

Seven Lakes Mountain Quadrangle

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Rock Descriptions

Quaternary Deposits

Alluvial Deposits

Qa Active alluvium Alluvium in recently to annually active washes generally consisting of cobble-pebble gravels and sands. Surfaces have rough bar-and-swale morphology where gravel dominated, and muted bar-and-swale morphology where sand dominated. Clasts are generally subrounded to rounded, but subangular clasts are locally common. Deposits typically 0.5 to more than 3 m thick.

Qaf Fine-grained alluvium (Holocene and late Pleistocene) Unconsolidated silt and very fine sand deposited in basin floors. Surfaces are generally flat, or locally hummocky due to undifferentiated eolian deposits.

Qt1 Alluvial terrace deposits (late and middle Holocene) Cobbly and pebbly coarse to medium sands, mostly poorly sorted and matrix supported, but locally clast supported; intercalated with well-sorted, medium-grained sand deposits up to 10 cm thick. Surfaces are generally smooth, but commonly have muted bar-and-swale morphology. Soils are typically absent or show a weak cambic horizon. Deposits typically 1 m thick or less.

Qs Spring deposits Organic-rich fine silt and clay around and down slope from active springs. The fine-grained materials are probably dominated by eolian material trapped by vegetation associated with spring discharge, but may include material transported by surface water. The deposits are variably calcareous and locally weakly stratified.

Qp Ponded deposits Light-colored, silty, clayey, finely stratified sand deposited in small closed, fault-controlled basins, generally in the higher areas of Seven Lakes Mountain. Deposits thickness is unknown, but probably ranges up to several meters. In most basins, the finer deposits surround exposed boulders of volcanic rocks, which suggests that the fine deposits are locally no more than a few tens of centimeters thick.

Alluvial Fan Deposits

Qf Alluvial fan deposits (undifferentiated) (Holocene to Pleistocene) Small- to medium-size fans that typically have small catchment areas. Bouldery, cobbly, pebbly sand deposits are typically clast-supported and dominated by subangular to angular clasts. Surfaces range from smooth to rough. Soils with well-developed argillic horizons are common, especially near the toe of the fans. Deposit thickness may locally exceed 20 m.

Qfy1, Qfvy1, Qfgy1 Younger alluvial fan deposits (late and middle Holocene) Cobbly, pebbly, coarse sands with isolated boulders near canyon mouths; generally nonindurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts. Surfaces commonly have rough bar-and-swale morphology. Soil development ranges from absent to A/Bw/C profiles, where cambic horizons are weakly developed and as much as 20 cm thick. Deposits are as much as 3 m thick. Unit designation reflects dominant clast lithology: **Qfy1** - undifferentiated or mixed; **Qfvy1** - volcanic; **Qfgy1** - granitic.

Qfy2, Qfvy2, Qfgy2 Young alluvial fan deposits (early Holocene and latest Pleistocene) Cobbly, pebbly, silty, coarse sands with isolated boulders; generally non- to weakly indurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts. Surfaces are commonly smooth with poorly to moderately developed pavements and sparse cobble or boulder gravel bars. Soil profiles typically have a thin eolian silt cap (A or Av), cambic (Bw) or weak argillic horizons (Bt) that are 20 to 50 cm thick, and calcic horizons (Bk)

are absent to weakly developed (up to stage II CaCO₃ development). Deposits are as much as 4 m thick. Unit designation reflects dominant clast lithology: **Qfy2** - undifferentiated or mixed; **Qfvy2** – volcanic; **Qfgy2** - granitic.

Qfi, Qfvi, Qfgi Intermediate-age alluvial fan deposits (late and middle Pleistocene) Cobbly, pebbly, silty, coarse sands with isolated boulders; generally weakly to moderately indurated, poorly to moderately stratified, moderately sorted, matrix-supported deposits with angular to subangular clasts. Surfaces are generally smooth, erosionally rounded near surface edges, and moderately to well dissected. Surficial granitic clasts are generally absent due to weathering. Soil profiles typically have eolian silt caps (A or Av) with varying thicknesses, well-developed, structured argillic horizons (Bt) up to 50 cm thick, discontinuous calcic horizons (Bk) with up to stage III CaCO₃ development, and oxidized, iron-stained horizons (Cox) up to 2 m thick. Deposits are up to 4 m thick. Unit designation reflects dominant clast lithology: **Qfi** - undifferentiated or mixed; **Qfvi** – volcanic; **Qfgi** - granitic.

Qfo, Qfvo, Qfgo Older alluvial fan deposits (middle and early Pleistocene) Cobbly, pebbly, silty, coarse sands with local boulders; generally weakly to moderately indurated, poorly to moderately stratified, moderately-sorted, matrix-supported deposits with angular to subangular clasts. Surfaces are generally smoothed, broadly rounded, and moderately to well dissected. Soil profiles typically have well-developed, structured argillic (Bt) horizons up to 50 cm thick, discontinuous calcic horizons (Bk) with up to stage III carbonate development, and oxidized, iron-stained horizons (Cox) up to 1- to 2-m thick. Deposits are as much as 4 m thick. Unit designation reflects dominant clast lithology: **Qfo** - undifferentiated or mixed; **Qfvo** – volcanic; **Qfgo** - granitic.

