Text and references accompanying Nevada Bureau of Mines and Geology Open-File Report 19-4

Geologic Map of the Washoe City Quadrangle, Washoe County, Nevada

by

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2019

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GEOLOGIC UNITS

Quaternary Deposits

Qx Disturbed areas and fill (Historical) Engineered fill, only delineated where extensive surface modification has occurred (i.e. along I-580) and several small areas where fill obscures geologic relations.

Qa Active alluvium (Holocene) Moderately to well sorted sand, silt, and gravel deposits along floodplains. Generally flat surface morphology associated with fluvial terraces. Distal Qfy fan deposits merge and interfinger with Qa deposits. Qa deposits make up the majority of Pleasant Valley, occur within isolated topographic lows in channels draining the Carson Range, and within an intermontaine basin within the Virginia Range. Generally less than 4 m thick.

Qc Colluvium (Holocene to Pleistocene?) Poorly sorted sand and gravel mantling steep to moderate slopes. Locally contains cobble to boulder sized clasts of granite and volcanic rocks from rockfall processes upslope; commonly greater than 2 m thick.

Qe Eolian deposits (Holocene) Gray to white, loose, medium to course-grained well sorted quartz feldspar sand, subangular to subrounded. Includes active sand dunes up to 10 m thick fringing Washoe Lake and sand ramps up to several meters thick along the western foothills of the Virginia Range.

Qeo Eolian deposits, older (late Pleistocene) Light brown to tan, loose medium to course grained, well sorted, quartz feldspar sand with trace pebbles. Occurs as sand ramps up to several meters thick along the western margin of the Virginia Range.

Qsi Sinter deposits (Holocene?) A small area, ~60 m across, of fibrous, vuggy silica less than 2 m thick is developed on Gardnerville Formation (JŦgs) in the northeastern part of the quadrangle but has been partly removed by construction of I-580. A cluster of three small areas of travertine is reported nearby (Thompson and White, 1964) but was not visited during this mapping because they are in residential back yards. Probably all are locations of former hydrothermal discharge of the Steamboat Springs system.

Qfy Young alluvial-fan deposits (late Holocene) Gravel and sand deposits with boulders within and adjacent to recently active washes. Surfaces characterized by mostly unmodified to slightly subdued bar-and-swale morphology. Contains anastomosing channels along active washes. Minimal or no soil development. Subject to frequent or intermittent flooding. Range in thickness from a few meters at fan heads to greater than 5 m in midslope areas. Includes broad anastomosing fans emanating from modern channels along the western and eastern margins of Washoe Valley and southern Pleasant Valley, and active channels draining across the Mt. Rose fan. A slightly older Qfy mapped as Qfy_2 occurs along the Mount Rose fan.

Qfy_2 Young alluvial-fan deposits (early Holocene) Gravel and sand deposits with boulders. Incised by and slightly older than Qfy. Mapped along Galena Creek; commonly 2-4 m thick.

Qfi Intermediate-aged alluvial-fan deposits (late Pleistocene) Gravel and sand deposits with trace boulders preserved above Qfy fans. Generally flat surface morphology between active channel interfluves that are incised 3–4 m. Moderately developed soils. Range in thickness from 5 to 15 m. Common along the eastern flank of the Carson Range. Isolated remnants of Qfi fans also occur along the western flank of the Virginia Range.

Qfo Older alluvial-fan deposits (middle Pleistocene?) Gravel and sand deposits with trace boulders preserved

above Qfi fans. Generally rounded surface morphology between active channel interfluves that are incised greater than 5 m. Major drainages have incised Qfo surfaces greater than 20 m providing a minimum thickness for these deposits. Distal parts of Qfo surfaces may be greater than 50 m thick and are buried by younger deposits. Well-developed soils. Occur as remnants along the eastern flank of the Carson Range where they consist of granitic source sediments. A prominent Qfo fan that consists of rounded volcanic cobbles and boulders in a sand and gravel matrix sourced from Tvs upslope occurs in the vicinity of Browns Creek along the southern margin of the Mount Rose fan. Isolated remnants of Qfo fans also occur along topographic highs along the western margin of the Virginia Range.

