Open-File REPORT

Geologic map and report for the Theodore Roosevelt Dam area, Gila and Maricopa Counties, Arizona

by

Jon E. Spencer and Stephen M. Richard

Arizona Geological Survey Open-File Report 99-6

April, 1999

Scale 1:24,000 (1 sheet), with 28 page text

PUBLISHED BY THE

ARIZONA GEOLOGICAL SURVEY

416 W. CONGRESS, SUITE 100
TUCSON, ARIZONA 85701
(520) 770-3500

Geologic map and report for the Theodore Roosevelt Dam area, Gila and Maricopa Counties, Arizona

by

Jon E. Spencer and Stephen M. Richard

Arizona Geological Survey Open-File Report 99-6

April, 1999

Scale 1:24,000 (1 sheet), with 28 page text

Arizona Geological Survey

416 W. Congress St., #100, Tucson, Arizona 85701

This report is preliminary and has not been edited or reviewed for conformity with Arizona Geological Survey standards

GEOLOGIC MAP AND REPORT FOR THE THEODORE ROOSEVELT DAM AREA, GILA AND MARICOPA COUNTIES, ARIZONA

by

Jon E. Spencer and Stephen M. Richard

Introduction

The Theodore Roosevelt Dam area is located approximately 90 km east of Phoenix on the southwest flank of Tonto Basin (Figure 1). The map area encompasses the southeastern end of the Mazatzal Mountains and the northern Two Bar Ridge area at the northeastern end of the Superstition Mountains. The area was mapped during November, 1997 to April, 1998, as part of a multiyear mapping program directed at producing a geologic map of the Theodore Roosevelt 30' x 60' Quadrangle. A 1:24,000 scale map is the primary product of this study (Plate 1; Figure 2), and the accompanying report describes rock units and other geologic features and includes modal mineral analyses of granitic rocks that was done in order to classify the granitoids.

The geology of the map area is characterized by a diverse suite of Proterozoic granitic rocks, gneiss, and metavolcanic rocks that are overlain by a generally northeast-dipping sequence of middle Proterozoic Apache Group strata, diabase sills, and Paleozoic strata as young as the Mississippian Redwall Limestone (see map and cross sections). Weakly consolidated Miocene conglomerate and sandstone overlies all of these rocks and are gently tilted and slightly to moderately faulted. Various younger deposits, including Quaternary river gravels, were deposited on older rocks and strata after faulting and tilting had ended. A newly identified structure, the Deer Hill fault, appears to be a north-northeast trending, faulted monocline. Its age is uncertain, and could be either Laramide or middle Proterozoic and associated with Proterozoic diabase emplacement. No large areas of metallic minerals or hydrothermal alteration were identified, although small quartz veins and mineralized fractures are present at many scattered locations.

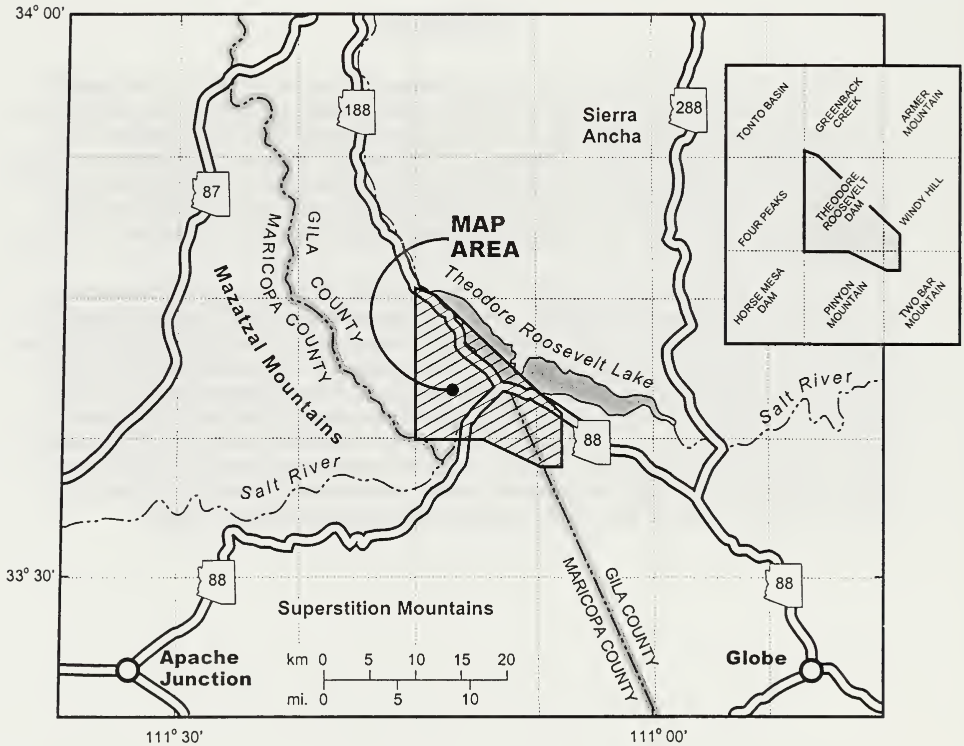

34° 00'
33° 30'
111° 30'
111° 00'
188
288
87
88
Sierra
Ancha
MAP
AREA
GILA COUNTY
MARICOPA COUNTY
Mazatzal Mountains
Theodore Roosevelt Lake
Salt River
Superstition Mountains
Apache
Junction
Globe
km 0 5 10 15 20
mi. 0 5 10
TONTO BASIN
GREENBACK CREEK
ARMER MOUNTAIN
FOUR PEAKS
THEODORE ROOSEVELT DAM
WINDY HILL
HORSE MESA DAM
PINYON MOUNTAIN
TWO BAR MOUNTAIN

Fig 1

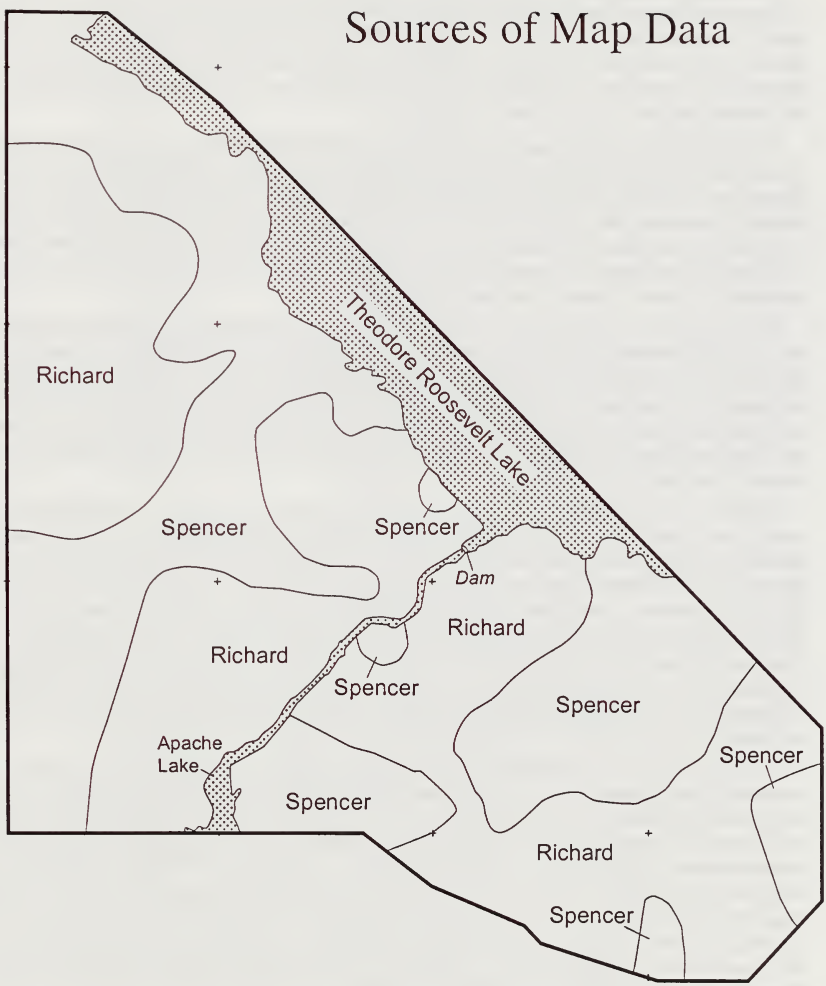

Sources of Map Data
Theodore Roosevelt Lake
Richard
Spencer
Spencer
Dam
Richard
Richard
Spencer
Apache
Lake
Spencer
Spencer
Spencer
Richard
Spencer

Fig. 2

Stratigraphy of youngest Proterozoic and oldest Paleozoic sandstones

Discontinuous sandstone units representing the Middle Proterozoic Troy quartzite, Cambrian Bolsa Quartzite, and Beckers Butte Member of the Devonian Martin Formation overlie Apache Group strata and underlie calcareous strata of the Martin Formation (Figure 3). Distinction of these three units is difficult because of the lithological similarity of the sandstones and marked lateral thickness variations and discontinuities (e.g. Tahmazian, 1964; Meader, 1977; see also McConnell, 1972, for a measured section through the Apache Group at Theodore Roosevelt dam).

All three units are exposed near the southeast abutment of Theodore Roosevelt dam where a 30-m-deep channel has been incised into Troy Quartzite, Mescal Limestone, and basalt associated with the Mescal Limestone. The channel fill includes a lower ferruginous sandstone and an overlying, very poorly sorted feldspathic sandstone (See detail map, Figure 4). We have assigned the lower unit to the Bolsa Quartzite. It is typically ferruginous in its lower part, but variably bleached in the upper part with locally striking Liesegang banding. Sand is moderately sorted, feldspar is not a prominent constituent, but in some places magnetite is common. Troughy cross beds are abundant.

Overlying, poorly sorted, iron-poor, pale colored sandstone within this channel fill is assigned to the Beckers Butte Member of the Devonian Martin Formation. Coarse, angular feldspar fragments are present in this sand. Cross bedding is common, and boundaries between beds are not sharp. The sand generally becomes finer up-section and greenish clay-rich bedding partings are present. Detrital(?) muscovite is commonly visible on these parting surfaces. A Devonian age for these strata is supported by paleomagnetic analysis (Elston and Bressler, 1978), and is consistent with Teichert's (1965) interpretation of this channel fill as Beckers Butte Member.

Teichert (1965, p. 22) described the Beckers Butte Member as consisting of "predominantly poorly sorted quartz grains that range from fine to coarse" and that "it differs from most sandstone subunits of the Jerome Member, which are generally well sorted." Feldspar and chert are locally minor components of the Beckers Butte Member, and most grains are subangular to angular. At Theodore Roosevelt Dam sandstone of the Beckers Butte Member is "easily distinguished by its susceptibility to disaggregation in hydrochloric acid, whereas the Troy Quartzite has siliceous cement and cannot be so disaggregated." (Teichert, 1965, p. 25). [See also Ransome (1916, p. 150-162), Hinds (1936, p. 33), and Huddle and Dobrovolny (1952, p. 105-106)]. It is not clear if the Troy Quartzite referred to by Teichert (1965) is the sandstone we are assigning to the Troy Quartzite (see below), or if it is the sandstone underlying the Beckers Butte Member in the channel fill sequence, which we assign to the Bolsa Quartzite.

