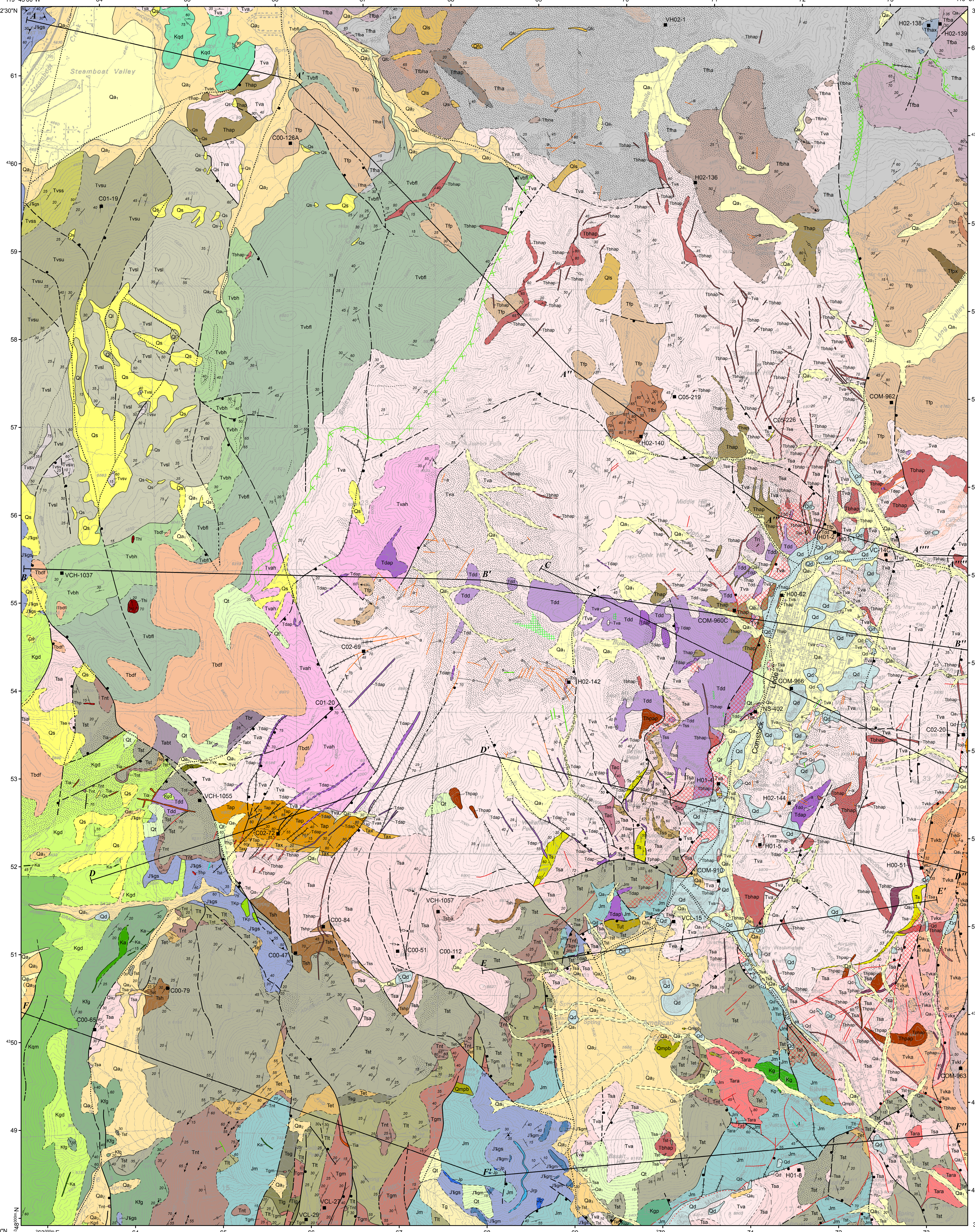
Nevada Bureau of Mines and Geology



GEOLOGIC MAP OF THE VIRGINIA CITY QUADRANGLE, WASHOE, STOREY, AND LYON COUNTIES AND CARSON CITY, NEVADA

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Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

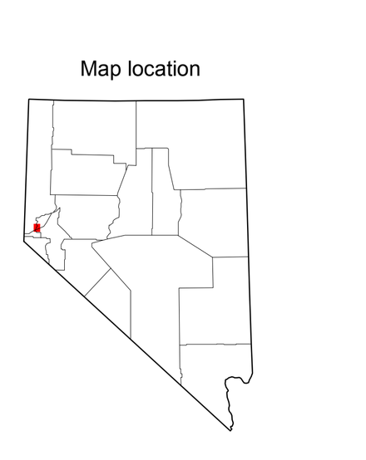
0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 40 FEET

Projection: Universal Transverse Mercator, Zone 11, North American Datum 1927 (m)

Base map: U.S. Geological Survey Virginia City 7.5' Quadrangle (1994)

Map location



Adjoining 7.5' quadrangle names

1	2	3
4	5	6
7	8	9

1 Mount Rose NE
2 Steamboat
3 Chalk Hills
4 Washoe City
5 Virginia City
6 Flowery Peak
7 Carson City
8 New Empire
9 Dayton

Symbology (per FGDC-STD-013-2006)

Contact Solid where certain and location accurate; long-dashed where approximate, dash-dotted where internal, queried if identity or existence uncertain.

Gravel contact Location approximate.

Fault Solid where certain and location accurate; long-dashed where approximate, dotted where concealed, queried if identity or existence uncertain. Ball marks downthrown side; arrow shows bearing and plunge.

Clay alteration along fault Solid where certain and location accurate; long-dashed where approximate, dotted where concealed. Ball marks downthrown side.

Vein Solid where certain and location accurate; long-dashed where approximate, dotted where concealed. Ball marks downthrown side; arrow shows bearing and plunge of slickenlines.

Lineament

Alunite alteration (along a structure too narrow to outline) Ball marks downthrown side; arrow shows bearing and plunge.

Silicification (along a structure too narrow to outline)

Tourmaline-quartz vein

Limit of propylitic alteration

Line of cross-section A — A'

Phyllosilicate alteration (see Table 6)

Alunite alteration and/or silicification

Stockwork veining

Area of tourmaline-quartz alteration or veining

Sample location COM-962 (see Table 4 for $^{40}Ar/^{39}Ar$ age)

Strike and dip of bedding
Inclined — Approximate — Horizontal

Strike and dip of compact foliation in ash-flow tuff
Inclined — Vertical — Approximate — Horizontal
Inclined, arrow shows bearing and plunge of lineation
Inclined, lineation subparallel to strike

Strike and dip of foliation in igneous rocks
Inclined — Vertical

Strike and dip of platy jointing in lavas and hypabyssal rocks
Inclined — Vertical

Strike and dip of foliation in metamorphic rocks
Inclined

Bearing and plunge of columnar joints
Point of observation at arrowhead

QUATERNARY DEPOSITS

Qd **Mine waste** Dumps of unconsolidated mine waste. Most dumps date from the 19th century in the Virginia City area. Some large waste dumps in the Gold Hill and American Flat areas are more modern. Locally includes garbage dumps and other culturally disturbed areas.

Ql **Lake deposits** Grayish white, fine-grained Holocene silts and clays in small, closed, fault-controlled basins south of Steamboat Valley. Probably a few to tens of meters thick.

Qs **Sand** Well-sorted, medium- to fine-grained, quartzose wind-blown sand in the western part of the quadrangle. Generally white to tan but locally reddish where alluvial material is intercalated. Unconsolidated but most well stabilized by vegetation, locally including trees. Includes some alluvial outwash and slope wash of sand originally deposited by wind. Commonly on the east to northeast sides of hills, but extends across some flat areas. Some rock outcrops in the vicinity of Qs are polished and grooved; wind-parallel grooves indicate a northeast sand-transport direction. As much as 15 m thick. Probably Pleistocene but may be Holocene in part.

Qt **Talus** Coarse, angular rock fragments on steep slopes derived from adjacent bedrock units. Mapped only where it is extensive or conceals contacts between older units.

Qa_1 **Young alluvium** Poorly sorted Holocene deposits of boulder- to silt-sized material deposited on alluvial fans and as channel deposits. Commonly non-indurated or poorly indurated. Includes alluvium in active channels.

Qa_2 **Intermediate-age alluvium** Poorly sorted Pleistocene deposits of boulder- to silt-sized material deposited on alluvial fans.