Qls Landslide deposits, undivided (Holocene to Pleistocene?) Slope failure deposits with a wide range in characteristics and composition. Locally dominated by highly fractured or jumbled bedrock and/or regolith, with a varying percentage of poorly to moderately sorted gravel. Typically form uneven, hummocky surfaces. Includes slumps, translational and rotational failure mechanisms. Range in thickness from a few to several tens of meters thick.

Qlsb Landslide blocks, undivided (Holocene to Pleistocene?) Blocks of semi-intact Tsd, within larger landslide complex along northwestern valley wall of Pleasant Valley. Individual blocks up to several hundred meters wide.

Qlss Lacustrine deposits, silt and sand (late Pleistocene) Gray to white silt deposits with trace sand and rare pebbles fringing Washoe Lake; commonly less than ~1 m thick.

Ql Lacustrine deposits, sand (late Pleistocene) Gray, silty sand with gravel and pebbles. Sand is medium to course grained. Occurs along the northwestern and eastern margins of Washoe Lake. Subtle shorelines are preserved along the southeast side of Washoe Lake. Along the western margin of Washoe Lake Ql deposits have been buried by distal Qfy fan deposits. Surficial sediments are locally mixed with Qe deposits. Ql deposits are associated with pluvial Lake Washoe which reached its highstand of 5080 ft (1548 m) in the late Pleistocene (Miflin and Wheat, 1979). Ql deposits thicken basinward from less than ~1 m to several tens of meters in nearshore environments. Thickness of Ql deposits in the middle of the basin is unknown.

Qlg Lacustrine deposits, gravel (late Pleistocene) Gravelly sand with subrounded pebbles (1–3 cm diameter) and trace cobbles; commonly 2-4 m thick and overlying Ql deposits. Greater percentage of gravel than Ql deposits. Occurs along the northwestern and northeastern margin of Washoe Lake at a slightly higher elevation than surrounding Ql deposits. A remnant Qlg deposit also occurs along the southwestern part of Washoe Lake where it may be uplifted along an inter-basin splay of the Carson Range front fault. Qlg deposits associated with pluvial Lake Washoe (Miflin and Wheat, 1979).

Qlo Lacustrine deposits, older (late Pleistocene) Gravelly sand with rounded pebbles and cobbles. Similar to Qlg deposits. Occurs as a valley fringing deposit in northwestern Washoe Valley. Oxidized (reddened) soil profile. Thickness ranges from ~1-2 meters.

Qlu Lacustrine deposits, undivided (Holocene to late Pleistocene) Mix of Qlo, Ql, Qlg, and Qlss. In cross section only. Thickness unknown.

Qdf_1 Debris-flow deposits (historical) Poorly sorted, angular blocks of unweathered granite in a silty sand matrix. Individual blocks up to 3–4 m in diameter. Includes deposits related to the 1983 Ophir Creek debris flow and debris flows along Franktown Creek and an unnamed drainage along the south side of Bowers Mansion County Park. Qdf_1 deposits are not displaced by the Washoe Valley section of the Carson Range fault system. Variable thickness ranging from ~1 to several meters where mantling bedrock slopes and greater than 5 m in valley floor locations.

Qdf_2 Debris-flow deposits (Holocene) Poorly sorted, angular blocks of unweathered granite in a silty sand matrix. Contains prominent debris flow levees in midslope areas and a well-defined lobe at the mouth of the Ophir Creek drainage. Qdf_2 deposits are not displaced by the Washoe Valley section of the Carson Range fault system. Variable thickness ranging from ~1 to several meters where mantling bedrock slopes and greater than 20 m in valley floor locations.

Qdf_3 Debris-flow deposits (late Pleistocene) Poorly sorted, angular blocks of granite in a silty sand matrix. Includes a prominent debris lobes at the north end of Bowers Mansion County Park and the southern end of Davis Creek Regional Park. Qdf_3 deposits are displaced 8–15 m across the Washoe Valley section of the Carson Range fault system. Variable thickness ranging from ~1 to several meters where mantling bedrock slopes and greater than 20 m in valley floor locations.

Qdf_4 Debris-flow deposits (late Pleistocene) Poorly sorted, angular blocks of granite in a silty sand matrix. Contains prominent well-defined debris lobe at the mouth of the Ophir Creek drainage. Qdf_4 deposits are displaced up to 30 m across the Washoe Valley section of the Carson Range fault system. Variable thickness ranging from ~1 to several meters where mantling bedrock slopes and greater than 20 m in valley floor locations.

