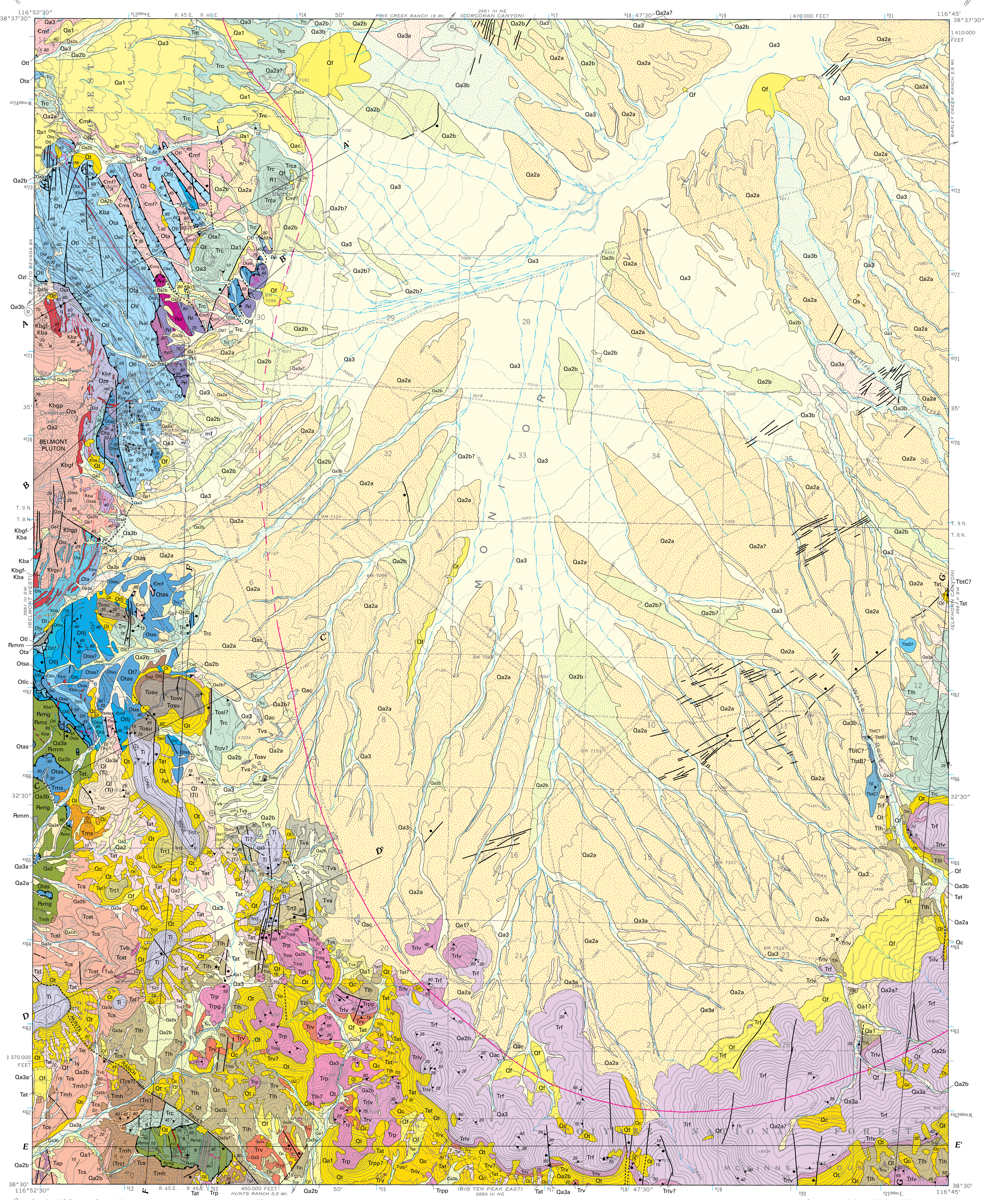
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INVESTIGATIONS SERIES
I–2675
Pamphlet accompanies map



Base from U.S. Geological Survey, 1971
Projection and 10,000-foot grid ticks: Nevada coordinate system, central zone (transverse Mercator)
1,000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue. 1927 North American datum

1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

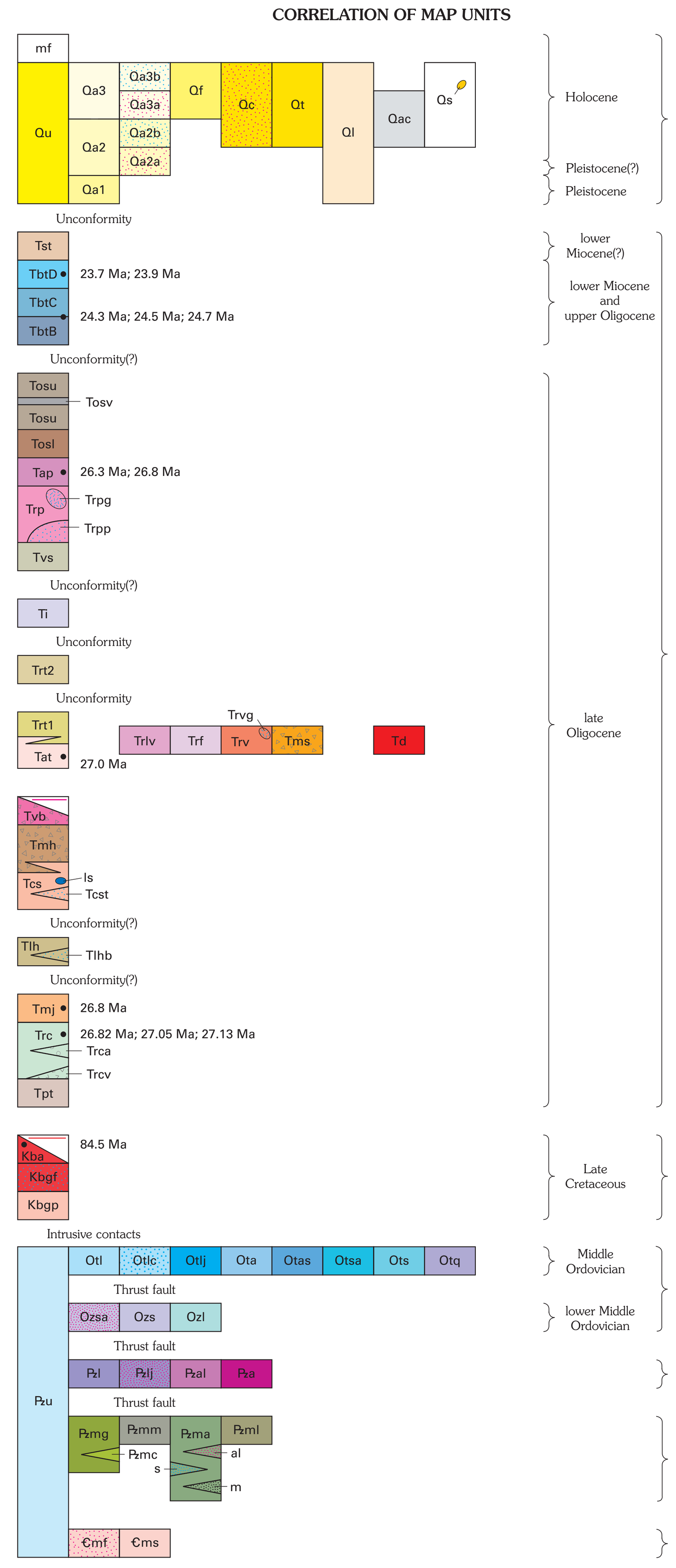
SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929


QUADRANGLE LOCATION

Geology mapped in August 1982, August 1987, July and August 1990, and July 1991
Editing and digital cartography by Alessandro J. Donatich
Geology digitized by Geologic Data Systems, Inc.
Cross sections drafted by Springfield and Springfield
Manuscript approved for publication February 18, 1999

CORRELATION OF MAP UNITS



LIST OF MAP UNITS

- mf — **Manmade fill (modern)**
- Qu — **Surficial deposits, undivided (Quaternary)**—Shown only on cross sections
- **Alluvium (Holocene, Pleistocene?, and Pleistocene)**
  - Qa3 — **Youngest alluvium, undivided (Holocene)**
    - Qa3b — **Youngest alluvium b (Holocene)**
    - Qa3a — **Youngest alluvium a (Holocene)**
  - Qa2 — **Older alluvium, undivided (Holocene and Pleistocene?)**
    - Qa2b — **Older alluvium b (Holocene)**
    - Qa2a — **Older alluvium a (Holocene and Pleistocene?)**
  - Qa1 — **Oldest alluvium, undivided (Pleistocene)**
- Qf — **Alluvial-fan deposits (Holocene)**
- Qc — **Colluvium and slope wash (Holocene)**
- Qt — **Talus (Holocene)**
- Ql — **Landslide deposits (Holocene and Pleistocene?)**
- Qac — **Caliche (Holocene)**
- Qs — **Sinkhole (Holocene)**
- Tst — **Tuffaceous siltstone (lower Miocene?)**
- **Bates Mountain Tuff (lower Miocene and upper Oligocene)**
  - TbtD — **Unit D**
  - TbtC — **Unit C**
  - TbtB — **Unit B**
- **Crystal-rich, welded ash-flow tuff (upper Oligocene)**
  - Tosu — **Upper member**
    - Tosv — **Basal vitrophyre**
  - Tosl — **Lower member**
- Tap — **Andesite plugs (late Oligocene)**
- Trp — **Rhyolite plugs (late Oligocene)**
  - Trpp — **Pumiceous rhyolite**
  - Trpg — **Glassy rhyolite**
- Tvs — **Volcanic sandstone (upper Oligocene)**
- Ti — **Isom-type welded ash-flow tuff formation (upper Oligocene)**
- **Rhyolitic ash-flow tuff (upper Oligocene)**
  - Trt2 — **Upper member**
  - Trt1 — **Lower member**
- **Rhyolite flows and domes (upper Oligocene)**
  - Trlv — **Lithophysal vitrophyre**
  - Trf — **Flow-layered rhyolite**
- Trv — **Vitrophyric rhyolitic lava (upper Oligocene)**
  - Trvg — **Body of dark-gray glass within vitrophyric rhyolitic lava**
- Tms — **Mesobreccia (upper Oligocene)**
- Td — **Felsite dikes (age unknown, likely late Oligocene)**
- Tat — **White ash-fall tuff (upper Oligocene)**
- Tvb — **Volcanic breccia (upper Oligocene)**
- Tmh — **Megabreccia of Hunts Canyon (upper Oligocene)**
- Tcs — **Claystone-siltstone-sandstone unit (upper Oligocene)**—ls, lacustrine limestone lens
  - Tcst — **Pumiceous tuff (upper Oligocene)**
- Tlh — **Rhyolitic lahar (upper Oligocene)**
  - Tlhb — **Bedded tuff**
- Tmj — **Tuff of Mount Jefferson(?) (upper Oligocene)**
- Trc — **Tuff of Ryecroft Canyon (upper Oligocene)**
  - Trca — **Unconsolidated tuff**
  - Trcv — **Vitrophyric ash-flow tuff**
- Tpt — **Layered pumice tuff (upper Oligocene)**
- **Granite of Shoshone Mountain (Late Cretaceous)**
  - **Belmont pluton**
    - Kba — **Aplite**
    - Kbgf — **Fine-grained granite**
    - Kbgp — **Porphyritic granite**
- Pzu — **Paleozoic rocks, undivided**—Shown only on cross sections
- **Toquima Formation (Middle Ordovician)**
  - Otl — **Limestone**
    - Otlc — **Calc-silicate-mineralized limestone**
    - Otlj — **Jasperized limestone**
  - Ota — **Argillite**
  - Otas — **Siliceous argillite**
  - Otsa — **Schist and subordinate argillite**
  - Ots — **Schist**
  - Otq — **Quartzite**
- **Zanzibar Formation (lower Middle Ordovician)**
  - Ozsa — **Schistose argillite**
  - Ozs — **Schist**
  - Ozl — **Limestone**
- **Paleozoic carbonate rocks (Ordovician?)**
  - Pzl — **Limestone**
    - Pzlj — **Jasperized limestone**
  - Pzal — **Interbedded argillite and limestone**
  - Pza — **Argillite**
- **Rocks of the Monarch area (Paleozoic, possibly in part Ordovician and (or) Cambrian)**
  - Pzmg — **Greenstone**
  - Pzmc — **Chert**
  - Pzmm — **Metasomatite**
  - Pzma — **Argillite**—al, gray argillite and limestone; s, dark-gray phyllitic schist; m, iron-mineralized lens
  - Pzml — **Limestone**
- **Mayflower Formation (Cambrian?)**
  - Ꞓmf — **Argillite**
  - Ꞓms — **Knotted schist**

