Geologic map of part of the southern Toquima Range and adjacent areas, Nye County, Nevada

By Daniel R. Shawe

Miscellaneous Field Studies Map MF–2327–A

Round Mountain (right of center) and the southern Toquima Range, November 1966; view southeast across Big Smoky Valley. The dome of Round Mountain is flanked on its left by Stebbins Hill; Sunnyside mine is on its right slope; waste dumps from placer operations lie at valley's edge; Fairview mine is left of and beyond Stebbins Hill. Town of Round Mountain lies farther left on the valley floor.

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INTRODUCTION

This geologic map is one of a series of maps depicting, at 1:48,000 scale, the geology, structure, aeromagnetic and gravity properties, and geochemistry of part of the southern Toquima Range and adjacent areas in northern Nye County, Nevada. The maps are intended to facilitate interpretation of the geology and mineral potential of the area.

The geologic map of part of the southern Toquima Range and adjacent areas covers an area bounded by lat 38°30' N. and lat 38°45' N., and long 116°45' W. and long 117°07'30" W. It is a generalized compilation at a scale of 1:48,000 of the detailed geology previously presented in six 1:24,000-scale quadrangle maps, as follows: Round Mountain (Shawe, 1995); Belmont West (Shawe, 1998); Manhattan (Shawe, 1999a); Jefferson (Shawe, 1999b); Belmont East (Shawe and Byers, 1999); and Corcoran Canyon (Shawe and others, 2000). Data presented here are taken from those publications; sources of data not cited here are provided therein.

To facilitate presentation of map units, the southern Toquima Range map is divided into three areas, each with a particular geologic column. Although several map units occur in all three areas, a number of map units are unique to one particular area. In addition, the close correspondence in age of some units, coupled with the fact that many units have not been radiometrically dated, precludes construction of a consistent stratigraphy for the entire map area.

The three areas are (1) the west half of the map, (2) the northeast quarter of the map, and (3) the southeast quarter of the map. In the descriptions of map units in each area, only the general character of each unit is presented. Detailed descriptions of the units (including member or other subdivisions) are given in the references cited above. A brief summary of major geologic events in the area is presented at the end of the map-unit descriptions.

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DESCRIPTION OF MAP UNITS

WEST HALF OF THE MAP (AREA 1)

Qs **Surficial deposits (Quaternary)**—Includes alluvium along stream channels and as valley fill; alluvial-fan deposits; colluvium and slope wash; talus; and landslide deposits. Occurs widely throughout map area

Tva **Glass-shard tuff (Miocene)**—Underlies two adjacent small knobs on the west side of Ralston Valley near the mouth of Silver Creek; apparently rests upon pedimented granite of the Belmont pluton (Kb). Dated at 12.0±2.6 Ma (Shawe and others, 1987; zircon fission track)

Trn **Rhyolite necks (Miocene?)**—Two small intrusive bodies each 100 m or so long, intruded into Paleozoic sedimentary rocks about 3 km south of Manhattan. Undated, but possibly related to 16 Ma mineralization in the Manhattan gold district

Tf **Dacite of Ferguson Hill (Miocene and Oligocene)**—Consists of two flow domes of flow-layered dacite-latite, each about 1 × 1.5 km in surface exposure, and associated dikes and sills; intruded into Oligocene volcanic rocks [tuff of The Bald Sister (Tbs), Bald Mountain Formation (Tbm), Diamond King Formation (Tdk), and Round Rock Formation (Trr)] in the west-central part of the Manhattan caldera. Average age about 24.5 Ma (Shawe and others, 1986; based on two K-Ar dates on biotite)

Tca **Crone Gulch Andesite (Oligocene)**—Forms a stock about 1 km in north-south dimension and 3 km in east-west dimension, probably intruded resurgently into Oligocene volcanic rocks (Tbs, Tbm, Tdk, and Trr) in the south-central part of the Manhattan caldera, as dikes in the south part of the caldera, and as sills and plugs in many parts of the central and east segments of the caldera

Tbs **Tuff of The Bald Sister (Oligocene)**—Rhyolitic welded ash-flow tuff. Distributed widely in the central and east parts of the Manhattan caldera (fig. 1) where its maximum exposed thickness is about 250 m. Dated at 24.6±0.8 and 24.8±0.8 Ma (Shawe and others, 1986; K-Ar on biotite)

Tbm **Bald Mountain Formation (Oligocene)**—Predominantly lacustrine tuffaceous siltstone and sandstone interlayered locally with fluvial sandstone and conglomerate and ash-fall and ash-flow tuff layers. Widespread throughout the Manhattan caldera (fig. 1) where it is 15–200 m thick

Trd **Rhyolite and rhyodacite plugs (Oligocene)**—Intrusive bodies about 100 m in diameter to almost 1 km long, at the east margin of the Manhattan caldera. Intrudes megabreccia of Silver Creek (Trs). Dated at 24.8±0.9 Ma (Shawe and others, 1987; K-Ar on biotite)

Tdk **Diamond King Formation (Oligocene)**—Rhyolitic welded ash-flow tuff and interlayered volcanic sandstone. Widespread throughout the Manhattan caldera (fig. 1). Thickness 100–230 m. Dated at 24.34±0.07 Ma (Henry, 1997; $^{40}Ar/^{39}Ar$ on sanidine)

Trr **Round Rock Formation (Oligocene)**—Rhyolitic-rhyodacitic welded ash-flow tuff, and minor ash-fall tuff, megabreccia, and tuff breccia, erupted from and widespread within the Manhattan caldera (fig. 1); deposited mostly as intracaldera facies. Apparent outflow deposits occur near the southeast margin of the caldera. Total inferred thickness 700–1,400 m. Dated at 25.0±0.8 Ma (Shawe and others, 1986; K-Ar on biotite), and 24.44±0.11 Ma (Henry, 1997; $^{40}Ar/^{39}Ar$ on sanidine).

Intruded by rhyolite plug and dikes (Tpd) near the southwest margin of the caldera. These rocks and other members of the Round Rock Formation [megabreccia of Silver Creek (Trs) and megabreccia of Sloppy Gulch (Tsg)] are described separately below because of their significance in the development of the Manhattan caldera

Tpd **Rhyolite plug and dikes**—Locally autobrecciated rhyolite that forms a plug (300 × 400 m) and associated dikes as much as 60 m wide near the margin of the Manhattan caldera 3 km northwest of Manhattan. Similar in composition to rhyolite that constitutes a major component of the middle (megabreccia) member of the Round Rock Formation (not differentiated on the map). Eruption of the megabreccia member from an inferred center, now marked by plug and dikes, resulted in a blanket deposit that is spread throughout the caldera, and is thickest near the plug and dikes. Eruption of megabreccia took place along the margin of the caldera, probably just prior to emplacement of the plug and dikes

Trs **Megabreccia of Silver Creek**—Eruptive megabreccia made up of small (less than 1 m) to large (10 m) blocks of granite (mostly Kb) in a matrix of comminuted granite and volcanic ash. Exposed through an area as much as 2 km wide and 7 km long, along the northeast margin of the Manhattan caldera. Local surface relief on the unit is about 200 m. Size sorting of the granite blocks outward from a central point at the margin of the caldera suggests an eruptive origin of the megabreccia (Shawe and Snyder, 1988)

Tsg **Megabreccia of Sloppy Gulch**—Eruptive megabreccia consisting of small to immense blocks and slabs (as long as 700 m) of mostly Paleozoic rocks and lesser amounts of granite and volcanic rocks, in a matrix of volcanic ash. Numerous blocks consist of indurated monolithologic breccia unlike any breccia in wallrocks, as well as minor amounts of rock types unknown in caldera walls, leading to the inference that the megabreccia was erupted from depth (Shawe and Snyder, 1988). Unit is exposed along the south margin of the Manhattan caldera for a distance of about 15 km. Where the megabreccia is inferred to be outflow from vents, it is as much as 200 m thick