Slope Deposits

Qc Colluvial deposits (undifferentiated) (Holocene to Pleistocene) Colluvial and talus deposits generally occurring at the base of steep slopes. Deposits typically consist of poorly sorted, angular to subangular, clast-supported cobbles and boulders. Deposits generally less than 3 m thick.

Qls Landslide deposits Coarse, unconsolidated debris composed of local bedrock, particularly basaltic andesite lava of the Pyramid sequence. Clasts range from silt sized to large blocks. Deposits are up to several meters thick. Original headwall scarp is commonly unrecognizable.

Eolian Deposits

Qe Eolian deposits Light-colored, well-sorted sands typically occurring as vegetated dunes or sand sheets. Deposits up to a few meters thick.

Pliocene to late Miocene Sedimentary Deposits

Tf Pliocene to late Miocene sedimentary deposits Heterogeneous, complexly interbedded sequence of generally poorly indurated, non-resistant, and therefore mostly poorly exposed sandstone, conglomerate, diatomite, and diatomaceous siltstone. Sandstones are composed mostly of mineral fragments derived from Cretaceous granodiorite or Tertiary ash-flow tuff, are poorly to moderately cemented, thin- to thick-bedded, and planar to cross-bedded. Coarser beds range from pebbly sandstone to conglomerates with generally well-rounded clasts commonly up to 1 m in diameter and as large as 12 m in boulder beds (Tfk, Tft). Coarse clasts are mostly granodiorite with lesser tuff and rocks of the Pyramid sequence but vary across the map area, presumably reflecting local source areas. Diatomaceous siltstone is finely laminated, whereas purer diatomite is commonly massive and in beds up to 1 m thick. Both weather to a lag of white chips. Most extensive in the western part of the map area, especially in Long Valley where the deposits form a west-dipping homoclinal sequence at least 1 km thick. Also on the northwest and southwest flanks of Seven Lakes Mountain, the south flank of the Fort Sage Mountains, and poorly exposed beneath Quaternary fan deposits in the northeastern part of the map area. This distribution suggests sedimentary deposits and basin they accumulated in were once continuous throughout the area, including extending over Seven Lakes and Petersen Mountains. In all areas, deposits are best exposed in the sides of gullies cut through Quaternary fans. Best outcrops are along northwest flank of Seven Lakes Mountain, where beds are more indurated than elsewhere. Boulder beds and other coarse conglomerates were mapped separately wherever possible but are included in this unit where not. The oldest deposits are at least as old as 11.66 ± 0.25 Ma, the age of a basaltic andesite lava near base

of sequence in Long Valley south of the Seven Lakes Mountain Quadrangle. The youngest deposits are late Pliocene (Blancan) based on vertebrate remains in the upper part of the deposits on the west side of Long Valley (Koehler, 1989; Grose and Mergner, 2000).

Tfc Conglomerate Marked by a lag of well-rounded clasts of Pyramid sequence rocks, Oligocene ash-flow tuff, and minor granitic rocks was mapped separately from the general sedimentary deposits (Tf) where outcrops were sufficiently large and continuous. Clasts are mostly up to 30 cm in diameter but locally up to 70 cm. Generally forms layers at or near the base of the unit, especially along the south flank of the Fort Sage Mountains.

Tfm Conglomerate of metavolcanic rocks Trains of mostly metavolcanic (Mmv) boulders up to 2.5 m in diameter in two areas may mark late Miocene conglomerate. These boulders, along with lesser Oligocene ash-flow tuff and granitic rock, stick up through the extensive Quaternary fan deposits in the northeastern part of the quadrangle. The northwest alignment of the boulder trains, parallel to the strike or other Tertiary rocks, suggests they are also Tertiary and not part of the Quaternary deposits. Similar conglomerate also crops out along the south flank of the Fort Sage Mountains where it overlies a thin sequence of Oligocene ash-flow tuff that overlies metavolcanic rocks. This deposit is also surrounded by and difficult to distinguish from Quaternary fan deposits.

Tfk Boulder beds of Cretaceous granodiorite Coarse debris-flow deposits and conglomerate composed almost entirely of moderately to well-rounded clasts of Cretaceous granodiorite of Petersen Mountain (Kgp) up to 12 m in diameter and commonly as large as 4 m, along with aplite and pegmatite. Rounding may partly have resulted from weathering of corestones in granodiorite outcrop. Unit typically forms a lag of boulders with no exposed matrix. Extensive in Long Valley along the west edge of the mapped area, where beds are found throughout the sequence of Pliocene to late Miocene sedimentary deposits. Although best exposed in sides of gullies, trails of residual boulders can be traced across Quaternary fan surfaces.

Tft Boulder beds of Tertiary ash-flow tuff Coarse debris-flow deposits and conglomerate composed predominantly of moderately rounded clasts of Tertiary ash-flow tuff up to 2.5 m in diameter, and lesser rocks of the Pyramid sequence and Cretaceous granodiorite. Unit typically forms a lag of boulders; matrix is generally not exposed. Beds occur low in the sequence along the northwest flank of Petersen Mountain and on southwest and northwest flanks of Seven Lakes Mountain.

