STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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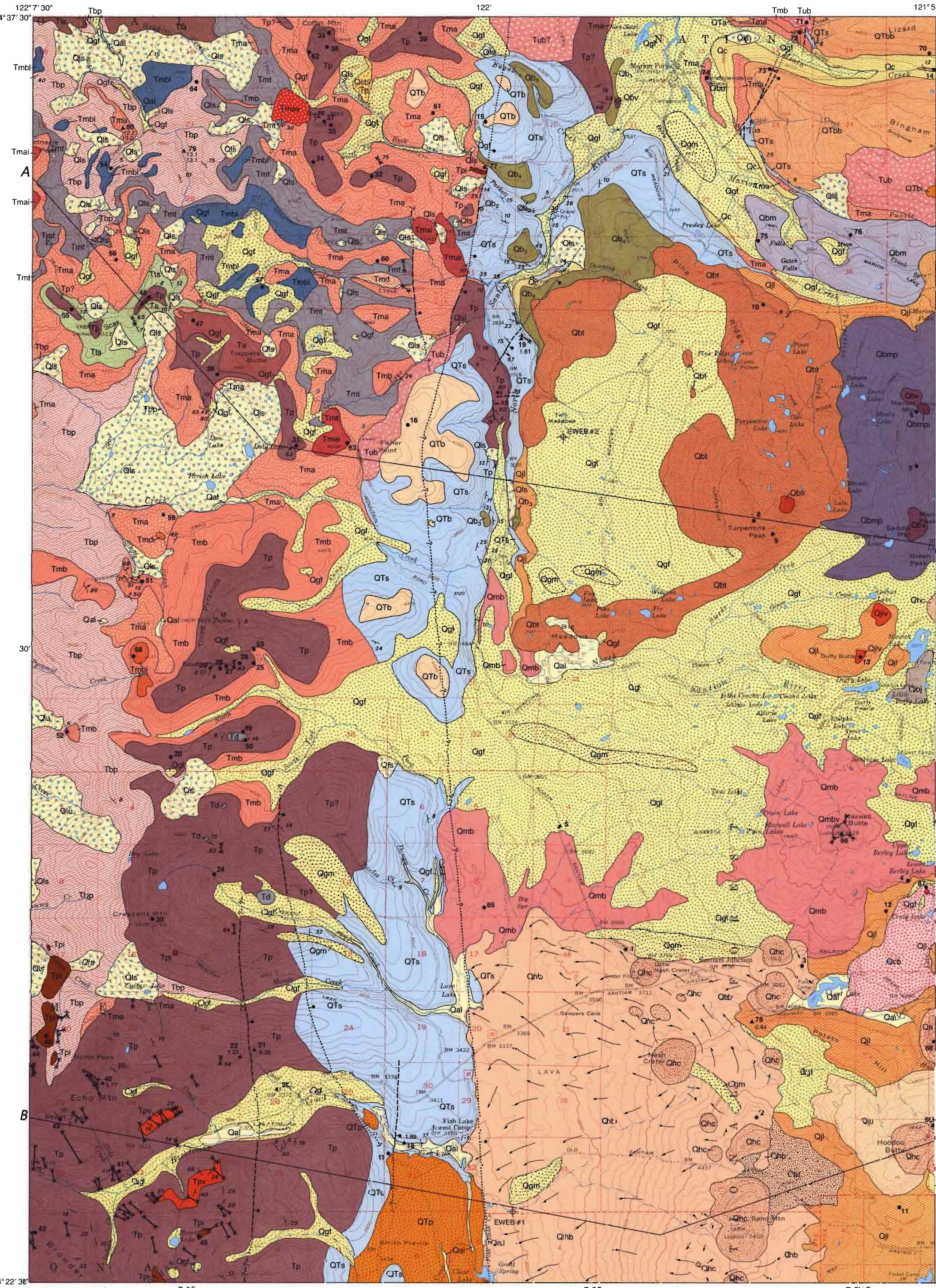
GEOLOGIC MAP OF THE CRESCENT MOUNTAIN AREA, LINN COUNTY, OREGON

1987

GMS-47
Geologic Map of the Crescent Mountain Area, Linn County, Oregon
By G.L. Black and others

Funded by U.S. Department of Energy Grant No. DE-FG07-84 ID 12526



Base map by U.S. Geological Survey — from portions of Detroit, Mt. Jefferson, Echo Mountain, and Three Fingered Jack 15' quadrangles.
Polyconic projection. 1927 North American datum.
Dashed land lines indicate approximate locations.

SCALE 1:62500

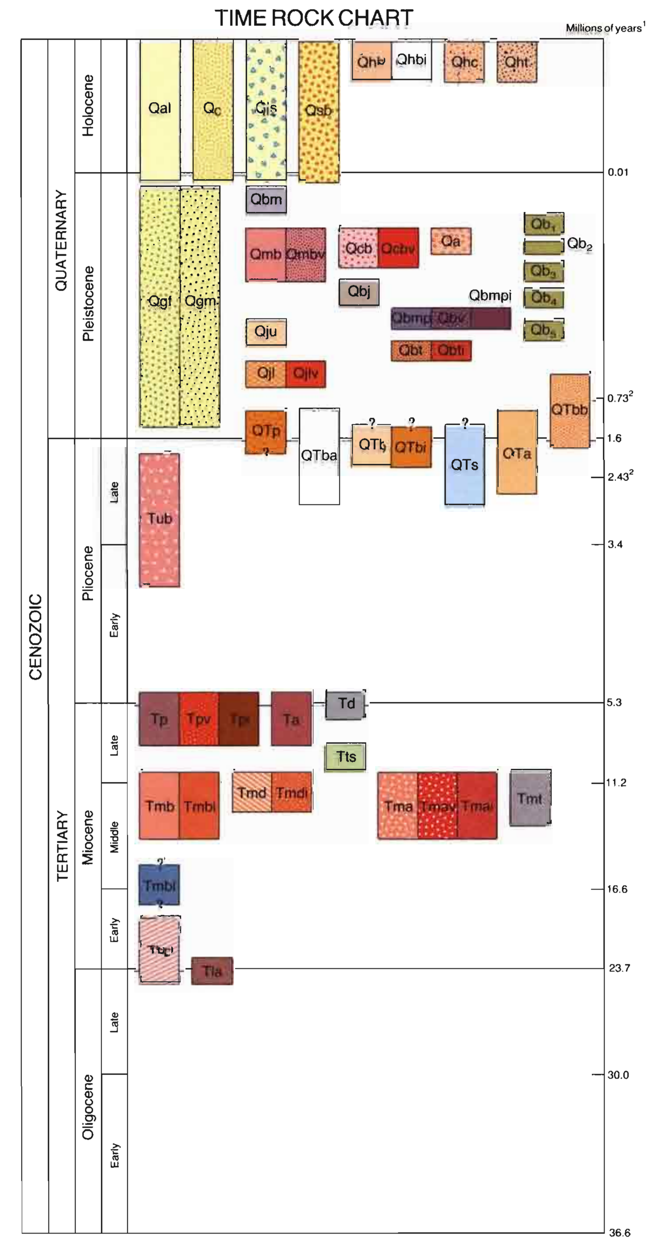
CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL

Geology by Gerald L. Black, Neil M. Woller, and Mark L. Ferns, Oregon Department of Geology and Mineral Industries

Field work conducted 1984-1985

Cartography by Mark E. Neuhaus

TIME ROCK CHART



¹Dates taken from Palmer (1983)
²Time boundaries of most recent magnetic reversal

MAP SYMBOLS

Contact — Approximately located

Strike and dip of beds

Fault — Dashed where inferred; dotted where concealed; queried where doubtful; bar and ball on downthrown side; arrow indicates dip

Strike and dip of shear zone — Arrow indicates dip

Dike

Flow direction in Holocene basalt lava flows

Sample point for whole-rock analysis — Raw data are listed in Table 1

Sample point for K-Ar date — Date(s) given next to the point in millions of years. Data are listed with references in Table 2 and discussed in the explanation

Temperature gradient hole — Only holes with publicly available temperature data are shown. All data are published in Department Open-File reports

Tables 1 and 2 are printed on a separate sheet accompanying this map.

MINERALIZATION

Samples from several alteration zones were analyzed for a broad spectrum of ore metals. Only one sample had a metal content above background levels. The sample came from a borrow pit on USFS Road 10, T. 11 S., R. 6 E., 17Bbb, where there is an approximately 500-ft zone of intense hydrothermal alteration. At the north end of the exposure are silicified zones containing pyrite; propylitic alteration occurs at the south end. One sample (SJ-53) was analyzed. It contained 7 parts per million (ppm) Cu, 8 ppm Pb, 60 ppm Zn, <1 ppm Mo, 1.2 ppm Ag, and 50 parts per billion (ppb) Au. The analyses were performed by Chemex Labs, Ltd., North Vancouver, B.C., utilizing a semiquantitative multielement ICP analysis.

ANALYTICAL PROCEDURES

Approximately 55 whole-rock chemical analyses were utilized in the study to help define and characterize stratigraphic units and to search for economic minerals. The data were generated by atomic absorption spectrophotometry, Christine McBirney, analyst, University of Oregon, and by semiquantitative multielement ICP analysis at Chemex Labs, Ltd. Multiple splits of samples and previously analyzed samples were submitted to aid in quality control.

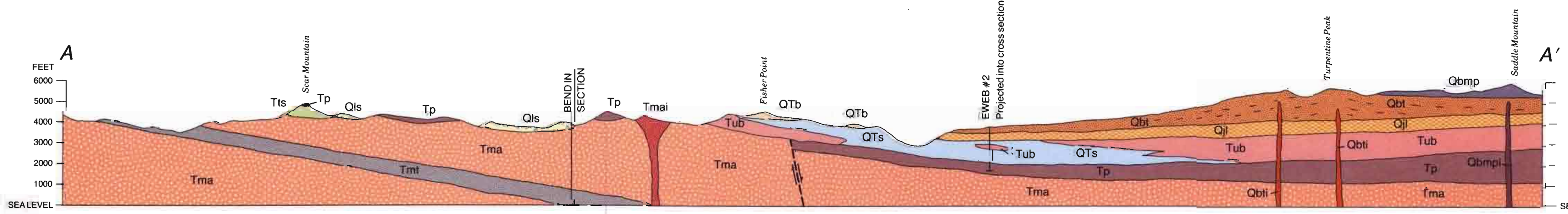
K-Ar data were generated by Robert Duncan, Oregon State University, Corvallis, Oregon, and Paul Damon, University of Arizona, Tucson, Arizona, utilizing standard methods. ^{40}Ar-^{39}Ar data were generated by Daniel Lux, University of Maine, Orono, Maine, utilizing standard methods. In some cases where the radiometric dates were obviously in error (e.g., an older date stratigraphically above a younger date), the samples were rerun. In most cases, the dates were exactly the same in the second run, suggesting that the errors were not in the analysis but were in the assumption that the isotopic systems had been closed to K and/or Ar exchange.

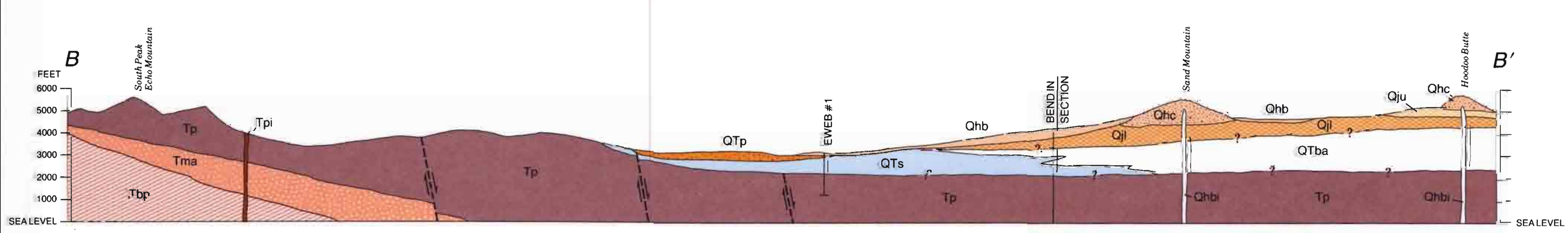
ACKNOWLEDGMENTS

The map was reviewed by Norman S. MacLeod and David R. Sherrod of the U.S. Geological Survey, Edward M. Taylor of Oregon State University, and Paul E. Hammond of Portland State University. Their comments and suggestions added greatly to the quality of the map. Britt Von Thaden, Rebecca A. Heisler, John Doerr, and Eileen L. Webb assisted in compilation and collection of the field and laboratory data. Gary Baxter supervised quality control on chemical data. The United States Department of Energy (USDOE) provided support for the analytical work and field work.