Qdf_5 Debris-flow deposits (middle Pleistocene?) Poorly sorted, angular blocks of granite in a silty sand matrix. Contains prominent debris bar levees. Qdf_5 deposits are displaced up to 60 m across the Washoe Valley section of the Carson Range fault system and is only preserved west of the fault as an isolated remnant; greater than 10 m thick.

Qdfu Debris-flow deposits, undivided (Holocene to middle Pleistocene?) Poorly sorted, angular blocks of granite in a silty sand matrix. Mapped primarily in the upper slope region of Ophir Creek at the base of Slide Mountain within a granitic shear zone where the lack of cross cutting

relations prevents dividing individual debris flows. An isolated block of Qdfu also occurs along I-580. Thickness unknown.

Qgm_1 Glacial moraine deposits (late Pleistocene) Unsorted or poorly sorted sand, gravel, and boulders (till). Granitic rocks slightly weathered and typically abundant on surfaces. Commonly form sharp-crested moraines. Equivalent to the Tioga Till of Blackwelder (1931); greater than 50 m thick.

Qgm_2 Glacial moraine deposits (late to middle Pleistocene) Unsorted or poorly sorted sand, gravel, and boulders (till). Granitic rocks typically moderately to highly weathered. Surfaces typically smoother, with fewer preserved boulders, relative to Qgm_1. Equivalent to the Tahoe Till of Blackwelder (1931); greater than 50 m thick.

Qgm_3 Glacial moraine deposits (middle Pleistocene) Unsorted or poorly sorted sand, gravel, and boulders (till). Granitic rocks entirely decomposed. Surfaces have subdued morphology with only subtle morainal forms. Relatively older than Tahoe (Qgm_2) aged till. Possibly equivalent to Donner Lake glaciation of Birkeland (1964); greater than 50 m thick.

Qgo_1 Glacial outwash deposits (late Pleistocene) Moderately to well sorted sand, gravel and boulders. Typically located downstream, and grade to Qgm_1 deposits of Tioga age. Thickness ranges from several to tens of meters thick.

Qgo_2 Glacial outwash deposits (late to middle Pleistocene) Moderately to well sorted sand, gravel and boulders. Typically located downstream, and grade to Qgm_2 deposits of Tahoe age. Thickness ranges from several to tens of meters thick.

Qgou Glacial outwash deposits, undivided (late to middle Pleistocene) Moderately to well sorted sand, gravel and boulders of unknown age. Occur in the Slide Mountain area and are completely separated from morainal deposits. Thickness ranges from several to tens of meters thick.

Quaternary Rocks

Qsr Rhyolite of Steamboat Hills (late Pleistocene) Massive to strongly flow banded, perlitic to devitrified, very finely vesicular, tan to light brown, porphyritic rhyolite makes a slightly northeast elongate, ~800 x 600 m, lava dome that cuts dacite of Steamboat Hills (Tsd) in the southwestern Steamboat Hills. Sparsely porphyritic, with 3% total phenocrysts of subequal amounts of quartz, sanidine, and plagioclase up to 1 mm diameter, and a trace of biotite ≤1 mm. A breccia of rhyolite with a few clasts of porphyritic volcanic rocks and Gardnerville Formation (JTRgs) lies along the eastern rim. $^{40}Ar/^{39}Ar$ date 1.205±0.014 Ma (sanidine, H04-87). The lava dome is the southwesternmost of four similar rhyolite bodies of the same age, the other three of which are in the southwestern part of the Steamboat 7.5' quadrangle (Bonham and Bell, 1993; Ramelli et al., 2011). These are the youngest volcanic rocks in the Reno area.

Qst Tuff of Steamboat Hills (late Pleistocene) Pyroclastic apron that surrounds, and was a precursor to eruption of, the rhyolite of the Steamboat Hills (Qsr). Consists mostly of clay-weathered soil derived from fine to coarse rhyolite pumice up to 5 cm long. Clasts of porphyritic intermediate volcanic rock (Tsa or Tsd) up to 1 m in diameter and Gardnerville Formation (JTRgs) up to 30 cm probably were ejected during explosive eruption of the rhyolite and pumice. Outcrops around the dome of Qsr in the Steamboat Hills are commonly <10 m thick.

