

# **Geologic map of the Adams Mesa Quadrangle, Maricopa County, Arizona**

by

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## INTRODUCTION

The Adams Mesa quadrangle straddles the boundary between Proterozoic granitic and mid-Tertiary rocks of the Transition Zone, and overlapping late Tertiary basin-fill sediments of the Lower Verde River Valley. The area is dominated by Sycamore Creek, which cuts diagonally across the quadrangle from northeast to southwest and defines the base level for most of the area (see Figures 1 and 2).

State Route 87 traverses the eastern side of the quadrangle. The road to Sugarloaf Mountain is in good condition and connects with several other 4-wheel-drive roads that provide good access to the region northwest of Sycamore Creek. A rough jeep trail heads northward up Sycamore Creek, where the creek intersects Mesquite wash, at least as far as Otero Canyon, but it is very rough and is impassable 3/4 of a mile up Otero Canyon.

Elevations range from about 1540 feet along Sycamore Creek to 3693 feet at Herder Mountain. Field work was carried out during February and March, 1997. Mapping of the surficial deposits was based on both field observations and interpretation of color 1:24,000 scale (approximately) aerial photographs (dated 6-12-88) obtained from the Tonto National Forest Service in Phoenix. The map includes the far northeastern corner of the Fort McDowell Indian Reservation; the rest of the land is administered by the Tonto National Forest. A stratigraphic correlation diagram is included as Figure 3.

## PREVIOUS STUDIES

Wilson, Moore, and Pierce (1957) published reconnaissance geology of the area in a geologic map of Maricopa County, and later in the geologic map of Arizona (Wilson and others, 1969). Anderson and others (1986), and more recently Pearthree and others (1995), made investigations along the Sugarloaf Fault in the northeast corner of the study area. Skotnicki (1992) completed a detailed study of the region and mapped the region to the west in the Lower Verde River Valley (Skotnicki, 1995, 1996a, 1996b). Pope (1974) investigated the Verde River terraces from Coon Bluff to Bartlett Dam, and also described the general bedrock and basin-fill geology of the Lower Verde River Valley. Camp (1986) produced a series of soil maps, in which the study area is included. This study was done during the same field season as mapping to the east in the Mine Mountain quadrangle (Skotnicki and Leighty, 1997a) and to the south in the Stewart Mountain quadrangle (Skotnicki and Leighty, 1997b).

## GEOLOGIC SETTING

### Metamorphic rocks

Foliated and slightly folded quartzite and rhyolite are exposed at the northern edge of the map near Herder Mountain. Bedding, cross-bedding, and locally ripple marks are visible within the quartzite and show that the quartzite overlies the rhyolite. Locally, the rhyolite contains light grey radiating crystals of pyrophyllite and black tourmaline. These rocks have been intruded by a nonfoliated, coarse-grained K-feldspar porphyritic granite. Exposures of metamorphic rocks segregated into small lens-like enclaves. The northeast-trending strike of the metamorphic rocks lines up with exposures of quartzite and rhyolite to the southwest in the McDowell Mountains and to the northeast in the Mazatzal Mountains (recently discovered in the Boulder Mountain quadrangle). These rocks may be part of the Alder Group.

### Granitic rocks

Granitic rocks comprise most of the basement in the map area. These rocks are divided into two major plutons; (1) a nonfoliated coarse-grained K-feldspar porphyritic granite northwest of Sycamore Creek (map unit Yg), and (2) a foliated coarse-grained, K-feldspar porphyritic quartz monzonite southeast of Sycamore Creek (map unit Xg). Foliation in the quartz monzonite varies from weak to strong. About 1/2 mile northwest of Sugarloaf Mountain the primary foliation is cut by a subhorizontal foliation restricted to thin (several centimeters wide) shear planes. This secondary foliation was not observed elsewhere. Southwest of Sugarloaf Mountain, the quartz monzonite is locally granitic in composition. The quartz monzonite contains