Late Miocene(?) Dacite or Andesite

Td Plagioclase-hornblende dacite or andesite lava Light-gray weathering, finely porphyritic lava containing abundant, aligned plagioclase laths up to ~1 mm long and a few percent equant hornblende grains up to 0.5 mm in diameter crops out in one area in the northwestern part of the map area. Locally columnar jointed and with a basal breccia containing matrix- to clast-supported clasts of lava up to 30 cm in diameter in a rubbly matrix. Groundmass consists of finer plagioclase, equant opaque grains (probably magnetite), and interstitial glass. Rests upon a thin layer of conglomerate that overlies granodiorite of the Fort Sage Mountains (Kgf). The conglomerate is composed mostly of granitic and aplitic clasts but also contains a few clasts of probable Pyramid sequence rocks. Therefore, the lava is probably younger than the Pyramid sequence and may correlate with dacite and andesite dated at between 9 and 11 Ma in the Diamond Mountains to the west (Hinz, 2004).

Tdi Plagioclase-hornblende dacite or andesite dike A 400 m long, ~20 m thick, northeast-striking dike of plagioclase-hornblende dacite or andesite cuts granodiorite of the Fort Sage Mountains (Kgf) about 700 m northwest of the plagioclase-hornblende lava. The dike is petrographically similar to the lava, containing abundant small plagioclase phenocrysts and ~5% hornblende needles up to 5 mm long, and may be a feeder to the lava.

Pyramid Sequence

Tppi Finely porphyritic basaltic andesite intrusion An elongate (~200 m east-west by as much as 75 m north-south) body of finely porphyritic basaltic andesite sits within granodiorite of Petersen Mountain west of Porcupine Mountain. It is petrographically similar to the finely porphyritic lavas (Tpp') but is probably a shallow intrusion. The rock is massive, is surrounded by granodiorite, and has no breccia that would suggest a lava sitting on granodiorite.

Tpp' Finely porphyritic basaltic andesite lava The most abundant Pyramid lava type in the Seven Lakes Mountain Quadrangle is characterized by abundant, tabular to more equant, plagioclase phenocrysts 1 to 3 mm long and pyroxene phenocrysts up to 5 mm in diameter. Occurs as a single flow about 20 m thick in the south-central part of Seven Lakes Mountain and as several flows totaling about 75 m thick in the northern and eastern parts. Basal and upper breccias, marked by a residuum of massive to scoriaceous, finely porphyritic boulders, are common and can be difficult to distinguish from weathered conglomerate (Tpc).

Tpc Conglomerate, sandstone, and breccia Massive to moderately well stratified, matrix- to clast-supported, poorly to moderately sorted, pale brown to light gray pebble to boulder conglomerate, breccia, and sandstone. Mostly marked by a residuum of clasts of Pyramid sequence, which can be difficult to distinguish from flow breccia. Clasts are subangular to subrounded and mostly Pyramid lavas with rare ash-flow tuff or Cretaceous granitic rocks. Where exposed, conglomerate commonly includes lenses of fine- to coarse-grained, pebbly sandstone; sand grains are subangular to subrounded and consist mainly of volcanic rock fragments and feldspar. The deposit is weakly to highly indurated and noncalcareous.

Tpp Porphyritic basaltic andesite lava Coarsely porphyritic lava distinguished by prominent, tabular plagioclase phenocrysts 5 to 20 mm long and also containing ~5% clinopyroxene phenocrysts crops out in two areas in the quadrangle. One flow ~20 m thick crops out in the northwestern part of Seven Lakes Mountain between finely porphyritic flows. Another flow crops out in a small area overlying other Pyramid lavas in the northeastern part of the quadrangle. Matrix consists of plagioclase, olivine, clinopyroxene, opaques, and variably altered, interstitial glass.

Tpb Basalt lava Aphyric basalt crops out in three areas. The largest area is in the northeastern part of the quadrangle, where one or more flows overlie Oligocene ash-flow tuffs. Another flow is marked by a lag of boulders to 1 m in diameter and underlies part of hill 1506 north of the Sand Hills. Additional flows cap a ridge just north of the northwest edge of the quadrangle and comprise several large landslide (Qls) masses in the quadrangle. Matrix consists of pilotaxitic, subophitic to intergranular plagioclase, pyroxene, olivine, and opaque minerals.

Tcp Pre-Pyramid sequence conglomerate Conglomerate consisting of moderately to well rounded clasts of various ash-flow tuffs, especially rhyolite-dacite ash-flow tuff (Trt) up to 1 m in diameter and, rarely, Cretaceous felsite to 20 cm that underlies the Pyramid sequence. Generally poorly exposed and probably poorly indurated and marked by a lag of boulders. Absence of Pyramid clasts indicates it is older than that sequence. Could have been deposited immediately following ash-flow eruptions or any time from then until just before emplacement of Pyramid rocks. Preserved thickness is about 10 m. Lithologically similar and approximately equivalent to rhyolite-clast conglomerate (Trds) of Dogskin Mountain Quadrangle.

Oligocene-Miocene Ash-Flow Tuffs

Trt Rhyolite-dacite ash-flow tuff Densely to moderately welded but relatively non-resistant, light to medium gray, abundantly and coarsely porphyritic ash-flow tuff crops out discontinuously above the Oligocene ash-flow tuffs and below rocks of the Pyramid sequence. Contains common flattened pumice to 10 cm long and sparse lithic fragments of biotite-hornblende dacite. The tuff is as much as 20 m thick. The tuff is petrographically similar to and probably the same age (~23.7 Ma) as the porphyritic rhyolite domes (Tri) in the Tule Peak, Sutcliffe, and Fraser Flat Quadrangles (Table 3; Faulds and others, 2003a, b; Garside and others, 2003).