GEOLOGIC CROSS SECTIONS

Units of Qal, Qgf, and Qht not shown





EXPLANATION

SURFICIAL UNITS

Qal — **Alluvium (upper Pleistocene and Holocene)** — Fluvial sand and gravel

Qc — **Colluvium (upper Pleistocene and Holocene)** — Unconsolidated talus and slope wash

Qls — **Landslide deposits (upper Pleistocene and Holocene)**

Qsb — **Slide block (upper Pleistocene and Holocene)**

Qgf, Qgm — **Glaciofluvial deposits (Pleistocene)** — Unit **Qgf** consists of outwash deposits. Unit **Qgm** consists of lateral and terminal moraines

VOLCANIC UNITS

Upper Pliocene, Pleistocene, and Holocene volcanic and volcaniclastic rocks

Rocks of varied composition that form benches, plateaus, or intracanyon fillings in present stream valleys. Subophitic to ophitic textures are common in basalt of the sequence; some basalt is diktytaxitic. The youngest rocks in the sequence include Holocene basalt and basaltic andesite flows and cinder cones in the vicinity of Santiam Junction. The oldest flow in the sequence is not dated, but it predates 1.89 Ma, the date of a flow interbedded in unit **QTs** at Fish Lake. North of the map area, the date of the oldest flow in the unit is between 4.2 and 3.7 Ma (based on dates of underlying and overlying units; see Priest and others, 1987). The rocks are equivalent to the volcanic rocks of the late High Cascades episode of Priest and others (1983) and the informally named volcanic rocks of the High Cascade Range of Peck and others (1964)

Qhb — **Olivine basalt and basaltic andesite (Holocene)** — Very fresh, dark-gray, vesicular olivine basalt and basaltic andesite erupted from the Sand Mountain chain of cinder cones. A lava flow erupted from the south end of the chain dammed the headwaters of the McKenzie River and formed Clear Lake. Radiocarbon dates from submerged trees in the lake are 2,705 ± 200 and 3,200 ± 220 ^{14}C years B.P. (Benson, 1965). Fish Lake formed similarly; a radiocarbon date of 3,850 ± 215 ^{14}C years B.P. was obtained on a charred root collected from beneath the flow that caused the formation of the lake (Taylor, 1967). Flow directions in unit **Qhb** were taken from Taylor (1967, 1981). Unit is equivalent to portions of the Sand Mountain lava field of Taylor (1968), the Sand Mountain lava field of Avramenko (1981), and Holocene basalts of Davie (1980)

Qhc — **Cinder cone deposits (Holocene)** — Basaltic lapilli and ash forming cinder cones

Qht — **Tephra (Holocene)** — Unconsolidated gray or red basaltic lapilli with lesser ash. Unit mantles much of the topography east of the Sand Mountain chain but was mapped as a separate unit only where underlying rocks are completely obscured

Qbm — **Lava of Marion Creek (Pleistocene)** — Very fresh, light- to medium-gray olivine basalt. Groundmass textures are ophitic, pilotaxitic, intergranular, and diktytaxitic. All flows, which are holocrystalline, fine to medium grained, and normally polarized, were erupted east of the map area and flowed into the Marion Creek drainage. Unit was mapped by Rollins (1976) as Pigeon Prairie lavas and by Davie (1980) as basalt of Jorn Lake

Qmb — **Basaltic andesite of Maxwell Butte (Pleistocene)** — Light- to medium-gray, compact to slightly diktytaxitic basaltic andesite containing microphenocrysts of olivine, hypersthene, and plagioclase, commonly as very tiny glomerocrysts. Unit **Qmb**, which forms a large shield volcano with the vent (unit **Qmbv**) at Maxwell Butte, has not been dated, but most flows have been glaciated. The flows are normally polarized and were mapped by Davie (1980) as the porphyritic basaltic andesites of Maxwell Butte. Unit **Qmb** includes the west Maxwell Butte and Park Creek lava flows of Taylor (1967), which, although compositionally identical to the basaltic andesite of Maxwell Butte, have not been glaciated. The flow features of these lavas are youthful in appearance because of this lack of glaciation (Taylor, 1967)

Qcb — **Basaltic andesite of Craig Butte (Pleistocene)** — Fresh, light-gray, diktytaxitic olivine and augite-bearing basaltic andesite. Unit forms glaciated highland of approximately 3 km² southeast of Maxwell Butte. The vent (unit **Qcbv**) is located at Craig Butte. Unit **Qcb** is normally polarized and was mapped by Davie (1980) as the porphyritic basaltic andesite of Craig Butte

Qa — **Andesite (Pleistocene)** — Light-gray, compact, nearly aphyric, very thick lava flows or domes at Hogg Rock and Hayrick Butte (southeast corner of the map). Both are flat-topped buttes interpreted by Taylor (1981) as andesite domes. Davie (1980) noted that rocks of unit **Qa** at Hayrick Butte and Hogg Rock possess glassy margins 1 to 6 m thick that perhaps formed during intraglacial eruptions

Qb₁–Qb₆ — **Basalt and basaltic andesite (Pleistocene)** — Light-gray, sparsely olivine-phyric, generally compact (unit Qb_1 is diktytaxitic), normally polarized basalt and basaltic andesite. Unit forms intracanyon benches representing inverted topography along the North Santiam River. Unit Qb_1 is the youngest and occurs at the lowest elevation; units Qb_{2-6} are successively older and occur at progressively higher elevations. Rocks from this unit were mapped by Hammond and others (1980, 1982) as parts of several different units in their High Cascades group