Contact—Dashed where approximately located or gradational; dotted where concealed; queried where uncertain. Arrow shows dip

Internal contact within map unit—Generally shows bedding plane on map; shows form line in cross section. Dashed and (or) queried where uncertain

High-angle fault—Dashed where approximately located; dotted where concealed; queried where uncertain. Bar and ball on downthrown side where relative movement is known. Opposed arrows show strike-slip movement. Arrow shows dip of fault plane; cross indicates vertical dip. In cross sections only, A indicates displacement away; T indicates displacement toward; arrow indicates relative vertical movement

Thrust fault—Dashed where approximately located; dotted where concealed; queried where uncertain. Arrow shows dip. Teeth on upper plate

Detachment fault—Teeth on upper plate

Hypothetical caldera structural margin—Dashed where projected

Minor synclinal fold—Arrow shows fold-axis plunge

Drag-fold axis or lineation—Showing trend and plunge

Strike and dip of layered rocks—Structural complexity prevents determination of original orientation of most layers

- **Inclined**
- **Vertical**
- **Overturned**

Strike and dip of foliation—Schistosity in metasedimentary rocks; foliation in granite; flow layering in rhyolite plugs and flow domes; compaction foliation in ash-flow tuff. Arrow shows trend and plunge of lineation or minor fold axis

- **Inclined**—Showing horizontal lineations, or plunge of lineations. Symbol lacking a number was plotted from aerial photographs
- **Vertical**
- **Horizontal compaction foliation in ash-flow tuff**

Post-metamorphism shear foliation in granite

- **Inclined**
- **Vertical**

Cleavage

- **Inclined**
- **Vertical**

Volcanic breccia dike (Tvb)—Arrow shows dip

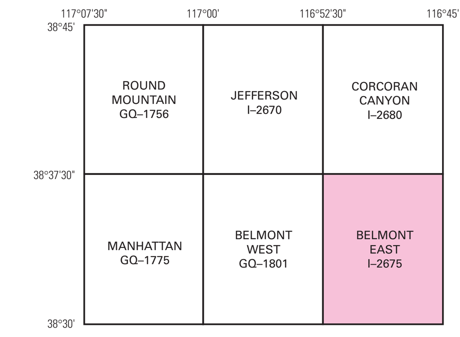
Vein—Arrow shows dip; cross indicates vertical vein. q, quartz vein; f, fissure vein

Breccia

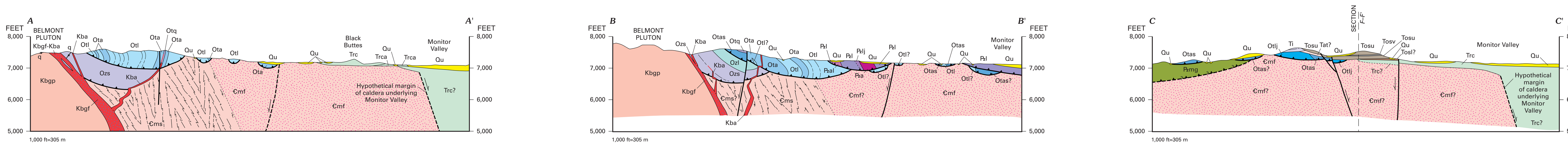
Breccia layer—Showing strike and dip

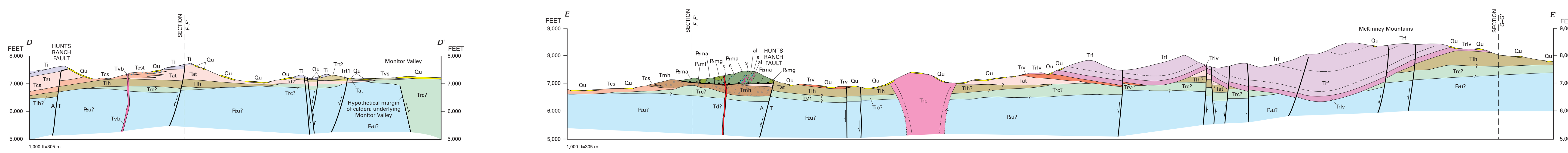
(Trc) **Outline of large clast in megabreccia**—Unit identity in parentheses where known

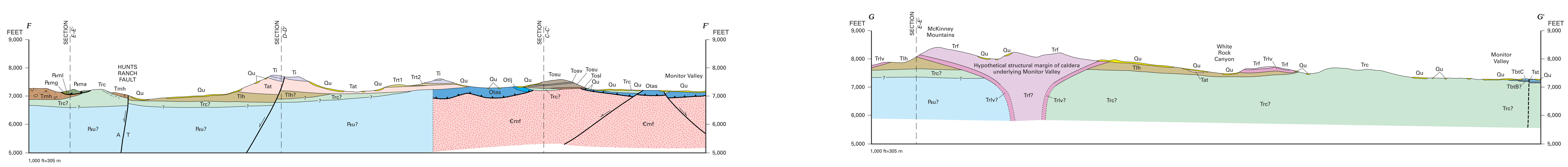
R1 **Radiometrically dated rock sample locality**



INDEX MAP







GEOLOGIC MAP OF THE BELMONT EAST QUADRANGLE, NYE COUNTY, NEVADA

By
Daniel R. Shawe and Frank M. Byers, Jr.
1999

Geologic map of the Belmont East quadrangle, Nye County, Nevada

By Daniel R. Shawe and Frank M. Byers, Jr.

Geologic Investigations Series I–2675

Ruin of Highbridge Mill, Belmont district. Photograph by the first author, 1990.

1999

U.S. Department of the Interior
U.S. Geological Survey

DESCRIPTION OF MAP UNITS

[Geologic mapping and map compilation of quadrangle, and text preparation, were by first author. Phenocryst contents of most of the ash-flow tuffs and other volcanic rocks described here were determined by modal analyses of thin sections by second author. Between 2,000 and 4,000 points per thin section of crystal-rich rocks (20 percent or more phenocrysts) generally were counted; points counted per thin section ranged to more than 10,000 for some crystal-poor rocks. Phenocryst contents are given as volume percent of total rock, and phenocryst minerals are given as volume percent of total phenocrysts; Q, quartz; K, alkali feldspar (sanidine unless otherwise noted); P, plagioclase; B, biotite; H, hornblende; C, clinopyroxene; O, opaque-oxide minerals; M, unspecified mafic minerals. Other specific mineral names are spelled out in places. Acessory minerals occur in trace amounts; their relative amounts are described as rare, sparse, and common. In some exposures of the volcanic rocks described here, hydrothermal alteration resulted in partial or complete replacement of feldspars and mafic minerals by secondary minerals. Chemical analyses are recalculated on a volatile-free basis; analyses by D.R. Siems, J.S. Mee, and J.E. Taggart, Jr. (U.S. Geological Survey), and Actlabs, Inc., Wheat Ridge, Colo. Volcanic rock names are based on the modal data showing phenocryst content; they are generally equivalent to the field terms used during mapping. Rock names based on the IUGS chemical classification (Le Bas and others, 1986) are shown in parentheses following the listed chemical data. Cited K-Ar dates that were determined before 1977 have been converted using new constants given in table 2 of Dalrymple (1979). Queries on map-unit symbols indicate uncertain assignment]

mf **Manmade fill (modern)**—Mostly mine dumps and mill tailings

Qu **Surficial deposits, undivided (Quaternary)**—Shown only on cross sections

Alluvium (Holocene, Pleistocene?, and Pleistocene)—Sand, silt, and gravel. Subdivisions of alluvium described below are based on relative age in local areas mostly determined by relative height above current stream levels. Specific units could not be correlated by age everywhere in quadrangle; thus sediment mapped as one unit (for example, Qa3a) may be same age as sediment mapped as a different unit (for example, Qa2b) elsewhere. Studies of soil characteristics of the different alluvium units, not attempted here, might clarify age relations.

Colors of all alluvium units described here are varied, ranging from yellowish brown, light yellowish brown and light brown, to light brownish gray and light gray. All alluvium units are unconsolidated unless otherwise noted, poorly to moderately sorted, and comprised of poorly- to well-rounded clasts

Qa3 **Youngest alluvium, undivided (Holocene)**—Active alluvium in drainage courses. Characterized by braided veinlike strands of recently deposited gravel, sand, and silt. Forms broad alluvial flats in Monitor Valley in north part of quadrangle, and fills feeder courses leading into broader flats. Maximum thickness a few meters

Qa3b **Youngest alluvium b**—Abundant strands of recently deposited sediment. May grade into alluvial-fan deposits (Qf) or colluvium and slope wash (Qc)

Qa3a **Youngest alluvium a**—Slightly older than Qa3b. Qa3a commonly at higher elevation than Qa3b along sides of drainage courses. Qa3a may grade into alluvial-fan deposits (Qf) or colluvium and slope wash (Qc)

Qa2 **Older alluvium, undivided (Holocene and Pleistocene?)**—Stabilized alluvium in stream terraces and courses, and flat valley-fill fans topographically higher (a meter or more) than youngest alluvium (Qa3 units); presently being eroded. Clasts generally are only slightly weathered and may be moderately sorted. Maximum thickness several tens of meters

Qa2b **Older alluvium b (Holocene)**—Forms stabilized alluvium in some stream courses, and stabilized alluvial flats in Monitor Valley

Qa2a **Older alluvium a (Holocene and Pleistocene?)**—Appreciably eroded alluvial deposits, notably alluvial flats in Monitor Valley, laced with strands of actively forming allluvium (Qa3 or Qa3b) too small to map. Where erosion of unit has been extensive around periphery of Monitor Valley, a few patches of caliche (Qac) have been exposed. Older parts of Qa2a may be as old as Pleistocene

Qa1 **Oldest alluvium, undivided (Pleistocene)**—Stabilized alluvium that underlies stream terraces and valley flats higher than older alluvium (Qa2 units). Larger clasts (cobbles and small boulders) may be significantly weathered. Underlies much of bench in northwest corner of quadrangle; exposed by erosion beneath Qa2a in heads of drainages emptying southward into Hunts Canyon south of quadrangle. Maximum thickness, including subsurface below younger alluvium in Monitor Valley, probably several hundred meters

Qf **Alluvial-fan deposits (Holocene)**—Commonly formed at foot of short drainages where they enter deeply incised courses in older alluvium (Qa2 units), and fronting steep escarpments. May grade into youngest alluvium (Qa3 units). Maximum thickness several tens of meters

Qc **Colluvium and slope wash (Holocene)**—Gently sloping accumulations of disintegrated rock more or less in place, or deposited by slope wash. May grade up into talus (Qt) or down into alluvium (Qa3 units or Qa2b). Maximum thickness a few meters

Qt **Talus (Holocene)**—Steeply sloping accumulations of angular rock, deposited below cliffs and steep slopes; mapped where accumulations are well defined or where they obscure geologic contacts. May grade downslope into colluvium and slope wash (Qc) and alluvial-fan deposits (Qf). Maximum thickness several meters

Ql **Landslide deposits (Holocene and Pleistocene?)**—Several large masses of dismembered and disoriented rock units not greatly intermixed, in southwest part of quadrangle near "Long Ridge" (informal name for topographic feature in southwest part of map area). Consist mostly of welded ash-flow tuff formations that overlay soft ash-fall tuff (Tat); collapse of ash-flow tuff may have occurred principally in Pleistocene time when increased moisture softened and sapped underlying ash-fall tuff sufficiently to induce its structural failure. Units involved in landslide deposits identified in parentheses [for example, Isom-type welded ash-flow tuff (Ti)]. Maximum thickness probably more than 100 m

Qac **Caliche (Holocene)**—Calcium carbonate cement as a matrix or veining in older alluvium (Qa2a), formed in an interval 1 m or more beneath original surface. Now exposed around periphery of Monitor Valley in a few patches where erosion has stripped the upper layer of Qa2a