On the south flank of the channel, the stratigraphically highest part of the Mescal Formation (argillite member) is preserved and is overlain concordantly by sandstone we assign to Troy Quartzite. This sandstone is also reddish brown in color, but has sharp, nearly planar bedding boundaries, and although the unit as a whole is poorly sorted (contrasting with sandstone interpreted as Bolsa quartzite), grain size variations within individual beds are smaller than grain size variations between beds (contrasting with the Beckers Butte member). This unit also contains red-brown mudstone partings. In all other areas within the map area, sandstone interpreted as Troy Quartzite rests on the basalt that directly underlies the argillite. Although fragments of chert and basalt from the underlying units are present in Troy Quartzite, and indicate some erosion of underlying units, Troy sands were not recognized in paleochannels that had cut through the basalt or older units. Significant channel formation thus postdates deposition of the Troy Quartzite in the study area.

Schematic cross section of stratigraphic relationships among Apache Group and Paleozoic strata

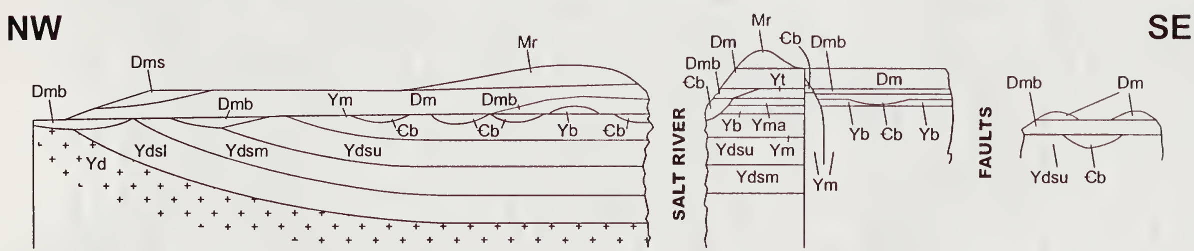


Fig. 3

pg. 5

Out crops Not Visited
Gila
Maricopa
Government Hill
$\epsilon Y_2 = \epsilon b$ = Bolsa Quartzite
$\epsilon Y_1 = Yt$ = Troy Quartzite

Fig. 4

In lower Cottonwood Canyon, pale gray sandstone mapped as Beckers Butte Member overlies brown sandstone mapped as Bolsa Quartzite. The Bolsa Quartzite occupies a channel cut into the upper Dripping Spring quartzite. Apparent preservation of thicker, coarser-grained Beckers Butte Member on top of Bolsa Quartzite channel fill suggests that the channels in which sand accumulated during Bolsa Quartzite deposition persisted into Beckers Butte time as wider and perhaps shallower channels.

The Proterozoic diabase that intrudes the Apache Group was widely exposed when marine transgression began deposition of the Cambrian Bolsa Quartzite and, in our interpretation, the highly ferruginous and magnetite-rich debris derived from the diabase was progressively less abundant as Bolsa Quartzite was deposited and diabase exposures were buried. This interpretation is supported by exposures in upper Roblas Canyon in the Picketpost Mountain quadrangle about 35 km (20 miles) to the south where a thick section of sandstone overlies diabase and contains a basal conglomerate with diabase cobbles. The sandstone is magnetite rich and chocolate brown at lower stratigraphic levels, and becomes increasingly clean and light colored over many tens of meters up section (Spencer and Richard, 1995). It is possible that Beckers Butte Member locally contains much sand derived from the diabase where it was not covered by Bolsa Quartzite, and so criteria outlined here for distinction are not definitive.

Structural Geology

Rocks in the Theodore Roosevelt Dam quadrangle record the effects of Proterozoic, Laramide(?) and middle Tertiary deformation events. Proterozoic granitoids in the map area generally contain a very weak, steeply dipping, north-northeast striking foliation. Gneissic layering in the Buckhorn Creek complex is defined by heterogeneous compositional banding and mineral shape fabric. The orientation of lithologic layering and foliation within the complex is quite variable, but near the northern and southern boundaries of the complex, fabrics are more regular and concordant with the regional northeast-trending foliation. Several discontinuous but aligned, steep, northeast-trending mylonite zones were observed along the southern boundary of the zone of heterogeneous fabric (about 0.5 km northwest of Apache Lake, northeast from Chuckar Wash). This mylonitic foliation appears to post-date the gneissic foliation in the Buckhorn Creek Complex, suggesting that the regional, northeast-trending mylonitic foliation is younger than the heterogeneous fabric in the complex which is probably related to high temperature emplacement of the complex.

Aligned, discontinuous mylonite zones were also observed along the screen of metavolcanic rocks (Xmv) that separates the granitic rocks in Rock Creek (Xg_2) from the granitic rocks in Mills Creek (Xgd_1).

A poorly exposed fault that trends north-northeast on the west side of Deer Hill is referred to here as the Deer Hill fault. Vertical separation on this fault is on the order of 60 m (200 feet), down on the northwest. At its northeast end, the fault dies out into a monoclinal flexure in the Pioneer Formation. Over most of its length, the fault juxtaposes Proterozoic granitic rocks against Pioneer Formation or against diabase that intrudes the upper Pioneer Formation. Granite along this fault contains a tectonite fabric in a zone 1-2 m wide. In an exposure of the fault in Burnt Corral Creek (UTM 3720550 N 484875 E), diabase (Yd) beneath the fault contains a cleavage parallel to the fault and is juxtaposed with hanging-wall granite that contains a tectonite fabric. The fault is thus no older than the diabase (Yd). The monocline developed along the fault is reminiscent of Laramide structures on the Colorado Plateau. Development of tectonite fabric in granite adjacent to the fault suggests formation of the fault at a deeper structural level than Tertiary faults in the area, which typically are zones of brecciation. The Deer Hill fault may be a Proterozoic structure related to emplacement of diabase or a Laramide monocline and related reverse fault. Structural similarity with other Laramide monoclines suggests the latter, but the fact that a diabase sill cuts across section beneath the monocline (cross section B-B' on Plate 1) suggests that the monocline is related to diabase emplacement.

The youngest faults in the map area cut conglomerate and sandstone units (map units Ts and Tss) that are interpreted to be Miocene in age. These are mostly minor normal faults, and tend to occur in domains of consistent separation. North of the Salt River roughly north-striking faults dip inward toward the axis of a basin containing Miocene conglomerate (map unit Ts) and the basin containing the conglomerate was likely produced by the normal faulting. Furthermore, conglomerate in the basin coarsens upward and to the west, and appears to reflect increasing prominence of the Mazatzal Mountains during sediment deposition, presumably due to movement on normal faults such as the faults that bound the basin. Some of these normal faults are buried by the stratigraphically highest basin-filling conglomerate. Southeast of the Deer Hill fault is a domain of northeast to east-trending, down-to-the-north normal faults. Along the eastern edge of exposed bedrock is a north- to northwest-trending, down-to-the-east fault system that is the western boundary of the southern Tonto Basin. This fault system appears to lose displacement to the north.

In lower Mills Creek Tertiary conglomerate is juxtaposed with sandstone of the Pioneer Shale along a contact where the sandstone is brecciated and silicified over 10 to 40 cm thickness but the Tertiary conglomerate is unconsolidated and unlithified. The fluted face of the silicified breccia surface, which dips 55° to the east, may have been produced by down-dip fault movement or by flowing water that removed crushed rock from around clasts and left the fluted form. Most likely this is a buried, northwest-trending fault scarp related to a down-to-the-northeast fault.

Mineral Deposits

At the west edge of the map area, in the drainage directly north of Mills Canyon, strong iron oxide staining and sparse fracture-filling specular hematite are hosted by early Proterozoic metavolcanic rocks and intruding Proterozoic granitic rocks. Association of mineralization with contact zone between the two suggests that it was related to granitoid intrusion.

Locations shown on map:

1. Northwest-trending, moderately to steeply southwest-dipping white quartz veins along southwest side of Buckhorn Canyon. Several small prospects and one short adit are present. Quartz veins have sparse open space with drusy quartz crystals. Some red-brown hematite staining. Some quartz veins contain a red colored mineral with adamantine luster that may be cinnabar. (UTM 3722670N 480830E).
2. In canyon south of Buckhorn Spring. Yellowish (goethite?) and reddish (hematite?) iron-stained shear in mafic Buckhorn Creek complex. Quartz vein in center of alteration zone with sericite-clay-chlorite selvage. (UTM 3723910N 479540E)
3. Swarm of 1-2 cm thick quartz veins in Buckhorn Creek Complex. Drusy quartz in open space in veins has red hematite coating on crystals. Veins have thin, sericitic selvages.
4. In canyon north of Mills Canyon, near contact with Ts on east, granite is cut by zones of strong fracturing that contain coarse calcite, with crystals up to 3 cm long.
5. West of Peters Mountain, swarm of quartz veinlets up to 1 cm thick, comb structure, some open space with drusy quartz. Trace red hematite in center of veins.
6. Near base of Ts, east of Peters Mountain, lenticular zones in conglomerate contain black powdery mineral (probably manganese oxides) coating clasts and disseminated in matrix.
7. Series of 1-2 cm thick white quartz veins cuts across foliation in Proterozoic metavolcanic rocks. Vertical veins strike about 116°. Hematite staining is abundant on fracture surfaces; predominant fractures oriented about 140°/40°SW. Some clotty manganese oxide is also

present on fracture surfaces. Fractures cut the quartz veins. Prospect consists of a series of bulldozed cuts in hillside. Located near west edge of map area, between Mills Canyon and Peters Mountain (UTM 3728880N 477285E)

8. Trench along hill slope, parallel to canyon, exposes brittle shear zone with scaly hematite-chlorite gouge. Breccia zones, some of which are silicified, cut Proterozoic metavolcanic rocks. Rare specular hematite and green secondary copper mineralization was observed in float blocks. The copper mineralization is located on fractures that cut silicified metavolcanic rock. (UTM 3729015N 477460E).

