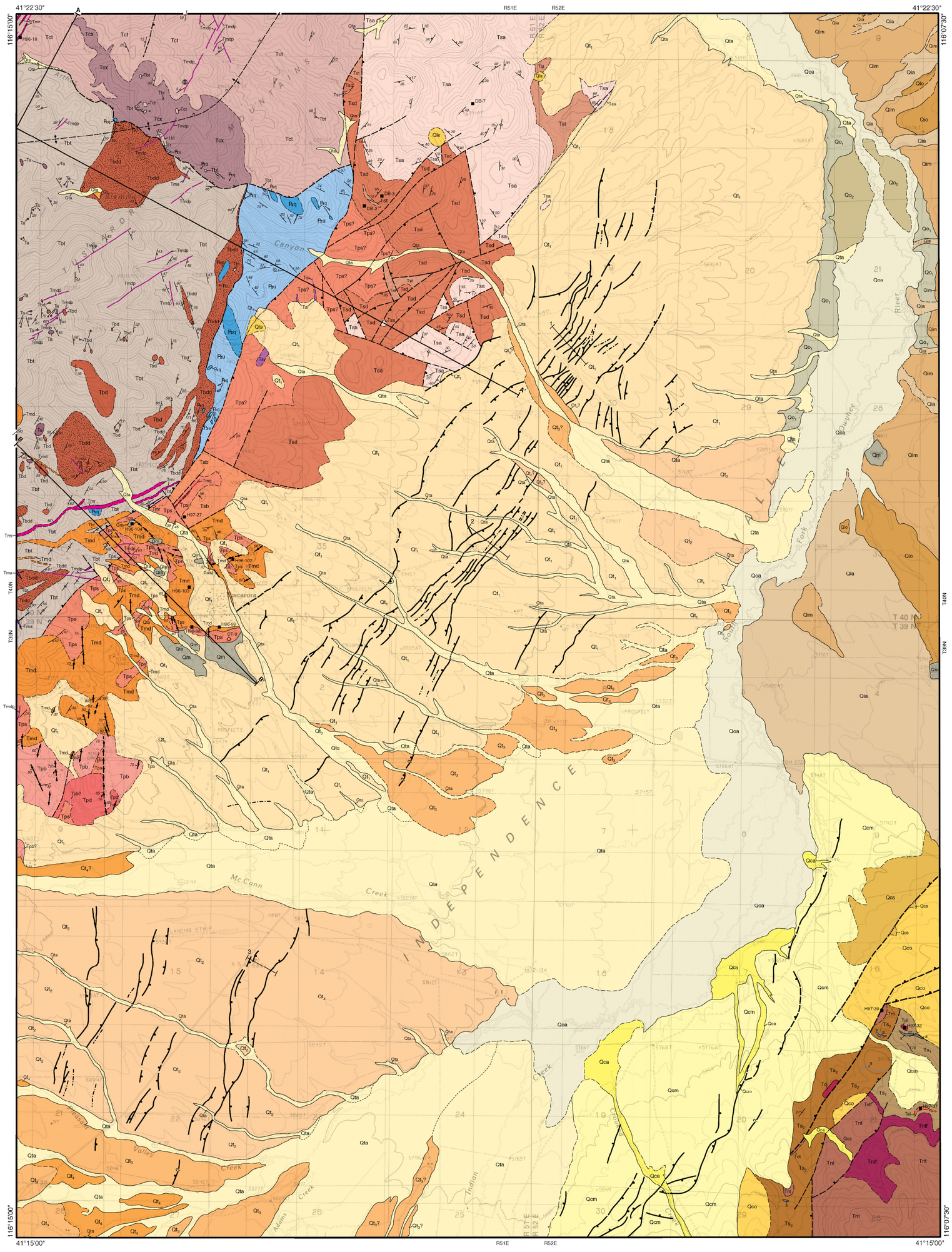
Prepared as part of the STATEMAP component of the National Cooperative Geologic Mapping Program in cooperation with the U.S. Geological Survey



Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET

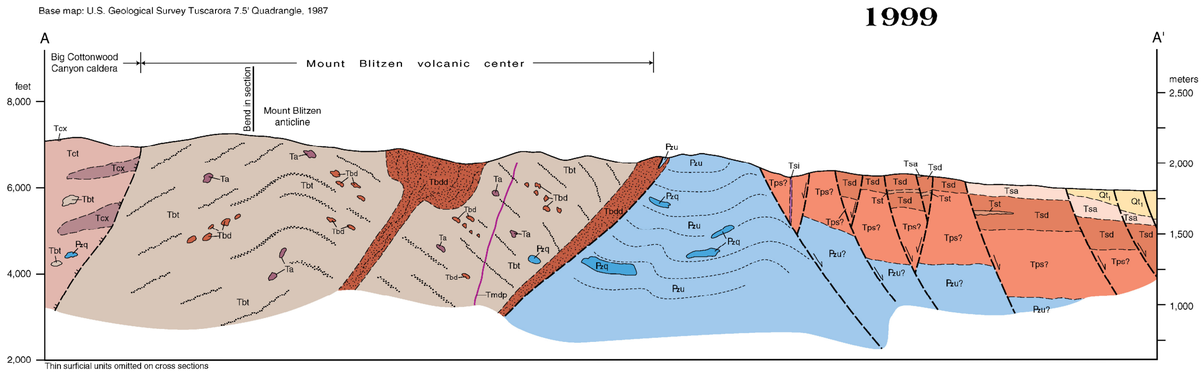
SUPPLEMENTARY CONTOUR INTERVAL 20 FEET

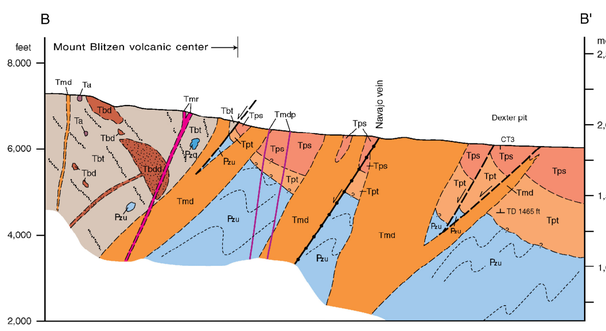
Base map: U.S. Geological Survey Tuscarora 7.5' Quadrangle, 1987

GEOLOGIC MAP OF THE TUSCARORA QUADRANGLE, NORTHERN NEVADA

Christopher D. Henry, David R. Boden, and Stephen B. Castor

1999





Contact Showing dip, long dashes where approximately located, short dashes between alluvium of different drainages within same unit, around magebreccia blocks, or form lines on cross sections, dotted where concealed, queried where uncertain.

Fault Showing sense of displacement and dip; ball on downthrown side, dashed where approximately located, dotted where concealed, queried where uncertain; arrow shows trend of slickenlines. Arrows show relative direction of movement.

Quaternary fault Fault showing distinct topographic scarp in Quaternary unit, dashed where approximately located, queried where sense of diplacement is uncertain, dotted where concealed.

Aerial photographic lineament Possible Quaternary fault but lacking definite topographic scarp.

Caldera margin Topographic or buried structural margin of Big Cottonwood Canyon caldera, dashed where approximately located, dotted where concealed.

Anticline axial trace Showing plunge, dashed where approximately located, queried where uncertain.

Vein coincident with normal fault Showing dip, dashed where approximately located.

Strike and dip of beds

Inclined — Vertical — Overturned

Strike and dip of compaction foliation in ash-flow tuff

Inclined — Vertical — Horizontal

Strike and dip of flow bands in lava or intrusion

Inclined — Vertical

Columnar joints Showing bearing and plunge

Inclined minor fold Showing bearing and plunge of hingeline

Sample location for $^{40}Ar/^{39}Ar$ date or chemical analysis

■ H96-103

Drill hole location

CT-3

Topographic profiles across Quaternary fault scarps

Probable sinter

SURFICIAL DEPOSITS

Quaternary

Qm **Man-made deposits** Mine dumps and leach piles in the Tuscarora mining district, and gravel piles and disturbed ground in alluvial fans of the Independence Mountains (Qi).

Qoa, Qo_2, Qo_1 **Alluvium and terraces of the South Fork of the Owyhee River** Active to Pleistocene alluvial deposits of the river, subdivided on the basis of inferred age. Major fans deflect the river alternately to the eastern and western parts of the valley. **Qoa** Active channel and floodplain of the Owyhee River. Numerous anastomosing, meandering channels and abandoned meander loops are set 1 to 3 m below the floodplain. Consist mostly of clay to silt; local lenses of gravel containing clasts up to about 20 cm are exposed in channels. Very dark toned on aerial photographs because soil is saturated much of year. Generally cultivated as pasture. **Qo_2** Lower terrace of the Owyhee River. Surface is approximately 1 m above the active floodplain and is not noticeably dissected. Composed of clay to sand, similar to the active floodplain. Probably equivalent to Qt_4. **Qo_1** Upper terrace of the Owyhee River. Surface is 3 to 4 m above the active floodplain and highly dissected along flanks and by numerous minor drainages within the unit. The surface consists of pebbly silt, similar to surfaces of older fans, and gravel to 30 cm is exposed along drainages. Very light toned on aerial photographs. Age uncertain but may be approximately equivalent to Qt_2 or Qt_3.

Qta, Qt_4, Qt_3, Qt_2, Qt_1 **Alluvium and fans of the Tuscarora Mountains** Complex series of active to late Pleistocene alluvial fans composed of unconsolidated fluvial and debris-flow deposits that developed along the east flank of the Tuscarora Mountains. They are subdivided on the basis of inferred age, from active channels (Qta) to oldest fan deposits (Qt_1); relative age is interpreted largely from elevation above active channels and amount of dissection. Clasts consist exclusively of volcanic rocks, except in Qta and Qt_1 in an arc between Brennan Gulch and about 2 km north of Sixmile Creek, where Paleozoic quartzite and lesser chert are a minor to the dominant component. Surfaces of fans have 5 to rarely 50% rock chips mostly 1 to 5 cm in a silty matrix. Qta is generally dark toned on aerial photographs, Qt_4 is distinctly lighter toned, and Qt_3, Qt_2, and Qt_1 are very light toned. **Qta** Unconsolidated alluvium in active channels of small to large drainages, which extend from highlands to the South Fork of the Owyhee River. Larger drainages, such as McCann and Sixmile Creeks, have anastomosing channels, ~1 to 5 m wide and up to 2 m deep, in floodplains up to 2 km wide. Smaller drainages have a single channel within a narrow floodplain. Maximum clast size in channels ranges from ~1 m within highlands to ~10 cm near the Owyhee River. Floodplains consist of clay, silt, and sand. Smaller drainages entering McCann Creek or the Owyhee River have distinct fans at their tocs, where gradient drops abruptly. Larger drainages are generally cultivated as pasture. **Qt_4** Lowest alluvial fan remnants are approximately 1 m above active channels and show no obvious dissection. **Qt_3** Approximately 2 m above Qt_4 and showing distinct erosion along flanks, where broad swales less than 1 m deep locally expose slightly coarser gravel with clasts to 10 cm. **Qt_2** Approximately 4 m above Qt_3 and substantially dissected both on flanks and as numerous rills within unit. Incipient desert pavement is locally developed. Erosion along flanks exposes as much as 3 m of gravel with clasts to 20 cm and well-developed caliche. **Qt_1** Oldest, variably dissected alluvial fans with surfaces 10 to 30 m above Qta. Probably includes deposits spanning a wide age range. Fans south of Sixmile Creek are relatively little dissected and retain flat, nearly primary upper surfaces. Fans north of Sixmile Creek are highly dissected, to rounded surfaces with scattered exposure of coarse gravel (clasts to 1 m) along flanks. Well-developed caliche is exposed in shallow mineral exploration pits.