Qtfj — **Basaltic andesite of Three-Fingered Jack (Pleistocene)** — Light- to medium-gray, glomeroporphyritic olivine basaltic andesite containing microphenocrysts of olivine, augite, and plagioclase. Individual flows are massive, poorly jointed, and normally polarized. Outcropping of unit on map is limited to one small patch south of Marion Peak. Unit was mapped by Davie (1980) as basaltic andesite of Three-Fingered Jack

Basalt and basaltic andesite of Jorn Lake (Pleistocene) — Olivine basalt and basaltic andesite. Jorn Lake basalt is distinguished from overlying lavas by its well-developed glomeroporphyritic textures and its more coarsely crystalline nature. (Although glomerocrysts also occur in the overlying lavas, they are not as abundant or as large.) Unit was mapped by Davie (1980) as porphyritic basalt and basaltic andesites of Jorn Lake, which lies just east of the map area. On this map, unit is divided into two informal members

Qju — **Upper Jorn Lake member** — Light- to medium-gray, compact olivine basaltic andesite containing sparse microphenocrysts of olivine and plagioclase. Unit occurs as normally polarized lava flows and breccias in the vicinity of Hoodoo Butte. Date of unit **Qju** is unknown, but the lava flows have been glaciated

Qjl — **Lower Jorn Lake member** — Light- to medium-gray, holocrystalline glomeroporphyritic olivine basalt containing 1-5 percent 2-6 mm in diameter glomerocrysts of olivine and plagioclase. Unit is normally polarized. Lava flows mapped as unit **Qjl** on Potato Hill are olivine basaltic andesite. A flow on the western end of Potato Hill has been dated at 0.44 ± 0.12 Ma (Armstrong and others, 1975; recalculated in Fiebelkorn and others, 1983). Unit is overlain by basaltic andesite of Maxwell Butte (unit **Qmb**), basaltic andesite of Craig Butte (unit **Qcb**), and basaltic andesite of unit **Qju**

Qbmp — **Lava of Marion Peak (Pleistocene)** — Plagioclase-phyric olivine basaltic andesite containing 1- to 3-mm-long plagioclase phenocrysts and microphenocrysts of fresh to iddingsitized olivine in an intergranular groundmass. All flows are fresh with blocky jointing and were erupted from vents at Saddle Mountain and Marion Mountain. On the west, Marion Peak lava flows abut the older eroded volcanic edifice of Turpentine Peak. Flows are normally polarized and were mapped by Davie (1980) as porphyritic basaltic andesite of the Marion Peak complex

Qbt — **Lava of Turpentine Peak (upper Pleistocene)** — Olivine basaltic andesite containing microphenocrysts of olivine and augite and 1- to 3-mm-long plagioclase phenocrysts. Individual flows are blocky jointed. The deeply eroded vent is marked by an intrusive plug (unit **Qbti**) located northeast of Turpentine Peak. Unit was mapped by Davie (1980) as basaltic andesite of Turpentine Peak

QTp — **Basalt of Smith Prairie (upper Pliocene? and Pleistocene)** — Medium- to dark-gray vesicular olivine basalt and basaltic andesite. Unit is approximately 300 m thick along the McKenzie River south of the map area (Avramenko, 1981). Flows of this unit were erupted from a series of north-trending fissures and central vents located along the Cascade crest (unit **QTs**). A few flows are exposed in the map area (Avramenko, 1981). These rocks are reversely polarized and form a bench south of Fish Lake, where they overlie Parkette Creek sedimentary rocks (unit **QTs**). A lava flow intercalated in the Parkette Creek sedimentary rocks at Fish Lake was dated at 1.89 Ma (Table 1). Two dates from lava flows in the upper part of the sequence just south of the map area are 1.1 ± 0.2 Ma and 1.6 ± 0.3 Ma (Armstrong and others, 1975; recalculated in Fiebelkorn and others, 1983). Unit was mapped by Avramenko (1981) as plateau lavas

QTba — **Reversely polarized basalt and basaltic andesite (upper Pliocene and lower Pleistocene)** — Shown only in cross section

QTb — **Olivine basalt (upper Pliocene and Pleistocene)** — Forms relatively flat-topped hills capping Parkette Creek sedimentary rocks (unit **QTs**). The lava flows south and east of Fisher Point are very distinctive porphyritic olivine basalt containing 7-8 percent olivine phenocrysts 2-3 mm in diameter. All flows are reversely polarized but are very fresh in appearance. A lava flow intercalated in the lower part of the underlying Parkette Creek sedimentary rocks was dated at 1.81 ± 0.06 Ma. Unit **QTb** was mapped by Rollins (1976) as part of the Nan Creek volcanics and by Hammond and others (1980, 1982) as older basalt and basaltic andesite (their unit QTb)

QTs — **Parkette Creek sedimentary rocks (upper Pliocene and Pleistocene?)** — Diatomite, claystone, siltstone, sandstone, and pebble conglomerate; includes interbedded lava flows and lahars, which are more abundant higher in the section. Unit is named for exposures along Parkette Creek and Parkette Creek Road (USFS Road 1168). The sedimentary rocks of this unit crop out in a relatively narrow north-trending band as far south as Carmen Reservoir (south of the map area), where Avramenko (1981) described sedimentary rocks in the cliffs adjacent to the reservoir that probably correlate with the formation. Unit thickness is at least 450 m in the vicinity of Parkette Creek, but total thickness is uncertain because the base is not exposed. Two lava flows interbedded with the sedimentary rocks were dated by K-Ar methods. One sample from a flow relatively low in the section on the Camp Pioneer Road (USFS Road 2261) gave a date of 1.81 ± 0.06 Ma. The second, collected near the shore of Fish Lake, gave a date of 1.89 ± 0.10 Ma. Diatoms indicate an equivocal Pliocene or perhaps early Pleistocene date for the deposits (J.P. Bradbury, personal communication, 1985). Rollins (1976) included the sedimentary rocks in his Nan Creek volcanics. Hammond and others (1980, 1982) tentatively included them with their basalt of Outerson Mountain