Qs **Sinkhole (Holocene)**—Two small isolated depressions in older alluvium (Qa2a) in northeast part of quadrangle are interpreted as sinkholes. Origin unknown

Tst **Tuffaceous siltstone (lower Miocene?)**—Light-yellowish-brown tuffaceous siltstone; crops out in two small areas at east edge of quadrangle about 3 km north of mouth of White Rock Canyon. Its stratigraphic position relative to unit C of Bates Mountain Tuff (TbtC) is unknown; it is shown overlying the tuff in cross section *G–G*'

Bates Mountain Tuff (lower Miocene and upper Oligocene)—Several members of Bates Mountain Tuff (units TbtB, TbtC, and TbtD) appear to be present near east edge of quadrangle. (See Gromмé and others, 1972, for definitions of the units.) Because of limited exposures and uncertainty as to stratigraphic relations of the three units, their symbols are queried on map

TbtD **Unit D**—Light-brownish-gray, crystal-poor, platy, partially to moderately welded rhyolitic ash-flow tuff; weathers light orangish brown. A modal analysis of one thin section of the rock indicates about 5 percent phenocrysts (about 1 mm in size) made up of the following components: Q, 7; K, 53; P, 30; B, 8; O, 1.5; and M, 1. Common zircon and sparse apatite are accessory minerals. A chemical analysis of this rock indicates the following composition: SiO_2, 75.3; Al_2O_3, 12.8; K_2O, 5.18; Na_2O, 3.80; CaO, 0.65; Fe_2O_3, 1.55; FeO, 0.22; MgO, 0.23; TiO_2, 0.17; P_2O_5, 0.07; and MnO, 0.03 (rhyolite). Unit D was identified only in one low outcrop about 200 m in diameter, 2.5 km north of mouth of White Rock Canyon near east edge of quadrangle. According to Grommé and others (1972), unit D has a sanidine K-Ar age of 23.7±0.6 Ma (Miocene-Oligocene boundary); McKee and Stewart (1971) determined a sanidine K-Ar age of 23.9±0.7 Ma. Base not exposed; thickness unknown, but probably no more than a few tens of meters

TbtC **Unit C**—Light-pinkish-brown to light-brownish-gray, crystal-poor, nonwelded to moderately welded rhyolitic ash-flow tuff; weathers orangish brown to reddish brown. Rock contains flattened pumice lapilli as long as 5 cm. Modal analyses of two thin sections indicate about 5 percent phenocrysts (1–3 mm) made up of the following components: Q, 29 each; K, 57 and 61 (in part anorthoclase); P, 12 and 8; B, 1 and 1.5; and O, 0 and 0.5. Zircon, allanite, and monazite(?) are sparse accessory minerals. Unit is exposed in isolated outcrops 0.5–3 km north of mouth of White Rock Canyon. Thickness unknown

TbtB **Unit B**—Pale-pinkish-gray, crystal-poor, partially to moderately welded rhyolitic ash-flow tuff; weathers light yellowish gray. Characterized by abundant small (to 1 cm long), gray, glassy, flattened pumice lapilli and dark-gray glass shards. Modal analysis of one thin section indicates about 9 percent phenocrysts (2–4 mm) made up of the following components: Q, 19; K, 50; P, 28; B, 3; O, 0.5; and H, 0.5. Zircon and apatite are sparse accessory minerals. Units B and C (undifferentiated) have sanidine K-Ar ages of 24.3±0.7, 24.5±0.7, and 24.7±0.7 Ma according to Sargent and McKee (1969), McKee and Stewart (1971), and McKee and Silberman (1970), respectively. Unit B underlies unit C conformably in two outcrops about 1 km north of mouth of White Rock Canyon. Thickness unknown; probably only a few meters

Crystal-rich, welded ash-flow tuff (upper Oligocene)—An exposed sequence of ash flows and (or) simple cooling units caps two hills that border Monitor Valley about 4 and 5 km south of Belmont. An upper member (Tosu) consists of two modally distinct parts; a lower member (Tosl) underlies upper member in southern of two hills. Upper member appears conformable on lower member on north side of southern hill, but it lies unconformably upon Isom-type ash-flow tuff formation (Ti) on south side of southern hill. Base of lower member is not exposed. Possibly equivalent to Diamond King Formation in Round Mountain quadrangle (Shawe, 1995), Belmont West quadrangle (Shawe, 1998), and Manhattan quadrangle (Shawe, 1999a), as well as to tuff of Arc Dome in Toiyabe Range 50 km to the northeast [dated by John (1992) as 24.9±0.6 Ma]

Tosu **Upper member**—Light-gray to light-brownish-gray, crystal-rich, partially to moderately welded rhyolitic ash-flow tuff; weathers light yellowish gray to light orangish brown. Contains mostly small (less than 1 cm long) flattened pumic lapilli and sparse lithic fragments (less than 1 cm long); characterized by smoky quartz crystals.

Upper part of member on hill 5 km south of Belmont has a dark-gray basal vitrophyre (Tosv). Modal analyses of three thin sections of samples from upper part indicated 20–30 percent phenocrysts (2–2.5 mm) consisting of the following percentages of components: Q, 27–31; K, 39–44; P, 23–24; B, 2–4; O. 0–0.5; and M, 1–1.5. Zircon is a common accessory mineral, and allanite is a sparse accessory mineral. A chemical analysis of one of the samples (vitrophyre) indicates the following percentages of components: SiO_2, 75.3; Al_2O_3, 13.3; K_2O, 5.30; Na_2O, 3.33; CaO, 0.90; Fe_2O_3, 0.98; FeO, 0.45; MgO, 0.16; TiO_2, 0.15; P_2O_5, 0.06; and MnO, 0.03 (rhyolite). Eroded remant of upper part of member on hill 5 km south of Belmont is about 40 m thick.

Lower part of upper member consists of light-gray to light-yellowish-gray, crystal-rich, moderately to densely welded quartz latitic ash-flow tuff; weathers pale orangish brown to light brownish gray. Characterized by common small veinlet and cavity fillings of white opaline silica (unit called opaline-silica tuff in the field), and smoky quartz crystals. Contains abundant slightly to greatly flattened pumice lapilli, mostly less than 1 cm long; common flattened gas cavities also evident; locally contains small (to 3 cm) Paleozoic rock fragments. Modal analyses of three thin sections of rock collected from hill 4 km south of Belmont indicate 21–26 percent phenocrysts (1.5–4 mm) made up of the following components: Q, 18–21; K, 25–29; P, 44–48; B, 5–6; O, 1 each; and H, 0.5–1. Common to sparse zircon, and sparse apatite and allanite, are accessory minerals. Chemical analyses of two of the three samples show SiO_2, 72.9 and 73.9; Al_2O_3, 15.0 and 14.1; K_2O, 4.73 and 4.93; Na_2O, 3.64 and 3.55; CaO, 1.42 and 1.23; Fe_2O_3, 1.35 each; FeO, 0.22 each; MgO, 0.35 and 0.34; TiO_2, 0.26 and 0.23; P_2O_5, 0.09 and 0.07; and MnO, 0.03 and 0.02 (rhyolite). Position of basal contact of member is uncertain. Thickness of lower part of upper member is about 70 m

Tosv **Basal vitrophyre**—Dark gray

Tosl **Lower member**—Light-gray to light-pinkish-gray, crystal-rich, partially to densely welded rhyodacitic ash-flow tuff; weathers light orangish brown. Contains pale-gray pumice fiamme (to 1 cm) and sparse small (5 mm) lithic fragments; colorless botryoidal opaline silica evident locally. Modal analyses of thin sections of two samples indicate 23 percent phenocrysts (1.5–3.5 mm) that consist of the following percentages of components: Q, 7 each; K, 9 each; P, 65 and 71; B, 15 and 7; O, 1 and 2; and M, 4 each. Zircon and apatite are sparse accessory minerals. Member exposed on lower northwest slope of hill 5 km south of Belmont; upper contact uncertain; base not exposed. Exposed thickness about 30 m

Tap **Andesite plugs (late Oligocene)**—Gray to lavender-gray, in part flow-layered, porphyritic biotite and hornblende-biotite andesite. More detailed description of andesite (Tap) given in Belmont West quadrangle (Shawe, 1998). Intrudes claystone-siltstone-sandstone unit (Tcs) as small bodies in southwest corner of quadrangle. Biotite K-Ar age 26.3±0.9 to 26.8±1.0 Ma (Shawe and others, 1987)

Trp **Rhyolite plugs (late Oligocene)**—Gray, nearly aphyric to crystal-poor, flow-layered rhyolite; weathers light yellowish gray to light brownish gray. Contains zones of pumiceous rhyolite (Trpp) and glassy rhyolite (Trpg). Some smaller plugs are strongly brecciated. Thin-section examination shows microlites and biotite and plagioclase aligned with flow laminae. Modal analyses of thin sections of three samples that contain 0.5–1.5 percent phenocrysts (0.2–2 mm) indicate the following percentages of components: Q, 0–7; K, 0–6; P, 76–90; B, 10 each; and O, 0–10. Zircon and apatite are sparse accessory minerals. A chemical analysis of a sample of the large rhyolite plug that underlies hill 7510 shows the following composition: SiO_2, 76.9; Al_2O_3, 12.7; K_2O, 4.78; Na_2O, 3.59; CaO, 0.84; Fe_2O_3, 0.78; FeO, 0.09; MgO, 0.11; TiO_2, 0.10; P_2O_5, less than 0.05; and MnO, 0.06 (rhyolite). A chemical analysis of a sample of dark-gray glass (Trpg) in the same plug indicates the following composition: SiO_2, 78.2; Al_2O_3, 12.0; K_2O, 5.06; Na_2O, 2.92; CaO, 0.70; Fe_2O_3, 0.49; FeO, 0.32; MgO, less than 0.10; TiO_2, 0.10; P_2O_5, less than 0.05; and MnO, 0.06 (rhyolite). Rhyolite plugs form a cluster of about a dozen intrusions in southwest part of quadrangle. They range in size from about 100 m in diameter to about 0.5 km x 1 km. Northern end of largest plug has an intrusive contact against rhyolitic ash-flow tuff formation (Trt units)

Trpp **Pumiceous rhyolite**—Gray

Trpg **Glassy rhyolite**—Dark gray

Tvs **Volcanic sandstone (upper Oligocene)**—Light-greenish-gray, light-yellowish-gray, light-brown, and brown, fine- to coarse-grained (angular to subrounded grains), poorly sorted tuffaceous sandstone. Locally pebbly. Poorly bedded to thin bedded; in places laminated with layers a few millimeters thick, some layers graded. Thin-section examination shows sandstone to consist of 8–20 percent crystals (mostly 0.5 mm and less in size); remainder of rock is volcanic clasts, devitrified shards, and clay, in part poorly cemented with chalcedonic silica or opal. Crystals consist of the following percentages of components: Q, 1–11; K, 1–13; P, 64–81; B, 1–3; O, 1–7; H, 1–22; and pyroxene (C and orthopyroxene together), 0–9. Crystal composition indicates that a large component was derived by erosion of Isom-type welded ash-flow tuff formation (Ti), widely exposed nearby. Source of the large amount of hornblende in some sandstone may be hornblende-biotite andesite plugs and flows (Tap) in southeast corner of adjacent Belmont West quadrangle (Shawe, 1998), which extend into extreme southwest corner of Belmont East quadrangle. If so, part of Tvs may be younger than Tap. Scattered exposures of volcanic sandstone lie east and southeast of "Long Ridge," at edge of Monitor Valley. Thickness not known, but probably not greater than a few tens of meters

Ti **Isom-type welded ash-flow tuff formation (upper Oligocene)**—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, which is about 27 Ma (Best and others, 1989). Consists of two modally distinct, crystal-poor rhyodacitic welded ash-flow tuff parts (upper and lower) that do not seem to be equivalent to upper and lower members of the same formation in Belmont West quadrangle (Shawe, 1998). Upper part of formation in Belmont East quadrangle is similar in modal composition to lower member in Belmont West quadrangle, whereas lower part of formation in Belmont East quadrangle is similar in modal composition to upper member in Belmont West quadrangle. A sanidine $^{40}Ar/^{39}Ar$ age of 27.16±0.04 (1σ) Ma (L.W. Snee, written commun., 1996) for the formation is based on analysis of a sample collected by R.F. Hardyman in Corcoran Canyon quadrangle north of Belmont East quadrangle. This age may be too old, as indicated by evidence of excess argon in sample (L.W. Snee, written commun., 1996).