Qia, Qim, Qio **Alluvium and fans of the Independence Mountains** Complex series of active to late Pleistocene alluvial fans that are developed in the eastern part of Independence Valley adjacent to the west flank of the Indendence Mountains. They are subdivided on the basis of inferred age, from active channels (Qia) to intermediate age (Qim), to older fan deposits (Qio); relative age is interpreted largely from elevation above active channels and amount of dissection. Geomorphically similar to alluvium and fans of the Tuscarora Mountains, except that clasts consist exclusively of Paleozoic rocks, particularly pebbles of chert 1 to 4 cm in diameter, and no fans appear as old as Qt_1. **Qia** Unconsolidated alluvium in active channels of small to large drainages. Larger drainages, such as Taylor Creek and unnamed creeks in the northeastern corner of the quadrangle, have anastomosing channels, ~1 to 5 m wide and up to 2 m deep, in floodplains up to 1.5 km wide; smaller drainages have a single channel in a narrow floodplain. Maximum clast size in channels is about 10 cm because highlands lie several kilometers east of the quadrangle. Floodplains consist of clay, silt, and sand. Smaller drainages entering the Owyhee River have small fans at their toes, where gradient drops slightly. Generally dark toned on aerial photographs. Larger drainages are cultivated as pasture. **Qim** Intermediate age alluvial fans. Surfaces are 1 to 3 m above active channels and are slightly to moderately dissected. Commonly cultivated as pasture. **Qio** Older alluvial fans. Surfaces are 4 to 5 m above active channels. They are highly eroded along flanks and dissected by numerous small drainages. Very light toned on aerial photographs.

Qca, Qcs, Qcm, Qco **Alluvium and fans of Crooked Creek** Complex series of active to late Pleistocene alluvial fans that are developed in the southeastern part of Independence Valley. They are subdivided on the basis of inferred age, from active channels (Qca) and secondary fans (Qcs), to intermediate age (Qcm), to older fan deposits (Qco); relative age is interpreted largely from elevation above active channels and amount of dissection. Geomorphically similar to alluvium and fans of the Tuscarora and Independence Mountains. Clasts consist of Paleozoic quartzite and chert with subequal to lesser amounts of Tertiary igneous rocks. **Qca** Unconsolidated alluvium in active channels of small drainages, which have distinct fans at their toes where gradient drops abruptly as they enter the Owyhee River. **Qcs** "Secondary" alluvial fans are developed along a large (10–15 m), highly dissected Pleistocene(?) fault scarp by reworking of older fan deposits (Qco). The fans distinctly grade to gullies eroded into the scarp and consist of clasts of Paleozoic rocks to 10 cm in a silty matrix. **Qcm** Intermediate age alluvial fans are 1 to 10 m above active channels. These range from nearly undissected to highly eroded, especially adjacent to fault scarps and along drainages. Relatively undissected surfaces consist of 5 to 15% pebbles from 2 to 8 cm in a silty matrix. Eroded areas show gravel composed of clasts to 30 cm with well-developed caliche interbedded with debris-flow deposits containing scattered cobbles in a muddy matrix. **Qco** Older alluvial fans cap higher ridges in the southeastern corner of the quadrangle. Most surfaces are deeply dissected and rounded. Clasts of Paleozoic rocks range up to 30 cm and of tuff of Big Cottonwood Canyon (Tct) to 1 m. Undissected surfaces dip gently (1° to 2°) to the southeast, probably as a result of tilting during Quaternary faulting.

Qls **Landslide deposits** Coarse, unconsolidated debris composed of local bedrock, developed especially where hard, massive rock overlies tuff or other soft rock. Clasts range from large blocks, up to 10 m in diameter, to silt. Generally no more than 20 m thick.

TERTIARY ROCKS

Eocene

Lavas of Sixmile Canyon

A series of andesitic to dacitic lavas exposed around Sixmile Canyon represent the youngest volcanic episode in the quadrangle. The lavas are in fault contact with tuff of Big Cottonwood Canyon (Tct) to the west, but dacite lava (Tsd) overlies tuff of Big Cottonwood Canyon (Tct) in the Cottonwood Peak Quadrangle to the north. Sixmile Canyon lavas are covered by alluvial fan deposits (Qt_1) in Independence Valley to the east and continue an unknown distance to the north. Sources for the lavas have not been identified but must be local. Sixmile Canyon lavas are petrographically similar to, overlap in age with, and may be extrusive equivalents of some Mount Neva dikes (Tma and Tmdp).