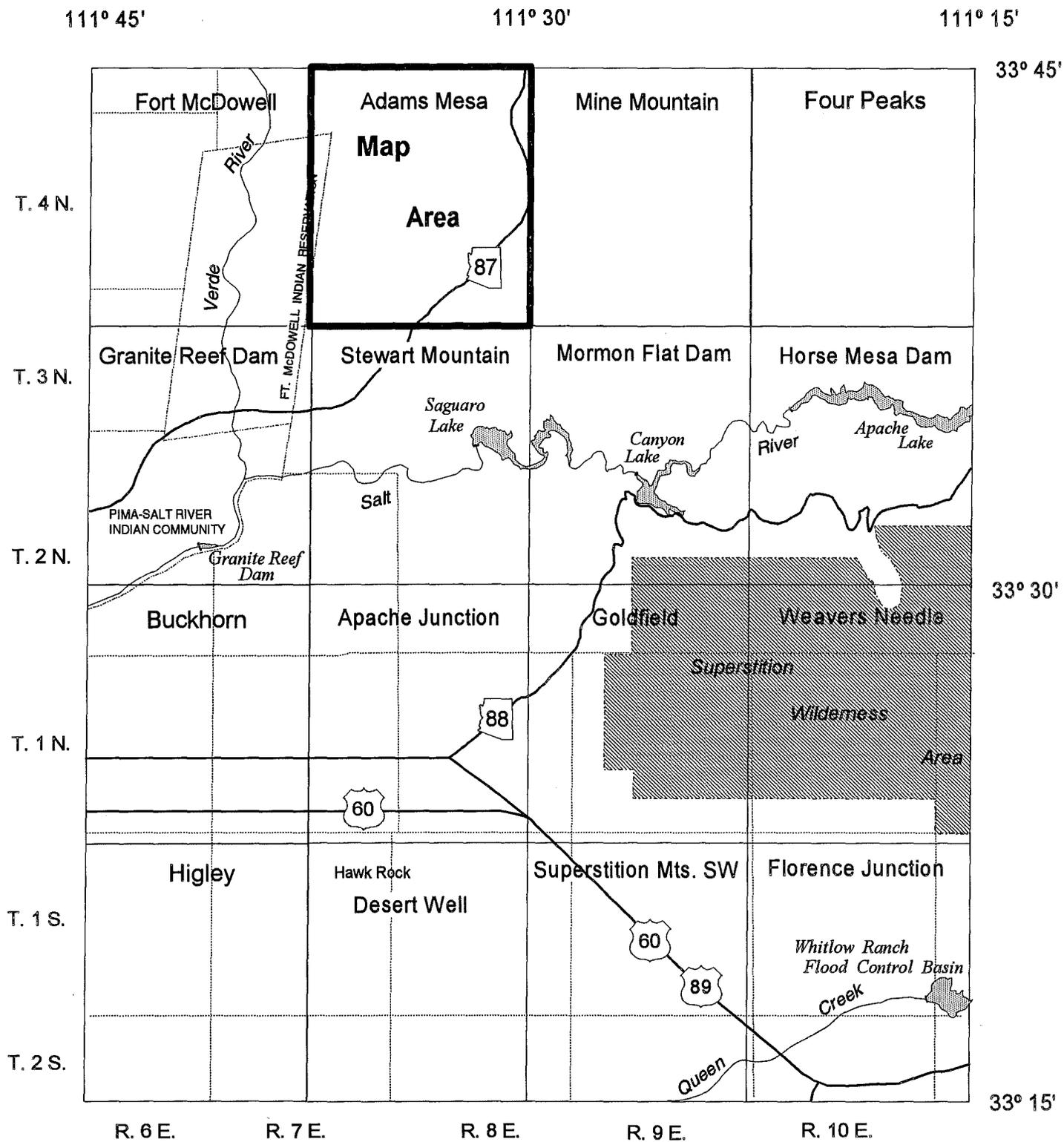
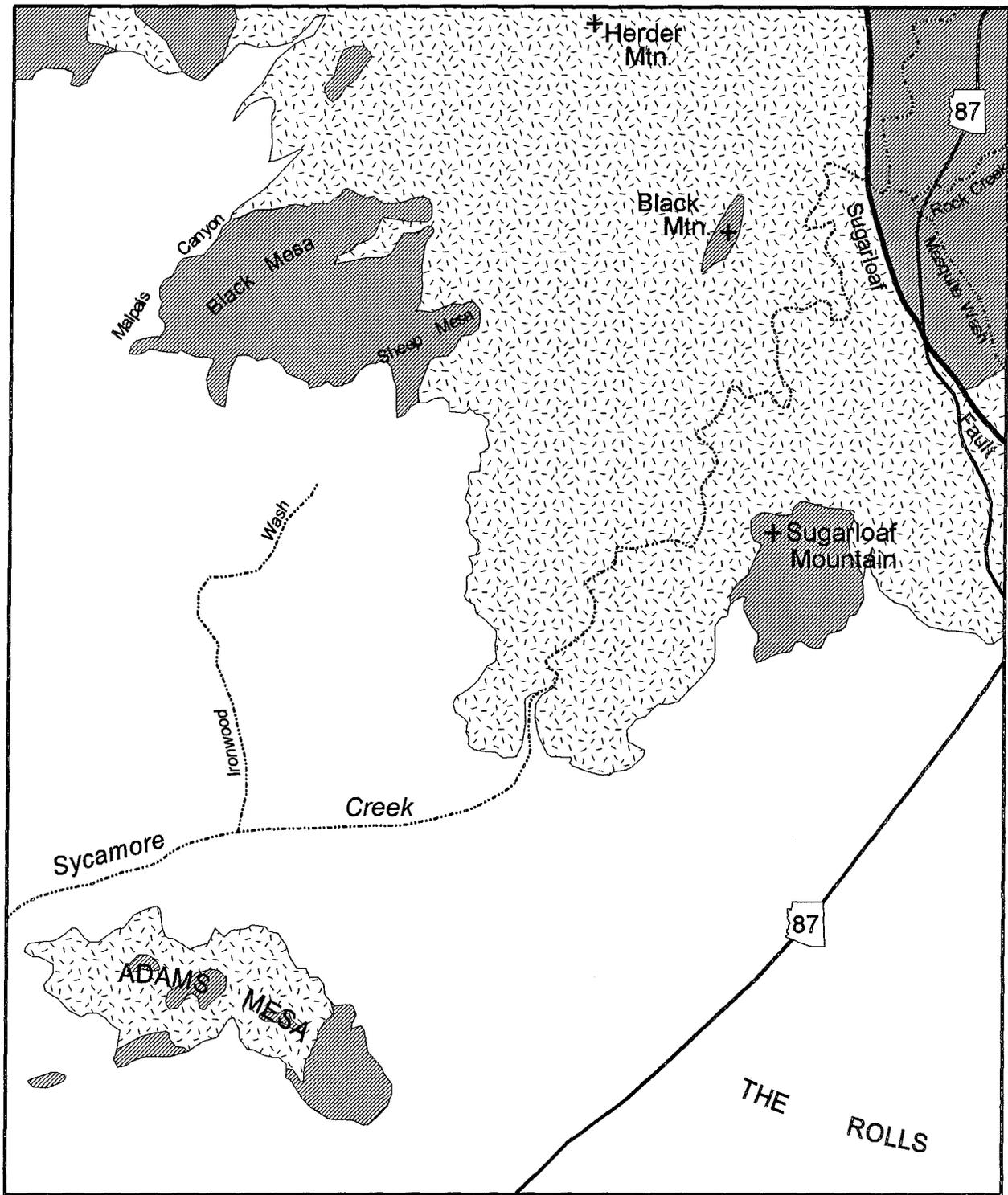


