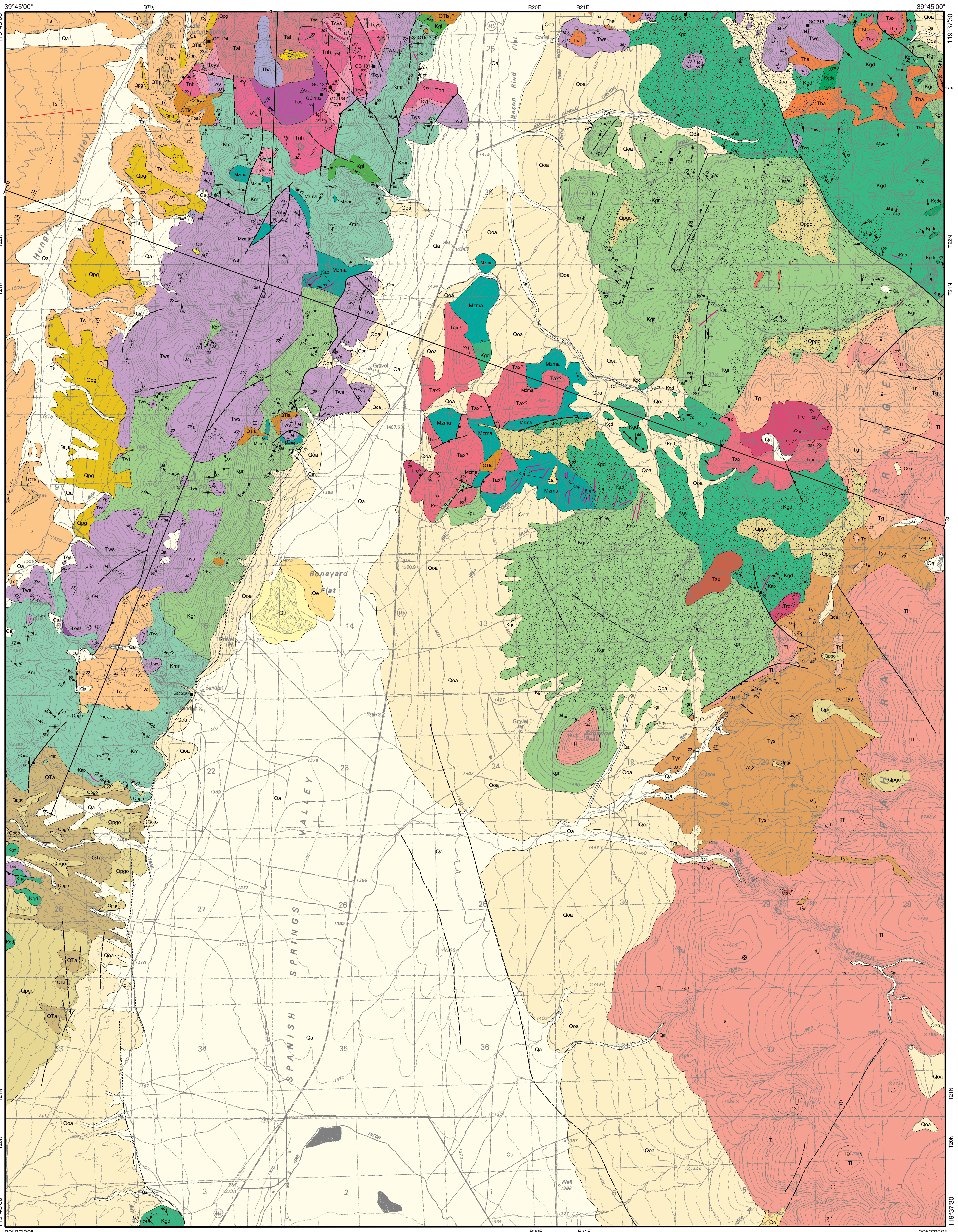

PRELIMINARY GEOLOGIC MAP OF THE GRIFFITH CANYON QUADRANGLE, NEVADA

Larry J. Garside and Fred L. Nials

1998

Scale 1:24,000

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

CONTOUR INTERVAL 10 METERS
WITH SUPPLEMENTARY CONTOURS AT 5 METERS

Base map: U.S. Geological Survey Griffith Canyon 7.5' Quadrangle, DRG

Qa **Alluvium** Holocene alluvium, restricted to valley bottoms and localized portions of some fan surfaces. Unconsolidated, predominantly arkosic, sand and gravelly sand deposited as sheetwash and wash alluvium in Holocene to modern channels or as broad, low-gradient alluvial plains. Locally contains abundant medium sand reworked from older aeolian deposits (e.g., at the mouth of unnamed canyon in NW1/4, NW1/4, Sec. 3, T21N, R20E). No soil development except on very localized Holocene terraces (not mapped), where weak 10-15 cm gray-brown A horizon is present in some places. Includes undifferentiated alluvial fan and colluvial deposits in upland areas.