QTa — **Andesite and basaltic andesite (upper Pliocene and Pleistocene)** — Fresh lava flows of porphyritic two-pyroxene andesite and basaltic andesite that form intracanyon benches representing inverted topography on the sides of modern stream valleys. Maximum thickness is about 430 m on Woodpecker Ridge (north of the map area), where a lava flow in the lower part of the section has a K-Ar date of 3.7 ± 0.1 Ma (Sutter, 1978; recalculated in Fiebelkorn and others, 1983). An andesitic lava flow in the Sentinel Hills (northeast of the map boundary), considered by Priest and others (1987) to be in the uppermost part of the sequence, was dated at 0.59 ± 0.14 Ma (Priest and others, 1987). Unit was mapped by Hammond and others (1980, 1982) as the basalt of Minto Mountain (their unit QTbm) or younger basalt and basaltic andesite (their unit Qb)

QTbb — **Lava of Bingham Ridge (upper Pliocene and lower Pleistocene)** — Olivine-augite basaltic andesite, olivine basaltic andesite, and augite andesite. Hypersthene is a common but minor phenocryst. Lava flows are fresh and compact with intergranular to intersertal textures. These lavas were erupted from vents in the High Cascades and flowed westward in canyons cut into pre-Pleistocene rocks. Total thickness of the unit, which includes normal and reversely polarized rocks, is about 300 m north of the map area near Minto Mountain. Lava flows in the lower part of this unit interfinger with the upper part of the Parkette Creek sedimentary rocks (unit **QTs**), dated at about 1.8 Ma. A lava flow from near the top of this unit at Grizzly Peak (northeast of the map area) yielded a K-Ar date of 0.681 ± 0.034 Ma (Priest and others, 1987). Unit was mapped by Hammond and others (1980, 1982) as basalt of Minto Mountain (their unit QTbm)

Tub — **Basalt and basaltic andesite (upper Pliocene)** — Olivine basalt and pyroxene-olivine basaltic andesite lava flows. Unit consists of mostly fresh, compact lavas. Olivine is fresh to iddingsitized; the groundmass is holocrystalline. The rocks commonly contain 2-4 mm in diameter glomeroporphyritic clusters of 0.1- to 0.5-mm olivine and plagioclase crystals. K-Ar dates near the bottom of the unit north of the map area are 3.06 ± 0.05 Ma (Minto Mountain) and 2.7 ± 0.1 Ma (Priest and others, 1987) (southeast end of the ridge adjoining Mount Bruno). Mapped by Hammond and others (1980, 1982) as the basalt of Minto Mountain (their unit QTbm)

Upper Miocene and lower Pliocene volcanic and volcaniclastic rocks

Basaltic lava flows (unit **Tp**) with minor sedimentary rocks, andesite (unit **Ta**), and dacite (unit **Td**), which unconformably overlie the middle and upper Miocene rocks. The relief on the unconformity increases from about 150 m to more than 370 m from the oldest to the youngest part of the section. Unlike the upper Pliocene and Quaternary volcanic rocks, which form obvious benches in present stream valleys, these lavas crop out on the highest peaks of the Western Cascades. This geomorphic feature and isotopic dates were used to separate these rocks from the younger upper Pliocene and Quaternary rocks. Lithologically and chemically, the rocks of this sequence are similar to many of the younger and older volcanic rocks. The older middle and upper Miocene rocks are, however, typically more altered, with the alteration of olivine and less commonly orthopyroxene to green phyllosilicates. The upper Miocene and lower Pliocene lavas, however, generally have a fresher, lighter color than the older lavas, and the unit contains more basalt with ophitic and subophitic textures. The date of the base of the sequence is unknown but is earlier than about 6.35 Ma and later than about 10 Ma; the date of the top of the sequence is about 4.2 Ma. These rocks are equivalent to the volcanic rocks of the early High Cascade episode of Priest and others (1983) and the volcanic rocks of the High Cascade Range of Peck and others (1964).

Tp — **Lava of the Three Pyramids (upper Miocene and lower Pliocene)** — Basalt and basaltic andesite lava flows that cap the highest peaks on the eastern margin of the Western Cascades, in most places at higher elevations than units **Tub**, **QTb**, or **QTa**. The base of the section is several hundred feet above the bases of units **Tub**, **QTb**, and **QTa** except where downfaulted on the east end of Lynx Creek). Unit includes lava flows, breccia, lahars, and palagonite tuff. Lithologically, the Three Pyramids lava is similar to basalt in unit **Tub** or unit **Tmb**, which makes it difficult to separate it from younger or older lava in some areas without isotopic dates. Basalt of unit **Tp** commonly has fresh or iddingsitized olivine phenocrysts and ophitic to subophitic textures and is rarely diktytaxitic. Basaltic andesite mapped as unit **Tp** in the vicinity of Echo Mountain is medium- to dark-gray, fine-grained compact olivine basaltic andesite. Olivine is usually the only phenocryst phase. Groundmass textures are typically intergranular to subophitic. Three Pyramids lava can be distinguished from older basalt and basaltic andesite in most places by its lack of alteration of ferromagnesian silicates or glass to green and greenish-yellow phyllosilicates and by the presence in some lavas of 2-4 mm in diameter glomeroporphyritic clusters of 0.1- to 0.5-mm olivine and plagioclase crystals, a texture that is lacking in basalt of unit **Tmb**. Glomeroporphyritic textures are also absent from basaltic andesite lava flows in the vicinity of Echo Mountain. Unit **Tp** reaches a maximum thickness of about 400 m at Three Pyramids and Crescent Mountain and 760 m at Echo Mountain. K-Ar dates from equivalent units outside the area range from about 9.5 to about 0.27 Ma (Sutter, 1978; Fiebelkorn and others, 1983; Priest and Woller, 1983), but there are many conflicts between the dates and stratigraphic position. A K-Ar date of 6.35 ± 0.15 Ma was obtained from a flow just north of the area near the top of the section exposed at Bachelor Mountain (Priest and others, 1987). K-Ar dates obtained for this study on unit **Tp** are 6.27 ± 0.16 Ma at the top of South Pyramid, 6.28 ± 0.15 Ma east of a fault in the southern part of the area near Hackleman Creek, 7.22 ± 0.17 Ma west of the same fault, and 5.77 ± 0.30 Ma from the top of North Peak on Echo Mountain. Numerous dikes (taken mostly from Avramenko, 1981) intrude the lava flows and palagonite tuffs in the vicinity of Echo Mountain, indicating that it represents a major volcanic center. Avramenko (1981) mapped rocks of this unit as his Iron Mountain formation (his unit Timf) and mapped lava flows of his Browder Bunchgrass formation (his unit Tbbf) overlying the compact basaltic andesites on Echo Mountain and the ridges to the south. He noted, however, that the contact was arbitrary because of the difficulty in distinguishing between basaltic units in the vicinity of Echo Mountain. The same problem was encountered in completing this map. As a result, all fine-grained compact olivine basaltic andesites in the vicinity of Echo Mountain were assigned to the Three Pyramids Formation. Unit was mapped by Hammond and others (1980, 1982) as older basalt and basaltic andesite (their unit QTb)