Figure 1. Location of U.S.G.S topographic maps and study area.



-  Tertiary volcanic and sedimentary rocks
-  Proterozoic granitic and metamorphic rocks

Figure 2. Index map showing place names and geographic locations in the Adams Mesa quadrangle.

many foliated northeast-striking leucocratic granite dikes that are particularly well-exposed southwest and northeast of Sugarloaf Mountain.

A nonfoliated granite (map unit Yg) intrudes the quartz monzonite. This rock is rich in quartz and contains abundant large pink K-feldspar megacrysts and fresh books of biotite. The coarse-grained phase of Yg was preceded, at least locally, by a finer-grained phase (map unit Ygf). The fine- to medium-grained phase (also granitic) is exposed at the edge of the pluton near the intersection of Mesquite Wash and Sycamore Creek. The contact between the coarse- and fine-grained rocks is very irregular and complex, but it appears the coarser phase intruded the finer phase. More evidence of this relationship can be seen on the west side of the creek west of Sugarloaf Mountain, where small lenses of nonfoliated leucocratic granite (not shown) intrude quartz monzonite. In turn, the bodies are truncated by the coarse-grained granite (Yg).

The quartz monzonite pluton is intruded by many northwest-striking, near vertical quartz-feldspar porphyry (granite porphyry) dikes. The dikes are not foliated and are locally either fine- or coarse-grained. They do not appear to cut the younger nonfoliated granite. One dike terminates abruptly at the quartz monzonite/granite contact. This suggests that the dikes may be related to intrusion of Yg.

### Tertiary rocks

West of the Sugarloaf Fault, thin, discontinuous exposures of prevolcanic, granitic (grussy) conglomerate (map unit Tc) underlie a sequence of alkali basalt flows (see Figure 3). At Sheep Mountain conglomerate containing minor amounts of low-density rhyolite/pumice clasts is interbedded with basalt near the base of the sequence. The basalt throughout the field area is typically fine-grained to massive and contains phenocrysts of clinopyroxene and olivine. At Sugarloaf Mountain, however, the uppermost flows contain olivine and appreciable amounts of quartz and hornblende. In these rocks both quartz and olivine are rimmed by hypersthene, indicating disequilibrium in the melt; the quartz may be a crustal contaminant. Hornblende occurs as coarse, intergrown crystals in xenoliths up to several centimeters across.