Qt **Talus** Limited to very small areas in volcanic rocks in northern Hungry Ridge.

Qp **Playa deposits** Light-brown, moderately well-sorted, sandy silt and clay. Present only in limited area of Boneyard Flat in Spanish Springs Valley. Mostly obscured by modern wash deposits associated with gravel quarrying activities in the area.

Qe **Aeolian deposits** Discontinuous thin mantles of aeolian sand are widespread in Hungry Valley and Spanish Springs Valley, especially near modern washes. These deposits lack dunal morphology, however, and are too thin and discontinuous to map as sand sheets. As a consequence, the only Qe deposits mapped are low, small dunes in the vicinity of Boneyard Flat. These low dunes are mostly low, rounded, stabilized features on the northern and eastern sides of the playa. Soil development is minimal, in most places consisting of a weak gray-brown A horizon 5-12 cm thick.

Qls **Landslide deposits** Only one late Pleistocene/Holocene mass wasting feature was observed, a very small, localized, modern debris slide on the western flank of Hungry Ridge. The slide may have been induced by human activities.

Qpg **Pediment deposits** Most late Pleistocene/Holocene piedmont surfaces adjacent to mountains in the western half of this quadrangle are pediments. Most younger pediment surfaces primarily consist of subexposures of older bedrock or alluvium, with widespread, but localized, patchy accumulations of pediment gravels. In particular, extensive areas of Tertiary deposits in Hungry Valley display pediment surfaces of various ages. In order to avoid obscuring stratigraphic and structural relationships of older rocks, pediment surfaces were not mapped unless accumulations of Qpg were sufficiently thick to obscure underlying materials. Where not removed or modified by subsequent erosion, pediment deposits above fine-grained Ts are characterized by thin (30-50 cm) but well-developed soils possessing a red argillic B horizon up to 30 cm thick. Visible carbonate accumulations, if present, are typically at or beneath the soil-bedrock contact, where they form thin, commonly continuous, cemented white coatings on fracture and bedding planes. Pediment surfaces cutting older alluvial sediments may display thicker, but less well-developed, soils up to 1 m or more in thickness. B horizons are weakly argillic, and carbonate, usually powdery, may discontinuously coat clasts, root channels, and bedding planes to a depth of several meters.

Qoa **Older alluvial fan deposits** Alluvial fan remnants with moderately to deeply incised surfaces, primarily consisting of semiconsolidated pebbly to bouldery arkosic sand derived from Hungry Ridge. In some areas, especially on the eastern margin of Hungry Ridge, these deposits grade into deposits of Qdg that may or may not contain corestones of relatively unweathered intrusive lithologies.

Qpgo **Older pediment deposits and/or surface** These deposits are associated with late and middle(?) Pleistocene and older, deeply dissected pediment surfaces cut into older bedrock and sediments. Exposures are especially prominent along the western margin of Hungry Ridge, where surfaces cut on Tertiary bedrock slope westward into Hungry Valley. Other deposits are present along the southeastern margin of Hungry Ridge north of Eagle Canyon Road, where surfaces are mostly formed on QTa deposits. Deposits typically vary from 1 to 4 m in thickness and locally have been partially or totally eroded. Localized, thin, patchy accumulations of older pediment gravels are widely present on many piedmont surfaces, but were not mapped unless sufficiently thick and extensive to obscure underlying materials. Where not modified by younger erosion, pediment deposits overlying fine-grained Tertiary bedrock are characterized by prominent red soils up to 1 m or more in thickness. Associated B horizons are red and distinctly argillic. Visible carbonate accumulations are typically at or beneath the soil-bedrock contact, where they form 1-3 mm, usually continuous, white coatings on fracture and bedding planes in zones 1-2 m thick. No massive, cemented B_k or K horizons were observed, however. Surfaces cutting older alluvial sediments may display thicker, but less well-developed, soils up to 1 m or more in thickness. B horizons are weakly argillic, and carbonate, usually powdery, may discontinuously coat clasts, root channels, and bedding planes. In the eastern half of the quadrangle, pediment surfaces are extensively developed, especially on Cretaceous intrusive rocks (stipple pattern). Deposits associated with these surfaces (Qpgo) are present in some areas but were not mapped separately unless extensive.