Qa_3 **Old alluvium** Poorly sorted middle(?) Pleistocene boulder- to silt-sized material deposited on alluvial fans that are commonly deeply dissected. Includes strata exposed in the Overman Pit that consist of moderately bedded fan gravels tilted westward as much as 25º toward the Comstock fault. Also includes alluvium that underlies McClellan Peak Basalt on American Flat. Some old alluvium may be late Tertiary in age.

Qls **Landslide deposits** Chaotic mixtures of sand- to boulder-size material in steep terrain deposited by debris flows or rock avalanches. Mostly derived from hydrothermally altered andesite (Tfha) in the northwest part of the quadrangle. Includes deposits ~2 km north of Mt. Abbie that are interpreted to have formed by rotational slump of Tfp on Tva. Probably Pleistocene; surfaces are not hummocky and deposits have been dissected and removed by active Holocene streams.

Qfc **Ferricrete** Iron oxide-cemented stream channel conglomerate and sandstone along the canyon adjacent to Toll Road in the northwest part of the quadrangle. As much as 5 m thick in remnants along margins of the present stream. Probably Pleistocene and formed by acidic surface waters derived from weathering of nearby pyrite-bearing andesite.

Qmpb **McClellan Peak Basalt** (1.17±0.04 Ma, Doell et al., 1966) Gray to dark gray, vesicular to dense olivine basalt flows, shallow microvesicular (voids ~0.4 mm) intrusive rocks, and minor scoria in small exposures in the south part of the quadrangle on McClellan Peak and American Flat, and in American Ravine. A sample from a plug south of the Delaware Mine contains ~30% phenocrysts of abundant olivine from 0.4 to 4.5 mm, augite to 0.7 mm, minor plagioclase laths to 0.7 mm and rarely to 2 mm, sparse biotite (≤0.1 mm diameter), and minor opaque grains (Table 1) in an intergranular groundmass of fine plagioclase, pyroxene, and glass. Apatite occurs as microlites in glass and as inclusions in plagioclase. Labradorite forms elongate laths from microlites to phenocryst size. As a whole, contains ~15% olivine, 10% augite, 55% plagioclase, 15% black glass, and 5% opaque minerals. Vesicular flow rock contains ~15% olivine and augite grading from matrix size to 2 mm phenocrysts.

LATE MIOCENE AND/OR PLIOCENE DEPOSITS

Tbdf **Big boulder debris flow** Laharic debris-flow deposits typified by large boulders. Crops out extensively north of Jumbo. Typically contains clasts to 3 m in diameter; locally contains blocks of partly disaggregated platy-jointed andesite as much as 10x100 m. Heterolithic, but clasts of black to dark gray vesicular to dense, finely porphyritic pyroxene andesite with ropy, wind-polished surfaces comprise ~50% of the unit. Other clasts include hornblende andesite and rare Cretaceous granitic boulders. As much as 15% of the clasts are highly altered rock (mostly silicified or quartz-alunitic), but these are not evenly distributed. Sand and mud matrix, which typically does not crop out, is exposed in the Virginia-Washoe Road; elsewhere weathered away, leaving boulder-strewn surfaces. As much as 30 m thick. Age not well constrained, but is likely Late Miocene or Pliocene.

Tbd **Black dike** (8.2±0.3 Ma and 8.6±0.3 Ma, Vikre et al., 1988) Basalt intruded along the footwall of the Comstock fault zone (Becker, 1882). As much as 8 m wide. Does not crop out, but encountered in nearly all underground workings from the Savage Mine to the Caledonia Mine. Apparently pinches out within ~50 m of the surface. Based on a sample from the New Savage Mine, Tbd contains ~10% olivine (nearly all altered to clay), 10% augite, 65% plagioclase, 5% opaque minerals, and 10% glass (altered to clay). Crystal sizes are <1.5 mm. Plagioclase forms laths with weak oscillatory zoning averaging ~An_{65}.

MIDDLE MIOCENE ANDESITIC TO RHYOLITIC ROCKS

Tod **Occidental dacite** (12.91±0.18 Ma, Table 4) Light gray biotite hornblende dacite with minor quartz in a small area along the eastern edge of the quadrangle. Forms a nearly circular exposure > 0.5 km in diameter to the east in the Flowery Peak Quadrangle. Contains abundant, commonly conjoined, plagioclase phenocrysts to 1.5 cm; hornblende phenocrysts to 1 cm; and minor biotite as books to 6 mm (Table 1). Minor quartz as rounded and embayed grains to 2 mm. Minor opaque grains and a trace of tiny, clear apatite prisms present. Matrix dominated by plagioclase laths that average ~50 µm long and form pilotaxitic texture in a field of granular potash feldspar, hornblende, and opaque microlites. One of the most silicic intermediate rocks in the quadrangle, containing ~64% SiO_2.

Tia **Andesite porphyry dikes** Andesite dikes of varied composition and texture west of Jumbo intruding Davidson Diorite(?), ash-flow tuffs, and Mesozoic rocks. Dikes contain 20-35% plagioclase phenocrysts to 3 mm and as much as 25% pyroxene phenocrysts to 10 mm or as much as 20% hornblende phenocrysts to 7 mm. Matrices generally dark and aphanitic but appear to be crystalline. A hornblende andesite dike cutting Oligocene ash-flow tuff near McClellan Peak is included. This locally microvesicular dike contains ~3% elongate, magnetite-rimmed hornblende to 2.3 mm and elongate plagioclase phenocrysts to 2.5 mm in a pilotaxitic groundmass of fine plagioclase laths and magnetite. Age of the dikes not well constrained. They cut sericitized ash-flow tuffs but do not appear to be sericitized themselves. Generally weakly to moderately propylitized with chlorite and trace epidote. Probably not part of the Virginia City suite because they were intruded along northeasterly faults that cut nearby Virginia City suite rocks. Assumed to be younger but do not resemble andesites of the Flowery Peak suite.

FLOWERY PEAK MAGMATIC SUITE

Tfba **Biotite hornblende andesite** (14.20±0.43 Ma, Table 4) Light-brownish-gray weathering, light gray rock in the northeast part of the quadrangle. Contains ~ 30% phenocrysts of stubby andesine to 5 mm, elongate hornblende to 2 mm, distinctive biotite books to 5x2 mm, and minor bottle-green augite (table 1) in a light gray groundmass. Some rock has traces of rounded pinkish quartz grains and rounded olivine. Unaltered in nearly all outcrops, with minor clay that could be either hypogene or supergene. Variable flow-banding attitudes and poorly developed columnar jointing suggest Tfba is probably a flow dome that cuts and lies on Tfha.

Tfha Tfhax Tfhap **Hornblende andesite** (14.51±0.12 Ma, Table 4) Medium to light gray andesite in the north part of the quadrangle with phenocrysts of elongate hornblende to 1 cm and equant, separate and conjoined plagioclase to 4x5 mm. Pyroxene observed by hand lens in some rock. Pervasive hydrothermal alteration and absence or near absence of biotite in Tfha serve to distinguish it from Tfba. Most Tfha is strongly hydrothermally altered to white or yellowish gray rock in which textures are commonly destroyed. Local propylitic to rarely fresh remnants. Both highly altered and relatively fresh samples contain conjoined and elongate plagioclase phenocrysts, brown hornblende (variably rimmed with opaque material), and in some samples minor pyroxene and trace biotite in a pilotaxitic groundmass of plagioclase microlites, opaques, and devitrified glass (Table 1). Some plagioclase phenocrysts have growth zones with fine sieve texture near the rims. Traces of strongly embayed quartz found in one sample. **Tfhax** is locally distinguished intrusive or flow(?) breccia in the unit. **Tfhap** is highly altered, bedded pyroclastic(?) rock found at two sites in probable lava sequences (but only extensive enough to be mapped at one). Tfha overlies Tva and underlies or is intruded by Tfba.

Tfbi **Biotite hornblende andesite intrusion** (14.82±0.17 Ma, Table 4) Strongly flow-banded, unaltered, highly magnetic (reverse polarity) plug at Mt. Abbie. Texturally and compositionally similar to the andesite of Flowery Peak, which it intrudes. Contains relatively coarse glomerophenocrysts of plagioclase, hornblende (rimmed by opaque material) as the dominant mafic, minor biotite and opaque, and a trace of clinopyroxene (Table 1).