The granitic basal conglomerate is much thicker east of the Sugarloaf Fault. It is only exposed in the extreme northeast corner of the map where it thickens to the northeast to about 110 meters thick. The conglomerate is much thicker here than to the west. Faulting along the Sugarloaf Fault created a basin, into which a thick sequence of conglomerates accumulated. East of the fault a sequence of alkali basalt flows overlie and interfinger near the base of the conglomerate (in the Boulder Mountain quadrangle). Overlying most of the basalt flows is another conglomerate that is rich in basalt clasts on the east side of Mesquite Wash (map unit Tcb) and rich in quartz monzonite clasts on the west side (map unit Tcg). This conglomerate is thickest in the south along Mesquite Wash and the southeastward-curving section of the Sugarloaf Fault, and thins rapidly to the north. The outcrop pattern suggests the unit filled a topographic low probably created by renewed faulting along the Sugarloaf Fault. The basaltic-rich phase of the conglomerate reflects deposition from the east, where basalt was exposed. The quartz monzonite-rich phase of the conglomerate reflects deposition from the west, where the fault scarp of the Sugarloaf Fault formed an easily erodible scarp. Overlying the conglomerate near the confluence of Sycamore Creek and Mesquite Wash is another fine-grained basalt containing fresh, dark green pyroxene phenocrysts. This basalt appears to be interbedded with Tcb and Tcg (see Figure 4).

At Sugarloaf Mountain and Adams Mesa basalts lap up onto steep, south-facing granitic slopes, belying the presence of considerable paleotopography. The basalt and conglomerate throughout the study area dip on average about 15 degrees to the southwest. Shafiqullah and others (1980) reported a K-Ar whole-rock age of  $15.53 \pm 0.4$  Ma for a basaltic andesite within a similar sequence of rocks to the south, north of Stewart Mountain. Given this age, these rocks are probably equivalent to the Hickey Formation (Eberly and Stanley, 1978).

Unconformably overlying the volcanic and granitic rocks is a thick sequence of interbedded tan-colored sandstones and conglomerates. These deposits are moderately to strongly consolidated and are undeformed, except on the northeast side of Adams Mesa where they are cut by a minor north-northwest striking, east-dipping normal fault. They contain poorly sorted clasts of granite and basalt, but also locally a

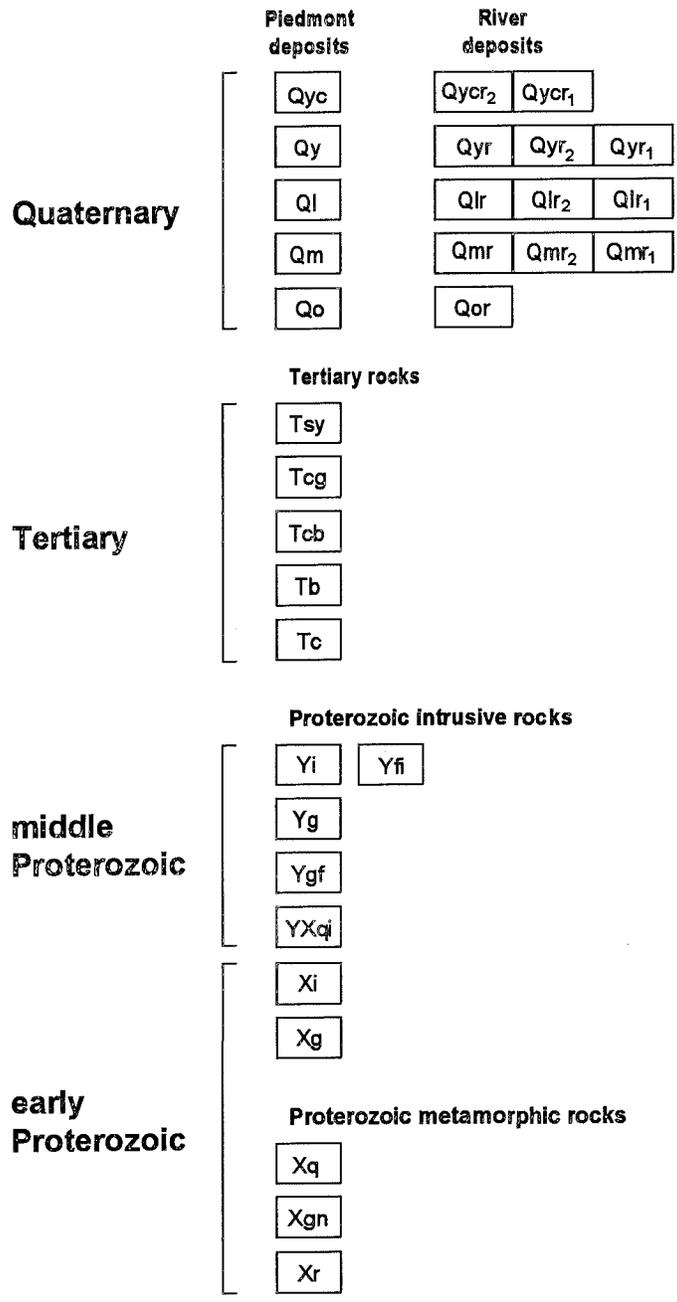


Figure 3. Correlation diagram for the Adams Mesa quadrangle.