Qsb Basaltic andesite of Steamboat Hills (early Pleistocene) Dark to medium gray, massive to highly vesicular, very finely porphyritic, basaltic andesite lava erupted from a cinder cone along the northeast ridge of the Steamboat Hills and mostly flowed north and northeast downward into the Mount Rose NE 7.5' quadrangle. The flow commonly has a basal scoria breccia and is ~3 m thick where the entire flow is exposed along its distal edge. The rock has 20% phenocrysts of plagioclase, ≤0.5 mm long, grading continuously to a matrix of fine plagioclase, clinopyroxene, olivine, and magnetite. Vesicles are locally highly stretched in the direction of flow, and some are filled with opal and chalcedony. An $^{40}Ar/^{39}Ar$ date of 2.16±0.05 Ma was obtained from outcrop north of map boundary (matrix, 01-LT-54A).

Tertiary Rocks

Tpxba Pyroxene-plagioclase porphyritic basaltic andesite (Miocene) Medium gray porphyritic andesite lavas that contain ~20–35% euhedral phenocrysts of plagioclase (10–20%, 1–5 mm long) and pyroxene (10–15%, 1–8 mm long, mostly 3–4 mm long). Found locally in the north-western edge of the map where it is overlying Tppa; outcrops range from ~1-2 m to ~5 m thick.

Tppa Plagioclase-pyroxene porphyritic andesite (Miocene) Light to dark gray porphyritic andesite lavas that contain ~20–35% phenocrysts of euhedral to subhedral plagioclase (15–28%, 1–2 mm long and up to 3 mm long), euhedral pyroxene (5–10%, 1–2 mm long, and up to 3 mm long), and occasional euhedral hornblende (0–2% phenocrysts, 1–5 mm long). This unit is the most abundant lava lithology across the west and northwest parts of the map area, up to ~250 m thick, and commonly overlying and intercalated with Tvs. In the north-westernmost corner of the map it is locally resting on Mesozoic basement (Kg).

Tsd Dacite of Steamboat Hills (Miocene) Medium gray, thickly platy and flow banded, coarsely porphyritic dacite lava caps the highest part 'Maguire Ridge' of the Steamboat Hills and makes a series of large landslide blocks (Qls) in the slope to the southeast. Flow ramps along 'Maquire Ridge' suggest the flow came from the south. A basal flow breccia composed of massive to slightly flow banded and vesicular clasts is exposed along the eastern base; a similar upper breccia makes up most of the western

part of outcrop. Phenocrysts consist of 25% glassy plagioclase, mostly <1–5 mm and rarely up to 10 mm, 12% subequal amounts of equant clinopyroxene and orthopyroxene up to 3 mm in diameter, and 5–6% hornblende up to 5 mm long in a fine matrix of trachytic plagioclase microlites; up to ~200 m thick. $^{40}Ar/^{39}Ar$ date 6.38±0.19 Ma (plagioclase, H11-1).

Tsa Andesite of Steamboat Hills (Miocene) Dark gray, finely porphyritic andesite lava that underlies dacite lava of Steamboat Hills (Tsd) in the northern Steamboat Hills; up to ~100 m thick. Not dated but probably similar to the 6.4 Ma age of the dacite.

Tvs Volcaniclastic sedimentary rock (Miocene) Heterogeneous complex of mostly coarse, massive volcanic debris-flow deposits. Consists of angular to subrounded clasts of intermediate volcanic rocks from 1 mm to 2.5 m in diameter in a granular to tuffaceous matrix, which is rarely exposed. Most deposits have diverse clasts and probably formed by sedimentary reworking of cold primary volcanic deposits. Monolithologic deposits may have formed during or immediately following eruption of lava flows that make up the clasts. In the eastern part of the map, this unit is stratigraphically constrained only to overlie Mesozoic rocks, which precludes assigning a specific age or stratigraphic position. In the western part of the map, this unit is commonly found stratigraphically below or intercalated with Tppa and is likely similar in age with local late Miocene volcanic rocks. Thicknesses vary across the map area, from pinched out to sections that may be up to ~300 m thick south of Galena Creek.