Granitic Rock Modal Mineralogy and Classification

Slabs were cut from samples of granitic rocks from the map area, and stained to allow distinction of K-feldspar and plagioclase. The plagioclase stain was not effective in most cases (for reasons unknown to the responsible commercial technician at QTS), but most of the slabs appear to have taken the K-feldspar stain, allowing identification of K-feldspar. After spraying the slabs with clear acrylic spray, quartz could generally be distinguished from plagioclase by the lack of secondary mineral development in the quartz. Plagioclase also tended to have a white chalky color, possibly in part due to attack by hydrofluoric acid during the staining process, and this chalky white contrasts with the gray color of quartz. Slabs were point counted using a binocular microscope and a set of counting grids consisting of clear acetate sheets with a rectangular grid of tiny dots marking the counting points. Each grid had a different spacing between the counting points. As the grid was traversed, the mineral underneath each dot was counted at that location. The counting grid was selected to use a grid with point spacing closest to the average diameter of mineral grains in the slab. In the cases where the slab was too small to obtain ~1000 counting points, a grid with closer point spacing was used. Seven rows of points were counted in each pass across the sample, and the sub totals for each 'pass' were recorded. Some slabs were counted using different grids to compare the results. In general, the modes obtained were similar when different grids were used. The count column in Table 1 indicates how many times the slab was counted. The mineral contents reported in Table 1 are the averages of all the passes across the slab for all the counts done on the slab. Table 2 lists sample locations and assigned rock units.

Uncertainties reported in Table 1 are the standard deviations of the average for each pass count, normalized for the total number of points counted in that pass. Small standard deviations indicate that the mineralogy of the slab is homogeneous, and that the area counted on each pass was sufficient to provide a representative sample of the rock. Larger standard deviations (>5%?) indicate either that the mineralogy of the rock is variable on the dimension of the slab, or that the slab was too small relative to the grain size of the rock for each pass to encompass a representative sample of the mineralogy. Variations in the degree of staining across some of the slabs, resulting in inconsistent mineral identification, may also be responsible for some of the larger standard deviations.

In general, most of the granitic rocks from the map area have compositions that put them in the granodiorite field or the plagioclase-rich half of the granite field (Figure 5). A few of the samples have so little K-feldspar that they fall in the tonalite or quartz diorite fields. Variations in modal mineralogy are large within granitoids included in a single map unit, and the mineralogy of granites from different units overlaps. Not surprisingly, modal mineralogy alone is insufficient to uniquely define granitic rock units.

Table 1. Slab Point Count

Buckhorn Creek complex

Mafic unit (Xbm) — # of Samples: 1

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
11-21-97-04	1006	1	0±0%	0±0%	47±1%	53±1%	100%	0%	100%	0%

Felsic unit (Xbf) — # of Samples: 6

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
11-19-97-03	682	1	17±3%	1±1%	61±4%	20±1%	98%	21%	77%	2%
11-20-97-01	925	1	28±5%	0±0%	54±3%	18±4%	100%	34%	66%	0%
11-19-97-08	807	1	31±7%	21±1%	33±5%	14±4%	61%	36%	39%	25%
03-05-98-02	782	1	29±6%	27±4%	31±5%	13±7%	53%	34%	35%	31%
11-19-97-06	743	1	31±2%	21±2%	44±4%	3±0%	67%	32%	46%	22%
11-19-97-04	772	1	39±1%	8±2%	51±1%	3±1%	87%	40%	52%	8%
		Avg	29%	13%	46%	12%				
		Min	17%	0%	31%	3%				
		Max	39%	27%	61%	20%				

Porphyritic biotite granite, probably Ruin (Yg) — # of Samples: 3

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
03-25-98-01	1137	1	30±3%	14±11	44±11	13±3%	76%	34%	50%	16%
01-13-98-05	2191	2	24±6%	23±8%	43±6%	10±2%	66%	27%	48%	25%
01-13-98-04	1826	3	33±9%	39±7%	25±5%	3±2%	39%	34%	26%	40%
		Avg	29%	25%	37%	9%				
		Min	24%	14%	25%	3%				
		Max	33%	39%	44%	13%				

Granitic Rocks in Mills Canyon

Granodiorite (Xgd_1) — # of Samples: 4

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
11-19-97-01	783	1	14±3%	0±0%	57±5%	29±7%	100%	19%	81%	0%
11-19-97-02	748	1	17±3%	0±1%	60±6%	23±3%	100%	21%	78%	0%
03-19-98-03	1219	1	26±4%	17±5%	43±3%	14±1%	71%	30%	50%	20%
03-13-98-01	444	1	32±1%	17±5%	40±3%	10±1%	70%	36%	45%	19%
		Avg	22%	9%	50%	19%				
		Min	14%	0%	40%	10%				
		Max	32%	17%	60%	29%				

Granite (Xg_1) — # of Samples: 3

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
11-18-97-01	1511	2	26±8%	10±4%	55±11	9±2%	84%	29%	60%	11%
11-18-97-02	776	1	32±7%	31±8%	31±3%	5±1%	51%	34%	33%	32%
11-18-97-03	310	1	31±7%	34±9%	32±5%	3±1%	48%	32%	32%	35%
		Avg	30%	25%	39%	6%				
		Min	26%	10%	31%	3%				
		Max	32%	34%	55%	9%				

Granitic Rocks in Rock Creek

Coarse-grained granite (Xg_2) — # of Samples: 1

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
03-11-98-01	1163	2	37±9%	35±11	25±3%	4±1%	42%	38%	26%	36%

Aplitic granite (Xga_2) — # of Samples: 1

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
03-11-98-02	1591	3	35±6%	41±2%	23±6%	1±0%	36%	35%	24%	41%

Granitic Rocks in Cottonwood Creek

Granitic rocks (Xg_3) — # of Samples: 7

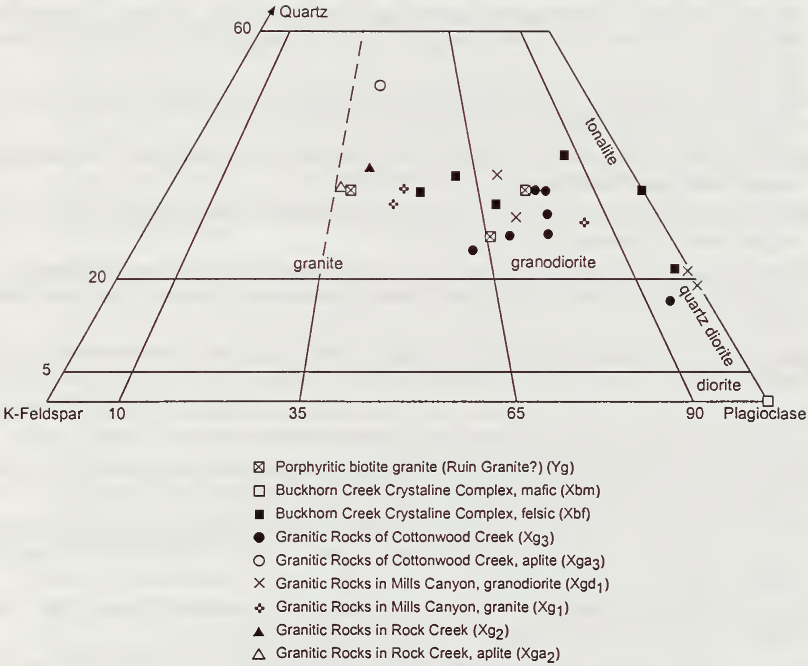
Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
01-13-98-01	1095	1	12±5%	4±4%	56±5%	29±6%	94%	16%	79%	5%
03-24-98-05	1473	2	27±5%	11±5%	42±6%	20±4%	79%	34%	52%	14%
01-13-98-02	2352	2	28±6%	13±3%	42±5%	18±3%	77%	34%	51%	15%
03-05-98-03	596	1	25±6%	13±6%	45±3%	18±2%	78%	30%	54%	15%
03-24-98-06	1272	1	22±2%	14±4%	46±4%	17±1%	77%	27%	56%	17%
01-13-98-03	1177	2	21±4%	24±4%	40±1%	14±2%	62%	24%	47%	29%
03-24-98-02	599	1	23±3%	19±2%	45±7%	13±5%	70%	27%	51%	22%
		Avg	22%	14%	45%	18%				
		Min	12%	4%	40%	13%				
		Max	28%	24%	56%	29%				

Aplite porphyry (Xga_3) — # of Samples: 1

Sample	Points counted:	Count	Modal Mineralogy: Qtz	Ksp	Plag.	Mafic	%plag/ total Fs	QPK Ternary plotting data Q:	P:	K:
01-27-98-01	1528	2	25±2%	13±3%	10±3%	52±5%	43%	51%	21%	28%

Table 2. Sample locations for granitic rocks used for point counting. The map label refers to the label for the sample location on the geologic map.

Map Label	Sample ID	Rock Unit	UTM N	UTM E	Lat.	Long.
P1	01-13-98-01	Granitic rocks, Cottonwood Creek	3722764	482151.5	33° 38.779'	-111° 11.548'
P2	01-13-98-02	Granitic rocks, Cottonwood Creek	3723686	483172.1	33° 39.278'	-111° 10.889'
P3	01-13-98-03	Granitic rocks, Cottonwood Creek	3724384	484223	33° 39.657'	-111° 10.210'
P4	01-13-98-04	Porphyritic biotite granite, Ruin?	3714547	478596.5	33° 34.327'	-111° 13.837'
P5	01-13-98-05	Porphyritic biotite granite, Ruin?	3714547	478596.5	33° 34.327'	-111° 13.837'
P6	01-27-98-01	Aplite, Cottonwood Creek	3720133	484099.6	33° 37.356'	-111° 10.285'
P7	03-05-98-02	Felsic unit, Buckhorn Creek Complex	3723704	481950.7	33° 39.287'	-111° 11.680'
P8	03-05-98-03	Granitic rocks, Cottonwood Creek	3724163	482676.5	33° 39.536'	-111° 11.211'
P9	03-11-98-01	Granite, Rock Creek, Mazatzal	3729932	478644.2	33° 42.654'	-111° 13.828'
P10	03-11-98-02	Aplitic granite, Rock Creek	3730123	478456.1	33° 42.757'	-111° 13.950'
P11	03-13-98-01	Granodiorite, Mills Canyon	3728883	480593.1	33° 42.089'	-111° 12.565'
P12	03-19-98-03	Granodiorite, Mills Canyon	3728008	477090.6	33° 41.610'	-111° 14.831'
P13	03-24-98-02	Granitic rocks, Cottonwood Creek	3724436	484251.2	33° 39.685'	-111° 10.192'
P14	03-24-98-05	Granitic rocks, Cottonwood Creek	3722351	481921.1	33° 38.555'	-111° 11.697'
P15	03-24-98-06	Granitic rocks, Cottonwood Creek	3722353	481924.4	33° 38.556'	-111° 11.695'
P16	03-25-98-01	Porphyritic biotite granite, Ruin?	3719183	489811.9	33° 36.847'	-111° 6.590'
P17	11-18-97-01	Granite, Mills Canyon	3727132	477957.3	33° 41.138'	-111° 14.269'
P18	11-18-97-02	Granite, Mills Canyon	3727133	477953.2	33° 41.138'	-111° 14.272'
P19	11-18-97-03	Granite, Mills Canyon	3727132	477952.4	33° 41.138'	-111° 14.272'
P20	11-19-97-01	Granodiorite, Mills Canyon	3725821	477853.6	33° 40.428'	-111° 14.334'
P21	11-19-97-02	Granodiorite, Mills Canyon	3725822	477851.6	33° 40.429'	-111° 14.335'
P22	11-19-97-03	Felsic unit, Buckhorn Creek Complex	3723915	479885	33° 39.399'	-111° 13.017'
P23	11-19-97-04	Felsic unit, Buckhorn Creek Complex	3723615	480262.3	33° 39.237'	-111° 12.772'
P24	11-19-97-06	Felsic unit, Buckhorn Creek Complex	3722774	480754.3	33° 38.782'	-111° 12.453'
P25	11-19-97-08	Felsic unit, Buckhorn Creek Complex	3722272	481513.8	33° 38.512'	-111° 11.960'
P26	11-20-97-01	Felsic unit, Buckhorn Creek Complex	3720553	480174.3	33° 37.580'	-111° 12.825'
P27	11-21-97-04	Mafic unit, Buckhorn Creek complex	3723930	479479.9	33° 39.407'	-111° 13.279'



