Geologic map and report for the Buckeye 7.5' Quadrangle, Maricopa County, Arizona

by

Steven J. Skotnicki

Arizona Geological Survey
Digital Geologic Map DGM-15

August, 2002

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

Includes 15-page text, and 1:24,000 scale geologic map.

Research partially supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number #01HQAG0098.

INTRODUCTION

The Buckeye Hills are located approximately 30-40 km west-southwest of Phoenix, Arizona, directly south of the Town of Buckeye (see figure 1). Regionally, the Buckeye hills are sandwiched between two broad alluvial bajadas. To the north, a vast alluvial plain slopes southward toward the hills from the White Tank Mountains, while to the south, another broad bajada slopes northward from the Maricopa Mountains, also toward the hills. The Gila River skirts the northern edge of the bedrock as it flows west across the northern part of the quadrangle.

Although some of the taller hills project over 600 feet above the surrounding plain, topographic relief in the map area is typically very low. Much of the bedrock has been eroded into low-relief pediments. From a distance these pediments deceptively resemble extensive alluvial plains. Several episodes of erosion, sedimentation, and entrenchment have resulted in a myriad of dissected alluvial deposits across the pediments.

The Buckeye hills are composed chiefly of three distinct early Proterozoic granitic rocks: (1) a coarse-grained granite, (2) a medium- to coarse-grained granite and (3) a fine-grained granite. There are at least two varieties of fine-grained granite (described below), distinguished from one another by the relative abundance of biotite. All of the granitic rocks are foliated. Non-foliated pegmatite dikes cross-cut the fine-grained granite and appear to post-date deformation.

Field work was carried out between November, 2001 and March, 2002. Two days a week were spent in the field for a total of about 36 days of fieldwork for the Buckeye and Avondale SW quads together. The surficial deposits in the southern part of the quadrangle were mapped using aerial photos from the BLM dated at 6/12/78. The Gila River flood plain was mapped using digital photos (not in stereo) obtained from the Maricopa County Flood Control District taken in 2001.

PREVIOUS WORK

Miller (1987) created the first detailed map of the Buckeye Hills. She focused on the fine-grained granite (the ‘Buckeye Pluton’, as she called it) and recognized that it is a peraluminous two-mica (biotite + muscovite) granite with chemistry consistent with other Proterozoic peraluminous granites in the southwest. Sommer (1982) studied the area directly east of the map area, at the north end of the Sierra Estrella, where he determined metamorphic conditions of ~725°C and ~5.5 Kbars (upper amphibolite metamorphic facies). Melchiorre (1993) mapped the bulk of the Sierra Estrella and described the petrology and structure of the range. Cunningham and others (1987) mapped the Maricopa Mountains to the south. They identified a fine-grained peraluminous granite, which Reynolds and Dewitt (1991) informally called the ‘Granite of Cotton Center’, intruding an extensive coarse-grained granite, which Reynolds and Dewitt (1991) informally called the ‘granite of the Maricopa Mountains’. Reynolds and Dewitt (1991) determined that rocks in the Maricopa Mountains were also metamorphosed to the upper amphibolite facies. Potochnik (2001) made subsurface interpretations based on seismic lines in the Maricopa Mountains region. This author did some reconnaissance mapping in the Buckeye Hills in 1993 that was incorporated into the 1:100,000 geologic map of the Phoenix South 30′ x 60′ quadrangle (Reynolds and Skotnicki, 1993). This quadrangle was studied concurrently with mapping to the east in the Avondale SW quad.

