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DEPARTMENT OF THE INTERIOR
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GEOLOGIC MAP OF BARE MOUNTAIN, NYE COUNTY, NEVADA

by

Susan A. Monsen[1/], Michael D. Carr[1/], Marith C. Reheis[2/], and P.P. Orkild[2/]

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1/ Menlo Park, California
2/ Denver, Colorado

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GEOLOGIC HISTORY

Bare Mountain comprises the isolated complex of mountain peaks southeast of the town of Beatty in southern Nye County, Nevada. This small mountain range lies between the alluvial basins of Crater Flat on the east and the northern Amargosa Desert on the southwest. The northern boundary of the range is less well defined, but for this report, the terrane of faulted Miocene volcanic rocks underlying Beatty Mountain and the unnamed hills on its east are considered to be the northernmost part of Bare Mountain. The southern tip of the mountain range is at Black Marble hill. The main body of the range, between Fluorspar Canyon and Black Marble hill, is constructed of a folded and complexly faulted, but generally northward-dipping (or southward-dipping and northward-overturned), sequence of weakly to moderately metamorphosed upper Proterozoic and Paleozoic marine strata, mostly miogeoclinal (continental-shelf) rocks. The geology of Bare Mountain and surrounding areas was mapped previously at a scale of 1:62,500 by Cornwall and Kleinhampl (1961). The surficial deposits surrounding Bare Mountain were mapped at a scale of 1:48,000 by Swadley and Parrish (1988).

The marine strata at Bare Mountain form a remarkably complete section representing Late Proterozoic through Mississippian time. The upper Proterozoic and Lower Cambrian rocks are mostly argillite, siltite, and quartzite, with sparse but conspicuous dolomite beds; they are part of the westward-thickening wedge of siliceous clastic rocks forming the lower part of the Cordilleran miogeoclinal (continental-shelf) succession, previously described by many authors (e.g. Stewart, 1970; Stewart and Poole, 1974). Middle Cambrian through Devonian time is represented mainly by continental-shelf carbonate rocks, which also are part of the Cordilleran miogeoclinal succession and described in many reports (e.g. Stewart and Poole, 1974). The Mississippian rocks are mostly argillite and quartzite, which have been interpreted as flysch deposited in the foreland basin of the Antler orogenic belt (Poole, 1974). Neither Pennsylvanian nor Permian rocks are exposed at Bare Mountain.

Metamorphism of the upper Proterozoic and Paleozoic rocks, which ranges from greenschist to low amphibolite grade, appears to be a product of thermal events that, at least in part, accompanied Mesozoic deformation. The ages of these events are not precisely known (Monsen, 1983). Low amphibolite- to high greenschist-grade rocks, having staurolite- and garnet-bearing mineral assemblages, occur in the northwestern part of the range (Conejo Canyon area), but rapidly give way southward and eastward to medium and low greenschist-grade, biotite- and (or) chlorite-bearing rocks (Monsen, 1983). Large-scale folding (amplitudes as large as several kilometers) and thrust faulting deformed and repeated sections of the originally flat-lying miogeoclinal rocks in one or more of the orogenic events that affected the Cordillera during the Mesozoic. Outcrop-scale folds, as well as both penetrative and spaced cleavages, occur locally in the pre-Tertiary rocks throughout the range, but prevail in the highest grade metamorphic rocks and the upper Proterozoic and Lower Cambrian units containing interbedded argillite and quartzite. These ductile structures also were interpreted as Mesozoic by Monsen (1983). Late Cretaceous (fig. 1 and table 1) granitic rocks crop out near the mouth of Fluorspar Canyon and are presumed to intrude the metasedimentary sequence. The granitic rocks are not penetratively deformed, suggesting that ductile deformation of the metasedimentary rocks largely had ceased and the peak of metamorphism had passed by

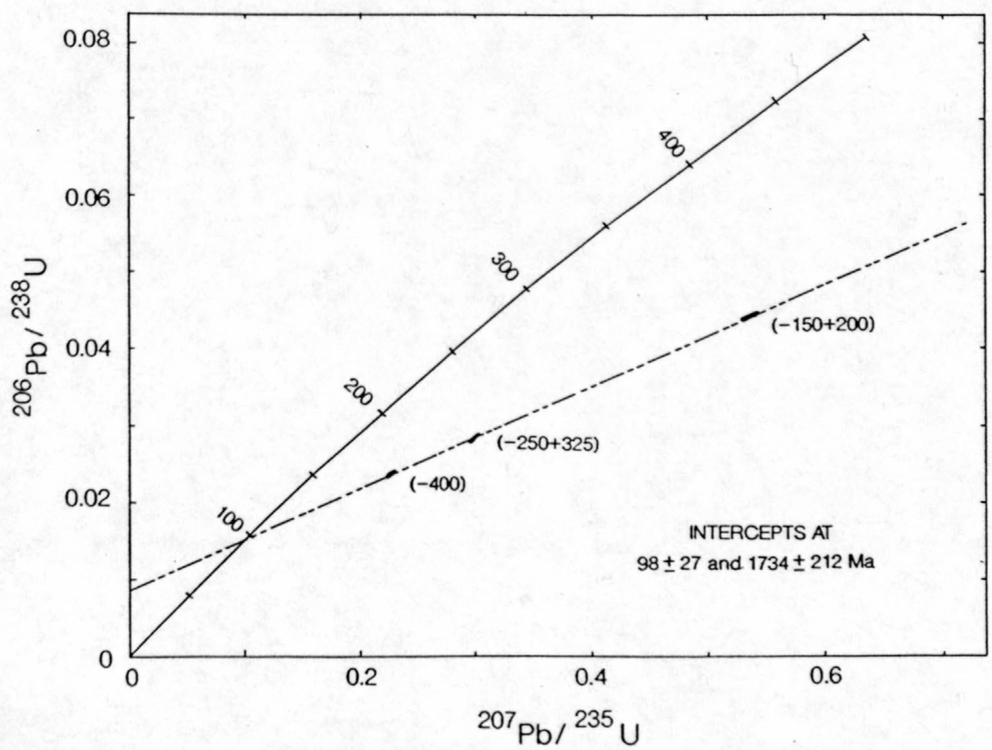

Figure 1. Concordia diagram for zircon from a granitic intrusion near the mouth of Fluorspar Canyon. See table 1 for supporting analytical data.

Table 1. Uranium-thorium-lead isotopic data for zircon from a granitic intrusion near the mouth of Fluorspar Canyon.

Sample	Mesh size	Concentration (ppm)			Isotopic composition of lead (atom percent)				Age (Ma)			
		U	Th	Pb	^{204}Pb	^{206}Pb	^{207}Pb	^{208}Pb	$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{232}Th$
83-90	-150+200	593.7	128.0	28.11	.0843	81.82	8.369	9.725	279	435	1379	323
	-250+325	651.2	156.3	18.68	.0196	85.27	6.798	7.909	180	265	1107	194
	-400	673.7	172.9	16.93	.0857	82.64	6.943	10.33	151	207	903	157

Note: Uranium-thorium-lead analysis and age calculation by R.E. Zartman, U.S. Geological Survey, Denver, Colorado.
Sample collected by S.A. Monsen and M.D. Carr, U.S. Geological Survey, Menlo Park, California.
Isotopic abundances and decay constants used in this study are those recommended by the IUGS Stratigraphic Commission, Subcommission on Geochronology (Steiger and Jager, 1977).
Location of sample 83-90: latitude 36°53′48", longitude 116°44′12".

the time of their intrusion. There is a gap in the geologic record at Bare Mountain between the intrusive event represented by these granitic rocks and the oldest documented Tertiary event, the intrusion of east-northeast-striking diorite dikes isotopically dated as approximately 26 Ma (table 2). Whereas the Late Cretaceous granitic rocks only are inferred to post-date ductile deformation and metamorphism at Bare Mountain, the late Oligocene dikes unequivocally cut the ductile structures and metamorphic fabrics.