Upper part of Isom-type tuff formation is medium-gray (grading up to light lavender gray), partially to densely welded, crystal-poor rhyodacitic ash-flow tuff; weathers dark brownish gray at base, grading up to light brownish gray. Strongly magnetic near base. Dark-gray to brown flattened pumice lapilli to 15 cm long near base, diminishing in size (down to 1 cm long) and abundance upward. Modal analyses of three thin sections of samples from upper part indicate 6–12 percent phenocrysts (1–3 mm) that consist of the following percentages of components: Q, 7–16; K, 4–7; P, 69–74; B, 0–1; and C and orthopyroxene together, 7–12. Apatite is a sparse accessory mineral. About 3–12 percent lithic fragments are mostly intermediate-composition lavas. Chemical analysis of a sample collected near base of upper part shows the following composition: SiO_2, 68.7; Al_2O_3, 15.5; K_2O, 4.77; Na_2O, 4.12; CaO, 2.01; Fe_2O_3, 2.67; FeO, 0.95; MgO, 0.49; TiO_2, 0.52; P_2O_5, 0.17; and MnO, 0.06 (trachydacite). Ovelies lower part conformably. Base of upper part exposed on “Long Ridge” and on southwest part of hill 7821 in southwest quadrant of quadrangle. Top eroded; maximum remant thickness about 15 m.

Lower part of Isom-type tuff formation is dark-brown to nearly black near base (grading up to light lavender gray), moderately to densely welded, crystal-poor to moderately crystal-rich rhyodacitic ash-flow tuff; weathers light brownish gray to light yellowish gray. Vitrophyric near base. Contains numerous dark-gray to brownish-gray, greatly flattened pumice lapilli as long as 20 cm near base, grading to smaller and fewer lapilli higher in unit. Locally abundant small lithic fragments, mostly volcanic rocks (to 1 cm), and small gas cavities (to 1 cm). Modal analyses of 12 thin sections of samples of unit indicate 6–16 percent phenocrysts (0.5–4 mm) that consist of the following percentages of components: Q, 0.2–5; K, 0–7; P, 69–88; B, 0–1; O, 0.5–11; and C and orthopyroxene together, 8–20. Accessory minerals are sparse apatite and rare zircon. Chemical analysis of a sample collected near base of lower part shows the following composition: SiO_2, 69.1; Al_2O_3, 15.4; K_2O, 4.99; Na_2O, 4.18; CaO, 1.85; Fe_2O_3, 3.12; FeO, 0.41; MgO, 0.34; TiO_2, 0.50; P_2O_5, 0.14; and MnO, 0.06 (rhyolite near trachydacite). The Isom-type tuff formation lies unconformably upon underlying units: upper and lower members of rhyolitic ash-flow tuff (Trt2, Trt1) and white ash-fall tuff (Tat). Lower part of Isom-type tuff formation appears to consist of two or three ash flows, not everywhere present, in a simple cooling unit. It is exposed in several small areas in southwest part of quadrangle where it is 15–60 m thick

Rhyolitic ash-flow tuff (upper Oligocene)—Consists of an upper member (Trt2) of crystal-poor tuff equivalent to crystal-poor rhyolitic tuff (Trt) in Belmont West quadrangle (Shawe, 1998), and a lower member (Trt1) of moderately crystal-rich tuff

Trt2 **Upper member**—Light-gray to pale-orangish-brown, partially to densely welded, shardy, crystal-poor rhyolitic welded ash-flow tuff; weathers light yellowish gray to light reddish brown. In places contains sparse black-glass shards, small (to 1 cm) light-orangish-brown to reddish-brown flattened pumice lapilli, or abundant small (less than 1 cm) lithic fragments, mostly volcanic. Three modal analyses indicate 2–3 percent phenocrysts (1–2 mm) made up of the following percentages of components: Q, 25–42; K, 37–53; P, 8–27; B, 0–1; O, 1–2.5; and H, 2–4. Zircon is a sparse accessory mineral and apatite is a rare accessory mineral. Chemical analysis of one sample of partially welded tuff that contains black-glass shards indicates the following composition: SiO_2, 75.6; Al_2O_3, 13.1; K_2O, 5.13; Na_2O, 2.87; CaO, 0.89; Fe_2O_3, 1.11; FeO, 0.19; MgO, 0.75; TiO_2, 0.09; P_2O_5, 0.13; and MnO, 0.09 (rhyolite). Chemical analysis of a densely welded shardy tuff shows the following composition: SiO_2, 79.8; Al_2O_3, 11.0; K_2O, 4.30; Na_2O, 3.04; CaO, 0.52; Fe_2O_3, 0.96; FeO, 0.09; MgO, 0.52; TiO_2, 0.09; P_2O_5, less than 0.05; and MnO, 0.02 (rhyolite). Unconformably underlies Isom-type ash-flow tuff formation (Ti) at south end of "Long Ridge" and about 1 km farther southeast; thickness 0–35 m

Trt1 **Lower member**—Light-gray, partially to densely welded, moderately crystal-rich rhyolitic ash-flow tuff; weathers light gray. Contains pinkish-gray pumice fiamme as long as 5 cm locally and sparse light-brown volcanic fragments as long as 2 cm, mostly less than 1 cm long. Three modal analyses indicate 17–18 percent phenocrysts (2–6 mm) made up of the following percentages of components: Q, 12–20; K, 41–48; P, 32–34; B, 4–6; O, 1.5 each; and H, trace–1. Sphene ranges from a trace to 1 percent. Common zircon and apatite, and sparse allanite are other accessory minerals. Chemical analyses of two samples of lower member indicate the following percentages of components: SiO_2, 78.6 and 76.1; Al_2O_3, 10.9 and 12.4; K_2O, 4.21 and 4.99; Na_2O, 2.57 and 3.06; CaO, 1.09 and 1.14; Fe_2O_3, 1.68 and 1.40; FeO, 0.23 and 0.16; MgO, 0.35 and 0.34; TiO_2, 0.24 and 0.25; P_2O_5, 0.06 and 0.08; and MnO, 0.05 each (rhyolite). Lower member unconformably underlies upper member (Trt2) and the Isom-type ash-flow tuff formation (Ti); it appears to conformably overlie and is interbedded with upper part of white ash tuff (Tat) in southwest part of quadrangle. Thickness 0–20 m

Rhyolite flows and domes (upper Oligocene)—Lithophysal vitrophyre (Trlv) and flow-layered rhyolite (Trf) form an arcuate group of hills, part of McKinney Mountains at south end of quadrangle. Their arcuate configuration suggests emplacement along the structural margin of a caldera, possibly buried beneath alluvial fill of Monitor Valley to the north. The caldera may have been the source of tuff of Ryecroft Canyon (Trc)

Trlv **Lithophysal vitrophyre**—Light-gray to medium-gray, flow-layered, lithophysal vitrophyric rhyolite; weathers light brownish gray. Characterized in some layers by stretched gas cavities and abundant spherulites mostly less than 1 cm in diameter, locally as large as 3 cm; some larger spherulites show "sunburst" form. Phenocryst poor, mostly aphyric; sparse phenocrysts include quartz, sanidine, plagioclase, and biotite. Grades into flow-layered rhyolite (Trf). Erodes to characteristic pinnacle forms. Makes up a layer 20–30 m thick along margins of arc of flow domes, probably a chilled zone against enclosing rocks. Also occurs in larger masses just west of arc of flow domes

Trf **Flow-layered rhyolite**—Light-gray to medium-gray, nearly aphyric to crystal-poor rhyolite; weathers light yellowish gray to light brownish gray or light orangish gray. Flow layering conspicuous in places, and locally contorted; not evident in places. Stretched gas bubbles present locally. Minor autobrecciated rhyolite. Modal analyses of four thin sections indicate 2–3 percent phenocrysts (1–4 mm) consisting of the following percentages: Q, 27–34; K, 33–57; P, 7–36; B, 2–6; and O, 0–2. Accessory minerals are common to sparse zircon and sparse allanite. Phenocryst compositions are similar to those of tuff of Ryecroft Canyon (Trc). Chemical analysis of a sample of flow-layered rhyolite indicates SiO_2, 76.8; Al_2O_3, 12.9; K_2O, 4.90; Na_2O, 3.36; CaO, 0.85; Fe_2O_3, 0.84; FeO, less than 0.02; MgO, less than 0.10; TiO_2, 0.11; P_2O_5, 0.06; and MnO, 0.06 (rhyolite). Flow-layered rhyolite makes up an array of domes and related forms, in a north-facing arc about 8 km long and as wide as 2 km, possibly emplaced along structural margin of a caldera underlying Monitor Valley. Inward-dipping flow layers suggest two major centers of irruption, one in northwest part of McKinney Mountains, and the other near center of sec. 28, T. 8 N., R. 46 E.

Trv **Vitrophyric rhyolitic lava (upper Oligocene)**—Light- to medium-gray and light-brownish-gray, locally dark-brownish-gray, flow-layered rhyolitic lava. In places autobrecciated or charged with spherulites. Perlitic locally. Unit contains small bodies of dark-gray glass (labeled Trvg), not all mapped. A modal analysis of one thin section of vitrophyre indicates about 3 percent phenocrysts (1–3 mm) that are made up of Q, 4; K, 52; anorthoclase, 7; P, 31; B, 4; and O, 2. Sparse zircon and allanite are present. Vitrophyric lava occurs in scattered patches that overlie rhyolitic lahar

(Tlh) and white ash-fall tuff (Tat) and that are intruded by both rhyolite plugs (Trp) and rhyolite flow domes (Trf) in southwest and south-central parts of quadrangle. In one place, vitrophyre appears to merge downward into rhyolitic lahar as though it incorporated fragments of lahar as it flowed across the lahar. Maximum thickness about 35 m

Trvg **Body of dark-gray glass within vitrophyric rhyolitic lava**

Tms **Mesobreccia (upper Oligocene)**—Scattered outcrops of mesobreccia south of hill 7457 near west edge of quadrangle. Contains varied clasts including dominant fragments (to 1 m in diameter) of quartz-rich tuff of Ryecroft Canyon (Trc); other clasts are Paleozoic greenstone (Pzmg), chert, siliceous argillite, and schist. Matrix is pale-gray to pale-brown ash tuff. Modal analyses of two thin sections of clasts of quartz-rich tuff show 16 and 26 percent phenocrysts (1.5–5 mm) consisting of Q, 51 and 42; K, 36 and 31; P, 11 and 23; B, 1.5 and 3; and O, 0.6 and 0.8. The largest exposure of mesobreccia, about 400 x 500 m in size, is on south flank of hill 7457, where unit may be 10–15 m thick

Td **Felsite dikes (age unknown, likely late Oligocene)**—Light-yellowish-brown felsite forms thin (a few meters) dikes intruded into Paleozoic rocks in detachment plate southwest of Hunts Ranch fault

Tat **White ash-fall tuff (upper Oligocene)**—White to pale-grayish-white, bedded, poorly consolidated, crystal-poor quartz latitic ash-fall tuff. Minor parts of ash-fall tuff are coarse grained and crystal rich; other parts are almost porcelaneous and hackly weathering. Contains abundant mostly small (less than 1 cm) slightly flattened white pumice lapilli; locally, strongly flattened white pumice lapilli as long as 5 cm. Light-gray glass fragments (less than 1 cm in diameter) are abundant in places. Lithic fragments (as long as 5 cm), mostly volcanic, are abundant locally. Probably in part water laid; contains lenses of pebble conglomerate (not mapped); pebbles are mostly volcanic rocks although sparse Paleozoic rock fragments are present. Modal and chemical data for unit in adjacent Belmont West quadrangle were reported by Shawe (1998). Contact relations with adjacent units are complex. Younger rocks lie unconformably upon white ash-fall tuff, except locally where (partly contemporaneous) rhyolitic welded ash-flow tuff (Trt1) is interbedded at top. White ash-fall tuff interfingers with claystone-siltstone-sandstone unit (Tcs) between hill 7821 and hill 7442 in southwest part of quadrangle. Elsewhere in southwest part of quadrangle, white ash-fall tuff overlies (conformably?) Tcs; south of Hunts Ranch fault at southwest edge of quadrangle it appears to conformably overlie megabreccia of Hunts Canyon (Tmh); and east of hill 7821 and for 3 km farther southeast, it unconformably overlies rhyolitic lahar (Tlh). Near mouth of White Rock Canyon (name of canyon derives from exposures of white ash-fall tuff) in southeast corner of quadrangle, white ash-fall tuff fills a deep channel cut into underlying rhyolitic lahar. Biotite K-Ar age of 27.0±1.0 was determined on a sample collected in Belmont West quadrangle (Shawe and others, 1987). Maximum thickness about 200 m