Quaternary/Tertiary landslide deposits These deposits were mapped in several areas along the western margin of the quadrangle. Although these deposits vary somewhat from one exposure to another, they generally consist of chaotically arranged medium to large boulders of intrusive or volcanic lithologies. Individual deposits are predominantly monolithologic, but all contain a mixture of rock types to some degree. The lower contact is commonly obscured by debris from above, but appears to be relatively smooth, perhaps coinciding with an older pediment surface in some locations. The deposits are deeply eroded and no weathering profile is discernable. Extensive erosion has removed or obscured primary morphologic characteristics of the deposits in all cases, and exact source areas cannot be determined. Characteristics of the remaining deposits suggest that the movement may have been in the form of rock avalanches. Temporal relationships between the various exposures are uncertain, and the distinction between map units was made on the basis of predominant clast lithology.

$QTls_3$ Deposits are dominated by blocks and smaller fragments of Kmr or Kgr in a sparse matrix of coarse arkosic material. Most blocks are 1 m, but rarely some are up to 9 m in diameter and 3 m thick. Some large boulders are rounded and weathered along pre-slide(?) internal fracture planes, but others display angular, irregular fracture surfaces with little apparent weathering and no matching boulder fragment opposite the fracture. Fracture plane orientations are inconsistent from boulder to boulder. Commonly 10 m thick. Includes two separate rock avalanche deposits; one narrow, elongate deposit along the east margin of Hungry Valley near the end of Eagle Canyon Road, and another 3-km-long deposit which caps ridges west and northwest of Little Hungry Spring. The deposits form resistant mantles atop slightly dipping Ts, in some cases protecting the older rocks from erosion and forming low ridges up to 20 m high with no apparent connection to potential source areas. Similar deposits of unquestionable mass wasting origin are present adjacent to coarse-grained intrusive bodies exposed along the edges of several ranges in the area, including Freds Mountain, Dogskin Mountain, and Peterson Mountain.

$QTls_2$ A single, thin ridge capping rock avalanche deposit dominated by blocks and smaller fragments of unit Tcs; believed to lie on Qtls1 south of Little Hungry Spring. A few meters thick.

$QTls_1$ Rock avalanche deposits consisting predominantly of blocks and smaller fragments of units Tws or Tnh, or in one area, Tba. Some avalanches apparently traveled only a short distance downslope and include large, slightly rotated blocks, while others may have traveled 1 km or more from unidentified sources. Found in several areas of northern Hungry Ridge; south of Little Hungry Spring the unit is interpreted to underlie $QTls_2$ and $QTls_3$. Thickness varies from a few meters to tens of meters.

QTa **Late Tertiary/early Pleistocene alluvial and alluvial fan deposits** Moderately to strongly consolidated alluvial gravels and alluvial fan sediments. These deposits are exposed only in a low pass near the western margin of the map area in Sec. 21, T21N, R20E, and portions of surrounding sections. In areas just outside the map boundary these deposits are well-bedded, clean, and tectonically deformed. Gravel units contain small quantities of rock types exotic to Hungry Ridge.

Alluvial fan sediments of this age are restricted to the southeastern side of Hungry Ridge. Deposits are poorly sorted and arkosic, with cobbles and boulders of various intrusive rock types. These deposits have been modified by pediment erosion and are poorly exposed in most areas. Soils associated with these sediments are deeply eroded in all available outcrops. Alluvial fan facies post-date the gravel facies of this map unit.

Tg **Gravel** Poorly exposed cobble to boulder gravel which is characterized by lag-mantled surfaces of cobbles and large boulders. Finer grained units (sandstone and pebble conglomerate), which are rarely exposed, resemble similar units in Tys. Boulders consist of granite (Kgr), ash-flow tuff (Tws), hornblende andesite (Tha?), and basalt (Tl?). Interfingers with underlying(?) Tl in the area south of Curnow Canyon but elsewhere lies with probable considerable relief on Kgr or Tertiary ash-flow tuff. At its southern extent, it is interpreted to mainly overlie Tys. Probably deposited as alluvial fan(s), including stream and debris flow deposits. Unit may be wedge shaped.