The oldest Tertiary basin deposits in the vicinity of Bare Mountain belong to the Oligocene and Miocene(?) Titus Canyon Formation of Reynolds (1969, 1974), which is unconformable on upper Proterozoic and Paleozoic rocks along the east flank of the Funeral and Grapevine Mountains (20 km west of Bare Mountain), but is not exposed at Bare Mountain. There is no stratigraphic record of extensional tectonism older than Oligocene in the region, and the exposure of upper Proterozoic rocks at the pre-Oligocene land surface indicates that substantial uplift and denudation of Proterozoic and Paleozoic bedrock units resulted from Mesozoic orogenesis, as well as pre-Oligocene isostatic uplift and denudation (Reynolds, 1974). Consequently, significant unroofing of the deformed, high-grade metamorphic rocks in the region that includes Bare Mountain must have predated the additional unroofing and exposure of such rocks that resulted from Cenozoic extension. Metamorphic micas from the Wood Canyon Formation in the northwestern part of Bare Mountain yield reset conventional potassium-argon ages ranging from 44 to 51 Ma (table 2). It is not yet known whether these isotopic systems finally reached their blocking conditions during the Eocene as a result of protracted cooling, whether the isotopic ages indicate an abrupt onset of extensional tectonism in the Eocene, or whether the ages result from some disturbance of the isotopic system and are meaningless in terms of a tectonic interpretation.

The oldest Tertiary rocks exposed at Bare Mountain are a succession of lacustrine siltstone, crystal tuff, and conglomerate in Joshua Hollow. These rocks may correlate with an unnamed sequence of Miocene tuff and sedimentary rocks described by Reynolds (1969, p. 124, 1974), which disconformably overlies the Titus Canyón Formation in the Funeral and Grapevine Mountains. The crystal tuff and sedimentary rock units in Joshua Hollow are faulted against underlying Paleozoic rocks.

The low hills north of Fluorspar Canyon expose a strongly faulted sequence of middle Miocene ash-flow tuffs, with subordinate silicic lava and basalt flows. The lower part of the section consists of a concordant sequence of ash-flow tuff units that are equivalent to some of the tuff units below the Crater Flat Tuff that were described by Carr, Byers, and others (1986), as well as the Crater Flat and Paintbrush Tuffs previously described from extensive exposures in the surrounding area (e.g. Byers and others, 1976; Carr, Byers, and others, 1986). These tuff units range in age from approximately 15 to 12.8* Ma (Marvin and others, 1970; Carr, Byers, and others, 1986). The middle part of the section is a paraconformable succession containing a bedded unit of nonwelded pyroclastic flows, a rhyolitic lava flow, and the Timber Mountain Tuff. The bedded pyroclastic flow unit rests with angular unconformity on the Paintbrush Tuff in the northernmost part of Bare Mountain and on the tilted crystal tuff and sedimentary rocks of Joshua Hollow. The rhyolitic lava flow wedges out from west to east across

* Isotopic ages marked by an asterisk are based on ages reported by Kistler (1968) and Marvin and others (1970) but are corrected for currently accepted decay and abundance constants using tables from Dalrymple (1979). The geologic time scale used throughout this report is that compiled by Palmer (1983).

Table 2. Potassium-argon age data for rocks from the Bare Mountain area.

Sample	Rock type/unit	Location general	Location latitude	Location longitude	Age (Ma)	Mineral	K_2O[1] weight percent	$^{40}Ar(rad)/^{40}Ar(total)$	$^{40}Ar_{rad}$ moles/gm	Collected by
JN85BM-2[2]	quartz latite dike	Joshua Hollow	$36^{\circ}54'$	$116^{\circ}39'$	13.9±0.3	biotite	8.45 8.49	0.68	1.705×10^{-10}	J.K. Nakata M.D. Carr
JN85BM-3[2]	quartz latite dike	Tarantula Canyon	$36^{\circ}52'$	$116^{\circ}39'$	13.8±0.2	biotite	8.57 8.64	0.58	1.720×10^{-10}	J.K. Nakata M.D. Carr
102887-3[2]	basalt--unit 1	east of Beatty Mountain	$36^{\circ}54'55''$	$116^{\circ}41'44''$	10.7±0.2	whole rock	1.79 1.83	0.69	2.799×10^{-11}	M.D.Carr
R85-B1B[2]	ash-fall tuff within the gravel of Sober-up Gulch	western Crater Flat (east of map area)	$36^{\circ}53'30''$	$116^{\circ}36'30''$	8.2±0.4	biotite	7.95[3] 8.00	0.10	9.434×10^{-11}	M.C. Reheis
					8.7±0.2	feldspar	1.04 1.06	0.55	1.317×10^{-11}	
					7.7±0.1	feldspar (backpicked)	1.07 1.06	0.56	1.180×10^{-11}	
83-89[3]	Wood Canyon Formation (schist)	northwest Bare Mountain	$36^{\circ}52'45''$	$116^{\circ}44'51''$	51.6±1.3	muscovite	9.51 9.58	0.71	7.187×10^{-10}	S.A. Monsen
					46.0±1.2	biotite	8.54	0.59	5.724×10^{-10}	
JN85B-3[2]	Wood Canyon Formation (schist)	southeast Bullfrog Hills	$36^{\circ}53'30''$	$116^{\circ}45'32''$	45.2±0.3	muscovite-1	9.88 9.86	0.87	6.503×10^{-10}	J.K. Nakata
					44.3±0.3	muscovite-2	do.	0.79	6.372×10^{-10}	
					48.6±0.3	biotite-1	9.21 (n=2)	0.90	6.529×10^{-10}	
					49.2±0.4	biotite-2	do.	0.80	6.610×10^{-10}	
82-489[3]	diorite dike	northwest Bare Mountain	$36^{\circ}51'45''$	$116^{\circ}44'36''$	26.1±1.7	hornblende	.854 .851	0.28	3.223×10^{-11}	S.A. Monsen
					16.6±1.2	biotite	7.11 7.16	0.29	1.718×10^{-10}	

Note: Isotopic abundances and decay constants used in this study are those recommended by the IUGS Stratigraphic Commission, Subcommission on Geochronology (Steiger and Jager, 1977).

(1) K_2O analyzed by L. Espos, P. Klock, S. Neil, and D. Vivit, U.S. Geological Survey, Menlo Park, California.

(2) Argon measurements and age calculation by John Nakata, U.S. Geological Survey, Menlo Park, California.

(3) Argon measurements and age calculation by James Saburomaru and Jarel Von Essen, U.S. Geological Survey, Menlo Park, California.

northernmost Bare Mountain. The two members of the Timber Mountain Tuff were dated isotopically elsewhere in the region at approximately 11.6* and 11.4* Ma (Kistler, 1968; Byers and others, 1976), placing an upper constraint on the age of the unconformity. The Timber Mountain Tuff is overlain by a bimodal sequence of intercalated basalt flows, silicic ash-flow tuff cooling units, and beds of nonwelded, silicic pyroclastic rocks, forming the upper part of the middle Miocene section at northernmost Bare Mountain. The lowermost basalt flows (unit 1), isotopically dated as 10.7 Ma (Table 2), appear to be conformable on the Timber Mountain Tuff, but at least one angular unconformity occurs higher within this bimodal sequence of volcanic rocks.