Trp **Rhyolite plug (Oligocene)**—A rhyolite plug, about 700 m long (east-west) and 350 m wide (north-south), intrudes the tuff of Mount Jefferson (Tmj) in Wild Horse Canyon northeast of the canyon juncture with Jefferson Canyon. The crystal-poor rhyolite is hydrothermally altered and locally brecciated; surrounding tuff of Mount Jefferson is hydrothermally altered

Tjs **Megabreccia of Jefferson Summit (Oligocene)**—Consists of eruptive megabreccia in three pipes and a dike intruded into granite of the Round Mountain pluton (Kr) and Paleozoic wallrocks, and spread as an outflow apron as much as 3 km from eruptive centers (fig. 2). Eruptive centers mark a northwest-trending zone that is subparallel with the southwest margin of the Mount Jefferson caldera. Megabreccia blocks, as long as several hundred meters but mostly much smaller, are of dominant granite (Kr) and lesser amounts of metamorphosed Paleozoic rocks and of andesite porphyry (Ta); some blocks consist of metamorphosed Paleozoic rocks intruded by andesite porphyry; matrix is mostly comminuted granite. The only plausible source of the andesite porphyry is intrusions at depth. The pipes are elongate bodies from 250 to 600 m long; the dike is as much as 250 m wide and is about 2 km long

Tmj **Tuff of Mount Jefferson (Oligocene)**—Rhyolitic, rhyodacitic, and quartz latitic welded ash-flow tuff erupted from the Mount Jefferson caldera and deposited mostly as caldera fill (fig. 3). Exposed in the north-central part of Area 1 in the south part of the caldera, where maximum exposed thickness is about 500 m and total caldera-fill thickness is probably at least 2,000 m. A small outlier a few hundred meters across is exposed near a rhyolite dike (Tr) in granite in the west part of the Belmont pluton (Kb). Age range of dated samples is 26.63±0.04 Ma to 26.82±0.06 Ma (Shawe and others, 2000; $^{40}Ar/^{39}Ar$ on sanidine) and 26.66±0.05 Ma to 26.93±0.06 Ma (Henry and others, 1996; $^{40}Ar/^{39}Ar$ on sanidine)

Ttr **Tuff of Round Mountain (Oligocene)**—Rhyolitic welded ash-flow tuff exposed in an area of a few square kilometers at and just south of Round Mountain. Thickness about 300 m. Dated at about 26.7±1.7 Ma and 27.0±1.0 Ma (Shawe and others, 1987; K-Ar on biotite and sanidine, respectively) and 26.50±0.06 Ma to 26.53±0.07 Ma (Henry and others, 1996; $^{40}Ar/^{39}Ar$ on sanidine). Probably erupted from a caldera underlying alluvium in Big Smoky Valley (Henry and others, 1996). Host to the large Round Mountain gold mine

Tjc **Megabreccia of Jefferson Canyon (Oligocene)**—Rhyolitic to quartz latitic ash-flow tuff containing sparse to abundant blocks as long as 350 m of Paleozoic rocks, granite (Kr), and a variety of volcanic rocks. Blocks of healed breccia, many with selvages of volcanic glass that vary in thickness from block to block, suggest an eruptive origin of the megabreccia (Shawe and Snyder, 1988). Dated at 32.3±0.7 Ma (Boden, 1986; K-Ar on biotite), 32.18±0.13 Ma (Henry and others, 1996; $^{40}Ar/^{39}Ar$ on sanidine), and 32.56±0.07 Ma and 32.69±0.04 Ma (Shawe, 1999b; $^{40}Ar/^{39}Ar$ on biotite and sanidine, respectively). Described by Henry and others (1996) as tuff of Dry Canyon and related to and confined within a 32.2 Ma caldera mostly buried beneath alluvium of Big Smoky Valley. However, some megabreccia fills a shallow channel extending at least 2 km eastward from the inferred margin of the caldera and cannot be considered to be intracaldera facies. Despite the indication of a 32.2–32.7 Ma age based on radiometric determinations, the megabreccia may be related in part to the tuff of Mount Jefferson (Tmj; about 26.7–26.9 Ma) because that unit contains similar megabreccias, and the matrix of the megabreccia of Jefferson Canyon exhibits extensive resorption of included granite materials that possibly compromised the determined ages. Further, some dated samples may have come from foundered blocks or slabs of older tuff within younger megabreccia. Exposed near the mouth of Jefferson Canyon, and for about 3 km westward toward Round Mountain. Thickness where exposed at the surface 0–65 m

Ta **Andesite dikes (Oligocene)**—Part of a swarm of dikes, most of which are rhyolite (Tr), about 8 km long, passing 2 km southeast of Round Mountain; most abundant in and near a granodiorite stock (Tgd) east of Round Mountain. Individual dikes no more than about 30 m wide and 1 km long. Dated at 36.5±1.2 Ma (Shawe and others, 1986; K-Ar on biotite)

Tgd **Granodiorite of Dry Canyon (Oligocene)**—Forms a crudely crescent-shaped stock about 2 km long on the south side of Jefferson Canyon just southwest of Dry Canyon. The stock intrudes granite (Kr) and adjacent Paleozoic wallrocks and rhyolite dikes (Tr) and is intruded by andesite dikes (Ta). Effects of contact metamorphism (iron-mineral and tourmaline mineralization) are evident as far as almost 3 km from the stock. Dated at 36.1±1.6 Ma and 37.4±2.3 Ma (Shawe and others, 1986; fission track on zircons) and 36.2±2.0 Ma (Shawe and others, 1986; fission track on sphene)

Tr **Rhyolite dikes, sills, and plug (Oligocene)**—Aphanitic to porphyritic, locally flow layered, bodies intruding granite and Paleozoic wallrocks. Rhyolite is the dominant rock type that intrudes granite as a swarm of dikes about 8 km long, passing 2 km southeast of Round Mountain; two long dikes intrude granite (Kr, Kb) north of the Manhattan caldera, and dikes and sills intrude Paleozoic rocks in Jefferson Canyon and south of Round Mountain. Small plugs (one 100 × 300 m, the other smaller) intrude Paleozoic rocks near the Round Mountain pluton (Kr) near Jefferson Canyon. Individual dikes are as much as 65 m wide and 3.5 km long. Dikes have been tourmalinized a kilometer or so outward from the stock. Dated at 35.1±1.2 Ma and 36.0±1.2 Ma (Shawe and others, 1986; K-Ar on biotite) and 34.3±0.9 Ma, 34.4±1.2 Ma, and 34.7±1.2 Ma (Shawe and others, 1986; K-Ar on sanidine)

Ks **Syenite plug (Cretaceous?)**—Syenite and minor shonkinite form a small (40 × 60 m) complex plug of irregularly textured rock intruded into Paleozoic rocks about 2.5 km south of Manhattan. Age of the plug is uncertain; because the plug is locally foliated (as is the foliated Cretaceous granite of Pipe Spring, Kp, to the south that was likely foliated in Cretaceous time), the syenite plug is inferred to be Cretaceous

Kp **Granite of Pipe Spring (Cretaceous)**—Part of a granite pluton about 10 × 13 km in size exposed at the south boundary of Area 1. A few small plugs and irregular apophyses of coarse- and fine-grained granite and aplite intrude Paleozoic sedimentary rocks at and near the margins of the pluton. The pluton is a two-mica granite that contains biotite and muscovite that crystallized during a post-emplacement metamorphism at about 75 Ma. Whole-rock isochron Rb-Sr age is 80.2±2.4 Ma (John and Robinson, 1989), and whole-rock-biotite isochron Rb-Sr age is 80.1±1.0 Ma (Shawe and others, 1986)

Kb **Belmont pluton of the granite of Shoshone Mountain (Cretaceous)**—Forms an oval-shaped pluton about 11 × 19 km in size exposed in the central part of Area 1 northwest of Belmont. The pluton is layered, grading upward from coarse-grained granite to porphyritic, coarse-grained granite. Coarse- and fine-grained granite intrude Paleozoic sedimentary rocks that have been contact metamorphosed near the pluton contact. The pluton is a two-mica granite that contains biotite and muscovite that crystallized during a post-emplacement metamorphism at about 80 Ma. Age of the granite is 84.5±2.3 and 84.8±4.4 Ma (Rb-Sr whole-rock isochrons, John and Robinson, 1989)