Tfbha **Biotite hornblende andesite** (14.58±0.12 Ma, Table 4) Reddish brown weathering, greenish gray rock with 15-30% phenocrysts (Table 1) of equant to elongate, rarely conjoined plagioclase to 4 mm, black to iron-oxide-rimmed hornblende mostly 2-3 mm long, but some to 9 mm, and euhedral biotite to 5 mm in a devitrified groundmass containing plagioclase microlites. Some plagioclase phenocrysts have finely sieve textured growth zones near the rims. Commonly propylitized, altered to clay minerals, or bleached and stained with iron oxides. Weakly altered to unaltered remnants occur locally. Probably represents flow domes or intrusions into Tfha and Tva, although contact relationships are commonly unclear due to destruction of minerals and textures by hydrothermal alteration. Similar to Tfba, but probably older because Tfba seems to postdate alteration that affects Tfbha.

Tfp Tfpx Tfpl **Andesite of Flowery Peak** (14.39±0.20 and 14.89±0.20 Ma, Table 4) As much as 300 m of interbedded andesite flows, minor lahars, and a few whitish ash beds. Base is commonly debris flows with Flowery Peak suite andesite boulders to 2 m and some clasts of older lithologic types. Unconformably overlies altered Virginia City suite andesites. Flow(?) breccia (**Tfpx**) and lahars (**Tfpl**) mapped separately in a probable flow dome complex north of Long Valley.

Unaltered Tfp is light to medium gray rock with 20-50% phenocrysts. Plagioclase phenocrysts are characteristically stubby, poorly formed, equant, conjoined grains. Hornblende, the most abundant mafic phenocryst (Table 1), is mostly broken crystals <2 mm, but well-formed phenocrysts reach 2 cm in some rocks. Hornblende commonly includes plagioclase grains. It is generally brown with magnetite rims or completely replaced by iron oxide, but some is corroded and partly replaced by biotite and/or pyroxene. Brown biotite phenocrysts, typically <2 mm, generally have magnetite rims and are locally corroded. Augite and(or) orthopyroxene may occur as stubby crystals <1 mm. Hypersthene is the only pyroxene in some hornblende-rich rocks. Magnetite present as grains to 0.5 mm. Variable proportions of plagioclase microlites, biotite microlites, brown devitrified glass or black glass make up matrix. Clear size difference between plagioclase phenocrysts and groundmass microlites is typical.

INTRUSIONS OF THE FLOWERY PEAK OR VIRGINIA CITY MAGMATIC SUITES

Tbhap **Biotite hornblende andesite dikes and intrusions** (14.72±0.14 and 14.53±0.11 Ma, Table 4) Many intrusions of biotite hornblende andesite porphyry in the northern and eastern parts of the quadrangle. Unaltered rock generally medium gray. Mineral assemblages variable and phenocrysts comprise 25-60% of rock (Table 1). Andesine phenocrysts typically stubby grains to 1 cm. Greenish to brownish green hornblende, the most abundant mafic, commonly present as broken crystals to 4 mm, some with magnetite rims. Brown biotite phenocrysts, which characterize these dikes, are typically <2 mm. Minor augite and rare orthopyroxene to 1 mm, typically altered. Some Tbhap contains sparse, round quartz phenocrysts to 1 mm. Minor magnetite, apatite, and zircon are present. The matrix consists of variable proportions of plagioclase and biotite microlites in glass or devitrified glass. Clear size difference between plagioclase phenocrysts and groundmass microlites is typical.

Near the Mahoney Mine at Jumbo, Tbhap includes hornblende biotite andesite porphyry dikes with abundant subhedral to euhedral green hornblende phenocrysts to 1 cm. Abundant andesine phenocrysts including some conjoined grains are present, but not as common as in Tbhap elsewhere. Phenocrysts grade in size nearly to matrix plagioclase and hornblende microlites. Minor magnetite, biotite, and quartz phenocrysts present. On the east flank of Basalt Hill is an intrusion similar to the Mahoney Mine dikes except that it has no quartz, is not seriate, and contains large xenoliths (or pendants) of Santiago Canyon Tuff and Virginia City volcanics.

Tbhap intrudes the Alta Formation and the Davidson Diorite of the Virginia City magmatic suite. It is commonly moderately to strongly altered and unconformably overlain by Tfp. Based on relationships with altered rock, Tbha intrusions may have a range of ages, and may represent both the Virginia City and Flowery Peak magmatic suites.

Thap **Hornblende andesite porphyry intrusions** (14.53±0.42 Ma, Table 4) Many plugs and dikes of hornblende andesite in the footwall of the Comstock Lode, mostly between Mount Davidson and Orleans Hill. Intrusive margins commonly have 10-20% plagioclase phenocrysts to 4 mm, whereas five to 15 m from contacts equant plagioclase phenocrysts to 5 mm make up 30-65% of the rock. Contains andesine phenocrysts with weak oscillatory zoning, ~25% of which have broad spongy cellular outer zones. Green to slightly brownish, stubby to fairly elongate, euhedral hornblende phenocrysts to 5 mm (rarely to 1 cm) present, as well as minor augite phenocrysts <1 mm and magnetite grains <0.5 mm. Matrix is plagioclase microlites in 5-15% devitrified brown glass. Altered to propylitic or phyllosilicate assemblages. Thap intrusions appear to cut the Davidson Diorite. Although the $^{40}Ar/^{39}Ar$ age puts Thap in the Flowery Peak suite, some Thap intrusions may be part of the Virginia City suite on the basis of relationships with altered rock.

Tri **Rhyolite intrusions** Massive to flow-banded rock of uncertain age altered to phyllosilicate assemblages. Includes a small plug south of Cedar Ravine with as much as 5% altered feldspar and 5% quartz phenocrysts <1 mm and poorly preserved flow foliation, and a dike west of Mt. Bullion with a few percent quartz phenocrysts and some discernable flow banding. Intrusive rhyolite in the Sutro Tunnel and not exposed at the surface (Becker Collection) contains ~15% altered feldspar phenocrysts <2 mm, 0-5% quartz phenocrysts and ~1% biotite phenocrysts <1 mm. Margins of this intrusion have strong lamellar to kink-banded flow foliation but the interior appears massive.

Tac **Andesite of Crown Point Ravine** Finely porphyritic gray to pale greenish gray andesite along Crown Point Ravine. Contains a few percent each of plagioclase and hornblende phenocrysts to 3 mm and quartz in trace amounts as grains to 2 mm. Sparse granitic xenoliths in one outcrop suggest that the quartz is xenocrystic. Strongly altered with pyrite near the mouth of Crown Point Ravine. Resembles Tap, but thought to occur as intrusions in Tva and Tsa.

VIRGINIA CITY MAGMATIC SUITE

Virginia City intrusions and rhyolites

Tdd Tdap **Davidson Diorite** (15.32±0.12 Ma, Table 4) Subequigranular granitic rock (Tdd) most common in the footwall of the Comstock Lode in the central part of the quadrangle. Intrudes Virginia City volcanics and older rocks. Virtually all exposures hydrothermally altered, but nearly unaltered in the footwall of the Comstock Lode in the New Savage Mine. Average grain size of major minerals variable, generally ~3 mm but locally to 5 mm. Contains weakly oscillatory-zoned subhedral to anhedral andesine (Table 1); a few grains with cellular outer zones. Major accessory anhedral to rarely subhedral pyroxene, nearly all completely altered to actinolite. Unaltered Tdd from the New Savage Mine has equant augite > stubby orthopyroxene. Locally contains traces to 3% hornblende. Minor brown biotite present as anhedra to 1 mm, but this is generally chloritized. Orthoclase and quartz, in an intergranular matrix between plagioclase and pyroxene grains, are typically anhedral equant grains <0.5 mm but some reach 1 mm. Stubby apatite ubiquitous. Traces of zircon and sphene present. Original chemical character unclear due to alteration; trachytic bulk chemistry (appendix 1, fig. 5) may result from sodium metasomatism.

Andesite porphyry phase (**Tdap**) borders exposures of Tdd and forms many dikes in the footwall of the Comstock Lode. Some Tdap forms chilled margins adjacent to Tdd. Exact contact locations commonly difficult to determine because of alteration; but propylitized Tdap is distinct from surrounding volcanic rocks because it has more and coarser plagioclase phenocrysts. Phenocryst content is variable, but generally Tdap has ~35% phenocrysts that grade in size to the matrix. In dikes near Wakefield Peak, phenocryst content ~10% near the contact to rock with ~60% 3 m from the contact. Most phenocrysts slightly elongated oscillatory zoned andesine to 3 mm. A few are conjoined and ~10% have glass-rich spongy outer zones. Accessory augite and orthopyroxene in grains to 2 mm are commonly altered to actinolite. Traces of oxybiotite occur locally. Magnetite is a minor mineral. Stubby apatite is included in plagioclase. Matrix consists of highly variable quantities of plagioclase microlites and devitrified brown glass.