Tbt Tuff breccia Reddish-brown breccia composed primarily of blocks of tuff of Chimney Springs in a moderately silica(?) -cemented matrix. Many of the blocks also appear to be slightly silicified. Matrix, which is rarely exposed, consists of still finer and variably silicified breccia. Most outcrops consist of a lag of boulders. Similar tuff breccia in the Dogskin Mountain and Tule Peak Quadrangles (Faulds and others, 2003b; Henry and others, 2004) probably originated as rock avalanches induced by slumping and catastrophic failure of steeply dipping strata around the flanks of rhyolite domes. However, no domes have been recognized near the Seven Lakes Mountain Quadrangle. Thickness is as much as 20 m.

Tha Hornblende andesite dike and lavas(?) A coarsely porphyritic, plagioclase-hornblende andesite dike cuts ash-flow tuff on the west flank of Dogskin Mountain. Boulders of flow breccia of similar rock occur as lag brought up by excavation along a natural gas pipeline in Quaternary deposits just to the west. Additional boulders occur in tuff breccia (Tbt) still farther west. These characteristics suggest hornblende andesite was once more extensive, including as lava flows in the upper part of the ash-flow sequence.

Tphl Tuff of Painted Hills White to light gray, nonwelded to poorly welded, nonresistant, pumiceous, moderately porphyritic ash-flow tuff. The tuff contains up to 20% white pumice up to 10 cm long and 3% fragments of porphyritic andesite up to 8 cm in diameter. The tuff is petrographically similar to the upper poorly welded part of the tuff of Chimney Springs but has fewer phenocrysts, more abundant biotite, less abundant quartz, and relatively sparse smoky quartz. Also, common presence of a red soil zone on top of the tuff of Chimney Springs and a white, platy, fine tuffaceous sandstone between the two tuffs indicate they are separate ash flows with some erosion and weathering between them. Probably equivalent to the lower tuff of Painted Hills in the Dogskin Mountain Quadrangle (Henry and others, 2004) and correlates with the tuff of Eleven Mile Canyon of the Stillwater Range (John, 1995), which is petrographically similar and has an indistinguishable age. Named for exposures in the Painted Hills in the Tule Peak Quadrangle (Faulds and others, 2003b).

Tcs/Tcsl Tuff of Chimney Spring Red-brown weathering, pinkish gray, densely to poorly welded, abundantly porphyritic ash-flow tuff characterized by smoky quartz and adularseous sanidine. Most of the tuff is densely welded and devitrified and has undergone vapor phase crystallization. A basal, white, poorly welded part (**Tcsl**) capped by a black vitrophyre is locally present in deeper parts of paleovalleys. An upper white, poorly welded tuff is rarely preserved. Greater abundance of biotite and plagioclase in the lower and upper, poorly welded parts than in the densely welded part suggests compositional zoning; however, intense devitrification and vapor phase crystallization in the welded part has destroyed most mafic minerals. The massive, densely welded part mostly contains little pumice, so eutaxitic texture is poorly developed, whereas upper and lower parts contain as much as 20% white pumice to 15 cm long. Lithic fragments, most abundant in the lower part, consist of porphyritic, silicic to intermediate volcanic rocks, and lesser quartzite and indurated shale. The tuff of Chimney Spring is as much as 30 m thick in a band from the western part of Dogskin Mountain westward through the central part of Seven Lakes Mountain. However, it is commonly absent because it was eroded before deposition of Pyramid sequence rocks or because it was not deposited over thick deposits of Nine Hill Tuff. Based on its age and distinctive phenocrysts, the tuff of Chimney Spring correlates with the tuff of Poco Canyon in the Stillwater Range and with the New Pass Tuff east of Austin, Nevada (Deino, 1989; John, 1995; Hudson and others, 2000). The Poco Canyon caldera in the Stillwater Range was the source (John, 1995; Hudson and others, 2000).

Tnh/Tnhu/Tnhl Nine Hill Tuff Sparsely to moderately porphyritic, commonly highly pumiceous, densely to poorly welded ash-flow tuff. A light-brown, poorly to densely welded, lower unit (**Tnhl**) contains ~5% phenocrysts. The upper unit (**Tnhu**) is generally dark red-brown and densely welded and has 12-15% phenocrysts. Where exposed, the contact between the two parts is sharp, but more porphyritic pumice occur in the top of less porphyritic part. Prominent pumice fragments make flattened lenses up to 40 cm long in welded tuff and ellipsoids up to 20 cm long in poorly welded tuff. The tuff contains sparse lithic fragments of porphyritic to aphyric silicic volcanic rocks up to a few centimeters in diameter. Thickness, degree of welding, and presence of either or both parts are highly variable because the tuff filled channels cut into older tuffs in the paleovalley through Seven Lakes Mountain. Maximum thickness is about 100 m along the southern flank of Seven Lakes Mountain. The Nine Hill Tuff is widely distributed through western Nevada and the Sierra Nevada (Bingler, 1978; Deino, 1985). Deino (1985, 1989) demonstrated that it correlates with the "D" unit of the Bates Mountain Tuff in central and eastern Nevada and suggested a source beneath the Carson Sink.