Kr **Round Mountain pluton of the granite of Shoshone Mountain (Cretaceous)**—Forms an oval-shaped pluton about 8 × 13 km in size exposed in the north part of Area 1 southeast of Round Mountain (fig. 4). Coarse- and fine-grained granite and aplite intrude Paleozoic sedimentary rocks that have been contact metamorphosed near the pluton contact. The pluton is a two-mica granite that contains biotite and muscovite that crystallized during a post-emplacement metamorphism at about 80 Ma. The Round Mountain pluton is separated from the Belmont pluton by a thin septum about 50–400 m wide of metamorphosed Paleozoic rocks. Age of the granite is 89.6±3.3 Ma (Rb-Sr whole-rock and mineral data, John and Robinson, 1989)

Og **Gabbro (Ordovician?)**—Schistose metagabbro forms podlike bodies as much as 500 m long intruded into interlayered argillite and limestone of the Toquima Formation (Ot) south of the mouth of Bald Mountain Wash

Ot **Toquima Formation (Ordovician)**—Typically thin-bedded, interlayered, marine sedimentary rocks consisting of argillite, limestone, siltstone, and quartzite. Gradations commonly exist between rock types, and some rocks have been metamorphosed to silicified argillite, schist, calc-silicate-mineralized limestone, dolostone, and jasperoid (jasperized or silicified limestone). Extremely deformed by laminar flow (fig. 5), folding (fig. 6), and faulting. Constitutes a thrust plate underlying a thrust plate that consists of the Harkless Formation (€h), and overlying thrust plates that consist respectively of the Zanzibar Formation (Oz), a Cambrian(?)

siltstone unit (Ꞓst), the Gold Hill Formation (Ꞓg), and the Mayflower Formation (Ꞓm). Exposed in the hills about 4–6 km south of Round Mountain; in scattered areas west, south, and east of Manhattan; and along the lower reach of East Manhattan Wash. Original thickness unknown because of extreme deformation; probably several hundred meters. Age of the Toquima Formation in the southern Toquima Range is Mohawkian (Middle Ordovician) based on fossil identifications by R.J. Ross, Jr., of graptolites I collected 5 km south of Round Mountain

Oz **Zanzibar Formation (Ordovician)**—Typically thin- to medium-bedded, interlayered marine sedimentary rocks consisting of argillite and limestone. Some argillite and limestone is silty. Minor limestone is cherty. Locally rocks have been metamorphosed to silicified argillite, schist, calc-silicate-mineralized limestone, dolostone, and jasperoid. Extremely deformed by folding and faulting. Constitutes a thrust plate underlying thrust plates that consist respectively of the Harkless Formation (Ꞓh) and the Toquima Formation (Ot), and overlying thrust plates that consist respectively of a Cambrian(?) siltstone unit (Ꞓst), the Gold Hill Formation (Ꞓg), and the Mayflower Formation (Ꞓm). Exposed in an area as much as 1.5 km wide and 5 km long extending along the southwest margin of the Mount Jefferson caldera; in the hills 4–6 km south of Round Mountain; in a wide area west, south, and east of Manhattan as far as the mouth of East Manhattan Wash; and for several kilometers along the southeast margin of the Round Mountain pluton and the north margin of the Belmont pluton. Original thickness unknown because of extreme deformation; probably several hundred meters. Age of the Zanzibar Formation is Whiterockian (early Middle Ordovician), based on fossil identifications by W.B.N. Berry, R.J. Ross, Jr., and J.W. Huddle of samples collected by F.G. Poole, from near the Manhattan quadrangle and in the Toiyabe Range west of the Toquima Range

Ꞓst **Siltstone unit (Cambrian?)**—Schistose and arkosic siltstone. Exposed in a small area (about 100 × 300 m) 2 km south of Manhattan, and in a second small area (about 500 m long) in the headwaters of Antone Canyon on the southeast side of the Round Mountain pluton (Kr), as a thrust plate lying above a plate of Gold Hill Formation (Ꞓg) and below a plate of Zanzibar Formation (Oz). Thickness unknown; only a few tens of meters exposed. Inferred to be Cambrian in age based on similarity in lithology to other Cambrian formations in the region

Ꞓg **Gold Hill Formation (Cambrian)**—Interlayered phyllitic argillite to mica schist, quartzite, and minor limestone. Limestone is metamorphosed to a calc-silicate mineral assemblage near Cretaceous plutons, and is dolomitized locally near the White Caps mine about 2 km east of Manhattan. Forms a thrust plate that overlies a lower plate of Mayflower Formation (Ꞓm) and underlies successive thrust plates of the Cambrian(?) siltstone unit (Ꞓst), Zanzibar Formation (Oz), Toquima Formation (Ot), and Harkless Formation (Ꞓh). Exposed near the lower reach of Jefferson Canyon; in a wide (1–3 km) area extending from Manhattan east-southeastward to the mouth of East Manhattan Wash; in scattered areas along the north margin of the Pipe Spring pluton; and along the east margin of the Round Mountain pluton for about 5 km south from Jefferson Summit. Exposed thickness uncertain because of strong internal deformation and thrust fault truncation; original thickness probably at least 1 km. Age of the Gold Hill Formation was considered by Ferguson and Cathcart (1954) to be Early Cambrian based on correlation with dated rocks of the formation in the Toiyabe Range to the west

Ꞓm **Mayflower Formation (Cambrian?)**—Schist, mostly knotted schist, and minor quartzite and limestone. Extremely deformed by shearing and isoclinal folding. Forms a plate below successive thrust plates of Gold Hill Formation (Ꞓg), Cambrian(?) siltstone unit (Ꞓst), Zanzibar Formation (Oz), Toquima Formation (Ot), and Harkless Formation (Ꞓh). Exposed on the north margin of the Round Mountain pluton south of Jefferson Canyon; in the hills 4–6 km south of Round Mountain; in a narrow east-trending strip less than 100 to a few hundred meters wide that forms a septum between the Round Mountain and Belmont plutons, widening eastward beyond the plutons to a kilometer or more; and in scattered areas west, south, and east of Manhattan as far as the mouth of East Manhattan Wash. Original thickness unknown, but probably a kilometer or more

Ꞓh **Harkless Formation (Cambrian)**—Interlayered phyllitic schist and silicified argillite, with minor siltstone, sandstone, limestone, and dolostone. Forms a thrust plate overlying thrust plates of the Toquima (Ot) and Zanzibar (Oz) Formations in an area of several square kilometers in the southwest corner of the map area and between Manhattan Wash and the southwest margin of the Manhattan caldera. Full thickness not exposed; exposed thickness about 500 m. The Harkless Formation is of Early Cambrian age, based on presence of *Salterella* (identified by E.L. Yochelson of the U.S. Geological Survey) collected by F.G. Poole from several localities near and just west of the edge of Area 1. Lithologically similar to and of the same age as the Harkless Formation in southwestern Nevada and southeastern California (for example, Stewart, 1966; McKee and Moiola, 1962)

NORTHEAST QUARTER OF THE MAP (AREA 2)

[For units previously discussed, only appropriate additional information, such as distribution, is provided]

Qs **Surficial deposits (Quaternary)**

Tcm **Megabreccia of Corcoran Creek (Miocene?)**—Small (a meter or more in diameter) to large (200 m long) blocks and slabs of variously brecciated (some multiply brecciated, some virtually intact) rhyolite, ash-flow tuff, and Paleozoic rocks in a matrix of microbrecciated rhyolitic fragments of both intrusive and ash-flow tuff origin. Inferred to fill a pipe or diatreme that underwent several phases of emplacement, possibly involving both eruption and subsidence. Exposed as a crudely oval-shaped body about 1 km long, between Corcoran Canyon and the south fork of Corcoran Canyon on the east side of the Toquima Range