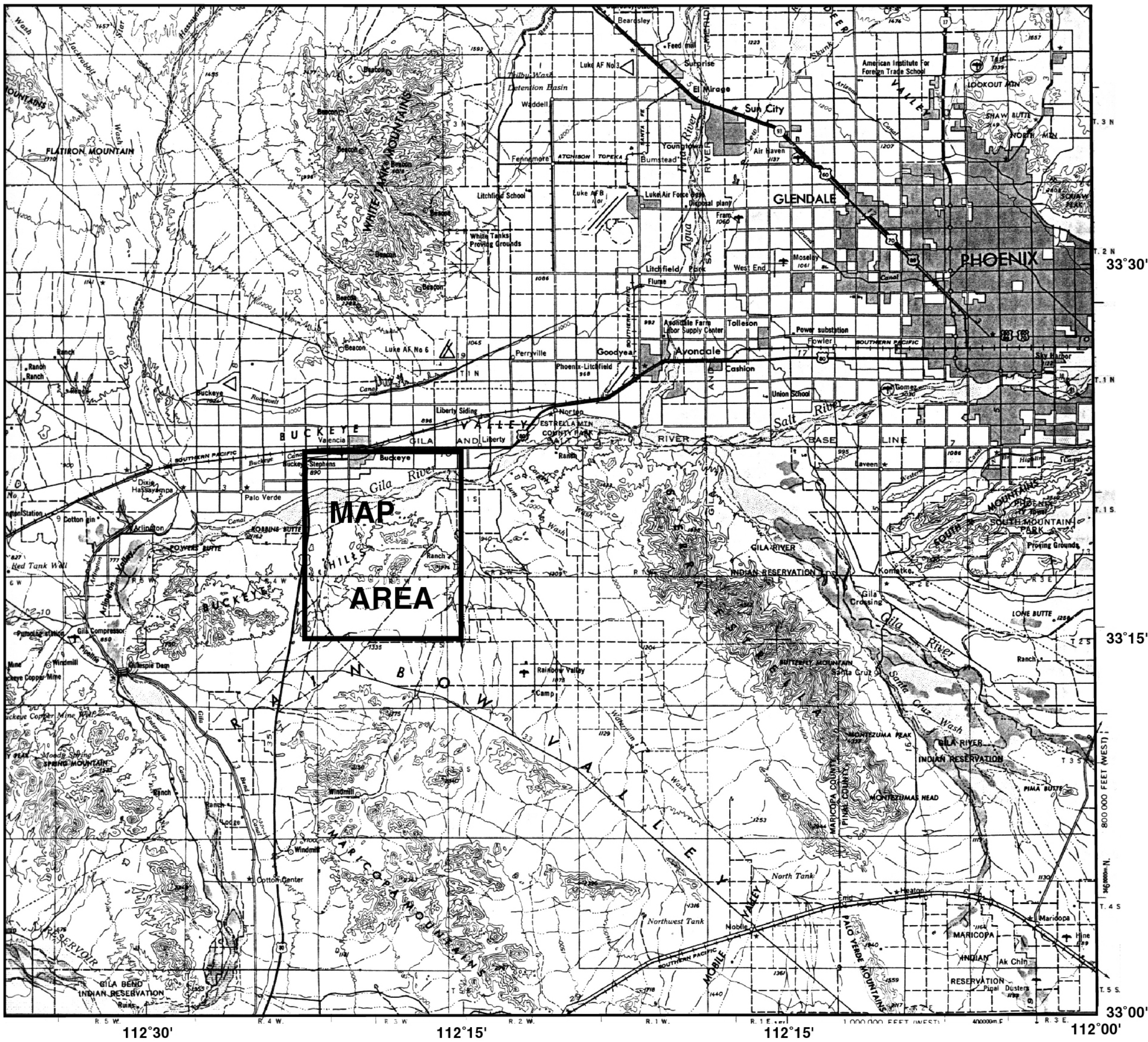

Figure 1. Index map showing the location of the Buckeye 7.5' quadrangle.

COARSE-GRAINED GRANITE (Maricopa Granite; map unit Xgc)

The coarse-grained granite that crops out in the southeastern part of the map area is very distinct from the other granites in the region. At first glance the granite resembles the typical ~1.4 Ga granites exposed elsewhere in the state. It is very coarse-grained, with K-feldspar phenocrysts up to 2 cm across. The K-feldspar phenocrysts are typically light gray and only locally pink. Biotite varies from about 5% to locally 15%, but overall is mostly between 5 and 10%. Biotite occurs as thin anhedral books and aggregates locally partially altered to hematite and/or chlorite. Cunningham and others (1987) mapped this unit in the Maricopa Mountains to the south as "porphyritic granite". Reynolds and DeWitt (1991) later gave it the informal name "granite of the Maricopa Mountains". Since the boundaries and character of this pluton are now fairly well mapped and understood the more formal designation, "Maricopa Granite", is here proposed.

Except for exposures in sections 3 and 10, T. 2 S., R. 3 W., most exposures are foliated. One thin (10-20 cm-thick) mylonitic shear zone was identified in section 11, T. 2 S., R. 3 W., where it strikes about 45° northeast and dips 60° east. To the east in the Avondale SW quad, mylonitic foliation is more widespread. It should be pointed out, however, that recrystallization outlasted strain in the highly deformed rocks. As a result, in thin-section the rocks show an annealed, sutured, mosaic pattern with no visible strain shadows nor pronounced undulatory extinction in quartz. Reynolds and Dewitt (1991) recognized this same recrystallization in similar rocks to the south.

The Maricopa Granite is intimately associated with the leucocratic granite (map unit Xgl) in the eastern part of the map area. Contacts are sharp and both granites form long, lenticular bodies within the other. Because of this, it is not certain which granite intrudes the other. Because this same leucocratic granite (if it really is the same) intrudes the Maricopa Granite to the south (Cunningham, 1987) and southwest (Gilbert, 1991) it has been inferred here that Xgl intrudes Xgc. The contact between the Maricopa Granite and the Corbett Wash Granite (map unit Xg) is poorly exposed but sharp and is not a fault contact. Hence, the age relationship between these two granites is uncertain.

Locally this granite contains sparsely distributed, dark-colored, fine-grained inclusions. The inclusions are typically rounded, pebble- to fist-sized, and are composed of feldspar, quartz, accessory zircon, sphene and apatite, and abundant biotite ± amphibole. Many inclusions contain larger, outsized K-feldspar phenocrysts up to 1 cm across, 'floating' in the fine-grained groundmass. In one thin-section examined quartz and feldspar crystals are separated from one another by a thin band of unknown material. The bands vary in thickness from one crystal to the next but are relatively constant in width along the length of an individual crystal. The bands appear to be made of a material that has very low birefringence and is almost isotropic, resembling quickly cooled 'glassy' melt. Besides being more mafic and finer-grained the overall mineralogy of the inclusions is similar to the mineralogy of the coarse-grained granite, and in this respect the inclusions resemble restite.

MEDIUM- TO COARSE-GRAINED GRANITE (Corgett Wash Granite; map units Xg and Xgw)

This medium- to coarse-grained biotite granite also contains subhedral microcline phenocrysts but is distinct from the Maricopa Granite (map unit Xgc) in two ways: (1) this unit is overall finer-grained than the Maricopa Granite, and (2) biotite in this rock occurs as thin, fresh, black, individual crystals distributed rather evenly, rather than in books. The granite is exposed in the central part of the quad where it forms some of the highest peaks and ridges in the map area. The rock tends to form large subrounded to subangular boulders that spall away from the mountains along near-vertical joints (not mapped). The granite is homogeneous over large areas, but varies slightly in texture from slightly coarse-grained and K-feldspar-porphyritic to more medium-grained and nearly equigranular. Two mappable varieties were recognized—the 'normal' variety (map unit Xg) and the leucocratic variety (map unit Xgw). The leucocratic variety has nearly the same mineralogy except for less biotite (~1-3%). The contact between the two varieties is everywhere sharp and the age relationship between the two is not clear. In the northeast corner of section 27, T. 1 S., R. 3 W., an isolated exposure of leucocratic granite (map unit Xgl) capping the hill appears to truncate the contact between the two varieties.

The formal name "Corgett Wash Granite" is here proposed for this granite. This unit is named for the large wash that cuts through exposures of this granite in the northern part of the Avondale SW quad. No other place-names are available in the Buckeye quad and the name 'Buckeye Granite' was not adopted to avoid confusion with Miller's (1987) name of 'Buckeye Pluton' that she used to refer to the leucocratic granite.

FINE-GRAINED GRANITES (Cotton Center Granite; map units Xgl and Xglb)

Two similar fine- to medium-grained granites intrude the Buckeye Hills: (1) a leucocratic, peraluminous, two-mica granite (biotite + muscovite), here labeled map unit Xgl, and (2) a more mafic, biotite-rich granite (biotite ± muscovite), here labeled map unit Xglb. The age relationship between the two 'phases' is not entirely clear. Both granites form lenticular bodies within the other, and all contacts, where visible, are sharp. Thin dike-like lenses of Xgl within Xglb in section 19, T. 1 S., R. 3 W., and small irregularly shaped lenticular bodies of Xgl apparently cutting Xglb in section 36, T. 1 S., R. 3 W., both suggest that Xgl is younger than Xglb. She observed that the two units grade into one another over a distance of about one meter. However, detailed mapping during this study has revealed that the contact between the two units is everywhere sharp. Texturally the two granites are very similar. Both vary from fine-grained to medium-grained and both locally contain zones several tens of meters across that approach coarse-grained, with feldspar phenocrysts up to about 4 mm across. Because of the textural and mineralogic similarities, and the fact that both units coexist in approximately the same area, it is likely that these two rocks are genetically related.

