# GEOLOGIC MAP OF THE SACATON MOUNTAINS, PINAL COUNTY, ARIZONA

by

Steven J. Skotnicki and Charles A. Ferguson

Arizona Geological Survey
**Open-File Report 96-10**

June 1996

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

Includes 15 page text and 1:24,000 scale geologic map (2 sheets).

*Partially funded by the Arizona Geological Survey*
*and the U.S. Geological Survey STATEMAP Program*
*Contract #1434-95-A-1353*

## INTRODUCTION

The Sacaton Mountains form an arc-shaped mountain range centered about 9 miles north of Casa Grande, in the Basin and Range physiographic province (see figures 1 and 2). The range is composed almost completely of granitic rocks which form at least three and possibly four distinct plutons. The plutons are Proterozoic and Laramide in age and are locally zoned, as first demonstrated by Balla (1972). One small outcrop area contains the only supracrustal rocks exposed in the range which consist of quartzite and altered fine-grained sedimentary rocks that are possibly equivalent to the Troy Quartzite and altered Paleozoic limestone (see figure 3).

Most of the Sacaton Mountains lie within the Gila River Indian Community and entry requires a permit. The region is arid and dominated by saguaro, palo verde, and creosote. During World War II a Japanese-American internment camp was built near Sacaton Butte. It was called the Gila River Relocation Camp, or Rivers Camp, or simply Gila. The complex nearest Sacaton Butte was called Butte Camp, and the eastern complex, Canal Camp. Opened in 1942, it held more than 15,000 Japanese-Americans until the end of the war (Spencer, 1992).

The range is easily accessible. Interstate 10 bisects the range from northwest to southeast. Highways 187 and 387 slice though the eastern half of the range toward Sacaton to the north and Coolidge, via State Route 87, to the east. Dirt roads branch off these arteries and most are suitable for a 2-wheel drive vehicle. Old Highway 93, which heads southward from Arizona Ave. in Chandler and crosses the Gila River just east of the Gila River Indian Arts and Crafts Center, has been blocked off at both ends, but is still accessible and intact. Several good dirt roads provide good access to the western edge of the range.

The Gila River abutts the northeastern side of the mountain range and defines the base level for most of the area. The north and south branches of the Santa Cruz Wash flow westward through Casa Grande to the south and are at a base level very similar to the Gila River. Before about 1914, during large floods a branch of the Santa Cruz River (wash) often flowed around the east side of the Sacaton Mountains, where it joined with the Gila River. In 1910 the Greene Canal near the Silver Reef Mountains to the south was completed and intended to supply water from the Santa Cruz River to a reservoir. The major flood of 1916 destroyed the diversion embankments of the canal and diverted the river. Since then the Santa Cruz River has only flowed on the west side of the Sacaton Mountains (Cooke and Reeves, 1976). The abundance of Holocene fan deposits on the surrounding piedmonts and the absence of dramatic dissection suggests the base level both on the north and south sides of the range have remained relatively constant since the Late Pleistocene, though it may also, in part, be due to the relatively continuous supply of sediment derived from the easily erodable granitic rocks. Small outcrops exposed locally in barrow pits indicate the presence of extensive pediments buried under a thin veneer of alluvium.

## PREVIOUS STUDIES

Wilson and Moore (1959) appear to have been the first to study the rocks in the Sacaton Mountains. Their reconnaissance studies were incorporated into the geologic map of Pinal County. Bideaux and others (1960) described mineral occurrences of corundum, cordierite, andalusite, and sillimanite west of Interstate 10 in the central part of the range. Chaffee and Hessin (1971), and later Ullmer (1978) described geochemical exploration models for locating the Sacaton porphyry copper deposit. Wilson (1969) published a report about the mineral deposits of the Gila River Indian Reservation which includes a 1:250,000 scale geologic map of rocks within the Reservation. Most of the previous information about the bedrock in the Sacaton Mountains comes from Balla (1972) who studied the mountain range and many surrounding areas. Balla also reported six K-Ar radiometric dates for Proterozoic and Laramide age granitic rocks. Bergquist and Blacet (1979 a,b) published detailed 1:24,000 scale geologic maps of the Casa Grande East and Casa Grande West Quadrangles.

Pushkar and Damon (1974) reported a K-Ar date of about 65.5 Ma from a core sample from a rock probably equivalent to the Three Peaks Monzonite (renamed the Sacaton Peak Granite). Lee (1984) provided geochemistry data for the Sacaton Peak Granite from samples collected near Agency Peak. Cummings (1982) provided detailed geologic maps, cross-sections and descriptions of the rocks at the Sacaton porphyry copper deposit. The surficial geology of the Sacaton Mountains was studied by Huckleberry (1992) who published a series of 1:24,000 scale maps of the eastern Gila River Indian community. Harris (1995) completed a survey of earth fissures near Stanfield, Maricopa, and Casa Grande.

**Acknowledgments**

Production of this map and report was funded jointly by the Arizona Geological Survey and the United States Geological Survey STATEMAP program under the terms of contract 1434-95-A-1353. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government. We thank Jon Spencer and Steve Richard of the Arizona Geological Survey for their advice, support, and encouragement. Jon Spencer reviewed the map and manuscript, and his suggestions were greatly appreciated. We thank Fred Ringlero, and Elaine Notah for their assistance with receiving and administering our permits to map on the Gila River Indian Community.

## CLASSIFICATION OF THE PLUTONIC ROCKS

Division of plutonic map units of the Sacaton Mountains was based primarily on compositional criteria. Textural criteria played a less significant role. Plutonic rocks in this report where classified using Streckeisen's IUGS (1973) scheme. Determination of quartz/potassium feldspar/plagioclase ratios required to name the rocks was done in the field. It is important to note that mafic minerals are excluded in the classification of the felsic plutonic rocks. Important textural and mafic mineralogical aspects are provided as modifiers to the rock name.

Cummings (1982) may have used a different classification scheme (for descriptions of rocks at the Sacaton porphyry copper deposit), because one of the rocks he called a monzonite (for which he gives mineral modes) would be called a quartz diorite using the IUGS classification.