Ty **Younger ash-flow tuffs and associated tuffaceous siltstone (Miocene and Oligocene)**—A section of ash-flow tuffs and underlying tuffaceous siltstone (all units not everywhere present) consists, from top down, of a biotite-bearing rhyodacitic ash-flow tuff; upper member of rhyolitic ash-flow tuff of Pipe Organ Spring that locally contains or overlies a lens of the rhyolitic ash-flow tuff of Clipper Gap dated at 22.7±0.6 Ma (Grommé and others, 1972; K-Ar on sanidine); rhyolitic Bates Mountain Tuff dated at 23.9±0.9 Ma (McKee and Stewart, 1971), 23.7±0.6 Ma (Grommé and others, 1972), 23.4±0.9 Ma (Sargent and McKee, 1969), and 24.5±1.0 Ma (McKee and Stewart, 1971) (all K-Ar on sanidine); lower member of the rhyolitic ash-flow tuff of Pipe Organ Spring (fig. 7) dated at 25.37±0.05 Ma and 25.42±0.05 Ma (Shawe and others, 2000; $^{40}Ar/^{39}Ar$ on sanidine); and tuffaceous siltstone. The younger ash-flow tuffs are exposed on slopes just west of the upper reach of Meadow Canyon, and on Three Summits Hill, Little Table Mountain, and hills 7975 and 7672, successively to the east, as well as on and near Meadow Creek Bench north and south of Meadow Creek. Tuffaceous siltstone is present only on Meadow Creek Bench. Aggregate maximum thickness of the younger ash-flow tuffs and tuffaceous siltstone is more than 300 m, but in any one place thickness does not exceed about 100 m

Thb **Heterolithic breccia (Oligocene)**—Breccia of mixed rock types including rhyolite (Trp), tuff of Ryecroft Canyon (Trc), pumice, and several varieties of Paleozoic rocks, in a pulverized matrix of the several rock types and tuff matrix of the megabreccia of Meadow Canyon (Tmc). Breccia fragments are as large as about 1 m in diameter. The unit forms a shell that surrounds, and extends outward as much as 300 m from, the rhyolite plugs (Trp) in Meadow Canyon about 3 km from the mouth of the canyon (fig. 8). The breccia is related to emplacement of the plugs: within a few meters of the plugs, slablike breccia fragments are crudely oriented parallel to the nearly vertical walls of the plugs, and in places blocks form vertical trains, suggesting laminar flow of material resulting from drag that accompanied emplacement of the plugs

Trp **Rhyolite plugs (Oligocene)**—Several plugs emplaced near the structural margin of the Mount Jefferson caldera in and northeast of Corcoran Canyon, and along the northwest-trending structural zone of the lower reach of Meadow Canyon. Two adjacent small plugs in Meadow Canyon are surrounded by heterolithic breccia (Thb) formed as a result of intrusion of the plugs into surrounding rocks (fig. 8). Size of plugs ranges from about 100 m in diameter to as large as 300 × 1,200 m. Plugs dated at 26.2±0.8 Ma (McKee and John, 1987; K-Ar on biotite) and 26.60±0.05 Ma (Shawe and others, 2000; $^{40}Ar/^{39}Ar$ on sanidine)

Tsp **Shingle Pass Tuff (Oligocene)**—Ash-flow tuff widely distributed in the north part of Area 2, where it underlies younger ash-flow tuffs (Ty) and overlies Isom-type ash-flow tuff (Ti; see below). Thickness 20–115 m. Two members that consist respectively of latitic ash-flow tuff and quartz latitic ash-flow tuff are dated at 26.00±0.03 Ma and 26.68±0.03 Ma (Best and others, 1989; $^{40}Ar/^{39}Ar$ on sanidine)

Ti **Isom-type ash-flow tuff (Oligocene)**—Rhyodacitic ash-flow tuff. The term "Isom compositional type" or "Isom type" was used by Page and Dixon (1994) to include a number of ash-flow tuff units in eastern Nevada and western Utah that are similar in phenocryst composition to the distinctive Isom Formation of eastern Nevada and western Utah. Locally present in a wide area in the north part of Area 2, where it underlies Shingle Pass Tuff (Tsp) and overlies volcaniclastic rocks of Little Table Mountain (Tlt). An isolated exposure about 1 km long of Isom-type ash-flow tuff is faulted down into the tuff of Ryecroft Canyon (Trc) just north of the mouth of Meadow Canyon. Maximum thickness about 35 m

Tbf **Megabreccia of Bull Frame Canyon (Oligocene)**—Ash-flow tuff containing small to large (as much as 30 m in diameter) blocks of a variety of rock types (Tertiary volcanic, Cretaceous granitic, and Paleozoic sedimentary rocks). Contains interlayered fluvial gravel in places, suggesting possible reworking from older deposits (for example, megabreccia of Meadow Canyon, Tmc). Exposed in a small area about 1 km long just south of Bull Frame Canyon, where it overlies mesobreccia of Paleozoic rock fragments (Tpm) and volcaniclastic rocks of Little Table Mountain (Tlt). Maximum remnant thickness about 30 m

Tlt **Volcaniclastic rocks of Little Table Mountain (Oligocene)**—Interlayered tuffaceous siltstone, sandstone, and conglomerate, zeolitic tuff, and ash-flow tuff. Underlies Isom-type ash-flow tuff (Ti) or slightly younger rocks; unconformably overlies tuff of Mount Jefferson (Tmj), megabreccia of Meadow Canyon (Tmc), and tuff of Corcoran Canyon (Tcc), and is conformable above and interbedded with mesobreccia of Paleozoic rock fragments (Tpm) and unnamed megabreccia (Tum). Widely exposed north and south of Three Summits Hill and Little Table Mountain and eastward to the edge of Monitor Valley. Maximum thickness about 350 m. Lower part dated at 26.65±0.07 Ma (Shawe and others, 2000; $^{40}Ar/^{39}Ar$ on sanidine).

In an area that covers about 1 km^2 between Corcoran Canyon and south fork of Corcoran Canyon, tuffaceous rocks of the unit are considerably disrupted and contain foundered blocks of younger ash-flow tuffs (Ty), probably because of slumping and loss of cohesion of a large slab of the unit as a result of removal of lateral support during formation (eruption and subsidence?) of the adjacent diatreme that consists of the megabreccia of Corcoran Creek (Tcm)

Tpm **Mesobreccia of Paleozoic rock fragments (Oligocene)**—Fragments of Paleozoic rocks mostly 1–20 cm long and no larger than 1.5 m long are mixed together; tuff matrix is rarely evident. The unit underlies volcaniclastic rocks of Little Table Mountain (Tlt), and it lies unconformably upon Gold Hill Formation (Ꞓg), Zanzibar Formation (Oz), and the tuff of Antone Canyon (Tac), in an area south of Meadow Canyon, from Bull Frame Canyon to Antone Canyon. It appears to tongue into the megabreccia of Meadow Canyon (Tmc) farther east. Thickness 0–60 m

Tum **Unnamed megabreccia (Oligocene)**—Contains blocks as large as 10 m in diameter of a variety of ash-flow tuff types and minor amounts of volcanic sandstone and conglomerate, granite, and Paleozoic sedimentary rocks. Characterized by common and distinctive well-rounded and polished boulders of light-gray densely welded rhyolitic ash-flow tuff of Ryecroft Canyon (Trc). Underlies and is interlayered with volcaniclastic rocks of Little Table Mountain (Tlt), and unconformably overlies tuff of Mount Jefferson (Tmj), megabreccia of Meadow Canyon (Tmc), and tuff of Corcoran Canyon (Tcc). Scattered exposures as much as 800 m long occur in the central part of Area 2. Maximum thickness about 15 m

Tjs **Megabreccia of Jefferson Summit (Oligocene)**—Present mostly in the west half of the map area (Area 1); a small part extends into the west edge of Area 2