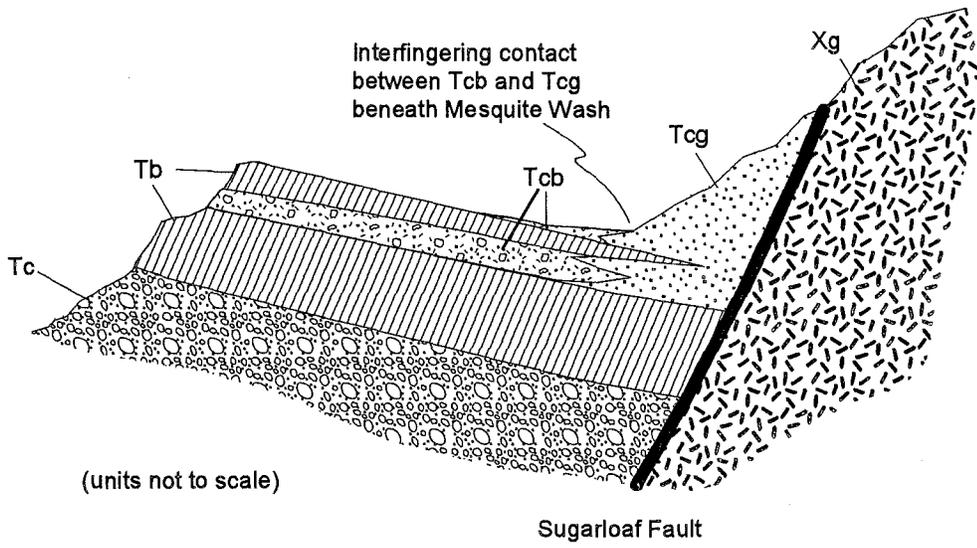


Figure 4. Diagrammatic cross-section across the basin formed by the Sugarloaf Fault.

large percentage of Tertiary and Proterozoic rhyolite, and various Proterozoic metamorphic clasts. These deposits are deeply dissected and form steep rounded ridges throughout much of the southern half of the map.

### Quaternary deposits

A complex series of terraces has developed along Sycamore Creek. Although the levels are not as well defined as those along the Salt and Verde Rivers, it is evident that there are multiple levels. The terraces occur as small isolated remnants along the meandering course of the creek and are difficult to correlate. The highest remnant (map unit Qor) is exposed on the northwest side of the meander where Mesquite Wash intersects Sycamore Creek. Here, the terrace is about 180 feet above the modern drainage.

Terrace remnants along Mesquite Wash and Rock Creek are similar to those along Sycamore Creek in that they contain well-rounded cobbles and boulders. Unlike the heterolithic Sycamore Creek terraces, however, these other terraces are composed almost solely of clasts derived from fine- to medium-grained granite eroded from Pine Mountain to the east (map unit Ygm in Skotnicki and Leighty, 1997a). The terrace remnants along Mesquite Wash and Rock Creek (map units Ql and Qm) could be classed as river terraces (i.e., with the suffix "r" on the label), but were not only because their respective drainage basins are much smaller than that of Sycamore Creek.

## STRUCTURE

Generally north-striking, down-to-the-east normal faults cut the middle Tertiary conglomerates and basalts and tilts some of them to the west. The major structure in the map area is the Sugarloaf Fault, which curves from northwest-striking to north-striking and continues for many miles northward at least as far north as Diamond Mountain. The change in strike from northwest to north is similar to other major basin-bounding faults in central Arizona (i.e., the Horseshoe Fault, faults in granite north of Bartlett Lake, and within the Tonto Basin, and the Payson Basin). Along the Sugarloaf Fault, east of State Route 87, the quartz monzonite is crushed and brecciated and stained red with hematite. Quartz veins and hematite locally fill fractures in the brecciated rock. On the ground the fault plane can be located relatively easily but it is not well-exposed. In air photos it is an obvious structure, defined by a small erosional scarp in the quartz monzonite up to 2 or 3 meters high in places. On the ground the scarp is locally, though not everywhere obvious. An old eroded scarp, dipping about 45 degrees east, is visible on the southern part of the fault and into the Mine Mountain quadrangle.

Younger Holocene alluvial deposits bury the Sugarloaf Fault in many places. A trench dug across the fault directly west of where the highway crosses the fault revealed a thin, unfaulted Holocene alluvial cover about 1 meter thick overlying faulted Late Pleistocene alluvial sediments (Pearthree et al., 1995). With data from this and other trenches and gullies along the fault, Pearthree and others (1995) concluded that the last rupture on the Sugarloaf Fault occurred not less than about 10,000 ka, with a probable surface rupture of about 1 meter.

Faulting along the Sugarloaf Fault created a structural basin into which conglomerates and basalts were deposited (see Figure 4). Thick accumulations of these rocks were deposited on the east side of the fault (within the basin) compared to thin deposits on the west side (see Figure 3). The upper conglomerate (map units Tcb and Tcg) and upper basalt flow(s) are thickest along the fault at Mesquite Wash and indicate that faulting continued on the southern part of the fault through deposition of these units.