Cunningham and others (1987) mapped a fine-grained leucocratic granite to the south in the Maricopa Mountains. Reynolds and Dewitt (1991) informally named this granite the 'granite of Cotton Center' for large exposures of this granite east of the hamlet of Cotton Center. Gilbert (1991) mapped a fine-grained leucocratic granite in the eastern Gila Bend Mountains and adopted the name 'Cotton Center Granite'. Examination of these outcrops during this study has shown that these separate exposures are mineralogically and texturally identical. Hence, the more formal designation, "Cotton Center Granite" is here adopted. Miller (1987) showed that the geochemistry of this unit is more similar to other Proterozoic peraluminous granites than it is to younger Mesozoic two-mica granites.

The western and eastern exposures of the leucocratic granite (map unit Xgl) are rather homogeneous both in texture and mineralogy. In the central part of the main exposure, particularly in sections 28 and 29, T. 1 S., R. 3 W., there is considerable variation from a light tan, sugary variety that contains muscovite as the only mica, to dark tan, varnished rocks containing both muscovite and biotite as well as more abundant feldspar phenocrysts. With careful mapping at a larger scale these variations can be distinguished. They appear to form northeast-striking bands roughly parallel to the local strike of the foliation.

Foliation is defined by alignment of biotite, but because biotite is so sparse in this rock (typically less than 1%) the foliation is faint even where strongly foliated. Muscovite also defines the foliation, but because its light color is so similar to the matrix of the rock the foliation is difficult to see in rocks that contain little biotite. The biotite-rich granite (map unit Xglb), on the other hand, commonly displays a well-developed foliation defined by alignment of fine-grained biotite clots. The biotite-rich granite is commonly slightly darker to much darker in color than the leucocratic granite, which aids in distinguishing the two rocks. However, locally the two are very similar in color and can only be distinguished by careful mapping.

In the far western part of the map area the biotite-rich granite (map unit Xglb) forms a long, ribbon-like band that trends more or less north-south. Many exposures within this band show compositional banding. Bands of fine-grained granite up to several centimeters across alternate with bands of medium-grained granite. The fine-grained bands are slightly darker and appear to contain slightly more biotite than the medium-grained bands. Technically, this compositional banding may be referred to as 'gneissic', although it is unclear if the banding represents primary magmatic banding or a later recrystallized fabric. In this area compositional banding is parallel to tectonic foliation within this band and within the surrounding region. If the banding represents primary magmatic foliation then at least this part of the biotite-rich leucogranite probably intruded syntectonically.

DIKES

Pegmatite Dikes

Coarse-grained pegmatite dikes cut across all of the granites in the study area. They contain large intergrown crystals of light gray K-feldspar, quartz, and muscovite ± biotite, and locally rare red garnet. Anhedral to euhedral magnetite crystals are locally abundant are commonly surrounded by a rusty red alteration halo. These magnetite crystals commonly weather out of the dikes and concentrate in nearby gullies to form local magnetite placers. The pegmatite dikes are most abundant in the west-central part of the quad where they intrude the leucocratic and biotite-rich fine-grained granites. In this are the dikes are so numerous that the lack of time prohibited mapping most of them. It is unknown if they have a preferred orientation, but they do intrude both concordant and discordant to the strike of the foliation. Miller (1987) stated that the pegmatite dikes are related to all of the granites that they cut. However, although the pegmatite dikes are locally strongly fractured, they do not show any preferred alignment of minerals and appear unfoliated. The lack of foliation indicates that these dikes intruded after deformation had ceased and, hence, they are probably not related to the granites they intrude.

The pegmatite dikes contain two rather distinct textural varieties. The first is very coarse-grained and contains crystals of K-feldspar, muscovite and/or biotite books, quartz, and magnetite. The second variety is equigranular medium- to coarse-grained granite with the same composition as the coarse-grained variety (one dike-like body was mapped as map unit Xgp). It is unclear if these two varieties represent two distinct episodes of intrusion, or if they are truly varieties of the same intrusive event.

Where the pegmatite dikes cut across the darker biotite-rich granite they stand out as obvious light gray stripes. However, the dikes are nearly the same color as the leucocratic two-mica granite. Because of the difficulty in distinguishing these dikes from the granite most of the pegmatite dikes were not mapped.

Mafic Dikes

Mafic dikes contain dark green laths of amphibole up to 6 mm long in a dark greenish gray matrix of plagioclase and amphibole. These dikes are not foliated, but other than that the age of these dikes is poorly constrained. They post-date deformation but the trend of many suggests their intrusion was controlled by the local strike of the foliation in the granites. Some dikes cut discordantly across foliation. The fact that the mineralogy is dominated by amphibole suggests that these were originally dikes of mafic composition that have subsequently recrystallized under amphibolite facies pressure and temperature conditions. If so, then these dikes were probably intruded while the country rocks were still at deeper levels of the crust. Some dikes show classic diabasic texture, but since no thin-sections were made of these rocks it is not certain if there are any marked compositional differences between the different types.

TERTIARY DEPOSITS

The Tertiary sedimentary deposits can be divided into two distinct groups: (1) the older, tilted deposits, and (2) the younger untilted deposits. The older, tilted deposits have been subdivided into conglomerate (map unit Tc) and breccia (map unit Txg). Map unit Tc forms deeply dissected rounded hills in the southwest part of the quadrangle. The composition of the clasts is variable but most are subrounded to subangular fine-grained granite in a tan sandy to silty matrix with silica cement. Clasts in the deposits are characteristically fresher and less weathered than the same rocks exposed in nearby outcrops. In aerial photos the deposits commonly appear darker, probably as a result of the abundance of fresher, darker gray clasts. Some Tc deposits contain almost nothing but clasts of coarse-grained granite (Maricopa granite) from pebbles to large rounded boulders. In the southwest part of the map area the older Tertiary deposits (map unit Tc) are tilted to the northeast, toward bedrock, between 40° and 50°. The presence of granite bedrock immediately to the north and northeast indicates the presence of one or more southwest-dipping normal faults. Although mostly buried, the contact between granite bedrock and the tilted Tertiary deposits may be the master normal fault, separating the down-dropped Rainbow Valley on the south from the uplifted granite hills on the north.

