Description of Map Units

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PRELIMINARY GEOLOGIC MAP OF THE MINDEN QUADRANGLE, DOUGLAS COUNTY, NEVADA, AND ALPINE COUNTY, CALIFORNIA

by
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Surficial Geologic Units of the Minden Quadrangle

by
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ALLUVIAL DEPOSITS OF CARSON RIVER

Meander-belt deposits of East Fork of the Carson River

- **Qmea Recently active meander-belt deposits** (late Holocene to modern)
- **Qme_1 Young East Carson meander-belt deposits**
  - **Qme_{1a}** (late Holocene)
  - **Qme_{1b}** (late Holocene)
  - **Qme_{1c}** (middle to late Holocene)
- **Qme2 Older East Carson meander-belt deposits** (early Holocene to latest Pleistocene)

Meander-belt deposits of West Fork of the Carson River

- **Qmw_1 Young West Carson meander-belt deposits**
  - **Qmw_{1a}** (late Holocene)
  - **Qmw_{1b}** (late Holocene)
  - **Qmw_{1c}** (early to late Holocene)
- **Qmw_2 Older West Carson meander-belt deposits** (early Holocene to latest Pleistocene)

Floodplain deposits of East and West Forks of the Carson River

Qf_1 Young floodplain deposits

Qf_{1a} (late Holocene)

Qf_{1b} (late Holocene)

Qf_2 Older floodplain deposits (latest Pleistocene)

Undivided deposits of East and West Forks of the Carson River

Qicr Intermediate age Carson River deposits (late Pleistocene)

ALLUVIAL FAN DEPOSITS

Qa Active alluvium (modern)

Qay Young alluvium

Qay_1 (middle to late Holocene)

Qay_2 (late Pleistocene to early Holocene)

Qai Intermediate age alluvium (late Pleistocene)

Qao Older alluvium (middle to late Pleistocene)

Other Alluvial deposits

Qb Basin deposits (Holocene)

Qs Spring deposits (Holocene to late Pleistocene)

Descriptions of Bedrock Geologic Units of the Minden Quadrangle

by
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The descriptions of bedrock rock units and tables of chemistry and age data are intended to supplement the preliminary geologic map of the Minden quadrangle. Descriptions of plutonic rocks are modified slightly from Armin and John (1983), rock age data are from Evernden and Kistler (1970), Armin and John (1983), and Robinson and Kistler (1986). Mineral modes and rock chemical data are from Armin and John (1983).

Ta **Hornblende andesite flows** (Tertiary) Light greenish gray, massive, coarsely jointed, locally flow banded andesite flows. The rock consists of phenocrysts (~10%) of glassy plagioclase (7%, 2–5 mm), oxidized hornblende (3%, 1–7 mm long), and rare biotite in a fine grained groundmass.

Ka **Aplite** (Cretaceous) White and very light gray aplite. Black tourmaline is a sparse constituent.

Kbm **Bryan Meadow Granodiorite** (Cretaceous) Light gray medium-grained hypidiomorphic-granular granodiorite typically containing about 5% subhedral and euhedral hornblende crystals as long as 1 cm and similar amounts of pseudohexagonal books of biotite in a groundmass of feldspar and quartz. Subhedral plagioclase crystals are commonly rimmed with myrmekite, and

poikilitic phenocrysts of weakly microperthitic microcline occur locally. Euhedral sphene crystals as long as 2 mm are ubiquitous. Discoid mafic enclaves are locally common. Relatively small areas of leucocratic rock are common, particularly near margins of the pluton. Age probably ~90 Ma (table 1).

Kkg **Granodiorite of Kingsbury Grade** (Cretaceous) Medium-grained hornblende-biotite granodiorite characteristically containing 5–10% coarse (7–10 mm) anhedral biotite flakes. The hypidiomorphic-granular granodiorite contains plagioclase laths, perthitic microcline occurring as poikilitic patches as much as 15 mm in diameter and as small interstitial grains, quartz, and 2–5 mm-long hornblende laths. This pluton is strongly foliated along its northern contact, where a fine-grained chilled margin indicates that it intruded Kdp.