Tys **Younger sedimentary rocks** Very light-gray, yellowish-gray, and light-brown volcaniclastic and arkosic sandstone, pebbly sandstone, conglomerate, and lesser finely laminated tuffaceous(?) shale. Local beds of dark-reddish-brown basaltic tephra. Thin to thick bedded. Sandstones are medium to coarse grained and locally cross bedded. Pebbles consist of granitic rock, basalt, vein quartz, hornblende and pyroxene andesite, rhyolitic ash-flow tuff (Tws?), and rare, but ubiquitous, polished black tourmaline-bearing rock. Beds and lenses of conglomerate and sandstone that are correlated with Tys are found between flows of Tl; some of these are too poorly exposed or too thin to be mapped, except as discontinuous intra-unit contacts (“form lines”).

Tl / Tli **Lousetown Formation** Dark-gray- to dark-brown-weathering, dark-gray olivine basalt flows. Massive to vesicular or microvesicular, locally platy jointed to crudely columnar jointed. Phenocrysts (commonly less than 5%) of olivine (1 mm), partly to completely altered to iddingsite. In addition, some flows contain tabular plagioclase (commonly 1 mm, but rarely 2 x 6 mm) and, rarely, orthopyroxene (0.5 mm). Pilotaxitic to trachytic, with an intergranular groundmass of fine pyroxene grains and plagioclase laths. Individual flows 10 m; total thickness unknown, but probably several hundred meters. Flows dip west and sequence thickens eastward; it may be part of a postulated shield volcano centered on Spanish Springs Peak in the Pah Rah Range to the west. **Tl**, flows; **Tli**, dikes. Age 11.12±0.03 Ma.

Ts **Sedimentary rocks of Hungry Valley** White, very light-gray, very pale-orange, and greenish-yellow, tuffaceous, coarse to fine volcaniclastic to feldspathic or arkosic bedded sandstone, pebbly sandstone and conglomerate interbedded with tuffaceous siltstone. Rare tufa and ostracode or pisolitic limestone. Finer grained beds are more common basinward. Locally cemented with calcite or, rarely, iron oxides. Lies with angular unconformity or nonconformity on most older Tertiary and pre-Tertiary rocks. Locally overlain by a very thin veneer pediment deposits and lag (particularly west of the axis of Hungry Valley), which is not mapped where the underlying unit can be discerned. Thickness probably <100 m on Hungry Ridge; thicker below alluvium in valley areas.

Tba / Tbai **Basaltic trachyandesite** Black, olivine-plagioclase phyric, massive to vesicular. Phenocrysts (~15%) of tabular plagioclase (~14%, 1-2 mm x 1 cm) and olivine (<1%, 0.4-2 mm). **Tba**, flow; **Tbai**, 1 m-wide dike. Tba overlies units Tcs and Tal with angular unconformity. See analysis of sample GC124 in table. Thickness <40 m. Age 18.73±0.07 Ma.

Tal **Andesite lahars** Reddish-brown-weathering, medium-gray, massive to very rarely crudely layered lahars consisting of blocks and clasts (a few cm to nearly 1 m in diameter) of light- to dark-gray, glassy to microcrystalline porphyritic andesite in a light gray matrix of finer andesitic material. Commonly matrix supported and monolithologic, although blocks of older ash-flow tuff up to 10 m in length are found locally near the base. Andesite clasts contain phenocrysts of plagioclase + basaltic hornblende ± biotite. Crops out on northern Hungry Ridge, where it overlies (with angular unconformity) Tcys, Tnh, and Tcs and underlies Tba. Thickness <200(?) m.

Tha **Hornblende andesite intrusive rocks** Dikes and sill-like and irregular intrusive masses of light-brownish-gray-weathering, light-gray to medium-light-gray andesite. Contains phenocrysts (20-30%, rarely 50%) of plagioclase (<1 mm to several millimeters, rarely to 1 cm; having complex oscillatory zoning and spongy cores mantled by clear plagioclase rims), and black hornblende (commonly as elongate euhedral crystals a few millimeters long, but very rarely 2 x 4 cm; commonly rimmed by a thin zone of dark magnetite and pyroxene?) in a pilotaxitic groundmass containing small plagioclase laths. Locally, phenocrysts of biotite and rarely pyroxene are observed. Commonly unaltered, but rarely propylitized (epidote, chlorite, albite?, ± pyrite). Exposed in the northeast part of the quadrangle, but includes a possibly related, single, narrow (1-3 m) dike with glassy margins exposed on Hungry Ridge. Age 20.82±0.1 Ma.