The upper Miocene and Pliocene gravel of Sober-up Gulch rests with angular unconformity on older Miocene volcanic and sedimentary rocks and on Paleozoic rocks north and northeast of Bare Mountain. The gravel beds appear to have retained their original depositional geometry in most places, lying flat or dipping a few degrees toward the basins; their deposition apparently postdated much of the faulting in the immediately subjacent rocks. However, the gravel beds are offset by the northern part of the fault system that follows the east side of Bare Mountain. East of this fault system, the gravel beds tilt gently westward toward the mountain range. (Outcrops of the gravel are poor, and although the general attitiude of layering can be seen from a distance, reliable bedding measurments were possible only in the dry stream cuts east of the map area.)

Upper Pliocene(?) and Quaternary alluvial fan deposits apron Bare Mountain on the southwest and east. These deposits lap over bedrock along the southwestern flank of the mountain range but are faulted against bedrock along the fault system following the east side of the range.

The network of Cenozoic faults that cut Bare Mountain formed during the protracted period of extension that has opened the Great Basin. Diachronous basin-filling episodes and unconformities, as well as cross cutting structural relations throughout the region suggest that extension was accomodated locally by episodic faulting concentrated during different times in different structural domains. Structures formed during an early phase of extension in one structural domain were, in many cases, reactivated during later deformational activity involving that same area.

The earliest documented Tertiary faulting at Bare Mountain occurred along the set of eastward-dipping faults that dominate the structural pattern of the central part of the range. One such fault, located 400 m southeast of the Panama mine, is cut by a quartz latite dike belonging to a set of dikes radiometrically dated elsewhere at Bare Mountain as 13.9 Ma (Table 2; Carr, 1984). Other such faults offset the 13.9-Ma dikes, but separate the dikes less than the country rock. Along the eastern front of Bare Mountain, faults belonging to this set offset latest Pleistocene or Holocene deposits (Reheis, 1988). Gently southeastward-dipping normal faults, such as the fault along the south wall of Chuckwalla Canyon, the fault that crosses the range north of Wildcat Peak, and the fault along the north side of Black Marble hill, cut off, or in other cases curve to join, members of the eastward-dipping fault set, dividing the central part of Bare Mountain into rhombehedral blocks. There are no constraints on the earliest movement history of the gently southeastward-dipping normal faults, except that they cut, and therefore postdate, some of the faults of the eastward-dipping fault set. The gently dipping fault north of Wildcat Peak appears to cut dikes of the 13.9-Ma dike set, but talus deposits obscure the critical exposures. The gently southeastward-dipping fault in Chuckwalla Canyon continues northeastward to join the fault system along the eastern front of the range, where it recurrently offset Quaternary deposits (Reheis, 1988). Thus, movement on the main fault network cutting central Bare Mountain has occurred episodically since before the early middle Miocene to the present. The onset of faulting predated the injection of the north-trending set of quartz latite dikes about 13.9 Ma. These dikes are older than or equivalent in age to all rocks in northernmost Bare Mountain section except the tuffs underlying the Crater Flat Tuff (Carr, Byers, and others, 1986, fig. 2), indicating that the onset of faulting at least predated the eruption of the Crater Flat Tuff.

The zone of gently north- to northeastward-dipping faults that crosses Conejo Canyon cuts numerous faults of the eastward-dipping set, and locally cut out as much as 1400 m of stratigraphic section. The metamorphic grade of the rocks in the hanging wall of the fault zone in Conejo Canyon is higher than that of equivalent rocks in the footwall farther south on Bare Mountian, and it appears that the hanging-wall rocks were derived from north-northwest of their present position. The zone of gently dipping faults in Conejo Canyon offsets elements of the eastward-dipping fault set and, therefore, formed later than the onset of the movement along the eastward-dipping faults. The later histories of both sets of faults are at least partly related because of geometric connections among individual members of each of the fault sets.

A gently northward-dipping fault in Fluorspar Canyon separates the faulted Miocene volcanic sequence in the hills of northernmost Bare Mountain from the faulted upper Proterozoic and Paleozoic rocks underlying the rest of Bare Mountain. This fault is interpreted as a segment of an areally extensive low-angle fault system at the base of a major extensional allochthon, which continues westward at least as far as the Grapevine Mountains (Carr and Monsen, 1988). This extensional allochthon apparently broke away from the relatively unfaulted terrane of Miocene volcanic rocks northeast of Bare Mountain. A fault pattern dominated by northwestward-dipping normal faults characterizes the upper plate of the fault in Fluorspar Canyon and is distinct from the fault pattern in most of Bare Mountain. Only in the Meiklejohn Peak area do Paleozoic rocks appear to be caught up in the upper plate. The Paleozoic rocks there are cut by a set of northwest-dipping faults with a similar pattern to those cutting the Miocene rocks in the rest of the extensional allochthon farther to the west. The eastern end of the Fluorspar Canyon fault apparently merges with segments of the system of thrust faults, inferred to be Mesozoic, that passes south of Meiklejohn Peak. Parts of that thrust system were reactivated with modest normal displacement during the Tertiary.

The ages of several events in the extensional allochthon above the low-angle fault in Fluorspar Canyon are constrained by unconformities. The oldest known faulting event in the allochthon (at Bare Mountain) is represented by an unconformity at the base of the bedded pyroclastic flows above the Paintbrush Tuff (between approximately 12.8 and 11.6* Ma). Two episodes of faulting, coeval with the deposition of the bimodal sequence of late Miocene volcanic rocks, are indicated by angular unconformities and by stratigraphic overlap of faults by unfaulted younger deposits. One episode began after the eruption of the unnamed late Miocene ash-flow tuff unit that overlies the 10.7-Ma basalt unit 1; the episode ended before the eruption of the basalt unit 2. Another episode followed the eruption of the basalt unit 3 and ended before the deposition of the gravel of Sober-up Gulch during the late Miocene (Carr and Monsen, 1988). North of Bare Mountain, there appear to have been no great offsets of the gravel of Sober-up Gulch since its deposition.

Quaternary deposits are known to be offset by faults along most of the eastern front of Bare Mountain (Swadley and others, 1984; Reheis, 1988), and by the fault along the southeast side of Tates Wash. Deposits of presumed latest Pleistocene or Holocene age are disrupted locally by faulting at the range front (Reheis, 1988). Older alluvial fan deposits (Pliocene and (or) early Pleistocene) are offset, but intermediate alluvial fan deposits (middle and late Pleistocene) do not appear to be cut, in a trench exposure of the northwest-dipping fault along the south side of Tates Wash. (This trench has been refilled). This fault projects northeastward to an intersection with the northernmost surface ruptures on the fault along the Bare Mountain range front. Quaternary movement could have occurred on the faults within the range but cannot be demonstrated owing to the lack of surficial deposits there.

The west-facing Beatty escarpment, along the west side of Bare Mountain, previously was interpreted as a Quaternary fault scarp (e.g. Cornwall and Kleinhampl, 1964). More recent studies, however, have suggested that this escarpment may not be tectonic feature, but rather an erosional escarpment cut by lateral migration of the Amargosa River into the lower parts of alluvial fans shed from the west side of Bare Mountain (Swadley and others 1988).

It is not known whether Quaternary faulting in the vicinity of Bare Mountain represents the final stages of a waning Miocene extensional regieme as suggested by Carr (1984) and Hamilton (1988), or whether such faulting marks the beginning of another episode of activity in the continuing regional extension of the Great Basin. Movement should be expected to continue into the near geologic future on the fault along the eastern front of Bare Mountain and on related faults, judging from their history of recurrent movement during the recent geologic past. The rates of such movement cannot be calculated meaningfully on the basis of currently available information.