Kdp **Granodiorite of Daggett Pass** (Cretaceous) Medium- to coarse-grained, well-foliated hornblende-biotite granodiorite that grades into a mafic quartz monzodiorite near the west quadrangle boundary about 1 km east of Daggett Pass (in the adjacent South Lake Tahoe quadrangle). The mafic outer(?) margin of this pluton consists of 50–60% plagioclase, 7–10% interstitial microcline perthite, 8–20% quartz, 10–15% biotite flakes (as long as 1 cm), and 8–15% hornblende prisms, which commonly have relict clinopyroxene cores. Myrmekite commonly occurs as late rims of plagioclase crystals and as small interstitial patches. A strong protoclastic foliation is present in the monzodiorite. The more leucocratic inner(?) granodioritic phase of this pluton consists of 40–50% plagioclase, 15–20% interstitial potassium feldspar, 12–24% quartz, 8–15% biotite flakes, and 5–10% hornblende prisms. Hornblende crystals define a strong protoclastic foliation. The unit is intruded both by Kkg and Kbm. Age probably ~92 Ma (table 1).

Kfp, Kfpp **Freel Peak Granodiorite** (Cretaceous) Light-gray medium-grained biotite granodiorite that weathers yellowish gray. Abundant ovoid aggregates of quartz, small potassium feldspar phenocrysts, and ragged biotite flakes are distinctive. Subhedral microperthitic microcline crystals average 3 mm long; crystals commonly as long as 1.5 cm give the rock a weakly porphyritic texture. Plagioclase crystals are locally antiperthitic. Oblate, spheroidal, and discoidal mafic enclaves are abundant; they commonly define local foliation, but no regional foliation pattern is apparent. Friable, deeply weathered outcrops have shed thick grus over much of the area underlain by this pluton. Named for Freel Peak, located a few kilometers southwest of the quadrangle (Armin and John, 1983). A conspicuously porphyritic granodiorite body, regarded as a porphyritic variant (**Kfpp**), makes up most of the unit in the Minden quadrangle. This medium- to coarse-grained unit is light pinkish orange to pale gray, and weathers pale orangish gray to ivory. Weakly microperthitic, subhedral to euhedral microcline phenocrysts, as long as 3 cm, form as much as 10% of the rock. Intrudes Kjc, and is intruded by Kbm (Armin and John, 1983). A whole-rock Rb/Sr isochron age of 93.5 Ma agrees well with a 93.2 Ma K-Ar age on hornblende and suggests that a somewhat younger biotite K-Ar age (table 1) may be too young, possibly due to Ar loss.

Kjc **Quartz diorite of Jobs Canyon** (Cretaceous) Fine- to medium-grained, equigranular, locally strongly foliated, hornblende-biotite quartz diorite cropping out in the southwest corner of the quadrangle, and named for outcrops just to the south in Jobs Canyon. Consists of 60–70% plagioclase, 3–5% perthitic potassium feldspar, 5–10% quartz, 15–20% biotite, and 5–10% hornblende. The quartz diorite of Jobs Canyon is intruded by Kbm.

Kqdp **Quartz monzodiorite north of Daggett Pass** (Cretaceous) Dark-blue-gray, medium-grained, equigranular, locally strongly foliated hornblende-biotite quartz diorite; exposed north of Daggett Pass (South Lake Tahoe quadrangle) in the northwestern part of the quadrangle. Consists of 45–60% oscillatory zoned plagioclase (An_{45}–An_{35}), 2–5% potassium feldspar, 5–10% interstitial quartz, and 30–40% anhedral biotite and hornblende in about equal amounts. Equivalent to the mafic granodiorite unit of Bonham and Burnett (1976) to the west in the adjoining South Lake Tahoe quadrangle.

Kqd **Quartz diorite and diorite** (Cretaceous) Small body of medium-gray, very fine-grained to locally coarse-grained rock consisting dominantly of subhedral plagioclase, hornblende, subordinate subhedral biotite, and interstitial quartz. Comb structure occurs in the relatively rare coarse-grained diorite.