Tcn Conglomerate below Nine Hill Tuff Coarse, poorly indurated conglomerate and conglomeratic sandstone consisting of subangular to rounded boulders of ash-flow tuff (mostly tuff of Dogskin Mountain; Tdm) and quartz monzodiorite (Kqmd) up to 1 m in diameter. The mapped unit is mostly overlain by the tuff of Chimney Spring or the Nine Hill Tuff. It is possible but not certain that some conglomerate is younger than Nine Hill Tuff. The conglomerate is as much as 30 m thick.

Tcc Tuff of Campbell Creek A dark to light gray to cream-colored, sparsely porphyritic, pumiceous, densely to mostly moderately or poorly welded ash-flow tuff characterized by common, smoky, vermicular quartz

phenocrysts and minor plagioclase. The tuff grades upward from a relatively sparsely and finely porphyritic, poorly welded and glassy base, which is commonly silicified, to more abundantly and coarsely porphyritic, densely welded, devitrified, nubbly weathering main part, to moderately or poorly welded top. Quartz and total phenocryst abundance decreases abruptly upward from the densely to moderately welded parts; biotite and plagioclase abundance increases. Pumice fragments up to about 25 cm long are common and locally include plagioclase-biotite-rich pumice unlike the host tuff. Shards are easily visible with a hand lens. Widely but discontinuously distributed across Seven Lakes Mountain, the tuff is as much as about 100 m thick. The age and petrographic character indicate correlation with the rhyolite of Campbell Creek (McKee and Conrad, 1987; Henry and others, 2004), which is an intracaldera tuff in the Desatoya Mountains approximately 200 km to the east-southeast. Equivalent to the Dry Valley tuff of Deino (1985).

Tcy Conglomerate below tuff of Campbell Creek The tuff of Campbell Creek is commonly underlain by a coarse to pebbly conglomerate marked by a lag of well-rounded boulders. Boulders are mostly tuff of Dogskin Mountain (Tdm) up to 1.5 m in diameter. Where exposed in several uranium exploration pits, the poorly indurated matrix consists of smaller clasts of ash-flow tuff. Most outcrops consist of a lag of coarse, rounded boulders.

Te Tuff E A light-colored, moderately porphyritic, poorly to moderately welded ash-flow tuff characterized by common, bipyramidal, smoky quartz phenocrysts. Recognized only north of Porcupine Mountain, where it is about 50 m thick. However, although distinguished by the bipyramidal and non-vermicular quartz, it is similar to tuff of Campbell Creek (Tcc) and may have been mistakenly mapped as such along the southern flank of Seven Lakes Mountain.

Tdm Tuff of Dogskin Mountain A thick, complex sequence of at least three cooling units of similar, plagioclase- and biotite-rich ash-flow tuff interbedded with platy, compacted, probably mostly reworked tuff and tuffaceous sedimentary rocks. The ash-flow tuffs are dark red-brown to medium gray, moderately pumiceous, and densely to poorly welded. Poorly welded parts form slopes, whereas dense parts locally form resistant ledges. White pumice that weathers to form ellipsoidal cavities up to 25 cm long is common in dense parts of the tuffs. The ash-flow tuffs are laterally discontinuous, probably reflecting both non-deposition and erosion. Individual cooling units are 8 to 30 m thick. The composite unit, including reworked tuff, is as much as 120 m thick. The tuff of Dogskin Mountain correlates with the tuff of Coyote Spring of Garside and Bonham (1992) and is widely distributed through the region. Equivalent to the Porcupine Mountain tuff of Deino (1985).

Thick-bedded to platy, dense but nonresistant and generally poorly exposed, greenish gray to gray to white, plagioclase- and biotite-rich tuff is common throughout the unit. This platy tuff shows no evidence of welding zonation. Lithic fragments up to ~10 cm in diameter are scattered randomly through the unit. Based on these characteristics and local presence of pebble to cobble conglomerate and conglomeratic sandstone, most and possibly all of the platy tuff is reworked. The dense character may result from sedimentary compaction rather than welding.

Tmc Tuff of Mine Canyon Red-brown to pinkish gray, moderately porphyritic, densely welded tuff containing large, glassy sanidine and smaller, cloudy white plagioclase phenocrysts. Biotite phenocrysts are distinctly more abundant than in the similar tuff of Cove Spring (Twc). The tuff contains sparse pumice fragments up to 2 cm long and lithic fragments of porphyritic andesite and metasedimentary rock (greenish-gray siltstone). The tuff of Mine Canyon was only recognized in Red Rock Canyon, in the western part of the map area, where it is as much as 20 m thick. In contrast, it is widely distributed around Dogskin Mountain and through the Virginia and Pah Rah Mountains to the east. Named for exposures in Mine Canyon in the Tule Peak Quadrangle (Faulds and others, 2003b).

Twc Tuff of Cove Spring A sparsely to moderately porphyritic ash-flow tuff with a thick, red brown to tan, densely welded lower part that passes upward into a light gray, poorly welded upper part, which is rarely preserved. The tuff is characterized by large, abundant sanidine, fine, mostly altered plagioclase, and sparse biotite: much less than 1% in the densely welded tuff to ~1% in the upper, poorly welded part. The lesser biotite content distinguishes unit Twc from unit Tmc, which is otherwise similar. Ellipsoidal cavities marking eroded pumice fragments are common in the densely welded part. The tuff of Cove Spring is present along the south-central flank of Seven Lakes

Mountain. The tuff may be as much as 50 m thick there, but thickness is difficult to determine because of complex faulting. Named for exposures near Cove Spring in the Tule Peak Quadrangle (Faulds and others, 2003b).