Trf **Rhyolite flow rock (Oligocene)**—Porphyritic rhyolite flow, some phenocrysts as long as 1 cm. Similar in phenocryst content to some of the rhyolite plugs (Trp) in the area. The flow caps Peak 9398 in the north-central part of Area 2; it overlies the tuff of Mount Jefferson (Tmj). Maximum remnant thickness 35 m

Tmj **Tuff of Mount Jefferson (Oligocene)**—Exposed widely in the north part of Area 2, as caldera fill within the Mount Jefferson caldera. Occurs as outflow as much as 90 m thick near Meadow Canyon near the west edge of Area 2

Tac **Tuff of Antone Canyon (Oligocene)**—Nonwelded pumiceous rhyolitic ash-flow tuff. Similar in phenocryst composition to the tuff of Ryecroft Canyon (Trc); possibly an aberrant part of that unit. Contains isolated scattered blocks and slabs as long as 200 m of Ordovician limestone, silicified limestone, and schist, quartzite of the Cambrian Gold Hill Formation (Ꞓg), Cambrian(?) Mayflower Formation (Ꞓm), rhyolitic welded ash-flow tuff, and rhyolite lava. Exposed in an area about 1 × 2 km along Antone and Round Meadow Canyons where they enter Meadow Canyon. Unconformably underlies outflow facies of the tuff of Mount Jefferson (Tmj) and mesobreccia of Paleozoic rock fragments (Tpm), intertongues with the megabreccia of Meadow Canyon (Tmc), and unconformably overlies Paleozoic formations. Maximum thickness about 150 m

Tmc **Megabreccia of Meadow Canyon (Oligocene)**—Eruptive megabreccia of small to huge (more than 300 m long) rounded blocks and slabs, mostly brecciated, of chiefly welded ash-flow tuff of Ryecroft Canyon (Trc) and minor amounts of other volcanic rocks, in a nonwelded to partially welded ash-flow tuff matrix in large part similar in phenocryst composition to the tuff of Ryecroft Canyon. Exposed on both sides of Meadow Canyon about 1.5–6 km from the mouth of the canyon, in an area about 2 × 6 km in size, and in scattered outcrops farther south. Locally contains layers of the tuff of Ryecroft Canyon (Trc). Large slablike blocks of welded tuff in the central part of exposed megabreccia stand vertically in surrounding ash-flow tuff matrix, suggesting a vertical component to movement when emplaced, perhaps resulting from eruption through a conduit underlying the area. Rhyolite plugs (Trp) that intrude the megabreccia in this area also indicate a conduit originating at great depth. Megabreccia is exposed through a relief of at least 200 m in the area

Trc **Tuff of Ryecroft Canyon (Oligocene)**—Rhyolitic ash-flow tuff erupted from an inferred caldera that mostly underlies the south end of Monitor Valley. The unit is exposed in the south-central part of Area 2, on both sides of Meadow Creek and in the lower reach of Meadow Canyon. Maximum exposed thickness about 200 m near Meadow Canyon where the unit lies in an apparent northwest-trending graben that parallels a major northwesterly structural zone in the canyon. The inferred graben may be a lateral protrusion stemming from the hypothetical caldera underlying Monitor Valley. The Ryecroft Canyon is dated at 26.82±0.04 Ma and 26.83±0.05 Ma (Shawe and others, 2000; 40Ar/39Ar on sanidine).

The tuff of Ryecroft Canyon is of the same age as, and petrographically similar to, the tuff of Moores Creek (Boden, 1986) that was erupted from a caldera described as lying 2–20 km north of the map area. If the tuff of Moores Creek and the tuff of Ryecroft Canyon were erupted from the same caldera, it was an extremely large structure, trending north-northwest and perhaps as much as 50 km long (Shawe and Byers, 1999)

Tmb **Monolithologic megabreccia (Oligocene)**—Generally rounded blocks and slabs as long as 15 m, ranging in size down to a pulverized groundmass of apparently the same material. Most blocks appear to be of the tuff of Ryecroft Canyon (Trc). Unit underlies exposed tuff of Ryecroft Canyon, on a moderately dipping contact, for about 1.7 km along the range front north and south of the mouth of Meadow Canyon. Maximum thickness about 200 m; base not exposed

Tcc **Tuff of Corcoran Canyon (Oligocene)**—Rhyolitic, quartz latitic, and rhyodacitic welded ash-flow tuff erupted from a caldera now largely obscured by a younger (nested?) Mount Jefferson caldera and the inferred caldera underlying Monitor Valley. Petrographically similar to the younger tuff of Mount Jefferson (Tmj). Unconformably underlies younger ash-flow tuffs (Ty), volcaniclastic rocks of Little Table Mountain (Tlt), unnamed megabreccia (Tum), and megabreccia of Meadow Canyon (Tmc); base not exposed. Constitutes a sequence of flows about 2,000 m thick that extends for about 7 km along the range front north of Meadow Canyon and beyond Corcoran Canyon. Upper part dated at 27.05±0.06 Ma and 27.17±0.05 Ma (Shawe and others, 2000; $^{40}Ar/^{39}Ar$ on sanidine)

Kb **Belmont pluton of the granite of Shoshone Mountain (Cretaceous)**—A few square kilometers of the pluton occupy the southwest corner of Area 2

Kr **Round Mountain pluton of the granite of Shoshone Mountain (Cretaceous)**—The eastern tip of the pluton lies just within the west edge of Area 2

Ot **Toquima Formation (Ordovician)**—About 2 km^2 of the Toquima Formation thrust plate are exposed in the southwest part of Area 2, overlying thrust plates of Zanzibar Formation (Oz) and Mayflower Schist (Ꞓm). Locally overlain unconformably by tuff of Ryecroft Canyon (Trc)

Oz **Zanzibar Formation (Ordovician)**—Several square kilometers of the Zanzibar Formation thrust plate form scattered exposures in the southwest part of Area 2, underlying the thrust plate of Toquima Formation (Ot), and overlying thrust plates of the siltstone unit (Ꞓst), Gold Hill Formation (Ꞓg), and Mayflower Schist (Ꞓm). In places the thrust plate is sharply infolded into the underlying plate of Mayflower Schist (Ꞓm) (fig. 9). Deformed and relatively undeformed limestone occur in close proximity locally, suggestive of structural complexity (figs. 10, 11). Locally overlain unconformably by mesobreccia of Paleozoic rock fragments (Tpm), tuff of Antone Canyon (Tac), and megabreccia of Meadow Canyon (Tmc)

Ꞓst **Siltstone unit (Cambrian?)**—Small areas (as much as several hundred meters long) of the siltstone unit are exposed in and near Antone Canyon in the southwest part of Area 2. The unit occurs in a thrust plate that lies between an overlying thrust plate of Zanzibar Formation (Oz) and an underlying thrust plate of Gold Hill Formation (Ꞓg)

Ꞓg **Gold Hill Formation (Cambrian)**—A thrust plate of the formation is exposed in two areas aggregating about 2 km^2 in the southwest part of Area 2. The plate underlies thrust plates of the Zanzibar Formation (Oz) and siltstone unit (Ꞓst) and overlies a thrust plate of the Mayflower Schist (Ꞓm). Locally overlain unconformably by mesobreccia of Paleozoic rock fragments (Tpm) and megabreccia of Meadow Canyon (Tmc)

Ꞓm **Mayflower Schist (Cambrian?)**—Widely exposed in the southwest part of Area 2, where it constitutes a lower plate beneath thrust plates of the Gold Hill Formation (Ꞓg), siltstone unit (Ꞓst), and Zanzibar Formation (Oz). Within 1–2 km of granite contacts the Mayflower consists of schist; at greater distance the unit is phyllitic argillite to platy shale. Locally overlain unconformably by the megabreccia of Meadow Canyon (Tmc) and the tuff of Ryecroft Canyon (Trc)

SOUTHEAST QUARTER OF THE MAP (AREA 3)

[For units previously discussed, only appropriate additional information, such as distribution, is provided.]