Ta — **Andesite (upper Miocene and lower Pliocene)** — Dark-gray, fine-grained aphyric platy andesites capping the ridges at Scar Mountain and Trappers Butte. The unit is only about 15 m thick at Scar Mountain but reaches a total thickness of 180 m at Trappers Butte east of Scar Mountain

Td — **Dacite (upper Miocene and lower Pliocene)** — Medium-bluish-gray, compact glomeroporphyritic two-pyroxene dacite forming areally restricted lava flows that cap the west-trending unnamed ridge south of the Three Pyramids and the north flank of Crescent Mountain. Other lava flows too small to map are interbedded with unit **Tp** on the north flank of Crescent Mountain. Maximum thickness is 120 m on the ridge south of South Pyramid

Middle and upper Miocene volcanic and volcaniclastic rocks

Basalt and basaltic andesite (unit **Tmb**), andesite (unit **Tma**), and dacite and rhyodacite (unit **Tmd**), with interbedded volcaniclastic sedimentary rocks (unit **Tts**) and ash-flow tuff (unit **Tmt**), which unconformably overlie the Breitenbush Tuff (unit **Tbp**) and associated lavas and are unconformably overlain by unit **Tp** and younger rocks. The sequence fills a paleotopographic surface with 200 to 400 m of relief. The rocks generally show some alteration with glass, olivine, and rarely orthopyroxene altered to green or yellow-green phyllosilicates. The lava is compact to vesicular, never diktytaxitic. Basalt in this group lacks the small glomeroporphyritic clusters of 0.1- to 0.5-mm olivine and plagioclase crystals that are common in younger basalt flows. Ophitic to subophitic textures are also much less common in this group than in younger basalt. Most of the lava flows are quartz normative with silica contents (analyses recalculated volatile-free) mostly in excess of 50 percent. The most mafic analyzed basalts from unit **Tp** and from younger units lack normative quartz and commonly have silica contents below 50 percent. The age is poorly constrained but is younger than about 18 Ma and older than about 6.35 Ma. The sequence is equivalent to the volcanic rocks of the late Western Cascade episode of Priest and others (1983). Many of the rocks were assigned by Peck and others (1964) to the Sardine Formation.

Tts — **Scar Mountain sedimentary rocks (upper Miocene)** — A sequence of indurated tuffaceous siltstone, sandstone, and pebble to cobble conglomerate. Sandstone is most commonly yellow-brown to gray volcanic wacke. Clasts are typically rounded and locally derived. Sedimentary structures are limited to poor- to well-developed bedding, poorly developed cross bedding, scour-and-fill, and imbrication. The unit is interpreted as composed of fluvial channel-fill deposits that overlie middle to upper Miocene andesites (unit **Tma**) and are in turn overlain by the basal flows of unit **Tp**. The unit is as thick as 180 m where exposed on Scar Mountain and the ridges to the immediate east and west

Tmb — **Basalt and basaltic andesite (middle and upper Miocene)** — Basaltic andesite volumetrically more abundant than basalt. Unit also includes a few, thin, two-pyroxene andesite interbeds and some locally thick sections of palagonite tuff and palagonite-rich laharic deposits. Plagioclase in basalt and basaltic andesite is commonly seriate. Unit **Tmb** reaches a maximum thickness of about 365 m at the Three Pyramids. Many K-Ar dates have been obtained from unit **Tmb** north of the map area, but the rocks have been affected to varying degrees by alteration and weathering, and most of the dates are considered to be unreliable (see Priest and others, 1987). A date of 11.5 ± 0.2 Ma obtained near the middle of the section at Devils Creek north of the study area (Sutter, 1978; recalculated in Fiebelkorn and others, 1983) is from a sample that is probably the least affected by alteration (see Priest and others, 1987). A slightly altered sample from the bottom of the section on the North Santiam River north of the area was dated by the ^{40}Ar-^{39}Ar method in order to obtain a crystallization date (D. Lux, personal communication, 1986). The attempt was not entirely successful. Dates ranging from 6.3 to 24.97 Ma were obtained during incremental heating with no obvious plateau. Dates from the first two increments of heating were 6.6 and 6.3 Ma, representing about 72.6 percent of the total ^{39}Ar released. These dates are similar to dates obtained on altered material in other parts of unit **Tmb**. Fairly consistent dates of about 10 Ma were obtained from the next two higher increments of heating, but these have high error estimates. The last increment yielded a date of 24.97 ± 1.78 Ma. This is clearly too old and may represent excess mantle argon trapped in the cores of phenocrysts. If a whole-rock K-Ar date had been done, it would have been about 8.56 Ma. The date of the base of the section is therefore not known but is younger than about 18 Ma, the approximate date of the top of unit **Tbp** and older than 11.5 Ma (Priest and others, 1987). Unit was mapped by Hammond and others (1980, 1982) mostly as the basalt of Outerson Mountain (their unit To)

Tma — **Andesite and dacite lavas (middle and upper Miocene)** — Porphyritic two-pyroxene andesite with minor dark-gray porphyritic vitrophyric dacite. Unit **Tma** reaches a maximum thickness of about 300 m at Coffin Mountain. K-Ar dates on this unit north of the area are 11.8 ± 0.4 and 11.2 ± 0.8 Ma (see Priest and others, 1987). Unit **Tma** was mapped by Hammond and others (1980, 1982) mostly as the basalt of Outerson Mountain (their unit To)