Tsi **Dacite dikes of Sixmile Canyon** Several dikes and more irregular, elongate intrusions cut volcaniclastic sedimentary rocks and tuff (Tps?) and dacite lava (Tsd) south of Sixmile Canyon. Dikes appear to intrude along faults and are hydrothermally altered. Phenocrysts (10%): plagioclase (10%) and biotite (<1%). Generally broken phenocrysts and wispy, streaky appearance of groundmass suggest partly fragmental emplacement.

Tsa **Andesite of Sixmile Canyon** Abundantly porphyritic andesite, possibly a single lava flow, makes prominent outcrops near the mouth of Sixmile Canyon and capping ridges on the north side. Well-developed platy parting that parallels flow layers is a distinctive outcrop feature. Distinguished from underlying dacite lava (Tsd) by lack of hornblende or biotite. Maximum exposed thickness is about 120 m. Phenocrysts (30–35%): plagioclase (23–28%, 6 mm), orthopyroxene (2–4%, 3 mm), clinopyroxene (2–3%, 4 mm), and opaques (1%, 0.1–0.3 mm).

Tst **Tuff and tuffaceous sedimentary rocks** Thin, discontinuous lenses of massive, nonwelded, pumiceous tuff and pebbly, tuffaceous sandstone are interbedded between andesite (Tsa) and dacite (Tsd) and between dacite flows.

Tsd **Dacite lava of Sixmile Canyon** At least two thick lava flows of porphyritic dacite make bold, crudely flow-layered outcrops that comprise the walls of lower Sixmile Canyon. Flows are interbedded with thin lenses of whitish- to reddish-pink, crystal-poor, lithic tuff and tuffaceous siltstone. Maximum exposed thickness is about 150 m. Phenocrysts (25-30%): plagioclase (18–24%, 1–5 mm), hornblende (5–7%, 3 mm), biotite (1–2%, 2 mm), orthopyroxene (0.5–1.5%, 0.2–1 mm), clinopyroxene (0.5%, 1–2 mm), and opaques (0.5%, 0.1–0.3 mm). Age: 39.25±0.32 Ma, hornblende, DB-3.

Tsb **Biotite dacite intrusion** Biotite-rich dacite makes a probable intrusion just north of the town of Tuscarora. Lack of basal breccia or vesicles, and presence of columnar joints that plunge perpendicular to the contact with volcaniclastic sedimentary rocks and tuff (Tps) suggest the body is a large dike or sill. Mostly unaltered, but propylitically altered and cut by calcite veins along fault contact with tuff of Mount Blitzen (Tbt). Phenocrysts (~40%): plagioclase (22%, 2-5 mm), biotite (2-4%, 1-3 mm, euhedral), chloritized pyroxene and hornblende (8-10%, 3 mm), and opaques (1%, 0.5 mm).

Rocks of the Mount Neva Intrusive Episode

During the Mount Neva intrusive episode, several irregular intrusions and numerous dikes were emplaced into and near the margin of the Mount Blitzen volcanic center. Individual intrusions range from andesite to rhyolite, but most are dacite. An early porphyritic dacite (Tmd) was emplaced dominantly along the margin of the Mount Blitzen center. Subsequently, dikes intruded within the center. Between these two sets of intrusions, the large (6 km²), related Mount Neva granodiorite intruded Paleozoic rocks and tuff of Mount Blitzen (Tbt) in the Mount Blitzen Quadrangle.

Late Dikes

Numerous intermediate to silicic dikes cut the tuff of Mount Blitzen (Tbt), tuff of Big Cottonwood Canyon (Tct), early porphyritic dacite (Tmd), and volcaniclastic sedimentary rocks and tuff (Tps) of the Pleasant Valley volcanic complex in the northwestern part of the quadrangle. Dikes mostly strike northeast and continue into the adjacent Mount Blitzen (where they are more abundant), Big Cottonwood Canyon, and Cottonwood Peak Quadrangles. Similar distribution, gradation in petrographic and chemical characteristics, and the presence of zoned dikes that grade inward from andesite or dacite to rhyolite suggest that these dikes are related and emplaced at about the same time.

Tmr **Porphyritic rhyolite** Coarsely, abundantly porphyritic rhyolite to rhyodacite crops out in two zones. One zone lies just within and approximately parallels the margin of the Mount Blitzen volcanic center near Tuscarora. The other cuts the northwestern corner of the quadrangle; dikes of this zone continue extensively to the southwest and northeast into the Mount Blitzen and Cottonwood Peak Quadrangles. Individual dikes are as much as 30 m wide and make en echelon steps. Phenocrysts (20–35%): plagioclase (10–20%, 1 cm), quartz (5–8%, 5 mm, variably resorbed, bipyramidal), hornblende (3–6%, 4 mm), biotite (3–5%, 5 mm), and sanidine (0–5%, 3 cm). Several dikes have more mafic margins, similar to porphyritic dacite or quartz-phyric porphyritic dacite; compositional contacts within dikes are gradational in some dikes but may be abrupt in others. These relations suggest nearly contemporaneous intrusion of the rhyolite and dacites. Age: 39.34±0.08 Ma, sanidine; 39.46±0.15 Ma, hornblende, H96-19.