Twm Tuff of Western Mine A light-colored, moderately porphyritic, poorly to moderately welded ash-flow tuff crops out only in a small area near some uranium prospects on the northwest flank of Seven Lakes Mountain. The tuff is about 30 m thick and has a light gray, perlitic vitrophyre about 5 m thick. The finely and sparsely porphyritic rock has phenocrysts of sanidine, plagioclase, and minor biotite and a few pumice fragments up to 1 cm long. The vitrophyre contains a few wood fragments up to about 1.5 cm long. Deino (1985) introduced the informal name for the uranium prospect.

Tts Conglomerate and tuffaceous sedimentary rock Conglomerate and tuffaceous sandstone and siltstone overlie the upper unit of the tuff of Sutcliffe (Tsu) and underlie tuff of Mine Canyon (Tmc) in Red Rock Canyon. Clasts of tuff of Sutcliffe up to 1 m in diameter indicate the rocks are mostly reworked from that tuff. Stratigraphic relationship to tuff of Western Mine (Twm) and tuff of Cove Spring (Twc) is unknown.

Ts Tuff of Sutcliffe Light gray- to brick red- to yellow-weathering, densely to moderately welded, mostly abundantly porphyritic ash-flow tuff. The tuff is one of the most widely distributed in the quadrangle and throughout the region and may be as much as 150 m thick in the central part of Seven Lakes Mountain. As many as three cooling units separated by poorly welded tuff or sedimentary rocks are recognized. Where separated by sedimentary rocks in the western part of the quadrangle, we have divided the tuff into upper (Tsu) and lower (Tsl) units. The upper unit commonly has a basal, light gray vitrophyre and is zoned upward from moderately porphyritic, plagioclase-sanidine tuff with ~2% biotite to abundantly porphyritic, plagioclase-biotite rich tuff with lesser sanidine. The lower unit lacks a basal vitrophyre but is petrographically similar except that it contains slightly less biotite and more sanidine. However, this difference can be difficult to recognize in altered or weathered samples. Both are similar in appearance to the plagioclase-biotite-rich welded tuffs in the tuff of Dogskin Mountain (Tdm) but distinguished by the presence of common, large sanidine. Pumice content is highly variable from ~1% in most of the tuff to 10-15% in lithophysal zones in upper parts where pumice is up to 40 cm long. Small fragments of shale and porphyritic andesite are common. Named for exposures near Sutcliffe in the Sutcliffe Quadrangle (Faulds and others, 2003a). The upper unit is equivalent to the Harrys Spring tuff and the lower unit to the Constantia Station and Zamboni Spring tuffs of Deino (1985).

Tcu Sedimentary rocks below or separating tuff of Sutcliffe Poorly exposed sequence of tuff and tuffaceous sedimentary rocks consisting mostly of platy tuffaceous sandstone interbedded with thin pebble to cobble conglomerate.

Trc Tuff of Rattlesnake Canyon Light red, densely welded grading upward to poorly welded ash-flow tuff characterized by large and abundant sanidine. Dense part is commonly columnar jointed and shows nubbly weathering. Upper, poorly welded part is more finely porphyritic and contains ~10% pumice up to 15 cm long. Fragments of porphyritic andesite and quartzite up to 1 cm across are common near the base. Recognized only in scattered locations in the western part of Seven Lakes Mountain. Named for exposures in Rattlesnake Canyon in the Fraser Flat Quadrangle (Garside and others, 2003).

Tcr Sedimentary rocks below tuff of Rattlesnake Canyon Poorly exposed sequence of platy, poorly bedded tuffaceous rocks interbedded with thin lenses of coarse sandstone and pebble to cobble conglomerate similar to those in unit Tts and Tcs. Mostly covered by colluvium. May also include some tuff of Hardscrabble Canyon (Thc).

Thc Tuff of Hardscrabble Canyon Poorly exposed, moderately to poorly welded, sparsely and finely porphyritic, white to light gray ash-flow tuff distinguished by the presence of about 5%, small, angular, smoky quartz phenocrysts. The tuff contains a few small (<1 cm long) pumice and sparse fragments of Cretaceous(?) granite. The tuff is exposed only in one location in the western part of Seven Lakes Mountain where it forms rubble on the slope below the communications towers. Named for exposures in Hardscrabble Canyon in the Tule Peak Quadrangle (Faulds and others, 2003b).

Tac Tuff of Axehandle Canyon Moderately welded, moderately pumice-rich, pink to light brown, dark red-brown weathering ash-flow tuff, the oldest exposed tuff in the region. Grades upward from sparsely porphyritic

base with sanidine more abundant than plagioclase and 1% biotite to upper part with plagioclase much more abundant than sanidine and 2-3% biotite. This upper part is similar in appearance to the tuff of Sutcliffe (Ts). Both parts contain common white pumice up to 10 cm long. Exposed only in the western part of Seven Lakes Mountain. Named for exposures in Axehandle Canyon in the Griffith Canyon Quadrangle, but possibly correlative with part of the Windous Butte Formation of central Nevada (M.R. Best, personal commun., 2001).