Quartz
60
20
5
K-Feldspar
10
35
65
90
Plagioclase
granite
granodiorite
tonalite
quartz diorite
diorite
Porphyritic biotite granite (Ruin Granite?) (Yg)
Buckhorn Creek Crystaline Complex, mafic (Xbm)
Buckhorn Creek Crystaline Complex, felsic (Xbf)
Granitic Rocks of Cottonwood Creek (Xg3)
Granitic Rocks of Cottonwood Creek, aplite (Xga3)
Granitic Rocks in Mills Canyon, granodiorite (Xgd1)
Granitic Rocks in Mills Canyon, granite (Xg1)
Granitic Rocks in Rock Creek (Xg2)
Granitic Rocks in Rock Creek, aplite (Xga2)

Fig. 5

pg. 13

References

Elston, D.P., and Bressler, S.L., 1978, Stratigraphic and paleomagnetic relations between basal Cambrian and Devonian strata in central Arizona, in Burt, D.M., and Pewe, T.L., eds., Guidebook to the geology of central Arizona; 74th Cordilleran Section Meeting, Geological Society of America, Arizona State University, Tempe, Arizona: Arizona Bureau of Geology and Mineral Technology Special Paper no. 2, p. 138-143.

Granger, H.C., and Raup, R.B., 1969, Geology of uranium deposits in the Dripping Spring Quartzite, Gila County, Arizona: U.S. Geological Survey Professional Paper 595, 108 p.

Hinds, N.E.A., 1936, Comment on 'Correlation of Arizona Paleozoic formations' by A.A. Stoyanow: Geological Society of America Bulletin, v. 47, p. 1994-1998.

Huddle, J.W., and Dobrovolny, E., 1952, Devonian and Mississippian rocks of central Arizona: U.S. Geological Survey Professional Paper 233-D, p. 67-112.

McConnell, R.L., 1972, The Apache Group (Proterozoic) of Central Arizona, with special reference to the paleoecology of the Mescal Formation: Santa Barbara, University of California, Ph.D. dissertation, 170 p.

Meader, N.M., 1977, Paleoecology and paleoenvironments of the Upper Devonian Martin Formation in the Roosevelt Dam-Globe area, Gila County, Arizona: Tucson, University of Arizona, M.S. thesis, 124 p.

Ransome, F.L., 1916, Some Paleozoic sections in Arizona and their correlation, *in* Shorter Contributions to General Geology, 1916: U.S. Geological Survey Professional Paper 98-K, p. 133-166.

Ransome, F.L., 1919, The copper deposits of Ray and Miami, Arizona: U.S. Geological Survey Professional Paper 115, 192 p., 15 sheets, scales 1:4,800, 1:12,000, 1:125,000.

Spencer, J.E., and Richard, S.M., 1995, Geologic map of the Picketpost Mountain and the southern part of the Iron Mountain 7.5' Quadrangles, Pinal County, Arizona: Arizona Geological Survey, Open-File Report 95-15, 12 p., scale 1:24,000.

Tahmazian, G.A., 1964, Petrography of the Troy and Martin clastics sequence at Roosevelt Dam, Gila County, Arizona: Tucson, University of Arizona, M.S. thesis, 95 p.

Teichert, C., 1965, Devonian rocks and paleogeography of central Arizona: U.S. Geological Survey Professional Paper 464, 181 p., 11 sheets, scale 1:500,000.

Rock Units

Cenozoic map units

Qyc **Young alluvium (Holocene)**--Deposits of sand, silt, pebbles, cobbles, and boulders in the channels of ephemeral and perennial streams, typically coarse and very poorly sorted within mountain areas and on upper piedmonts. Particle size ranges from silt to cobbles or boulders. Deposits are typically composed of sand, silt, and pebbles on lower piedmonts, sand in major drainages, and sand, silt and mud in areas subject to overbank flooding. Within the larger channels distributary and anastomosing channel patterns are common. The deposits are generally well-stratified and lack appreciable soil formation; soils are classified as Torrifluvents or Torriorthents. Most of the channel surfaces are modern in age, but vegetated bars may be several hundred years old.

Qs **Surficial deposits, undivided (Quaternary)**--Undivided alluvium, talus, colluvium, and local active channel deposits (map units Qoa, Qtc, and, locally, Qyc, undivided). Typically consists of weakly to moderately indurated gravel and sand. Primarily crops out on weathered, slightly to moderately incised alluvial fans and alluvial valley filling deposits that form gentle to moderate slopes adjacent to hills and mountains. Also includes alluvium in recently active channels and some colluvium and talus.

Qtc **Talus and colluvium (Quaternary)**--Weakly to non-indurated gravel mantling hill slopes on bedrock. Consists of angular clasts of locally derived rock in a sand and clay matrix, derived by weathering of bedrock and downslope movement of regolith material. Mapped where hill slope deposits are thick enough to obscure the nature of the underlying bedrock. Non-conformably overlies all older deposits.

Qr **River gravel (Pleistocene)**--Deposits composed of moderately to well rounded cobbles in a sand matrix. A dark red-brown soil is developed on the surface underlain by this deposit about 1500 feet (450 m) downstream from the point where Buckhorn Canyon enters the Salt River. Desert pavement and rock varnish development is weak to moderate.

Gravels containing well rounded, far-traveled cobbles, probably related to Tonto Creek, are included in this unit in the northern part of the map area. Such gravels are exposed in highway road cuts in the extreme northwestern part of the map area, southeast of the highway maintenance station (sec. 28). The northern exposures are apparently interbedded in old alluvium (Qoa).

Qoa **Old alluvium (Middle Pleistocene to Early Pleistocene)**--Weakly to moderately indurated cobble and boulder conglomerate that forms terraces 3-10 m above active channels and flood plains. Surfaces on old alluvium have a well developed red-brown soil. Deposits are generally locally derived. In upper Mills Canyon, old alluvium is weakly indurated cobble-boulder conglomerate with a matrix of coarse, disaggregated granite sand. Boulders are up to 1 m in diameter, and are locally derived. Old alluvium at the south edge of the map area on the northeast side of Bronco Creek is a massive boulder conglomerate.

On the piedmont around Theodore Roosevelt Lake, this unit forms a veneer that blankets terrace surfaces on a pediment cut into older basin fill deposits (Ts and Tss). The reddish color of the old alluvium contrasts with underlying, generally tan to brown color of the older sandstone and conglomerate (Tss and Ts). Exposures of Ts and Tss in the arroyos cutting this unit are probably more abundant than shown.

QTls **Landslide deposits (Quaternary to Pliocene)**--Poorly consolidated to unconsolidated, very poorly sorted mud to large boulders, characterized by a hummocky surface littered with boulders. Bedding or foliation in boulders (when present) varies greatly between outcrops. Landslides in Salt River Canyon appear to have failed in middle Dripping Spring Quartzite (just west of Theodore Roosevelt Dam) or in diabase (Yd) sheets in granitic rocks. Landslides near the southern edge of the map area consist of lower Dripping Spring Quartzite, and probably are due to failure within the Pioneer Formation.

QTs **Old alluvium (Quaternary to Miocene)**--Non-indurated to weakly indurated cobble to boulder fanglomerate. Mapped in the piedmont around Theodore Roosevelt Lake where Miocene conglomerate (Ts) is suspected, but is overlain by younger deposits including old alluvium (Qoa) and colluvium (Qtc). Also includes conglomerate deposits on ridge tops of uncertain age that may correlate with Miocene conglomerate (Ts) or old alluvium (Qoa). Old alluvium overlies Ts and Tss conformably or with slight to moderate angular unconformity.

QTsa **Conglomerate, Apache Group clasts (Quaternary to Miocene)**--Weakly to moderately indurated conglomerate consisting of cobbles to boulders derived from Apache Group formations

QTsm **Conglomerate, mixed clasts (Quaternary to Miocene)**--Weakly to moderately indurated conglomerate consisting of cobbles to boulders of Paleozoic formations and Apache Group formations

Tss **Sandstone, pebbly sandstone, and siltstone (Miocene)**--Tan, medium to very thin bedded gravelly sandstone, coarse to very fine-grained sandstone, and siltstone. This unit is a distal, fluvial to lacustrine facies of conglomerate of map unit Ts, and grades laterally into conglomerate. Consolidation and lithification are generally poor. The transition between the two units is a zone of interbedded coarse sandstone and pebbly conglomerate. Siltstone consists of very thin-bedded, light grayish or reddish brown, fine-grained sandstone and mudstone with a few lenses of cobble conglomerate.

Ts **Conglomerate (Miocene)**--Typically moderately to poorly bedded and sorted conglomerate. Lithification is variable and generally fairly weak but is commonly sufficient to form steep slopes and small cliffs. This unit underlies several square miles near the western edge of the map area in upper Buckhorn, Vineyard, and Mills canyons. In this area, eastern and stratigraphically lower exposures are generally finer grained and include bedded sandy conglomerate as well as cobble to locally boulder conglomerate, whereas western exposures consist of coarse, massive to poorly bedded conglomerate with clasts locally to 3 meters. Clast compositions also vary, with eastern areas containing a mixed assemblage of rocks of the Apache Group, diabase, lower Paleozoic rocks, and some mafic and felsic granitoids, whereas western exposures are compositionally diverse granitoids, gneiss, and sparse, highly indurated quartzite of presumed early Proterozoic age. North of Buckhorn Spring dominantly sandy conglomerate is overlain by conglomerate along a mappable contact shown on the map as a marker bed (+—+—+—+). A reworked tuff with sparse fresh biotite is exposed at one location along this contact, but minor faulting or slumping has obscured the original stratigraphic relationship of tuff to conglomerate. Northern exposures contain sparse clasts of Proterozoic felsic metavolcanic rocks.