Tvb **Volcanic breccia (upper Oligocene)**—Four dikelike bodies of volcanic breccia are exposed in claystone-siltstone-sandstone unit (Tcs) and associated pumiceous tuff lenses (Tcst). A north-trending dike about 200 m long and 1 m wide on west flank of hill 7129 in southwest corner of quadrangle consists of tuff that contains lithic fragments, mostly volcanic, as large as 10 cm in size. An east-trending breccia dike about 250 m long and as wide as 25 m on southwest flank of hill 7821 consists of a heterogeneous mixture of volcanic blocks of great variety, as large as 1 m in diameter, set in a light-yellowish-brown ash-tuff matrix. A body of similar lithology lies about 200 m to the north; its north-northeast-oriented form, about 200 m long and as much as 40 m wide, merges laterally at its north end with crudely layered breccia that appears to be part of a pumiceous tuff lens (Tcst). A fourth body farther west has the outcrop form of a lens interlayered in Tcs; it may be depositional rather than intruded. Age of volcanic breccia bodies is unknown; they probably are not much younger than, or perhaps contemporaneous with, the youngest parts of Tcs and Tcst

Tmh **Megabreccia of Hunts Canyon (upper Oligocene)**—Eruptive(?) megabreccia consisting of small to large blocks, in part brecciated, mostly of welded rhyolitic ash-flow tuff. 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 partially welded, crystal-rich rhyolitic ash-flow tuff. Rhyolitic welded ash-flow tuff blocks are as large as 200 x 65 m, rhyolite lava as large as 100 m in diameter, ash-fall tuff as large as 130 x 65 m, vitrophyre to 40 m in diameter, and Paleozoic limestone to 10 m in size. Matrix is light greenish brown to light yellowish brown to pale pinkish gray; weathers light orangish buff. Modal analyses of two samples of matrix indicate 11 and 23 percent phenocrysts (2–5 mm) made up of the following percentages of components: Q, 28 and 39; K, 41 and 37; P, 27 and 23; B, 3 and 1; O, 0.5 and 1; and M, 0–1. Zircon and apatite are sparse accessory minerals. Modal analyses of sample of four large clasts of partially to moderately welded, crystal-rich rhyolitic ash-flow tuff indicate 20–40 percent phenocrysts (1–3.5 mm) made of Q, 28–45; K, 29–49; P, 20–23; B, 1–3; and O, 0–0.5. Accessory minerals are common to sparse zircon and sparse to rare allanite and apatite. Phenocryst compositions of matrix and rhyolitic ash-flow tuff clasts are similar to those of tuff of Ryecroft Canyon (Trc), and megabreccia likely is related to Trc in the same manner as megabreccia of Meadow Canyon is related to tuff of Ryecroft Canyon in Jefferson quadrangle (Shawe, 1999b); that is, both are of the same volcanic cycle and share the same source.

A large block of pale-yellowish-brown ash-fall tuff, possibly derived from underlying claystone-siltstone-sandstone unit (Tcs), is exposed in Tmh on northwest side of canyon in Horse Heaven. The block is unusual in that it is intruded by plugs or dikes of breccia a few meters across that appear confined to the large block. Restriction of plugs or dikes to the large block indicates that intrusions were emplaced before block was incorporated in megabreccia. Most breccia clasts in intrusions, as large as 15 cm and commonly rounded, are volcanic; lesser amounts of Paleozoic chert, schist, greenstone(?), and quartzite, and coarsely-crystalline hornblende-biotite quartz monzonite are present in one pebble dike. Presence of plutonic igneous rock, unknown at surface within more than 5 km, suggests that clast was derived from depth during eruptive emplacement of megabreccia.

Megabreccia of Hunts Canyon covers an area of about 1 km^2 in southwest corner of quadrangle, where it appears to conformably underlie white ash-fall tuff (Tat), conformably overlie and intertongue with claystone-siltstone-sandstone unit (Tcs), and conformably overlie layered pumice tuff (Tpt). Maximum exposed thickness about 130 m

Tcs **Claystone-siltstone-sandstone unit (upper Oligocene)**—Light-yellowish-brown to light-brownish-gray, thin-bedded and platy volcanic claystone, siltstone, and sandstone, and minor pebble conglomerate lenses. Probably mostly lacustrine. Locally extensively fractured; closely spaced fractures with minor displacements suggest slumping of sediments following partial lithification. A modal analysis of a laminated shardy siltstone-sandstone sample, probably water-laid tuff, shows about 18 percent angular to subrounded crystals (maximum diameter 1 mm) that consist of the following percentages of components: Q, 25; K, 21; P, 43; B, 11; and O, 0.5. Matrix of crystals consists of broken devitrified shards. Unit conformably underlies and interfingers with white ash-fall tuff (Tat); south of Hunts Ranch fault in southwest corner of quadrangle, it underlies and interfingers eastward with megabreccia of Hunts Canyon (Tmh). It appears to unconformably overlie rhyolitic lahar (Tlh). Maximum thickness 40 m.

West of hill 7821 in southwest part of quadrangle, claystone-siltstone-sandstone unit contains several large lenses of pumiceous tuff (Tcst). Farther south, about 500 m south-southeast of hill 7732, a small lens of lacustrine limestone (labeled ls) in unit is similar to that described in unit in Belmont West quadrangle (Shawe, 1998)

Tcst **Pumiceous tuff (upper Oligocene)**—Pale-yellowish-brown, crystal-poor, nonwelded quartz latitic lithic-pumice tuff; weathers light yellowish brown. Characterized by abundant small (mostly less than 1 cm) noncompacted pumice fragments and volcanic rock fragments; minor Paleozoic rock fragments are present. Modal analysis of one sample of pumiceous tuff shows 4 percent phenocrysts (1–1.5 mm) that consist of the following percentages of components: Q, 32; K, 20; P, 39; B, 8; and O, 1. Forms lenses interlayered in claystone-siltstone-sandstone unit (Tcs) west of hill 7821. A layer of pale-grayish-white pumiceous tuff (weathers light grayish to yellowish brown) similar to Tcst is interlayered in white ash-fall tuff (Tat) on northwest flank of hill 7821, and is indicative of intertonguing relation of Tcs and Tat. Maximum thickness 35 m

Tlh **Rhyolitic lahar (upper Oligocene)**—Light-gray and light-lavender-gray, locally whitish-gray or light-brown, rhyolitic lahar. Contains blocks of mostly flow-layered light-gray rhyolite, and lesser amounts of pumiceous rhyolite and vitrophyre, in a matrix of smaller fragments and pulverized rhyolite, and locally, whitish ash tuff. Larger blocks in lahar are 2–3 m in diameter; bocks are uncommonly as large as 5 m across. In some areas, lahar contains fragments as large as only a few centimeters across. In a few places, lahar is layered, particularly in its upper parts. Contains local lenses of bedded tuff (Tlhb), mostly not mapped. One large mapped lens overlies lahar that consists of locally broken and disoriented flow-layered rhyolite; lens is overlain by lahar that contains thoroughly disoriented rhyolite blocks. Lahar is intruded both by rhyolite plugs (Trp) and rhyolite flow domes (Trf and Trlv), and overlain unconformably by claystone-siltstone-sandstone unit (Tcs), white ash-fall tuff (Tat), and vitrophyric rhyolite flows (Trv). Surface apparently significantly eroded before overlying units were deposited, as contacts with them are commonly steep. Locally eroded to pedestals where larger blocks remain as resistant caps upon the pedestals. Exposed widely in southwest and southeast corners of quadrangle. Base not exposed; thickness at least 200 m

Tlhb **Bedded tuff**—Light-gray bedded tuff lenses in rhyolitic lahar (Tlh). Only one lens mapped, about 300 m northwest of hill 7500. Maximum thickness a few meters

Tmj **Tuff of Mount Jefferson(?) (upper Oligocene)**—Light-gray to light-yellowish-brown, moderately crystal-rich, partially to moderately welded rhyodacitic ash-flow tuff; weathers light orangish brown, yellowish brown, and brown. Contains a thin dark-gray layer of vitrophyre (not mapped). Two modal analyses indicate 13 and 24 percent phenocrysts (2–3.5 mm) made up of the following percentages of components: Q, 16 and 18; K, 29 and 12; P, 50 and 61; B, 5 and 9; and O, 1 and trace. These modes are similar to those of category 2 rocks of tuff of Mount Jefferson in Jefferson quadrangle about 25 km to the north-northwest (Shawe, 1999b); the tuffs may represent outflow from Mount Jefferson caldera. Sanidine and biotite $^{40}Ar/^{39}Ar$ ages of tuff of Mount Jefferson determined by L.S. Snee (written commun., 1996) on samples collected by R.F. Hardyman in Corcoran Canyon quadrangle to the north average about 26.8 Ma. Rocks conformably(?) overlie steeply tilted layers of tuff of Ryecroft Canyon (Trc) in southwest corner of quadrangle. Thickness about 200 m

Trc **Tuff of Ryecroft Canyon (upper Oligocene)**—Consists of welded rhyolitic ash-flow tuff exposed near inferred margin of, and possibly related to, a caldera underlying Monitor Valley. Caldera is inferred on the basis of (1) thick (several hundred meters) sections of tuff of Ryecroft Canyon peripheral to south end of Monitor Valley, (2) megabreccia (megabreccia of Hunts Canyon, Tmh) of composition similar to the Ryecroft Canyon near inferred margin of caldera, and (3) an arc of rhyolite flow domes (Trlv, Trf) of Ryecroft Canyon composition that are emplaced along inferred structural margin of caldera. Two modally distinct types of ash-flow tuff, (“typical” and “quartz rich”) probably are both intracaldera and outflow facies. An unconsolidated tuff (Trca) at base of welded tuff in Black Buttes in northwest part of quadrangle is considered part of the Ryecroft Canyon. Blocks of tuff in mesobreccia (Tms) outside the caldera in southwest part of quadrangle are modally similar (quartz-rich type) to intracaldera tuff in southeast part of caldera. A sample of black vitrophyre collected from formation just above unconsolidated tuff (Trca) in Black Buttes (dated locality R1) gave a sanidine $^{40}Ar/^{39}Ar$ isochron date of 27.13±0.03 (1σ) Ma; sanidine $^{40}Ar/^{39}Ar$ dates determined on samples of typical ash-flow tuff collected in Corcoran Canyon quadrangle range from 26.82±0.04 (1σ) Ma to 27.05±0.06 (1σ) Ma (L.W. Snee, written communs., 1996, 1997).

Tuff of Ryecroft Canyon may be correlative with tuff of Moores Creek, thought by Boden (1986) to have erupted during an initial phase of development of Toquima caldera complex in Toquima Range to the north. A sanidine K-Ar date for tuff of Moores Creek is 27.3±0.5 Ma and a biotite K-Ar date for tuff of Moores Creek is 27.0±0.8 (Boden, 1986). Also, modal data for the Ryecroft Canyon (given below) are virtually the same as those presented by Boden (1986) for tuff of Moores Creek. If the two formations are in fact correlative, and if the inferred caldera underlying Monitor Valley is indeed the source of tuff of Ryecroft Canyon, the combined Moores Creek and caldera beneath Monitor Valley formed a structure about 50 km long trending northwest-southeast.

