laurance Lake. Unit commonly 60-120 m thick; maximum thickness 150 m at eastern limit of outcrop where flows apparently filled an ancestral canyon. Traceable upslope and west to Vista Ridge, which may be the vent area. Contains phenocrysts of olivine 1-2 mm across (1 percent) and clinopyroxene 1-2 mm (1-2 percent) and numerous microphenocrysts of opacitized amphibole smaller than 1 mm (~1 percent). Reversed-polarity magnetization. (Note: spelling of lake name varies between Mount Hood North 7.5-minute quadrangle (Laurance) and Mount Hood 30- by 60-minute quadrangle (Lawrance))

QTat **Andesite of Tom Dick and Harry Mountain (Pleistocene or Pliocene)**—Slightly to moderately porphyritic pyroxene andesite lava flows. Mostly reversed-polarity magnetization, including stratigraphically highest exposures

Qsg **Rocks of Sandy Glacier volcano (Pleistocene)**—Thin flows and interlayered tuff and breccia. Composition ranges from basalt to andesite (four analyses, SiO_2 from 52.5 to 60.0 percent) but interpreted by Wise (1969) as a single magmatic sequence that evolved during the building of a pre-Mount Hood cone. Reversed-polarity magnetization determined by laboratory analyses (C.A. Gardner, USGS, oral commun., 1994); in contrast, measurements using portable fluxgate magnetometer commonly exhibit nondipole behavior. Age controversial owing to discordant K-Ar ages of 3.2±0.3 and 1.27±0.02 m.y. (table 1, Nos. 18 and 9). We believe, however, that the younger age is more likely correct because rocks of Sandy Glacier overlie basalt of Bald Mountain, which in turn has similar remnant magnetism, petrography, and topographic elevation as dated basalt (in QTb) northwest across Lolo Pass (age 1.37±0.10 m.y.)

Qah **Andesite of Hiyu Mountain (Pleistocene)**—Clinopyroxene-bearing andesite with clots (to 1 cm) of olivine. Reversed-polarity magnetization determined by laboratory analyses (C.A. Gardner, USGS, oral commun., 1994); in contrast, measurements using portable fluxgate magnetometer commonly exhibit nondipole behavior. Overlies basalt flow (in unit QTb) from which K-Ar age of 1.37±0.10 m.y. was obtained

QTbme **Basaltic andesite of Mirror Lake and Eureka Peak (Pliocene)**—Lava flows on north side of Tom Dick and Harry Mountain and southeastward to Eureka Peak. Correlation between exposures at these separate geographic locations is tentatively based on roughly similar elevations; however, mapping in the head of Still Creek is limited only to generalized work by Wise (1969), who did not subdivide rocks in this area by composition

Tbbu **Basalt of Bull Run Watershed and other ridge-capping basalt (Pliocene and Miocene?)**—Lava flows chiefly basaltic in composition but including minor basaltic andesite. Isotopic ages are mostly between about 3 and 2 m.y., although ages of 5.5±0.7 and 6.23±0.23 m.y. (table 1, Nos. 22 and 24) are reported from strata that cap Horseshoe Ridge in the Mount Hood Wilderness. The older ages are difficult to interpret presently; for example, the aforementioned age of 6.23 m.y. is lithologically similar to a sample collected 0.5 km distant that yielded an age of 2.48 m.y. (table 1, No. 14). Tentative acceptance of the older ages is the reason for extending the base of the sequence into late Miocene time

Lookout Mountain volcanic sequence (Pliocene)—Chiefly lava flows that range in composition from basalt to dacite. Forms most of Bluegrass Ridge and main part of escarpment east of East Fork Hood River in area of Lookout Mountain. Correlates in part with the rocks of Barlow Ridge and Gunsight Butte. Divided according to composition into:

Tlma **Andesite**—Moderately porphyritic two-pyroxene andesite. Includes interlayered olivine basalt flows in lowest parts. Potassium-argon ages of 2.74±0.03 and 3.1±0.2 m.y. (table 1, Nos. 16 and 17). Andesite lava typically contains 59-61 percent SiO_2 (Wise, 1969, his analyses 17, 63, 64, and 66)

Tlmb **Basalt and basaltic andesite**—Lava flows and tuff breccia of basalt and basaltic andesite. Exposure at southwest end of Bluegrass Ridge is olivine basalt and may be near-vent material; it consists chiefly of tuff breccia containing subangular clasts 1-10 cm across and fewer lava flows 1-3 m thick that possess reversed-polarity magnetization. Exposure on east side of Bluegrass Ridge is vesicular, pyroxene-bearing basaltic andesite lava flows of uncertain magnetic polarity

Tlmd **Dacite**—Slightly porphyritic, orthopyroxene-bearing dacite and rhyodacite(?). Probably correlative with rhyodacite of Gordon Butte (Trgx and Trgd), which is exposed ~4 km east of Lookout Mountain in northeastern part of map area. Mainly underlies the andesite member. Map unit symbol shown queried for hornblende dacite dome of uncertain age east of Dog River

Trbg **Rocks of Barlow Ridge and Gunsight Butte (Pliocene and Miocene)**—Chiefly andesite lava flows and minor volcaniclastic strata; composition ranges from basalt to dacite, but mapping is insufficient to subdivide by lithology. Includes slightly pyritized rocks exposed locally in roadcuts along State Highway 35 between Barlow and Bennett Passes. Potassium-argon age near top of sequence at Gunsight Butte is 4.1±0.6 m.y. (table 1, No. 19). Age of oldest parts unknown, but rocks low in section at White River are cut by dike with K-Ar age of 5.26±0.44 m.y. (table 1, No. 20). Pattern indicates tuff breccia, probably block-and-ash and laharic deposits

Tatc **Andesite of Tumble Creek (Pliocene)**—Slightly to moderately porphyritic lava flow (or perhaps two flows) exposed on east canyon wall of East Fork Hood River near Polallie Creek. Contains 5-10 percent of blocky plagioclase phenocrysts 2-3 mm across, scant opacitized amphibole phenocrysts generally less than 2 mm, and trace amounts of fresh olivine 1 mm across. Lacks pyroxene phenocrysts, which distinguishes it from overlying andesite of Lookout Mountain volcanic sequence (Tlma). As much as 200 m thick; columnar jointed in 60-m-high cliffs east of State Highway 35 (near Sherwood campground)

Tb **Basalt (Pliocene and (or) Miocene)**—Vesicular to massive, slightly porphyritic olivine basalt lava flows. Exposed in three small separated areas, each occurrence probably unrelated to any other. Basalt near Bear Creek (north edge of map) contains ~51 percent SiO_2 (one analysis,Wise, 1969, No. 36); it presumably is interbedded with volcaniclastic rocks of Middle Fork (Tvmf). Basalt west of Butcherknife Ridge contains 52 percent SiO_2 (one analysis, Wise, 1969, No. 87), possesses reversed-polarity magnetization, and is interbedded with or overlies andesite of Lolo Pass. Basalt near Barlow Crossing lacks chemical analyses

Taop **Andesite of Lolo Pass (Pliocene? and Miocene)**—Two-pyroxene andesite lava flows and hornblende-bearing andesite lava and tuff breccia. Unit is poorly exposed and known mainly from roadcuts, although a few thick lava flows and massive domes crop out locally. Potassium-argon age of 5.8±0.8 m.y. from pyroxene andesite lava near Lolo Pass (table 1, No. 23); hornblende andesite dome yielded age of 6.25±0.11 m.y. (table 1, No. 25). Queried to indicate rocks of uncertain assignment northwest of Vista Ridge

Tvmf **Volcaniclastic rocks of Middle Fork (Miocene)**—Tuff breccia, conglomerate, and sandstone. Generally poorly exposed in northwestern part of Mount Hood quadrangle. Nearly 100 m thick where exposed in a gully northeast of Lawrance Lake: coarse tuff breccia in lower part has radially jointed blocks as large as 4 m; other primary pyroclastic beds farther upsection contain bombs 80 cm across of frothed, dark-brown or olive-gray pyroxene andesite in a pink-weathering ashy matrix; highest beds are conglomeratic. Mapped as Dalles Formation by Wise (1969), although unit here may be as much as 3 m.y. younger than the main mass of Dalles Formation (Td) exposed in the northeastern part of the Mount Hood quadrangle (from the East Fork Hood River eastward onto the Columbia Plain; see discussion of unit Td for northeastern part of map area). Map-unit symbol shown queried for poorly exposed slope north of The Pinnacle

Taef **Andesite of East Fork (Miocene)**—Slightly to moderately porphyritic two-pyroxene andesite lava flows and minor breccia or tuff breccia. Described in more detail for northeastern part of map area

Tilh **Intrusive rocks of Laurel Hill (Miocene)**—The following description is taken from Wise (1969): Porphyritic quartz diorite to quartz monzonite, with scattered patches of granophyre; exposures at west end of Still Creek mass show hornblende hornfels zone about 60 m wide, and an epidote hornfels zone as much as 1.5 km wide is present in most of the wall rocks surrounding the intrusions. Rocks assigned to this unit may represent several ages of intrusion. The main Laurel Hill mass has an age between about 9 and 8 m.y., on basis of three different determinations (table 1, No. 29 and the two preceding unnumbered samples that lack precise sample locations). A sill penetrated at 3,750-ft depth in drill hole OMF-7a (on Old Maid Flat) has an age of 9.30±0.87 (table 1, No. 31), and the large standard deviation may indicate that it, too, is about the same age as the Laurel Hill mass. An older age of intrusive activity may be indicated by K-Ar age of 11.6±1.2 m.y. from the Still Creek mass (table 1, No. 37)