Thi **Hornblende andesite intrusions** In two small plugs that cut rocks of the Bailey Canyon sequence near the west edge of the quadrangle. Contains a few percent of black hornblende phenocrysts rarely > 5 mm. Plagioclase phenocrysts to 5 mm are slightly more abundant. Generally pale greenish gray and vesicular. The larger plug contains bands of dense black glassy andesite that alternate with partially devitrified and frothy andesite. Thi resembles frothy flow rocks in Tvbh (below) and the plugs may represent feeders for Tvbh flows.

Thpap **Hollow hornblende pyroxene andesite porphyry** Several intrusions northeast of Silver City of dark brown (where unaltered) rock with abundant distinctive "hollow" brownish green hornblende phenocrysts to 3 cm long that are easily seen in hand specimen. These phenocrysts typically have a discontinuous matrix-filled central cavity along the c-axis; many have H-shaped cross sections. They are generally rimmed to totally replaced by magnetite and commonly corroded along the margins, where they are replaced by microscopic intergrowths of other minerals. Stubby andesine phenocrysts to 2 mm, and sparse augite euhedra to 1 mm also present (table 1). Plagioclase and augite phenocrysts grade in size to matrix grains. Most of the mass of the intrusions forms a crude ring dike. Probably comagmatic with Tva because a few flows in that unit have similar, but smaller (to 5 mm), hollow hornblende phenocrysts.

Tphap **Pyroxene hornblende andesite porphyry** Several dikes of gray to greenish altered pyroxene hornblende andesite porphyry near the Overman Pit, only one extensive enough to show on the map. Contains abundant phenocrysts of plagioclase to 2 mm, and sparse augite and hornblende phenocrysts to 1 mm. Felted matrix consists of plagioclase microlites and altered, devitrified glass.

Thp **Hornblende andesite porphyry dike** A few scattered dikes of weakly propylitized porphyry west of Jumbo. Typified by abundant (20-40%), commonly sub-parallel, slender hornblende phenocrysts to 1 cm thinly rimmed by magnetite. Contains abundant stubby to equant plagioclase phenocrysts to 1.5 mm. Plagioclase phenocrysts average ~An_{50}, and ~25% have cellular zones. Minor stubby to rounded augite to 0.2 mm present. There is a fairly strong difference in size between phenocrysts and plagioclase microlites set in devitrified glass.

Tabt **Biotite rhyolite(?) tuff** At least 70 m of non-welded to poorly welded, pinkish gray biotite tuff northeast of Jumbo. Generally poorly exposed. Contains sparse phenocrysts of plagioclase to 1.5 mm, sanidine and biotite to 1 mm, and a trace of quartz to 0.5 mm. Uncollapsed to slightly collapsed pumice fragments to 20 mm diameter, rarely to 40 mm, are 2-20% of the rock, with amounts varying through the exposed thickness of the unit. Lithic fragments, rarely >15 mm across, of tuff, gabbro, andesite, and siltstone make up 0-40% (commonly ~25%) of the rock. Stratigraphic position uncertain because the base is not exposed, but appears to be a local unit in or above the Alta Formation.

Tbr **Flow-banded biotite rhyolite** Poorly exposed, pink to white, altered rhyolite with pronounced laminar to slightly undulate flow banding northwest of Jumbo. Overlies and is possibly interbedded with Tabt. Contains minor biotite plates to 1 mm and equant plagioclase phenocrysts to 2 mm in a matrix of as much as 10% plagioclase laths (<0.1 mm) and distinctly banded, devitrified, and altered glass. Composition unclear due to alteration and microcrystalline texture; may be latite or rhyolite. Contains much less than 1% scattered, irregular, gray cognate(?) microgranitic inclusions to 7 cm that contain ~20% biotite, 5% quartz, 20% orthoclase, and 55% plagioclase. Inclusions are anhedral-granular with average grain 0.07 mm across, except biotite, which is euhedral and as much as 0.3 mm across.

Virginia City volcanics

Steamboat Valley sequence

Tvss **Volcaniclastic sedimentary rocks of Steamboat Valley** Very light-gray to pinkish-gray and yellowish-gray (GSA Rock Color Chart) volcanic conglomerate, sandstone, and tuff in the northwest corner of the quadrangle. Conglomerate contains pebble- to cobble-sized clasts of pale red to light gray hornblende andesite, glassy medium gray pyroxene-hornblende andesite, dark gray andesite, and pale red glassy biotite-hornblende-pyroxene andesite. Contains local beds with angular pebble- to boulder-size clasts that were likely deposited by debris flows. Includes cross-bedded, fine- to coarse-grained, generally well sorted, tuffaceous sandstone with angular to rounded andesite fragments, glass shards, and grains of plagioclase, hornblende, pyroxene, and opaque minerals. White to very light gray clayey tuff is a minor constituent.

Tvsu **Upper andesites of Steamboat Valley** (15.35±0.22 Ma, Table 4) Medium-gray andesite flows, generally not vesicular, with common columnar and platy jointing, exposed in a relatively small area south of Steamboat Valley. Distinguished by the presence, in some flows, of olivine that is partially to wholly replaced by glassy orange iddingsite. Phenocrysts include andesine to 7 mm, augite to 2 mm, hypersthene to 1.5 mm, and opaque grains to 1 mm. Hornblende to 5 mm, olivine in rounded anhedral to sharply euhedral grains to 2 mm, and biotite to 3 mm may be present (Table 1). Trace amounts of stubby gray to brown apatite prisms to 0.5 mm ubiquitous. Matrix generally pilotaxitic and finely granular, with plagioclase, pyroxene, and opaque microlites. Some flows nearly seriate. Breccias, possibly common but poorly exposed, include some laharic breccias in the upper part of the unit.

Tvsl Tvsv **Lower andesites of Steamboat Valley** Andesitic debris flows and flows that generally contain pyroxene with or without minor hornblende, but no olivine, in the northwest part of the quadrangle. Flows, which probably comprise <10% of the unit, are medium to dark gray. Some strongly resemble two-pyroxene flows in Tva. Debris-flow breccia, generally matrix supported, has angular to subrounded clasts to 2 m or more. Clasts, mostly two-pyroxene andesite, range from dark gray scoria to light gray locally flow-banded rock. Debris flow matrix is light to pinkish gray pulverized andesite and may contain some shards. Phenocryst content of flows and clasts variable (Table 1), but generally includes abundant labradorite to 7 mm, pyroxene to 2 mm (mostly clinopyroxene, but minor orthopyroxene common), locally abundant hornblende to 1 cm, and small opaque grains. Unit includes **Tvsv**, distinctive medium gray frothy rock (weathering to light brown or orange-pink) with as much as 25% irregular vesicles locally lined by vapor-phase minerals. Tvsv forms a flow to 25 m thick with local crude columnar jointing and flow banding with variable attitudes. It contains abundant labradorite-bytownite phenocrysts to 4 mm and small clinopyroxene, hypersthene, and opaque grains. Matrix is pale brownish gray devitrified glass with plagioclase, opaque, and pyroxene microlites. Tvsl is locally separated from underlying Tvbh by a thin section of white to very pale orange, sandy to silty sediments and lapilli tuffs.

Kate Peak Formation

Tvka **Hornblende and pyroxene andesite flows** (15.43±0.26 Ma, Table 4) Flow sequence forming the upper part of the Virginia City volcanics east of the Occidental Lode near Kate Peak. Base not exposed. The lower part, mostly west of Nevada Route 341, is much like rock in the Alta Formation and mainly consists of pyroxene andesite flows with a few hornblende andesite flows that mostly occur low in the section. Unaltered Tvka is generally medium gray. It contains mostly stubby plagioclase phenocrysts, generally as broken fragments grown together in crystal aggregates 2-5 mm across (locally to 7 mm) typically in irregular equant clusters. Augite and rare orthopyroxene occur as stubby crystals <1 mm, but may be obscured by alteration. In hornblende-bearing flows, abundant brown hornblende commonly occurs as broken crystals mostly <2 mm, some with magnetite rims or completely replaced by magnetite. Magnetite is a minor mineral as grains to 0.5 mm. The matrix consists of variable proportions of plagioclase and hornblende microlites in brown devitrified glass or black glass and may contain minor biotite. Interbeds of lahars, autobreccias, and biotite-bearing andesite flows distinguish Tvka from the Alta Formation west of the Occidental Lode. Flows and lahars of dark andesite north of Kate Peak and east of the quadrangle have 20-30% fine plagioclase phenocrysts, lesser equant augite, tiny magnetite, and as much as 1% euhedral olivine.