Typical ash-flow tuff is light-gray to light-lavender-gray, crystal-rich, partially to densely welded rhyolitic ash-flow tuff; weathers light yellowish brown to light pinkish gray to light brownish gray. Contains inconspicuous gray pumice fiamme as long as 2 cm, mostly less than 1 cm, and in places numerous lithic fragments, chiefly volcanic rocks, less than 1 cm long and uncommonly as large as 4 cm. Smoky quartz is evident in some parts. Modal analyses of six thin sections show 25–39 percent phenocrysts (1.5–5 mm) that consist of the following percentages of components: Q, 26–35; K, 28–41; P, 27–40; B, 3–6; O, trace–0.5; and H, 0.5–2. Zircon is common to sparse, apatite is sparse, and allanite is rare. Chemical analyses of three samples indicate the following percentages of components: SiO_2, 73.3–74.7; Al_2O_3, 13.6–14.2; K_2O, 4.54–5.13; Na_2O, 2.66–3.30; CaO, 1.13–1.75; Fe_2O_3, 1.36–1.61; FeO, 0.28–0.32; MgO, 0.54–0.58; TiO_2, 0.21–0.25; P_2O_5, 0.08–0.10; and MnO, 0.01–0.06 (rhyolite). Typical rocks of tuff of Ryecroft Canyon crop out in northwest corner of quadrangle where their base is not exposed and upper part is eroded away. Maximum exposed thickness in hill 7504 about 1 km southwest of Black Buttes is about 100 m.

Quartz-rich tuff of Ryecroft Canyon is pale-gray to light-gray, crystal-rich, partially to densely welded rhyolitic ash-flow tuff; weathers light yellowish brown, light brown, and light brownish gray. In places it contains small lithic fragments, mostly volcanic rocks less than 1 cm in size. Modal analyses of two thin sections show 30 and 37 percent phenocrysts (1.5–5 mm) that consist of the following percentages of components: Q, 41 and 42; K, 33 and 26; P, 23 and 27; B, 3 and 5; O, 0.2 and 0; and H, 0 and 0.7. Common zircon, common to sparse apatite, and sparse allanite and sphene are accessory minerals. Quartz-rich tuff, apparently intracaldera facies as its exposed thickness of at least 200 m lies within inferred margin of a caldera beneath Monitor Valley, is found at east edge of quadrangle north of White Rock Canyon; neither top nor base of formation is exposed there. A small outcrop about 80 m in diameter of inferred outflow lies just west of “Long Ridge” in southwest part of quadrangle.

Inferred outflow facies of tuff of Ryecroft Canyon just southwest of Hunts Ranch fault is gray to light-lavender-gray, moderately crystal-rich to crystal-rich, partially to moderately welded rhyolitic ash-flow tuff; weathers light brown to light orangish brown. Contains light-yellowish-brown to light-pinkish-brown, moderately to greatly flattened pumice lapilli, mostly less than 0.5 cm in size. Modal analyses of six thin sections indicate 9–24 percent phenocrysts (1.5–3 mm) that consist of the following percentages of components: Q, 25–33; K, 37–42; P, 25–30; B, 2–4; O, 0–1; and H, 0–2. Zircon is common, allanite is common to sparse, and apatite is sparse. Chemical analyses of two samples show the following percentages of components: SiO_2, 74.0 and 74.8; Al_2O_3, 13.8 and 13.3; K_2O, 4.91 and 5.21; Na_2O, 2.95 and 3.00; CaO, 1.81 and 1.10; Fe_2O_3, 1.18 and 1.69; FeO, 0.28 and 0.23; MgO, 0.55 and 0.38; TiO_2, 0.33 and 0.19; P_2O_5, 0.12 and 0.08; and MnO, 0.02 and 0.01 (rhyolite). Forms a sequence of steeply tilted ash flows on southwest side of Hunts Ranch fault. Tilting may have resulted from drag along the fault, which probably is a strike-slip fault with significant right-lateral slip

Trca **Unconsolidated tuff**—White to pale-greenish- to pale-yellowish-brown, pulverulent porous ash tuff at base of welded tuff of Ryecroft Canyon (Trc) in Black Buttes.

May be either the lower or upper unconsolidated part of an ash-flow sheet. No petrographic data were obtained on unit. Exposed thickness a few meters

Trcv **Vitrophyric ash-flow tuff**—Dark gray. Mapped only at base of Trc northeast of "Long Ridge"

Tpt **Layered pumice tuff (upper Oligocene)**—Pale-yellowish-brown to light-yellowish-brown, interlayered air-fall tuffs, surge(?) deposits, and water-laid tuffaceous sediments; weathers light orangish brown. Consists of a series of tuffaceous layers, each several centimeters to several meters thick, that contain pumice fragments as large as a few centimeters in diameter, and varied amounts of lithic fragments, from sparse to as much as 50 percent, of rhyolite and Paleozoic rocks (chiefly siliceous argillite and shale) as large as 30 cm in size. A modal analysis of a tuff layer that contains abundant clay-altered uncompacted biotite-bearing pumice fragments as large as 1 cm shows 28 percent phenocrysts (0.5–5 mm) that consist of the following percentages of components: Q, 1.5; K, 15; P, 66; B, 12; O, 3; and M, 3. Layered pumice tuff unit conformably(?) underlies megabreccia of Hunts Canyon (Tmh) and probably also claystone-siltstone-sandstone unit (Tcs) southwest of Hunts Ranch fault at south boundary of quadrangle. Unit is several tens of meters thick within quadrangle and its base is not exposed; unit overlies, apparently conformably, a thick section of ash-flow tuffs south of Belmont East quadrangle that may be part of the principal unit that fills the Big Ten Peak caldera to the south (Keith, 1987a, b)

Granite of Shoshone Mountain (Late Cretaceous)—Mostly coarse-grained two-mica granite that forms two large oval-shaped plutons: the Round Mountain and Belmont plutons. Only east edge of texturally zoned Belmont pluton is exposed in Belmont East quadrangle

Belmont pluton—Several phases of the domed, zoned granite pluton in Belmont West and Jefferson quadrangles were described by Shawe (1998, 1999b). The only phases present in Belmont East quadrangle are porphyritic coarse-grained granite (Kbgp), fine-grained granite (Kbgf), and aplite (Kba). Some bodies are mixtures of fine-grained granite and aplite (mapped as Kbgf-Kba). Age of Belmont pluton, based on Rb-Sr whole-rock data (John and Robinson, 1989), is 84.5±3.4 Ma (average of two isochrons). Doming of pluton occurred about 80–82 Ma, based on K-Ar ages of biotite and muscovite in granite (Shawe and others, 1986, 1987)

Kba **Aplite**—Pale-gray to pale-yellowish-brown, leucocratic aplite. Makes up dikes intruding granite, and sills and dikes that intrude or form apophyses into Paleozoic metasedimentary wall rocks. Pods of quartz and pegmatite occur locally in aplite. Detailed descriptions of aplite in Belmont West and Jefferson quadrangles given in Shawe (1998, 1999b). Aplite in granite is confined to within a few hundred meters of granite contact, and in wall rocks it is confined to within about 1 km of granite contact

Kbgf **Fine-grained granite**—Pale-gray to pale-yellowish-brown, fine- to medium-grained granite. Commonly leucocratic or alaskitic (nearly white). Detailed descriptions of fine-grained granite in Belmont West and Jefferson quadrangles given in Shawe (1998, 1999b). Forms bodies 50–120 m wide and several hundred meters long, and parts of smaller bodies mixed with aplite, intruded along margin of Belmont pluton

Kbgp **Porphyritic granite**—Light-gray, coarse-grained granite that contains abundant (about 15 percent or more) large phenocrysts of orthoclase and (or) microcline 2–10 cm long. More complete descriptions of porphyritic granite in Belmont West and Jefferson quadrangles were given by Shawe (1998, 1999b). Forms outer shell of domed, zoned Belmont pluton.

Dark-gray, schlierenlike layers 1–30 cm thick in porphyritic granite were observed near schist inliers about 1 km southwest of Highbridge Mill ruins in Belmont mining area. Somewhat irregulary shaped, the layers dip at a shallow angle to the east, about 1 km inside granite contact. They are similar in appearance to dark layers in sparsely porphyritic granite mapped in Jefferson quadrangle (Shawe, 1999b), and they may represent deformed and somewhat metasomatized layers of heavier minerals deposited by convection currents active before solidification of granite. One layer consists of quartz diorite; two modal analyses of thin sections of the rock indicate the following percentages of components: Q, 23 and 24; P, 38 and 32; B, 37 and 43; O, 0.5 each; and minor to trace amounts of muscovite, hornblende, allanite, apatite, and zircon. Chemical analysis of a sample of the diorite shows the following percentages of components: SiO_2, 57.3; Al_2O_3, 13.8; K_2O, 4.26; Na_2O, 2.02; CaO, 1.86; Fe_2O_3, 3.46; FeO, 12.5; MgO, 1.83; TiO_2, 2.26; P_2O_5, 0.49; and MnO, 0.17

Pzu **Paleozoic rocks, undivided**—Shown only on cross sections

Toquima Formation (Middle Ordovician)—Typically thin-bedded, interlayered, marine sedimentary rocks and their silicified and (or) metamorphosed equivalents. Divided into limestone (Otl), argillite (Ota), siliceous argillite (Otas), schist and subordinate argillite (Otsa), schist (Ots), and quartzite (Otq); limestone in places is jasperized (Otlj) or calc-silicate mineralized (Otlc). Lithologies may be transitional from one unit to an adjacent unit; minor amounts of other rock types may be present in some units. Strongly deformed by folding and thrust faulting, probably in several episodes from late Paleozoic to Late Cretaceous time. Where intruded by the Late Cretaceous Belmont pluton, rocks are metamorphosed to schist or calc-silicate-mineralized limestone, or are silicified (jasperized). Units in the Toquima are shown in the "Correlation of Map Units" to be correlative in age because extreme deformation has resulted in disruption such that some lithologic units are juxtaposed out of stratigraphic context, and their original sequence cannot be determined. Correlative with part of Ordovician Palmetto Formation in southern Nevada (for example, Ferguson, 1924; McKee, 1968) and Middle and Upper Ordovician part of Vinini Formation in northern Toquima Range (McKee, 1976). Forms a thrust plate underlying a plate of mostly carbonate rocks (Pzl) of uncertain age exposed at edge of Monitor Valley east of hill 7504 southwest of Black Buttes, and overlying a plate of Zanzibar Formation (Oz units); in folded-thrust contact with underlying Mayflower Formation (€m units) northeast of Belmont; and overlying a plate of oceanic rocks (Pzm units) south of Belmont. The Toquima plate is internally thrust faulted in places. Plate is exposed around periphery of Belmont pluton from about 1–2 km north and northeast of Belmont to about 6 km south of Belmont. Original thickness uncertain because of deformation, but probably at least several hundred meters to perhaps 1,000 m

Otl **Limestone**—Light- to dark-gray, mostly medium-gray, thin-bedded to platy and laminated limestone; weathers pinkish to light orangish brown. In part silty; thin interbeds of argillite common. Tremolitized locally, particularly within a few hundred meters of an aplite sill (Kba) about 1 km north and northeast of Belmont. Some thin beds have been converted to a mass of jackstrawed tremolite needles. Also sparsely dolomitized where quartz knots and lenses are streaked along bedding in same area. Contains thin irregularly shaped white quartz veins in places. Occurs as a series of beds forming units as much as 500 m thick interlayered with argillite units, best exposed northeast of Belmont. A mass of isoclinally folded limestone in the Belmont mine area southeast of Belmont sharply interpenetrates argillite (Ota) to the north

Otlc **Calc-silicate-mineralized limestone**—Light-yellowish-brown to light-pinkish-brown, faintly laminated rock. Thin-section examination of one sample shows a granular aggregate of mosaic quartz crystals and ragged diopside grains (as large as 0.3 mm), and minor irregulary shaped sphene grains (to 0.1 mm). Forms a unit perhaps 15 m thick interlayered within siliceous argillite (Otas) 2.5 km south of Belmont. A few thin layers of light-yellowish-brown to light-gray calc-silicate-mineralized limestone within limestone (Otl) wered not mapped

Otlj **Jasperized limestone**—Black, gray, brown, reddish-brown, or yellowish-brown silicified limestone (jasperoid). Commonly brecciated, locally tightly folded. Small scattered areas of jasperoid northeast of Belmont and in area of Belmont mines not mapped; extensive areas of jasperoid are exposed south of Belmont mines, where units may be several tens of meters thick