Tck Basal Tertiary conglomerate Conglomerate composed exclusively of pre-Cenozoic clasts. Crops out above granitic rocks in Seven Lakes and Porcupine Mountains and in the Sand Hills. Exposed as a lag of generally rounded boulders of granitic rock mostly up to 50 cm but locally as much as 1.5 m in diameter. Clasts are most commonly locally reworked granitic rocks and aplite or pegmatite but include quartz monzodiorite (Kqmd) in the Sand Hills, which demonstrate transport from east to west in the paleovalley. This unit includes a lens of coarse, matrix-supported conglomerate consisting of subangular to moderately rounded blocks of granodiorite and aplite and underlying, poorly exposed, fine, white tuffaceous sandstone and siltstone that in turn rest upon granodiorite of the Sand Hills (Kgs?) at the eastern end of Red Rock Canyon.

Tt Oligocene ash-flow tuffs undivided Shown on cross sections only.

Mesozoic Rocks

Cretaceous granitic rocks (relative ages of the major intrusions are unknown)

Kqw Weathered Cretaceous granitic rocks Distinct, nearly continuous paleoweathered zone as much as 15 m thick developed in granodiorite of the Sand Hills (Kgs) and quartz monzodiorite of Dogskin Mountain (Kqmd) along the unconformity with Cenozoic rocks. Distinguished by its pink to brick-red color on the ground and air photos. Locally, weathered and disaggregated granodiorite was recemented by silica(?) to form a hard, dark-red zone up to 3 m thick at the contact.

Kf Aplitic to pegmatitic dikes and irregular intrusions Dikes and irregular shaped intrusions of aplite and pegmatite in granodiorites of the Sand Hills (Kgs) and of Petersen Mountain (Kgp). Dikes are a few centimeters to as much as 10 m wide. All rocks consist of orthoclase, quartz, lesser plagioclase, and minor biotite. Grains in aplites are generally equant and less than 2 mm in diameter. Pegmatites can contain orthoclase up to 6 cm in diameter and quartz up to 10 cm long. Many dikes have parallel, gradational bands of aplite and pegmatite. Aplite dikes with irregular pods of pegmatite. Most dikes on Petersen Mountain and in the Sand Hills strike northeast; additional orientations on Petersen Mountain are north-northeast or east and northwest in the Sand Hills.

Kgs Granodiorite of the Sand Hills Massive, medium grained, speckled light gray to white, commonly deeply weathered granodiorite characterized by large, euhedral biotite and hornblende grains. Makes up all of the granitic rock of Seven Lakes Mountain and extends southeastward into the Sand Hills. Commonly forms prominent knobs surrounded by areas of deep sand. A pink to brick red, paleoweathered zone (Kgw) is developed in granodiorite close to the overlying Oligocene ash-flow tuffs. Biotite and hornblende decrease in abundance, with hornblende becoming nearly absent, southward across a transition zone in the Sand Hills near the southeastern corner of the quadrangle. Mineralogy: orthoclase (15 to 20%, to 1 cm, commonly enclosing plagioclase, biotite, and hornblende), plagioclase (50 to 60%, subhedral to 7 mm), quartz (20 to 30%, to 4 mm), biotite (3 to 5%, to 5 mm), and hornblende (0 to 3%, to 1 cm long rods). Sphene is a common accessory visible with a hand lens, and zircon and titanomagnetite are apparent in thin section.

Kgpp Quartz-pegmatite of Petersen Mountain North-elongate area about 250 by 150 m of abundant, irregularly shaped, quartz- and pegmatite-filled cavities developed in granodiorite of Petersen Mountain (Kgp) near the southwestern corner of the quadrangle. Observed quartz crystals are as much as 10 cm long. Pegmatite consists of quartz, orthoclase, and, locally, black tourmaline and muscovite. Cavities are developed both in unfractured, massive parts of the granodiorite and along fractures, especially at intersections of multiple fractures, which appear to have no preferred orientation. A wide area of talus and colluvium on the west flank of Petersen Mountain contains pieces of this rock and is hunted for quartz crystals.

Kgp Granodiorite of Petersen Mountain Massive, medium-grained, white to slightly speckled granodiorite characterized by prominent phenocrysts of orthoclase up to 2 cm across and by a relatively low abundance of mafic minerals crops out in the northern part of Petersen Mountain and on Porcupine Mountain. Variably weathered to rounded boulders up to 3 m in diameter surrounded by grus. Cut by numerous aplitic to pegmatitic dikes. Mineralogy: orthoclase (15 to 20%, both irregular, interstitial grains and phenocrysts up to 2 cm), plagioclase (60%, subhedral, 1 to 5mm), quartz (20%, to 3mm), biotite (4 to 5%, to 2mm), and hornblende (0 to 1%, scattered rods, mostly to 5mm long). Sphene is a common accessory visible with a hand lens, and zircon and titanomagnetite are apparent in thin section.