Tvkb **Biotite-hornblende andesite flows** A flow or sequence of flows of biotite-bearing andesite porphyry ~70 m above autobreccia (Tvkx) east of the Occidental Shaft. Resembles intrusions (Tbhap) in the Comstock district. Contains minor biotite phenocrysts to 2 mm, a few percent hornblende to 3 mm, and square to weakly castellated plagioclase phenocrysts to 3 mm.

Tvkx **Autobreccia** Breccia as much as 50 m thick in Tvka in Long Canyon. Predominantly composed of angular andesite clasts to 30 cm that consist of hornblende and pyroxene andesite similar to Tvka.

Tvkl **Andesite lahars** Several lahars, most <10 m thick, interbedded with andesite flows in Tvka. Most too thin or poorly exposed to show on the geologic map. Typically heterolithic, containing subrounded clasts <30 cm and rarely as much as 50 cm in diameter of several textural or compositional types of andesite. Matrix consists of gray silt, sand, and mud.

Bailey Canyon sequence

Tvbh **Hornblende andesite flows** (15.79±0.20 Ma, Table 4) Flows with abundant hornblende as much as 2 cm long. Rock with sparse hornblende rare. Generally light to medium gray or pale brown to pale red. Commonly forms bold outcrops. Mostly highly vesicular, with as much as 15% irregular voids to 4 mm; but locally dense and dark gray. Flow breccia locally common and generally less resistant than the flow rock. Flow foliation highly variable and commonly oriented at high angles to flow contacts. Phenocrysts (Table 1) include andesine as moderately elongate to blocky, mostly subhedral grains to 5 mm; euhedral to anhedral brown hornblende, commonly rimmed or wholly replaced by iron oxide; pyroxene phenocrysts to 3 mm (dominantly clinopyroxene, but minor hypersthene in some specimens); and opaque grains to 0.5 mm that commonly occur in clusters. Many flows contain hornblende phenocrysts that have been strongly embayed by the groundmass or partially replaced by augite; however, in other flows hornblende appears to have been stable. Matrix consists of flow-aligned to felty plagioclase laths with mafic and opaque microlites in brown to brownish gray glass.

Tvbfl **Andesite lahars and flows** Debris-flow breccias and generally minor interbedded pyroxene andesite flow rock. Locally, may contain more flow rock than breccia (as much as 75% flows). Breccias typically heterolithic, matrix- to clast-supported, and likely represent lahars. They locally form sequences at least 70 m thick, and contain pebble- to boulder-sized andesitic clasts of variable color and texture that range from angular to somewhat rounded and spherical. Matrix is generally pinkish gray, pale brownish gray, or light gray sand and mud. Flows typically of dark gray to black pyroxene andesite similar to that in the Alta Formation. Phenocryst content 15-35% (Table 1). Plagioclase phenocrysts tend to be more equant than lathy and are generally isolated and only rarely glomeroporphyritic. A few flows have no apparent mafic phenocrysts, but most have augite to 2 mm and some orthopyroxene. Orthopyroxene > augite in some rocks.

Alta Formation

Tva Tvas Tvah Tvx (15.23±0.20 to 15.82±0.13 Ma, six ages, Table 4) Includes hornblende-augite, augite, or two-pyroxene andesite flows. Generally dense and dark colored, with weathered black surfaces or light to dark brown or gray surface crusts, but commonly hydrothermally altered and relatively pale without weathered crusts. In altered rocks, pyribole minerals may be impossible to tell apart. Flow rocks strongly resemble those in the underlying Silver City andesites (Tsa). In places Sutro Tuff (Ts) underlies Tva. It may be impossible to distinguish Tva from Tsa in areas without the Sutro Tuff or extensive breccias characteristic of the underlying Tsa. Tva commonly has roughly planar platy jointing, in some cases parallel to flow foliation defined by phenocryst alignment. In other cases, jointing cannot definitively be linked to flow foliation. Platy jointing is generally absent in altered rocks. Although mostly composed of flows, laharic breccias occur northeast of Orleans Hill and near Ophir Hill, and autobreccias occur near Jumbo and Geiger Summit.

Tva contains variable amounts of stubby andesine-labradorite phenocrysts (Table 1) rarely >2 mm. Augite and less abundant orthopyroxene phenocrysts, rarely >1 mm, commonly in clumps. Some flows contain sparse to abundant brown hornblende phenocrysts commonly <2 mm, but locally to 7 mm. Hornblende generally rimmed to wholly replaced by iron oxide. Magnetite crystals to 0.5 mm are present. Phenocrysts generally grade in size to a locally pilotaxitic matrix that makes up 20-40% of the rock and consists mainly of plagioclase microlites in generally devitrified brown glass. Biotite, normally absent, occurs in flows between Mt. Abbie and Orleans Hill, and north of the Scorpion Shaft. Here, medium reddish brown weathering, dark brown flows, commonly with indistinct flow foliation, contain abundant phenocrysts rarely >3 mm. The rock contains typically stubby andesine, along with augite and orthopyroxene. Shredlike brown biotite makes up <1% of the rock, generally as grains <1 mm.

Distinctive massive hornblende andesite porphyry flow rock (**Tvah**) mapped separately north of Jumbo may comprise one flow or a series of flows. It is at least 150 m thick, and no top is exposed. Euhedral black hornblende phenocrysts to 3 cm, which comprise variable portions of the rock, have been partially replaced by magnetite and other minerals. The rock contains abundant plagioclase crystals to 5 mm that grade in size to the matrix. Rare sedimentary rock (**Tvas**) includes as much as 4 m of andesitic conglomerate and sandstone on Twin Peaks. As much as 30 m of heterolithic lahar (**Tvx**) northwest of Jumbo contains dominantly a variety of subrounded clasts of hornblende and pyroxene andesite to 1 m but generally <50 cm in diameter. Clasts comprise 60-90% of the rock and are in a sandy to silty matrix.

UNITS IN THE VIRGINIA CITY OR SILVER CITY SUITES

Ts **Sutro Tuff** A locally significant unit of bedded sedimentary rocks and tuff. Contains white to tan or pale greenish gray feldspathic sandstone, ash to lapilli tuff, and conglomerate. Locally includes mudstone, siltstone, and welded tuff in minor amounts. Ranges from a few meters to nearly 300 m thick; however, the greatest thickness, exposed in the south lateral of the Sutro Tunnel (Gianella, 1936), may be repeated by faulting. In the Suicide Rock and Cedar Canyon areas Ts lies above large amounts of well-exposed heterolithic debris-flow breccia and interbedded sediments of the Silver City andesites. No dates are available. We place Ts between the Silver City and Virginia City magmatic episodes.

Tap **Phenocryst-poor andesite** Medium gray andesite flow rock in the Jumbo area typified by low phenocryst content. Contains sparse plagioclase phenocrysts (Table 1) <3 mm long, minor hornblende generally <3 mm (mostly replaced by iron oxide), trace to minor opaques, and locally traces of pyroxene, biotite, and quartz. The matrix is felty to pilotaxitic with plagioclase laths ~5 µm long in devitrified glass. Flow foliation is locally prominent and commonly at high angles to the base of the unit, which is nearly flat lying. Tap is of unknown age, but seems to lie between Tsa and Tva in the Jumbo area.

Tax **Lahar unit** As much as 30 m of lahar beneath Tap in the Jumbo area. Heterolithic with a variety of subrounded clasts of hornblende and pyroxene andesite to 1 m but more commonly <50 cm in diameter. Clasts comprise 60-90% of the rock and are in a sandy to silty matrix. Scattered clasts of distinctive whitish, typically aphyric, felsic rock to 30 cm in diameter occur near the unit base. Blocks of fine sedimentary rock resembling rock in Ts occur locally along the contact with the overlying Tap unit, but this rock has not been found in outcrop. A thin wedge of similar andesitic breccia with sparse granitic clasts is mapped as Tax east of the Tap exposure.