Ota **Argillite**—Medium- to dark-gray, mostly platy and in part silty or limy argillite; weathers pinkish to orangish brown to brown in places. Graptolitic shale adjacent to quartzite (Otq) is dark gray and graphite rich. Graptolites identified in samples collected in Round Mountain quadrangle (Shawe, 1995) indicate a Mohawkian (Middle Ordovician) age. A thin section of silty argillite shows a fine-grained (as large as 0.02 mm) aggregate of angular to subrounded grains of quartz and feldspar(?) set in a nearly opaque matrix of clay(?) and graphite dust. Crystals of tremolite (as long as 2 mm) and small crystals of metamorphic sphene (0.1 mm long) are scattered throughout. Thin (1 mm) veinlets of quartz and (oxidized) pyrite cut rock. Forms units as thick as 200 m interlayered with limestone (Otl) northeast of Belmont, and interpenetrates limestone where isoclinally folded southeast of Belmont

Otas **Siliceous argillite**—Mostly dark-gray, locally medium- to light-gray, thin-bedded and laminated argillite; weathers brownish gray to brown in places. Minor parts are phyllitic or schistose. Sparse interlayered medium-gray, thin-bedded limestone and dark-gray schist. Thin seams (a few millimeters wide) of turquoise occur in siliceous argillite about 5 km south of Belmont. Silicification of argillite may have occurred at time of mineralization at Belmont silver deposits, probably in Late Cretaceous time during late doming, metamorphism, and mineralization of Belmont pluton (Shawe, 1988). Scattered patches of siliceous argillite are found for about 7 km south of Belmont, where rock lies in thrust contact upon underlying units. Maximum local thickness probably about 30 m

Otsa **Schist and subordinate argillite**—Dark-gray interlayered phyllitic schist and dark-gray argillite. Occurs in scattered small areas 2–3 km south of Belmont where unit is in strongly deformed thrust slices. Maximum thickness perhaps 10 m

Ots **Schist**—Dark-gray, fine-grained schist in small inliers in porphyritic granite (Kbgp) near margin of Belmont pluton, and in larger masses as thick as perhaps 100 m in contact with the margin of the pluton, about 2.5–3 km south of Belmont

Otq **Quartzite**—Pale-gray to dark-gray quartzite; weathers brownish gray in places. Thin-section examination of a sample from southernmost exposure of Otq shows a poorly sorted aggregate of subrounded to subangular quartz grains (as much as 0.4 mm, down to about 0.05 mm in diameter) in a matrix of silica and calcite. Sparse grains of plagioclase and chert are present. Blebs (as large as 0.05 mm, rarely to 0.4 mm) of oxidized pyrite, and small (0.2 mm) sunbursts of tremolite needles, are scattered throughout. This rock appears less metamorphosed than Toquima quartzite samples studied elsewhere, as those quartzites consist of mosaic quartz with interstitial calcite and scattered crystals of muscovite and tremolite. Interbedded in argillite (Ota or Otas) or schist (Ots) as a small truncated layer about 5 km south of Belmont, as a more extensive layer as much as 10 m thick in area of Belmont mines, and as a thin (1–2 m), in places boudinaged, layer, or pair of closely-spaced layers, northeast of Belmont. Northeast of Belmont, quartzite is intruded by aplite (shown as Kba along one contact of quartzite); intrusion locally has broken up and engulfed blocks of quartzite. Correlative with Middle Ordovician Eureka Quartzite in eastern Nevada (for example, Nolan and others, 1956) and Middle Ordovician quartzites in Vinini Formation in central Nevada

Zanzibar Formation (lower Middle Ordovician)—Generally thin-bedded schistose argillite (Ozsa) and schist (Ozs), interlayered in places, and thin- to medium-bedded limestone (Ozl). Deposited as marine turbiditic sediments and subsequently lithified and metamorphosed. Much more extensive, and with more varied lithologies, in nearby quadrangles (Shawe, 1995, 1998, 1999a, b). Formation constitutes a thrust plate underlying plate of Toquima Formation and overlying plates of older formations (which are not exposed in quadrangle). Rocks are metamorphosed to schist where intruded by Belmont pluton. Exposed along margin of pluton for about 3 km south of Belmont. Age is Whiterockian (early Middle Ordovician, based on fossil identifications by W.B.N. Berry, R.J. Ross, Jr., and J.W. Huddle of samples from Manhattan quadrangle; Shawe, 1999a). Correlative with part of Palmetto Formation in southern Nevada (for example, Ferguson and Cathcart, 1954) and part of Vinini Formation in central Nevada, and equivalent in age to part of Antelope Valley Limestone in eastern Nevada (Ross, 1970)

Ozsa **Schistose argillite**—Medium- to dark-gray, thin-bedded to laminated, in places limy, silty, or silicified argillite. Thin beds of limestone and siltstone are interlayered in places. Contains minor interlayered schist and phyllitic argillite. Occurs as thin lenses (as much as 10 m wide) in porphyritic granite near margin of Belmont granite pluton (Kbgp), and as larger masses outside pluton, south of area of Belmont mines

Ozs **Schist**—Dark-gray, foliated and locally lineated schist; weathers brown. Quartz-biotite schist, in places with varied amounts of tremolite, muscovite, and graphite. Exposed along margin of, and as inliers in, Belmont pluton (Kbgp), near west margin of quadrangle. Formed by metamorphism of argillite

Ozl **Limestone**—Medium- to dark-gray, thin- to medium-bedded limestone. Forms a layer 10–15 m thick lying upon schist (Ozs) and underlying plate of Toquima Formation on west side of Belmont mines area

Paleozoic carbonate rocks (Ordovician?)—A thrust plate composed mostly of marine turbiditic limestone overlies Toquima and Mayflower Formations (Ot and Ꞓm units) east of Belmont along edge of Monitor Valley. Rocks in plate have some similarities to rocks in both Toquima and Zanzibar Formations (Ot and Oz units), but they exhibit no distinguishing features, and they are in a structural position different from those of Toquima and Zanzibar Formations in southern Toquima Range. On the basis of lithologic content, they are judged to be most likely Ordovician in age. Lithologic units described are limestone (Pzl), jasperized limestone (Pzlj), interbedded argillite and limestone (Pzal), and argillite (Pza)

Pzl **Limestone**—Light- to dark-gray, mostly medium-gray, thin-bedded to platy and laminated limestone. In part silty; thin beds of chert, argillite, and silicified argillite interlayered in places. Chert is dark gray; weathers brown. Irregularly seamed with thin veinlets of quartz and calcite. Deformed and brecciated just above underlying thrust fault. Forms units as much as 150 m thick interlayered with argillite (Pza) and interbedded argillite and limestone (Pzal)

Pzlj **Jasperized limestone**—Black, brown, reddish-brown, and light-yellowish-brown, brecciated silicified limestone (jasperoid) in small outcrop 2 km southeast of Belmont

Pzal **Interbedded argillite and limestone**—Form a unit about 120 m thick isoclinally infolded(?) into limestone (Pzl)

Pza **Argillite**—Gray, thin-platy to laminated argillite. Silicified locally. Forms a unit about 300 m thick

Rocks of the Monarch area (Paleozoic, possibly in part Ordovician and (or) Cambrian)—An oceanic suite of rocks, partly ophiolitic, was described near the Monarch site in adjacent Belmont West quadrangle (Shawe, 1998). Units of suite that are present in Belmont East quadrangle are greenstone (Pzmg), chert (Pzmc), metasomatite (Pzmm), argillite (Pzma), and limestone (Pzml)

Pzmg **Greenstone**—Greenish-gray to olive-gray, fine- to coarse-grained andesite flows, flow breccias or debris flows, and interlayered graywacke and tuff; weathers brown. Contains local lenses and layers of chert (Pzmc), not all mapped. Thin-section examinations show that most of unit consists of altered mafic lavas in which plagioclase phenocrysts are altered to calcite, albite, quartz, and (or) chlorite. Mafic minerals are altered to calcite, chlorite, and actinolite. Abundant altered plagioclase microlites in groundmass may or may not be flow oriented. Modal analyses of four mafic lavas indicate 4–35 percent phenocrysts (2–8 mm) that consist of the following percentages of components: P, 47–90; and M, 10–53. Mafic minerals are clinopyroxene or pseudomorphs of clinopyroxene and olivine, and opaque minerals. A chemical analysis of a mafic lava (recalculated to remove secondary calcite, based on CO_2 content of 4.21 percent indicating 9.57 percent calcite) shows the following percentages of components: SiO_2, 51.3; Al_2O_3, 15.5; K_2O, 1.06; Na_2O, 4.57; CaO, 7.15; Fe_2O_3, 2.37; FeO, 9.14; MgO, 5.12; TiO_2, 3.19; P_2O_5, 0.45; and MnO, 0.18 (trachybasalt). The exceptionally high TiO_2 content suggests affinity with Ordovician gabbroic intrusive rocks (Og) in Toquima Formation in Belmont West quadrangle (Shawe, 1998). Coarse-grained graywacke and tuff layers a few meters thick occur sporadically within greenstone unit. A thin section of graywacke shows mostly mafic volcanic rock clasts (as large as 10 mm) in a matrix of devitrified shard and pumice fragments. A strongly altered tuff characterized by moderately flattened pumice fragments and altered phenocrysts (as much as 3 mm long) contains sparse actinolite metacrysts. Greenstone crops out beneath a thrust plate of Toquima Formation (Ot units) along west edge of quadrangle 5–7.5 km south of Belmont. Neither top nor base of unit is exposed there; original thickness probably was at least 1,000 m. Cross-section reconstruction (section *C–C'*) suggests that the greenstone was thrust over rocks of Mayflower Formation (Ꞓmf). Greenstone layers as much as 200 m thick are interlayered with argillite and associated rocks (Pzma) in detachment plate overlying megabreccia (Tmh) and other volcanic units southwest of Hunts Ranch fault in southwest corner of quadrangle

Pzmc **Chert**—Medium- to dark-greenish-gray, laminated chert. As seen in thin section, chert is made up of alternating, even to somewhat lenticular layers 1–10 mm thick of fine-grained laminated silica (0.05 mm maximum grain size) charged with dustlike material, and coarser (grain size as much as 0.5 mm) silicified ash layers showing abundant shard structures. Layers contain scattered clasts of hornblende (0.1–0.2 mm), altered in part to actinolite or retrograded to chlorite. Mosaic quartz occurs as thin fracture fillings. Chert layers mapped in greenstone (Pzmg) near west margin of quadrangle are as much as 10 m thick and may extend along strike for a few hundred meters

Pzmm **Metasomatite**—Yellowish-brown, light-brown, and brown carbonate rock, in places brecciated and "mashed" as though crushed and stirred, and in places strongly silicified and iron mineralized. A more complete description of metasomatite in Belmont West quadrangle was given by Shawe (1998). Protolith of metasomatite likely was a marine carbonate rock. Small exposures of metasomatite are associated with greenstone unit (Pzmg) at west margin of quadrangle

Pzma **Argillite**—Dark-gray to greenish-gray, silicified argillite, commonly containing interbedded dark-gray chert; weathers brown to brownish-gray. Locally, interbedded thin layers of medium- to dark-gray limestone, in part boudinaged. Thin layers and lenses of dark-gray phyllitic schist (labeled "s") and interlayered thin-platy gray argillite and limestone (labeled "al") mapped in a few places. Isoclinally folded, sheared and brecciated, or iron mineralized in places; strongly iron-mineralized lens is labeled "m". Units as much as 400 m thick interlayered with greenstone (Pzmg) in detachment plate that overrides megabreccia (Tmh) and other volcanic units southwest of Hunts Ranch fault in southwest corner of quadrangle

Pzml **Limestone**—Medium-gray, thin-bedded limestone; fractured, brecciated, and locally crinkled. Cherty and (or) silicified in part. Makes up deformed layers and lenses as much as 30 m thick, interlayered with greenstone (Pzmg) and argillite (Pzma) in detachment plate southwest of Hunts Ranch fault

Mayflower Formation (Cambrian?)—Argillite (Ꞓma) and knotted schist (Ꞓms) deposited as predominantly marine clay. Where schistose, extremely deformed by shearing and isoclinal folding. Within about 1 km of Cretaceous Belmont pluton, formation is metamorphosed to knotted schist; farther from pluton, formation consists of phyllitic argillite grading outward to platy to flaky argillite. Widely exposed 1–3 km northeast and north of Belmont where overthrust Toquima Formation is sharply infolded into the Mayflower, and in scattered patches as far as 5 km south of Belmont. Entire formation not exposed; original thickness unknown, but it likely was several hundred meters to a kilometer or more; considerably more than this may remain in subsurface. Considered by Ferguson (1921, 1924) to be Ordovician(?); unfossiliferous phyllite referrred to the Mayflower in Toiyabe Range to the west was considered by Finney and Perry (1991) to be Lower Ordovician; here, formation is believed to be Cambrian(?) on the basis of similarity to known Cambrian rocks elsewhere in region

Ꞓmf **Argillite**—Light- to medium-gray, locally pale-greenish-gray to pale-olive-gray, argillite; weathers light yellowish brown. Commonly thin-platy to fissile, and much like "paper shale"; fissility in part similar to cleavage. Becomes phyllitic closer to Belmont pluton

Ꞓms **Knotted schist**—Medium- to dark-olive-gray, well-foliated knotted schist. More complete descriptions have been given of Mayflower Schist in Round Mountain, Belmont West, Manhattan, and Jefferson quadrangles (Shawe, 1995, 1998, 1999a, b). In places about 1 km from Belmont pluton, contains interlayered phyllitic argillite

SUMMARY OF GEOLOGIC EVENTS

The Cambrian(?) marine Mayflower Formation (€m units) in the Belmont East quadrangle was deposited as part of a westward-thickening, mostly clastic wedge on the continental shelf at what was then the western edge of the North American continent (Stewart, 1980). Ordovician marine rocks (Toquima and Zanzibar Formations, Ot and Oz units) were deposited probably as transitional facies sediments between predominantly carbonate-facies sediments on the shelf and siliceous facies sediments in a western ocean basin. Rocks of the Toquima Formation are more siliceous than those of the Zanzibar Formation, and they may have been deposited west of the Zanzibar. The Paleozoic (Ordovician?) carbonate formation (Pzl, Pzal, Pza), with similarities to both the Toquima and Zanzibar Formations, was deposited in a transitional shelf-basin environment.