The recognition of quartz in most of the rocks is fairly easy, and on smooth weathered surfaces, the feldspars can locally be distinguished by slight differences in their response to weathering. Plagioclase is typically an opaque, chalky white color, and K-feldspar is locally more translucent and pinkish in color, but this is not always the case. In some rocks, particularly the finer-grained mafic varieties, distinguishing between the two feldspars was difficult, and in general, the degree of mafic mineral content was used to implicate the feldspar assemblage as being dominantly plagioclase or potassium feldspar (more mafic rocks were presumed to be higher in plagioclase).

## SACATON PEAK GRANITE

Balla (1972) distinguished two separate Cretaceous plutons in the Sacaton Mountains, the Three Peaks Monzonite (Ltp of Balla) and the Sacaton Peak Granite (Lspg of Balla), on the basis of 'textural' differences. During this study spatial variations in mineralogy were observed within the two plutons, as mentioned by Balla, but the variations did not appear to correspond with Balla's pluton divisions and we concluded that these two units are probably one and the same pluton. The two units both contain a mafic border phase grading between quartz monzonite and diorite, though mostly monzonite. Balla describes four different phases in the Three Peaks Monzonite: "a diorite border facies, which is divisible into (1) a fine-grained outer zone and (2) a coarse-grained inner zone, (3) an intermediate monzonite facies, and (4) a central, monzonite core facies". In this study, variation in grain-size and abundances of hornblende and biotite were found in the mafic border phase of the 'Three Peaks Monzonite', but also in the 'Sacaton Peak Granite'. Furthermore, the variations were not found everywhere and, locally, instead of a fine-grained facies near the border with the coarse-grained granite, the mafic phase was in many places coarser-grained or no different from the inner facies. The main 'core' phase of the Three Peaks Monzonite and a major phase of the Sacaton Peak Granite (map unit Kg of this study) are mineralogically indistinguishable. They are both medium-grained, equigranular quartz monzonites to granites.

Exposures of the Sacaton Peak Granite (which in this study is the name given to the pluton that encompasses Balla's Three Peaks Monzonite and Sacaton Peak Granite) also crop out in the western side of the range. In section 7, T. 5 S., R. 5 E., a very dark hill is underlain by the mafic phase (map unit Kgm). The contact between Kgm and coarse-grained granite here is well exposed and sharp. The coarse-grained granite is locally stained orange-red, due to partial to complete hematitic alteration of biotite in the coarse-grained granite. The mafic phase locally is very rich in hornblende, and is slightly hornblende-porphyritic. A few isolated hills in the extreme northwest corner of the map are underlain by the 'normal' phase of the Sacaton Peak Granite. Exposures here are slightly coarser-grained than exposures farther east, though they are not quartz-porphyritic.

Balla attributes the linear trace of the contact between the Three Peaks Monzonite and the coarse-grained granite to an older fault which guided the emplacement of the younger pluton. Though quite possible, the contact exposed today is sharp, irregular, and clearly intrusive.

## LEUCOCRATIC GRANITE AND COARSE-GRAINED GRANITE

Field work during this study has shown that what Balla (1972) named the 'Sacaton Granite' is probably a felsic phase of the coarse-grained granite. The leucocratic body (map unit Ygl) is everywhere in contact with Yg and is commonly intimately associated with it, forming dikes and irregularly shaped bodies with zones locally grading into K-feldspar porphyritic granite (though locally the contact is sharp). Furthermore, diabase dikes of possible Proterozoic age cross-cut only units Yg, Ygf, and YXg.

Balla named outcrops of coarse-grained granite "Oracle Granite" because of their similarity to the Oracle Granite in the San Manuel Area. This name was not adopted in this study because there are probably several separate, though possibly cogenetic, coarse-grained plutons exposed in mountain ranges surrounding the Sacaton and San Tan Mountains. These coarse-grained granites show slight to obvious mineralogic differences (based on observations by the authors), and the correlation of the granite in the Sacaton Mountains with the granite specifically in the San Manuel area does not appear justified.

## STRUCTURE

During the study very few faults were seen. Only three high-angle faults with unknown offsets were mapped to the northwest of Sacaton Peak in the Sacaton Peak granite. One fault juxtaposes equigranular Sacaton Peak Granite (map unit Kg) against the quartz-porphyritic phase (map unit Kgq). Berquist and Blacet (1979) mapped several northwest-trending and a few northeast-trending faults within equigranular granite (their unit Km is equivalent to Kg in this study) in the southwestern part of the range. These faults were not observed in this study.

Unfortunately, due to the absence of bedded supracrustal rocks in the Sacaton Mountains it is difficult to determine the direction and magnitude of tilting in the range, if any. Southward dips of 53° and 70° in the sole exposure of quartzite indicate the rocks were tilted to the south. However, this dip may only reflect local tilting possibly caused by magma rafting during intrusion of the Sacaton Peak Granite. The quartzite may also be more complexly faulted than is visible in outcrop and may, again, reflect a local dip.

Northwest-trending pegmatite dikes near Agency Peak, and northwest-trending diabase dikes in the western part of the range, all dip moderately to the northeast, whereas all northeast-trending dikes of various compositions are near-vertical. If the northwest-trending dikes are tilted back to vertical, the northeast-trending dikes remain vertical. If the assumption that both sets of dikes intruded near-vertically is valid, then it seems that the rocks in the range have been tilted to the southwest about 40°-50° (based on dips of the pegmatite dikes). Tilting the dikes back to near-vertical would also rotate most of the magmatic layering to near-vertical, which would mean that the compositional layering was not created by gravity settling, but by some other process. Southwest tilting in the Sacaton Mountains would be consistent with southwesterly dips of bedded supracrustal rocks in the San Tan Mountains.