Tphabr Plagioclase-hornblende-pyroxene porphyritic andesite breccia (Miocene) Angular and subangular clast- and matrix-supported breccia. Composed entirely of clasts of medium to light gray porphyritic andesite lavas that contain ~22–35% phenocrysts of euhedral plagioclase (13–30%, 1–4 mm), euhedral hornblende (2–8%, 1–5 mm long), and subhedral pyroxene (1–6%, 1–3 m long). Probably derived from a combination of pyroclastic block and ash flows, rock avalanches, and flow breccias; up to 150 m thick.

Tba Sparsely porphyritic basaltic andesite (Miocene) Medium to dark gray sparsely porphyritic basaltic andesite lavas that contain 5–8% phenocrysts of euhedral to subhedral plagioclase (5–7%, 1–2 mm long) and subhedral pyroxene (<1–1%, 1 mm long). Only exposed in one outcrop at the western side of the quadrangle, above Highway 431; ~2-3 m thick.

Tpba Platy plagioclase porphyritic basaltic andesite (Miocene) Dark gray porphyritic basaltic andesite lavas that contain ~20% phenocrysts of thin, platy euhedral to subhedral plagioclase (2–15 mm long). Only exposed in one outcrop in the northwest corner of the quadrangle; ~2 m thick.

Virginia City magmatic suite, Steamboat Valley sequence (15–16 Ma)

Rocks of the Steamboat Valley sequence are exposed in a narrow belt along the northeastern boundary of the quadrangle, where they connect with more extensive exposures in the Virginia City quadrangle to the east (Hudson et al., 2009).

Tvss Volcaniclastic sedimentary rocks of Steamboat Valley (Miocene) Very poorly exposed volcanic conglomerate, sandstone, and debris-flow deposits crop out over an ~400 x 100 m area in the northeastern corner of the map. Fluvial deposits are conglomerate composed of pebble- to cobble-sized clasts of various andesites and cross-bedded, fine- to coarse-grained, generally well sorted, volcanic sandstone with angular to rounded andesite and mineral fragments. Probable debris-flow deposits are mostly marked by a lag of angular to subrounded, pebble- to boulder-sized andesite clasts; sparse exposures of matrix are massive to poorly bedded, poorly sorted, and matrix- to clast-supported. Unit is mapped up to ~20-30 m thick directly east of map boundary in the Virginia City quadrangle.

Tvsu Lavas of Steamboat Valley, upper (Miocene) Consists mostly of dark to medium gray to dark reddish brown, variably plagioclase-pyroxene-hornblende-phyric andesite and probable dacite lavas. Some interbedded breccia and debris-flow deposits of similar rock types. Lavas commonly show continuous, massive outcrops, locally with flow bands and platy joints, that contrast with the discontinuous boulder lag of debris-flow deposits. Phenocrysts in andesites consist of 25–35% plagioclase <1–2 mm, 5–10% pyroxene to 2 mm, and 1–3% hornblende. Probable dacites contain similar amounts of plagioclase up to 7 mm long, larger and more abundant hornblende (as much as 5% to 5 mm long), and minor biotite to 1.5 mm in diameter. Dacites contain common rounded inclusions (enclaves) of fine-grained diorite(?) with plagioclase and hornblende phenocrysts. Hudson et al. (2009) report olivine that is commonly altered to iddingsite in some lavas. Unit is mapped up to ~200 m thick directly east of map boundary in the Virginia City quadrangle.

Tvsl Lavas of Steamboat Valley, lower (Miocene) Unit is similar to upper andesites of Steamboat Valley (Tvsu), mostly andesite to dacite(?) lavas and interbedded debris-flow deposits. Distinguished in the Virginia City 7.5' quadrangle by the absence of olivine in any lavas (Hudson et al., 2009). Their contact was extrapolated ~500 m into the Washoe City 7.5' quadrangle, to the major Steamboat Valley fault. Interbedded debris-flow and fluvial deposits are commonly better exposed. Debris-flow deposits are massive to poorly bedded, very poorly sorted, and matrix- to clast-supported. Clasts are a mix of andesite types, subrounded, and up to 1 m in diameter. Loose blocks up to 2.5 m in diameter are probably weathered from debris-flow deposits. Moderately bedded, pebbly conglomerate crops out in a few

locations. Unit is mapped up to ~250-300 m thick directly east of map boundary in the Virginia City quadrangle.