The breccia unit (map unit Txg) is composed of very poorly sorted conglomerates exposed in the east-central part of the map. These deposits are composed of angular to rounded clasts of Xgl and Xgc ranging in size from pebbles to large boulders up to 2 meters across. The large, subrounded boulders of Xgc are most conspicuous on the surface. Rare exposures in stream-cuts show no bedding and contain large shattered blocks whose pieces have moved slightly with respect to the whole. The matrix is sand, silt and grus. These deposits probably represent rock avalanche deposits shed from a nearby paleotopographic high that likely formed as a result of Tertiary faulting.

The younger Tertiary deposits (map unit Tsy) form rounded, moderately dissected hills. Bedding in these deposits (where visible) is subhorizontal and the deposits form wedges of material that thicken gradually away from the bedrock. In contrast to the older deposits where the cement is silica, the younger sediments contain abundant carbonate in the matrix. This commonly gives the unit a lighter tan appearance both on aerial photos and in the field. One tiny outcrop of monolithic breccia is exposed within younger Tertiary deposits (map unit Tsy) in section 26, T. 1 S., R. 3 W. Since there are no visible outcrops of coarse-grained granite anywhere in the area, its source is enigmatic.

Near the far northeast corner of section 9, T. 2 S., R. 3 W., is a remarkable exposure unlike any within the Tertiary deposits described so far. In the stream cut here about 1-2 meters of tan-colored, grus-rich middle Pleistocene alluvial deposits overlie a 1-2 meter-thick exposure of greenish gray, thinly bedded, alternating beds of siltstone and claystone. Some beds contain minor disk-like concretions a few centimeters across, parallel to bedding and cemented by carbonate. Some soft-sediment deformation (swales and fluid-escape features) is visible in these deposits. A few sandy beds contain fresh granitic sand and rare subangular Xgc clasts, and are interbedded with thin platy shale beds. One massive sand bed contains tubular concretions up to 1.5 cm in diameter and 10 cm long that resemble burrows. These deposits dip very shallowly northward and form a very slight angular unconformity with the overlying horizontal alluvial deposits. Lack of time prohibited a more thorough exploration of the area, but color contrasts on aerial photos suggests there may be more exposures downstream. The greenish color, fine-grained nature of the deposits, and the presence of possible burrows suggests these deposits formed in a lacustrine setting.

STRUCTURE AND METAMORPHISM

Foliation

At least two separate foliations deform the rocks in the Buckeye quadrangle. The first (S_1) is pervasive in all granites except Xgb, where it deforms only the easternmost exposures. The second (S_2) is rare and localized mostly to thin micaceous lenses between phases of the leucocratic granite (map unit Xgl).

The primary S_1 foliation is defined mostly by the alignment of mica minerals. In the courser-grained granites containing more than about 5-10 biotite this foliation is obvious. In the finer-grained granites where mica content is typically less than about 5% foliation is more difficult to see. Also, thin-sections have revealed that there has been some recrystallization of quartz such that it forms rather equant grains and not elongated crystals that would better define the foliation. Regionally, in the western part of the quadrangle the primary foliation strikes north-northeast in a direction consistent with the foliation direction in other early Proterozoic rocks. Towards the east, though, the strike of the foliation bends progressively eastward, forming a broad fold in the foliation. Contacts between plutonic rocks in the area strike more or less northeast and there is no evidence that they were folded along with the foliation. The folds in the primary foliation likely represent local perturbations in the regional stress field.

The secondary (S_2) foliation is sparsely exposed mostly in thin micaceous bands separating the leucocratic granite (map unit Xgl) from the biotite-rich phase of the leucocratic granite (map unit Xglb). These micaceous bands are typically several tens of centimeters to several meters thick. They are composed of light greenish gray muscovite schist. Most exposures are remarkable in that they are composed almost completely of muscovite. A prominent crenulation cleavage and kink banding define S_2. With few exceptions, nowhere else except in these micaceous bands is the S_2 foliation visible to the naked eye. Interestingly, most of the prospects in the area were dug into these micaceous lenses. The strike of the S_2 foliation varies from northwest to northeast. Unlike the steeply dipping S_1 foliation, the S_2 foliation is not as steep and dips between 20° and 70° to the northeast. Offset of the primary foliation along kink bands indicates a consistent normal-sense offset, with the top side down to the east-northeast. The age of the secondary foliation is uncertain. The dominant northwest strike is consistent with the compression direction during the Laramide orogeny. However, Proterozoic granitic rocks to the west in the Harquahala Mountains were deformed and foliated during the middle Mesozoic (Richard et al., 1994; Bill Rehrig, personal comm.).

Faulting

Few faults are visible in the Buckeye quadrangle. A small, east-west-trending fault in section 29, T. 1 S., R. 3 W., appears to dip steeply to the south based on the way it crossed contours. The fault offsets lens-like bodies of biotite-rich leucogranite (map unit Xglb), but reconstruction and total offset of these bodies is difficult to interpret. Likewise the age of this fault is uncertain. It's strike suggests it may be Tertiary in age.

Another small, west-northwest-striking fault in section 1, T. 2 S., R. 4 W., displaces the contacts between map units Xgl, Xgb, and Xglb. Notably, it also displaces the ribbon-like zone of hematitic alteration (map unit Xh). Since the zone of hematitic alteration cuts across both phases of the leucocratic granite (map units Xgl and Xglb) it is younger than both are. Likewise, the fault is younger than the alteration. How much younger is uncertain, although it's strike also suggests it is Tertiary in age.

