Geologic Map of the Antelope Peak NE 7 ½' Quadrangle and the southern 2/3 of the Maricopa 7 ½' Quadrangle, Pinal County, Arizona

by

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Introduction

This report and accompanying maps describe the geology, geomorphology, and geologic hazards of the Maricopa area in western Pinal County, central Arizona. This mapping covers all of the Antelope Peak NE 7 ½' quadrangle and most of the Maricopa 7 ½', and includes the community of Maricopa (Figure 1). The map area encompasses part of the basin floor occupied by Santa Rosa Wash and the Santa Cruz River, the gently sloping piedmonts flanking the west side of the basin floor, and a few bedrock hills (inselbergs) outboard from the Haley Hills, Palo Verde Mountains and Table Top Mountains to the west and southwest of the map area. Agricultural activity and more recently urban development have substantially modified the surface of the basin floor and most of the piedmont areas. Maricopa is developing into a significant population center and rapid development is occurring on the basin floor and the piedmont in the northern part of the map area. The map area includes part of the Maricopa-Stanfield sedimentary basin, from which tremendous amounts of ground water have been extracted primarily for agricultural purposes.

This mapping effort has focused on the surficial deposits of the Maricopa area, which had not been mapped in detail previously. This surficial geologic mapping complements previous mapping efforts by the AZGS in surrounding areas (Jackson, 1989; Huckleberry, 1992; Pendall, 1994; Klawon et al., 1998). Pearthree is responsible for the surficial geologic mapping of these quadrangles. The maps depict the bedrock geology of a few low hills in the southern and western part of the Antelope Peak NE quadrangle; Ferguson is responsible for bedrock mapping. The maps also include new, high-precision field mapping of earth fissures near the bedrock hills in the southern part of the Antelope Peak NE quadrangle; Mahan is responsible for fissure mapping. The report is organized into a brief introduction and explanation of mapping methods, unit descriptions, a summary of the geologic and geomorphic framework of the area, and a discussion of geologic hazards.

Climate. The climate of the map area is hot and dry, with extreme seasonal temperature variations and two distinct seasons of rainfall. The average July high temperature at the Casa Grande weather station (elevation 1400 feet above sea level, located about 10 miles east of the map area) is 106° F, and the average January low temperature is 35° F. Average annual precipitation at Casa Grande is 8.5 in. Occasional freezing temperatures occur at Casa Grande during most winters, but snow is rare and not persistent. Slightly less than one-half of the annual precipitation falls between July and September (Western Regional Climate Center, 2007). Late summer rainfall occurs as heavy thunderstorms when moist air sweeps northwards from the Gulf of California and the Gulf of Mexico. Incursions of moist air derived from dissipating tropical storms in the Pacific Ocean cause occasional intense late summer to early fall precipitation in this region. Winter precipitation generally results from cyclonic storms originating in the Pacific. It is usually less intense and may be more prolonged, and therefore infiltrates into the soil more deeply than summer rainfall (summarized from Sellers and Hill, 1974).