Tcs **Tuff of Chimney Spring** Pinkish-gray, locally reddish-brown-weathering, crystal-rich, rhyolite (see table, sample GC133), ash-flow tuff. Slightly to moderately welded, containing phenocrysts (~25-27%) of smoky, bipyramidal to equant quartz (6%, 1-3 mm); equant to euhedral or broken, locally chatoyant, sanidine (20%, 1-2 mm), plagioclase (1-2%, ~1-2 mm), rare biotite plates (<1%, 0.5 x 0.9 mm), and accessory opaque iron-titanium oxides (0.2 mm). Contains uncommon indistinct pumice up to 3 x 20 mm. Portions weather to rounded, reddish boulders of decomposition. Appears to be a single cooling unit in the quadrangle, overlying units Tcys and Tnh with angular unconformity. Thickness 100-150 m. Age, 24.90±0.07 Ma.

Tnh **Nine Hill Tuff** Brownish-weathering, pinkish gray or grayish, strongly welded rhyolite (see table, sample GC132) ash-flow tuff. Contains phenocrysts (~15%) of subequal amounts of spongy to sieve-textured (resorbed) anorthoclase (~6%, up to 4 x 1.3 mm) and equant, fractured sanidine .(~6%, 1 mm), with plagioclase (3%, <1 mm), small biotite (trace) and accessory ilmenite? (converted to hematite). Some samples contain rare small lithic fragments of glassy, sanidine-bearing silicic volcanic rock similar to the Nine Hill. Commonly partial to complete vapor-phase alteration, with formation of tridymite and alkali feldspar in cavities (former pumice sites); elsewhere devitrified. Local dark grayish black vitrophyre at base. Distinctive compressed pumice (1:3 to 1:7 aspect ratio) from less than 1 mm x 5 mm to 15 x 45 cm.The unit is apparently equivalent to the upper or "rhyodacitic" phase of the tuff (A.L. Deino, in Best and others, 1989). Thickness 130 m, variable. Age, 25.11 Ma (Deino, 1989), 25.07±0.07 Ma.

Tcys **Tuff of Coyote Spring** Light-gray, nonwelded to slightly welded, dacite (table, sample GC134) ash-flow tuff with a distinctive phenocryst assemblage (~15-20%) of plagioclase (17%, <2.5 mm) and biotite (~2%, ~0.2 x 0.8 mm) in a glassy, shard-rich groundmass. Contains white, uncompressed pumice lapilli (~5%, most <1 cm, but up to several cm) and sparse light gray lithic fragments (< 3-4 mm) of glassy biotite-plagioclase volcanic rock. Commonly occurs between unit Tnh and Tws, but locally lies directly on pre-Tertiary plutonic rocks. Thickness <100 m. Age 29.13±0.08 Ma.

Tws / Twss **Tuffs of Whiskey Spring** Sequence of several (probably three or more) commonly moderately welded rhyolitic (e.g., sample GC131 in table) ash-flow tuffs. Usually light-brown-weathering, pale-orange rocks containing phenocrysts of platy-fractured glassy sanidine, plagioclase, and biotite, with only a trace of quartz. Moderately welded ash-flow tuffs commonly contain phenocrysts (~15-18%) of sanidine (11%,) plagioclase (4-5%), and biotite (commonly <1%, but >2% in some tuffs, which also may have plagioclase > sanidine). One ash-flow unit contains only ~5% phenocrysts. Lithic fragments (~1%, 0.5-3 cm) include metasiltstone, granodiorite, intermediate lava, and ash-flow tuff similar to the Whiskey Spring. Basal vitrophyre locally; in places, a "nubbly" weathering surface is developed by closely spaced joints in devitrified vitrophyre near the base. Deposited on a locally irregular erosion surface on pre-Tertiary rocks; at one site, overlies a few meters of volcaniclastic sandstone and granitic-cobble and -boulder conglomerate, unit Twss. Compressed pumice (commonly >5%, 1 x 5-8 cm) above basal nonwelded zones may have aspect ratios of approx. 1:5; one nonwelded unit includes blocks of pumice up to 45 x 75 cm. Thickness 150-250? m. An upper ash flow is 29.72±0.10 Ma; three samples from ash flows near the base average 31.0 Ma.