Qs **Surficial deposits (Quaternary)**

Ty **Younger ash-flow tuffs and associated tuffaceous siltstone (Miocene and Oligocene)**—Exposed at the east-central margin of Area 3 in limited exposures, the largest of which is about 1 km long

Tbs **Tuff of The Bald Sister (Oligocene)**—A small outcrop caps a knob underlain by ash-flow tuff of the Diamond King Formation (Tdk) and megabreccia of Silver Creek (Trs) upon granite (Kb) 2 km west of Belmont

Trd **Rhyolite and rhyodacite plugs (Oligocene)**—Several small (less than 150 m long) rhyolite plugs intrude southern facies of Paleozoic rocks of the Monarch area

(Pzms) in the southwest part of Area 3. Dated at 25.1±2.3 Ma (Shawe and others, 1987; fission track on zircon)

Tdk **Diamond King Formation (Oligocene)**—Remnants of a once extensive ash-flow sheet crop out on five knobs of granite (Kb) 1–3 km west of Belmont. All remnants are underlain by thin layers of megabreccia of Silver Creek (Trs); the middle remnant is capped by a small outcrop of ash-flow tuff of The Bald Sister (Tbs)

Tos **Crystal-rich ash-flow tuff (Oligocene)**—Rhyolitic ash-flow tuff characterized by small veinlet and cavity fillings of white opaline silica. May correlate with the Diamond King Formation (Tdk). Exposed as small remnants overlying Isom-type tuff (Ti) in the southwest corner of Area 3, and as larger remnants, as much as 900 m across, unconformably overlying Isom-type tuff and the tuff of Ryecroft Canyon (Trc) in the central part of Area 3, near the west edge of Monitor Valley. Maximum remnant thickness about 110 m

Trs **Megabreccia of Silver Creek (Oligocene)**—Thin layers of megabreccia underlie ash-flow tuff of the Diamond King Formation (Tdk) and are unconformable upon granite (Kb) on five knobs 1–3 km west of Belmont

Tvs **Volcanic sandstone (Oligocene)**—Composed of detritus apparently reworked partly from Isom-type welded ash-flow tuff formation (Ti) and hornblende-biotite andesitic plugs and flows (Tap) to the west. Scattered exposures lie east and southeast of Long Ridge (informal name) at the edge of Monitor Valley, in the south-central part of Area 3. Thickness not known, but probably not greater than a few tens of meters

Ti **Isom-type ash-flow tuff (Oligocene)**—Rhyodacitic ash-flow tuff. Exposed in the southwest part of Area 3, for several kilometers along the crest of an unnamed ridge (fig. 12) and along Long Ridge, as well as capping small hills in that vicinity. Maximum thickness about 155 m

Tap **Andesite plugs and flows (Oligocene)**—Porphyritic biotite and hornblende-biotite andesite intrude and overlie quartz latite ash-flow tuff (Tbql), lacustrine limestone (Tl), white ash-fall tuff (Tat), and a claystone-siltstone-sandstone unit (Tcs) in the southwest part of Area 3. The largest mass is a plug and flow complex that extends for about 1.7 km along the south edge of Area 3. Dated at 26.3±0.9 Ma, 26.6±1.0 Ma, and 26.8±1.0 Ma (Shawe and others, 1987; K-Ar on biotite)

Trt **Rhyolitic ash-flow tuff (Oligocene)**—Unconformably underlies Isom-type ash-flow tuff (Ti) and appears conformable above, or intertonguing with, underlying white ash-fall tuff (Tat). Restricted to small areas a few hundred meters or less long in the south-central part of Area 3. Thickness 0–55 m

Tmj **Tuff of Mount Jefferson (Oligocene)**—Exposed only in a small area a few hundred meters long in the south-central part of Area 3, where the rocks conformably(?) overlie steeply tilted layers of the tuff of Ryecroft Canyon (Trc) along a segment of the Hunts Ranch fault. Tilting of the layers is attributed to drag along the fault during inferred strike-slip movement. Thickness about 200 m

Tfd **Rhyolite flows and domes (Oligocene)**—Flow-layered rhyolite and lithophysal vitrophyre form an arcuate group of hills about 8 km long, part of the McKinney Mountains in the south part of Area 3. The rocks may have been emplaced along the structural margin of a hypothetical caldera underlying Monitor Valley, mostly buried beneath alluvial fill of the valley. The rhyolite is compositionally similar to ash-flow tuff of Ryecroft Canyon (Trc), thought to have been erupted from the hypothetical caldera

Trv **Vitrophyric rhyolite lava (Oligocene)**—Vitrophyric flow-layered lava occurs in scattered areas where it overlies rhyolitic lahar (Tlh) and white ash-fall tuff (Tat) and is intruded by both rhyolite plugs (Trv) and rhyolite flows and domes (Tfd) in the south-central part of Area 3. Maximum thickness of flows about 35 m; in part intrusive

Tms **Mesobreccia (Oligocene)**—Scattered outcrops of mesobreccia south of hill 7457 and about 1 km west of Long Ridge in the south part of Area 3 contain varied clasts including dominant fragments (as large as 1 m in diameter) of quartz-rich tuff of Ryecroft Canyon (Trc). Other clasts are Paleozoic greenstone (Pzmn), chert, siliceous argillite, and schist. The unit in its largest exposure, about 400 × 500 m in size and where it appears to overlie white ash-fall tuff (Tat) conformably, is about 10–15 m thick

Tat **White ash-fall tuff (Oligocene)**—Bedded, poorly consolidated, pumiceous, crystal-poor quartz latitic ash-fall tuff exposed in the south part of Area 3 (fig. 12). Probably in part water laid; contains lenses of pebble conglomerate. Contact relations with adjacent units are complex. Younger rocks lie unconformably upon the unit, except locally where rhyolitic ash-flow tuff (Trt) is interbedded at the top. The white ash-fall tuff interfingers with or lies conformably(?) on the claystone-siltstone-sandstone unit (Tcs). It appears to overlie conformably megabreccia of Hunts Canyon (Tmh) and to overlie unconformably rhyolitic lahar (Tlh). In the southeast corner of Area 3 white ash-fall tuff fills a deep channel cut into underlying rhyolitic lahar. Maximum thickness about 200 m. Dated at 27.0±1.0 Ma (K-Ar on biotite; Shawe and others, 1987)

Tl **Lacustrine limestone unit (Oligocene)**—Fresh-water algal limestone that contains local lenses of hot springs sinter and chert-rich conglomerate with some volcanic clasts, and microbreccia of volcanic rocks. Where it surrounds a small plug of andesite (Tap) that intruded and domed limestone, a contained microbreccia includes clasts of andesite that probably were emplaced as a result of phreatic explosions accompanying intrusion of andesite into water-saturated limestone. Limestone, exposed in a few small areas in the southwest part of Area 3, is unconformable beneath white ash-fall tuff (Tat) and above the claystone-siltstone-sandstone unit (Tcs) and biotite-quartz latite ash-flow tuff (Tbql). Maximum thickness about 10 m

Tmh **Megabreccia of Hunts Canyon (Oligocene)**—Eruptive(?) megabreccia consisting of small (1 m) to large (200 m) blocks, in part brecciated, mostly of welded rhyolitic ash-flow tuff similar in composition to the rhyolitic tuff of Ryecroft Canyon (Trc). The megabreccia also contains less abundant clasts of flow breccia, flow-layered rhyolite lava, ash-fall tuff, and platy volcaniclastic rocks, as well as minor Paleozoic limestone, chert, siliceous shale, and quartzite. Matrix is crystal-rich rhyolitic ash-flow tuff similar in phenocryst composition to the tuff of Ryecroft Canyon. The megabreccia likely is related to that unit because the two appear to be of the same volcanic cycle and source. A large block of ash-fall tuff possibly derived from the claystone-siltstone-sandstone unit (Tcs) encloses a dike that contains mostly volcanic fragments and lesser amounts of Paleozoic chert, schist, greenstone(?), and quartzite, and coarsely-crystalline hornblende-biotite quartz monzonite. Presence of plutonic quartz monzonite, unknown at the surface within more than 5 km, suggests that the clast was derived from depth during eruptive emplacement of the megabreccia. The megabreccia covers an area of about a square kilometer near the south-central edge of Area 3, where it appears to conformably underlie the white ash-fall tuff (Tat), conformably overlie and intertongue with the claystone-siltstone-sandstone unit (Tcs), and conformably overlie layered pumice tuff (Tpt). It also underlies, beneath a detachment fault, a small plate of southern facies of Paleozoic oceanic rocks of the Monarch area (Pzms)