Drill-hole data and exposures, created since 1978 by ASARCO in what has become known as the Sacaton porphyry copper deposit (see Cummings, 1982), reveal at least two high-angle, northeast-dipping normal faults (the fault exposed in the open pit has been named the Sacaton Fault). These faults displace continental red-bed conglomerates in the hanging wall against granite, monzonite and quartz monzonite porphyries in the footwall. The red-bed deposits are similar to those exposed at Barnes Butte near Casa Grande. The high-angle faults cut an older, southwest-dipping, low-angle fault (segments of which have been named the West Fault and the South Fault) which itself has displaced continental red-bed conglomerates in the hanging wall against plutonic rocks in the footwall. This low-angle fault, though nowhere visible, probably underlies the thin alluvium along the southwestern piedmont of the Sacaton Mountains. Its orientation suggests it may be related to mid-Tertiary extension of the metamorphic core complexes, though the absence of abundant shearing and brecciation in rocks adjacent to the fault indicates that if it is related to detachment faulting it likely represents a shallow level of the fault.

The Signal Peak Granite, at the southeast end of the range, is both tectonically foliated and lineated. Foliations strike predominantly to the northeast and dip to the southeast. Lineations trend south-southeast. Both foliations and lineations are stronger towards the south. The Signal Peak Granite is mineralogically very similar to the Sacaton Peak Granite (map unit Kg), and may indeed be a phase of the later. If the Signal Peak Granite is Laramide in age, then the foliations and lineations are Laramide or mid-Tertiary and are possibly related to metamorphic core complex tectonics.

[Note: The term "S-C foliation", as used on the map, is used to denote mylonitic fabrics within granitic rocks where the S and C surfaces are well-displayed. This is in contrast to the term "mylonite" and the symbol for mylonite used on the map, where the term is used to denote intensely foliated and lineated zones with few or no S surfaces remaining, and displaying only one very prominent C foliation. This convention is useful because mylonites (as defined here) mainly occur in this area (and in the Santan Mountains) in narrow zones, whereas S-C fabrics are more widespread. The authors understand that this definition deviates from the thorough decription of S-C mylonites as defined by Lister and Snoke (1984).]

## MINERALIZATION:

Cummings (1982) provides an excellent discussion of the mineralization at the Sacaton porphyry copper deposit, so mineralization there will not be discussed in this report. Other mineral localities in the Sacaton Mountains are rare.

In the south-central part of section 7, T. 5 S., R. 5 E., at the northwest tip of the hill in the corner of the Sacaton Butte Quadrangle, a small pit has been dug into a near-vertical siderite vein about 1 meter thick, with a strike of N65°E. From this pit, an old narrow road winds its way up both sides of the hill. On the southeast side of the hill a trench has been dug into hematite-stained monzonite belonging to the mafic phase of the Sacaton Peak Granite.

In the west-central part of section 15, T. 5 S., R. 5 E., where the shaft symbol is on the map, several large trenches were dug into monzonite with fractures stained with chrysocolla.

Minor chrysocola and hematite staining also fills fractures in the west-central part of section 24, T. 5 S., R. 5 E..

Minor amounts of chrysocola and hematite also locally fill a fault southwest of Hayden Peak in the north part of section 2, T. 5 S., R. 6 E.

It is interesting to note that, where measured, mineralized fractures strike to the northeast. This is consistent with mineralized fractures to the south at the Sacaton porphyry copper deposit (see Cummings, 1982) and to the northeast in the San Tan Mountains where a prominent joint-set strikes north-northeast (study in progress).

Corundum, andalusite (var. titanandalusite), and cyclic twins of cordierite and sillimanite have been reported from a locality in the southwest part of section 7, T. 5 S., R. 6 E. (Bideaux and others, 1960). The host rock is an altered metasedimentary rock of probable Paleozoic age.

## REFERENCES


Balla, J.C., 1972, The relationship of Laramide stocks to regional structure in central Arizona: Tucson, University of Arizona unpub. Ph.D. dissertation, 132 p.

Bergquist, J.R., and Blacet, P.M., 1979a, Preliminary reconnaissance geologic map of the Casa Grande West Quadrangle, Pinal County, Arizona: U.S. Geological Survey Open-File Report 79-0390, scale 1:24,000.

Bergquist, J.R., and Blacet, P.M., 1979b, Preliminary reconnaissance bedrock geologic map of the Casa Grande East Quadrangle, Pinal County, Arizona: U.S. Geological Survey Open-File Report 79-0391, scale 1:24,000.

Bideaux, R.A., Williams, S.A., and Thomssen, R.W., 1960, Some new occurrences of minerals of Arizona: Arizona Geological Society Digest, v. 3, p. 53-56.

Chaffee, M.A., and Hessin, T.D. 1971, An evaluation of geochemical sampling in the search for concealed "porphyry" copper-molybdenum deposits on pediments in southern Arizona, in Geochemical exploration: International Geochemical Exploration Symposium, 3rd, Toronto, Ontario, 1971, Proceedings; Montreal, Quebec, Canadian Institute of Mining and Metallurgy, Special Volume 11, p. 401-409.

Cooke, R.U., and Reeves, R.W., eds., 1976, Arroyos and environmental change in the American southwest: Oxford University Press, 213 p.

Cummings, R.B., 1982, Geology of the Sacaton porphyry copper deposit, in Titley, S.R., ed., Advances in geology of the porphyry copper deposits, south western north America: Tucson, University of Arizona Press, p. 507-521.

Ferguson, C. A., and Skotnicki, S. J., 1995, Geology of the Florence Junction, and southern portion of the Weaver's Needle 7.5' quadrangles, Pinal County, Arizona: Arizona Geological Survey Open-file Report 95-10, scale 1:24,000.

Ferguson, C.A., and Skotnicki, S.J., 1996, Bedrock geology of the Santan Mountains, Pinal and Maricopa County, Arizona: Arizona Geological Survey Open-File Report 96-9, 2 sheets, scale 1:24,000.

Harris, R.C., 1995, A reconnaissance of earth fissures near Stanfield, Maricopa, and Casa Grande, western Pinal County, Arizona: Arizona Geological Survey Open-File Report 90-6, 6 p., 1 sheet, scale 1:24,000.

Huckleberry, Gary, 1992, Surficial geology of the eastern Gila River Indian Community Area, western Pinal County, Arizona (maps revised June 1994)[Gila Butte NW, Gila Butte, Sacaton Butte, Gila Butte SE, Sacaton, and Blackwater 7.5 min.]: Arizona Geological Survey Open-File Report 92-07, 27 p., 6 sheets, scale 1:24,000.