In the western part of its outcrop in Mills Canyon, the conglomerate consists of angular to subangular boulders of hornblende granodiorite (Xgd_1) and mafic dike rock (TXm) in a pinkish tan, very fine-grained muddy matrix. The conglomerate is clast supported. Clasts of metavolcanic rocks (Xv) that are common in the young alluvium along Mills Canyon appear to be absent in this older conglomerate.

At the mouth of Vineyard Canyon, pale tan, sandy fanglomerate, with weakly to moderately defined bedding, contains 5-50 cm, subrounded to subangular clasts of Apache Leap tuff, granitoids, and minor quartzite probably derived from the Apache Group.

East of Peters Mountain conglomerate clasts of porphyritic granite are as large as three meters, and clasts of Barnes (map unit Ydsb) or Scanlan conglomerate (basal conglomerate of the Pioneer Formation) and Early Proterozoic quartzite are as large as two meters. Conglomerate in this area contains fairly little locally derived granite, but contains abundant early Proterozoic quartzite, metamorphic rocks, and porphyritic granite. In lower Cottonwood Canyon and on Two Bar Ridge this unit contains clasts of Apache Leap tuff, granite like that exposed locally, rocks of the Apache Group and associated diabase, and lower Paleozoic clastic and carbonate rocks. The small exposure on the ridge crest above the lower ruin of Tonto National Monument is rubble of Mescal Limestone, Dripping Spring Quartzite, and very sparse basalt of the Apache Group, all resting on Mescal Limestone. This unit overlies Proterozoic granitic and metamorphic rocks on erosional unconformity. In Mills Canyon, the conglomerate appears to be faulted against granitic rocks (map units Xgd_1 and Xg_1) at low elevations, but overlaps the bounding fault on the ridge crests to depositionally overlie the granitic rocks.

Tta **Apache Leap Tuff (Early Miocene)**--Weakly welded, moderately to strongly indurated crystal tuff forming one small outcrop southeast of Burnt Corral Canyon. Rocks of this unit contain 2-3% 1-2 mm diameter biotite crystals, 10-15% quartz and feldspar crystals, including sanidine, and sparse fiamme and dark gray aphanitic lithic lapilli. Eutaxitic foliation is quite discordant to lower contact of unit, indication deposition on a slope or some post-depositional rotation of blocks due to failure and down-slope movement on underlying non-welded tuff. Overlies non-welded tuff (Tt) on a sharp contact.

Tt **Tuff (Middle Miocene to Early Miocene)**--Discontinuous lenses of white or light gray non-welded tuff are exposed at the base of Tertiary conglomerate and sandstone in many areas. Typically the lower part of the exposed tuff contains abundant blocks of underlying pre-Tertiary rocks, which become less abundant up section. The tuff is well bedded, locally laminated, but generally lacks evidence of reworking. Phenocrysts of biotite, plagioclase and sanidine in variable amounts are invariably present. Lithic fragments of light gray felsite are present in many beds. Tuff nonconformably overlies pre-Tertiary rocks on a surface of significant (10's of m) erosional relief.

Tc **Conglomerate (Pliocene or Miocene)**—Thin, monolithologic deposits on hill slopes consisting of sub-rounded boulders of Pioneer Formation and granite (Xg_3) up to 2 m in diameter. Matrix is not exposed, but float suggests that it is sandy. Soil formed on this unit is slightly darker colored and more clay rich than soil formed on granite (Xg_3). Appears to be a lag deposit left by erosion of Pioneer formation that previously overlay the granite. This deposit lies at elevations lower than polymict conglomerate of map unit Ts in adjacent hill tops. Unconformably overlies Proterozoic granite.

Cenozoic or Proterozoic rocks

TXm **Mafic dikes (Miocene to Early Proterozoic)**--Dark gray green, very fine grained to aphyric microdiorite(?). Dikes up to 3 m thick, contacts sheared in some dikes. Aphanitic chilled margins

1-2 cm thick are present at unsheared contacts. Dikes cutting granodiorite (Xgd_1) in the canyon north of Mills Canyon are dark gray to black, and locally contain 5% 1-3 mm long plagioclase crystals with a weak trachytic texture. These dikes are nearly concordant to the foliation in the host granite, but their very fine-grained chilled margins do not have cleavage, suggesting that they post-date fabric development in the granite. Intrude granitic rocks of map unit Xgd_1 in Mills Canyon area.

Paleozoic rocks

Mr **Redwall Limestone (Mississippian)**--Massive, light gray crystalline limestone. Locally preserved calcarenite (crinoidal grainstone?) texture. Vague bedding partings appear to be slightly silty. Contains scattered horn coral. Stylolites parallel to bedding are common. Base is generally poorly exposed, placed at bottom of first thick limestone bed.

Martin Formation (Late Devonian)

The Devonian Martin Formation in central Arizona has been divided into two members by Teichert (1965), as follows: The lower Beckers Butte Member, up to 200 feet thick, of cross bedded, poorly sorted sandstone, and the upper Jerome Member that consists largely of carbonates. The Jerome member is divided by Teichert into three units, in ascending order as follows: (1) The feted dolomite unit consists of up to 55 feet of fine to medium grained dolomite interlaminated with organic-rich carbonate. (2) The aphanitic dolomite unit consists of typically 100 to 150 feet of aphanitic to very fine grained dolomite with local intercalations of aphanitic limestone and fine-grained sandstone. (3) The mixed unit, up to 385 feet thick, consists of aphanitic dolomite and limestone, medium to fine grained, commonly mottled dolomite, and sandstone and calcareous sandstone. The Jerome Member, which onlaps onto the Defiance uplift to the northeast and is increasingly sandy near the uplift, contains early Late Devonian fossils.

Dm **Jerome Member, Martin formation (Late Devonian to Middle Devonian)**--Thin to medium bedded, generally light gray dolomite, sandy dolomite, sandstone and shale. Thicker intervals of sandstone north of the Salt River are mapped as unit Dms. Lithology is variable. A good section is exposed in road cuts along the abandoned part of Arizona State Route 88 beneath the SE abutment of the new bridge over the Salt River Canyon (SW sec. 20, T. 4 N., R. 12 E., UTM 485450E 3725550N). The base of the section at the contact with the Beckers Butte Member is disrupted in this section. The lowest beds are medium- to thin bedded-porcelaneous, white to light gray dolomicrite (4 m minimum thickness; thicknesses estimated by pacing). These are overlain by about 23 m of thin-bedded, yellowish and greenish gray sandy dolomite(?) with shale partings. Up section, shale becomes more abundant, carbonate beds are sandier and thicker. Tiny green spheres of glauconite(?) are present in the carbonate beds. Above this is an interval of about 30 m of medium-bedded, ledge-forming, laminated sandy dolomite. Small-scale planar troughy cross beds, and some siliceous stringers or chert nodules are present. The next interval is about 9 m of medium-bedded, marly dolomite that weathers to discoid chips and dolomitic, fine-grained, laminated sandstone. Sparse crinoid columnals are present. This is overlain by 15 m of very thin bedded, gray dolomite with interbedded shale. The shale is pinkish to greenish gray, and contains sand-filled tubes (burrows?) about 2 cm in diameter. The top of the section consists of about 28 m of tan orange to gray, slightly sandy dolomite in the lower part that grades up into terra rossa consisting of blocks of dolomite in a red-brown mudstone or siltstone matrix.

Sparse fenestrate bryozoa and crinoid columnals are present in silty carbonate beds in the middle or upper part of the section exposed in road cuts along Arizona State Highway 188 north of Theodore Roosevelt Dam.

Where the Beckers Butte Member is very thin or absent north of Theodore Roosevelt Dam, the basal bed of the Martin Formation is a dolomitic sandstone with abundant dish structures. The sandstone is very poorly sorted, and contains 2-5 mm diameter angular grains of chert (from Ym?), rounded quartz grains up to about 1 mm diameter, and finer-grained, less rounded quartz sand. Contact with Beckers Butte Member is placed at base of light gray porcelaneous dolomite where it overlies sandstone or sandy dolomite.

Dms **Sandstone in the Martin Formation (Middle Devonian or Late Devonian)**--In the northern part of the map area, progressively more of the middle part of the Martin Formation consists of sandstone, and a predominantly sandstone facies of the Jerome? Member is mapped. A section through much of unit is well exposed in a road cut in NW, sec. 18, T. 4 N., R. 12 E. (UTM 483750E 3727800N), where the unit consists of fine-grained to silty, quartz-rich sandstone, overlain by medium- to coarse-grained quartz-rich sandstone interbedded with calcareous siltstone and silty carbonate. The upper sandstone is moderately cemented and slightly to strongly calcareous, with cross beds 10 to 100 cm thick. Sparse quartzite pebbles are present in one bed. Sandy rocks are typically tan; silty rocks typically have a greenish cast. Lithologically the sandstone is very similar to that in the Beckers Butte Member.

Dmb **Beckers Butte Member of the Martin Formation (Middle Devonian to Early Devonian)**--Light gray to whitish gray, medium- to coarse-grained, arkosic to quartz-rich sandstone, cross bedded and plane bedded, with beds 3-30 cm thick. Planar tabular cross bedding is most common. Some greenish or purplish gray shale partings are present, becoming more abundant up section. Conspicuously poor sorting of this gritty sandstone is distinctive, with sand grains commonly 1-10 mm diameter. This unit also contains local pebbly beds and rare conglomerate with rounded quartzite cobbles up to 15 cm diameter. A few percent of pebbles are black chert. Finer grained sandstone beds in the upper part of the unit contain conspicuous, nearly spherical grains disseminated among smaller, sub-rounded grains (texture inversion). The Beckers Butte Member lacks the hematitic zones that are common in sandstone assigned to the Cambrian Bolsa Quartzite. In the type area of the Beckers Butte Member, 40 miles east of Theodore Roosevelt Dam, shale and impure dolomite at the top of the member contain Early or Middle Devonian psilophyte flora.

The Beckers Butte Member pinches out in some areas north of Theodore Roosevelt Dam. Contact on Bolsa Quartzite is exposed at the west end of the road cut on west side of Government Hill. Grit of Beckers Butte Member concordantly overlies finer-grained, better sorted sand assigned to Bolsa. There is no indication of significant erosion or recycling of Bolsa sand or clasts into Beckers Butte Member.