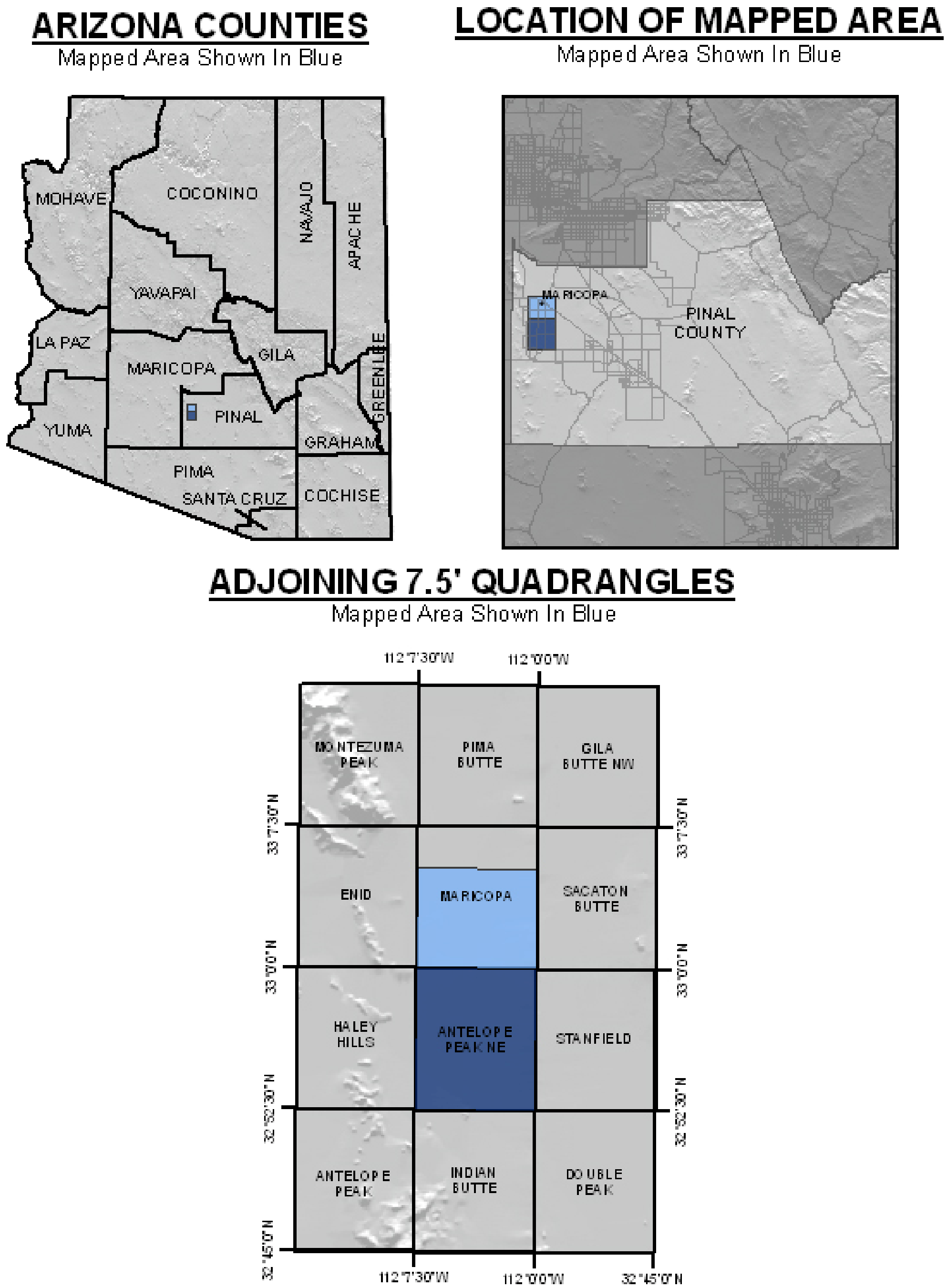

Figure 1. Location of the Antelope Peak NE and Maricopa quadrangles in south-central Arizona. The adjacent Sacaton Butte and Gila Butte NW (Huckleberry, 1994), Stanfield and Double Peak (Klawon et al., 1998), and parts of the Indian Butte and Antelope Peak (Pendall, 1994) quadrangles have been mapped previously.

Methodology

The surficial geologic mapping of this area was done using several sets of aerial photographs and soil survey maps, with limited field checking and observations of surface characteristics. Basin-floor and piedmont areas were mapped primarily using digital orthophotos taken in 2005, soil survey mapping completed in 1983 (Hall et al., 1991), and Fairchild/SCS orthophotographs taken in 1937. Geologic mapping of these quadrangles presented an interesting challenge because agricultural activities and urban development have substantially altered the surface of nearly all of the map area. In these areas, the character of surficial deposits is masked and the geomorphic expression of alluvial landforms has been thoroughly altered. The older aerial photos are black-and-white and of lower resolution than modern aerial photos, but they were vital to the mapping process in these areas because they predate nearly all of the agricultural alteration of the landscape (see Figure 2 for example). Soil survey maps (Hall et al, 1991) were also extremely useful, as characterizations of soil map units include descriptions of soil-profile development and the general sedimentology of the upper 5 ft. of the sediment column. Soil map polygons are rather general, however, so the pre-development orthophotos were used to map the distribution of piedmont and basin-floor deposits of various ages derived from different sources in more detail. Lands of the Maricopa – Ak Chin Indian Reservation in the study area were mapped on a reconnaissance basis using aerial photos only; unit boundaries and labels in these areas should be considered tentative.