Lee, D.E., 1984, Analytical data for a suite of granitoid rocks from the Basin and Range Province: U.S. Geological Survey Bulletin 1602, 54 p.

Lister, G.S., and Snoke, A. W., 1984, S-C mylonites: Journal of Structural Geology, v. 6, p. 617-638.

Pushkar, P.D., and Damon, P.E., 1974, Apparent Paleozoic ages from southern Arizona, K-Ar and Rb-Sr geochronology: Isochron/West, no. 10, p. 7-10.

Reynolds, S.J., Florence, F.P., Welty, J.W., Roddy, M.S., Currier, D.A., Anderson, A.V., and Keith, S.B., 1986, Compilation of radiometric age determinations in Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 197, 258 p., 2 maps.

Spencer, R.F., 1992, The relocation center at Rivers, Arizona; concentration camp or community?: Casa Grande Valley Histories, Casa Grande Valley Historical Society, p. 7-20.

Ullmer, E., 1978, Sacaton mine area, Pinal County, Arizona, *in* Lovering, T.G., and McCarthy, J.H., Jr., eds., Conceptual models in exploration geochemistry; the Basin and Range province of the western United States and northern Mexico: Journal of Geochemical Exploration, v. 9, nos. 2-3, p. 235-236.

Wilson, E.D., 1969, Mineral resources of the Gila River Indian Reservation, Arizona: Arizona Bureau of Mines Bulletin 179, 34 p., 3 sheets, scales 1:12,000 and 1:125,000.

Wilson, E.D., and Moore, R.T., 1959, Geologic map of Pinal County, Arizona: Arizona Bureau of Mines, 1 sheet, scale 1:375,000 [now available as Arizona Geological Survey Map M-3-9].

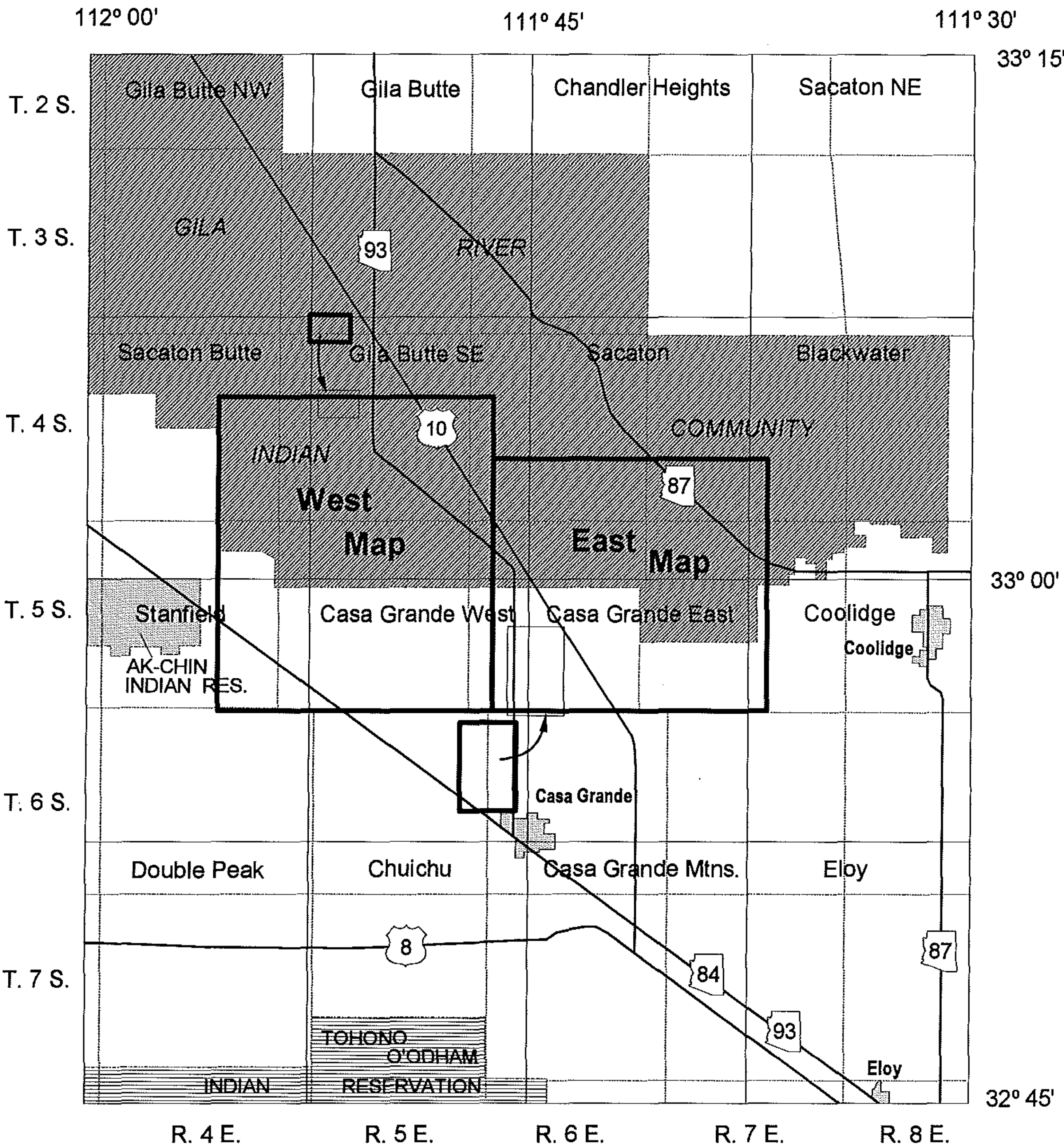


Figure 1. Location map of the maps of the Sacaton Mountains showing the location of the U.S.G.S. topographic quadrangles and political boundaries.