Ꞓb **Bolsa Quartzite (Middle Cambrian)**--Fine- to coarse-grained quartz arenite and feldspathic quartz arenite. Lower part is typically dark red brown. In thicker sections, grades up into buff to white sandstone with irregular zones of red brown sandstone, mostly along bedding planes. Picturesque Liesegang banding is developed in some outcrops. Small scale planar tabular and troughy cross bedding is abundant. Unit is medium- to thin-bedded. Magnetite-rich laminations are common in some outcrops. Sand grains are typically <1 mm diameter. Middle and upper Bolsa Quartzite consists of fine-grained, medium brown and white sandstone in beds up to 1 m thick, with shaley partings and beds up to 10 cm thick. Cross beds in lower Cottonwood Canyon, form sets 5-10 cm thick. Distinctive, magnetite-rich laminations along the lower part of the cross-bed slip faces flatten and merge downward into a planar, magnetite-rich zone along the base of the cross bed set. Near the base of the unit in this area, rare beds up to 1 m thick are full of flat rip-up fragments, 1-10 cm long, of underlying Dripping Spring Formation.

This sandstone is preserved in paleovalleys cut into Dripping Spring Quartzite in lower Cottonwood Canyon, cut into the upper part of the Mescal Limestone near Theodore Roosevelt Dam, and into upper, then middle Dripping Spring Quartzite northward from the dam.. The erosional unconformity along the sides of a paleovalley are well exposed in road cuts along the Apache Trail near the SE abutment of Theodore Roosevelt Dam. Blocks of Mescal argillite (unit Yma) are present in the Bolsa within about 2-4 m of the contact. Troy(?) sandstone appears to be absent where Bolsa is recognized. Overlain disconformably by Beckers Butte member of Martin formation on a sharp contact.

Middle Proterozoic rocks

Yd **Diabase (Middle Proterozoic)**--Dark gray, dark greenish gray, and grayish black sills and dikes with typical sub-ophitic, diabasic texture. Consists of 35-45% 1-3mm plagioclase lathes in black groundmass of pyroxene(?); accessory magnetite(?) is common. Locally crude layering is defined by variation in ratio of plagioclase to groundmass and in size of plagioclase crystals. Major sills intrude granitic rocks 200-400 feet (60-120 m) below the base of the Pioneer Formation, and in the upper part of the Pioneer Formation. Diabase intrudes Proterozoic granitoid and Apache Group.

Yt **Troy Quartzite (Middle Proterozoic)**--Red brown thin to medium bedded sandstone. Poorly sorted sand; fine to very coarse grained, mostly fine- to medium-grained. Grain sized within individual beds is less variable than grain-size variations between beds (contrasting with generally more uniform grain size in Bolsa, and wide within-bed variations in Beckers Butte sandstone). Shale partings are common. Planar tabular cross bedding is present but not ubiquitous. Bedding partings are more sharply defined and planar that in Bolsa or Troy sandstones. Contact with underlying upper Mescal argillite unit south of Theodore Roosevelt Dam is erosional. Chert from argillite unit (Yma) occurs as clasts in basal part of sandstone. On ridges in the southeastern part of the map area, overlies basalt (Yb), and clasts of basalt are present in the basal part of the sandstone.

Apache Group (Middle Proterozoic)

Yma **Argillite in the Mescal Limestone (Middle Proterozoic)**--Interbedded chert and massive, very fine-grained sandstone or argillite, with minor shale and medium grained sandstone. Characterized by medium- to thin-bedding, and medium to dark gray color; becomes reddish at top of unit. Chert beds are the most resistant and tend to form the only outcrops. Only present in a small area immediately south of Theodore Roosevelt Dam, and as very thin remnants between Beckers Butte Member of the Martin Formation and basalt (Yb) north of the dam. Disconformably(?) overlies basalt (Yb).

Yb **Basalt in the Mescal Limestone (Middle Proterozoic)**--Dark gray to black, massive, aphyric basalt lava. Locally contains vesicular or fragmental zones. Conformably(?) overlies stromatolite unit in upper Mescal Limestone.

Ym **Dolomite in the Mescal Limestone (Middle Proterozoic)**--Brown to reddish tan dolomite with blobs, stringers, and laminations of protruding silica. Dolomite weathers in some areas to reveal faint to moderately well developed, 1-2 mm laminations. Locally, protruding siliceous laminations, 2-5 mm thick, define cross bedding in beds 10 cm thick. Basal red-brown, non-resistant beds consists of poorly sorted quartz sand in argillaceous or dolomitic matrix. Breccia zones commonly present in the lower part are possibly related to dissolution of evaporite minerals. These consist of angular chert and dolomite fragments in a dolomite matrix that is lithologically identical to many of the clasts. Basal beds are overlain by a lower member (informal division) of thin to thick bedded dolomite or limestone, with variable amounts of chert as bedding parallel stringers, and calcareous shale partings. Dolomite is tan, limestone light gray to white. These strata are ordinarily 150-200 feet thick, and form most of the formation. A middle member of massive dolomite or limestone with structural features attributed to the growth of algal colonies during deposition is present in well preserved sections (50-100 feet thick). The upper member of chert, feldspathic siltstone, and thin limestone (Unit Yma) is rarely preserved, and is mapped separately where present. Mescal Limestone beneath the lens of Bolsa quartzite on the south side of Inspiration Point is silicified, varicolored, breccia that may be the product of pre-Bolsa karst.

One mile northeast of Pinyon Mountain the following 4-part division was recognized, from base to top: (1) mottled, silty, tan to brown dolomite, about 5 m thick, (2) siliceous dolomite with abundant, protruding, 1-5 cm thick stringers of brown silica separated by recess-forming, yellowish tan dolomite. This unit is about 30 m thick. (3) Twenty meters of interbedded, silica-stringer-rich dolomite and massive, reddish tan dolomite without siliceous stringers. (4) Ten meters of massive, reddish tan dolomite that locally contains 10-30 cm thick beds of massive to laminated, aphanitic, pale gray to grayish white, indurated and conchoidally fracturing, siliceous rock that could be air-fall tuff (more likely) or very fine-grained siltstone (less likely).

Overlain gradationally by argillite unit (Yma) on south side of Theodore Roosevelt Dam. Otherwise overlain disconformably by sandstone of Troy, Bolsa, or Martin Formation. Pinches out about one mile north of Vineyard Mountain due to pre-Martin erosion.

Yds **Dripping Spring Quartzite, undivided (Middle Proterozoic)**--formal unit defined by Ransome 1919.

Ydsu **Upper unit, Dripping Spring Quartzite (Middle Proterozoic)**--Slope-forming very fine to fine grained sandstone with interbedded shale, grading up to thin-bedded fine-grained sandstone. Light gray to pink on fresh surfaces, weathers dark brown or shades of orange and red because of iron-staining along fractures. The upper unit contains little interbedded shale or siltstone except as thin partings on bedding planes. Stylolites are common in fine-grained quartzite of this unit. The upper part commonly forms a cliff. One to several white, vitreous quartzite beds are typically present at the top of this unit. Top is base of orange and red, poorly sorted calcareous or dolomitic sandstone at base of Mescal Formation. Several thin vitreous quartzite beds commonly present at top of this unit.

Ydsm **Middle unit, Dripping Spring Quartzite (Middle Proterozoic)**--Maroonish brown to light gray siltstone to shale and very fine grained, silty sandstone that forms gentle slopes or, most commonly, is buried by talus and colluvium. Scattered quartzite beds form subtle to prominent ledges. Unit locally contain sparse to abundant, 2-20 mm, pale reddish-tan spots known as "reduction spots" that apparently formed where oxidation and maroon to red color development were prevented by the reducing environment around a pyrite grain (now gone) at the center of the reduction spot. Fine grained, plane bedded and low-angle cross-bedded sandstone locally form resistant, amalgamated beds

20-100 cm thick within more abundant siltstone and silty, very fine grained sandstone. Cross beds are typically 10-30 cm thick. Sand contains progressively less K-feldspar up section. Estimated K-feldspar content ranges from 10-20% near base to 2% for an almost vitreous bed near top. An interval of light gray fissile shale is present, but rarely exposed, near the middle of the unit. Slopes on this unit are littered with thin, varicolored rock fragments bounded by planar bedding surfaces. The upper contact is placed at the base of a prominent gray, vitreous quartzite bed (probably correlates with gray sandstone of Granger and Raup [1964]) in the Salt River Canyon area. southward, this bed disappears or is not prominent, and the upper contact is placed at the base of steep slopes or cliffs formed by the upper unit.

Ydsl **Lower unit, Dripping Spring Quartzite (Middle Proterozoic)**--Orangish gray, indurated, medium- to coarse-grained, medium- to thick-bedded, sandstone or quartzite that weathers into angular blocks and forms bold outcrops and steep slopes and cliffs. Estimated 15-25% K-feldspar grains impart orangish color. In some areas, abundant, troughy low-angle cross bedding is visible. Bedding parallel burrows(?) and mud cracks are common in the uppermost part. A conspicuous ledge of white, vitreous quartzite is present at the top of the member (as mapped) on Vineyard Mountain; this marker disappears to the north due to pre-Martin Erosion, and thins and becomes inconspicuous south of the Salt River. The basal Barnes Conglomerate member ranges from 0-5 m thick, and varies from a clast-supported pebble to cobble conglomerate to a sandstone with rare well rounded pebbles. Clasts are subrounded to well rounded, and include conspicuous white vein quartz, red jasper, and less conspicuous quartzite.

At one location, approximately 3/4 mile north-northwest of the headquarters of Tonto National Monument, sandstone of this unit rests depositionally on medium to coarse grained, pink to orange, equigranular granite (Xg_3), which helps account for the high abundance of pink to red K-feldspar in the sandstone. Contact with underlying Pioneer Formation is easily identified when the Barnes Conglomerate is well developed; where the conglomerate is absent, the contact is placed at the base of thick bedded cream or pink-colored medium to coarse-grained quartzite. The upper contact is placed at the break in slope where quartzite beds become thinner and less resistant.

Ydsb **Barnes Conglomerate, Dripping Spring Quartzite (Middle Proterozoic)**--The Barnes Conglomerate member ranges from 0-5 m thick, and varies from a clast-supported pebble to cobble conglomerate to a sandstone with rare well rounded pebbles. Clasts are subrounded to well rounded, and include conspicuous white vein quartz, red jasper, and less conspicuous quartzite. Present only at the base of the Dripping Spring Quartzite. This unit is mapped separately at Deer Hill where it forms screens within diabase.

Yp **Pioneer Formation (Middle Proterozoic)**--Formal unit defined by Ransome [1919]. The basal Scanlan Conglomerate is overlain by maroon, maroonish gray, tan, and brown sandstone and silty sandstone with about 10 m of maroon siltstone and very fine grained sandstone within the upper half. Sandstone is generally medium to thick bedded, poorly sorted, and feldspathic. Includes reddish brown, fine-grained sandstone with silty layers where the rock has parted to reveal polygonal mudcracks, and locally contains conspicuous red K-feldspar grains presumably derived from underlying granite. Sandstone generally thins and fines up section, and dark red-brown shale partings are common, but no intervals of shale has been observed in the section. Upper beds of the Pioneer Shale are thin-bedded siltstone.