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Mapping of the Tertiary rocks in the hills west of Amargosa Narrows is modified in part from Ransome and others (1910) and Maldonado and Hausback (in press). We thank Florian Maldonado and Brain Hausback for making their unpublished work available to us and for discussions of the geology of the Bullfrog Hills. We are grateful to F.M. Byers, W.J. Carr, K.F. Fox, W.B. Myers, F.G. Poole, M.W. Reynolds, R.J. Ross, C.H. Stevens, WC Swadley, B.W. Troxel, L.A. Wright, and J.C. Yount for their visits to the field area and discussions of the regional geology and stratigraphy.

Part of this work was done under interagency agreements with the U.S. Department of Energy and its predecessor agencies. Part of the work by Monsen was done as a Master of Science thesis at the University of California, Davis.

The data shown on this map were collected prior to the establishment and implementation of the current quality assurance program that governs the Yucca Mountain Project, which comprises studies administered by the United States Department of Energy to characterize the site in southern Nevada proposed for the disposal of high-level nuclear waste.

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

(See Swadley and Parrish, 1988, for additional mapping and descriptions of surficial deposits. The following descriptions are, in part, generalized from their work.)

Qts **Talus and slope wash (Quaternary and Tertiary?)**—Unconsolidated gravel, sand, and silt of local derivation, forming talus aprons and thin surficial veneers that obscure bedrock. Older deposits may have strong desert varnish. May include some Pliocene deposits

Qar **Deposits of Amargosa River (Quaternary)**—Unconsolidated sand, silt, and gravel deposited in the channel and on the floodplain of the Amargosa River. Consists mainly of sheetflood sand deposits derived in part through reworking of windblown material (Swadley and Parrish, 1988). Equivalent, in part. to units Q1s, Q2s, and Q1ab (part) of Swadley and Parrish (1988)

Qyf **Younger alluvial fan deposits (Holocene)**—Unconsolidated gravel, gravelly sand, silty sand, and sandy silt. Clast are locally derived. Light gray to grayish brown, poorly to moderately well sorted, poorly to well bedded. Deposited as discontinuous beds and lenses forming alluvial fan aprons adjacent to the range front, thin sheet-like deposits, terraces in large washes, and bottoms of active washes. Includes some talus wedges adjacent to fault scarps along eastern front of Bare Mountain. Equivalent, in part, to units Q1a, Q1ab (part), and Q1c of Swadley and Parrish (1988)

Qif **Intermediate alluvial fan deposits (late Pleistocene)**—Unconsolidated gravel, gravelly sand, and silty sand. Clasts are locally derived. Yellowish brown to grayish brown, poorly to moderately well sorted, poorly to well bedded. Forms terraces in washes and dissected alluvial fans. Desert pavement is common on most deposits. Equivalent, in part, to units Q2b, Q2bc, and Q2c of Swadley and Parrish (1988)

QTof **Older Alluvial fan deposits (early Pleistocene and (or) Pliocene)**—Poorly consolidated gravel, generally with sparse sand and silt in matrix. Clasts are locally derived. Angular to subrounded, poorly sorted, poorly bedded to non-bedded. Forms dissected alluvial fans and fan remnants. Typically has well developed stage IV calcrete horizon as much as 2 m thick. Commonly has desert pavement. Equivalent, in part, to unit QTa of Swadley and Parrish (1988). Along the southern part of the eastern range front, the intermediate alluvial fan deposits were not distinguished from the older alluvial fan deposits and are designated by the map-unit symbol QTof/Qif

Tgs **Gravel of Sober-up Gulch (Pliocene and late Miocene)**—Poorly consolidated, poorly sorted, subrounded to well-rounded gravel and sand forming strongly dissected alluvial surfaces north and northeast of Bare Mountain. Contains locally derived clasts of Tertiary volcanic and upper Proterozoic to Paleozoic sedimentary rocks; boulders are as large as 3 m in diameter. Broken, well-rounded, pebble- to cobble-sized clasts of quartzite and chert appear to be recycled from older Tertiary deposits. Monolithologic breccia derived from Paleozoic carbonate rocks occurs at base of unit in Joshua Hollow area. Deposits locally contain buried soils with properties indicative of a climate more moist than the present climate. Deposits also locally contain tephra beds and reworked tephra-rich beds. Conventional potassium-argon ages of 7.7 and 8.7 Ma for feldspar and 8.2 Ma for biotite were determined for samples from one of these tephra beds collected about 500 m east of the map boundary (latitude: 36°53'30", longitude: 116°36'30"; table 2). These radiometric ages suggest a late Miocene age for the gravel of Sober-up Gulch in this area.

Farther west in the northeast quater of the Bullfrog 15' quadrangle, the unit contains Pliocene deposits (Maldonado and Hausback, in press). Minimum thicknesses range from 0 to 180 m (Swadley and Parrish, 1988)

BEDROCK

Tb **Basalt (late Miocene)**—Light brownish-gray to moderate yellowish-brown, fine-grained, dense to vesicular basalt; locally contains calcite-filled amygdules. This map-unit designation is used for undivided basalt lava-flow units north of Fluorspar Canyon where there is no stratigraphic basis for further subdivision. Includes basalt dikes intruding Tertiary rocks north of Fluorspar Canyon, which probably were feeder dikes for one or more of the sequences of basalt flows distinguished in that area. Locally, divided into:

Tb3 **Unit 3**—Multiple flows of light brownish-gray to moderate yellowish-brown, fine-grained, dense to vesicular basalt, locally containing calcite-filled amygdules. Individual flows are separated by layers of basalt cinders or by silicic pyroclastic deposits. A thinly bedded pale reddish-brown pyroclastic deposit (p), 10 to 15 m thick, containing cobble to boulder-sized clasts of ash-flow tuff and less abundant basalt clasts occurs below this series of basalt flows. Estimated minimum thickness excluding pyroclastic deposit 200 ft (61 m)

Tb2 **Unit 2**—Multiple flows of light brownish-gray to moderate yellowish-brown, fine-grained, dense to vesicular basalt, locally containing calcite-filled amygdules. Individual flows are separated by layers of basalt cinders or by thin beds of silicic pyroclastic material. Locally, a thinly bedded, fine-grained, moderate orange pink, silicic pyroclastic unit, containing pumice and phenocrysts including quartz, feldspar, and biotite, separates this series of basalt flows from underlying units. This basalt rests in angular unconformity on older units. Estimated minimum thickness 240 ft (73.2 m)

Tb1 **Unit 1**—Multiple flows of light brownish-gray to moderate yellowish-brown, fine-grained, dense to vesicular basalt, locally containing calcite-filled amygdules. Individual flows are separated by layers of basalt cinders or by silicic pyroclastic deposits as much as 2 m thick. The basal contact is sharp and appears to be conformable on the Ammonia Tanks Member of the Timber Mountain Tuff. A whole rock sample of this basalt yielded an isotopic age of 10.7 Ma using conventional potassium-argon dating methods (table 2). Estimated thickness 560 ft (170.8 m)

Taf **Ash-flow tuff (late Miocene)**—Nonwelded to densely welded ash-flow tuff. Forms a single cooling unit. Upper part is non-resistant, nonwelded tuff grading downward into light-brown, partly welded tuff, which is a moderate cliff-forming unit. Typically contains vapor-phase crystals. Grades downward to pale-pink, densely welded interval, which forms moderately resistant rounded slopes. Lower part is moderate cliff-forming unit approximately 10 m thick that consists of light- to moderate-brown, partly welded ash-flow tuff and tuff breccia; vitric near top. Estimated minimum thickness 400 ft (122 m)