Tmd — **Dacite and rhyodacite (middle and upper Miocene)** — Banded, nearly aphyric vitrophyric dacite and rhyodacite in thick lava flows of limited areal extent. Unit **Tmd** occurs in one small patch on Straight Creek, where it reaches a maximum thickness of 80 m. Hammond and others (1980, 1982) tentatively included these rocks with their basalt of Outerson Mountain (their unit To)

Tmt — **Ash-flow and air-fall tuff (middle and upper Miocene)** — Lithic-rich, welded to nonwelded, gray ash-flow tuff interbedded with minor light-colored air-fall and lacustrine tuff. Unit forms low to moderate slopes and is responsible for most of the large landslides in the area. Unit **Tmt** reaches a maximum thickness of about 200 m in the central part of map. A K-Ar date of 10.4 ± 1.2 Ma (Hammond and others, 1980, 1982; recalculated in Fiebelkorn and others, 1983) was obtained on the uppermost ash-flow tuff interbedded in unit **Tmb** on Boulder Ridge (north of the area; see Priest and others, 1987). K-Ar dates of 12.3 ± 0.2 and 12.6 ± 0.2 Ma (Hammond and others, 1980, 1982; recalculated in Fiebelkorn and others, 1983) were obtained on the base of the unit south of Collawash Mountain (also north of the area). Basal rocks dated south of Collawash Mountain are, however, from an isolated outcrop that may not be representative of the base of the unit elsewhere (see Priest and others, 1987). The unit is everywhere younger than uppermost unit **Tbp**, which was fission-track dated at about 18 Ma (Hammond and others, 1980, 1982)

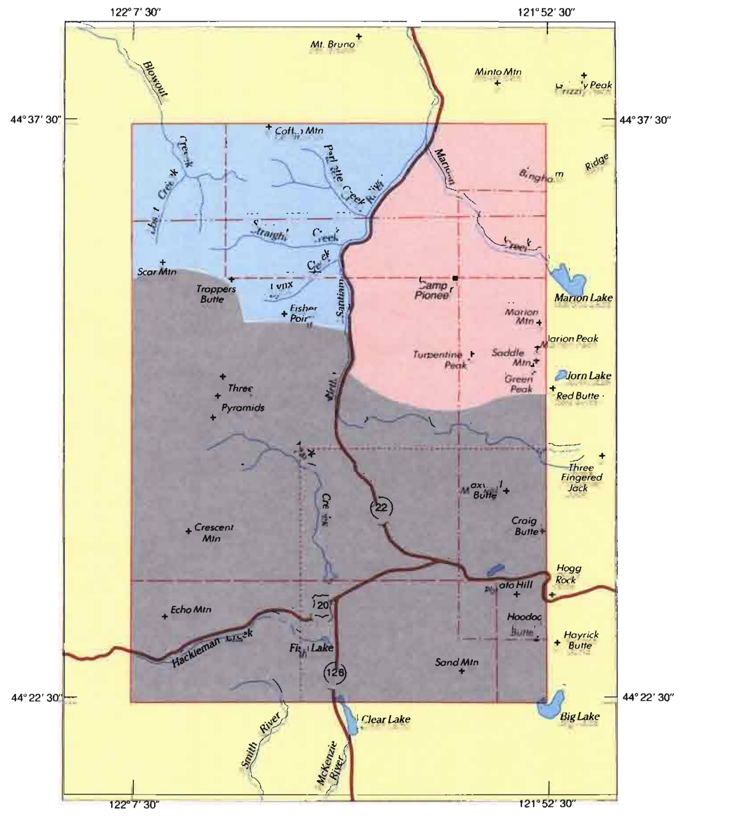
Tmbl — **Basalt of Lost Creek (lower? and middle? Miocene)** — Dark-gray to black, fine-grained, compact olivine and plagioclase microphyric basalt. Groundmass textures are intersertal, intergranular, and subophitic. Basalt of this unit typically possesses very well-developed columnar jointing and is interpreted as deeply intracanyon into the pyroxene-bearing member of the Breitenbush Tuff (unit **Tbp**). Unit **Tmbl** is very mafic, with silica contents less than 50 percent. Unit was mapped by Hammond and others (1980, 1982) as basalt of Lost Creek (their unit QTbl)

Oligocene and lower Miocene volcanic and volcaniclastic rocks

A thick sequence of predominantly welded tuff (unit **Tbp**) and interbedded andesite flows (unit **Tla**). These rocks are unconformably overlain by younger rocks. The date of the top is approximately 18 Ma. The base is not dated but is older than 25.5 Ma. The rocks are equivalent to volcanic rocks of the early Western Cascade episode of Priest and others (1983) and the Little Butte Volcanic Series of Peck and others (1964).

Tbp — **Welded pyroxene-bearing ash-flow tuff (upper Oligocene and lower Miocene)** — Lithic-poor, clinopyroxene-bearing, welded ash-flow tuff with local epiclastic and air-fall tuff interbeds. Dense welding is much more common in this sequence than in older ash flows (see Priest and others, 1987). Unit **Tbp** contains several ash flows in simple cooling units that exceed 50 m in thickness. The rocks are reddish to dark gray and form prominent cliffs in many areas. Eutaxitic texture is locally prominent with some large (10-20 cm) flattened pumice but is more often obscured in densely welded zones. Rocks of this unit contain 5-10 percent plagioclase (1-3 mm) with minor clinopyroxene and orthopyroxene in the matrix. Only minor (1-3 percent) phenocrysts of plagioclase occur in the pumice. Rocks also contain 2-5 percent andesitic and dacitic(?) lithic fragments (0.5-2.0 cm). Plagioclase separates from two localities on Blowout Creek yielded dates of 13.1 ± 0.6, 13.1 ± 0.5, 13.0 ± 0.6, and 12.2 ± 0.6 Ma (Laurson and Hammond, 1978). This unit was mapped by Hammond and others (1980, 1982) as their Boulder Ridge and Blowout Creek members of the Breitenbush Formation but was also locally included in their Cleator Bend member and beds of Detroit