Ka Aplite dikes of the Fort Sage Mountains Numerous thick dikes of very light-colored, equigranular to finely porphyritic aplite and rarely pegmatite cut metavolcanic rocks (Mmv) and granodiorite of the Fort Sage Mountains (Kgf) along the south flank of those mountains. Dikes generally intruded parallel to layering and foliation in the metamorphic rocks, are commonly complexly branching, and are up to 2 km long and 50 m thick. Dikes consist mostly of small (≤ 2 mm) orthoclase grains in a finer matrix of orthoclase, quartz, plagioclase, and minor biotite. Cores of dikes are mineralogically similar but more equigranular. Local pegmatite lenses contain orthoclase and quartz up to 5 cm in diameter and sphene up to 2 cm in diameter. Thin veinlets of quartz, epidote, and albite(?) cut the dikes, generally perpendicular to intrusive contacts. Many fractures parallel to intrusive contacts are bleached and coated with sprays of black tourmaline.

Kgf Granodiorite of the Fort Sage Mountains Medium-grained, speckled, mafic granodiorite makes up most of the southwestern part of the Fort Sage Mountains, where it intruded metavolcanic rocks (Mmv) along a sharp, northeast-striking contact that parallels layering and foliation in the metamorphic rocks. Along and near the contact, the granodiorite is slightly foliated and contains lenses of angular to rounded pods of diorite up to 1 m long, possibly the mafic granodiorite of the Fort Sage Mountains (Kgm). Two diorite pods consisting of plagioclase, hornblende, and minor biotite were large enough to map separately. Elsewhere, the granodiorite is massive and generally forms rounded boulders surrounded by grus. Black tourmaline coats many fractures. Mineralogy: plagioclase (70%, anhedral, 1 to 4mm, slightly altered to sericite and epidote), quartz (10%, interstitial to 2mm, strained), orthoclase (5%, interstitial grains), biotite (9%, 1 to 2mm), and hornblende (6%, to 3mm). Accessory minerals are equant opaques (probably magnetite) mostly as inclusions in biotite or hornblende, apatite, anhedral sphene, and minor zircon. Equivalent to biotite granite of Grose (1984) and hornblende-biotite granodiorite of Grose and others (1989).

Kgm (was Kdf) Mafic granodiorite of the Fort Sage Mountains Heterogeneous, light to dark gray, fine to medium-grained, variably altered, mafic granodiorite and diorite crop out in the southeastern Fort Sage Mountains where both the main body and several dikes intrude Mesozoic metavolcanic rocks (Mmv). Forms large, massive, dark outcrops. Inclusions of the metavolcanic rocks are common near the contact. Mineralogy: plagioclase (45-70%, subhedral, 1-2 mm), orthoclase (25%, as interstitial, poikilitic grains up to 5 mm in diameter enclosing plagioclase and mafic minerals), quartz (10%, interstitial, moderately strained), hornblende (10%, subhedral to anhedral, 1-3 mm), biotite (7%, anhedral <1-2 mm), clinopyroxene ($\leq 1\%$, <1 mm), and titanomagnetite (1%, 0.5 mm). Mafic minerals are locally altered to chlorite. Sphene and apatite are common accessories. Locally moderately sheared and with fracture coatings or veinlets of quartz±epidote±tourmaline veinlets. Approximately equivalent to hornblende diorite of Grose (1984).

Kqmd Quartz monzodiorite of Dogskin Mountain Coarse-grained, light to medium gray quartz monzodiorite and granodiorite consisting of, in decreasing order of abundance, plagioclase, microcline, quartz, hornblende, biotite, and accessory titanomagnetite, anhedral sphene, and zircon, make up most of the southern part of Dogskin Mountain. A weak foliation defined by the preferred orientation of hornblende is common. Enclaves of diorite range up to 20 cm long. Local veinlets of black tourmaline. Generally weathers to large angular blocks or rounded boulders surrounded by grus. Much greater abundance of plagioclase relative to potassium feldspar and quartz, weak foliation, and occurrence of potassium feldspar as microcline distinguish this from the granodiorites of Sand Hills (Kgs) and of Petersen Mountain (Kgp). This unit is the same as unit Kqmd in the Dogskin Mountain Quadrangle (Henry and others, 2004).

Mmv Mesozoic (Jurassic?) metavolcanic rocks A heterogeneous assemblage of metamorphosed volcanic, volcanoclastic, and sedimentary rocks makes up most of the southeast flank of the Fort Sage Mountains. The

metamorphic rocks commonly form dark, resistant crags separated by large areas with no outcrop. The rocks strike northeast to north and dip steeply to moderately to the east. Metavolcanic rocks are massive to rarely flow-banded, locally vesicular, and finely to coarsely porphyritic, with phenocrysts of plagioclase 1 to 12 mm long altered to albite, epidote, and sericite and mafic phenocrysts (pyroxene?) altered to opaque minerals and biotite. Metamorphic hornblende and biotite are scattered through the matrix. The rocks were probably originally andesite and basaltic andesite. Volcaniclastic rocks are massive to thickly bedded, contain matrix- to clast-supported angular fragments of the volcanic rocks up to 50 cm in diameter in a fine matrix, and probably include flow breccias, debris-flow deposits, and other sedimentary deposits. Finer sedimentary rocks are well-bedded, are as fine as siltstone, and increase in abundance westward. The finest deposits were probably slightly clayey siltstones that are now metamorphosed to quartz, orthoclase, biotite, and muscovite, with different layers containing different proportions of the minerals probably indicating different detrital components. Numerous veins and irregular pods of epidote and quartz cut all rocks. Black tourmaline commonly coats fracture surfaces. Equivalent to metavolcanic rocks of Grose (1984).

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