Tm **Timber Mountain Tuff (middle Miocene)**—In this area, consists of:

Tma **Ammonia Tanks Member**—Nonwelded to densely welded ash-flow tuff, forming a single cooling unit. Upper part grades downward from nonwelded tuff to a pale-red, partly to moderately welded, moderate cliff-forming interval with large pinkish-gray pumice fragments. Middle part is a pale-pink, densely welded, rounded slope forming interval. Lower part is a grayish orange-pink to pale yellowish-brown, moderate cliff-forming unit with abundant pumice fragments. An interval of vitrophyre, 5 to 10 m thick, near the base of the unit grades downward into a moderate orange-pink to pale red interval of nonwelded to partly welded tuff, also about 10 m thick. A few meters of bedded tuff locally present at the base of the unit. Estimated thickness increases westward from 380 ft (115.9 m) to more than 640 ft (195.2 m)

Tmr **Rainier Mesa Member**—Nonwelded to densely welded ash-flow tuff, forming a single cooling unit. Nonwelded tuff in the uppermost part grades downward to a pale-red, partly to moderately welded, moderate cliff forming interval with large pinkish-gray pumice fragments. Middle part is a pale-pink, densely welded, rounded slope forming interval. Lower part is a grayish orange-pink to pale yellowish-brown, moderate cliff forming, partly welded interval with abundant pumice fragments. A vitrophyre near the base of the Rainier Mesa Member is underlain by a distinctive interval of pale-red tuff, 5 to 10 m thick. The basal contact is sharp and appears to be conformable. Estimated thickness increases westward from 400 ft (122 m) to 800 ft (244 m)

Tr **Rhyolite lava (middle Miocene)**—Medium light-gray, glassy lava flow. Locally has perlitic texture and (or) flow banding. Moderately resistant cliff former. Estimated thickness ranges from 480 ft (146.4 m) to more than 1280 ft (390.4 m) in the northwest part of the map area; the unit pinches out from west to east across the northernmost part of the area

Tbt **Bedded ash-flow tuff (middle Miocene)**—A bedded sequence of nonwelded, vitric to zeolitized, ash-flow tuff. Beds range from a few centimeters to several tens of meters thick. Tuffs locally are channeled and cross bedded. In many cases, disconformable contacts separate individual ash flows. Upper part is mottled yellowish gray and pale greenish yellow. Locally contains abundant black vitrophyric rock fragments (2 to 6 mm), white fibrous pumice, and fragments of vitric rhyolitic lava breccia as large as 20 mm. Middle part consists of thickly bedded to massive ash-flows. Varies from grayish pink to pale red to light brown. Lower part consists of thin to moderately thick layers of well-bedded ash-flow tuff; contains distinctive tounges of tuff breccia, as much as several tens of meters thick, composed predominantly of fragments derived from the Paintbrush Tuff. Minimum estimated thicknesses range from more than 760 ft (231.8 m) to 1280 ft (390.4 m)

Tp **Paintbrush tuff (middle Miocene)**—In this area, consists of:

Tpc **Tiva Canyon Member**—Nonwelded to densely welded ash-flow tuff forming a single cooling unit; mostly dark grayish red, moderately to densly welded, and devitrified. Thin dark gray vitrophyre near base grades downward to several meters of light-gray to brown, nonwelded vitric tuff. Phenocrysts are mostly alkali feldspar, plagioclase, and traces of quartz, clinopyroxene, hornblende and sphene; phenocrysts decrease in abundance downward from about 15 to 5 percent. Magnetic polarity is reversed (Swadley and Carr, 1987). Separated from underlying unit by several meters of bedded tuff. Estimated thickness increases westward from 720 ft (219.6 m) to 1040 ft (317.2 m)

Tpt **Topopah Spring Member**—Nonwelded to densely welded ash-flow tuff forming a single cooling unit. Nonwelded, light-gray, pumiceous tuff in upper part grades abruptly downward into a distinctive thin, dark-gray, upper vitrophyre. Middle part is grayish red, moderately to densely welded, distinguished locally by zones of abundant lithophysal cavities. Lower part consists of black lower vitrophyre that grades downward into several meters of orange-brown, nonwelded, vitric tuff. Phenocrysts are mostly alkali feldspar, plagioclase, and traces of quartz, biotite, hornblende, and clinopyroxene; phenocrysts decrease in abundance downward from about 15 to 5 percent. Magnetic polarity is normal (Swadley and Carr, 1987). Ash-flow cooling unit separated from underlying cooling units by approximately 10 m of bedded tuff, which are included in this map unit. Estimated thickness 800 ft (244 m)

Tc **Crater Flat Tuff (middle Miocene)**—In this area, consists of:

Tcb **Bullfrog Member**—Nonwelded to densely welded ash-flow tuff. Contains approximately 15 percent phenocrysts consisting of plagioclase, alkali feldspar, quartz, and biotite. Upper part is moderate reddish-brown, moderately to densely welded tuff. Lower part, 10 to 15 m thick, contains pale-red zone with weak columnar cooling joints above a partly welded, grayish-orange, vitric zone with an abrupt lower contact. Estimated thickness 920 ft (280.6 m)

Tct **Tram Member**—Light gray to pinkish-gray, moderately to densely welded tuff; generally contains a few percent fragments of silicic volcanic rocks. Contains approximately 15 percent phenocrysts consisting of plagioclase, alkali feldspar, quartz, and biotite. Estimated thickness 800 ft (244 m)

Ttb **Tuff breccia (middle Miocene)**—Pale-red, angular clasts of crystal-poor, ash-flow tuff in a pale to moderate reddish-brown, devitrified matrix. Clasts range in size from pebbles to boulders. Estimated thickness not more than 800 ft (244 m)

Tot **Older tuff (middle Miocene)**—Grayish-yellow, devitrified, ash-flow tuff. No meaningful estimate of thickness

Tl **Quartz latite dikes (middle Miocene)**—Grayish-orange to pale yellowish-orange, silicic porphyry classified as quartz latite by Carr (1984). Contains phenocryst as large as 2 mm of sanidine, quartz, plagioclase, and biotite. Finely crystalline matrix is predominantly quartz and sanidine with sparse opaque oxide minerals. May be glassy along chilled margins. Forms en echelon sets of north-trending dikes as much as 20 m wide and 1 km long intruding upper Proterozoic and Paleozoic rocks on the east side of Bare Mountain. In lower Joshua Hollow, dikes and small irregular masses of quartz latite intrude crystal tuff and siltstone units belonging to the rocks of Joshua Hollow. North of the main drainage in Joshua Hollow, the quartz latite intrusive masses were not mapped separately from the rocks of Joshua Hollow due to poor, weathered outcrop and complex structural and intrusive relations that could not be portrayed at the scale of this map. Biotite from this unit yielded conventional potassium-argon ages of approximately 13.9 Ma (table 2; Carr, 1984)

Tj/Tl **Rocks of Joshua Hollow and quartz latite dikes, undivided (middle and early? Miocene)**—Unit mapped north of the main drainage in lower Joshua Hollow, where small bodies of quartz latite intrude the rocks of Joshua Hollow, but were not mapped separately due to poor outcrop and complex structural and intrusive relations in that area that could not be represented at the scale of this map. Locally contains fragments of silicified fossil wood

Tj **Rocks of Joshua Hollow (middle and early? Miocene)**—Consists of:

Tjg **Gravel unit**—Conglomerate, sandstone, and limy siltstone. Conglomerate is poorly sorted with rounded to well-rounded clasts of chert and quartzite, as well as sparse clasts of volcanic rocks and pale greenish-yellow porcellaneous siltstone. Sandstone is medium grained and occurs as discontinuous lenses and layers. No meaningful estimate of thickness