Mzmv **Metavolcanic rocks** (Mesozoic) Mostly metamorphosed dacite and andesite flows(?), with smaller volumes of pyroclastic and volcaniclastic rocks. Predominantly dark greenish-gray rocks that are commonly moderately to strongly foliated. Rocks range from dark spotted hornfels to lighter gray flaser semi-schists. Relict phenocrysts of albitized plagioclase and altered mafic minerals are locally observed. Rare, thin units of lighter-colored rock represent probable rhyolitic pyroclastic rocks and stretched-pebble volcanic conglomerate (elongation of 2:1 to 3:1). Relict bedding in dark intermediate-composition volcaniclastic rocks is commonly subparallel to foliation. The penetrative foliation is locally developed into a slaty cleavage; lineation is rarely observed to rake 90º. The pendant north of Kingsbury Grade is part of a larger pendant covering about 30 square km that extends northward to Genoa Peak and near Spooner Summit (Pease, 1980; Grose, 1985). This pendant was briefly described by Moore (1969) who assigned it a Triassic and Jurassic age. More recent work suggests that these volcanic units may correlate with other Middle Jurassic(?) metavolcanic units of western Nevada (Stewart, 1997; Garside, 1998). Most rocks are metamorphosed to the greenschist facies, and locally to amphibolite-facies assemblages near contacts with the granodiorite of Daggett Pass. Common metamorphic assemblages include: (1) plagioclase + epidote + actinolite + chlorite + quartz, (2) plagioclase + chlorite + quartz + biotite + sericite ± epidote, (3) plagioclase + quartz + biotite ± sericite, (4) plagioclase + epidote + chlorite + quartz + muscovite, and (5) plagioclase + hornblende (blue green) + quartz + biotite (all assemblages + opaque minerals and sphene).

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Table 1. K/Ar and Rb/Sr ages for the Minden quadrangle and vicinity

Unit	Symbol	Sample no.	N. Lat.	W. Long.	Age (Ma)[1]	±1s	Mineral	Method	Reference
Bryan Meadow Granodiorite	Kbm	KA1518	38°47'07"	119°52'50"	89.3	2.0	biotite	K-Ar	Evernden and Kistler, 1970
Bryan Meadow Granodiorite	Kbm	KA1518-R	38°47'07"	119°52'50"	89.6	2	biotite	K-Ar	Evernden and Kistler, 1970
Bryan Meadow Granodiorite	Kbm	FP-78-104	38°54'16"	119°57'57"	84.1	0.5	biotite	K-Ar	Robinson and Kistler, 1986
Bryan Meadow Granodiorite	Kbm	FP-78-104	38°54'16"	119°57'57"	78.1	0.6	hornblende	K-Ar	Robinson and Kistler, 1986
Bryan Meadow Granodiorite	Kbm	FP-78-106	38°48'19"	119°58'20"	87.5	0.5	biotite	K-Ar	Robinson and Kistler, 1986
Bryan Meadow Granodiorite	Kbm	FP-78-106	38°48'19"	119°58'20"	82.6	0.6	hornblende	K-Ar	Robinson and Kistler, 1986
Bryan Meadow Granodiorite	Kbm	FP-78-106	38°48'19"	119°58'20"	83.9	0.6	hornblende	K-Ar	Robinson and Kistler, 1986
Bryan Meadow Granodiorite	Kbm	FP-78-108	38°46'33"	119°54'00"	89.6	2	biotite	K-Ar	Robinson and Kistler, 1986
Granodiorite of Daggett Pass	Kdp	KA1516-HBD	38°58'37"	119°53'15"	92.1	2	hornblende	K-Ar	Evernden and Kistler, 1970
Granodiorite of Daggett Pass	Kdp	KA1516	38°58'37"	119°53'15"	88.3	2	biotite	K-Ar	Evernden and Kistler, 1970
Granodiorite of Daggett Pass	Kdp	KA1517	38°57'52"	119°51'00"	85.6	2	biottie	K-Ar	Evernden and Kistler, 1970
Freel Peak Granodiorite	Kfp	FP-78-105	38°49'56"	119°54'56"	93.2	3	hornblende	K-Ar	Armin and John, 1983
Freel Peak Granodiorite	Kfp	FP-78-105	38°49'56"	119°54'56"	82.9	1.5	biotite	K-Ar	Armin and John, 1983
Freel Peak Granodiorite	Kfp	FP-78-105	38°49'56"	119°54'56"	85.4	0.5	biotite	K-Ar	Robinson and Kistler, 1986
Freel Peak Granodiorite	Kfp	FP-78-105	38°49'56"	119°54'56"	84.4	0.6	hornblende	K-Ar	Robinson and Kistler, 1986
Freel Peak Granodiorite	Kfp				93.5	2.8	whole rock	Rb-Sr	A.C. Robinson, written commun., 1994