Ts **Sedimentary rocks (Miocene)**—Fine- to medium-grained volcaniclastic sandstone. Caps ridges in Zigzag Mountain area where interfingered with youngest parts of andesite of Zigzag Mountain (Tazm). Unit there is hornfelsed, suggesting it may be fine-grained upper part of Rhododendron Formation (Trh) and that intervening andesite lava is intrusive. Overlain by ridge-capping basalt (Tbbu) at old Zigzag East fire lookout (site of dating localities 14 and 24)

Tazm **Andesite of Zigzag Mountain (Miocene)**—Very porphyritic pyroxene andesite lava containing plagioclase and hypersthene phenocrysts as large as 1 cm. Widely exposed throughout northwest corner of map area. Originally named Zigzag Mountain andesites by Wise (1969), who recognized the petrographic distinctiveness of these rocks and mapped them as far north as Lost Lake. Equivalent to informally named Last Chance andesite of Priest and others (1982), but the name "Last Chance Andesite" is herein abandoned because it was long ago preempted for a formally designated unit in New Mexico. Age is late Miocene; potassium-argon ages from flows on Last Chance Mountain are 10.7±0.5, 10.5±0.4, and 9.04±0.04 m.y. (table 1, Nos. 35b , 35a, and 30)

Trh **Rhododendron Formation (Miocene)**—Andesitic tuff breccia. Clast petrography varies but is chiefly slightly porphyritic pyroxene andesite. Unit originated mainly as pyroclastic flows and lahars, but some parts also contain fluvial volcaniclastic sandstone and minor siltstone. Age is middle and earliest late Miocene; overlies Columbia River Basalt Group ($Tcgn_2$ and Tcwf) and underlies andesite of Zigzag Mountain (Tazm). Potassium-argon ages from lava flows in upper part of unit are 12.1±1.7, 11.26±0.08, 10.6±0.5, 10.58±0.08, and 9.5±2.4 m.y. (table 1, Nos. 38, 36, 34, 33, and 32)

Columbia River Basalt Group (Miocene)—Lava flows of tholeiitic flood basalt. Age in map area is middle Miocene. Stipple in Salmon River canyon indicates wide zone of basaltic breccia in hanging wall of reverse fault. Divided into:

Wanapum Basalt—

Tcwpr **Priest Rapids member**—Fine- to medium-grained basalt. Reversed-polarity magnetization (Vogt, 1981). Age about 14.5 m.y. (Rockwell Hanford Operations, in table 3 of Tolan and others, 1989; no error assigned to age)

Tcwf **Frenchman Springs member**—Fine- to medium-grained basalt, commonly containing scant plagioclase phenocrysts as large as 1 cm across

Grande Ronde Basalt—Fine-grained to very fine grained basalt. Subdivided on basis of magnetic polarity into four magnetostratigraphic units, of which only two are exposed in the northwestern part of map area. Age between about 17.2 and 15.4 m.y. on basis of K-Ar age of 16.2±1.0 m.y. from oldest known flow of the reversed-polarity unit 1 on Columbia Plateau (Reidel and others, 1989, p. 25) and ^{40}Ar-^{39}Ar age of

15.6±0.2 m.y. from one of youngest flows in the normal-polarity unit 2 (drill core sample from central Columbia Plateau; Long and Duncan, 1983)

Tcgn2 **Normal-polarity unit 2**—Chiefly low-MgO chemical type in lower part and high-MgO chemical type in upper part (Vogt, 1981)

Tcgr2 **Reversed-polarity unit 2**—Aphyric to slightly porphyritic lava flow. Base not exposed; oldest stratum exposed in northwestern part of map area

STRATIGRAPHIC UNITS EXPOSED IN SOUTHWESTERN PART OF MAP AREA

Qyba **Younger basaltic andesite (Pleistocene)**—Slightly porphyritic lava flows and minor flow breccia. Normal-polarity magnetization. Erupted from shield volcanoes of Summit Butte and North Wilson and from a few small cinder cones

Qac **Andesite of Cabin Creek (Pleistocene)**—Nearly aphyric, medium-gray andesite with scant clinopyroxene less than 1 mm across and trace amounts of small opacitized hornblende and olivine phenocrysts. Exposed only along southwest edge of map; erupted from vents 1 km to the south in Breitenbush Hot Springs quadrangle. Normal-polarity magnetization; younger than 0.78 m.y.

Qas **Andesite of Skyline Road (Pleistocene)**—Light-gray, slightly porphyritic lava, commonly with scant, small opacitized amphibole phenocrysts. Forms scattered domes along Cascade Range crest in southwestern part of map area. Polarity not well characterized because few of the domes form bold outcrops suitable for sampling. Probably entirely Pleistocene in age, but duration therein uncertain

Qob **Olivine basalt (Pleistocene)**—Slightly porphyritic lava flows and minor breccia. Lithologically similar to older basaltic andesite (Qoba) but chiefly basaltic in composition. Includes rocks with normal- and reversed-polarity magnetization; probably mostly early Pleistocene (older than 0.78 m.y.), but youngest part may be late Pleistocene. Exposed only in area east and southeast of Linney Creek campground

Qoba **Older basaltic andesite (Pleistocene)**—Slightly porphyritic lava flows and minor flow breccia. Contained chiefly in shield volcanoes of Mount Wilson, Clear Lake Butte, and Wests Butte. Reversed-polarity magnetization in most exposures, although polarity of Wests Butte remains unknown

Qaw **Andesite of Wapinitia Pass (Pleistocene)**—Medium-gray, moderately porphyritic lava. Plagioclase phenocrysts (1-3 mm) 5-10 percent; clinopyroxene and orthopyroxene phenocrysts (< 1 mm) 1-2 percent; and traces of much-altered, fine-grained olivine. Blocky- to platy-weathering. One analysis, 62 percent SiO_2 (R.M. Conrey, Wash. State Univ., unpub. data). Reversed-polarity magnetization. Potassium-argon age of 1.37±0.03 m.y. (weighted mean of two determinations; table 1, No. 56)

Qdf **Dacite of Frog Lake Buttes (Pleistocene)**—Thick, massive lava, probably domes, at Frog Lake Buttes and hill southwest of Wapinitia Pass. Two analyses; 62.5-63.5 percent SiO_2 (our unpublished data). Reversed-polarity magnetization; early Pleistocene in age. Unit may mark vent area for 1.37-m.y. andesite of Wapinitia Pass (unit Qaw)

Qacl **Andesite west of Clear Lake (Pleistocene)**—Lava flows of slightly porphyritic two-pyroxene andesite. Reversed-polarity magnetization; probably similar in age to andesite of Wapinitia Pass (unit Qaw, ~1.37 m.y. old) but somewhat less porphyritic. Queried for exposure of uncertain correlation on south valley wall of Salmon Creek

Volcanic rocks in Trillium Lake area (Pleistocene?, Pliocene, and Miocene?)—Lava flows of andesite and minor basalt. Unit name is applied to inadequately mapped and undated rocks with uncertain stratigraphic relation to strata in adjacent areas; could be late Miocene and Pliocene in age and represent deeply glaciated parts of the stratigraphic sequence—or could be late Pliocene and early Pleistocene and result from emplacement after downcutting of Salmon River canyon. Divided into:

$QTtla_2$ **Andesite (Pleistocene or Pliocene)**—Lava flows of two-pyroxene andesite. Reversed-polarity magnetization. Overlies basalt unit (QTtlb) (correlation chart shows overlapping age in order that this unit and the basalt unit (QTtlb) may both show possible Pleistocene age assignment)

QTtlb **Basalt (Pleistocene or Pliocene)**—Lava flows of olivine basalt. Normally polarized

$Ttla_1$ **Andesite (Pliocene and (or) Miocene)**—Reversely polarized lava flows. Magnetostratigraphy of overlying flows indicates that this chronozone is Pliocene or older. Exposed only in area west and east of Salmon River, about 4 km south of Trillium Lake

QTb **Basalt (Pleistocene and Pliocene?)**—Diktytaxitic (open-textured) to intergranular olivine basalt and minor basaltic andesite. Lithologically similar to underlying basaltic andesite of Oak Grove Fork (Tbao) but predominantly basaltic; contact between the two in southwest corner of map area is conjectural, and the purpose in showing the unit there is to separate known Pliocene rocks from younger strata. Elsewhere the unit consists of isolated basalt lava flows

QTba **Basaltic andesite (Pleistocene or Pliocene?)**—Slope-mantling lava flow that forms bench at its northern limit along the Clackamas River, south edge of map sheet. Corresponds to a unit with K-Ar age of 1.59±0.21 m.y. and chemical analysis containing ~57 percent SiO_2 (White, 1980b, his sample No. 29)

Tbg **Basalt near Ghost Creek (Pliocene or Miocene)**—Very dark gray to black, columnar-jointed lava. Exposed only in roadcut along U.S. Highway 26 between Government Camp and Wapinitia

Pass. Contains scattered, fine-grained olivine phenocrysts and very sparse, yellow-weathering plagioclase phenocrysts as large as 4 mm. Similar in hand specimen and in manner of its columnar jointing to some flows in the Wanapum Basalt of the Columbia River Basalt Group (Swanson and others, 1979), but chemical analysis indicates otherwise (R.M. Conrey, Wash. State Univ., unpub. data). Reversed-polarity magnetization; magnetostratigraphy of overlying flows indicates that this chronozone is Pliocene or older