Tjt **Crystal-tuff unit**—Pale yellowish-orange crystal tuff with sparse lithic fragments. Phenocrysts predominantly plagioclase and sanidine with sparse quartz and mafic minerals. Tuff is poorly stratified in layers with abundant lithic fragments and layers with few lithic fragments. No meaningful estimate of thickness

Tjs **Siltstone unit**—Grayish-orange weathering, very light- to dark-gray siltstone and shale. Finely laminated and platy. Thinly bedded where exposed in stream cuts and excavations. Sparse plant fragments present on some parting surfaces. No meaningful estimate of thickness

Td **Diorite dikes (Oligocene)**—Dusky-green, fine- to medium-grained porphyritic diorite. Contains plagioclase (75 percent), hornblende (10 percent), clinopyroxene (7 percent), biotite (5 percent), opaque oxide minerals (3 percent), and traces of epidote. Occurs as dikes mainly on the west side of Bare Mountain. Dikes are as wide as 10 m and as long as several hundred meters. Dikes cut ductile fabrics and post-date metamorphism of country rock (Monsen, 1983). Conventional potassium-argon ages of 26.1$\pm$1.7 Ma (hornblende) and 16.6$\pm$1.2 Ma (biotite) were determined for one of these dikes (table 2, sample 82-489)

Kg **Granite (Cretaceous)**—Weakly foliated, very pale-orange to pale yellowish-orange, medium-grained, equigranular, granitic rocks. Contains quartz (50 percent), potassium feldspar (30 percent), and plagioclase (15 percent), as well as muscovite and opaque oxide minerals (5 percent), which appear to be alteration products. The granite appears as a sill-like body enclosed within the Bonanza King Formation north of the mouth of Fluorspar Canyon, but all contacts with the host rock are faulted. The younger intercept age on a concordia plot of U-Pb data for zircon from this granite is 98$\pm$27 Ma (fig. 1 and table 1, sample 83-90). A fission track age for zircon of 25.4$\pm$1.3 Ma was reported by Carr (1984)

Note: Miogeoclinal rocks of Paleozoic and Late Proterozoic age are weakly to moderately metamorphosed at Bare Mountain. Except in the Conejo Canyon area and the area west of Amargosa Narrows, most of the rocks retain their characteristic sedimentary appearance and no effects of metamorphism were distinguished in outcrop. Where the rocks have undergone medium-grade metamorphism in the vicinity of Conejo Canyon and west of Amargosa Narrows, the fine-grained clastic rocks of the Carrara and Wood Canyon Formations, as well as the Stirling Quartzite, commonly are recrystallized to phyllite or schist, whereas the coarse-grained clastic rocks and carbonate rocks remain similar in appearance to their counterparts in other areas of the range. In the following unit descriptions, the rock names used are those of the protoliths, because they are most appropriate for the general case.

MDe **Eleana Formation (Mississippian and Late Devonian?)**—A thick sequence of clastic rocks consisting predominantly of argillite and cherty argillite, but with intervals containing numerous gravity-flow deposits of chert-pebble conglomerate, quartzite, and (or) detrital limestone. Upper part consists of olive-black shale, locally with sparse beds of detrital limestone. An interval of olive-gray to light olive-gray silicified argillite underlies the shale interval. The middle part of the formation, which forms a moderate rounded ridge in a reference section north of Tarantula Canyon, consists of olive-gray argillite with numerous interbeds of medium-bedded, chert-pebble conglomerate, quartzite, and grayish-orange or medium-gray, fine- to medium-grained detrital limestone. The middle part is underlain by an interval of thinly bedded, platy, olive-gray to olive-black silicified or cherty argillite. The lower part consists of light brownish-gray siltstone that is slightly calcareous near the base. In Tarantula Canyon, the basal contact of the siltstone interval grades abruptly into concordant beds of underlying Middle Devonian carbonate rocks, allowing the possibility that the lower part (siltstone) of the Eleana may be Late Devonian in age here. Elsewhere both the upper and lower contacts of the Eleana Formation are faults. Fossils indicative of a Late Mississippian age for at least part of the formation were reported from Bare Mountain by Cornwall and Kleinhampl (1964). Total thickness more than 3,200 ft (976 m) (Cornwall and Kleinhampl, 1961). Equivalent to the Meiklejohn Formation of former usage (Cornwall and Kleinhampl, 1961, 1964; Cornwall, 1972)

Df **Fluorspar Canyon Formation of former usage (Devonian)**--Steep slope and cliff forming unit consisting predominantly of medium to thick layers of light- to dark-gray, fine- to medium-grained dolomite and limy dolomite, with limestone and quartzite beds in some intervals. Generally divisible into four subunits. Uppermost subunit is medium- to light-gray, moderately well-bedded dolomite and limestone with conspicuous beds, as much as 2 m thick, of medium to light brown-weathering quartzite, limy quartzite, and sandy limestone. Next lower subunit is medium dark gray, poorly to well bedded dolomite with laminated beds and beds containing abundant stromatoporids (Amphipora). Next lower subunit is poorly to moderately well-bedded, medium-grained, light-gray dolomite forming medium to thick beds. Contains sparse layers of intraformational pebble conglomerate. The lowermost subunit consists of medium dark- to medium light-gray, poorly bedded, medium-crystalline dolomite containing sparse light-brown chert nodules; some distinct layers contain moderately abundant chert nodules. Grades downward into the Lone Mountain Dolomite; basal contact is indistinct. Thickness of incomplete section at Razorback Ridge more than 840 ft (256.2 m) (Cornwall and Kleinhampl, 1961)

Dt **Rocks of Tarantula Canyon (Devonian)**--Moderately resistant, light- to dark-gray, dolomite, limestone, silty dolomite, and silty limestone unit. Predominantly consists of moderately well-bedded, laminated limestone, dolomite, silty limestone, and silty dolomite. Contains debris flows of detrital carbonate rock as much as 10 m thick. Laminated intervals commonly contain intraformational breccia beds. Debris flows contain sand-, cobble-, and boulder-sized clasts of limestone or dolomite, quartzite and limy quartzite, and coral heads. Upper one-fourth of the unit is mostly limestone, whereas the remainder of the unit is predominantly dolomite. Upper contact is abruptly gradational with overlying light brownish-gray, limy siltstone assigned to the lower part of the Eleana Formation. Conodont fauna from the uppermost part of the unit is indicative of a Middle to Late Devonian age. A conodont fauna from 15 m below the top of the unit is considered early Middle Devonian in age. Basal contact is gradational and defined by change from light- to dark-gray, moderately well stratified dolomite and cherty dolomite to light gray poorly stratified craggy-weathering dolomite. A moderately distinct break in slope coincides with the basal contact. Thickness 300 ft (91.5 m) near the mouth of Tarantula Canyon (Cornwall and Kleinhampl, 1961). Crops out only at the mouth and along the south side of Tarantula Canyon, and formerly was included within the now-abandoned Fluorspar Canyon Formation by Cornwall and Kleinhampl (1961)

Sl **Lone Mountain Dolomite (Silurian)**--Very light-gray craggy dolomite, with a distinct medium-gray interval approximately 60 meters thick near the middle of the unit. Total thickness is approximately 1600 ft (488 m) (Cornwall and Kleinhampl, 1961). Dolomite ranges from fine- to medium-grained, is indistinctly bedded, and commonly is brecciated. It is sparsely fossiliferous with poorly-preserved crinoid debris being moderately common. Basal contact is gradational and distinguished from a distance by a distinct darkening of the gray dolomite downward into the Roberts Mountains Formation.