1. K-Ar ages of Evernden and Kistler (1970) converted to the constants of Steiger and Jager (1977)

Table 2. Mineral modes (volume percent) for plutonic rocks of the Minden quadrangle

Unit	Symbol	no.	Plagioclase	Pl %An	K feldspar	Quartz	Biotite	Hornblende	Opaques	Sphene	Other
Bryan Meadow Granodiorite	Kbm	28	32–61 (46.1)	38–24	5–27 (18.5)	6–38 (22.1)	2–15 (6.6)	0–14 (4.8)	0.3–2.2 (1.0)	0.1–1.6 (0.8)	ap, z
Granodiorite of Kingsbury Grade	Kkg	17	40–52 (45.6)	45–22	11–30 (19.0)	15–36 (20.2)	3–14 (8.7)	2–13 (6.0)	0.4–1.1 (0.8)	0.1–0.8 (0.4)	al, ap, tour, z
Granodiorite of Daggett Pass	Kdp	18	37–60 (47.4)	45–20	7–20 (13.8)	8–21 (16.2)	8–15 (11.6)	7–15 (8.9)	0.7–1.6 (1.0)	tr–1.0 (0.4)	ap, cpx, tour, z
Freel Peak Granodiorite, equigranular	Kfp	14	41–57 (49.4)	32–22	11–25 (15.7)	19–32 (23.4)	4–11 (7.7)	0–4 (1.8)	0.2–1.9 (1.1)	0–0.7 (0.3)	al, ap. Z
Freel Peak Granodiorite, porphyritic	Kfp	8	32–50 (42.6)	33–12	19–39 (28.8)	17–26 (22.6)	4–7 (5.7)	0 (0)	0.4–1.3 (0.9)	tr–0.8 (0.3)	al, ap, z
Quartz monzodiorite north of Daggett Pass	Kqdp	4	44–53 (49.1)	52–33	3–20 (11.2)	6–12 (8.8)	8–20 (14.3)	7–18 (12.7)	0.4–2.9 (1.3)	0–0.3 (0.1`)	ap, cpx, z

From Armin and John (1983). Numbers give the range and (mean) values for all samples. Pl %An, typical anorthite content of plagioclase. Abbreviations: tr, trace; al, allanite; ap, apatite; cpx, clinopyroxene; tour, tourmaline; z, zircon

Table 3. Chemical data for granitic units of the Minden quadrangle. From Armin and John (1983). Values are not normalized to 100%.

Unit	Kbm	Kbm	Kbm	Kfp	Kqdp
Sample Number	FP-78-104	FP-78-106	FP-78-108	FP-78-105	79WM33
SiO_2	65.4	64.7	68.5	68.3	61.2
Al_2O_3	14.8	15.1	14.2	14.2	16.0
Fe_2O_3	2.3	2.5	1.8	2.0	1.9
FeO	2.0	2.2	1.6	1.8	4.6
MgO	1.7	1.8	1.2	1.0	4.1
CaO	4.1	4.4	3.1	2.6	6.1
Na_2O	3.9	3.8	3.7	4.4	3.2
K_2O	2.9	3.0	3.4	3.2	2.5
H_2O^+	0.56	0.43	0.36	0.41	0.77
H_2O^-	0.23	0.16	0.15	0.25	0.05
TiO_2	0.63	0.61	0.44	0.40	0.76
P_2O_5	0.16	0.18	0.15	0.13	0.16
MnO	0.11	0.12	0.09	0.13	0.09
CO_2	0.04	0.05	0.03	0.03	0.03
F	0.04	0.04	0.04	0.05	
Total	99.87	99.09	98.76	98.90	101.46