Tla — **Lower andesite sequence (upper Oligocene and lower Miocene)** — Two-pyroxene andesite lava flows interbedded with unit **Tbp**. The rocks are mostly highly porphyritic with 1- to 5-mm-long plagioclase, clinopyroxene, and orthopyroxene phenocrysts set in a fine-grained groundmass of devitrified to hydrated glass that is now completely altered to zeolites and clays. Where glass is altered to clays, orthopyroxene is mostly altered to greenish celadonite. In the most intensely altered rocks, plagioclase is also partially to completely altered to clays, calcite, and zeolites. The unit varies in thickness from 30 to 240 m. The uppermost part of the sequence is interbedded in unit **Tbp**. These rocks were mapped by Hammond and others (1980, 1982) as their Coopers Ridge andesite and as the Nohorn andesite



Index map of geographic features and mapping of other workers
Scale 1:250,000

Boundary of this study
Mapped by Black
Mapped by Woller
Mapped by Ferns

Geologic mapping of others:
Taylor (1967)
Rollins (1976)
Davie (1980)
Avramenko (1981)
Hammond (1982)

Mapping by Taylor (1967, 1981) and the attitudes and dikes of Avramenko (1981) used with little or no modification. Other geology modified from Avramenko (1981), Davie (1980), Hammond (1982), and Rollins (1976).

VENT COMPLEXES

Vent complexes consist of abundant near-vent accumulation features such as agglomerate, agglutinate, palagonitic tuff cone sequences, radial dike swarms, thick cinder deposits with steep initial dips, and, in ash-flow sequences, possible intracaldera landslide deposits.

Qmbv — **Basaltic vent complex of unit Qmb**

Qcbv — **Basaltic vent complex of unit Qcb**

Qbmpv — **Basaltic vent complex of unit Qbmp**

Qjlv — **Basaltic vent complex of unit Qjl**

Tpv — **Basaltic vent complex of unit Tp**

Tmav — **Andesitic vent complex of unit Tma**

INTRUSIVES

Qhbi — **Intrusive rocks of unit Qhb** — Shown only in cross section

Qbmpi — **Intrusive rocks of unit Qbmp**

Qbti — **Intrusive rocks of unit Qbt**

QTbi — **Intrusive rocks of unit QTb**

Tpi — **Intrusive rocks of unit Tp** — Includes a sheeted dike complex on Parkette Creek

Tmbi — **Intrusive rocks of unit Tmb**

Tmdi — **Intrusive rocks of unit Tmd**

Tmai — **Intrusive rocks of unit Tma**

REFERENCES

Armstrong, R.L., Taylor, E.M., Hales, P.O., and Parker, D.J., 1975, K-Ar dates for volcanic rocks, central Cascade Range of Oregon: Isochron/West, no. 13, p. 5-10.

Avramenko, W., 1981, Volcanism and structure in the vicinity of Echo Mountain, central Oregon Cascade Range: Eugene, Oreg., University of Oregon master's thesis, 156 p.

Benson, G.T., 1965, The age of Clear Lake, Oregon: Ore Bin, v. 27, no. 2, p. 37-40.

Davie, E.I., II, 1980, The geology and petrology of Three Fingered Jack, a High Cascade volcano in central Oregon: Eugene, Oreg., University of Oregon doctoral dissertation, 138 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.

Hammond, P.E., Anderson, J.L., and Manning, K.J., 1980, Guide to the geology of the upper Clackamas and North Santiam Rivers area, northern Oregon Cascade Range, *in* Oles, K.F., Johnson, J.G., Niem, A.R., and Niem, W.A., eds., Geologic field trips in western Oregon and southwestern Washington: Oregon Department of Geology and Mineral Industries Bulletin 101, p. 133-167.

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

Laursen, J.M., and Hammond, P.E., 1978, Summary of radiometric ages of Oregon rocks, supplement 1: July 1972 through December 1976: Isochron/West, no. 23, p. 3-28.

Palmer, A.R., 1983, The Decade of North American Geology 1983 geologic time scale: Geology, v. 11, no. 9, p. 503-504.

Peck, D.L., Griggs, A.B., Schlicker, H.G., Wells, F.G., and Dole, H.M., 1964, Geology of the central and northern parts of the Western Cascade Range in Oregon: U.S. Geological Survey Professional Paper 449, 56 p.

Priest, G.R., 1983, Geothermal exploration in the central Oregon Cascade Range, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the central Oregon Cascade Range: Oregon Department of Geology and Mineral Industries Special Paper 15, p. 77-87.

Priest, G.R., and Woller, N.M., 1983, Preliminary geology of the Outerson Mountain-Devils Creek area, Marion County, Oregon, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the central Oregon Cascade Range: Oregon Department of Geology and Mineral Industries Special Paper 15, p. 29-38.

Priest, G.R., Woller, N.M., Black, G.L., and Evans, S.H., 1983, Overview of the geology of the central Oregon Cascade Range, *in* Priest, G.R., and Vogt, B.F., eds., Geology and geothermal resources of the central Oregon Cascade Range: Oregon Department of Geology and Mineral Industries Special Paper 15, p. 3-28.

Priest, G.R., Woller, N.M., and Ferns, M., 1987, Geologic map of the Breitenbush River area, Marion County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-46, scale 1:62,500.

Rollins, A., 1976, Geology of the Bachelor Mountain area, Linn and Marion Counties, Oregon: Corvallis, Oreg., Oregon State University master's thesis, 83 p.

Sutter, J.F., 1978, K-Ar ages of Cenozoic volcanic rocks from the Oregon Cascades west of 121°30': Isochron/West, no. 21, p. 15-21.

Taylor, E.M., 1967, Recent volcanism between Three Fingered Jack and North Sister, Oregon Cascade Range: Pullman, Wash., Washington State University doctoral dissertation, 84 p.

———1968, Roadside geology, Santiam and McKenzie Pass Highways, Oregon, *in* Dole, H.M., ed., Andesite Conference guidebook: Oregon Department of Geology and Mineral Industries Bulletin 62, p. 3-33.

———1981, Roadlog for central High Cascade geology, Bend, Sisters, McKenzie Pass, and Santiam Pass, Oregon, *in* Johnston, D.A., and Donnelly-Nolan, J., eds., Guides to some volcanic terranes in Washington, Idaho, Oregon, and northern California: U.S. Geological Survey Circular 838, p. 59-83.