INTRUSIVE ROCK IN THE VIRGINIA CITY OR SILVER CITY MAGMATIC SUITES

Tara **American Ravine Andesite** Stocks and dikes that cut Mesozoic intrusions, Tertiary ash-flow tuffs, and the Silver City andesites. Variable phenocryst content; rock with more abundant phenocrysts is generally in the interior of larger intrusive masses (Calkins, 1945). Generally light gray and porphyritic, with minor to abundant slender phenocrysts of hornblende (Table 1) to 5 mm mostly rimmed by magnetite. Sparse plagioclase phenocrysts to 2 mm long. According to Calkins, Tara contains sparse augite phenocrysts and scattered quartz grains; the latter are likely xenocrystic. The matrix consists of pilotaxitic plagioclase microlites, a few percent glass, and <2% opaque minerals. In a few marginal exposures west of the Vulcano Mine, Tara is nearly devoid of phenocrysts and is white. There are no isotopic ages for Tara.

SILVER CITY MAGMATIC SUITE

Tsa Tsba Tss **Silver City andesites** (17.69±0.22 to 18.25±0.36 Ma, five ages, Table 4) Finely porphyritic andesite flows that contain 20-40% phenocrysts <3 mm long. Andesine labradorite phenocrysts generally stubby and predominantly single crystals but may include a few conjoined grains. Augite, the dominant mafic mineral (Table 1), commonly euhedral and locally intergrown with magnetite and hornblende. Hornblende, in some flows as prisms to 4 mm, is commonly partly to wholly replaced by magnetite. Minor hypersthene in hornblende-poor rock. Compositions range from basaltic andesite to andesite to trachyandesite (Figure 5), but many samples may be partly alkali metasomatized. Where relatively unaltered, a rare occurrence in the quadrangle, Tsa andesites have gray to black devitrified matrix and generally light gray to locally reddish weathered crusts.

Autobreccias and debris-flow breccias comprise major amounts of Tsa, particularly in Crown Point Ravine. The autobreccias contain 20-50% angular, but relatively equant, clasts that are generally 5-40 cm, and rarely as much as 1 m, of devitrified andesite that is texturally and compositionally like the matrix, and similar to that of interbedded flows. Autobreccia clasts are commonly gray to greenish and matrix andesite is devitrified and commonly hematitic. Debris-flow breccias were likely lahars, and include both matrix- and clast-supported breccia with a variety of andesite clasts to 40 cm and rarely as much as 1 m in diameter. Cobble-sized and larger clasts typically >70% of the rock. Debris-flow matrix is generally andesitic sand and silt.

Tsba is a flow within Tsa. It is dark greenish gray to greenish gray and somewhat like typical Tsa, but contains large hornblende phenocrysts and minor altered biotite. Labradorite phenocrysts to 5 mm moderately elongate, with larger crystals rounded. Pale brown to olive-green hornblende to 8 mm with opaque rims, pyroxene partially replaced by calcite, chloritized biotite to 2 mm, and small grains of magnetite also occur as phenocrysts (Table 1). Matrix is felty plagioclase, altered pyroxene, and opaque minerals, possibly in altered glass. Contains some rounded, fine-grained xenoliths of biotite-pyroxene-hornblende diorite.

Tss is white to pale olive sedimentary rock in Tsa. It includes sedimentary horizons interbedded with Tsa flows and breccia south of Mt. Davidson in the Bullion Ravine-Suicide Rock area. Between Bullion Ravine and Crown Point Ravine, as much as 17 m of poorly bedded andesitic conglomerate with interbedded reddish andesitic sandstone are overlain and underlain by breccias. Between Suicide Rock and Confidence Ravine, at least two sedimentary units, including one with as much as 15 m of gray laminated tuffaceous siltstone, are overlain and underlain by breccias and are locally associated with ash-flow tuff.

Tshp **Hornblende-plagioclase andesite** (18.02±0.24 Ma, Table 4) Relatively phenocryst-rich, light greenish gray flow rock mapped separately at and near the base of Tsa. Phenocrysts include stubby plagioclase to 5 mm, black hornblende to 1 cm, and tiny opaque grains (Table 1) in a matrix of tiny plagioclase laths, granular feldspar, devitrified glass(?), and opaque and hornblende microlites. Near the Virginia City reservoir, includes a relatively unaltered flow with well-developed columnar jointing perpendicular to its base. May be as much as 75 m thick.

Tsh **Hornblende andesite** (17.43±0.16 and 18.32±0.32 Ma, Table 4) Flows and possible domes as much as 100 m thick at the base of Tsa. Distinctive greenish gray to medium gray rock with abundant black (olive-green in thin section) hornblende phenocrysts to 1 cm or more and sparse stubby labradorite-bytownite phenocrysts to 1 cm. Hornblende phenocrysts commonly form radial rosettes and plagioclase occurs locally in glomeroporphyritic clots. Hornblende has thin iron oxide rims. Plagioclase partially altered to calcite+chlorite. Trace to minor opaque grains to 0.5 mm present. Tsh has a finely pilotaxitic matrix of plagioclase laths with altered glass(?), intersertal pyroxene, and tiny opaque grains.

MIOCENE-OLIGOCENE TUFFS AND SEDIMENTS

Tut **Unnamed lithic tuff** Weakly hydrothermally altered Miocene lithic ash-flow tuff disconformably overlying Santiago Canyon Tuff north of the Baltimore Shaft. At least 18 m thick, but lower and upper contacts unexposed. Densely welded, with ~5% collapsed pumice fragments to 30 mm long. Phenocrysts (<10% of rock) are plagioclase to 1.5 mm, sanidine to 1 mm, biotite to 0.5 mm, and quartz to 0.5 mm (Table 2). Lithic fragments (15-30% of rock), almost all <4 cm across, include common siltstone and tuff fragments and lesser amounts of carbonate rock, andesite, and gabbro. All lithics except tuffs probably from Mesozoic units.

Tst Tsg **Santiago Canyon Tuff** (23.12±0.05 Ma, Henry, in prep.) Light gray to pinkish gray, moderately to strongly welded, rhyolitic tuff as much as 120 m thick. Contains 30-40% phenocrysts of plagioclase; slightly smoky or rosy, vermicular quartz; and sanidine. Quartz and feldspar phenocrysts to 4 mm across, most commonly ~2 mm. Minor biotite and hornblende phenocrysts ~1.5 mm. Contains rare but ubiquitous euhedral, honey-colored sphene (≤0.5 mm) generally replaced by yellowish anatase(?) or leucoxene and difficult to identify megascopically, particularly in altered rocks. Light gray, moderately to strongly compressed pumice to 2 cm long common. Pumice generally well preserved in altered rocks; green in propylitized rocks and white in sericitized rocks. Pumice in lower Tst may be difficult to recognize due to strong welding. Sparse pinkish gray felsic lithic fragments (1-1.5 cm). Underlain in places by poorly exposed gravel, **Tsg**, generally a lag containing cobbles and boulders of older tuffs.

Tet **Eureka Canyon Tuff** (24.90±0.06 Ma, Henry, in prep.) Light-gray, pale red, or very pale orange, poorly to moderately welded, phenocryst-poor (3-10%) ash-flow tuff in scattered exposures. Underlies Tsg and disconformably overlies Nine Hill Tuff or older rocks. As much as 40 m thick. Approximately equal amounts of sanidine and vermicular quartz phenocrysts (Table 2) to 2 mm. Lesser amounts of smaller plagioclase and thin biotite phenocrysts. Matrix is slightly welded glass shards. Minor amounts of weakly compacted, gray, banded or axiolitic pumice fragments to 1 cm commonly obscured by alteration. A small exposure of highly altered phenocryst-poor tuff west of Jumbo is tentatively assigned to Tet.

Tnt Tng **Nine Hill Tuff** (25.32±0.07 Ma, Henry, in preparation) Strongly welded pale red-purple or light gray to medium gray rhyolitic ash-flow tuff. Readily recognizable by the presence of strongly compressed and stretched pumice fragments to 15 cm long with aspect ratios of 10:1 or more. White, pumice-poor, weakly welded tuff comprises the lower part of Tst locally. Contains 5-7% phenocrysts of sanidine, anorthoclase, and quartz to 1 mm with a trace of biotite (table 2). Matrix is strongly welded, devitrified glass shards and pumice. Minor amounts of small lithic fragments. Lower Tst is somewhat more phenocryst poor (~3%) and contains no anorthoclase (Deino, 1985). Biotite not commonly found in rocks affected by vapor-phase alteration. As much as 5 m of gravel (**Tng**) with cobbles of Mesozoic rocks and Tgm lies beneath Tnt ~1.5 km west of Silver City, and thinner gravel underlies it east of McClellan Peak.