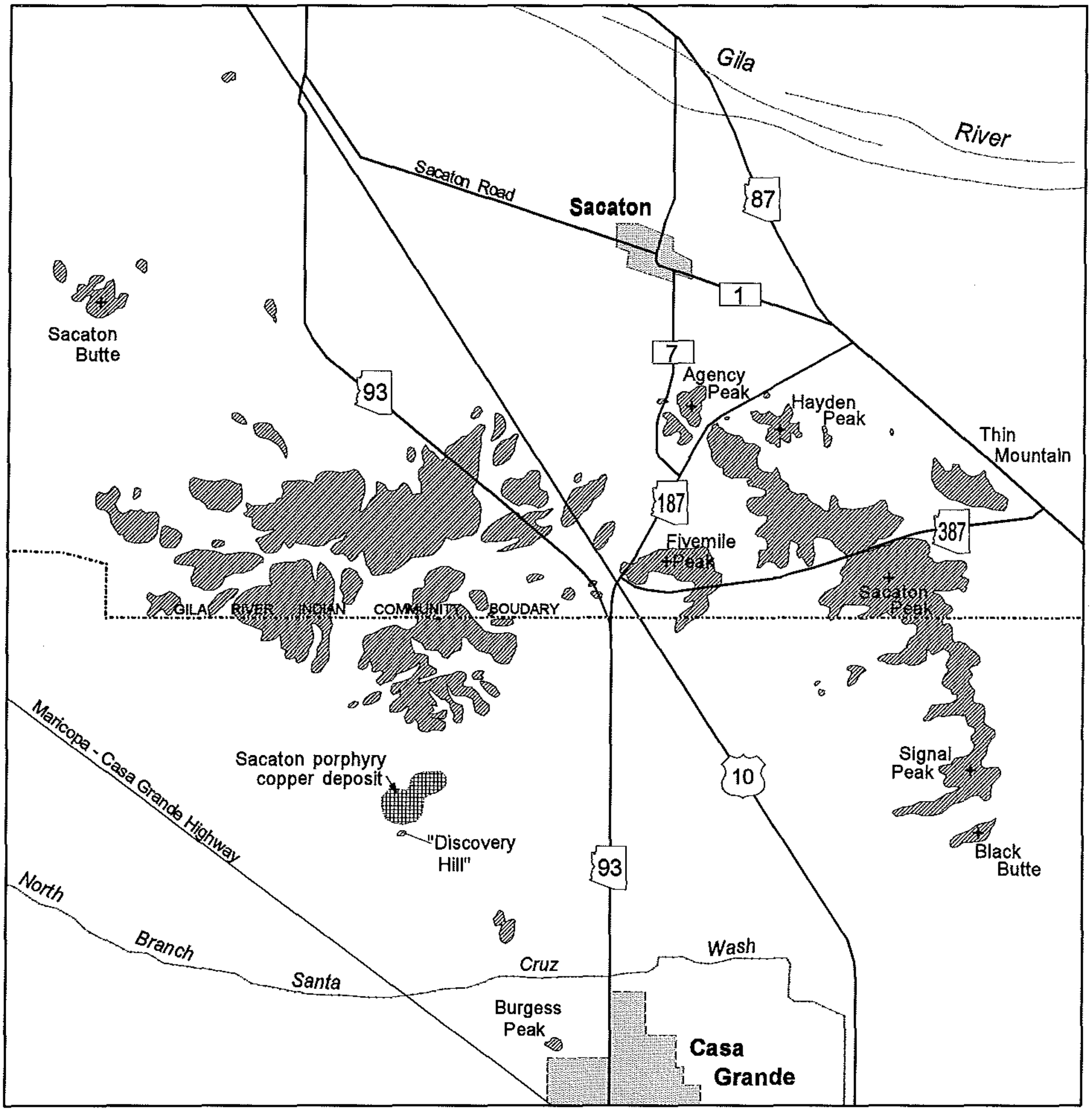


Figure 2. Index map of the Sacaton Mountains

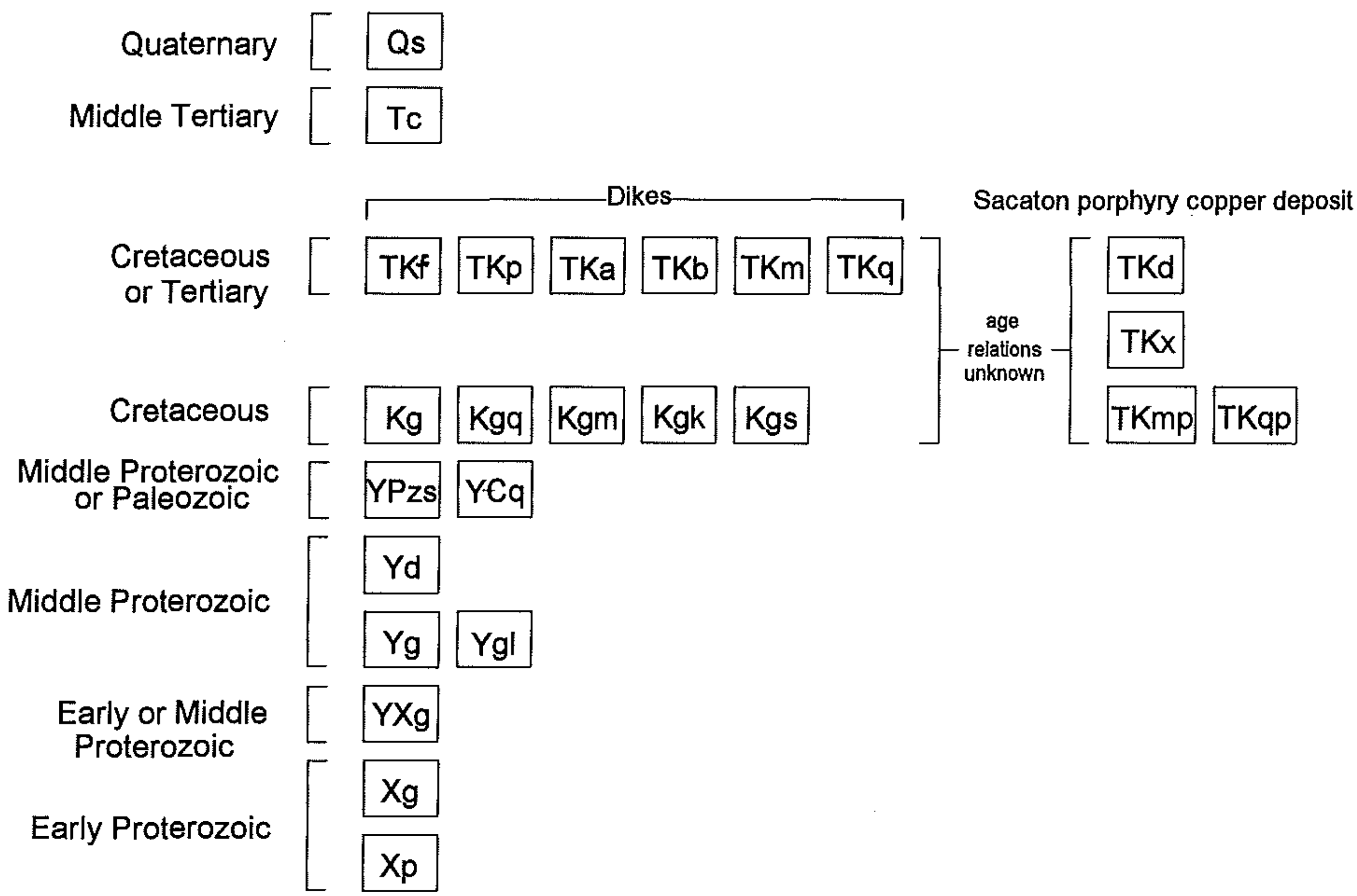


Figure 3. Correlation diagram for rocks in the Sacaton Mountains

## UNIT DESCRIPTIONS FOR THE SACATON MOUNTAINS

**Qs** **Quaternary surficial deposits (Quaternary)**--This unit consists of moderately consolidated to poorly consolidated sand and gravel deposits of various ages, undivided.

**Tc** **Breccia and conglomerate (middle Tertiary)**--Consists of interbedded matrix-supported breccia, clast-supported conglomerate, and minor red sandstone. The unit is exposed at Burgess Peak, immediately northwest of the city of Casa Grande, and in the West orebody and in core samples from the East orebody of the Sacaton porphyry copper deposit. The poorly sorted deposits contain angular to subrounded clasts of quartz-porphyritic medium- to slightly coarse-grained granitoid (map unit Kgq), equigranular medium-grained granitoid with minor hornblende (map unit Kg), and less abundant granite porphyry (map unit Kgp), all in a red sandy matrix. Clast sizes range from sand to boulders, though most are between sand and about 30 cm. The deposits are thinly to moderately stratified. Individual beds are between 0.3-1.5 meters thick. Beds are normally graded, reversely graded, and nongraded. Most are poorly sorted. Fine red silty sandstone beds a few centimeters thick separate beds. This unit resembles deposits at the Papago Buttes in Tempe, at Camelback Mountain in Scottsdale, and at Mount McDowell near Fountain Hills.

### Dikes

**TKf** **Felsite dikes (Cretaceous or Tertiary)**-- Crystal-poor felsic dikes with phenocrysts, less than 5 mm diameter, of feldspar (plagioclase and/or K-feldspar) and highly variable amounts of biotite set in a dark gray matrix that is typically light tan colored on weathered surfaces. Biotite content ranges from $<<$ 1% to 10% and where it is abundant it is coarse-grained (flakes up to 3 cm long). These dikes were given the field term rhyolite to distinguish them from the more crystal-rich dikes, but may not actualy be a rhyolite. Rock is similar petrographically to the lamproite of Elephant Butte in the Whitlow Canyon area (Ferguson and Skotnicki, 1995).

**TKp** **Granite porphyry dikes (Cretaceous or Tertiary)**--This rock contains 1-5 mm wide, subhedral phenocrysts of light gray K-feldspar, biotite books, and quartz, all in a dark gray, aphanitic to very fine-grained matrix. Weathers dark tan. From a distance the dikes are dark gray on the lighter-colored granite.