Tbao **Basaltic andesite of the Oak Grove Fork (Pliocene)**—Lava flows and minor breccia, chiefly basaltic andesite in composition. Slightly porphyritic, with most rocks containing plagioclase and olivine phenocrysts. Flows north of High Rock commonly contain 3-5 percent clinopyroxene phenocrysts 2-3 mm across. Includes minor basalt and andesite scattered throughout stratigraphic sequence, with diktytaxitic basalt found most commonly at base of unit. Erupted from cinder cones and small shields, most of which have been destroyed by erosion or buried by successive lava flows. Forms eastward-thickening wedge nearly 1 km thick along Oak Grove Fork of Clackamas River. Farther east, base of unit is unexposed and maximum thickness is unknown; buried by younger rocks east of there. Thins northward towards Salmon Butte, probably owing to northward-diminishing eruptive activity. Farther north, however, basalt and lesser basaltic andesite of similar age are widely exposed in the Bull Run River watershed. Potassium argon ages from near base and top of unit in Oak Grove Fork are 2.92±0.13 m.y. and 2.78±0.09 m.y., respectively (table 1, Nos. 42 and 41). Lower part increases in age southward, however, because unit interfingers with ~4-m.y. andesite (unit Ta) in the Clackamas River

Tha **Hornblende-bearing andesite (Pliocene)**—Pale- to medium-gray, slightly to moderately porphyritic, hornblende-bearing andesite lava flows. Unit near Mount Mitchell is displaced approximately 30 m by a north-striking normal fault. Unit near Linney Butte is small remnant of lava flow exposed along ridge top

Tdb **Dacite of Beaver Butte (Pliocene)**—Moderately to very porphyritic, two-pyroxene dacite lava. One analysis; contains 65 percent SiO_2 (R.M. Conrey, Wash. State Univ., unpub. data). Normally polarized. Beaver Butte diverted the reversely polarized 1.37-m.y.-old andesite of Wapinitia Pass (unit Qaw); thus the Beaver Butte unit likely was erupted during the Gauss Normal-Polarity chron or earlier (prior to 2.60 m.y., time scale of Cande and Kent, 1992)

Tba **Basaltic andesite (Pliocene)**—Lava flows south of Mount Wilson (south edge of map). Normal-polarity magnetization; probably about same age as dacite of Beaver Butte (Tdb) or andesite of Rocky Point (Tar)

Ta **Andesite (Pliocene)**—Lava flows of slightly porphyritic, two-pyroxene andesite. Interbedded with lower part of basaltic andesite of Oak Grove Fork (Tbao) in the Clackamas River drainage. Continues south of the map area in Breitenbush Hot Springs quadrangle, where it correlates with andesite and dacite of the Clackamas River (Sherrod and Conrey, 1988); latter unit has K-Ar ages of 4.20±0.10 m.y. (L.B. Gray, USGS, unpub. data, 1990) and 4.04±0.17 m.y. (White, 1980b)

Tar **Andesite of Rocky Point (Pliocene)**—Platy, two-pyroxene andesite. Slightly porphyritic; ferromagnesian minerals (< 1 mm) 1-2 percent in abundance and plagioclase (<1 mm) 5 percent. Unit probably formed a broad andesitic shield volcano as interpreted from the vertical and lateral distribution of flows. One vent area (shown patterned) recognized at Rocky Point (south of Beaver Butte) on basis of abundant scoria and breccia. Normally polarized. Overlain by dacite of Beaver Butte (Tdb)

Tdl **Dacite north of Long Ridge (Pliocene)**—Domes and lava flows south of Beaver Butte. Moderately porphyritic; contains fresh to variably oxidized hornblende phenocrysts ranging from 1 to 2 mm in length

Tys **Younger sedimentary rocks (Pliocene and Miocene?)**—Sandstone and siltstone exposed beneath the basaltic andesite of Oak Grove Fork (Tbao). Locally includes minor pebbly conglomerate. Thickness about 30 m. Well-known for roadcuts in siltstone rich in fossil flora. According to J.A. Wolfe (USGS, written commun., 1992), the fine-grained beds contain abundant megafossils of *Abies* (true fir), *Pinus* (pine), and *Picea* (spruce) accompanied by broad-leaved plants such as *Quercus* (oak), *Castanopsis* (chinquapin), *Acer* (maple), and *Arcostaphylos* (manzanita). The fossil assemblage indicates a climate both warmer and drier than presently found in the area; rainfall during late Pliocene time may have been one-half the 200 cm per year that occurs presently (Wolfe, 1990)

Tr **Rhyolite (Pliocene or Miocene)**—Slightly porphyritic rhyolite in area southeast of Beaver Butte (head of Butte Creek). Soft-weathering owing to clay content; unit is hydrothermally altered. Forms angular, monolithologic rhyolite float in roadcuts, all of which have sloughed to some degree; forms light-colored soil elsewhere. Probably correlative to equally poorly exposed rhyolite at Hehe and Sidwalter Buttes, 10 km south of map area. Those buttes were considered part of the Oligocene and lower Miocene John Day Formation by Waters (1968b), probably because rhyolitic rocks farther east underlie the Columbia River Basalt Group. It seems more likely, however, that the rhyolite in the Mount Hood quadrangle west of U.S. Highway 26 is younger than the Columbia River Basalt Group and hence late Miocene or Pliocene in age

Tma **Andesite of middle and late Miocene age (Miocene)**—Porphyritic pyroxene andesite lava exposed near Clackamas River and between the Salmon River and

Still Creek in the western part of map area. Younger than the Columbia River Basalt Group, on basis of stratigraphic relations immediately west of map area; potassium-argon age of 11.5±0.2 m.y. from sample along Clackamas River highway (table 1, No. 43)

Tfa **Fine-grained andesite (Miocene)**—Nearly aphyric medium-gray andesite that forms plugs and sills(?) or lava flows. Only exposed near Salmon Butte and a few kilometers to southwest

Tas **Andesite of Salmon Butte (Miocene)**—Moderately porphyritic lava flows and volcaniclastic rocks

Tdp **Dacite of Plaza Lake (Miocene)**—Light-bluish-gray to light-greenish-gray pyroxene dacite lava. Plagioclase phenocrysts 3-4 mm long, 10-15 percent; orthopyroxene phenocrysts only about 1 mm long and less than 1 percent. Exposed only as small body west of Salmon Butte (west edge of map). The name "Plaza Lake" appears on the High Rock 15-minute and 7.5-minute quadrangles

Tbam **Basaltic andesite of Mack Hall Creek (Miocene)**—Slightly porphyritic lava flows and minor near-vent(?) breccia. Olivine, 1-2 mm across and 1-3 percent in abundance, is characteristically oxidized to hematitic clays. Locally erupted unit exposed at head of Mack Hall Creek, probably the core of a small shield volcano. Maximum thickness approximately 250 m

Trh **Rhododendron Formation (Miocene)**—Andesitic tuff breccia. Clast petrography varies but chiefly is slightly porphyritic pyroxene andesite. Unit originated mainly as pyroclastic flows and lahars but includes minor fluvial volcaniclastic sandstone. Age is middle Miocene; overlies Columbia River Basalt Group (units Tcg and Tcw) and underlies basaltic andesite of Mack Hall Creek (unit Tbam) and andesite of Salmon Butte (unit Tas) in southwest corner of map area. As thick as 500 m in canyon walls of Salmon River. Unit can be traced across canyon walls northward to village of Rhododendron and beyond nearly to Lolo Pass in northwest corner of map area. Thins southward and pinches out in Oak Grove Fork. Only partly equivalent to Rhododendron Formation of Hammond and others (1982), which was more broadly defined to include andesitic rocks ranging from middle Miocene to Pliocene in age west and south of the map area

Columbia River Basalt Group—Divided into:

Tcwf **Frenchman Springs member of the Wanapum Basalt**—Fine-grained lava flows with rare plagioclase phenocrysts as large as 2 cm. Normal-polarity magnetization (Anderson, 1978)

$Tcgn_2$ **Reversed-polarity unit 2 of the Grande Ronde Basalt**—Very fine grained lava flows

Tos **Older sedimentary rocks (Miocene)**—Chiefly cobble-to-boulder volcaniclastic conglomerate and sandstone. Commonly found beneath the Columbia River Basalt

Group or at about that stratigraphic level

Toa **Older andesite (Miocene and Oligocene?)**—Slightly to moderately porphyritic andesite and basaltic andesite(?) lava flows. Rocks exposed along Clackamas River are hornblende bearing

STRATIGRAPHIC UNITS EXPOSED IN NORTHEASTERN PART OF MAP AREA

Qbdr **Basaltic andesite of Dog River (Pleistocene)**—Medium-gray porphyritic lava that erupted from cinder cones on Hood River escarpment near headwaters of Dog River and flowed northwest toward Hood River valley and northeast down South Fork of Mill Creek. Distinctive rock owing to its pale-gray plagioclase phenocrysts, which probably contain numerous glass inclusions. One analysis, 56.7 percent SiO_2 (R.M. Conrey, Wash. State Univ., unpub. data). Younger than 0.78 m.y., on basis of normal polarity magnetization, relatively well-preserved cinder cones, and position of lava on or near canyon floor. Potassium-argon age of 3.7±0.2 m.y. (table 1, No. 46) was obtained from sample collected by Anderson (1987) in South Fork of Mill Creek north of map area and seemingly part of the same intracanyon flow as mapped by Newcomb (1969) north of map area. Anderson's sample JA85022 contains about 65 percent SiO_2, however, and therefore is an unlikely equivalent to basaltic andesite of Dog River as defined here

QTb **Basaltic andesite and basalt (Pleistocene and Pliocene?)**—Lava flows erupted from vents at Flag and Frailey Points and in the headwaters of Dog River along Hood River escarpment. Typically contains 1-2 percent of plagioclase phenocrysts (1-2 mm) and ~1 percent of olivine phenocrysts (~1 mm). Chemical analyses of five samples collected along Hood River escarpment range from 51.5 to 56 percent SiO_2 (Wise, 1969, his numbers 108-112). Lava from Flag Point vent shows reversed-polarity magnetization and thus is older than 0.78 m.y.