Tvso Volcaniclastic sedimentary rocks, older (Miocene) Extremely poorly exposed and mostly relatively fine-grained clastic deposits composed mostly of Mesozoic rock fragments; up to ~25 m thick. Commonly marked by red-brown clayey soil, no outcrop, and a sparse lag of Gardnerville (JTRgs) clasts, mostly pebbles and rarely up to boulders. Sparse outcrops show weakly ferruginous-cemented, pebble gravel (or conglomerate) and sandstone and more indurated (silica-cemented?), well-bedded sandstone composed of reworked Gardnerville rock fragments, plagioclase, and sparse quartz grains. The few larger clasts include rounded granodiorite (Kgd) up to 1.3 m in diameter, distinctive "turkey-track porphyry" containing elongate plagioclase phenocrysts to 1.5 cm long, probably also reworked from the Gardnerville Formation (JTRgs), and a few Miocene hornblende andesite. Lesser volcanic debris-flow deposits interbedded with the sandstone and fine gravel in the paleochannel below the hornblende andesite lava (Tvsu?) are included in this unit.

Tiu Andesite and dacite intrusions, undivided (Miocene) A dark gray, abundantly plagioclase-hornblende-phyric andesite makes a 350 m long, 20–130 m wide, east-northeast striking dike that intruded Gardnerville Formation(?) (JTRgs) in the northeastern part of the quadrangle. Phenocrysts are 30% plagioclase 0.5–2 mm long and 10%, commonly trachytic hornblende up to 10 mm long.

Oligocene ash-flow tuffs

Outcrops of Oligocene ash-flow tuffs in the map area are relatively small, poor exposures near the central part of the eastern boundary.

Tcg Tuff of Chimney Springs (Oligocene) Poorly to moderately welded, quartz- and sanidine-rich ash-flow tuff crops out next to granodiorite (Kgd) and below hornblende andesite lava (Tvsu?) along the northwestern edge of a paleovalley in the east-central part of the quadrangle. The white, platy weathering tuff makes a small outcrop surrounded by lag that together cover an area of about 40 x 10 m. The tuff is distinguished by abundant quartz and sanidine phenocrysts to 4 mm in diameter and minor 1 mm biotite. Erupted from a caldera in the Stillwater Range (John, 1995; Henry and John, 2013).

Tnh Nine Hill Tuff (Oligocene) Numerous angular boulders of reddish brown, densely welded, finely, sparsely porphyritic ash-flow tuff up to 50 cm long rest on weathered granodiorite along the northern edge of the same paleovalley as tuff of Chimney Spring (Tcs). Sparse phenocrysts of sanidine, "plagioclase, anorthoclase", and minor quartz and biotite at up to 1 mm in diameter. The presence of tuff only as blocks, with no real outcrop, and the densely welded character allow the tuff to be reworked from outcrop to the east.

Mesozoic Rocks

Kq Quartz veins (Cretaceous) Veins a few cm to 70 cm wide. Composed of quartz and minor pyrite and other sulfide minerals, commonly oxidized to limonite. Larger veins are mostly along or in aplite-pegmatite dikes (Kai). Small, unmapped veins are widely scattered through granodiorite (Kgd) and Gardnerville Formation(?) (JTRgs).

Kai Aplite-pegmatite dikes (Cretaceous) White to light and pinkish gray, aplite and pegmatite form commonly composite dikes a few centimeters to as much as 10 m wide. Best developed and exposed along the contact between granodiorite (Kgd) and metasedimentary rocks (JTRgs) but present within granodiorite, both in the eastern part of the quadrangle. Both rock types contain quartz, K feldspar, plagioclase, and minor biotite. Pegmatites additionally have muscovite and sparse black tourmaline. Aplites are fine- to medium-grained, whereas pegmatites have grains up to 5 cm long.

Kg Granite (Cretaceous) Light- to medium-gray, medium-grained plutonic igneous rock along the western part of the quadrangle. Composed of approximately equal amounts of plagioclase, quartz, K-feldspar, and brown to black, anhedral to subhedral biotite 2–5 mm in diameter. Biotite phenocrysts are commonly intergrown giving a hackled appearance. Outcrops along the western boundary of the quadrangle are commonly highly fractured and/or sheared.