Tlt Tlg **Lenihan Canyon Tuff** (26.77±0.06 Ma, Table 4) Pale red, pale red-purple, or light brownish gray (pale greenish-gray near top) welded ash-flow tuff to 120 m thick. Distinguished by abundant foliation-aligned thin black biotite plates. Contains 25-30% phenocrysts including abundant plagioclase averaging ~0.5 mm and lesser amounts of sanidine to 4 mm, quartz to 5 mm, and biotite (Table 2). Quartz is rounded, slightly vermicular, and locally smoky. Minor hornblende and a trace of opaque grains present. Sparse flattened pumice fragments to 5 mm long. Hornblende and pumice rarely visible in hand specimen. Rare volcanic lithic fragments to 5 mm have phenocryst content similar to Tlt. Matrix contains spherulitically crystallized and axiolitic shards. **Tlg** is a local basal gravel with clasts of Tgm and granodiorite to 1 m.

Tgm **Guild Mine Member, Mickey Pass Tuff** (27.12±0.10 Ma, Table 4, and 27.30±0.07 Ma, Henry, in prep.) White, light greenish gray or pale red-purple rhyolitic ash-flow tuff with variable phenocryst content (15-40%). Phenocrysts are vermicular, bipyramidal quartz to 2 mm, clear to yellowish sanidine to 3 mm, plagioclase mostly ~2 mm, biotite ≤1 mm, and opaque grains (Table 2). Matrix is of commonly strongly welded glass shards and compressed pumice. Much of Tgm is reddish with sparse pumice as white, 2-3 cm, vapor-phase altered patches and cavities. In upper part, pumice increases to 10% (Bingler, 1978), as do quartz phenocrysts. Contains minor ≤1 cm to 1x6 cm lithic fragments of dark metaigneous rock and argillite (Jm and JTRgs?).

Tg **Gravels** Channel-filling gravels to 10 m thick with unknown stratigraphic position. Consist mainly of unsorted cobbles to boulders, primarily of gabbro. A large exposure near McClellan Peak is mainly lag and includes clasts of Tgm, Tlt, and rare Tnt, with clasts of Jm and JTRgs near the base. Smaller exposures on Hartford Hill overlain by Tst may be younger than some tuffs, but may predate Tgm because no tuff fragments were observed. Rounded boulders of granitic rocks to 1.5 m across occur in both exposures.

TERTIARY OR MESOZOIC ROCKS

TKp **Cretaceous or Tertiary hornblende diorite porphyry** Light gray to greenish gray seriate-textured porphyry in two small masses cutting Gardnerville Formation in the footwall of the Jumbo Canyon fault. Composed mostly of unaltered or weakly sericitized plagioclase to 8 mm with oscillatory zoning and some finely sieved zones. Has abundant black hornblende (olive to pale green in thin section) to 6 mm with ragged borders and local epidote alteration. Minor magnetite, mostly as fine grains, and traces of tiny apatite prisms present. Locally strongly altered and bleached with abundant disseminated pyrite. Resembles Tdap but is coarser and more likely a phase of the Cretaceous granitic complex to the west.

MESOZOIC ROCKS

CRETACEOUS PLUTONIC ROCKS

Kqd **Biotite-hornblende quartz diorite** Medium-grained gray subhedral granular quartz diorite east of Steamboat Valley. Average grain size ~2 mm. Contains anhedral to subhedral oligoclase-andesine to 7 mm; interstitial quartz to 2 mm; and irregular, oikocrystic, and weakly perthitic potassium feldspar to 4 mm. Mafics are anhedral to subhedral biotite books to 3 mm and pale-green irregular to subhedral hornblende grains to 5 mm with abundant plagioclase and biotite inclusions. Has minor irregular opaque grains to 1.5 mm and traces of small irregular sphene grains and small apatite prisms. Weak flow(?) foliation is defined by plagioclase, hornblende, and biotite grain alignment.

Ka **Granite aplite** White to very light gray and pinkish gray, fine- to medium-grained, anhedral granular aplite as dikes and irregular masses cutting Kgd and Kfg in the southwest part of the quadrangle. Probably more prevalent than shown in poorly exposed areas of Kgd, but could not be mapped separately. Contains subequal amounts of alkali feldspar, quartz, and plagioclase. Has sparse biotite and minor opaque grains. Locally pegmatitic, rarely with black tourmaline.

Kgd **Granodiorite** Very light gray to white, commonly poorly exposed, subhedral granular to locally anhedral granular, medium-grained granodiorite in the southwest part of the quadrangle. Consists mainly of stubby (some broken) subhedral plagioclase (0.1-2 mm), with anhedral quartz (0.2-2 mm), alkali feldspar (1- 4 mm), anhedral brown biotite (0.2-2 mm), and elongate subhedral to anhedral hornblende (0.2-2 mm) (Table 3). Also contains minor euhedral to subhedral sphene (0.1-1 mm), zircon, apatite (≤1 mm), and subhedral opaque grains (≤0.1 mm). North of Jumbo Grade, hornblende is apparently more abundant, alkali feldspar occurs locally as oikocrysts, and ~2% myrmekite (≤0.1 mm) mantles some plagioclase. Kgd south of Jumbo Grade is mostly interpretative; outcrops are rare and commonly covered by deep grus plus aplite clasts. Probably gradational with Kqm and similar in age, 86-88 Ma (see text).

Kqm **Leuco quartz monzodiorite** Very light gray subhedral granular to porphyritic, medium-grained plutonic igneous rock in the southwest part of the quadrangle weathering to rounded, elongate corestones (≥1 m long). Mostly composed of plagioclase, but with major alkali feldspar and quartz, and minor hornblende and biotite (Table 3). Largest hornblende crystals are 4x18 mm. Locally, euhedral alkali feldspar crystals to 10 mm contain small, aligned mafic minerals. Contains rare, rounded, dark gray enclaves (to 8x15 cm) of fine grained hornblende diorite.

Kfg **Foliated granite** Light gray, porphyritic foliated granite in the southwest part of the quadrangle. Contains equant to elongate subhedral plagioclase to 4.5 mm and hornblende to 1.5 mm in fine (≤0.1 mm) groundmass of anhedral quartz, alkali feldspar, and aligned, shredlike biotite (Table 3). Sphene, apatite, and Fe-Ti oxides are minor accessories. Igneous foliation defined mainly by biotite, but elongate hornblende and plagioclase phenocrysts also aligned.

Kgp **Granodiorite porphyry** Pale pink granitic rock that intrudes gabbro (Jm) south of Basalt Hill. Referred to as Cretaceous granodiorite porphyry (Kgp) by Bingler (1977) to the south in the New Empire Quadrangle. Contains ~60% plagioclase phenocrysts (0.5-3.5 mm long) as weakly zoned (~An_{30}) anhedral laths with 2:1-3:1 elongation. Stubby, anhedral, completely actinolized pyroxene and/or hornblende to 1.5 mm make up ~15% of the rock. Has large size difference between phenocrysts and interstitial, subhedral-granular matrix of intergrown 0.1-0.2 mm grains with ~30% quartz and 60% orthoclase. Also contains ~0.5% magnetite to 0.4 mm and a trace of stubby apatite.

Kg **Undivided granitic rocks** Includes moderately to strongly sericitized granitic rock exposed along American Ravine and not correlated with other units exposed near the southwest edge of the quadrangle. Granitic rocks known or interpreted at depth (see cross-sections) are included. American Ravine granitic rock, possibly the same as subsurface rock in the Rock Island Mine, is quartz monzonite with essential oligoclase, microcline, and quartz, minor biotite, and accessory apatite and sphene (Table 3). Oligoclase, mostly 1-4 mm, is oscillatory-normal zoned. Microcline in irregular grains to 6 mm, generally with numerous plagioclase inclusions. Quartz is in intergranular anhedra ~1 mm across. Biotite generally as thick books to 1 mm across.