QTa **Andesite (Pleistocene or Pliocene)**—Lava flow exposed along a 15-km stretch of Fivemile Creek. Possesses geomorphic setting characteristic of an intracanyon lava flow and a K-Ar age of 1.7±0.4 m.y. (table 1, No. 44). Vent area unknown

QTab **Andesite of Badger Butte (Pleistocene or Pliocene)**—Two-pyroxene, slightly porphyritic lava flows. Reversed-polarity magnetization

QTs **Sedimentary rocks and deposits (Pleistocene and Pliocene?)**—Poorly indurated or unconsolidated sand and gravel. Forms broad fans east of ancestral Badger Creek and White River; elsewhere is restricted to narrow lobes derived from smaller drainages

Taft **Andesite of Fifteenmile Creek (Pliocene)**—Medium-gray to greenish-gray, porphyritic silicic andesite. Blocky plagioclase phenocrysts 2-5 mm across, 12-15 percent. Orthopyroxene much more abundant than clinopyroxene, but both are less than 1 mm across and less than 1 percent of rock. Contains 62.6 percent SiO_2 (R.M. Conrey, Wash. State Univ., unpub. analysis of dated sample). Age is late Pliocene on basis of K-Ar age of 2.86±0.04 m.y. (table 1, No. 45)

Rhyodacite of Gordon Butte (Pliocene)—Divided into:

Trgx **Tuff breccia**—Block-and-ash deposits that mantle slopes east of Gordon Butte and Hootnany Point. Unit probably originated as debris from collapse of domes (Trgd), on the basis of clast similarity, and was perhaps emplaced well after eruptions ceased. Predates erosion that carved the modern canyons in map area

Trgd **Domes and flows**—Medium- to light-gray, light-purplish-gray, and white rhyodacite and rhyolite. Massive to thickly flow jointed. Blocky plagioclase phenocrysts from 1 to 3 mm across, 10-30 percent in abundance, and commonly slightly clay-altered and locally stained with iron hydroxide minerals. Orthopyroxene and clinopyroxene visible locally, less than 1 mm across, and less than 1 percent

Tbah **Basaltic andesite of Happy Ridge (Pliocene)**—Lava flow in lower part of Happy Ridge at east end of Tygh Valley. One analysis, 55.6 percent SiO_2 (R.M. Conrey, Wash. State Univ., unpub. data). Potassium-argon age of 7.6±0.8 m.y. reported by Farooqui and others (1981b) (table 1, No. 50) is probably too old; unit is younger than andesite of Jordan Butte (Taj), from which they reported an age of 5.1±0.5 m.y. (table 1, No. 48)

Talb **Andesite of Little Badger Creek (Pliocene)**—Medium-gray porphyritic lava. Varies from platy at base to vesicular and massive in upper part. Phenocrysts of plagioclase as large as 3 mm, 3-5 percent; clinopyroxene and orthopyroxene (<1 mm) less than 1 percent; and trace amounts of highly altered olivine as large as 1 mm. Reversed-polarity magnetization. Mainly younger than but partly interfingered with Tygh Valley Formation

Ttv **Tygh Valley Formation (Pliocene and Miocene?)**—Volcaniclastic rocks, chiefly sandstone and conglomerate in eastern part and ash-flow and air-fall tuff in western part. A tuff exposed in the unit south of Tygh Valley yielded a K-Ar age of 4.9±0.5 m.y. (table 1, No. 47). Similar to the Tygh Valley Formation of Farooqui and others (1981a) but lacks the basaltic lava flows, which have been mapped separately. Unit is lithologically similar to and probably correlative with the Deschutes Formation of Smith (1986), although it may include rocks slightly younger than youngest strata in the Deschutes Formation. The Deschutes and Tygh Valley Formations formed in structurally separate basins, and their primary volcanogenic detritus probably was derived from discrete, noncontiguous volcanic fields in the Cascade Range. Contains increasing amount of primary pyroclastic material westward towards Cascade Range, where pyroclastic-rich beds are shown separately as:

Ttvp **Pyroclastic and sedimentary rocks**—Partially welded ash-flow tuff and unwelded air-fall deposits. Includes locally interbedded sandstone and conglomerate. Deposit west of Friend townsite is a unwelded rhyodacitic ash-flow tuff (67.5 percent SiO_2, R.M. Conrey, Wash. State Univ., unpub. data) with black pumiceous lapilli and bombs as large as 30 cm. Overlies the Dalles Formation (Td) along chiefly conformable but perhaps locally unconformable contact. Distinguished from the Dalles Formation by its dominantly pumiceous clastic component, in contrast to the lithic-rich, pumice-poor Dalles Formation

Tb **Basalt and basaltic andesite (Pliocene)**—Diktytaxitic olivine basalt and minor intergranular basaltic andesite lava flows. Youngest part of unit is normally polarized and forms areally extensive exposures southeast of Gordon Butte. Older part, of undetermined magnetic polarity, is interfingered with Tygh Valley Formation

Taj **Andesite of Jordan Butte (Pliocene or Miocene)**—Platy to massive, locally vesicular medium-gray porphyritic andesite lava flows. Potassium-argon age of 5.1±0.5 m.y. (table 1, No. 48)

Tbas **Basaltic andesite of Sunset Spring (Miocene)**—Fine-grained, medium-gray lava, commonly with small clinopyroxene phenocrysts. Outcrops restricted to two small areas near Sunset Spring in headwaters of Tygh Creek, where unit underlies the andesite of Jordan Butte (Taj) and the rhyodacite of Gordon Butte (Trgd)

Tdm **Dacite of Mill Creek Buttes (Miocene)**—Hornblende dacite domes at headwaters of South Fork of Mill Creek. Chemical analyses of three samples range from 62 to 65 percent SiO_2 (Wise, 1969, his numbers 99-101). Stipple indicates hornblende-bearing volcaniclastic deposits adjacent to main domal mass. Potassium-argon age of 6.2±1.3 m.y. (table 1, No. 49)

Td **Dalles Formation (Miocene)**—Andesitic to dacitic volcaniclastic rocks ranging from block-and-ash deposits in area east of Upper Hood River Valley to sandstone and conglomerate with subangular clasts at east edge of map area. Much of unit is lithic tuff breccia that was probably deposited as debris flows. Pumiceous pyroclastic flows are lacking or unexposed in map area. Silica content of five clasts ranges from about 60 to 64 percent (sites in map area and to north; Gannett, 1982). Stratigraphic section exposed in canyon walls of Fifteenmile Creek is dominated by sandstone and conglomerate but contains as much as 30 percent angular-clast debris-flow deposits, some of which were emplaced hot as suggested by brownish-orange oxidized tops and monolithologic clast assemblage. Sample collected from this locality yielded K-Ar age of 7.73±0.16 m.y. (table 1, No. 52) using crystals separated from an andesite clast in one of the monolithologic lahar beds

Taef **Andesite of East Fork Hood River (Miocene)**—Slightly to moderately porphyritic two-pyroxene andesite lava flows and minor breccia or tuff breccia. Rocks increasingly iron-stained and altered southward towards Robinhood Creek, where they overlie pyritized and moderately altered lava of the Columbia River Basalt Group. Rocks moderately to very fresh north of Polallie Creek. Potassium-argon ages of 7.0±0.8 m.y. from andesite lava east of Hood River and 8.18±0.06 m.y. from stratigraphically lower flow exposed in new roadcuts along State Highway 35 (table 1, Nos. 26 and 28, respectively). Interfingers northward with volcaniclastic strata of the Dalles Formation

Tafv **Andesite of Fivemile Butte (Miocene)**—Slightly to moderately porphyritic two-pyroxene andesite. Potassium-argon age of 7.71±0.17 m.y. (table 1, No. 51). May also be unit from which Bunker and others (1982) obtained an age of 8.2±0.8 m.y. (see table 1, No. 53); if so, their reported sample locality is incorrect. Normal-polarity magnetization

Tvs **Volcaniclastic rocks (Miocene)**—Tuff breccia, pumiceous lapilli tuff, and minor sandstone and conglomerate. Unit conformably overlies Columbia River Basalt Group and is unconformably overlain by the Dalles Formation (Td) and Tygh Valley Formation (Ttv and Ttvp). Strata within unit on south flank of Tygh Ridge anticline were deposited during growth of the anticline and consequently diminish in dip upsection; lowest beds dip about 40°, whereas dips of about 5° characterize a capping conglomerate that contains abundant clasts of the Columbia River Basalt Group. Studies elsewhere on Columbia Plateau suggest that folding occurred mainly between 17 and 11 m.y. ago (for example, Reidel, 1984), and if applicable to timing of deformation at Tygh Ridge, then unit is chiefly or entirely middle Miocene in age. Considered correlative with lower parts of Ellensburg Formation and Simtustus Formation of Smith (1986) (Smith and others, 1989). Also probably correlative with the Rhododendron Formation (Trh, northwest corner of map), a volcaniclastic unit west and southwest of Mount Hood that was emplaced between approximately 14 and 11 m.y. ago. Queried for exposures of uncertain correlation northeast of Maupin

Columbia River Basalt Group (Miocene)—Lava flows of tholeiitic flood basalt erupted from dike swarms in Columbia Plateau and Blue Mountains in eastern Oregon. Only middle Miocene formations of the group are present in map area. Divided into:

Wanapum Basalt—Divided into

Tcwpr **Priest Rapids member**—Fine- to medium-grained basalt. Reversed-polarity magnetization. Age about 14.5 m.y. (Rockwell Hanford Operations, in table 3 of Tolan and others, 1989; no error assigned to age). On Columbia Plateau at northeast corner of map area

Tcwf **Frenchman Springs member**—Slightly porphyritic lava, typically with a few scattered glomerophyric clots of plagioclase. In East Fork Hood River valley and on Columbia Plateau. Normal-polarity magnetization (Swanson and others, 1981)