Kgd Biotite-hornblende granodiorite of Steamboat Valley (Cretaceous) Light gray, commonly porphyritic, medium-grained plutonic igneous rock in the eastern part of the quadrangle. Composed of plagioclase, quartz, K feldspar (some as megacrysts up to 15 mm in diameter), and euhedral biotite up to 6 mm in diameter and hornblende up to 6 x 14 mm, which give the rock a distinctive speckled appearance. Also contains minor sphene (titanite). Typical outcrops consist of irregular, jointed columns and lags of rounded boulders up to 3 m in diameter. Where most intensely weathered, granodiorite disaggregates to extensive areas of grus, individual quartz and feldspar grains. Grus locally can be difficult to distinguish from eolian sand (Qe), which is also composed of quartz and feldspars, but grus is commonly coarser grained and has scattered larger fragments of quartz veins, aplite, and other more resistant rock types.

JTRgm Metasedimentary rocks, Gardnerville Formation (Jurassic to Triassic) The upper most part of the metasedimentary sequence consists of dark limestone, calcareous fine pebble conglomerate, and variably fissile shale. Limestone is slightly metamorphosed to marble with 1 mm calcite grains. Unidentified calc-silicate minerals developed at contacts with quartz veins. Locally highly carbonaceous, particularly near the east border of the quadrangle (NW. Sec. 28, T17N, R20E) where graphite was mined. Pyrite cubes <1 to 4 mm in diameter are locally developed in matrix and along fractures.

JTRgs Gardnerville Formation, metasedimentary and metavolcanic rock (Jurassic to Triassic) Metamorphosed, clastic and volcaniclastic sedimentary rocks crop out extensively in the Steamboat Hills and the hills northeast of Washoe Lake. Rock types range from coarse, clast- to matrix-supported, volcanic conglomerate with clasts up to 50 cm in diameter to fine, massive, black hornfels whose sedimentary origin is uncertain. Also includes very poorly bedded, to planar, to rarely cross-bedded sandstone and conglomerate with sparse, matrix-supported clasts to 15 cm diameter. Clasts are variably porphyritic andesite to dacite. A distinctive lapilli tuff(?) makes prominent knobs north of the Rocky Hill Mine, east of Pleasant Valley. Forms a series of irregularly fining-upward sequences, which may represent stratigraphic repetition of rock types or structural repetition by normal faulting or possibly folding (Tabor and Ellen, 1975). Garside (1998) said the unit could be as much as 1000 m thick, but uncertainty about structural repetition precludes determining a precise thickness. A pervasive but variably weak to moderate metamorphism has generated massive hornfels marked by fine biotite throughout the unit. More intense metamorphism near the contact with granodiorite (Kgd) generated a slightly schistose rock containing fine biotite and fine to coarse muscovite in clots. Thompson and White (1964), Garside (1998), and Hudson et al. (2009) report andalusite, sillimanite, and cordierite. Variably developed cleavage parallels bedding through most of the unit but turns to parallel the contact with granodiorite near the contact. Hudson et al. (2009) mapped similar rocks in the Virginia City 7.5' quadrangle to the east, and Garside (1998) in a regional study identified them, as Early Jurassic Gardnerville Formation. However, the age and correlation of these rocks is uncertain other than that they are older than the probably Cretaceous (ca. 100 Ma) granodiorite that intrudes them. Thompson and White (1964) considered them to be most likely Triassic and/or Jurassic based on regional comparisons. The abundance of volcanic material, although reworked, strongly supports Triassic or Jurassic and broadly coeval with major pulses of arc magmatism in the region (Garside, 1998; Wyld and Wright, 1993). The Gardnerville, Middle Jurassic Veta Grande, and Late Triassic Oreana Peak Formations contain broadly similar rock types in the Pine Nut Mountains, 30 km to the southeast (Wyld and Wright, 1993), but stratigraphic successions, specific rock types, and thicknesses differ. For example, clean limestone in the upper Gardnerville Formation is unlike the carbonaceous limestones in the Washoe City quadrangle, a thick middle andesite lava member in the Veta Grande Formation is not present in Washoe City, and the Oreana Peak Formation has much more overall limestone. Apparent thicknesses in the Pine Nut Mountains make the ca. 1000 m thick Veta Grande Formation and ca. 2000 m thick Oreana Peak Formation better matches than the ca. 400 m thick Gardnerville Formation (Wyld and Wright, 1993). Given how diverse rock types and their distribution might be in a subaerial to shallow marine volcanic arc, strict correlation between areas seems unlikely.