Steep northward dips in the Tertiary conglomerate (map unit Tc) in the southwest part of the map area suggest the presence of one or more south-dipping normal faults in this area. The presence of conglomerates dipping 53° north toward granite basement less than ¾ mile to the north seems to mandate the presence of a fault separating the basement from the conglomerate. Potochnik (2001) examined several seismic lines between the Sierra Estrella and the Gila Bend

Mountains. His interpretation indicates the presence of a shallow, west-southwest-dipping normal fault projecting westward under Rainbow Valley. The west end of his seismic line #2 is not far to the south of the Buckeye quadrangle. He shows no obvious detachment fault at depth in this area, but that may be because the seismic line is parallel to its inferred strike. In such a case no obvious tilted reflectors would be visible. The contact between bedrock and Tc has been mapped as a depositional contact because there is no obvious evidence for faulting. However, most exposures are not well-exposed and it is possible that some or all of this contact may be a low-angle fault.

Small brecciated quartz dikes may locally fill faults. The dikes are typically 1 meter or less thick and are typically composed of small, angular, pebble-size fragments of white quartz welded together by a rusty-red matrix of fine-grained hematite and silica. No offset is visible within the granites.

MINERALIZATION

In the western part of the Buckeye quadrangle long ribbons of altered rock overprint both the leucocratic granite and the biotite-rich granite. The rock in these zones is rusty red and contains abundant fine-grained hematite both in fractures and disseminated throughout the rock. Most of the biotite in the host rock is completely altered to hematite, although in many areas the amount of hematite seems much more than that produced by weathering of biotite. Locally, the rock has been replaced by variable amounts of silica. A mineral summary report of the "Red Lead" prospect (KAP WR 9/16/83) in E1/2 section 1, T. 2 S., R. 4 W., describes the prospects as a low-grade gold target and reports assays of gold of 0.01 and silver of up to 0.31 (units?).

The alteration zones form thin ribbons that trend mostly north-south and parallel to compositional banding and foliation in the granites. A few of these alteration zones contain prospects, but no other mineralization is visible. The age of these hematite alteration zones is uncertain. Their ribbon-like distribution was obviously controlled by the strike of the foliation in the granites, indicating the alteration is either syn- or post-tectonic. At least one fault displaces the alteration zones. The west-northwest-striking attitude of the fault suggests the fault may be mid-Tertiary in age, making the mineralization older. Extensive brecciation of the host rocks indicates that mineralization may have taken place at shallower levels in the crust compared to the deeper level at which the foliation was likely produced.

Almost all of the prospects in the Buckeye Hills have been dug into thin bands of light greenish gray muscovite schist mostly at the contact between the leucocratic granite and the biotite-rich granite. Some of the workings are quite extensive and involve inclined adits at least 10 meters deep. The S_2 foliation is visible in these micaceous bands and most of the inclined adits closely parallel its dip. No other mineralization was seen in the workings.

Many of the pegmatite dikes contain abundant magnetite crystals in the form of anhedral to euhedral bipyramidal-shaped crystals. Upon weathering and disintegration of the dikes, the magnetite minerals collect as a lag down-slope from the dike. These minerals have subsequently been incorporated into the Quaternary deposits. Some of the deposits (especially in the western part of the quadrangle) contain so much detrital magnetite that they can be considered placer deposits.

SOME NOTES ON ARCHAEOLOGY

Individual, well-rounded river cobbles are widely scattered across the Buckeye Hills, at various elevations. None of the younger Tertiary (map unit Tsy) and Quaternary deposits in the area contains well-rounded river cobbles, so the cobbles did not weather out of these deposits. Thus, they are likely imported artifacts. The locations of these artifacts were carefully mapped (not included in this report). Nearly every cobble observed was partially broken or chipped. It is notable that although lithics (stone artifacts) are widespread, ceramics (pottery) are not. In fact with the exception of two sherd localities in the northeast-trending valley in the east-central part of the map area, and on a bedrock hill next to the Gila River in the Avondale SW quad, no ceramics were found anywhere else in the Buckeye and Avondale SW quads. The lack of ceramics suggests that the cobble artifacts belong to a pre-ceramic, Archaic culture. The proximity of bedrock hills so close to the Gila River would seem to be an ideal area from which to hunt and gather resources. Mapping of older river terraces indicates that the Gila River flood plain during the last 10,000 years was in approximately the same position as it is today. So why there was very little apparent settlement by post-Archaic cultures is a mystery.

REFERENCES

Cunnigham, Dickson, DeWitt, Ed, Haxel, Gordon, Reynolds, S.J., and Spencer, J.E., 1987, Geologic map of the Maricopa Mountains, central Arizona: Arizona Bureau of Geology and Mineral Technology Open-File Report 87-4, scale 1:62,500.

Demsey, K.A., 1989, Geologic map of Quaternary and upper Tertiary alluvium in the Phoenix South 30′ x 60′ quadrangle, Arizona (revised August, 1990): Arizona Geological Survey Open-File Report 89-07, 1 sheet, scale 1:100,000.

Gilbert, W.G., 1991, Geologic map of the eastern Gila Bend Mountains, Maricopa County, Arizona: Arizona Geological Survey Open-File Report 91-5, 1 sheet, scale 1:24,000.

Melchiorre, E.B., 1993, Proterozoic geology of the Sierra Estrella, Arizona: Tempe, Arizona State University unpub. M.S. thesis, 143 p., 1 sheet, scale 1:50,000.

Miller, E.J., 1987, The Buckeye Pluton; a peraluminous two-mica granite: Tempe, Arizona State University, M.S. thesis, 105 p., 2 sheets, scale 1:12,000.

Potochnik, A.R., 2001, Cenozoic structural and paleogrographical evolution of the transition zone, central Arizona: Tempe, Arizona State University, unpub. Ph.D. dissertation.

Reynolds, S.J., and DeWitt, Ed, 1991, Proterozoic geology of the Phoenix region, central Arizona, in Karlstrom, K.E., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 237-250.

Reynolds, S.J., and Skotnicki, S.J., 1993, Geologic map of the Phoenix South 30′ x 60′ quadrangle, central Arizona: Arizona Geological Survey Open-File Report 93-18, 1 sheet, scale 1:100,000.

Richard, S.M., Spencer, J.E., and Reynolds, S.J., 1994, Geologic map of the Salome 30’x 60’ quadrangle, west-central Arizona: Arizona Geological Survey Open-File Report 94-17, 33page text, 1 sheet, scale 1:100,000.

Sommer, J.V., 1982, Structural geology and metamorphic petrology of the northern Sierra Estrella, Maricopa County, Arizona: Tempe, Arizona State University, M.S. thesis, 127 p., 1 sheet, scale 1:24,000.