Grande Ronde Basalt—Divided into

Tcgn2 **Normal-polarity unit 2**—Aphyric to very slightly porphyritic lava. In East Fork Hood River valley and on Columbia Plateau. Potassium-argon age of 15.0±0.3 m.y. (table 1, No. 54) from normally polarized sample collected by Watkins and Baksi (1974) near Tygh Ridge

Tcgr2 **Reversed-polarity unit 2**—Aphyric to very slightly porphyritic lava. Only on Columbia Plain at east edge of map. Potassium-argon age of 16.8±0.3 m.y. (table 1, No. 55) from reversely polarized sample collected by Watkins and Baksi (1974) near Tygh Ridge

STRATIGRAPHIC UNITS EXPOSED IN SOUTHEASTERN PART OF MAP AREA

QTs **Sedimentary rocks and deposits (Pleistocene and Pliocene)**—Poorly indurated sand and gravel in southeast corner of map area. Weathers to form hillslopes mantled by pebbles and cobbles. Oldest part of unit near Tygh Valley probably includes rhyodacite breccia of Gordon Butte (Trgx) and is partly of Pliocene age. Narrow lobe of sedimentary deposits near the junction of State Highway 216 and U.S. Highway 26 overlies 1.37-m.y. andesite of Wapinitia Pass (unit Qaw) and terminates abruptly against reversely polarized andesite of McCubbins Gulch (unit Qam); it probably indicates ancient drainage eastward towards Juniper Flat through area now occupied by andesite of McCubbins Gulch. Sedimentary deposits south of Laughlin Hills are older than 1.37-m.y.-old andesite of Wapinitia Pass, because they extend from beneath an even older basalt (unit QTb). These deposits continue south of map area, where they overlie prairie-forming basalt with K-Ar age of 3.21±0.14 m.y. (table 1, No. 58). Sedimentary unit there could be outwash, but its relatively old age would correspond to glacial episodes that are undocumented from the Cascade Range in Oregon

QTb **Basalt (Pleistocene and Pliocene)**—Slightly porphyritic olivine basalt. Commonly shows reversed-polarity magnetization

Qam **Andesite of McCubbins Gulch (Pleistocene)**—Lava flow or flows characterized by distinctive plagioclase phenocrysts, which are 2-3 mm across and equant in outline (10 percent); waxy olivine phenocrysts less than 1 mm across (1 percent), and traces of fine-grained clinopyroxene. Chemical analysis from sample at east edge of flow near Pine Grove contains 59 percent SiO_2; unit probably varies from andesite to basaltic andesite in composition. Reversed-polarity magnetization. Early Pleistocene, approximately same age as ~1.37-m.y. andesite of Wapinitia Pass (unit Qaw)

Qabl **Andesite of Boulder Lake (Pleistocene)**—Slightly porphyritic lava flows. Normal-polarity magnetization. Only exposed west of Boulder Lake (head of Boulder

Creek), west of Grasshopper Point

QTbg **Basaltic andesite of Grasshopper Point (Pleistocene or Pliocene)**—Porphyritic, olivine-bearing lava flows. Commonly contains plagioclase phenocrysts 2-3 mm across, 10 percent; some flows contain orthopyroxene and clinopyroxene as microphenocrysts. Forms large shield volcano with summit at Grasshopper Point. Silica content ranges from 54 to 58 percent on basis of two analyses (R.M. Conrey, Wash. State Univ., unpub. data). Reversed-polarity magnetization. Age probably Pleistocene but only known to be older than 0.78 m.y., and a late Pliocene age cannot be ruled out

Tbj **Basalt of Juniper Flat (Pliocene)**—Diktytaxitic (open-textured) olivine basalt lava flows. Normal-polarity magnetization. Potassium-argon age is 2.77±0.36 m.y. (R.M. Conrey, Wash. State Univ., unpub. data)

Tdgb **Dacite of Graveyard Butte (Pliocene? or Miocene)**—Domes of intermediate to silicic, slightly porphyritic lava. Includes two domes 4 km east of Graveyard Butte. Stipple indicates dacitic cinder cone that underlies Graveyard Butte and adjacent area

Columbia River Basalt Group (Miocene)—Divided into:

Tcwf **Wanapum Basalt, Frenchman Springs member**—Normal-polarity magnetization (Swanson and others, 1981). May rest on thin tuffaceous sandstone or siltstone that locally overlies Grande Ronde Basalt

Grande Ronde Basalt—Description from Swanson and others (1981): Aphyric to very sparsely plagioclase-phyric lava flows. Generally fine-grained and petrographically nondistinctive. Flow thickness commonly 15-25 m but ranges from 1 m to more than 50 m. Divided into:

Tcgn2 **Normal-polarity unit 2**

Tcgr2 **Reversed-polarity unit 2**

Older volcanic rocks of the Mutton Mountains (Miocene and Oligocene)—

Tomt **Tuff and tuffaceous sedimentary rocks (Miocene)**—Rhyolitic air-fall and water-laid tuff and tuffaceous sandstone (Waters, 1968a)

Toma **Andesite (Miocene and Oligocene)**—Chiefly platy aphyric lava flows. Contains minor pyroclastic and epiclastic strata. Potassium-argon age from interbedded sandine- and biotite-bearing ash-flow tuff is 29.3±0.6 m.y. (table 1, No. 59)

Tomr **Rhyolite (Miocene and Oligocene)**—Lava flows and domes

EXPLANATION OF MAP SYMBOLS

Contact—Approximately located. Shown very short dashed where inferred; shown dotted to enclose a zone of propylitic alteration between Salmon River and Still Creek as mapped by Wise (1969)

Contact—Separating sequentially younger deposits of Polallie eruptive period in and adjacent to Newton Creek east of Mount Hood (unit Qhpc). Contact labeled to show relative age of deposits: Y, younger; O, older

Contact—Bounding unmapped area in Salmon Creek drainage and poorly mapped area in Mutton Mountains

Fault—Showing dip locally; dashed where approximately located or inferred, dotted where concealed. Ball and bar on downthrown side

Reverse or thrust fault—Dashed where approximately located or inferred; dotted where concealed. Teeth on upper plate

Anticline—Showing crestline and locally showing plunge

Syncline—Showing troughline

Monocline—Shown only on Columbia Plateau and on east wall of Hood River escarpment—

Abrupt decrease of dip in direction of arrows

Abrupt increase of dip in direction of arrows

Lineament—Interpreted from aerial photographs

Moraine crest—Shown in glacial deposits (unit Qg)

Strike and dip of clastic strata or layering in basalt flows

Inclined

Horizontal

Overturned—Found in lava flows of Columbia River Basalt Group on Tygh Ridge

Dike—Tick marks indicate composition; two ticks, basalt or basaltic andesite; three ticks, andesite or dacite

Intermediate-size volcano—Showing central buildup of basalt or basaltic andesite shield volcanoes. Many occurrences interpreted on basis of landform, owing to lack of dissection

Thermal remanent magnetization (TRM) measurement—N, normal polarity; R, reversed polarity

Potassium-argon sample locality—Showing map number (table 1). Samples from bedrock exposures except No. 31, which is from drill core. Nos. 46, 57, and 58 are from outside map area and not plotted on map. Thermal remanent magnetization indicated by R (reversed polarity) or N (normal polarity) where known

Drill hole locality—Showing name or number for holes deeper than 1 km. Two holes west of Mount Hood in upper reach of Old Maid Flat (OMF-1 and OMF-7A) and one hole on south flank of Mount Hood (Pucci). Locations from Priest and others (1982) and Hook (1982). Symbol for OMF-7A nearly filled by dot showing K-Ar sample locality No. 31

Snow and ice—Showing extent of major glaciers. Limited to higher elevations of Mount Hood. Names of separate glaciers shown where space allows

REFERENCES CITED

Anderson, J.L., 1978, The stratigraphy and structure of the Columbia River Basalt in the Clackamas River drainage: Portland, Oreg., Portland State University, M.S. thesis, 136 p.

———1987, The structural geology and ages of deformation of a portion of the southwest Columbia plateau, Washington and Oregon: Los Angeles, University of Southern California, Ph.D. dissertation, 283 p.

Baksi, A.K., Hsu, V., McWilliams, M.O., and Farrar, E., 1992, ^{40}Ar-^{39}Ar dating of the Brunhes-Matuyama geomagnetic field reversal: Science, v. 256, p. 356-357.

Bargar, K.E., Keith, T.E.C., and Beeson, M.H., 1993, Hydrothermal alteration in the Mount Hood area, Oregon: U.S. Geological Survey Bulletin 2054, 70 p.

Beeson, M.H., Tolan, T.L., and Anderson, J.L., 1989, The Columbia River Basalt Group in western Oregon; geologic structures and other factors that controlled flow emplacement patterns, in Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 223-246.

Bela, J.L., compiler, 1982, Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1° by 2° quadrangle: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-27, scale 1:250,000.

Bikerman, Michael, 1970, K-Ar ages of Laurel Hill pluton and dike, Oregon: Ore Bin, v. 32, no. 11, p. 211-215.

Bunker, R.C., Farooqui, S.M., and Thoms, R.E., 1982, K-Ar dates for volcanic rocks associated with Neogene sedimentary deposits in north-central and northeastern Oregon: Isochron/West, no. 33, p. 21-22.

Burck, M.S., 1986, The Stratigraphy and structure of the Columbia River Basalt Group in the Salmon River area, Oregon: Portland, Oreg., Portland State University, 108 p.

Cameron, K.A., and Pringle, P.T., 1987, A detailed chronology of the most recent major eruptive period at Mount Hood, Oregon: Geological Society of America Bulletin, v. 99, no. 12, p. 845-851.