Fine-grained sandstone and siltstone commonly contains sparse to abundant, 2-20 mm, pale reddish-tan spots known as "reduction spots" that apparently formed where oxidation and maroon to red color development were prevented by the reducing environment around a pyrite grain (now gone) at the center of the reduction spot.

Scanlan Conglomerate Member is poorly sorted, massive to poorly bedded, clast-supported conglomerate with subrounded to rounded quartzite cobbles up to 30 cm diameter. Thickness varies from approximately 12 meters west of Vineyard Mountain (south of peak 5559) to zero in lower Cottonwood Canyon. Scanlan conglomerate overlays Proterozoic granite on a sharp unconformity with very little local relief. Upper contact with Dripping Spring Quartzite is placed at base of Barnes conglomerate where that can be identified. Upper beds of Pioneer are thin-bedded siltstone; where Barnes is absent, contact is placed at base of massive, relatively well sorted feldspathic Dripping Spring Quartzite. A thick diabase sill intrudes near the contact between Pioneer and Dripping Spring, obscuring the contact in many places.

Yg **Coarse-grained, porphyritic biotite granite (Middle Proterozoic)**--Coarse-grained biotite granite with sparse, 5-15 cm mafic enclaves. K-feldspar phenocrysts up to 4 cm diameter poikilitically enclose sparse, 1-2 mm plagioclase and biotite. The granite consists of 15-25% K-feldspar, both as phenocrysts and 1-6 mm diameter anhedral grains, 5-10% biotite in 1-3 mm-diameter flakes, 25-30% quartz in aggregates of 1-2 mm-diameter grains that are up to 6 mm in diameter, and 35-45% plagioclase in subhedral grains 2-5 mm in diameter. Granite contains fine-grained, resistant, dike-like zones that grade into equigranular to weakly porphyritic granite locally containing conspicuous 8-10 mm quartz phenocrysts. Forms grussy slopes and very poor exposures in small outcrop area at north end of Pinyon Mountain. Rock is more distinctly porphyritic than Early Proterozoic granitoid in the map area, and is completely non-foliated. This granite is overlain depositionally by Pioneer Formation. The contact with Xg_3 north of Pinyon Mountain is not exposed; a zone of mixed metasedimentary rocks (Xms) and granite (Xg_3? or Yg?) crops out along the contact.

Yga **Aplite associated with coarse-grained porphyritic biotite granite (Middle Proterozoic)**--Fine-grained aplite forming irregular masses within map unit Yg.

Early to middle Proterozoic rocks

YXgm **Granite and schist (Middle Proterozoic and Early Proterozoic)**--Fine-grained granite, containing abundant magnetite and muscovite, mixed with muscovite schist, and quartzite and quartz-feldspar-mica gneiss, forming one small outcrop at the southern edge of the map. Interpreted as border zone to coarse grained, porphyritic biotite granite of map unit Yg or to aplite and aplitic granite of map unit Xga_3. Contacts with other pre-Apache Group units are not exposed.

Early Proterozoic rocks

Granitic Rocks (Early Proterozoic)

Early Proterozoic(?) granitic rocks are abundant in the southeastern Mazatzal Mountains and Two Bar Ridge area. Rocks included in this group are characterized by textural and mineralogical variability, but have in common the presence of zones of weak to strong foliation that are generally steep and trend northeast. Typically they are medium- to coarse-grained, homogranular to weakly porphyritic granitoids that grade from granite with 1% biotite to granodiorite with up to 30% biotite (±hornblende). Most of these rocks are described in three groups here, based on spatial association. The development of more regionally applicable nomenclature for these rocks awaits completion of mapping in the southern Mazatzal Mountains. The northern unit of granitic rocks consists largely of coarse-grained granite and aplitic granite. It crops out along Rock Creek and around Peters Mountain, and is bounded on the south by a northeast-trending screen of Proterozoic metavolcanic rocks (Xvs) and a high-strain zone. South of the metavolcanic screen is the second unit, consisting mostly of medium- to coarse-grained granodiorite, but ranging from tonalite to granite. These rocks are best exposed in upper Mills Canyon within the map area, and intrude gneiss of the Buckhorn Creek Complex (Xb) on the south. The third unit crops out south of the Buckhorn Creek Complex, along the Salt River Canyon and in the Cottonwood Creek drainage. It consists of granite to granodiorite and aplite. The boundary between the Buckhorn Creek Complex and this unit is poorly defined, and appears gradational. Finally, a set of mafic dioritic to gabbroic rocks, including hornblendite, forms small outcrop areas in all three of the granitic rock groups outlined above.

Granitic rocks of Cottonwood Creek (Early Proterozoic)

This unit includes granitic rocks between the Buckhorn Creek Complex and the Ruin Granite, along the Salt River Canyon below Theodore Roosevelt Dam south into the Cottonwood Creek and Burnt Corral Creek drainages. The contact into the Buckhorn Creek Complex is gradational from relatively homogeneous tonalite to granodiorite with abundant aplite dikes into finer-grained, much more heterogeneous igneous and metamorphic rocks.

Xga_3 **Aplite and aplitic granite (Early Proterozoic)**--Mixed medium- to coarse-grained granite similar to Xg_3, fine-grained granite, and aplite to aplite porphyry. Aplitic granite is more resistant to weathering and tends to form most of the float, whereas the coarser-grained granite decomposes to grus. It is thus difficult to estimate the relative abundance of the two rock types. The aplite porphyry contains about 50% phenocrysts up to 8 mm diameter. The groundmass is a very fine-grained aggregate of equant, anhedral quartz and feldspar, with 1-2% recrystallized biotite. Phenocrysts include 20-25% plagioclase, 45-55% quartz, and 25-30% K-feldspar. Some of the aplite has a weak foliation due to alignment of biotite in the groundmass. Contact with granite (Xg3) is gradational.

Xg_3 **Granodiorite (Early Proterozoic)**--Granitoid consisting primarily of granodiorite and less common quartz diorite to granite. Granitic rocks of this unit are typically medium- to coarse-grained with seriate texture. Along the Salt River Canyon, the unit consists mostly of medium-grained, seriate granodiorite containing: 15-20% mafic minerals, mostly biotite with some hornblende, forming clots up to 4 mm diameter; 40-45% plagioclase in subhedral to anhedral grains 2-8 mm in diameter; 10-20% K-feldspar in equant, subhedral to anhedral grains 2-10 mm in diameter; 20-30% quartz in equant, anhedral grains up to 6 mm diameter (See point count data). In the Two Bar Ridge area this unit is pale orangish tan, medium- to coarse-grained, equigranular biotite granite. In the area south of Burnt Corral Canyon the rock appears to be alkali granite with 25-35% quartz up to 1 cm diameter, 60-70% K-feldspar up to 2 cm in diameter, 3-7% biotite in 2-4 mm diameter recrystallized clots, and 10-20% plagioclase; no samples of this rock were stained and point counted. Discrete contacts between lithologically distinct granitoids were not observed in the field. Feldspars are stained pink throughout much of the unit, making distinction of plagioclase and K-feldspar difficult, and rock classified as alkali granite in the field is likely to be granodiorite. Near the base of the Apache group, the granite is dark red-brown, biotite is chloritized, and the cores of some feldspar are replaced by opaque minerals. This red zone is interpreted to result from pre-Apache Group weathering. Aplite and fine-grained granite dikes are abundant near the contact with the Buckhorn Creek Complex, and are apparently identical with the non-foliated granite dike component of that unit. To the southeast, aplite again becomes more abundant and unit grades into aplitic granite unit (Xga3).

Xgbc Granitic rocks in Bronco Creek (Early Proterozoic)--In the far southwestern corner of the Theodore Roosevelt Dam 7 1/2' Quadrangle, this unit consists of medium to coarse grained, biotite + hornblende granite with roughly equal amounts of quartz, plagioclase, and K-feldspar and about 10% mafic minerals. Fine grained, pale orange leucogranite dikes are abundant and typically form ridge crests. Together with the leucogranite dikes, this granite resembles the granitic rocks of Cottonwood Creek and is tentatively correlated with them. This unit appears to intrude the Buckhorn Creek Complex.

Granitic rocks in Rock Creek area (Early Proterozoic)

Xga_2 Aplitic granite (Early Proterozoic)--Pinkish colored aplitic granite and granodiorite, consists of 60-70% anhedral feldspar (mostly K-feldspar?), and 30-40% anhedral quartz. Grain size and texture is variable. Fine to medium-grained (up to about 5 mm average grain size), generally homogranular, but in some places has 3-10 mm diameter quartz and feldspar phenocrysts in a fine-grained (1mm) groundmass. Much of the exposed rock along lower Rock Creek is slightly silicified, with ubiquitous quartz veinlets, and weathers to angular blocks, forming bold cliffs. Contact into coarse grained granite is gradational to abrupt.

Xg_2 Coarse-grained granite (Early Proterozoic)--Homogranular to seriate granite, consists of 50-60% subhedral to anhedral feldspar, up to 1.5 cm diameter, 25-35% anhedral, equant quartz grains up to 7 mm diameter, and 2-4% biotite. Pinkish color makes distinction of feldspars difficult. In areas where the plagioclase is bleached white (sericite or clay), and can be distinguished from K-feldspar, it forms grains up to 6 mm diameter composing 10-35% of the rock. Biotite is recrystallized to clots of very-fine grained biotite. Much of eastern part of outcrop is weakly silicified and pinkish due to iron staining. Thin bull quartz veins are common in this area, and the rock is penetratively microfractured with chlorite, epidote, and hematite along the fractures. Contact with metavolcanic rocks to south is a zone of mixed hornfelsed metavolcanic rock and texturally variable granitoid. Rocks in the vicinity of the contact are silicified and iron stained.

Xmvg Mixed granite and metavolcanic rocks (Early Proterozoic)--Mixed Xg_2 and hornfelsed metavolcanic rocks in border zone of Xg_2.

Granitic rocks in Mills Canyon area (Early Proterozoic)—Includes the following phases:

Xg_1 Granite (Early Proterozoic)--Ranges from biotite granodiorite to granite. Biotite granodiorite phase consists of 7-10% 1-3 mm biotite flakes in clots; 45-55% 3-7 mm anhedral to subhedral white plagioclase; 25-30% 2-5 mm anhedral colorless quartz and 10-15% K-feldspar in subhedral, pinkish crystals, carlsbad twins commonly visible. Sphene was not observed. The granite phase is coarse grained, with 25-35% quartz, 30-40% subhedral plagioclase, 30-40% subhedral K-feldspar, 3-5% 1-3 mm biotite flakes. Granite and biotite granodiorite are intermingled and gradationally mixed on a decimeter scale; contacts both sharp and gradational. Granite in the Mills Canyon area is generally coarser grained, and contains more quartz and fewer mafic enclaves than the granodiorite (Xgd_1). Hornblende is absent in the granite unit. This unit includes two small exposures of alkalic granite ¼ mile southwest of trailhead north of upper Buckhorn Canyon. This rock contains abundant 5-15 mm-diameter blocky K-feldspar and 10% biotite(?) altered to chlorite + epidote.