METAIGNEOUS AND METASEDIMENTARY ROCKS

Jm **Mafic metaigneous rock** Dark gray and dark greenish gray, fine- to medium-grained (1-2 mm), phaneritic, equigranular or porphyritic metagabbro or rarely, metabasalt, with color index of 50-60%. Metamorphosed to greenschist facies with fine-grained mafic minerals converted to biotite, chlorite, actinolite, and epidote. Gabbro generally has pyroxene and plagioclase in about equal amounts, although locally either may be as much as 60% of the rock. Equigranular to somewhat porphyritic gabbro contains distinctive, stubby, equant grains (≤1-7 mm) of a mafic mineral, likely predominantly augite, now completely or rarely partly replaced by actinolite. Locally subhedral pyroxene grains to 7 mm long are as much as 30% of porphyritic gabbro. Smaller, elongate or equant plagioclase grains (2-3 mm) display fluidal textures on weathered surfaces and are locally saussuritized or partly converted to white mica. Matrix is low in alkali feldspar. Some fine-grained, porphyritic gabbro appears rhythmically banded.

Locally, dikes and irregular masses of gabbro porphyry to 30 m across (not mapped separately) intrude the main mass of gabbro. These contain actinolite after subhedral pyroxene grains as much as 60 mm long with roughly equal amounts of plagioclase to 2 mm. Jm rarely has amygdaloidal, fragmental (welded tuff?), or breccia (fragments 1-10 cm) textures, particularly west of McClellan Peak.

Gabbro on the dump of the Sutro Mine adit, which goes through the Comstock fault west of the Utah Shaft, contains ~60% weakly zoned calcic plagioclase laths, 30% brown hornblende, and 10% partly actinolized augite. Hornblende forms irregular oikocrysts to 50 mm that host many ~3 mm plagioclase and augite crystals.

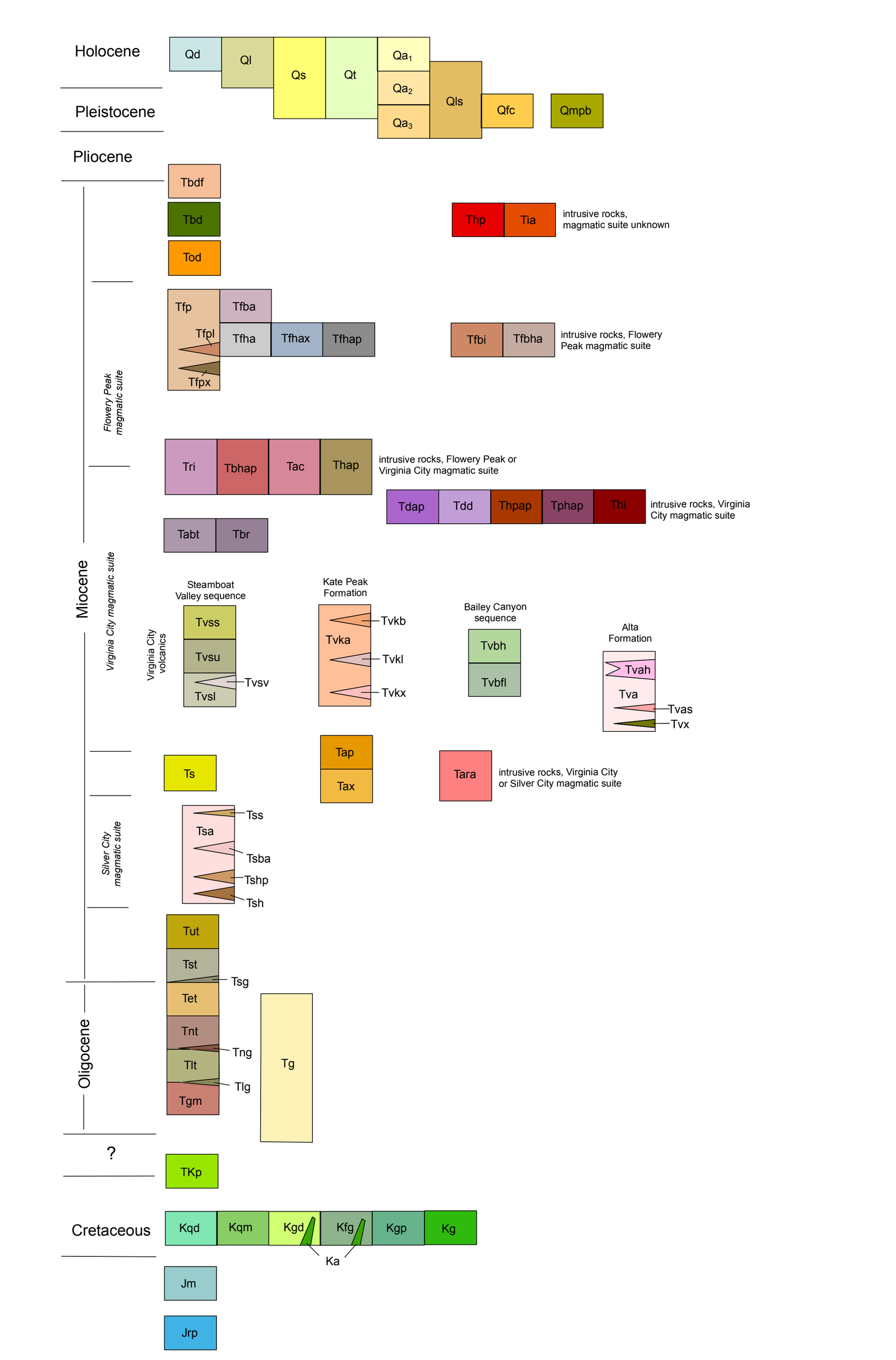
Jrp **Foliated lithic rhyolite porphyry** Dikes of foliated lithic rhyolite porphyry cutting Gardnerville Formation on the east flank of McClellan Peak. Jrp contains 10-15% anhedral stubby plagioclase phenocrysts to 5 mm. Rounded, commonly highly embayed, and partially recrystallized quartz phenocrysts to 4 mm make up 3-5% of the rock, anhedral orthoclase phenocrysts to 1.5 mm comprise 7-10%, and slender mafic phenocrysts to 5 mm make up 5-7%. The mafic mineral, probably originally biotite, is replaced by fine-grained shreddy brown biotite and some chlorite. Well-rounded to somewhat jagged, commonly elliptical lithic fragments of JTRgs siliciclastic rocks mostly < 40 mm make up 2-30% (commonly ~5%) of the rock. Matrix consists of anhedral intergrowths of ~55% orthoclase, 30% quartz, and 15% shreddy biotite (probably metamorphic in origin). Traces of apatite and zircon present. Strong foliation, mainly defined by replaced biotite(?) flakes, parallels elongation of lithic fragments.

Jp **Preachers Formation** A few small exposures, <10 m thick, of white quartzite with silica cement on the east flank of McClellan Peak. Some medium-thick laminations observed in float samples but not in outcrop.

JTRgs JTRgm **Gardnerville Formation** Siliciclastic rocks (**JTRgs**) dominantly thinly laminated, medium gray siltstone and very fine-grained feldspathic sandstone. Thin pebble conglomerate beds occur locally. At least 300 m thick in the quadrangle. Siltstone has 10-30% argillaceous matrix, and trace to several percent of calcite cement is typical. Disseminated pyrite cubes to 1 mm present in places. Locally highly carbonaceous, particularly near the west border of the quadrangle (NW¼ Sec. 28, T17N, R20E) where graphite was mined. Siltstone and fine-grained sandstone in a tiny exposure east of Silver City contains rounded clasts of intermediate composition volcanic rocks to 30 mm. Several interbeds of marbleized limestone (**JTRgm**) to 10 m thick crop out on the east flank of McClellan Peak.

The unit is metamorphosed near Mesozoic plutonic rocks. The most intensely metamorphosed siliciclastic rocks are hornfels or schists with as much as 40% metamorphic biotite. Local cordierite seen in hand sample. Sericite (fine-grained aggregate of mica-like phases) schist common more distantly from intrusive rocks, and andalusite occurs in originally argillaceous beds. Spotted cordierite-biotite and sericite-andalusite schists occur at the Tyler Mine. Limey beds on the east flank of McClellan Peak 70-100% recrystallized to fine-grained, slightly schistose white marble. Near Steamboat Valley the unit consists mostly of pelitic rocks metamorphosed to quartzo-feldspathic biotite-sericite schist and biotite spotted hornfels; but it also includes quartzose sandstone, thin bands of marble, and rare rhyolite-pebble conglomerate, pebbly sandstone, and lapilli tuff(?). Compositional layering here appears to be subparallel to metamorphic foliation.

See accompanying text for full unit descriptions, notes, and references for this map. All tables, figures, and references cited above are also found in this text.



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