Sr **Roberts Mountains Formation (Silurian)**--Slope-forming, light brownish-gray to medium-gray dolomite and limestone containing interbedded silty and sandy dolomite and sparse beds of dolomite-pebble conglomerate. Thin to thickly bedded, commonly flaggy. In a measured section in Chuckwalla Canyon (Carr, Waddell, and others, 1986), upper part is predominately thin- to medium-bedded, light- to medium-gray dolomite, with sparse silty partings and dolomite-cobble conglomerate layers. Middle and lower parts contain platy to medium-bedded dolomite, limestone, dolomitic mudstone, and calcarenite. Dark-gray chert layers and nodules and dolomite-pebble conglomerate occur locally. Fossils including silicified brachiopods and corals are common locally throughout the unit. Conodonts from measured section indicative of an age range from very latest Early Silurian to very early Middle Silurian at the base to Late Silurian or Early Devonian at the top (Carr, Waddell, and others, 1986). Basal contact is disconformable and mapped at the base of a persistent 0.3-m thick, dolomite pebble-and-cobble conglomerate. Thickness 198 m

Oes **Ely Springs Dolomite (Ordovician)**—Ledge-forming, medium- to dark-gray dolomite and limy dolomite with abundant dark gray-chert layers and nodules 5 to 20 cm thick. Bedding varies from thin to medium. In measured section in Chuckwalla Canyon (Carr, Waddell, and others, 1986), uppermost 5 m consist of medium- to dark-gray cherty dolomite. Chert decreases in abundance downward as the rock color becomes lighter forming a distinct light-gray band approximately 40 m thick. Lower part is thin- to medium-bedded, medium- to dark-gray dolomite with chert layers and nodules as thick as 4 cm. Conodonts from the measured section indicative of an age range from late Middle through Late Ordovician at the base to Late Ordovician at the top. Basal contact marked by an abrupt gradation from dolomite to quartzite and is recognized from a distance by a distinct change from dark-gray to reddish-brown rocks. Thickness 127 m

Oe **Eureka Quartzite (Ordovician)**—Ledge-forming, light-gray to pale-red quartzite and sandstone. Predominantly medium- to thick- bedded, fine-grained, well-sorted quartzite, with a thin interval of limy sandstone at the base and top. Basal contact is placed at the first appearance of limestone and limy sandstone downward in the section. Thickness approximately 360 ft (109.8 m) (Cornwall and Kleinhampl, 1961)

Op **Pogonip Group**—In this area, consists of:

Opa **Antelope Valley Formation (Ordovician)**—Ledge- and cliff-forming unit of medium-gray limestone and silty limestone. Predominantly nodular, fine- to coarsely-crystalline limestone forming medium to thick beds of massive to laminated and platy-splitting rock. Pale-orange weathering silty partings are common in lower and upper parts of formation. The middle part is predominately massive medium-bedded limestone. The unit is fossiliferous. The basal contact is abruptly gradational from limestone into siltstone and silty carbonate rocks of the Ninemile Formation. Estimated thickness 680 ft (207.4 m)

Opn **Ninemile Formation (Ordovician)**—Light- to moderate-brown siltstone and olive-black to dark medium-gray silty limestone or dolomite. Irregular, thin, platy layers of siltstone alternate with nodular interbeds of carbonate rocks. Unit distinguished from a distance as a moderate-brown slope. Abruptly gradational basal contact. Estimated thickness 280 ft (85.4 m)

Opg **Goodwin Limestone (Ordovician)**—Ledge-forming unit consists predominantly of medium- to dark-gray limestone with some silty limestone. Limestone is thin to thick bedded, commonly platy-splitting. Contains pale-orange silty laminae and partings and brown-weathering chert lenses. Basal contact is placed arbitrarily at the base of the lowermost, ledge-forming limestone bed above the dolomite and silty dolomite of the Nopah Formation. Estimated thickness 440 ft (134.2 m)

Ꞓn **Nopah Formation (Cambrian)**—Poorly bedded, light- and medium-gray, saccharoidal dolomite. Forms distinctive cliffs that appear from a distance as a prominent white to very light-gray band approximately 70 m thick sandwiched between two medium-gray bands. Consists of:

Єns **Smoky Member**—Cliff-forming unit of very light- to medium-gray dolomite, forming indistinct medium to thick beds. Dolomite is medium to coarsely crystalline and has a saccharoidal texture. Upper part of unit is alternating dark- to medium-gray dolomite with sparse very light-gray beds; lowermost 70 m is white to very light-gray dolomite. Lower contact of the white to very light-gray dolomite, which forms the prominent color band from a distance, was mapped as the base of the member. Estimated thickness 305 m

Єnh **Halfpint Member**—Predominantly medium- to dark-gray, thin- to thick-bedded, finely to coarsely crystalline dolomite, which locally contains adundant black chert nodules and layers; bedding generally indistinct. Forms steep slopes and cliffs. Cliff forming dark-gray limestone occurs locally in the lowermost part. Basal contact with the Dunderberg Shale Member is abrupt. Estimated thickness 185 m

Єnd **Dunderberg Shale Member**—Greenish-brown, platy-splitting shale with subordinate medium-gray to pale-brown, thinly bedded, limestone. Slope former, commonly forms a distinctive dark-brown recessed band on hillsides and forms notches where it crosses ridges. Contacts are sharp. Thickness 100 ft (30.5 m)

Єb **BONANZA KING FORMATION (CAMBRIAN)**—Consists of:

Єbb **Banded Mountain Member**—Light- to dark-gray, medium- to thick-bedded dolomite and limestone. Divided into:

Єbu **Upper part**—Cliff-forming dolomite; fine to medium crystalline, thickly bedded, ranging in color from light to dark gray. From a distance, this upper part of the member appears as three prominent color bands of approximately equal thicknesses; these are from top to bottom: medium gray, very light gray, and dark gray. The basal contact was mapped at the base of the dark-gray band. Thickness approximately 600 ft (183 m) (Cornwall and Kleinhampl, 1961)

Єbl **Lower part**—Cliff-forming dolomite and limestone. Distinctively striped in alternating light- to dark-gray bands ranging from 0.5 to 6 m thick. The basal contact mapped at the top of a prominent silty and sandy dolomite and limestone interval that forms the uppermost part of the Papoose Lake Member and appears from a distance as a pale-orange band. Estimated thickness 1300 ft (396.5 m)

Єbp **Papoose Lake Member**—Cliff-forming, white to dark-gray dolomite and limestone intercalated with sparse but distinctive yellowish-orange silty and sandy intervals. The uppermost 20 m is silty and sandy dolomite and limestone, which grades downward into an interval consisting mainly of medium- to thick-bedded dolomite and limestone with interspersed silty and sandy beds. The basal part is typically white dolomite and limestone with yellowish-orange, silty laminae and layers. The basal contact is gradational and mapped at a contact between white, silty limestone and dolomite above and dark-gray limestone below. Estimated thickness 1900 ft (579.5 m)

Єc **Carrara Formation (Cambrian)**—A heterogeneous unit mostly containing phyllite or schist and fine-grained micaceous quartzite, but with prominent intervals of limestone and silty limestone. Consists of:

Єcu **Upper part**—Slope-forming succession of intercalated thin- to medium-bedded, dark greenish-gray phyllite or schist, micaceous quartzite, and medium dark-gray limestone. Intervals of medium-gray, medium-bedded algal limestone form resistant ribs at the top and near the middle of the upper part of the formation. The proportion of pelitic rocks increases downward in the section, and phyllite or schist predominate throughout the rest of the upper part of the formation. The basal contact of the upper part of the Carrara