Contacts with granodiorite of Mills Canyon are gradational and sharp. Gradational mixed contact with Buckhorn Creek Complex is interpreted to be intrusive. Overlain nonconformably by Tertiary conglomerate of map unit Ts.

Xgd_1 Granodiorite (Early Proterozoic)--This unit includes diorite or gabbro, tonalite, and granodiorite, with gradational contacts between the various phases. The predominant rock is hornblende-biotite granodiorite, medium- to coarse-grained, consisting of 15-25% hornblende and biotite; hornblende crystals are up to 1 cm long, biotite is in 1-3mm diameter flakes; 45-60% plagioclase in 2-15 mm equant to slightly elongate subhedral grains; 15-25% quartz in 2-10 mm equant grains, interstitial to other minerals and frequently as 1 cm equant 'quartz-eyes'; conspicuous 1-3 mm brown sphene is a common accessory. Typically slightly finer-grained than granite unit (Xg_1), and distinguished by ubiquitous presence of hornblende. Weathers to form grussy slopes and rounded granite boulders. Mafic enclaves are common. Flattened enclaves and aligned hornblende crystals define a gneissoid foliation in most of the rock. Mylonite zones up to 20 m thick are present.

Xgb--Diorite-gabbro phase is medium grained and equigranular, consisting of 50-60% plagioclase and 40-50% hornblende or pyroxene, both in subhedral grains 2-7 mm in diameter. Small bodies of this more mafic rock, 10-100 m in long dimension, are scattered in the granodiorite.

Intrudes metamorphic rocks and foliated to gneissic granitoid. Contacts with granite unit (Xg_1) are both gradational and sharp, and the two units are interpreted to be co-magmatic. At sharp contacts, a gneissic zone 1-2 m thick separates the granite and granodiorite. Relationship to Buckhorn Complex is uncertain.

Buckhorn Creek Crystalline Complex (Early Proterozoic)

The Buckhorn Creek Crystalline Complex (new name) consists of igneous and metamorphic rocks composed of mineralogically variable feldspar-quartz-biotite-amphibole gneisses, and granitoid rocks ranging from pyroxene gabbro to muscovite granite. Lithology is quite variable from place to place.

Typically 20-60% of the rock is nonfoliated, fine-grained, pale orange-colored, granitic dikes and irregular intrusions; dikes are typically 1-4 m thick. This intrusive component is fine-grained, homogranular granite to granodiorite with hypidiomorphic-granular or aplitic texture. The granite consists of 25-35% anhedral quartz, 35-50% white (sericite-clay altered?) plagioclase, 0-20% anhedral K-feldspar, 5-20% mafic minerals, mostly chloritized biotite; 2-7% muscovite is present in some areas. Typical grain size is 1-3 mm, but granite becomes medium-grained (2-6 mm) in some areas. Granitic dikes are typically 1-4 m thick, and commonly have gneissoid foliation parallel to dike margins. The dikes are generally discordant to foliation in their host rock. Non-foliated, aplitic granitic rocks are more resistant than more mafic and foliated components of the complex, and typically are exposed on ridge crests and hill tops and form rubble that obscures other less resistant components. Thin quartz-feldspar pegmatite-aplite dikes are also common.

The granitic dikes and intrusions intrude and grade into highly variable mafic igneous rocks, gneiss, and gneissic granitic rocks. Mafic igneous components include very fine-grained diorite, and foliated to massive gabbro. The very fine-grained diorite is an aphanitic to very fine-grained dark gray to black rock, sometimes with a weak cleavage, commonly massive; sparse 1-2 mm plagioclase crystals are sometimes present. Gabbro is fine- to medium-grained, equigranular, and consist of 20-50% plagioclase, and 50-80% equant mafic minerals, apparently mostly pyroxene. Gabbro bodies are generally massive, but foliated near contacts with mafic gneiss, and are commonly agmatitic with veins of fine-grained granite. In some places the gabbro contains 2-3 cm diameter pyroxene(?) phenocrysts; orbicular zones have also been observed, with 3-7 cm diameter, black, elliptical globs of mafic minerals in a matrix of lighter colored, more plagioclase-rich gabbro or diorite.

Gneissic rocks range from mafic to intermediate in composition, and mostly appear to be derived from igneous rocks. The mafic gneiss ranges from fine-grained to medium-grained, and consists of 20-50% plagioclase, 0-10% quartz, 50-80% mafic minerals. Mafic minerals are apparently mostly hornblende, but biotite is commonly present in variable amounts, and the presence of pyroxene is suspected in some gneisses. In the northern part of the complex, the dominant gneissic component is fine-grained quartz-feldspar-biotite gneiss, highly injected with quartzo-feldspathic veinlets that are mostly sub-parallel to dominant gneissic layering, but locally ptygmatically folded. Throughout the complex, gneissic foliation, defined by cm-scale variations in grain size and color index, is folded, chaotic, and locally planar.

The gneissic granitic component includes fine- to medium-grained, homogranular to seriate, weakly foliated to gneissic granodiorite to granite. Rocks intermediate in composition between granodiorite and gabbro are probably present, but were not observed in abundance. These felsic rocks form a continuum with the granitic rocks of the intrusive component described above. Typical granodiorite contains 40-50% subhedral plagioclase in 2-4 mm crystal, 25-30% quartz in 2-3 mm anhedral equant grains, 10-20% anhedral K-feldspar 2-3 mm in diameter, and 3-10% biotite in 1-3 mm diameter, very fine-grained, recrystallized clots. In good exposures in stream bottoms, gneissoid foliation is apparent in the gneissic granitic rocks, defined by grain size and color index variations on a cm- to dm-scale. This foliation is difficult to discern on deeply weathered hill-slope exposures, making the distinction between relatively nonfoliated, late-stage granitoid and the gneissic granitoid host rocks impossible.

The mafic components of the complex are oldest. Gabbro apparently intruded mafic gneiss during a deformation event. Gabbro can be observed intruding across foliation in the gneiss, and as boudins in the gneiss; foliation observed along many gabbro-gneiss contacts is interpreted to be related to deformation that formed the gneissic foliation in the mafic gneiss. Very fine-grained mafic rocks appear to be mafic dikes intruded while granitic components of the complex were still at least partially liquid. The high liquidus temperature of the mafic dike magma allowed the dikes to solidify even as they intruded granitic magmas. Dikes were subsequently dismembered by flow of the granitic magma. Ongoing deformation of the crystalline complex also resulted in fracturing of gabbro bodies and veining by granitic magma to form agmatite. Foliation in felsic components of the complex is crystalloblastic, and the absence of shape fabrics related to mineral plasticity suggest deformation near liquidus temperatures, perhaps at least in part related to intrusion of magma. The late-stage granitic dikes are largely nonfoliated, except for vague gneissoid foliation parallel to dike margins, probably related to flow of magma in the dikes.

The Buckhorn Creek Complex is intruded by granite and granodiorite (Xgd_1 and Xg_1) on the north, and grades into more homogeneous granitoid (Xg_3) southward across the Salt River Canyon along a poorly defined contact.

Xbf **felsic unit (Early Proterozoic)**--Part of Buckhorn Creek complex in which granite and gneissic granitic rocks are the predominant host rock for late granitic dikes. The contact with the mafic unit of the Buckhorn Creek Complex is gradational.

Xbm **Mafic unit (Early Proterozoic)**--Part of Buckhorn Creek crystalline complex in which the predominant host rock for granitic dikes is mafic gneiss and gabbro gradational contact in felsic unit of Buckhorn Creek Crystalline Complex

Mafic intrusive rocks (Early Proterozoic)

Xhm **Hornblendite and mafic intrusive rocks (Early Proterozoic)**--Heterogeneous, with large variations in ratio of mafic to felsic minerals, but generally medium-grained.

In the upper Buckhorn Canyon area this unit contains clots of hornblende up to 10 mm diameter and medium to fine grained, chalky white plagioclase, with rare hornblende(?) crystals up to 3 cm with poikilitically enclosed feldspar. A mafic dike in granodiorite (map unit Xgd_1) adjacent to hornblende diorite may be related to the diorite, suggesting that the diorite is younger than the granodiorite.

Two dike-like bodies of diorite near Burnt Corral campground on the east side of Apache Lake contain 50 to 95% hornblende and are completely unfoliated, with much variation in mafic/felsic ratio.

About two miles southeast of Peters Mountain this unit consists of hornblendite that is intruded by a dike of granite, probably of map unit Xgd_1.

Metamorphic rocks (Early Proterozoic)

Xms **Metasedimentary rocks, undivided (Early Proterozoic)**--Generally quartz-rich metasedimentary rocks. On the south flank of Vineyard Mountain, consists of quartz+sericite and quartz+sericite+feldspar schist, with steep foliation defined by sericite orientation and flattened quartz. Feldspar is generally altered to micaceous minerals (clays?) and is stained with iron oxides. These outcrops resemble Pinal Schist.

Outcrops in the Cottonwood Creek drainage consist of thin bedded, light tan-colored, sericitic arkose grit and sandstone that do not appear significantly deformed. Conglomeratic beds in this unit contain pebbles of quartz. These southern outcrops may be younger than the metasedimentary rocks on Vineyard Mountain. In Cottonwood Creek, intruded by granite (Xg_3) and overlain in angular unconformity by Pioneer Shale.

Xmv **Metavolcanic rocks (Early Proterozoic)**--Felsic to intermediate-composition metavolcanic rocks form a northeast-trending outcrop belt between Mills Canyon and Rock Creek. These rocks separate the granitic rocks in Mills Canyon from the granitic rocks in Rock Creek. The unit consists mostly of light gray felsic tuff(?) that contains common 1-2 mm diameter quartz and feldspar crystals in a microcrystalline, granular groundmass of quartz and feldspar. The rock has a foliation defined by composition or texture variations in the groundmass that define discontinuous lamina. This foliation could be related to a primary eutaxitic foliation, but the rock parts on the foliation planes, revealing aligned chlorite in the foliation, and suggesting that the foliation is a tectonically induced cleavage.

Near the northern boundary of the unit several different tuff units can be recognized, but were not mapped separately. These included the light gray crystal-rich variety described above, a red-brown crystal poor tuff that contains only feldspar crystals, a gray crystal rich tuff that does not contain quartz crystals, and a gray, crystal-rich lithic tuff that contains crystals up to 6 mm diameter and lithic fragments of dense gray felsite.

Intruded by granitic rocks in Rock Creek on the north through a complex mixed zone of hornfelsed volcanic rocks and texturally variable granitoid. Southeastern boundary is poorly exposed high strain zone juxtaposing tectonite derived from the metavolcanic rocks with granodiorite of Mills Canyon.

in the Martin Formation (Middle to Late Devonian)