Cande, S.C., and Kent, D.V., 1992, A new geomagnetic polarity time scale for the Late Cretaceous and Cenozoic: Journal of Geophysical Research, v. 97, no. B10, p. 13,917-13,951.

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.

Duncan, R.A., and Kulm, L.D., 1989, Plate tectonic evolution of the Cascades arc-subduction complex, *in* Winterer, E.L., Hussong, D.M., and Decker, R.W., eds., the eastern Pacific Ocean and Hawaii: Boulder, Colo., Geological Society of America, The geology of North America, v. N., p. 413-438.

Evans, S.H., and Brown, F.H., 1981, Summary of potassium-argon dating—1981: Department of Energy Division of Geothermal Energy ID-12079-45, 29 p.

Farooqui, S.M., Beaulieu, J.D., Bunker, R.C., Stensland, D.E., and Thoms, R.E., 1981a, Dalles Group: Neogene formations overlying the Columbia River Basalt Group in north-central Oregon: Oregon Geology, v. 43, no. 10, p. 131-140.

Farooqui, S.M., Bunker, R.C., Thoms, R.E., Clayton, D.C., and Bela, J.L., 1981b, Post-Columbia River Basalt Group stratigraphy and map compilation of the Columbia Plateau, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-81-10, 79 p.

Fiebelkorn, R.B., Walker, G.W., MacLeod, N.S., McKee, E.H., and Smith, J.G., 1983, Index to K-Ar age determinations for the state of Oregon: Isochron/West, no. 37, p. 3-60.

Gannett, M.W., 1982, A geochemical study of the Rhododendron and Dalles Formation in the area of Mount Hood, Oregon: Portland, Oreg., Portland State University, M.S. thesis, 64 p.

Gray, L.B., Sherrod, D.R., and Conrey, R.M., in press, Potassium-argon ages from the northern Oregon Cascade Range: Isochron/West.

Hammond, P.E., Geyer, K.M., and Anderson, J.L., 1982, Preliminary geologic map and cross sections of the upper Clackmas and Santiam Rivers area, northern Oregon Cascade Range: Portland, Oreg., Portland State University Department of Earth Sciences, scale 1:62,500.

Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G., and Walters, R., 1982, A geologic time scale: Cambridge, Cambridge University Press, 131 p.

Harris, B.L., 1973, Genesis, mineralogy, and properties of Parkdale soils, Oregon: Corvallis, Oregon State University, Ph.D. dissertation, 174 p.

Hook, J.W., 1982, History of geothermal exploration in the Mount Hood area, Oregon, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the Mount Hood area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 14, p. 3-5.

Keith, T.E.C., Donnelly-Nolan, J.M., Markman, J.L., and Beeson, M.H., 1985, K-Ar ages of rocks in the Mount Hood area, Oregon: Isochron/West, no 42, p. 12-16.

Le Bas, M.J., and Streckeisen, A.L., 1991, The IUGS systematics of igneous rocks: Journal of the Geological Society of London, v. 148, p. 825-833.

Long, P.E., and Duncan, R.A., 1983, $^{40}Ar/^{39}Ar$ ages of Columbia River Basalt from deep boreholes in south-central Washington: Eos, American Geophysical Union Transactions, v. 64, no. 9, p. 90.

Nelson, D.O., 1989, Geochemistry of the Grande Ronde Basalt of the Columbia River Basalt Group; a reevaluation of source control and assimilation effects, *in* Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 333-342.

Newcomb, R.C., 1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of The Dalles area, Oregon and Washington: U.S. Geological Survey Professional Paper 383-C, 33 p.

Priest, G.R., Beeson, M.H., Gannett, M.W., and Berri, D.A., 1982, Geology, geochemistry, and geothermal resources of the Old Maid Flat area, Oregon, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the Mount Hood area, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 14, p. 16-30.

Reidel, S.P., 1984, The Saddle Mountains: The evolution of an anticline in the Yakima Fold Belt: American Journal of Science, v. 284, no. 8, p. 942-978.

Reidel, S.P., Tolan, T.L., Hooper, P.R., Beeson, M.H., Fecht, K.R., Bentley, R.D., and Anderson, J.L., 1989, The Grande Ronde Basalt, Columbia River Basalt Group; stratigraphic descriptions and correlations in Washington, Oregon, and Idaho, *in* Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 21-53.

Scott, W.E., Sherrod, D.R., Gardner, C.A., Vallance, J.W., Tilling, R.I., and Lanphere, M.A., 1994, New geologic map of Mount Hood, Oregon [abs.]: Geological Society of America Abstracts with Programs, v. 26, no. 7, p. 116.

Shackleton, N.J., Berger, A., and Peltier, W.R., 1990, An alternative astronomical calibration of the lower Pleistocene timescale based on ODP Site 667: Royal Society of Edinburgh Transactions, Earth Sciences, v. 81, no. 4, p. 251-261.

Sherrod, D.R., and Conrey, R.M., 1988, Geologic setting of the Breitenbush-Austin Hot Springs area, Cascade Range, north-central Oregon, *in* Sherrod, D.R., ed., Geology and geothermal resources of the Breitenbush-Austin Hot Springs area, Clackamas and Marion Counties, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-88-5, p. 1-14.

Sherrod, D.R., and Pickthorn, L.G., 1989, A note on the origin of Bull Run and Lost Lakes, Western Cascades, Oregon: Oregon Geology, v. 51, no. 3, p. 60.

Sherrod, D.R., and Smith, J.G., 1989, Preliminary map of upper Eocene to Holocene volcanic and related rocks in the Cascade Range, Oregon: U.S. Geological Survey Open-File Report 89-14, scale 1:500,000.

Smith, G.A., 1986, Simtustus Formation: Paleogeographic and stratigraphic significance of a newly defined Miocene unit in the Deschutes basin, central Oregon: Oregon Geology, v. 48, no. 6, p. 63-72.

Smith, G.A., Bjornstad, B.N., and Fecht, K.R., 1989, Neogene terrestrial sedimentation on and adjacent to the Columbia Plateau; Washington, Oregon, and Idaho, *in* Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 187-198.

Steiger, R.H., and Jäger, E., 1977, Subcommission on geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, no. 3, p. 359-362.

Swanson, D.A., Anderson, J.L., Camp, V.E., Hooper, P.R., Taubeneck, W.H., and Wright, T.L., 1981, Reconnaissance geologic map of the Columbia River Basalt Group, northern Oregon and western Idaho: U.S. Geological Survey Open-File Report 81-797, scale 1:250,000.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Taylor, J.R., 1982, An introduction to error analysis: Mill Valley, Calif., University Science Books, 270 p.

Tolan, T.L., Reidel, S.P., Beeson, M.H., Anderson, J.L., Fecht, K.R., and Swanson, D.A., 1989, Revisions to the estimates of the areal extent and volume of the Columbia River Basalt Group, *in* Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 1-20.

Vandiver-Powell, Lorraine, 1978, The structure, stratigraphy, and correlation of the Grande Ronde basalts on Tygh Ridge, Wasco County, Oregon: Moscow, University of Idaho, M.S. thesis, 57 p.

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, Oreg., Portland State University, M.S. thesis, 151 p.

Waters, A.C., 1968a, Reconnaissance geologic map of the Dufur quadrangle, Hood River, Sherman, and Wasco Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-556, scale 1:125,000.

———1968b, Reconnaissance geologic map of the Madras quadrangle, Jefferson and Wasco Counties, Oregon: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-555, scale 1:125,000.

Watkins, N.D., and Baksi, A.K., 1974, Magnetostratigraphy and oroclinal folding of the Columbia River, Steens, and Owyhee Basalts in Oregon, Washington, and Idaho: American Journal of Science, v. 274, no. 2, p. 148-189.

White, Craig, 1980a, Geology and geochemistry of Mt. Hood volcano: Oregon Department of Geology and Mineral Industries Special Paper 8, 26 p.

———1980b, Geology of the Breitenbush Hot Springs quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Special Paper 9, 26 p.

Wise, W.S., 1969, Geology and petrology of the Mt. Hood area: A study of High Cascade volcanism: Geological Society of America Bulletin, v. 80, no. 6, p. 969-1,006.

Wright, T.L., Mangan, Margaret, Swanson, D.A., 1989, Chemical data for flows and feeder dikes of the Yakima Basalt Subgroup, Columbia River Basalt Group, Washington, Oregon, and Idaho, and their bearing on a petrogenetic model: U.S. Geological Survey Bulletin 1821, 71 p.

Wolfe, J.A., 1990, Estimates of Pliocene precipitation and temperature based on multivariate analysis of leaf physiognomy, *in* Gosnell, L.B., and Poore, R.Z., eds., Pliocene climates: scenario for global warming: U.S. Geological Survey Open-File Report 90-64, p. 39-42.