Trc **Tuff of Rattlesnake Canyon** Moderately welded rhyolitic ash-flow tuff containing phenocrysts (~12%) of glassy, platy-fracturing sanidine (6%, 1-3 mm), plagioclase (6%, commonly 1 mm, but rarely 1 x 3 mm), and trace biotite and quartz. Basal gray vitrophyre has 1- to 5-cm-long pumice and coarse, welded shards. Pumice indistinct in much of unit. Mapped separately locally in eastern part of quadrangle; unit Tws includes similar ash-flow units elsewhere.

Tax **Tuff of Axe Handle Canyon** Light-gray or pinkish-gray rhyolitic ash-flow tuff with sparse (5-10%), small (1 mm) phenocrysts of sanidine (2-4%), plagioclase (2-4%), quartz (1-2%), and biotite (1%). Moderately welded with coarse shard groundmass texture where not affected by vapor-phase crystallization; contains sparse, small (<1 cm) accidental lithic fragments of granitic rock and sparse, indistinct pumice (< 1 cm). Probably lowest ash-flow unit in Tws; sits on granitic rock northeast of the mouth of Axe Handle Canyon and in an area northeast of Boneyard Flat. May be present elsewhere in Tws (undivided).

Kap **Aplite-pegmatite dikes** Very light-gray to pinkish-gray aplitic and locally pegmatitic dikes, consisting predominantly of pink alkali feldspar and clear quartz, locally with sparse biotite, zircon, magnetite, and tourmaline (rare). Cut units Mzma, Kgd, and Kgr; probably related to Kgr. Commonly 1 m wide.

Kgr **Granite** Very light-gray, pinkish-gray-weathering, medium grained, equigranular to locally porphyritic rock consisting of plagioclase (15-40%, ave. 29%), locally euhedral alkali feldspar (30-40%, ave. 33%), anhedral to rounded quartz (30-43%, ave. 33%), biotite (1-5%, ave. 4%), iron-titanium oxides (1%), trace zircon, and rarely, sphene. Alkali feldspar occurs locally as poikilitic megacrysts (1.5 x 2.5 cm), and muscovite is locally present as separate crystals or intergrown with biotite. Weathers to corestones (1 to several meters in diameter) and grus. Appears to intrude Kmr and Kgd, where it is locally aplitic. Similar to Kqm of the nearby Reno and Reno NE Quadrangles (Bonham and Bingler, 1975; Cordy, 1983). Age probably < 85 Ma (disturbed spectrum on biotite).

Kgl **Leucocratic granodiorite** Light-gray or very light-gray to yellowish-gray, medium-grained, subhedral granular, light-colored granodiorite containing plagioclase (~55%, locally as <1 cm phenocrysts), quartz (~20%), interstitial alkali feldspar (10-15%), biotite + hornblende (~10%), and accessory sphene and iron-titanium oxides. Occurs as small (< 0.5 km in maximum dimension) intrusive(?) masses in Kmr

Kgd / Kgde **Granodiorite** Light-to medium-gray, medium-grained, subhedral granular to rarely porphyritic, plutonic igneous rock consisting of plagioclase (33-53%, ave. 48%), quartz (10-33%, ave. 21%), commonly interstitial alkali feldspar (7-28%, ave. 19%), and subequal amounts of biotite and green hornblende (3-10% each, ave. 6% each), with accessory sphene and magnetite-ilmenite (1%). Honey-colored sphene (1 mm) is ubiquitous and distinctive. A few hornblende phenocrysts are up to 1 cm long. Possibly a phase of or closely related to Kmr. Age 92.5±0.4 Ma. Portions rich (commonly >80%) in enclaves of microgranular (1 mm plagioclase, hornblende, biotite, and sphene) diorite, **Kgde**, mapped separately where exposures permit. Enclaves, commonly rounded to discoidal, vary from a few centimeters to 1 m in diameter.

Kmr **Monzodiorite and diorite of Rocky Ridge** Commonly medium-gray, porphyritic to subhedral granular plutonic igneous rock consisting of euhedral gray plagioclase (55-70%, <4 x 8 mm); interstitial, fine-grained, anhedral alkali feldspar (10-25%) and quartz (~3%); distinctive, thin, euhedral books of biotite (~7%, 4 mm); green hornblende (7-14%, 1 cm); and accessory sphene and iron-titanium oxides (3%). Sphene commonly rims the iron-titanium oxides.