West of the Sugarloaf Fault, another north-striking normal fault cuts through Black Mountain and projects southward along the modern course of Sycamore Creek. Locally along the fault, the groundmass of Yg is extensively altered to fine-grained chlorite, and forms dark green outcrops. Pods of chlorite-altered granite also occur far away from the fault and are not associated with any other visible structures. Therefore, alteration is probably not directly associated with faulting. Similar chlorite-altered zones were observed in a different granite pluton southeast of Blue Point Bridge, in the Stewart Mountain quadrangle.

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**UNIT DESCRIPTIONS  
FOR THE ADAMS MESA QUADRANGLE  
AZGS OFR-97-10**

Quaternary

Piedmont Deposits

- Qyc** **Modern alluvium (<100 yr).** Unconsolidated sand and gravel in modern active stream channels. Deposits consist of stratified, poorly to moderately sorted sands, gravels, pebbles, cobbles, and boulders. These deposits are highly porous and permeable. Minimal soil development.
- Qy** **Holocene alluvium (<10 ka).** Unconsolidated sand to small boulders reaching several tens of centimeters in diameter upstream but are smaller and fewer downstream. These deposits are dissected as much as about 4 meters in tributaries where they enter Sycamore Creek. Qy deposits are characterized by stratified, poorly to moderately sorted sands, gravels, and cobbles frequently mantled by sandy loam sediment. On this surface the main channel commonly diverges into braided channels. Locally exhibits bar and swale topography, the bars being typically more vegetated. Soil development is relatively weak with only slight texturally or structurally modified B horizons and slight calcification (Stage I). Some of the older Qy soils may contain weakly developed argillic horizons. Because surface soils have little clay or calcium carbonate, Qy deposits have relatively high permeability and porosity.
- Ql** **Late Pleistocene alluvium (10 to 250 ka).** Moderately sorted, clast-supported sandstones and conglomerates containing subangular to subrounded granitic, metamorphic, and basaltic clasts in a grussy and sandy tan to brown matrix. Ql surfaces are moderately incised by stream channels but still contain constructional, relatively flat, interfluvial surfaces. Ql soils typically have moderately clay-rich, tan to red-brown argillic horizons. They contain some pedogenic clay and some calcium carbonate, resulting in moderate infiltration rates. Thus, these surfaces favor plants that draw moisture from near the surface. Ql soils typically have Stage II calcium carbonate development.
- Qm** **Middle Pleistocene alluvium (250 to 750 ka).** Moderately to poorly sorted, clast-supported sandstones and conglomerates containing subangular to subrounded clasts of granite, basalt, rhyolite, and metamorphic rocks. Argillic horizons are weak to strong. The deposits are locally strongly indurated by calcium carbonate. Clasts are slightly to moderately varnished. The unit is deeply dissected and ravines reveal relatively thin deposits, from 2 to 5 meters thick. Argillic horizons are strongly developed where original depositional surfaces are well-preserved, but are much weaker or nonexistent on ridge slopes.

River Deposits

- Qycr<sub>2</sub>** **Active channel deposits.** Unconsolidated, moderately to poorly sorted, clast-supported sand, cobbles, and small boulders. Deposits along Sycamore Creek alternate between rounded cobbles and grussy sand. Downstream from where the creek exits the confined gorge and dramatically widens, the majority of the sediments are grussy and sandy. Because the channel is relatively active there is little or no vegetation.
- Qycr<sub>1</sub>** **Modern flood plain deposits (0 to 100 yrs).** This surface is inundated during floods. It consists of moderately sorted, unconsolidated to poorly consolidated sand, cobbles, and small boulders in

recently active channels separated from the main active channel. The unit also contains sandy and silty overbank deposits.

- Qyr** Holocene river terrace deposits (0 to 10 ka). Equivalent to the Lehi Terrace of Pewe (1978). Consists mostly of unconsolidated, well-rounded pebble- to cobble-sized river gravels surrounded by a sand and minor silt matrix. Also includes overbank sediments (finely laminated clays, silts, and fine sands) Soil development is weak, primarily consisting of slight organic accumulation at the surface and some bioturbation. This unit is used for terraces along Sycamore Creek that are about 10 to 20 feet above the modern channel and do not show evidence of recent flooding. Most have upper surfaces covered by thick groves of mesquite. Surfaces with obvious alluvial fan morphology are grouped in unit Qy.
- Qyr<sub>2</sub>** Younger member of the Lehi terrace. May be inundated in largest floods.
- Qyr<sub>1</sub>** Older member of the Lehi terrace.
- Qlr** Late Pleistocene river terrace deposits (10 to 250 ka). Equivalent to the Blue Point terrace of Pewe (1978). Well-rounded, pebble- to cobble-size river gravels surrounded by a sand and minor silt matrix. Soil development includes moderate clay and calcium carbonate accumulation.
- Qlr<sub>2</sub>** Younger member of the Blue Point terrace.
- Qlr<sub>1</sub>** Older member of the Blue Point terrace.
- Qmr** Middle Pleistocene river terrace deposits (400 to 750 ka). Equivalent to the Mesa terrace of Pewe (1978). Well-rounded pebble- to cobble-size river gravels strongly indurated by calcium carbonate (poorly exposed). Well-developed argillic horizons where terrace surface is well-preserved.
- Qmr<sub>2</sub>** Younger member of the Mesa terrace.
- Qmr<sub>1</sub>** Older member of the Mesa terrace.
- Qor** Early Pleistocene river terrace deposits (750 ka to 2 Ma). Equivalent to the Sawik terrace of Pewe (1978). Well-rounded pebble- to cobble-size river gravels, strongly indurated by caliche. An exposure on the northwest side of the confluence of Mesquite Wash and Sycamore Creek is 180 feet above the modern channel and contains some very large rounded boulders of basalt 1 to 2 meters across. Clasts exhibit strong desert varnish, and larger clasts are split and pitted.