Tcs **Claystone-siltstone-sandstone unit (Oligocene)**—Thin-bedded and platy volcanic claystone, siltstone, and sandstone, and minor pebble conglomerate lenses. Probably mostly lacustrine. Contains several large lenses of pumiceous tuff, similar in phenocryst composition to the tuff of Ryecroft Canyon (Trc). Unit exposed in a north-trending zone about 4 km long in the south-central part of Area 3. It conformably underlies and interfingers with white ash-fall tuff (Tat); south of Hunts Ranch fault it underlies and interfingers with megabreccia of Hunts Canyon (Tmh). It appears to unconformably overlie rhyolitic lahar (Tlh). Maximum thickness about 75 m

Tbql **Ash-flow tuff (Oligocene)**—Crystal-rich biotite-quartz latite ash-flow tuff. Exposed in small areas no more than a few hundred meters across in the southwest corner of Area 3. Appears to underlie the claystone-siltstone-sandstone unit (Tcs). Probably correlates with the main ash-flow tuff unit that fills the Big Ten Peak caldera to the south (tuff of Big Ten Peak; Keith, 1987a, b, 1993). Exposed thickness about 130 m

Tlh **Rhyolitic lahar (Oligocene)**—Contains blocks (as large as 5 m in diameter) of mostly flow-layered rhyolite, and lesser amounts of pumiceous rhyolite and vitrophyre, in a matrix of smaller fragments and pulverized rhyolite, and locally, whitish ash-fall tuff. Mostly structureless; in places layered or contains lenses of bedded tuff. Lahar is intruded both by rhyolite plugs (Trv) and by rhyolite flows and domes (Tfd). It is overlain unconformably by the claystone-siltstone-sandstone unit (Tcs), white ash-fall tuff (Tat), and vitrophyric rhyolite flows (Trv). Exposed widely northeast of Hunts Ranch fault in the south part of Area 3; base not exposed; thickness at least 120 m

Trc **Tuff of Ryecroft Canyon (Oligocene)**—Exposed widely around the periphery of the south end of Monitor Valley where its maximum thickness is a few hundred meters locally; there the unit is interpreted as caldera fill within a caldera inferred to underlie Monitor Valley. Steeply tilted layers of the unit on the southwest side of Hunts Ranch fault may have been deformed as a result of drag along the fault during inferred strike-slip movement

Tpt **Layered pumice tuff (Oligocene)**—Interlayered air-fall tuffs, surge(?) deposits, and water-laid tuffaceous sediments. Made up of a sequence of tuffaceous layers that contain pumice fragments and varied amounts of lithic fragments (rhyolite and Paleozoic siliceous argillite and shale). The unit conformably(?) underlies megabreccia of Hunts Canyon (Tmh) and probably also the claystone-siltstone-sandstone unit (Tcs) in a small area south of Hunts Ranch fault at the south edge of Area 3. Thickness several tens of meters within the map area; base not exposed. South of Area 3 the unit overlies a thick section of ash-flow tuffs that may be part of the caldera fill in the Big Ten Peak caldera (Keith, 1987a, b)

Kb **Belmont pluton of the granite of Shoshone Mountain (Cretaceous)**—Several square kilometers of the southeast part of the pluton is exposed around the north end of Ralston Valley in the west part of Area 3. Alluvium in the valley forms a relatively thin layer upon a pedimented surface of the granite; erosion of alluvium locally has exposed granite (fig. 13)

Ot **Toquima Formation (Ordovician)**—The formation is exposed in a strip about 1 km wide and extending for about 10 km near the east and southeast margins of the Belmont pluton, in the west part of Area 3. In the north part of its exposure, the Toquima Formation forms a thrust plate above the Ordovician Zanzibar Formation (Oz) and the Cambrian(?) Mayflower Schist (Єm). About 1–2 km east of the town of Belmont the formation is overlain on a thrust contact by a plate made up mainly of limestone of undetermined Paleozoic age (Pz). Near the south end of the strip of exposed Toquima Formation, the unit is thrust over northern facies of oceanic rocks of the Monarch area (Pzmn). The formation is principal host to the silver deposits of the Belmont mining district; principal localizers of the silver deposits are a north-striking fault and the thrust fault underlying the Toquima plate

Oz **Zanzibar Formation (Ordovician)**—The formation is exposed in a narrow strip less than 1 km wide along the east margin of the Belmont pluton, and in another narrow strip about 1 km farther east in the north part of Area 3. It is intruded by the Belmont pluton at the west edge of the strip. Elsewhere it constitutes a thrust plate overlying a plate of Cambrian(?) Mayflower Schist (Єm) and underlying a plate of Toquima Formation (Ot)

Pz **Limestone unit (Paleozoic, undivided)**—A thrust plate composed mostly of marine turbiditic limestone overlies the Toquima Formation (Ot) and Mayflower Schist (Єm) east of Belmont along the edge of Monitor Valley. In addition to limestone, varied amounts of jasperized limestone, interbedded limestone and argillite, and argillite are present. The rocks in the plate have similarities to rocks in both the Toquima (Ot) and Zanzibar (Oz) Formations, but they exhibit no features that could be used to assign them to one or the other of those formations. The rocks are mostly only mildly deformed (fig. 14); a minor amount is relatively undeformed (fig. 15). They are in a structural position different from those of the Toquima and Zanzibar

Rocks of the Monarch area (Paleozoic, undivided)—A thrust plate of oceanic (ophiolitic) rocks is exposed in an area of several square kilometers in the southwest part of Area 3. A northern facies and a southern facies are distinguished, separated by the northwest-striking Hunts Ranch fault

Pzmn **Northern facies**—North of the Hunts Ranch fault, greenstone consisting of interlayered intermediate to mafic tuffs and flows, graywackes, chert, and agglomerates is interlayered and (or) tectonically intermixed with metasomatite (metasomatised carbonate rock, probably marine sedimentary). Greenstone is in part schistose. Northern facies is overlain by a thrust plate of Ordovician Toquima Formation (Ot). Base of the greenstone unit is not exposed

Pzms **Southern facies**—South of the Hunts Ranch fault, rocks consist of greenstone as flows associated with argillite-chert, dolostone, metasomatite, and serpentinite. This facies also probably is tectonically intermixed, and may be part of a separate but related thrust plate. A detached slab of the southern facies lies upon Tertiary volcanic rocks [tuff of Ryecroft Canyon (Trc), megabreccia of Hunts Canyon (Tmh), and White ash-fall tuff (Tat)] on the southwest side of Hunts Ranch fault, and 4 km southeast of allochthonous southern facies, the apparent equivalent of the detached slab. Movement of the detached slab is thought to have resulted from drag of a "flap" of southern facies rocks southeastward during right-lateral movement along the Hunts Ranch fault

€m **Mayflower Schist (Cambrian?)**—Elongate exposures of the formation in the west part of Area 3 represent eroded antiforms in a thrust fault that brought chiefly Toquima Formation (Ot) over Mayflower Formation. Some parts of the formation in the area are not schistose

SUMMARY OF GEOLOGIC EVENTS

Summaries of geologic events that affected the six quadrangles that are recompiled in the 1:48,000-scale map of part of the southern Toquima Range and adjacent areas were presented previously [Round Mountain (Shawe, 1995); Belmont West (Shawe, 1998); Manhattan (Shawe, 1999a); Jefferson (Shawe, 1999b); Belmont East (Shawe and Byers, 1999); and Corcoran Canyon (Shawe and others, 2000)]. A brief summary is presented here also, to aid users of this map. Data presented herewith on mineralizing events are taken principally from Shawe (1988).