Mzma **Metavolcanic rocks** Medium-gray, locally greenish-gray, meta-andesite and metadacite, with rare volcaniclastic sandstone and metatuff. Probably includes both lavas and hypabyssal rocks, which are now found as their metamorphic equivalents in pendants in Cretaceous granitic rocks. Predominantly porphyritic metavolcanic rock with original phenocrysts (~10%) of milky plagioclase (mainly 5 mm), and smaller hornblende and biotite; locally contains pyroxene (?), alkali feldspar (?), and rare quartz. The original rocks have been metamorphosed to lower greenschist grade; mafic and groundmass minerals are converted to mixtures of finer grained chlorite, actinolite, biotite, and rarely hornblende, epidote, and piemontite. Locally, rocks could be referred to as semischist, but most are nonfoliated.

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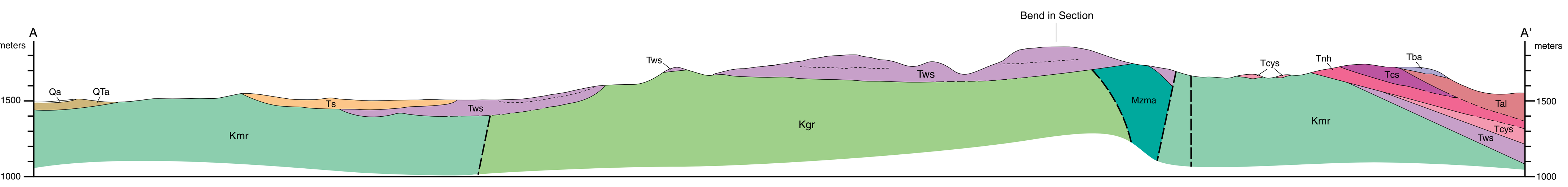
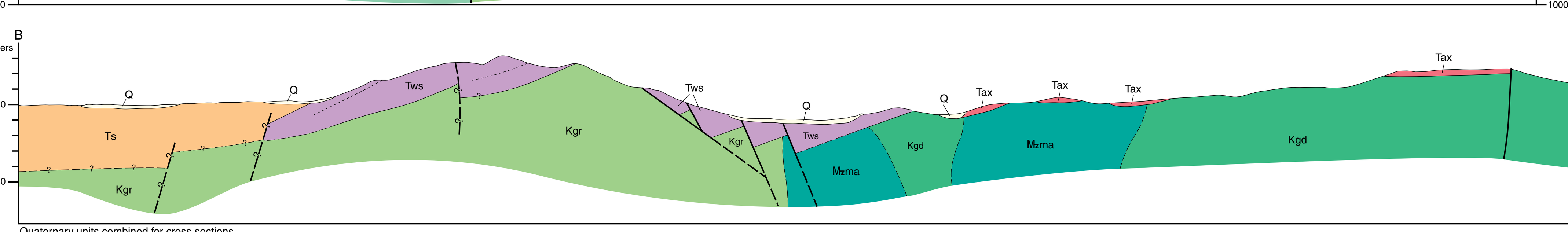
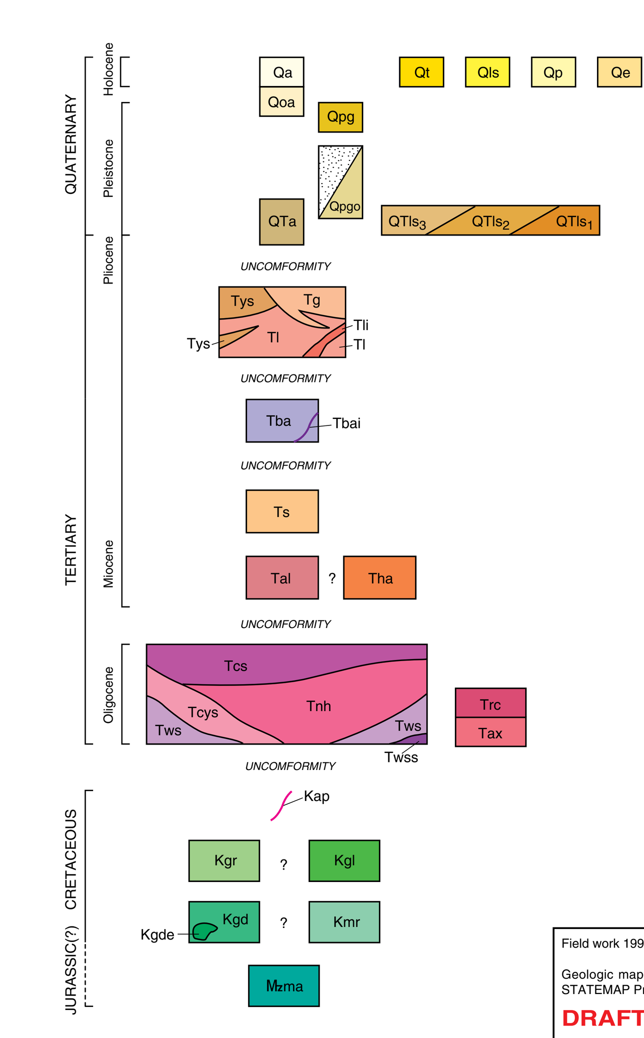




Quaternary units combined for cross sections.