Tmdp **Porphyritic dacite** Dark-gray porphyritic dacite occurs as 2- to 15-m-wide dikes that are widely distributed in the northern part of the quadrangle. Phenocrysts (most ~35%, but as little as 10%): plagioclase (5–22%, 6 mm), biotite (2–5%, <5 mm, euhedral), hornblende (2–4%, 4 mm), clinopyroxene (2–5%, 1 mm), magnetite (<1%, clots to 5 mm), quartz (0–1%, 2 mm) and possible altered orthopyroxene. Mafic minerals are commonly altered to chlorite ± calcite ± epidote. Fine-grained, dioritic inclusions are common. Age: 39.51±0.36 Ma, hornblende, DB-35, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Tmq **Quartz-phyric porphyritic dacite** Similar to the porphyritic dacite (Tmdp) but also contains a few percent bipyramidal quartz to 3 mm. Age: 39.37±0.24 Ma, hornblende, DB-43, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Tma **Porphyritic andesite** A few dikes of dark-gray, abundantly porphyritic andesite crop out at the western edge of the quadrangle, west of Tuscarora, and in Sixmile Canyon. Phenocrysts (30–50%): plagioclase (25–40%, 6 mm), clinopyroxene (3–5%, 3 mm), orthopyroxene (1–3%, 3 mm), and biotite (1–2%, 3 mm). Felty groundmass of plagioclase microlites. Dikes are commonly zoned to less porphyritic margins.

Early Intrusions

Tmd **Early porphyritic dacite** Early porphyritic dacite forms numerous thick, irregular-shaped intrusions and a few dikes that cut tuff of Mount Blitzen (Tbt) and tuff and volcaniclastic sedimentary rock (Tps). These are concentrated along and just outside the margin of the Mount Blitzen volcanic center near Tuscarora, where they are the most common vein host. Based on field relations in the Mount Blitzen Quadrangle, individual mapped intrusions are probably composite. Phenocrysts (25–30%): plagioclase (15–20%, 3 mm), hornblende (3–5%, 1–9 mm, conspicuous prismatic), biotite (1–3%, 2 mm), and clinopyroxene (1%, 1 mm). The rock is porphyritic-seriate; plagioclase grades continuously in size between groundmass and phenocrysts. Rounded inclusions of fine-grained diorite with sparse phenocrysts of plagioclase, hornblende, and pyroxene are notably abundant. Age: 39.43±0.26 Ma, hornblende, H96-103. Also, 39.58±0.40, hornblende, H96-63, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Rocks of the Big Cottonwood Canyon Caldera

The Big Cottonwood Canyon caldera (Berger and others, 1991; Henry and Boden, 1998) formed during eruption of the voluminous tuff of Big Cottonwood Canyon (Tct) and is the youngest large volcano in the quadrangle. The caldera lies mostly within the Mount Blitzen and Big Cottonwood Canyon Quadrangles to the northwest, but its southeasternmost part extends into the northwestern corner of the Tuscarora Quadrangle. The caldera truncates the tuff of Mount Blitzen and the Mount Blitzen volcanic center and extends for an undetermined distance to the north and northwest. The eastern margin of the caldera is cut by a north-striking normal fault that drops the tuff beneath lavas of Sixmile Canyon to the east.

Intracaldera Ash-Flow Tuff, Debris Deposits, and Megabreccia

Tct **Tuff of Big Cottonwood Canyon** Compound cooling unit of light-gray, devitrified, lithic, densely to moderately welded, rhyolitic ash-flow tuff. Crops out exclusively within and along the topographic margin of the Cottonwood Canyon caldera in the northwestern part of the quadrangle. Intracaldera tuff may be several kilometers thick, based on its 15° to 25° westward dip across a 12-km-wide belt into the Mount Blitzen Quadrangle. Sequence upward from megabreccia-rich tuff, to 1-m-thick sandstone and conglomeratic sandstone, to lithic, megabreccia-poor tuff in Big Cottonwood Canyon Quadrangle (Henry and Boden, 1998) to the west suggests catastrophic eruption and major caldera collapse, followed by a brief hiatus, sedimentation, and renewed eruption. Phenocrysts (20–25%): quartz (6%, 3 mm), sanidine (6–7%, 2.5 mm), plagioclase (7–10%, 3 mm), biotite (1%, 2 mm), and hornblende (<1%, <1mm); individual fiamme, which are up to 25 cm long, contain 15% of the same phenocrysts. Commonly weakly propylitically altered. Age: 39.67±0.10, sanidine, H96-42; 39.67±0.10, sanidine, H96-60. Both samples in Big Cottonwood Canyon Quadrangle (Henry and Boden, 1998).

Tcx **Breccia and debris deposits** Lenses and irregular masses of massive breccia and poorly bedded debris-flow deposits occur within the tuff of Big Cottonwood Canyon near the caldera margin. Deposits consist of various older rocks, including tuff and dacite of Mount Blitzen (Tbt and Tbd), early andesite (Ta), and Paleozoic chert, quartzite, and siltstone, up to several meters in diameter (larger blocks are mapped as megabreccia). Where exposed, matrix consists of finer pieces of the same rocks, although some deposits may be extremely lithic ash-flow tuff. Commonly form poor outcrops and expressed as abundant weathered out clasts littering the surface. Interpreted as landslide debris from the caldera wall during eruption of the tuff and initial caldera collapse.