**UNIT DESCIPTION FOR THE
BUCKEYE 7.5' QUADRANGLE
AZGS DGM-15**

Quaternary and Tertiary Deposits

Piedmont Deposits

Qyc **Modern alluvium (modern channel deposits).** Unconsolidated sand and gravel in active stream channels. Deposits consist of stratified, poorly to moderate sorted sands, gravels, pebbles, and cobbles. These deposits are highly porous and permeable. Soils are generally absent.

Qy_2 **Holocene alluvium, younger member (<100 yrs).** These deposits are similar to Qy_1 deposits, but are slightly lower in the landscape and, thus, younger. These surfaces were mapped only in the far eastern part of the map area where they are more easily distinguishable from Qy_1 deposits by the greater abundance of vegetation (typically mesquite).

Qy_1 **Holocene alluvium, older member (<10 ka).** Unconsolidated sand to cobbles reaching sizes up to 20 cm in diameter upstream but smaller and fewer downstream. Larger clasts are fine- to medium-grained granites. Smaller clasts are subangular granitic grus. 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 are not indurated with clay or calcium carbonate, these surfaces have relatively high permeability and porosity.

Qye **Holocene eolian deposits (< 10 ka).** These massive to weakly bedded silt deposits are exposed in the northeastern part of the quad where they sit on the southern border of the Gila River flood plain. Overbank flooding may have deposited these silts but the more or less massive character (where visible) and the relative higher relief and degree of dissection, compared to both piedmont and axial stream deposits nearby, suggests they are eolian deposits. Soil development is weak, with cambic horizons and carbonate filaments (stage I calcic horizons). Surface color typically is light brown. The preservation of eolian deposits indicates that these areas have not been subject to substantial flooding recently.

Ql **Late Pleistocene alluvium (10 to 250 ka).** Moderately sorted clast-supported sandstones and conglomerates. 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. These soils contain much pedogenic clay and some calcium carbonate, resulting in relatively low infiltration rates. Thus these surfaces favor plants that draw moisture from near the surface. Ql soils typically have Stage II calcium carbonate development. These surfaces are commonly slightly darker than Qm deposits in the region because the older soils generally contain more, lighter-colored carbonate closer to the surface.

Qm **Middle Pleistocene alluvium (250 to 750 ka).** In the western part of the quad detrital magnetite is locally so abundant that it forms placers. At first glance the anhedral to euhedral, bipyramidal magnetite clasts look nearly identical to the abundant similarly-sized varnished pebbles, but upon closer examination can commonly be distinguished by their dark, metallic sheen.

Qo **Early Pleistocene alluvium (750 ka to 1.2 Ma).** This unit is poorly to moderately sorted conglomerate and minor interbedded sandstone. The clast lithologies are similar to those in the surrounding bedrock (mostly map unit Xgl, and less abundant Xgc). The matrix is grussy to silty, with grus derived mostly from the coarse-grained granite (map unit Xgc). Locally, abundant platy carbonate laminae (Stage III) are exposed at the surface. Where constructional surfaces are preserved cobble pavement is common. Surface clasts on pavements typically exhibit dark varnish. Most deposits are moderately to deeply dissected.

Axial River Deposits

Qyrc **Modern river channel deposits (< 100 years).** This unit consists of modern river channel deposits of the Gila River. They are composed primarily of sand, gravel, and well-rounded far-traveled cobbles. Deposits are typically moderately to poorly sorted and have well-preserved planar beds and cross-bedding where visible in dissected bars. There is no soil development in these deposits. Modern channels are entrenched up to 1 or 2 meters below adjacent young terraces. The current entrenched channel configuration began to evolve with the development of arroyos in the late 1800's, and is continuing to evolve through this century. As mapped, the current configuration reflects modification of the active channel after the major floods of 1993. Channels are extremely flood prone and are subject to deep, high velocity in moderate to large flow events. Channel banks formed in weakly consolidated Holocene deposit and are subject to severe lateral erosion during floods.

Qyr_2 **Holocene floodplain deposits (< ca. 4 ka).** Generally fine- to coarse-grained deposits on the active floodplain of the Gila River. Deposits generally consist of cobbles, sand, silt, and clay. Soil development is minimal, consisting of brown A horizons and carbonate filaments (weak stage I calcic horizons); surface colors are brown to grayish brown. Variegated surface color depends mainly on vegetation density, dark brown color along channels and where vegetated, brown where more sparsely vegetated. These areas are prone to inundation in floods and may be subject to intense erosion along existing small channels.

Qyr_1 **Holocene terrace deposits (< 10 ka).** Deposits associated with low terraces the Gila River. Typically, they are broad, flat surfaces that are on the fringes of and less than 2 m above the active floodplain, but small channels exist in some places within this unit. Deposits are generally fine-grained, but locally surfaces have weak, discontinuous gravel lags composed of mixed lithologies. Soil development is weak, with cambic horizons and carbonate filaments (stage I calcic horizons). Surface color typically is light brown, and surface clasts have no varnish. Portions of the Qyr_1 surfaces may be inundated in the largest floods.

Tertiary Deposits

Tsy **Younger sedimentary deposits (Late Tertiary).** These interbedded conglomerates and sandstones contain angular to subrounded clasts of all local bedrock types. Most clasts are pebble- to cobble-size, but locally some are up to 1.5 meters across (commonly broken into several pieces). Locally these deposits are monolithic and may represent debris flows. In the southern part of the map, a course grussy matrix derived from map unit Xgc commonly surrounds clasts. The finer-grained Xgl surface clasts commonly exhibit varnish. Within the deposits, however, they are typically fresh blue-gray. These deposits are cemented by carbonate, are typically well-indurated, and form smooth rounded, dissected hills.

Tc **Older sedimentary deposits (Middle to Late Tertiary).** Locally this unit contains monolithic, poorly sorted deposits containing only angular fragments of leucocratic granite (map unit Xgl), coarse-grained granite (map unit Xgc), or metarhyolite (map unit Xr). Outcrops of this unit are almost everywhere mantled by thin colluvium and outcrops are rare. The best (and nearly the only) fresh exposures are in the northern part of section 8 and southern part of section 5 in T. 2 S., R. 3 W., where a stream has cut down into the deposits. In these stream-cuts bedding dips to the northwest between about 40° and 50°.