ACKNOWLEDGMENTS

The current mapping draws from previous mapping completed by Tabor and Ellen (1975) and Ramelli et al. (2011). Adjacent quadrangle mapping completed by Hinz et al. (2014) and Hudson et al. (2009) was referenced for unit correlations.

Research supported by the USGS National Cooperative Geologic Mapping Program under STATEMAP award number G18AC00198, 2019. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

REFERENCES

Birkeland, P.W., 1964, Pleistocene glaciation of the northern Sierra Nevada, north of Lake Tahoe, California: The Journal of Geology, v. 72, no. 6, p. 810–825.

Blackwelder, E.B., 1931, Pleistocene glaciation of the Sierra Nevada and basin ranges: Geological Society of America Bulletin, v. 42, no.4, p. 865–922.

Bonham, Jr., H.F., and Bell, J.W., 1993, Steamboat quadrangle—geologic map: Nevada Bureau of Mines and Geology Urban Series Map 4Fg, scale 1:24,000.

Garside, L.J., 1998, Mesozoic metavolcanic and metasedimentary rocks of the Reno-Carson City area, Nevada and adjacent California: Nevada Bureau of Mines and Geology Report 49, 30 p.

Henry, C.D., and John, D.A., 2013, Magmatism, ash-flow tuffs, and calderas of the ignimbrite flareup in the western Nevada volcanic field, Great Basin, USA: Geosphere, v. 9, p. 951–1008.

Hinz, N.H., Ramelli, A.R., and Faulds, J.E., 2014, Preliminary geologic map of the Mount Rose quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 14-7, scale 1:24,000, 4 p.

Hudson, D.M., Castor, S.B., Garside, L.J., and Henry, C.D., 2009, Geologic map of the Virginia City quadrangle, Washoe, Storey, and Lyon counties Nevada: Nevada Bureau of Mines and Geology Map 165, scale 1:24,000, 37 p.

John, D.A., 1995, Tilted middle Tertiary ash-flow calderas and subjacent granitic plutons, southern Stillwater Range, Nevada—cross sections of an Oligocene igneous center: Geological Society of America Bulletin, v. 107, p. 180–200.

Marvin, R.F., and Cole, J.C., 1978, Radiometric ages—compilation A: U.S. Geological Survey: Isochron/West, No. 22, P.3–14.

Mifflin, M.D., and Wheat, M.M., 1979, Pluvial lakes and estimated pluvial climates of Nevada: Nevada Bureau of Mines and Geology Bulletin 94, 56 p.

Ramelli, A.R., Henry, C.D., and Walker, J.P., 2011, Preliminary revised geologic maps of the Reno urban area, Nevada: Nevada Bureau of Mines and Geology Open-File Report 11-7, 3 plates, scale 1:24,000.

Tabor, R.W., and Ellen, S., 1975, Washoe City folio—geologic map: Nevada Bureau of Mines and Geology Urban Series Map 5Ag, scale 1:24,000.

Tabor, R.W., Ellen, S.E., Clark, M.M., Glancy, P.A., Katzer, T.L., 1983, Geology, geophysics, geologic hazards and engineering and geologic character of earth materials in the Washoe Lake area—text to accompany maps of the Environmental Series, Washoe City quadrangle, Nevada: Nevada Bureau of Mines and Geology Open-File Report 83-7, 87 p.

Thompson, G.A., and White, D.E., 1964, Regional geology of the Steamboat Springs area, Washoe County, Nevada: U.S. Geological Survey Professional Paper 458-A, 52 p.

Wyld, S.J., and Wright, J.E., 1993, Mesozoic stratigraphy and structural history of the southern Pine Nut Range, west-central Nevada, *in* Dunn, G. and McDougall, K., editors., Mesozoic paleogeography of the western United States -11: Pacific Section SEPM, Book 7 1, p. 289–306.

Suggested Citation:

Carlson, C.W., Koehler, R.D., and Henry, C.D., 2019, Geologic map of the Washoe City quadrangle, Washoe County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 19-4, scale 1:24,000, 7 p.

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