**TKa** **Amphibole-porphyritic dikes (Cretaceous or Tertiary)**--These dikes contain thin, needle-like, black amphibole phenocrysts from 1-4 mm long, in a medium to light gray fine-grained matrix. Locally, they contain small, light gray feldspar phenocrysts less than 1 mm wide, and large anhedral quartz xenocrysts(?) locally.

**TKb** **Biotite-porphyritic dikes (Cretaceous or Tertiary)**--Plagioclase and biotite porphyritic intermediate dikes with aphanitic to fine-grained matrix, and little or no quartz phenocrysts. Probably a more hypabyssal version of the plagioclase porphyritic monzonite dikes (map unit TKm).

**TKm** **Monzonite dikes (Cretaceous or Tertiary)**--Plagioclase porphyritic, to equigranular monzonite with up to 20% biotite and fine- to medium-grained dark-colored matrix.

**TKq** **Quartz-porphyritic dikes (Cretaceous or Tertiary)**--Quartz porphyry dikes. Equigranular to plagioclase and quartz porphyritic quartz monzonite to quartz monzodiorite dikes, with medium to fine-grained matrix. Biotite is typically the most abundant mafic mineral, and amphibole is also commonly present.

## Units at the Sacaton porphyry copper deposit (from Cummings, 1982)

**TKd** **Dacite porphyry (Cretaceous of Tertiary)**--The dacite porphyry contains phenocrysts of sodic plagioclase, quartz, and biotite. Phenocrysts compose 15-25% of the rock and vary in diameter from 0.08 to 0.16 in. The groundmass is a fine-grained granular intergrowth of feldspar, quartz, chlorite, and biotite. Two dacite porphyry dikes, about 250 feet apart, strike N65°E through the central portion of the West orebody in the Sacaton porphyry copper deposit. In the East orebody, a single dacite porphyry dike is found south of the block cave limits. The presence of weak alteration and sulfide mineralization in the dacite porphyry suggests that it was intruded during the later stages of mineralization.

**TKmp** **Monzonite porphyry (Cretaceous or Tertiary)**--Contains phenocrysts of 75% euhedral plagioclase 0.08 0.16 inches in length, 10-15% euhedral biotite books 0.08 inches wide, 10% subhedral quartz 0.08 to 0.12 inches in diameter, and 1-3% subhedral orthoclase 0.08 to 0.12 inches wide, all in a fine-grained matrix of intergrown feldspar and quartz [the IUGS classification for this rock as described is quartz diorite]. The feldspars in the matrix are altered. Contains hornblende locally. This unit is exposed in the open pit and in core samples from the Sacaton porphyry copper deposit. The unit may be equivalent to the granite porphyry dikes (map unit TKp) or monzonite dikes (map unit TKm) in the Sacaton Mountains.