Txg **Breccia** (**Middle to Late Tertiary).** These deposits are composed of very poorly sorted conglomerates and breccias exposed in the east-central part of the map. These deposits are composed of angular to rounded clasts of Xgl and Xgc ranging in size from pebbles to large boulders up to 2 meters across. The large, subrounded boulders of Xgc are most conspicuous on the surface. Rare exposures in stream-cuts show no bedding and contain large shattered blocks whose pieces have moved slightly with respect to the whole. The matrix is sand, silt and grus. These deposits probably represent rock avalanche deposits shed from a nearby paleotopographic high that likely formed as a result of Tertiary faulting.

Early to Middle Proterozoic Intrusive Rocks

YXd **Diorite (early to middle Proterozoic).** This coarse-grained intrusive rock contains ~40% mafic minerals composed of dark green anhedral to subhedral biotite and amphibole in clots 0.5 to 1 cm across. Light gray areas are quartz and feldspar. Minor amber-colored sphene ~ 1 mm across is visible. In thin-section, plagioclase is locally extensively replaced by fine-grained muscovite. Most biotite has been replaced by chlorite. Amphibole exhibits light to dark green pleochroism and locally contains abundant quartz inclusions. One section contains ~15-20% subhedral to beautifully euhedral zircon. Quartz (~10%) is poikalitic to plagioclase. In some samples large, subhedral, inclusion-free apatite crystals are abundant, especially as inclusions within amphibole crystals. Sphene rims opaque minerals. Outcrops show no obvious foliation, although some outcrops to the east in the Avondale SW quad are locally weakly foliated. The rock is very difficult to break. It weathers into low, dark, crumbly outcrops in the eastern part of the map area only in section 35, T. 1 S., R. 3 W. This unit may be equivalent to unfoliated diorite to the east in the Avondale SW quadrangle (mapped also as map unit YXd).

Early Proterozoic Intrusive Rocks

Xh **Hematite alteration zones (early Proterozoic).** The rock in these zones is rusty red and contains abundant fine-grained hematite both in fractures and disseminated throughout the rock. Locally, the rock has been replaced by variable amounts of silica. Forms long ribbons of altered rock in both the leucocratic granite and the biotite-rich granite.

Xgp **Granite porphyry/pegmatite (early Proterozoic?).** This unit was mapped only in one place, in sections 32 and 33, T. 1 S., R. 3 W., where it forms a thick dike-like body up to about 8 meters thick. The rock is mostly medium-grained, leucocratic and light gray, and contains light gray feldspar, quartz and books of muscovite and locally minor biotite. Its mineralogy is very similar to the coarser-grained pegmatite dikes that cross-cut the leucocratic granites (map units Xgl and Xglb). The mapped dike strikes northwest, both concordant and locally discordant to the strike of the local foliation. There are other bodies present in the area, but because they are so similar in color and texture to the surrounding granite, there was not enough time to map them carefully.

Xgl **Leucocratic granite—Cotton Center Granite (early Proterozoic).** This fine- to medium-grained contains ~5-10% biotite and muscovite. The texture of this unit as mapped varies from fine-grained equigranular to slightly K-feldspar porphyritic. Locally muscovite is more abundant than biotite, and vise versa. In thin-section feldspars consist of microcline and plagioclase. Plagioclase is preferentially extensively replaced by fine-grained muscovite, while microcline is fresh. Mica minerals have their crystallographic axes preferentially aligned and most approach extinction parallel to the foliation. Most outcrops are light gray and weather into sharp, jagged hills with little varnish. A primary tectonic foliation defined by alignment of micas is difficult to see where micas are sparse. The strike of the foliation is predominantly oriented north-northeast, but locally strikes southeast-northwest. Predominant alignment of contacts with foliation suggests this unit was emplaced syntectonically. Joseph Wooden reported a preliminary (unpublished) U/Pb age of about 1627 Ma for a sample of the Cotton Center Granite from southeast of Sheep Mountain in the Maricopa Mountains.

Xglb **Biotite-rich leucogranite—biotite-rich phase of the Cotton Center Granite (early Proterozoic).** This fine- to medium-grained granite is similar to the leucocratic granite (map unit Xgl) but contains less muscovite and more biotite. It is equigranular to weakly K-feldspar-porphyritic. In thin-section the K-feldspar phenocrysts are irregularly shaped and show either no twinning or carlsbad twinning. The matrix contains these non-twinned feldspars but also a population of ~20% microcline and stubby, rather equant quartz exhibiting sharp extinction. Even though the micas define an obvious foliation the intergrown matrix of feldspar and quartz show no foliation at all. In some samples quartz phenocrysts are not single crystals but are composed of many interlocking crystals. Contains ~2% opaques and trace apatite and zircon. Where zircon is more abundant (~5%) it is associated with biotite and forms trains that drape over and around K-feldspar crystals. Subhedral opaque minerals are commonly rimmed by sphene. In the western part of the quad the difference between the two leucocratic units is more obvious and here the units were mapped separately. However, in the eastern part of the quad, the units more closely resemble one another. Here it is not clear if there are really two separate units or if there is only one. In the western part of the quad this unit is darker gray than map unit Xgl. It is locally compositionally banded. Medium-grained more leucocratic bands up to 2-3 mm thick alternate with darker, very fine-grained bands containing more abundant biotite. Compositional banding is parallel to foliation (north-northeast), suggesting this unit intruded syntectonically. Exposures in the southeast corner of section 1, T. 2 S., R. 4 W., and southwest corner of section 8, T. 2 S., R. 3 W., contain ~40% subhedral to euhedral light gray feldspars and minor biotite in a dark gray aphanitic matrix, and appear hypabyssal. The crystal-rich rock here appears to grade eastward into map unit Xglb over a distance of about 25 meters.

Xgw **Leucocratic phase of the medium- to coarse-grained granite (early Proterozoic).** This unit is lighter gray-colored than map unit Xg. The rock contains light gray, anhedral to subhedral feldspars, clear-gray quartz, and 1-3% fresh anhedral biotite. Foliation is defined by alignment of biotite, but is locally difficult to discern. The unit weathers into light gray rounded hills shedding small subrounded cobbles, pebbles, and grus.