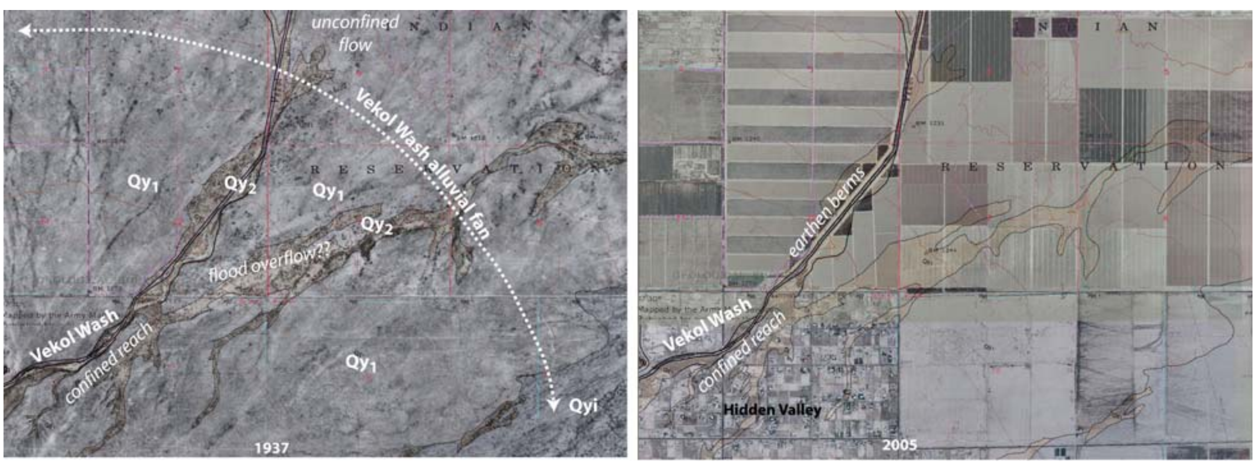

Figure 2. An example of the human alteration of the land surface that is pervasive in the map area. This particular example shows the Vekol Wash alluvial fan in the northwestern corner of the Antelope Peak NE quadrangle and the southwestern corner of the Maricopa quadrangle. In 1937, Vekol Wash was moderately incised into older Holocene fan deposits (unit Qy_1) where it entered the map area, but topographic constraints diminished downstream so that the wash was unconfined about 2.5 miles to the northeast on the Ak Chin Indian Reservation. Agricultural activity and more recently suburban development has modified flow paths and masked the underlying surficial geologic units.

Where the natural surface is preserved, physical characteristics of alluvial surfaces (channels, alluvial fans, floodplains, stream terraces) were used to differentiate their associated deposits by age. Alluvial surfaces of similar age have a distinctive appearance and soil characteristics because they have undergone similar post-depositional modifications, and they are different from both younger and older surfaces. Young (less than a few thousand years old) alluvial-fan surfaces, for example, still retain clear evidence of the original depositional topography, such as of bars of coarse deposits, swales (troughlike depressions) where low flows passed between bars, and distributary channel networks, which are characteristic of active alluvial fans. Young fan surfaces also show minimal development of soil, desert pavement, and rock varnish and are basically undissected. Older fan surfaces, in contrast, have been isolated from substantial fluvial deposition or reworking for thousands of years. These surfaces have more strongly developed soils with clay- and calcium-carbonate-rich horizons, local tributary stream networks that are entrenched up to 2 m below the fan surface, and moderately developed varnish on surface rocks.

In this map, surficial deposits are subdivided based on their source (rivers and large washes on the basin floor, smaller tributary washes on piedmonts, wind activity) and estimated age of deposits. We use soil characteristics, and where preserved, surface characteristics, to correlate alluvial deposits and to estimate their ages. Soil characteristics associated with deposits of different ages and from different sources are summarized in Table 1. Soils and surfaces documented in the map area were generally correlated with soils and surfaces described in surficial mapping studies of adjacent areas conducted by Jackson (1989), Huckleberry (1992), Pendall (1994), and Klawon et al (1998). Soil and surface characteristics were also used to estimate the ages of surficial deposits in the map area (Gile et al, 1981; Bull, 1991).