Table 1. *Potassium-argon ages from Mount Hood 30' by 60' quadrangle*

[Samples grouped according to map sector and arranged in order of increasing age within each group. Ages calculated using constants for radioactive decay and abundance of ^{40}K recommended by the International Union of Geological Sciences Subcommission on Geochronology (Steiger and Jäger, 1977); therefore, ages may differ slightly when compared to original reference. For multiple K_2O determinations, value in parentheses is arithmetic mean used in age calculation. Assigned age is the calculated age from each gas extraction except where multiple extractions are listed; in those cases the assigned age is the weighted mean age (weighting proportional to the inverse of the variances of individual analyses by method of Taylor, 1982). Ages lacking map numbers aré of uncertain location. Many sample locations were verified and remeasured by us using original air photos (samples referable to Wise, 1969), sample location maps (field sheets; Keith and others, 1985), or published map (Priest and others, 1982, fig. 5). Sample locations are reported to nearest 0.01 minute (error is probably ±0.02 minutes) except for less precisely located samples, which are shown to nearest 0.1 minute (error may be several tenths of minutes in some cases). Footnotes at end of table give additional sample-specific information. The ages of stratigraphic units are further elucidated in the Description of Map Units]

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
Ages for northwestern part of map area												
1	82MH12	45°27.20'	121°40.25'	The Pinnacle, Qbap	Basaltic andesite	Whole rock	0.95	0.01994	1.9		0.14±0.02	Keith and others (1985)
2	81MH29	45°20.58'	121°44.58'	Mount Hood, Qha	Andesite	Whole rock	1.45				0.38±0.02	Keith and others (1985)
								0.07485	9.0	0.36±0.03		
								0.08857	7.4	0.42±0.04		
3	79SGV1085	45°23.25'	121°43.83'	Mount Hood, Qha[1]	Andesite	Whole rock	1.03				0.45±0.02	Keith and others (1985)
								0.05831	4.8	0.39±0.05		
								0.06323	7.2	0.43±0.04		
								0.07618	19.4	0.51±0.04		
4	79ZZ1048	45°20.58'	121°44.58'	Mount Hood, Qha	Andesite	Whole rock	1.56				0.49±0.04	Keith and others (1985)
								0.1017	4.9	0.45±0.06		
								0.1155	7.9	0.51±0.05		
5	81MH28	45°20.63'	121°44.48'	Mount Hood, Qha	Andesite	Whole rock	0.96				0.53±0.04	Keith and others (1985)
								0.03959	5.6	0.29±0.08		
								0.07909	11.5	0.57±0.05		
								0.07840	3.2	0.57±0.10		
								0.1139	9.3	0.82±0.13		
6	81MH10	45°24.30'	121°39.23'	Cloud Cap, Qbac	Basaltic andesite	Whole rock	1.09				0.59±0.03	Keith and others (1985)
								0.07701	4.8	0.49±0.06		
								0.09822	8.8	0.63±0.07		
								0.1015	15.8	0.65±0.05		

Footnotes at end of tabular data

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
7	79ZM0078	45°20.62'	121°47.33'	Devil Canyon, Qbdc	Basaltic andesite	Whole rock	0.78				0.71±0.04	Keith and others (1985)
								0.07042	4.5	0.63±0.06		
								0.08838	8.7	0.79±0.06		
8	82MH2	45°26.10'	121°43.25'	Vista Ridge, Qbr	Basaltic andesite	Whole rock	1.05				1.12±0.03	Keith and others (1985)
								0.1547	9.4	1.02±0.04		
								0.1839	7.8	1.22±0.04		
9	79SGV1111A	45°22.97'	121°43.83'	Sandy Glacier volcano, Qsg	Andesite	Whole rock	(1.08)				1.27±0.02	Keith and others (1985)
							1.08	0.1769	7.8	1.14±0.05		
							1.08	0.1944	10.9	1.25±0.05		
							1.07	0.2015	23.3	1.30±0.03		
								0.2046	18.7	1.32±0.05		
10	79RH1032	45°26.50'	121°43.30'	Blue Ridge, Qbr	Basaltic andesite	Whole rock	1.07				1.27±0.03	Keith and others (1985)
								0.1679	19.4	1.09±0.06		
								0.1750	16.0	1.14±0.06		
								0.2273	21.7	1.48±0.05		
11	79LP1109	45°25.30'	121°49.60'	West side of Lolo Pass, QTb	Basalt	Whole rock	0.81				1.37±0.10	Keith and others (1985)
								0.1517	6.2	1.30±0.13		
								0.1717	13.6	1.47±0.15		
12	79TF0004	45°23.95'	121°35.20'	Tamanawas Falls, Qha?	Andesite	Whole rock	1.54				1.80±0.04	Keith and others (1985)
								0.3730	6.4	1.68±0.06		
								0.4165	9.2	1.88±0.05		
13	79ZM0086	45°20.78'	121°51.17'	Horseshoe Ridge, Tbbu	Basaltic andesite	Whole rock	1.32				2.39±0.07	Keith and others (1985)
								0.4263	34.4	2.24±0.10		
								0.4891	36.1	2.57±0.11		
14	79ZZL1085	45°21.05'	121°48.85'	Horseshoe Ridge, Tbbu	Basaltic andesite	Whole rock	0.78				2.48±0.04	Keith and others (1985)
								0.2695	14.2	2.40±0.05		
								0.2874	27.0	2.56±0.07		
								0.3684	16.9	3.28±0.21		
15	S5-47	45°25.62'	121°55.54'	Thimble Mountain, Tbbu	Basalt	Whole rock	(1.619)				2.54±0.05	Sherrod and Pickthorn (1989); Gray and others (in press)
							1.612	0.5998	41.0	2.57±0.07		
							1.608	0.5860	46.6	2.51±0.07		
							1.633					
							1.624					

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
16	79SWC0010A	45°23.72'	121°33.55'	East Fork Hood River (escarpment), Tlma	Andesite	Whole rock	1.69	0.6668	44.3		2.74±0.03	Keith and others (1985)
17	70	45°20.5'	121°31.6'	West end of Lookout Mountain, Tlma	Andesite	Whole rock	2.13	0.95			3.1±0.2	Wise (1969); Fiebelkorn and others (1983)
18	97	45°23.0'	121°43.9'	Sandy Glacier volcano, Qsg	Andesite	Whole rock	1.62	0.775			3.2±0.3	Wise (1969); Fiebelkorn and others (1983)
19	49	45°18.9'	121°32.6'	Gunsight Butte, Trbg	Andesite	Whole rock	1.53	0.925			4.1±0.6	Wise (1969); Fiebelkorn and others (1983)
20	79IC2039A	45°17.22'	121°38.50'	Upper White River canyon, dike cutting unit Trbg	Diorite	Plagioclase	0.51	0.3869	5.9		5.26±0.44	Keith and others (1985)
21	82MH1	45°25.50'	121°43.20'	Vista Ridge, Qbr	Basaltic andesite	Whole rock	0.55	0.4314	5.5		5.44±0.19[2]	Keith and others (1985)
22	72	45°21.03'	121°50.97'	Horseshoe Ridge, Tbbu	Basaltic andesite	Whole rock	1.45	1.175			5.5±0.7	Wise (1969); Fiebelkorn and others (1983)
23	33	45°25.64'	121°48.16'	Lolo Pass, Taop	Andesite	Whole rock	1.20	1.025			5.8±0.8	Wise (1969); Fiebelkorn and others (1983)
24	79ZZL1089	45°21.05'	121°49.20'	Horseshoe Ridge, Tbbu	Basaltic andesite	Whole rock	0.26				6.23±0.23	Keith and others (1985)
								0.2315	14.2	6.17±0.29		
								0.2376	9.7	6.34±0.39		
25	79LP1108	45°25.13'	121°49.77'	Lolo Pass, Taop	Andesite	Whole rock	1.22				6.25±0.11	Keith and others (1985)
								1.072	42.0	6.09±0.22		
								1.108	53.2	6.30±0.12		
26	40	45°25.4'	121°34.0'	Above Polallie campground, Taef	Andesite	Whole rock	1.33	1.35			7.0±0.8	Wise (1969); Fiebelkorn and others (1983)
27	Hornblende	45°22.5'[3]	121°50.8'[3]	Zigzag Mountain area, Trh	Andesite clast	Hornblende	0.35	0.350			7±2[3]	Wise (1969); Fiebelkorn and others (1983)
28	79EF0016A	45°26.52'	121°34.47'	East Fork Hood River, Taef	Andesite	Whole rock	1.3	1.535	66.2		8.18±0.06	Keith and others (1985)
--	Ito 509	Roadcut on U.S. Hwy 26		West of Govt. Camp, Tilh	Quartz diorite	Hornblende	0.29	0.3379	11.3		8.1±0.6	Bikerman (1970); Fiebelkorn and others (1983)

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
--	Ito 512	Roadcut on U.S. Hwy 26		West of Govt. Camp, Tilh	Quartz diorite	Hornblende	0.31	0.3885	13.6		8.6±0.6	Bikerman (1970); Fiebelkorn and others (1983)
29	79LH1058A	45°18.35'	121°48.87'	Laurel Hill, Tilh	Quartz diorite	Whole rock	0.67				8.66±0.11	Keith and others (1985)
								0.8316	27.3	8.60±0.14		
								0.8458	27.0	8.75±0.18		
30	80CF0022A	45°24.03'	121°49.55'	Last Chance Mountain, Tazm	Andesite	Whole rock	0.90				9.04±0.04	Keith and others (1985)
								0.9961	47.6	7.67±0.10		
								1.128	43.5	8.69±0.09		
								1.255	48.5	9.66±0.07		
								1.256	67.8	9.67±0.11		
31	OMF-7A-3750/ UT-224	45°23.74'	121°48.42'	Old Maid Flat, Tilh (3,750-ft depth in OMF-7A)	Quartz diorite	Hornblende	0.230	0.309	15[4]		9.30±0.87	Evans and Brown (1981); Priest and others (1982)
32	MH-19/AH-47	45°23.74'	121°49.56'	Last Chance Mountain, lava flow in unit Trh	Andesite	Whole rock	0.945	1.300	5[4]		9.5±2.4	Evans and Brown (1981); Priest and others (1982)
33	81MH14	45°20.66'	121°54.32'	W. end Zigzag Mtn lava flow in unit Trh (type section)	Andesite	Whole rock	0.95				10.58±0.08	Keith and others (1985)
								1.449	55.8	10.56±0.12		
								1.152	60.3	10.59±0.11		
34	MH-10/UT-227	45°23.81'	121°48.70'	Last Chance Mountain, lava flow in unit Trh	Basaltic andesite	Whole rock	0.956	1.469	36[4]		10.6±0.5	Evans and Brown (1981); Priest and others (1982)
35a	LCM/AH-48	45°23.84'	121°49.87'	Last Chance Mountain, Tazm	Andesite	Whole rock	0.965	1.460	48[4]		10.5±0.4	Evans and Brown (1981); Priest and others (1982)
35b	LCM/UT-240	45°23.84'	121°49.87'	Last Chance Mountain, Tazm	Andesite	Whole rock	0.965	1.495	32[4]		10.7±0.5	Evans and Brown (1981); Priest and others (1982)
36	81MH21	45°23.03'	121°52.50'	Lolo Pass road, lava flow in unit Trh	Andesite	Whole rock	0.98				11.26±0.08	Keith and others (1985)
								1.581	66.8	11.17±0.12		
								1.605	53.6	11.34±0.12		
37	42	45°16.19'	121°47.55'	Still Creek phase of Laurel Hill intrusion, Tilh	Quartz diorite	Whole rock	2.14	3.65			11.6±1.2	Wise (1969); Fiebelkorn and others (1983)