Xg **Medium- to coarse-grained granite—Corgett Wash Granite (early Proterozoic).** This medium- to coarse-grained granite is marginally equigranular to K-feldspar-porphyritic. Clear-gray quartz, plagioclase, and biotite surround Subhedral microcline phenocrysts up to 1 cm across. Biotite typically occurs as dark, fresh, individual flakes dispersed rather evenly throughout the rock. This is in contrast to the thin books and aggregates of biotite in map unit Xgc. In thin-section, the rock consists of intergrown anhedral microcline, plagioclase, quartz, and 5-10% biotite. Quartz shows sharp to slightly undulatory extinction. Biotite is fresh. No muscovite is visible. Accessory minerals include abundant, large, anhedral to euhedral sphene, minor zircon, and large conspicuous opaque minerals. In relatively medium-grained, equigranular outcrops, sparse, subhedral magnetite crystals appear as conspicuous dark spots in the rock. This unit is named for the large wash that cuts through exposures of this granite in the northern part of the Avondale SW quad. No other place-names are available in the Buckeye quad and the name ‘Buckeye Granite’ was not adopted to avoid confusion with Miller’s (1987) name of ‘Buckeye Pluton’ that he used to refer to the leucocratic granite.

Xgm **Mafic granite (early Proterozoic).** This dark, moderately to strongly foliated, coarse-grained rock contains ~25% mafic minerals—mostly biotite with minor amphibole. Accessory sphene (titanite) is visible as tiny yellow spots. The contact with the biotite granite (map unit Xgb) is sharp, though mostly covered by slope wash. Irregularly shaped bodies of leucocratic granite (map unit Xgl) intrude both and obscure relationships.

Xgc_2 **Medium to coarse-grained granite (early Proterozoic).** This medium- to coarse-grained granite resembles both map unit Xgc and coarse-grained areas of map unit Xglb. The rock is foliated and contains about 10-15 % biotite, and characteristic blue-gray twinned, subhedral K-feldspar up to 8 mm across that stand out in relief on weathered surfaces. The unit forms a narrow lenticular north-south outcrop within map unit Xglb. The contact between the unit and map unit Xglb is mostly sharp. Since both rocks contain similar mineralogy and occur together it is possible that they are phases of one another. However, since relationships are uncertain this rock was mapped as a different unit.

Xgb **Biotite granite (early Proterozoic).** This weakly to strongly K-feldspar-porphyritic biotite granite contains subhedral microcline phenocrysts up to about 1 cm across. Plagioclase phenocrysts are partly to mostly replaced by fine-grained muscovite. Anhedral biotite is light- to dark-green-pleochroic and is commonly in association with anhedral to euhedral opaques, sphene (titanite), zircon, and minor apatite. Plagioclase(?) phenocrysts also contain abundant high-relief, high-birefringent mineral grains that resemble zircon. Quartz has irregular, sutured boundaries. Strength of foliation decreases, in general, from northeast to southwest. Some exposures in the east are mylonite, while exposures in the southwest appear nonfoliated. A thin-section of mylonitized granite shows elongated quartz ribbons with rather sharp extinction. Even though the mineralogy of the rock is similar to the mineralogy of map unit Xgc, the overall texture is not as course-grained and, hence, this area was mapped as a different unit.

Xgc **Coarse-grained granite—Maricopa Granite (early Proterozoic).** This coarse-grained granite contains 5-15% biotite (variable) in thin books, clear-gray quartz, light gray plagioclase, and light gray phenocrysts of K-feldspar 1-2 cm across. In most areas biotite is weakly to strongly aligned in small felty clumps that define the foliation. Locally strongly foliated. In thin-section, large K-feldspar phenocrysts show microcline twinning and no twinning. Where strongly foliated most feldspars are partially replaced by fine-grained muscovite. Sphene and zircon are abundant and associated with biotite. Fine- to medium-grained leucocratic veins cut across foliation in the western part of the quad and parallel to foliation in the east. Here, phenocrysts of light gray K-feldspar are locally as large as 1 cm across, but most exposures are relatively equigranular. The unit typically weathers into rounded hills with crumbly outcrops. Disk-shaped mafic inclusions in the southwest corner of section 36, T. 1 S., R. 4 W. are parallel to a weak foliation defined by alignment of biotite. Together with much stronger alignment of dark-colored disk-shaped xenoliths in section 36, T. 1 S., R. 3 W., this alignment suggests this granite may have intruded in part syntectonically. Joseph Wooden reported a preliminary (unpublished) U/Pb age of 1641 ± 5 Ma for a sample from southeast of Sheep Mountain in the Maricopa Mountains. Eisele and Isachsen (2001) reported a U/Pb date of 1647 ± 1 Ma for a sample of granite in the Hassayampa 7.5' quadrangle that is probably coarse-grained Maricopa Granite.

Early Proterozoic Metamorphic Rocks

Xr **Metarhyolite (early Proterozoic).** This rock contains 2-5% phenocrysts of feldspar and less abundant subspherical quartz, both up to 3 mm in diameter. Tan spots (replaced feldspars) are locally elongated parallel to foliation. In hand sample some of the feldspar phenocrysts appear to be replaced by fined-grained quartz. In thin-section, however, most feldspars show albite twinning (plagioclase?) and microcline twinning, and are partly replaced by fine-grained muscovite. Dark spots in hand-samples are clots of fine-grained biotite. In thin-section these dark spots contain aggregates of anhedral green-pleochroic biotite, muscovite, opaques, and minor zircon. The matrix, and the majority of the rock, is composed of very fine-grained quartz (>30 μm). Foliation varies from weak to strong. On fresh surfaces the matrix appears dark gray and aphanitic. Weathered surfaces are medium gray. Erodes into angular fragments that are commonly varnished, giving outcrops an overall darker color compared to the nearby granitic rocks. Small cavities are locally lined by fine-grained megaquartz.

Xrs **Slaty metarhyolite (early Proterozoic).** This rock is more crystal-rich than map unit Xr, but appears to have the same mineralogy. Small feldspar (K-feldspar and plagioclase) and quartz (?) phenocrysts are commonly less than 1 mm across. The aphanitic matrix is composed of very fine-grained quartz. In thin-section the mineralogy of this rock is nearly the same as that of the metarhyolite (map unit Xr) but with more abundant fine-grained muscovite. Abundant fine-grained muscovite locally imparts a phyllitic sheen to the rock. Outcrops break into thin plates rather than into the angular fragments of the metarhyolite. In outcrop this rock is slightly darker than map unit Xr and because it breaks into thin plates it is easily distinguishable from the more massive outcrops of the metarhyolite.