Lower Paleozoic marine sedimentary rocks [Cambrian Harkless (€h), Mayflower (€m), Gold Hill (€g), and siltstone unit (€st), Ordovician Zanzibar (Oz) and Toquima (Ot), Paleozoic limestone (Pz), and Paleozoic ophiolite (Pzmn and Pzms)] were deposited near and outward of the western margin of paleo-North America. Subsequently, they were obducted onto the continent during several stages probably from late Paleozoic to late Mesozoic time. As a result of this deformation, several thrust plates were emplaced in the area of the southern Toquima Range, including a lower plate of Mayflower Schist and successively higher plates of Gold Hill Formation, the Cambrian(?) siltstone unit, Zanzibar Formation, Toquima Formation, Harkless Formation, and Paleozoic limestone unit. A plate (possibly two plates) of Paleozoic ophiolite was thrust into the area before the Toquima Formation was emplaced. A separate plate of Paleozoic limestone also was thrust into the area, but following emplacement of the Toquima Formation. The thrust plates generally were severely deformed internally during emplacement, the lower plates appearing to be more extensively deformed than were the higher plates, and earlier thrust faults were themselves deformed as a result of younger thrusting. Unresolved structural complexities remain.

Three granitic plutons were intruded into the severely deformed Paleozoic rocks in Cretaceous time, the Round Mountain pluton (Kr) at about 90 Ma, the Belmont pluton (Kb) at about 85 Ma, and the Pipe Spring pluton (Kp) at about 80 Ma. The Round Mountain and Belmont plutons were intruded by fine-grained granite and aplite, domed, metamorphosed, and mineralized at about 80 Ma. The Pipe Spring pluton was affected by similar events at about 75 Ma. Metamorphism of the plutons resulted in their conversion to two-mica granites. Silver mineralization at Belmont probably occurred during the mineralizing event that affected the Belmont pluton at about 80 Ma. Tungsten and related mineralization took place in the Round Mountain and Belmont plutons also at about 80 Ma (fig. 16).

Tertiary igneous activity commenced at about 36 Ma with emplacement of a swarm of northeast-striking rhyolite dikes (Tr), mostly intruded into the Round Mountain pluton east of Round Mountain. Intrusion of a granodiorite stock (Tgd), and then andesite dikes (Ta), followed shortly thereafter. Intrusion of the stock was accompanied by mineralization that formed a tourmaline halo, and base and precious metal deposition, surrounding the stock. An initial phase of mineralization at the Jefferson mining district may have occurred at the same time.

Volcanic activity flared in the area at about 27 Ma with formation of a caldera in which the tuff of Corcoran Canyon (Tcc) was deposited. Configuration and extent of the caldera are unknown. Following in quick succession were formation of a caldera that produced the tuff of Ryecroft Canyon at about 26.8 Ma (located mostly beneath alluvial fill in Monitor Valley?) and formation of the Mount Jefferson caldera from which the tuff of Mount Jefferson was erupted at about 26.9–26.6 Ma. The tuff of Round Mountain (Ttr) appears to have been erupted from a 26.5–26 Ma caldera mostly underlying alluvium of Big Smoky Valley near Round Mountain, described by Henry and others (1996). The caldera was unrecognized in the present study. Significant megabreccia units [for example, megabreccia of Hunts Canyon (Tmh), megabreccia of Meadow Canyon (Tmc), and megabreccia of Jefferson Canyon (Tjc)] were erupted in association with caldera development. A second phase of mineralization may have occurred in the Jefferson district in closing stages of igneous activity related to the Mount Jefferson caldera. During and shortly following this relatively brief period (to about 26.2 Ma), a great number of different volcanic units were emplaced near the Mount Jefferson caldera and the inferred calderas underlying Monitor Valley and Big Smoky Valley. Some of these volcanic units may have been emplaced as a result of activity of the Big Ten Peak caldera south and southeast of the map area. The Round Mountain gold deposit formed at 26.0 Ma (Henry and others, 1997).

The Manhattan caldera formed with eruption of the Round Rock Formation (Trr) at about 24.5 Ma. Eruptive megabreccias (Tsg, Trs) were emplaced during formation of the Manhattan caldera. Resurgent dacitic (Tf) and andesitic (Tca) magmas intruded the Manhattan caldera shortly following its collapse. Between 24.5 Ma and about 23 Ma a number of ash-flow tuffs from outside sources were deposited in the area of the southern Toquima Range. For example, the Diamond King Formation (Tdk) came from a western source, whereas the Shingle Pass Tuff (Tsp) and younger volcanic rocks (Ty)—which includes biotite-bearing tuff tuff of Pipe Organ Spring, Bates Mountain Tuff, and tuff of Clipper Gap—had eastern sources.

Igneous activity related to the mineralization of gold-silver deposits at Manhattan (fig. 17) at about 16 Ma has not been identified. Possibly two small undated rhyolite necks (Trn) south of Manhattan may have been intruded at that time, and are related to the mineralizing event. Radiometric data suggest an older episode of mineralization (at about 40–35 Ma?) in part of the Manhattan district (Shawe and others, 1987).

The latest phase of igneous activity recorded in the southern Toquima Range was deposition of glass-shard tuff (Tva) in the upper end of Ralston Valley at about 12 Ma. The glass-shard tuff may correlate with one of four large-volume silicic tuffs that range in age from 12.93 Ma to 11.57 Ma that are widespread in southwestern Nevada—the Ammonia Tanks, Rainier Mesa, Tiva Canyon, and Topopah Spring Tuffs (Perkins and others, 1998). These tuffs all had sources in the southwestern Nevada volcanic field centered about 170 km south-southeast of the Toquima Range.

Faults record important events in the structural development of the area. Major northwest-striking faults, probably of right-lateral, strike-slip displacement, include the Manhattan, Jefferson Canyon, and Hunts Ranch faults, likely related to the northwest-striking Walker Lane system of subparallel strike-slip faults to the southwest. Evidence supporting this conclusion is presented in the description of a fracture map of the southern Toquima Range area, as part of this series of 1:48,000-scale maps (Shawe, 2001). The Manhattan and Jefferson Canyon faults appear to have partly controlled localization of the Manhattan and Mount Jefferson calderas, as they form the southwest structural margins of these calderas. In addition, the faults were major controls on localization of precious-metal mineralization that took place in the Manhattan and Jefferson mining districts. Also, a northwest-striking fault was significant in controlling deposition of precious metals at Round Mountain.

The Jefferson Canyon fault may extend southeastward from the Jefferson mining district, beneath megabreccia of Jefferson Summit (Tjs), as a possible conduit for eruption of the megabreccia. The Meadow Canyon fault father southeast is en echelon to the Jefferson Canyon fault; the two faults may merge at depth with a throughgoing right-slip flaw. This proposed system is shown as the Jefferson fault zone on the "Index to major structures" accompanying the geologic map.

A widespread set of subparallel, north-striking faults that show mostly normal displacements, dominates fracture patterns in the southern Toquima Range. [For a fuller discussion of the north-striking faults, see Shawe (2001).] They have persisted in the area since at least about 80 Ma, as some of the aplite dikes of Cretaceous age were localized in north-striking fractures, and the faults commonly cut young alluvium (most not shown on the map). They were important local controls on mineralization in the Manhattan district (at 40–35? Ma and 16 Ma).

Faults that are related to Basin-range structure (commencing about 17 Ma) in the area do not strike north, however. They strike north-northeast to northeast, as is particularly evident on the southeast front of the Toquima Range. There, prominent range-bounding faults southwest and northeast of the Belmont pluton (**Kb**) do not extend through the pluton, as though the granite provided a bulwark impervious to fracturing. A second set of Basin-range faults east of the main set that bounds the range, forming a structural step outward into Monitor Valley, projects near the southeast end of the exposed pluton. The north-striking faults are controlled by structural grain established before the onset of Basin-range deformation.

Remnants of early human activity in the southern Toquima Range are gradually disappearing (fig. 18).

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