Tbd, Pzu, Pzq **Megabreccia** Large blocks of older rocks within the tuff of Big Cottonwood Canyon (Tct) are mapped as their individual rock type, including tuff of Mount Blitzen (Tbt), Paleozoic quartzite (Pzq), and Paleozoic chert (Pzu). Blocks range up to several hundred meters across and were not mapped if smaller than about 10 m. Blocks of tuff of Mount Blitzen include a quartz-bearing, biotite-rich, densely welded ash-flow tuff that could be a different tuff. Similar to the breccia and debris deposits (Tcx), megabreccia blocks are interpreted as landslides from the caldera wall.

Rocks of the Mount Blitzen Volcanic Center

The Mount Blitzen volcanic center occupies much of the northwestern part of the quadrangle and continues to the west in the Mount Blitzen Quadrangle. Numerous dacite lava domes and intrusions (Tbd) and dacitic ash-flow tuff and epiclastic deposits (Tbt) accumulated in a fault-bounded basin. The dacite locally intrudes the tuff, whereas the tuff commonly contains clasts to megablocks of dacite. These relations indicate the two units developed contemporaneously. The nature of the volcanic center is uncertain. The fault-bounded basin suggests a caldera, but the heterogeneous assemblage of tuff and reworked deposits within the basin is distinctly unlike typical massive, homogeneous intracaldera tuff such as the tuff of Big Cottonwood Canyon (Tct).

Tbd, Tbdd **Dacite of Mount Blitzen** Sparsely to moderately porphyritic dacite forms numerous lava domes, shallow intrusions, and megabreccia blocks within or at the margins of the Mount Blitzen volcanic center. Phenocrysts (8–20%): plagioclase (5–15%, 1–4 mm), biotite (1–4%, 1–2 mm), clino- and orthopyroxene (<0.5%, 0.5 mm), and hornblende (0.5%, 1 mm); mafic minerals are generally chloritized. Domes are commonly flow laminated, spherulitic, and locally brecciated, particularly at their margins. Most dacite is propylitically altered with replacement of groundmass by fine-grained quartz and K-feldspar, biotite by chlorite and sericite, and plagioclase by clay and calcite. Disseminated limonite after pyrite is common, and oxidized examples are bleached white. A few, mostly larger (500 m in diameter) areas of outcrop are definite or probable lava domes or shallow intrusions in place (**Tbdd**). Many other outcrops, including most smaller ones, are coarse breccia blocks within the tuff of Mount Blitzen. Definite domes occur approximately 2 km northwest of Tuscarora and at the junction of Arthur and Sixmile Creeks. Definite intrusions include a long dike in the wall of the Mount Blitzen center south of Sixmile Canyon and a smaller dike just west of it. Age: 39.40±0.14 Ma, biotite, H96-92, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Tbt **Tuff of Mount Blitzen** A heterogeneous, complexly interbedded mix of dacitic ash-flow tuff and various epiclastic deposits fills the fault-bound Mount Blitzen volcanic center. Devitrified, poorly to densely welded, and variably lithic- to pumice-rich tuff makes up most of the unit and appears to represent pyroclastic eruptions from or related to the dacite of Mount Blitzen (Tbd). Phenocrysts (15–30%): plagioclase (13–25%, 3 mm), biotite (0.5–2%, 2 mm), hornblende and clinopyroxene (0.5%, ~1 mm, preserved only in rare, unaltered samples). A local variant with 1–2% quartz phenocrysts crops out in the northwestern part of the quadrangle. Characteristic, green, flattened to ovoid, sparsely porphyritic pumice up to 5 cm long makes up a few to 30% of the tuff. Lithic fragments are mostly of dacite of Mount Blitzen (Tbd), which can comprise as much as 50% of tuff, but include Paleozoic rocks and various other igneous rocks. Megabreccia blocks up to several hundred meters in diameter are common near the margins of the basin. Interbedded epiclastic rocks range from massive breccia to well-bedded sedimentary rock. Breccias generally are thick, contain abundant, angular to subrounded clasts of dacite of Mount Blitzen as much as 2 m in diameter, and appear to be landslide or debris-flow deposits from the domes. Other rock types include coarse, massive to poorly bedded, plagioclase-rich, lithic sandstone and conglomerate with variable amounts of green pumice and well-bedded, graded sandstone and siltstone. Both tuff and epiclastic layers are discontinuous along strike. The unit is at least 1 km and possibly as much as 3 km thick, but the base is not exposed and complex stratigraphy, lack of marker beds, and uncertainty in repetition by faults preclude determining an accurate thickness. Propylitic alteration, characterized by replacement of plagioclase by albite, clay minerals, and calcite and of biotite and hornblende by chlorite, epidote, calcite, and iron oxides, is widespread. Age: 39.88±0.22 Ma, biotite, DB-28, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Tbd, Tbdd, Tbt, Tct, Tcx, Pzq, Pzu, Ta **Megabreccia** Large blocks of older rocks within the tuff of Mount Blitzen (Tbt) are mapped as their individual rock type, including tuff of Big Cottonwood Canyon (Tct), dacite of Mount Blitzen (Tbd), quartzite (Pzq), and Paleozoic chert (Pzu), and early porphyritic andesite (Ta). Blocks range up to several hundred meters across and were not mapped if smaller than about 10 m. Blocks of tuff of Mount Blitzen include a quartz-bearing, biotite-rich, densely welded ash-flow tuff that could be a different tuff. Similar to the breccia and debris deposits (Tcx), megabreccia blocks are interpreted as landslides from the caldera wall. Most blocks are dacite of Mount Blitzen (**Tbd**), probably shed from nearby in-situ lava domes, or early andesite (Ta). Only one block is Paleozoic quartzite (**Pzq**), although Paleozoic rock fragments are common in the tuff of Mount Blitzen. **Ta early andesite** Porphyritic andesite lava flows. Only present as blocks within tuff of Mount Blitzen (Tbt) and as clasts in breccia and debris deposits (Tcx) of the Big Cottonwood Canyon caldera. Two petrographic types: andesite with pyroxene as the only or dominant mafic phenocryst, and dacite? with hornblende and biotite in addition to pyroxene. Phenocrysts (20–25%): plagioclase (19–24%, 3 mm), hornblende (0–3%, 1–7 mm), biotite (0–2%, ~1 mm), clinopyroxene (1–3%, 1.5 mm), and orthopyroxene (1–2%, 1 mm); phenocrysts commonly form glomerocrysts. Commonly altered, with all mafic minerals converted to chlorite and calcite. Similar to andesite lavas of the Pleasant Valley complex, but relative age and possible relation are uncertain.