Contact Dashed where approximately located, querried where uncertain, short dashes between different flows or fans within the same unit.

Fault Dashed where approximately located, dotted where concealed, queried where uncertain; ball on downthrown side.

Lineament Determined from aerial photography.

Strike and dip of beds

25 Inclined Horizontal

Approximate strike and dip of beds or flows

15 Inclined Horizontal

Strike and dip compaction foliation in ash-flow tuff

30 Inclined Horizontal

Strike and dip of metamorphic foliation

80 Inclined

Strike and dip of flow foliation in igneous rocks

80 Inclined

Strike and dip of joints

40 Inclined Vertical

Strike and dip of platy jointing in lava

35 Inclined

Syncline axial trace Showing plunge.

Vein

Vein, coincident with fault Showing dip.

55

GC 220

Sample location for $^{40}Ar/^{39}Ar$ date and (or) chemical analysis.

Pediment surface developed on bedrock. Deposits mapped as unit Qpgo.

ROCK ANALYSES FOR THE GRIFFITH CANYON QUADRANGLE

Sample	GC-124	GC-131	GC-132	GC-133	GC-134
Map unit	Tba	Tws	Tnh	Tcs	Tcys
W. Longitude	119° 43.7'	119° 42.1'	119° 42.4'	119° 42.5'	119° 42.3'
N. Latitude	39° 44.6'	39° 44.7'	39° 44.5'	39° 44.5'	39° 44.5'
Major Elements (%):					
SiO_2	54.30	73.47	71.03	74.96	67.53
TiO_2	1.61	0.29	0.40	0.17	0.42
Al_2O_3	18.51	14.91	15.55	13.79	17.89
FeO*	7.73	0.84	2.33	0.90	2.72
MnO	0.13	0.01	0.07	0.01	0.06
MgO	2.63	0.03	0.30	0.01	1.21
CaO	6.63	0.95	1.07	0.56	2.86
Na_2O	4.71	4.54	3.82	3.94	3.64
K_2O	2.89	4.90	5.34	5.62	3.57
P_2O_5	0.88	0.05	0.08	0.04	0.10
Total**	98.24	99.31	97.34	99.02	96.91
Trace Elements (ppm):					
Sc	21	9	6	2	8
V	178	21	18	16	38
Cr	18	1	0	0	1
Ni	5	9	11	9	7
Cu	130	1	1	0	2
Zn	113	18	117	31	77
Ga	26	17	22	23	20
Rb	95	147	153	160	128
Sr	556	199	122	46	618
Y	38	17	71	35	18
Zr	365	228	324	267	227
Nb	21.2	13.3	26.9	22.1	11.6
Ba	958	1776	1772	172	1384
La	51	37	73	79	44
Ce	90	61	119	156	67
Pb	22	20	32	23	26
Th	9	14	18	18	11

Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO*.
Total** = total before normalization

Mineral contents of igneous rocks were estimated visually from thin sections and rock slabs (which were stained for potassium feldspar). Igneous rock names are based on the IUGS classification (e.g., Le Maitre, 1989). Unit thickness estimated from the geologic map and topographic base map. Strikes and dips were averaged or rounded to the nearest 5° unless accuracy was better than that. Published sources of isotopic ages of igneous rocks are listed; where the source is not given, $^{40}Ar/^{39}Ar$ age data are from C.D. Henry, written commun., 1997 and 1998. Errors reported for these determinations are one standard deviation of the mean (1σ).Cretaceous ages of plutonic rocks are based on the ubiquitous ~90 Ma K-Ar ages of nearby plutons (e.g., Garside and others, 1992). Map-scale photo-lineations in Spanish Springs Valley were mapped by examination of low sun-angle photographs. They could not be examined on the ground because of urbanization disturbance or because they were not visible from the ground perspective. Dike widths on map commonly exaggerated. Thin surficial units omitted on cross sections.

Field work 1996–1997.

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DRAFT

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