Footnotes at end of tabular data

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
38	MH-20/UT-228	45°23.70'	121°49.54'	Last Chance Mountain, lava flow in unit Trh	Dacite	Whole rock	2.28	3.983	10^4		12.1±1.7	Evans and Brown (1981); Priest and others (1982)
Ages for southwestern part of map area												
39	GWW-2-85	45°01.73'	121°52.57'	NW of Peavine Mtn, QTb	Andesite	Whole rock	0.916	0.20298	25		1.54±0.07	R.A. Duncan, in Sherrod and Conrey (1988)
40	S88-22	45°19.65'	121°55.90'	Hunchback Mountain, Tbbu	Basalt	Whole rock	(0.715)				2.62±0.06	Gray and others (in press)
							0.723	0.2671	22.8	2.59±0.08		
							0.716	0.2722	18.2	2.64±0.08		
							0.712					
							0.708					
41	S5-26	45°09.44'	121°56.39'	Near Frazier Forks, Tbao	Basaltic andesite	Whole rock	(0.848)				2.78±0.06	L.B. Gray, in Sherrod and Conrey (1988); Gray and others (in press)
							0.843	0.3468	32.8	2.84±0.08		
							0.843	0.3324	19.0	2.72±0.08		
							0.846					
							0.858					
42	GWW-1-85	45°03.95'	121°57.42'	Kink Creek quarry, Tbao	Basaltic andesite	Whole rock	1.012	4.2637	11		2.92±0.13	R.A. Duncan, in Sherrod and Conrey (1988)
43	S88-26	45°01.60'	121°57.46'	Clackamas River, Tma	Andesite	Plagioclase	(0.249)				11.5±0.2	Gray and others (in press)
							0.250	0.409	25.1	11.4±0.34		
							0.251	0.421	32.6	11.7±0.35		
							0.251					
							0.244					
Ages for northeastern part of map area												
44	JA85023	45°29.52'	121°16.98'	Fivemile Creek canyon[5]	Basaltic andesite	Whole rock	1.078	0.265			1.7±0.4	Anderson (1987)
45	S88-25	45°20.45'	121°27.45'	Cold Point, Taft	Andesite	Plagioclase	(0.991)				2.86±0.06	Gray and others (in press)
							0.984	0.4176	77.7	2.93±0.07		
							0.986	0.3920	60.7	2.75±0.07		
							0.996	0.4122	38.7	2.89±0.07		
							0.996					

Footnotes at end of tabular data

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
46	JA85022	45°31.35' (east of map area)	121°19.67'	South Fork Mill Creek, Qbmc?[6]	Dacite	Whole rock	3.043	1.620			3.7±0.2	Anderson (1987)
47	106-WB	45°14.7'	121°10.8'	Tygh Valley, Ttv	Tuff	Plagioclase	1.592	 1.048 1.260	 9.1[4] 16.0[4]	 4.6 5.5	5.0±0.5[7]	Bunker and others (1982); Bela (1982)
48	109-WB	45°20.5'	121°20.5'	West of Friend, Taj	Andesite	Whole rock	1.715	 1.280 1.328	 9.1[4] 6.3[4]	 5.2 5.4	5.3±0.5[7]	Bunker and others (1982); Bela (1982)
49	PH-MCB-1	45°27.00'	121°31.92'[8]	Mill Creek Buttes, Tdm	Dacite	Hornblende	0.271	0.1384	3.7		6.2±1.3	P.E. Hammond, in Fiebelkorn and others (1983)
50	101-WB	45°16.5'	121°15.6'	North of Happy Ridge, Tbah	Basaltic andesite	--[9]	--[9]	--[9]	--[9]	--[9]	7.6±0.8[10]	Farooqui and others (1981b); Bela (1982)
51	S88-23	45°24.39'	121°27.78'	Fivemile Butte, Tafv	Dacite	Plagioclase	(0.224) 0.221 0.220 0.226 0.229	 0.2525 0.2459	 28.5 33.7	 7.81±0.24 7.61±0.23	7.71±0.17	Gray and others (in press)
52	S88-24	45°23.26'	121°20.05'	Fifteenmile Creek, Td	Dacite (lahar clast)	Plagioclase	(0.250) 0.249 0.249 0.255 0.248	 0.2780 0.2797	 34.6 28.1	 7.70±0.23 7.75±0.23	7.73±0.16	Gray and others (in press)
53	103-WB	45°24.0'[11]	121°25.5'[11]	Eightmile Crossing, Tafv	Andesite	Whole rock	1.028	 1.435 .995	 13.4[4] 23.5[4]	 9.7 6.7	8.2±0.8[7, 11]	Bunker and others (1982); Bela (1982)
54	14th flow[12]	45°17.4'	121°10.8'	Butler Canyon (Tygh Ridge anticline), Tcgn2	Basalt	Whole rock	1.84	(3.990) 3.972 4.007	(67.9) 66.0 69.8	 14.9 15.0	15.0±0.3	Watkins and Baksi (1974)

Footnotes at end of tabular data

Map No.	Sample no.	Location: Latitude (N)	Location: Longitude (W)	General geographic locale and map unit	Rock type	Material dated	K_2O (wt percent)	$^{40}Ar_{rad}$ (10^{-11} moles/g)	Percent $^{40}Ar_{rad}$	Calculated age (Ma)	Assigned age (Ma)	Reference
55	18th flow[12]	45°16.4'	121°11.3'	Butler Canyon (Tygh Ridge anticline), $Tcgr_2$	Basalt	Whole rock	1.89	(4.596)[13] 4.596 4.596 5.176	(82.8)[13] 80.5 85.0 34.1	 16.8 16.8 18.9	16.8±0.3	Watkins and Baksi (1974)
Ages for southeastern part of map area												
56	S5-44	45°09.43'	121°39.15'	U.S. Highway 26, Qaw	Andesite	Whole rock	(1.427) 1.417 1.439 1.419 1.433	 0.2741 0.2905	 30.7 51.2	 1.33±0.04 1.41±0.04	1.37±0.04	Gray and others (in press)
57	GWW-16-85	44°58.3' (south of map area)	121°34.9'	Schoolie Pasture, QTb	Basalt	Whole rock					1.44±0.09	E.P. Verplanck and R.A. Duncan, unpub. data
58	S5-13	44°52.3' (southeast of map area)	121°25.1'	Mill Creek bridge, Tb	Basalt	Whole rock					3.21±0.14	E.P. Verplanck and R.A. Duncan, unpub. data
59	S5-28	45°03.91'	121°27.90'	Mutton Mountains, interbedded in unit Tomb	Rhyolitic ash-flow tuff	Soda-sanidine	(7.08) 7.14 7.15 7.02 7.02	 30.11	 82.8		29.3±0.6	Gray and others (in press)

[1](No. 3) Originally described as dike cutting Sandy Glacier volcano (Keith and others (1985)), but our work indicates it is an oddly jointed andesite lava flow that cooled against a steep paleocanyon wall.

[2](No. 21) Age impossibly old from field relations.

3(No. 27) Latitude and longitude from Fiebelkorn and others (1983), which places the sample in Cast Creek drainage. In contrast, original location data place this sample no more precisely than "breccia bed in Lost Creek" (Wise (1969), footnote to table 2). We use the Cast Creek site but, regardless, age is too young.

[4](Nos. 31, 32, 34, 35a, 35b, 38, 47, 48, 53) An earlier compilation (Fiebelkorn and others (1983)) incorrectly listed the percent of atmospheric argon as percent radiogenic argon.

[5](No. 44) Stratigraphic unit uncertain. Age discussed further in Description of Map Units for andesite of Fivemile Butte (unit Tafv)

[6](No. 46) See Description of Map Units for discussion of this sample's age and stratigraphic assignment.

[7](Nos. 47, 48, 53) Age is arithmetic mean and, as calculated here, is slightly older (0.2 m..y.) than that reported by Bunker and others (1982).

[8](No. 49) Sample location corroborated by P. E. Hammond (written commun., 1986) and modified slightly from that reported by Fiebelkorn and others (1983).

[9](No. 50) Data never published.

[10](No. 50) Age too old. Unit overlies strata with K-Ar ages of 5.1±0.5 Ma and 4.9±0.5 Ma.

[11](No. 53) Sample is mislocated or age is too old. Location is in Pliocene or Pleistocene basalt but within 600 m of Miocene andesite.

[12](Nos. 54, 55) On geologic map, sample location is plotted to match geology. Published sample location map (Watkins and Baksi (1974), their fig. 10) is at very small scale and unsuitable for precisely locating the samples.

[13](No. 54) Value in parentheses is average from two extractions. The 18.9-Ma age for No. 54 apparently was discarded by Watkins and Baksi (1974).