#### Tertiary Units

- Tsy** Younger sedimentary basin-fill deposits (late Tertiary). Tan-colored, moderately to poorly sorted, sandstones and conglomerates. Finer-grained silt, sand, and pebbles are composed mostly of subangular granitic gneiss. Coarser cobbles and small boulders are mostly subangular to subrounded metamorphic clasts, Tertiary volcanic clasts and, locally, granite. Northwest of Sycamore Creek the deposits contain abundant basalt clasts. South of Sugarloaf Mountain they contain abundant Proterozoic metamorphic clasts (including rhyolite, argillite, quartzite, and granitic rocks). Near Adams Mesa the unit contains mostly clasts of Tertiary rhyolite. Southeast of Sugarloaf Mountain deeply dissected deposits reveal a lower part that is rich in granitic material which erodes into steep

gullies, and an upper part that contains abundant clasts of quartzite, argillite, and basalt, that weathers into smooth ridge tops.

- Tcg Granite-clast conglomerate (middle Tertiary).** Tan to light grey, thinly bedded, weakly to moderately consolidated sandstone and conglomerate, forming the light colored, dissected hills west of Mesquite Wash. Contains clasts of quartz monzonite (map unit Xg), and minor fine-grained granite (Ygf) and basalt. Probably derived from the paleo-scarp/ridge immediately to the west. This unit probably overlies the tan, basaltic conglomerate (map unit Tcb) and/or probably interfingers with it under Mesquite Wash. The unit dips to the west-southwest. On the south side of the confluence of Mesquite Wash and Sycamore Creek, hidden in trees, is an outcrop of Tcg that looks horizontally bedded. A spring seeps from the ledge.
- Tcb Basalt-clast conglomerate (middle or late Tertiary).** Tan to light grey and brown, thinly to moderately bedded sandstones and conglomerates. The lower parts contain abundant basalt clasts 1-5 cm across, in a grussy matrix. The upper parts contain fewer basalt clasts, especially towards the east in the Mine Mountain quadrangle. This unit is moderately consolidated and forms well-exposed, resistant tan-colored hills. These deposits may grade upward into the granitic conglomerate (map unit Tcg) or may interfinger laterally into it. This unit thins northward where it is capped by a fresh basalt flow.
- Tb Basalt (middle Tertiary).** Mostly olivine basalt. The rock is typically fine-grained to massive, dark grey, and contains anhedral to euhedral 1-3 mm phenocrysts of olivine altered to serpentine, talc, and iddingsite. Locally, outcrops are vesicular, with vesicles filled with calcite and/or zeolite. The rocks comprise a sequence of thin flows several meters thick locally separated by basaltic autobreccia. The uppermost flows on Sugarloaf Mountain contain quartz and hornblende xenocrysts or phenocrysts. At Adams Mesa basalt overlies and is interbedded with conglomerate and contains 5-10% olivine phenocrysts <1mm in diameter. The unit is cut by normal faults and forms southwest-tilted fault blocks.
- Tc Conglomerate (middle Tertiary).** Tan to slightly red-colored, interbedded sandstone and conglomerate. The unit is clast-supported, inversely to normally graded (where grading exists), and consists almost entirely of granitic clasts and gruss. The larger clasts range in size from a few centimeters to half a meter or more, and are commonly poorly sorted and subangular to rounded. Stratification is best seen from a distance. Locally bedding is well defined by variation in cobble size. Exposures are poorly to moderately consolidated. Interbedded with basalt at Adams Mesa and Sheep Mountain. At Black Mountain west of the Sugarloaf Fault channels filled with coarse pebbles weather out in relief. At Adams Mesa the unit contains alternating coarse-grained and fine-grained beds that contain mostly granitic material but also basalt clasts and bombs up to about 50 cm across.