Formation is sharply defined at the upper contact of a resistant, dark-gray limestone unit that constitutes the middle part of the formation. Thickness 200 m (Palmer and Halley, 1979)

Ꞓcm **Middle part**—Cliff-forming, thickly bedded, dark-gray limestone. Girvenella characteristically are present. Forms a distinctive gray rib between nonresistant brown pelite slopes. The basal contact is sharp. Thickness 62 m (Palmer and Halley, 1979). Equivalent to the Gold Ace Limestone Member of the Carrara Formation (Palmer and Halley, 1979)

Ꞓcl **Lower part**—Nonresistant lower part of formation is similar to the upper part, and also consists of greenish-gray, thinly interbedded phyllite or schist, fine-grained micaceous quartzite, and dark-gray limestone. Limestone predominates near the top, grading downward to thinly interbedded phyllite or schist, fine-grained quartzite, and subordinate limestone. Lower part abruptly grades into orthoquartzite; contact mapped where quartzite becomes dominant rock type. Thickness 87 m (Palmer and Halley, 1979)

Ꞓz **Zabriskie Quartzite (Cambrian)**—Cliff-forming unit of pale-red to dusky-red, fine- to medium-grained, orthoquartzite; thick-bedded and commonly laminated or cross-stratified. Trace fossils, particularly Scolithus, are common in the lower part. Basal contact is gradational from quartzite to pelitic rocks of the Wood Canyon Formation and is marked by a sharp break in slope. Thickness 1,140 ft (347.7 m) (Stewart, 1970)

ꞒZw **Wood Canyon Formation (Cambrian and Late Proterozoic)**—Consists of:

ꞒZwu **Upper member (Cambrian and Late Proterozoic)**—Divided into:

Ꞓuu **Upper part (Cambrian)**—Steep slope-forming sequence of interbedded quartzite and siltstone with sparse dolomite or limestone beds. Thick beds of pale-red, fine-grained quartzite predominate near the top of this upper part of the member; these quartzite beds commonly contain abundant trace fossils including Scolithus. Proportion of grayish-green, thin- to medium-bedded siltstone and micaceous quartzite increases relative to quartzite downward in section. The basal contact is sharp and defined as the upper contact of a conspicuous yellowish-brown carbonate subunit that forms the top of the underlying unit. Thickness 833 ft (254.1 m) (Monsen, 1983)

ꞒZul **Lower part (Cambrian and Late Proterozoic)**—Interbedded micaceous quartzite, siltstone, quartzite and carbonate rocks. Uppermost 60 m is dark yellowish-gray, thickly bedded limestone and dolomite. Carbonate rocks are medium to coarsely crystalline, laminated, and commonly contain abundant fossil fragments, as well as oolitic beds. Remainder of unit mostly medium to thick interbeds of moderate-brown to pale-gray, very fine-grained, micaceous quartzite and siltstone with subordinate quartzite. Forms steep slopes. The basal contact is gradational from interbedded, fine-grained quartzite and siltstone into coarse-grained orthoquartzite and quartz-pebble conglomerate of the middle member. Thickness 1,148 ft (350.1 m) (Monsen, 1983)

Zwm **Middle member (Late Proterozoic)**—Pale-green, very coarse-grained, poorly sorted, gritty quartzite with beds of very light-gray, quartz-pebble conglomerate and sparse beds of pale-green siltstone. Thin to thickly bedded. Moderate slope forming unit. Abundance of quartz-pebble conglomerate increases downward in section. Basal contact defined as the base of the lowermost quartz-pebble conglomerate bed in the section. Thickness 689 ft (210.1 m) (Monsen, 1983)

Zwl **Lower member (Late Proterozoic)**—Divided into:

Zld **Unit D**—Thickly bedded, brownish-black to moderate-brown, very fine-grained micaceous quartzite and quartzite with sparse interbeds of light-green siltstone. Forms steep slopes and ledges. The basal contact is sharp and is mapped at the top of the upper of the three pale-orange dolomite marker beds in the lower member. Thickness 161 ft (49.1 m) (Monsen, 1983)

Zlc **Unit C**--Uppermost 25 m consists of pale-orange dolomite and limestone. Carbonate rocks grade abruptly downward into thin to medium interbeds of greenish-gray, very fine-grained micaceous quartzite and siltstone. Slope forming unit. The basal contact is abrupt and is mapped at the top of the middle of the three pale-orange dolomite marker beds in the lower member. Thickness 262 ft (79.9 m) (Monsen, 1983)

Zlb **Unit B**--Uppermost 20 m consists of pale-orange, medium- to thick-bedded dolomite and limestone. Carbonate rocks grade abruptly downward into thin to medium interbeds of greenish-gray, very fine-grained, quartzite, micaceous quartzite, and siltstone. Slope forming unit. The basal contact is abrupt and is mapped at the top of the lower of the three pale-orange dolomite marker beds in the lower member. Thickness 354 ft (108 m) (Monsen, 1983)

Zla **Unit A**--Uppermost 10 m consist of pale-orange, medium- to thick-bedded, dolomite and limestone with intercalated beds of sandy dolomite and quartzite. The lower part is very fine-grained, thin- to medium-bedded, greenish-gray micaceous quartzite and siltstone. Quartzite beds become abundant in lowermost part. The basal contact is gradational into the E member of the Stirling Quartzite and is mapped where quartzite becomes the predominant rock type. Thickness 321 ft (97.9 m) (Monsen, 1983)

Zs **Stirling Quartzite (Late Proterozoic)**--Consists of:

Zse **E member**--White to pale yellowish-brown, medium- to thick-bedded, fine-grained orthoquartzite. Lamination and cross lamination are common. Moderate ridge-forming unit. Basal contact gradational into interbedded quartzite, micaceous quartzite, siltstone, and dolomite of the D member, and is defined as the horizon at which orthoquartzite beds comprise less than 50 percent of the rock unit. Thickness 295 ft (90 m) (Monsen, 1983)

Zsd **D member**--Divided into:

Zdu **Upper part**--Medium to thick interbeds of light brownish-gray, fine-grained quartzite and micaceous quartzite, yellowish-brown dolomite and sandy dolomite, and pale-green siltstone. Relative abundance of dolomite beds increases downward at the expense of quartzite beds. Moderate slope forming unit. Basal contact gradational into pale-orange dolomite, and is defined where dolomite becomes the predominant rock type. Thickness 1,358 ft (414.2 m) (Monsen, 1983)

Zdl **Lower part**--Pale-gray to pale-orange, coarsely crystalline limestone and dolomite; medium to thick bedded and commonly is laminated. Ledge forming unit. Basal contact sharp. Thickness 217 ft (66.2 m) (Monsen, 1983)

Zsc **C member**--Pale-green siltstone, phyllite or schist with sparse thin beds of micaceous quartzite, limestone, and dolomite. Siltstone is thinly bedded and platy-splitting where metamorphism is slight. Basal contact not exposed. Thickness of partial section 57 ft+ (17.4 m+) (Stewart, 1970).

B member--Not present in mapped area

Zsa **A member**--Pale-red to purplish-red, thin- to medium-bedded, fine- to coarse-grained quartzite. Contains some beds of quartz-pebble conglomerate with sparse jasperoid pebbles. Pale-orange dolomite occurs in southwest part of outcrop area. Only crops out south of Steve's Pass. Member is stratigraphically lower than all other units at Bare Mountain, but upper and lower contacts are faulted. Tentatively correlated with the A member of the Stirling Quartzite as defined by Stewart (1970). No meaningful estimate of thickness

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