Lavas, Tuffs, and Sedimentary Rocks of the Pleasant Valley Volcanic Complex

The Pleasant Valley volcanic complex consists mostly of tuff and volcaniclastic sedimentary rock (Tps) with a few dacite lava flows (Tpb) and one dacite dome or intrusion (Tpd). Moderately welded ash-flow tuff (Tpt) was penetrated by drill holes near Tuscarora but does not crop out. The complex is named for exposures of the rocks in the Mount Blitzen Quadrangle (Henry and Boden, 1998) and extends to the south into the China Camp and Sugarloaf Butte Quadrangles. Rocks in the Tuscarora Quadrangle are mostly distal deposits from source vents and domes in the upper part of Pleasant Valley in the Mount Blitzen Quadrangle, although the dacite intrusion may also have been a vent. Tuff and volcaniclastic sedimentary rock crop out extensively from the western edge of the quadrangle as far northeast as Sixmile Canyon. Biotite-bearing dacite lavas crop out only in the westernmost part of the quadrangle. Additional andesite and hornblende-phyric dacite lavas crop out in the Mount Blitzen Quadrangle. Pleasant Valley rocks are the oldest volcanic rocks in the quadrangle and directly overlie basal Tertiary conglomerate in the Mount Blitzen Quadrangle. All Pleasant Valley rocks in the Tuscarora Quadrangle are extensively propylitically altered. Age: 39.86±0.24, hornblende, H96-73; 39.69±0.28, hornblende, H96-86; both on hornblende-phyric dacite lavas in the Mount Blitzen Quadrangle (Henry and Boden, 1998).

Tpd **Dacite intrusion** Silicified, porphyritic dacite forms an apparent intrusion that cuts biotite-bearing andesite-dacite lava (Tpb) and volcaniclastic sedimentary rocks and tuff (Tps) just north of McCann Creek. The body is strongly flow banded and locally spherulitic near its margins and more massive and slightly coarser inward. Altered phenocrysts of plagioclase and biotite increase in abundance from 8-10% near the margin to 15–18% in the center. The rock is petrographically similar to the dacite of Mount Blitzen (Tbd) and may be related. However, unlike other Mount Blitzen dacites, it lies ~2 km outside the Mount Blitzen volcanic center.

Tps **Volcaniclastic sedimentary rocks and tuff** Poorly indurated, poorly exposed sedimentary deposits and tuff crop out in a 1–2-km-wide, northeast-striking, southeast-dipping belt between the Mount Blitzen volcanic center and overlying alluvium and fans of the Tuscarora Mountains (Qt). Most deposits are white, massive to well-laminated, tuffaceous sandstone and siltstone. Some massive, nonwelded, pumiceous tuffs are probably primary ash-flow tuffs or debris-flow deposits. Apparent thickness is ~350 m near Tuscarora, but the rocks may be repeated by faults.

Tpb **Biotite-bearing andesite-dacite lava** Poorly exposed biotite-bearing lava crops out in a small area of low hills just north of McCann Creek and may continue in the subsurface farther northeast. Total thickness and number of flows are unknown, but thickness is probably less than 50 m. Phenocrysts (20–30%): plagioclase (18–25%, 5 mm), clinopyroxene (1–3%, 2 mm), biotite (1–2%, <1.5 mm), and orthopyroxene (1–2%, 1 mm).

Tpt **Dacite ash-flow tuff** Poorly to moderately welded ash-flow tuff was encountered in a 1,465-foot (446 m) deep drill hole (CT-3) in the Dexter pit. The tuff does not crop out and is shown only in cross section B-B'. The rock is commonly brecciated and per- vasively propylitically altered. Plagioclase phenocrysts are altered to clay minerals, and no mafic phenocrysts are preserved. The tuff contains as much as 15% moderately flattened, green pumice up to 2 cm long and scattered fragments of porphyritic igneous rocks and Paleozoic shale. Thickness may be as much as 300 m, but the drill hole did not reach the base and the tuff is repeated by faults and cut by early porphyritic dacite (Tmd).

Rocks in the Southeastern Part of the Quadrangle

The tuff of Nelson Creek, first recognized in the Toe Jam Mountain Quadrangle to the west (Henry and Boden, in press), is interbedded with very poorly exposed tuffaceous sediments and minor dacite and andesite lava or shallow intrusions in the southeastern corner of the quadrangle. The rocks are commonly silicified and have undergone weak local hydrothermal alteration. Siliceous sinter forms several 1 to 2 m thick, mottled (or pelletal?), chalcedonic to opaline, white to varicolored to locally black (organic?) layers in the tuffaceous sedimentary rocks. One layer has nearly vertical tubes at base, possibly former reed stems.