Rocks of the Monarch area (Pzm units) are of Paleozoic age, but their specific age is unknown. Rocks in the detached slab southwest of the Hunts Ranch fault may be of Cambrian age, on the basis of similarity of the argillite unit (Pzma) to known Cambrian rocks in the region (F.G. Poole, oral commun., 1982). Greenstone (Pzmg) has a high TiO_2 content, suggesting possible affinity to Ordovician gabbro (Og) in the Belmont West quadrangle (Shawe, 1998). Whatever their age, it is clear they are of oceanic affinity.

No sedimentary rocks of known late Paleozoic and Mesozoic ages are present in the quadrangle, and the geologic history of the area during those eras is imperfectly known. On the basis of regional evidence, the area likely underwent significant periodic compressional deformation starting in the late Paleozoic and continuing through the Mesozoic. Rock relations in adjacent quadrangles [Round Mountain, Belmont West, Manhattan, and Jefferson (Shawe, 1995, 1998, 1999a, b)] indicate emplacement of higher thrust plates (plates correspond to formational units) successively above lower ones, which consequently produced more deformation in lower plates. In the Belmont East quadrangle, a plate of Zanzibar Formation was thrust over the Mayflower Formation. Subsequently, a plate of Toquima Formation was thrust over the rocks of the Monarch area (mostly Pzmg) and the Mayflower and Zanzibar Formations; the thrust fault is tightly folded where the Toquima lies above the Mayflower. A thrust plate of Paleozoic carbonate rock (Pzl, Pzal, Pza) was subsequently thrust over infolded Toquima and Mayflower Formations.

The rocks of the Monarch area represent a prism of oceanic rocks obducted onto the continent sometime during Paleozoic or Mesozoic time (Poole and Desborough, 1973). Their presence beneath a thrust plate of Toquima Formation, and uncertainty as to what rocks may lie beneath the oceanic rocks, present an intriguing question whose resolution may provide significant insight into the tectonic history of this structurally complex part of the continent.

The Late Cretaceous Belmont granite pluton (Kb units) was intruded during the waning stages of compressional deformation. It likely was emplaced initially, at about 85–84 Ma, as a flat-topped intrusion; subsequently it was domed by rise of granitic magma from a deeper level, metamorphosed, and mineralized at about 80 Ma. The pluton differentiated into layered phases while its roof was still nearly horizontal. Possibly the pluton was emplaced as a thick sill-like body at a crustal level where magma pressure was sufficient to raise overlying rocks. Some details of mineralization were described by Shawe (1988).

At about 27 Ma, many different volcanic units were emplaced in the Belmont East quadrangle. The sequence and absolute ages of emplacement of these units are imperfectly known. Some units appear related to a caldera inferred to underlie Monitor Valley, and some appear related to the Big Ten Peak caldera south of the quadrangle (Keith, 1993). The two calderas apparently were active at about the same time. Shawe earlier proposed (1998) that the claystone-siltstone-sandstone unit (Tcs) and associated lacustrine limestones were deposited in the moat of the Big Ten Peak caldera. He also suggested (Shawe, 1998) that the white ash-fall tuff (Tat), which interfingers with and lies above much of Tcs, and lies above the major caldera fill of the Big Ten Peak caldera, was derived from volcanoes related to the Big Ten Peak caldera. Andesite plugs (Tap) that invaded Tcs and Tat were emplaced at about 26.8–26.3 Ma, possibly along the structural margin of the Big Ten Peak caldera.

Some other units, undated, may be related to either the Big Ten Peak caldera or to a caldera inferred to underlie Monitor Valley.

Rhyolitic lahar (Tlh) underlies both the claystone-siltstone-sandstone unit and the white ash-fall tuff, and it most likely is younger than the tuff of Ryecroft Canyon (the assumed product of eruption of a caldera underlying Monitor Valley). The rhyolitic lahar probably was derived from post-collapse rhyolitic volcanoes associated with the caldera. Rhyolite plugs (Trp) in the southwest part of the quadrangle are not compositionally akin to rocks identified with a caldera underlying Monitor Valley, and they thus may be related to the Big Ten Peak caldera. However, one of the rhyolite plugs intrudes the lower member of the rhyolitic ash-flow tuff (Trt1) and hence appears to be younger than the white-ash tuff (Tat) that underlies Trt1, which is about 27.0 Ma in age. Vitrophyric rhyolitic lava (Trv) overlies rhyolitic lahar (Tlh) and white ash-fall tuff (Tat), but its relation to other adjacent units is unclear.

The tuff of Ryecroft Canyon (Trc) was erupted about 27.1–26.8 Ma, possibly associated with collapse of a caldera underlying Monitor Valley. Evidence for the caldera consists of (1) thick (hundreds of meters) remnants of the Ryecroft Canyon at the periphery of Monitor Valley in and near the northwest and southeast parts of the quadrangle, (2) megabreccia of Ryecroft Canyon composition (Tmh) about 4 km southwest of the inferred caldera structural margin, and (3) an arc of rhyolite flow domes (Trf, Trlv) also of Ryecroft Canyon composition emplaced along the inferred south structural margin of the caldera. Remnants of ash flows interpreted as outflow rim the west margin of Monitor Valley, and are exposed 3–4 km southwest of the inferred structural margin of the caldera. Probably not long after collapse of the caldera, the arc of rhyolite flow domes was emplaced along the south margin of the caldera.

Eruption of the tuff of Mount Jefferson (Tmj) was contemporaneous with, and extended probably slightly younger than, eruption of the Ryecroft Canyon. Tuffs interpreted as outflow from the Mount Jefferson caldera overlie outflow tuff of Ryecroft Canyon in the southwest corner of the quadrangle.

During the eruption-collapse cycle of the inferred caldera beneath Monitor Valley at about 27.1–26.8 Ma, the megabreccia of Hunts Canyon (Tmh) was emplaced. It lies 3–4 km beyond the inferred structural margin of the caldera, and the matrix and major clast component are of the tuff of Ryecroft Canyon. The megabreccia appears to overlie outflow facies of the tuff of Ryecroft Canyon. The megabreccia contains a large block of ash tuff (Tcst?) intruded by breccia bodies that contain fragments of quartz monzonite probably derived from depth, implying that the megabreccia was erupted rather than formed as a result of collapse of the caldera. The origin of the megabreccia is uncertain; similar megabreccias in the southern Toquima Range have been interpreted to be of eruptive origin (Shawe and Snyder, 1988).

Volcanic breccia dikes (Tvb), mesobreccia (Tms), and vitrophyric rhyolite lava (Trv) probably were emplaced during the period of extensive volcanism at about 27 Ma.

A sequence of ash-flow tuffs, derived from outside the area of the southern Toquima Range, was deposited next. They include rhyolitic ash-flow tuff units (Trt1 and Trt2), and lower and upper parts of the Isom-type welded ash-flow tuff formation (Ti). Intervals of erosion separated deposition of most of these ash-flow units. Probably shortly following deposition of Ti, a volcanic sandstone unit (Tvs) was deposited locally, deriving its detritus from erosion of Isom-type tuffs and from andesite plugs (Tap) emplaced at 27–26 Ma.

Crystal-rich welded ash-flow tuffs (Tosl and Tosu) were deposited upon the Isom-type tuffs. The crystal-rich tuffs are similar in composition to those of the Diamond King Formation in the Round Mountain, Belmont West, and Manhattan quadrangles that were deposited about 25 Ma (Shawe, 1995, 1998, 1999a), and to the tuff of Arc Dome of similar age in the Toiyabe Range (John, 1992) 50 km to the northwest. The source of the tuffs likely was a caldera in the southern Toiyabe Range.

The youngest volcanic activity recorded in the Belmont East quadrangle was deposition of units of the Bates Mountain Tuff (TbtB, TbtC, and TbtD) unconformably upon older volcanic rocks at about 24–23 Ma. The Bates Mountain units were derived from an eastern source.

Movement on the Hunts Ranch fault followed deposition of the Isom-type tuffs, as evidenced in the Belmont West quadrangle (Shawe, 1998), but no evidence indicates the minimum age of the fault. The fault shows considerable dispacement, probably mostly strike-slip, as suggested by the fault's association with the Walker Lane zone of northwesterly strike-slip faults. Rhyolitic lahar (Tlh) on the northeast side of the fault is juxtaposed against claystone-siltstone-sandstone unit (Tcs), megabreccia of Hunts Canyon (Tmh), tuff of Ryecroft Canyon (Trc), white ash-fall tuff (Tat), pumice tuff (Tpt), and Paleozoic (Ordovician?) rocks (Pzm units), on the southwest side of the fault. Nevertherless, the fault does not break Isom-type tuff (Ti) that overlies white ash-fall tuff in the southwest corner of the quadrangle, even though the fault's projection carries it beneath the Isom-type tuff. Evidently the Isom-type tuff is detached from underlying rocks northeast of the fault (see cross section *D–D'*).

A similar detachment relation probably explains the slab of Paleozoic rocks (₽zm units) that lies upon megabreccia of Hunts Canyon (Tmh) on the southwest side of the Hunts Ranch fault. The slab is interpreted as a flap of detached Paleozoic rocks dragged, perhaps as much as 4 km, by right-slip movement from farther to the northwest in the Belmont West quadrangle where similar rocks are exposed (Shawe, 1998). The mechanism of detachment likely is similar to that described by Hardyman and Oldow (1991) for structures in the Walker Lane to the northwest. Alluvial deposits ranging in age from Pleistocene to modern were laid down in the quadrangle as a result of erosion of the older rocks. Pleistocene gravels (Qa1) are preserved on a raised bench in the northwest corner of the quadrangle, because of uplift at the south end of range-front faults marginal to Monitor Valley. Oldest alluvium (Qa1) also crops out beneath younger gravels (Qa2a) as a result of erosion caused by headward working of drainages that empty southward into Hunts Canyon. Valley-fill alluvium (Qa2a) peripheral to Monitor Valley has been eroded sufficiently to expose caliche (Qac) that normally lies a meter or more below the surface. Youngest alluvium (Qa3 and Qa3b) is still being deposited in modern stream courses. Swarms of northeast-trending faults occur in alluvium mostly in the east part of Monitor Valley. They cut both youngest alluvium (Qa3 units) and older alluvium (Qa2 units). However, in specific swarms, some individual faults cut both ages of alluvium, but some others cut only older alluvium, indicating recurring deformation within individual swarms. Moreover, the fault swarms are not associated with conspicuous bedrock scarps, suggesting that they may have resulted primarily from strike-slip deformation rather than from normal faulting. The south end of Monitor Valley is not bounded by range-front faults typical of Basin-range structure, but instead, it appears to be primarily a sag structure.

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