**TKqp** **Quartz monzonite porphyry (Cretaceous or Tertiary)**--Texturally and mineralogically this rock is identical to the monzonite porphyry, but is distinguished from it by the presence of 10% or more clear quartz phenocrysts. Quartz monzonite porphyry occurs as monolithic and mixed breccias, irregular masses, and dike-like bodies in the west and southwest portions of the West orebody and in the East orebody in the Sacaton porphyry copper deposit. Gradational contacts are common between the quartz monzonite porphyry and the monzonite porphyry. The two rocks are probably co-magmatic.

**TKx** **Mixed porphyry-granite breccia (Cretaceous or Tertiary)**--This is a mixed unit composed of bodies containing variable amounts of monzonite breccia/quartz monzonite breccia and granite breccia. It contains both mixed porphyry-granite breccia and mixed granite-porphyry breccia as defined by Cummings (1982). Contacts between mixed breccias and monolithic breccias are locally gradational. In places, weakly brecciated monzonite porphyry dikes and masses appear to intrude the mixed breccias. Mixed breccias are found throughout the West orebody, in the Sacaton porphyry copper deposit, but appear concentrated between the granite masses on the north and south sides of the open pit.

## Sacaton Peak suite of granitoids

**Kgq** **Quartz-porphyritic phase of the Sacaton Peak Granite(Cretaceous/Tertiary)**--Equigranular, medium-grained, slightly quartz-porphyritic granite to quartz monzonite. It crops out in the eastern part of the range at Sacaton Peak, where the unit gets its name. Quartz phenocrysts are clear to milky gray and are typically rounded. The contact between this unit and map unit Kg is sharp but very subtle. The quartz-porphyritic unit is slightly coarser-grained than map unit Kg. This unit is intruded by two distinctive types of dikes--(1) dark-colored monzonite with up to 20% biotite, and (2) crystal-poor rhyolite. All dikes are steeply dipping and northeast-striking. The Sacaton Peak Granite is prominently jointed, particularly at Thin Mountain and the southwest corner of Sacaton Peak. The jointing is obvious from a distance but difficult to see up close. Apparently the jointing is not associated with any penetrative fabric or compositional banding. At one locality (SE 1/4 of section 1, T. 5 S., R. 6 E.) a cataclastic fabric believed to be associated with a steep fault has a strike parallel to the regional strike of this jointing, but no other evidence of an association between the jointing and faulting was found. Compositional banding in this phase, and in the 'main phase' (map unit Kg), is well-developed locally, particularly in section 10, T.5 E., R. 6 E., south of Fivemile Peak. The banding is defined by centimeter-scale bands of leucocratic and melanocratic granite. The leucocratic band contain about 5-10% biotite, whereas the melanocratic bands contain between 20-50% biotite. The bands themselves are not internally foliated. The banding is sporadically exposed and is consistently northeast-dipping at about 40-60 degrees. One exception is on the spur directly below and to the southwest of Sacaton Peak where well-developed banding is essentially flat-lying. Balla (1972) reported a K-Ar biotite age from north of Sacaton Peak of 62.9 $\pm$ 1.40 Ma (recalculated in Reynolds et al., 1986).

**Kg** **Sacaton Peak Granite (Cretaceous/Tertiary)**--The Sacaton Peak Granite is a medium-grained, equigranular quartz monzonite to granite containing clear-gray quartz, gray to clear subhedral feldspars, biotite, and locally hornblende. K-feldspar crystals are locally poikilitic. The rock contains about 1-2% hornblende phenocrysts locally near the contact with the mafic phase of the Sacaton Peak Granite to the north. Hornblende commonly occurs as large 4-8 mm wide black crystals, and generally stand out as the largest phenocryst in the rock. Also near the contact, large, euhedral to subhedral green-yellow sphene phenocrysts are abundant. The abundance of hornblende and sphene decrease away from the contact to the southeast. Flow-banding is visible locally, defined by a very subtle alignment of biotite and feldspar crystals. As with the hornblende, the flow-banding also disappears to the southeast away from the contact. This unit weathers into steep, rugged buttes covered with medium tan-colored boulders. From Fivemile Peak looking northeast, this unit exhibits a slightly darker varnish than the quartz-porphyritic phase (map unit Kgq). This unit was originally named the "Three Peaks Monzonite" by Balla (1972), but has been renamed because of its probable genetic association with map unit Kg (which is what Balla originally defined as the Sacaton Peak Granite--map unit Lspg). This unit is probably equivalent to the granitoid in the southeast end of the San Tan Mountains. Balla also reported a K-Ar biotite age of 71.40 $\pm$ 1.40 Ma (recalculated in Reynolds et al., 1986)).

**Kgm** **Mafic phase of the Sacaton Peak Granite (Cretaceous/Tertiary)**--Biotite-rich, medium-grained, equigranular granitoid ranging in composition from quartz monzonite to quartz monzodiorite, and diorite. The rock contains about 5% quartz, 60% light gray feldspars, and 15-25% biotite and less abundant and variable amounts of hornblende. Biotite occurs in felty clumps. Hornblende phenocrysts are generally slightly larger that biotite (locally up to 1 cm long) and are locally very abundant. Subhedral to euhedral green-yellow sphene crystal are abundant. On the west side of Agency Peak the rock is locally foliated and lineated. The mafic minerals are generally fresh, but locally altered to chlorite. Epidote is locally common in fractures. The unit is cut by thin pegmatite veins. Fresh surfaces are medium to dark gray. Contact with map unit Kg is difficult to discern at the outcrop, but from a distance the contact can be seen as a subtle color difference between the darker Kgm and the slightly lighter Kg.