Ts_2 **Upper sedimentary sequence** Mostly fine, massive to finely laminated sandstone to siltstone and sparsely porphyritic, pumiceous tuff that is either nonwelded ash-flow tuff or tuffaceous debris deposits. These deposits may be in part correlative with volcaniclastic sedimentary rocks and tuff (Tps) of the Pleasant Valley volcanic complex.

Tdi **Dacite** Porphyritic dacite is present as clustered boulders and minor subvolcanic in two locations: a narrow band along the downthrown side of a major, northeast-striking fault and a small pod surrounded by tuffaceous sedimentary rock (Ts_2). Whether the dacite is intrusive or extrusive is unclear, so it may be contemporaneous with or younger than the host sediments. The dacite is glassy (hydrated) to rarely devitrified, faintly flow banded, and finely vesicular. Phenocrysts (25–30%): plagioclase (20–25%, mostly 1–2 but up to 5 mm), clinopyroxene (6%, 1 3 mm), orthopyroxene (2%, 2 mm), biotite (1%, 2 mm), hornblende (<1%, to 5mm), and opaques (<1%, 0.1 mm) in a glassy, microlitic matrix.

Tnt, Tntf **Tuff of Nelson Creek** Ash-flow tuff that is probably correlative with the tuff of Nelson Creek of the Toe Jam Mountain Quadrangle (Henry and Boden, in press) crops out in the southeastern part of the quadrangle. We mapped two facies, a basal nonwelded, moderately porphyritic tuff (Tntf) and an overlying, densely welded, more abundantly porphyritic tuff (Tnt), that are probably a single cooling unit. The contact between the two appears to be gradational. Composite thickness is at least 120 m, most of which is the upper densely welded part. **Tnt** Densely welded tuff is devitrified and locally silicified, weathers gray to light red, and contains sparse fragments of finely porphyritic andesite and Paleozoic chert and shale to 1 cm. Phenocrysts (30–35%): plagioclase (25%, 4 mm), quartz (2–3%, 3 mm), sanidine (1–2%, 3 mm), biotite (3–4%, 2 mm), and hornblende (1–3%, to 3 mm). 39.92±0.11 Ma, sanidine, H97-30. **Tntf** Underlying nonwelded tuff is devitrified, weathers white, and contains 5% fragments of porphyritic igneous rocks to 1 cm and 2–3% fine pumice to 1 mm. Phenocrysts (20%): plagioclase (15–20%, mostly 2, rarely 3 mm, altered) and biotite (1%, 2 mm, generally oxidized). Sanidine and quartz are at most minor.

Ts_1 **Lower sedimentary sequence** Similar to the upper sedimentary sequence (Ts_2) but also containing lenses of poorly to moderately bedded, coarse, pebbly sandstone and conglomerate and coarse, debris-flow deposits or lithic tuff. Clasts in sandstone and conglomerate are porphyritic igneous rocks and Paleozoic chert to 5 mm. The debris deposits or tuff contain 30 to 50% clasts to 25 cm of porphyritic felsic igneous rocks and Paleozoic chert and shale in a tuffaceous matrix with sparse grains of feldspar, quartz, and biotite. Fragments of petrified wood are locally common.

Tal **Andesite** A black, flow-banded andesite crops out as a short lenses within tuffaceous sedimentary rock (Ts_1) just below outflow tuff of Nelson Creek (Tntf and Tnt). Planar flow bands strike dominantly N45°E and dip steeply to the northwest. The body may be a lava flow or a thick dike, so may be contemporaneous with the sediments or younger. It is petrographically similar to and may be a distal part of the Pleasant Valley volcanic complex. Phenocrysts (25%): plagioclase (18%, 4 mm), clinopyroxene and orthopyroxene (5%, 2 mm), hornblende (<1%, 0.5 mm), and opaques (2%, 0.1 mm).

PALEOZOIC ROCKS

Paleozoic rocks form a narrow, fault-bounded wedge in the northwestern part of the quadrangle. Pods of quartzite (**Pzq**) reside within a matrix of siltstone, chert, and minor sandstone and limestone (**Pzu**). The quartzite is almost certainly correlative with the Ordovician Valmy Formation, but Devonian conodonts were found in limestone in undivided siltstone and chert (**Pzu**) at one locality near Sixmile Canyon (Coats, 1987). The total areas of outcrop are definite or probable lava domes or shallow intrusions in place (**Tbdd**). Many other outcrops, including most smaller ones, are coarse breccia blocks within the tuff of Mount Blitzen. Definite domes occur approximately 2 km northwest of Tuscarora and at the junction of Arthur and Sixmile Creeks. Definite intrusions include a long dike in the wall of the Mount Blitzen center south of Sixmile Canyon and a smaller dike just west of it. Age: 39.40±0.14 Ma, biotite, H96-92, Mount Blitzen Quadrangle (Henry and Boden, 1998).

Pzu **Undivided siltstone and chert** Heterogeneous, generally recessive mix of siltstone or argillite, chert, and minor sandstone and limestone forms poor outcrop. Siltstone is finely laminated, tan to black (carbonaceous?), rarely micaceous, and locally in graded beds with fine sandstone. Chert mostly consists of thick-