#### Proterozoic Intrusive Rocks

- Yi Quartz-feldspar porphyry dikes (middle Proterozoic).** These dikes contain subhedral phenocrysts of quartz (20%), plagioclase (40%), and K-feldspar (40%), in a light grey to red-grey aphanitic matrix. They form long, west-northwest-trending dikes that vary in thickness from a few meters to about 10 meters thick, and extend for several kilometers eastward outside the quadrangle. The dikes may be locally fine-grained.

- Yfi** **Fine-grained dike (middle Proterozoic).** One dike west of the Sugarloaf Fault that is light grey, aphanitic, and non-foliated. Other smaller dikes of similar composition are present, particularly in the road cuts along State Route 87, but were not mapped.
- Yg** **Granite (middle Proterozoic).** Nonfoliated, coarse-grained granite containing large, abundant, pink, subhedral K-feldspar phenocrysts up to 5 cm long, in a matrix of plagioclase, quartz and biotite. Plagioclase is light grey and commonly sericitized. Biotite (about 2-10% of rock) occurs as anhedral to subhedral books 4-5 mm wide. Quartz is clear-grey. This rock is less resistant than the quartz monzonite and weathers into smooth rounded hills with spheroidal boulders and guss. Locally intruded by aplite dikes commonly about 10-30 cm thick. Some are gradational with the granite. Others dip about 70° north. This appears to be the same granite that is exposed in the northern McDowell Mountains and Carefree.
- Ygf** **Fine-grained granite (middle Proterozoic).** This unfoliated granite contains crystals of K-feldspar, plagioclase, quartz and biotite 1-3 mm wide. Locally, the rock contains larger phenocrysts of K-feldspar up to 1-2 cm. The contact between map unit Yg and this rock unit is irregular and not sharp, but embayments of Yg within Ygf suggest Yg intruded this unit. Exposed west of the confluence of Mesquite Wash and Sycamore Creek. The rock is similar to the fine-grained granite exposed near Bartlett Dam.
- YXqi** **Quartz intrusions (early or middle Proterozoic).** Small elongate white quartz intrusions on the west side of Adams Mesa. Exposures are highly fractured.
- Xi** **Leucocratic granite dikes (early Proterozoic).** These dikes contain anhedral to subhedral 1-3 mm phenocrysts of light grey feldspar, clear quartz, and minor biotite mostly altered to hematite. Locally, K-feldspar crystals are up to 1.5 cm long. The rocks are foliated and forms resistant, light-colored ridges within the quartz monzonite they intrude. Most of the dikes strike northeast.
- Xg** **Quartz monzonite (early Proterozoic).** Foliated, coarse-grained, K-feldspar porphyritic quartz monzonite. Contains anhedral to subhedral, light grey to locally pink K-feldspar phenocrysts, that are nowhere larger than 1.5-2 cm across. Light grey plagioclase and clear-grey quartz are 2-8 mm wide. Biotite occurs as felty clumps and is locally altered to chlorite. This unit forms most of the mass of the southern Mazatzal Mountains south of Boulder Mountain. In the Adams Mesa quadrangle foliation is typically weak, and is strongest southwest of Sugarloaf Mountain. This unit forms the spheroidal boulder fields through which State Route 87 passes.

### Proterozoic Metamorphic Rocks

- Xq** **Quartzite.** Metamorphosed, blue-grey to tan, fine- to coarse-grained quartzite. Typically fine-grained (grains less than 1 mm) and laminated with thin ilmenite/magnetite layers. Grains are well-sorted and subrounded to rounded. Contains minor metamorphic muscovite. Locally it contains light grey, radiating mica crystals (pyrophyllite?), black tourmaline, rectangular hematite crystals up to about 3 mm wide, and rare red garnet. Locally, the unit contains siltstone and stretched-pebble conglomerate. The pebbles are felsic (probably vein quartz or quartzite) and are elongated in a northeast-southwest direction. Conglomerate quartzite also locally contains small distinctive jasper grains. Bedding is approximately parallel to foliation, though foliation is not expressed well in the more competent units. Abundant cross-bedding and minor ripple marks show that the top of the sequence is to the northwest. Contacts with Yg are sharp. The quartzite becomes more massive and less foliated to the north.

- Xgu** **Felsic gneiss (early Proterozoic).** This leucocratic gneiss is highly deformed locally and contains leucosomes of quartz and feldspar, and quartz and muscovite. Locally it is very fine-grained and resembles deformed rhyolite. In other places it resembles deformed, interbedded rhyolite and quartzite. Exposures of this rock are very few and are found about 1 mile southwest of Herder Mountain near the dirt road.
- Xr** **Rhyolite (early Proterozoic).** Fine-grained metamorphosed rhyolite. This rock contains about 5-10% phenocrysts of quartz and feldspar in a pink to tan aphanitic to sericitic matrix. The unit commonly shows contorted to relatively laminar flow-banding. Stretched pumice clasts and blocks are visible locally. In places near the contact with the quartzite the rhyolite is deformed into a gneiss (mapped separately as Xgu). Contacts with Yg are sharp.