**Kgk** **K-feldspar porphyritic phase of the Sacaton Peak Granite(Cretaceous/Tertiary)**--Slightly K-feldspar porphyritic granite to quartz monzonite. It grades northward into the quartz-porphyritic phase (map unit Kgq), the contact being very indistinct. In the middle of section 17 T. 5 S., R7 E., it is bounded from a quartz-porphyritic body by a thin, dark colored quartz monzonite to monzonite body that has sharp contacts with bodies to the north and south. The granite is not intruded by any visible dikes. Balla (1972) reported a K-Ar date of 49.80 + 0.70 Ma (recalculated in Reynolds et al., 1986) which seems too young since this rock is so similar to, and probably a phase of, the Sacaton Peak Granite (map unit Kg).

**Kgs** **Signal Peak Granite (Cretaceous/Tertiary)**--Equigranular granite and quartz monzonite. The rock is foliated and locally lineated. It is exposed at the southeastern end of the range at Signal Peak, where the unit gets its name. Here, pegmatitic syenite to alkali feldspar granite dikes and pods occur along the western edge of the body. The rock is mineralogically very similar to the Sacaton Peak Granite (map unit Kg) and may be related, but is distinguished from it because it is foliated. Sparse hornblende crystals are slightly larger than biotite phenocrysts, similar to the rock at Agency Peak. A tectonic S-C fabric is best developed to the south, with predominantly down-dip lineations and clear top-to-the-north (mostly reverse) kinematic indicators at a number of localities, the best being at the very south end of Black Butte. The contact with the Sacaton Peak Granite to the north is very sharp, though subtle. The Signal Peak Granite is characteristically barren of dikes or other intrusive bodies, and also displays rare magmatic layering which is cross-cut by the tectonic foliation.

## Older Rocks

**YPzs** **Metasedimentary rocks (middle Proterozoic or Paleozoic)**--A poorly exposed, contact metamorphosed, metasedimentary rock containing porphyroblasts of corundum? (based on description of Balla, 1972). The rock is massive, white to light-gray colored, and fine-grained, with a relict, cm-scale, granular or filled-vugs texture (possibly a fenestral fabric). It may be a calc-silicate derived from some sort of carbonate or calcareous siltstone, probably one of the lower Paleozoic units or the middle Proterozoic Apache Group.

**YCq** **Quartzite (middle Proterozoic or Cambrian)**--Medium-bedded, light-gray colored quartzite, extremely shattered and very difficult to identify bedding. Beds are defined by dark-colored laminae. Possibly middle Proterozoic Dripping Spring Quartzite or Cambrian Bolsa Quartzite.

**Yd** **Diabase (Middle Proterozoic)**--Mostly fine-grained, but locally medium- to coarse-grained, diorite displaying diabase texture (except where coarse-grained). The rock contains dark green pyroxene, gray plagioclase, and smaller magnetite. The rock is mostly dark green, but locally stained orange by hematite altering from pyroxene. It intrudes only the Proterozoic rocks, and its presence helps distinguish between Proterozoic and Laramide units.

**Ygl** **Leucocratic granite (Middle Proterozoic)**--Medium- to fine-grained, equigranular syenite to alkali feldspar granite. It is locally slightly K-feldspar porphyritic and contains 2-10% biotite and/or muscovite, which is locally altered to hematite and gives the rock a light orange tint. Exposures are light gray to light rusty orange and have angular, cobble-size debris. Locally exposures contain small enclaves of coarse-grained granite (map unit Yg). The rock forms irregular intrusive bodies, everywhere in contact with the coarse-grained granite, and is likely a younger phase of the later. The rock generally forms resistant buttes. In sections 10 and 16, T. 5 N., R. 5 E. debris shed from this unit has formed resistant, cobble-rich fans of middle Pleistocene age. This unit was named the 'Sacaton Granite' by Balla (1972), but the name is not used here. Balla also reported an age of about 857 Ma for this rock, which, as he states, is most unusual.

**Yg** **Coarse-grained granitoid (Middle Proterozoic)**--K-feldspar porphyritic granite to quartz monzonite containing about 15-20% clear to milky gray quartz, light gray to light pink K-feldspar, and variable amounts of biotite (between 5-15%). The matrix is medium- to coarse-grained. K-feldspar phenocrysts are subhedral, display carlsbad twinning, and are up to 5 cm long. Biotite is anhedral to subhedral, fresh, and occurs in loose, felty masses. Exposures with less abundant biotite (about 5%) are lighter in color than more biotite-rich outcrops. The rock is medium to light gray on fresh surfaces. Locally, a flow foliation is defined by a crude alignment of biotite clots and feldspar crystals. Weathered surfaces are rusty tan and locally moderately varnished. Outcrops form steep hills covered with large spheroidal boulders, as well as expansive dissected pediments in the west half of the range. This unit is probably equivalent to the coarse-grained granite in the San Tan Mountains. Balla (1972) reported an age of 1240 Ma from this rock.

**YXg** **Foliated coarse-grained granite (Early to Middle Proterozoic)**--This medium- to coarse-grained, K-feldspar porphyritic granite/quartz monzonite contains abundant fresh black biotite (20-25%) which occurs in loose, felty masses, pink-gray quartz, and light gray to pink subhedral K-feldspar up to 2-3 cm long. The rock is foliated and locally lineated. Locally, aligned K-feldspar phenocrysts define a flow foliation. The rock also contains 1-10 cm-wide xenoliths of fine-grained biotite+quartz+feldspar. The unit forms dark resistant hills commonly covered with irregularly shaped boulders. Intrudes Pinal Schist and is itself intruded by thin quartz and pegmatite veins.

**Xg** **Foliated granite (Cretaceous or Proterozoic)**--Medium-grained, equigranular granodiorite to quartz monzonite. Contains about 5-10% biotite. Forms light gray exposures in aerially small dike-like body near the western end of the range where it intrudes Pinal Schist. The foliation is defined by alignment of biotite phenocrysts and is mostly concordant to foliation in the neighboring Pinal schist.

**Xp** **Pinal Schist (Early Proterozoic)**--The Pinal Schist in the Sacaton Mountains is a medium- to coarse-grained quartz-muscovite schist. Crenulation cleavages are notably absent in most areas. The unit is exposed in small isolated hills. Most exposures occur in the western part of the range.