Several isolated hills in the southern and southwestern parts of the map area consist entirely of plutonic rocks. Medium- to coarse-grained granite in the southernmost hills is assigned a probable Mesoproterozoic age based on petrographic similarity to a widespread suite of granitic rocks of this age that is present throughout central Arizona. The granite is intruded by mafic and felsic dikes that dip moderately to the northeast. Farther north, a mafic, somewhat heterogeneous plutonic suite is present whose probable age is very poorly constrained. Rocks of this type in central Arizona are known to range in age from Paleoproterozoic to Cenozoic. These rocks are cut by a prominent mylonite zone that dips gently to the west with southwesterly plunging stretching lineation.

Following field checking, linework was compiled digitally over 2005 and 1937 orthophotos and 7 ½’ topographic quadrangles by the first author. Map layout was done by Stevan Gyetvai and Ryan Clark. Mapping was conducted as part of the STATEMAP Program of the U.S. Geological Survey, assistance award number 06HQAG0051.

Soil unit	landforms	soil classification	surface color	max reddening	max texture	B structure	calcic horizon	age estimate
Holocene piedmont								
Cuerda fine sandy loam	alluvial fans	Fluventic Camborthids	brown 10-7.5 YR	brown 10-7.5 YR	fine sandy loam	weak (wk) fine (f) subangular blocky (sbk)	pores and roots	middle Holocene
Dateland fine sandy loam	fan terraces, stream terraces	Typic Camborthids	yellow brown 10 YR	brown 7.5 YR	fine sandy loam	wk coarse (c) sbk	roots and pebble coatings	middle -early Holocene
Denure very gravelly sandy loam	fan terraces	Typic Camborthids	lite brown 10 YR	lite brown 7.5 YR	sandy loam	wk medium (m) sbk	common lime accumulations	middle-early Holocene
Denure sandy loam	fan terraces	Typic Camborthids	lite brown 10 YR	lite brown 7.5 YR	sandy loam	wk m sbk	common lime accumulations	middle-early Holocene
Denure fine sandy loam	stream terraces	Typic Camborthids	lite brown 10 YR	lite brown 7.5 YR	sandy loam	wk m sbk	common lime accumulations	middle-early Holocene
Denure sandy loam	fan terraces	Typic Camborthids	lite brown 10 YR	lite brown 7.5 YR	sandy loam	wk m sbk	common lime accumulations	middle-early Holocene
Holocene basin floor								
Gilman fine sandy loam	floodplains, alluvial fans	Typic Torrifluvents	yellow brown 10 YR	pale brown 10 YR	sandy loam	massive (ma)		late Holocene
Carrizo very gravelly fine sandy loam	floodplains	Typic Torriorthents	lite yellow brown 10 YR	10 YR	sandy loam	single grain		late Holocene
Glenbar clay loam	floodplains	Typic Torrifluvents	yellow brown 10 YR	yellow brown 10 YR	clay loam	stratified	common fine threads	late Holocene
Marana silty clay loam	stream terraces	Typic Camborthids	yellow brown 10 YR	brown 10 YR	silty clay loam	moderate (mod) m sbk	roots	Holocene
Dateland fine sandy loam, saline	relict basin floors	Typic Camborthids	yellow brown 10 YR	brown 7.5 YR	fine sandy loam	wk c sbk	roots and pebble coatings	middle -early Holocene

Table 1. Summary of soil map units in the Maricopa area. All data is extracted from Hall et al. (1991) except the age estimates in the last column.

Soil map unit	landforms	soil classification	surface color	max reddening	max texture	B structure	calcic horizon	age estimate
Rositas loamy fine sand	eolian sand dunes	Typic Torripsamments	lite brown 7.5 yr	lite brown 7.5 YR	sand	ma		late Holocene
Sasco silt loam	stream terraces	Typic Camborthids	yellow brown 10 YR	pale brown 10 YR	silt loam	mod sbk- wk prismatic	roots	Holocene
Trix clay loam	floodplains	Typic Torrifluvents	brown 7.5 YR	brown 7.5 YR	clay loam	ma		late Holocene thin over Pleist.
Valencia sandy loam	floodplains, alluvial fans	Fluventic Camborthids	yellow brown 10 YR	lt brown 7.5 YR	sandy loam	wk fine sbk	roots and few masses	Holocene thin over Pleistocene
Pleistocene piedmont								
Tremant gravelly loam	fan terraces	Typic Haplargids	lite brown 7.5 YR	brown 7.5 YR	clay loam	wk m sbk	many soft masses	late Pleistocene
Mohall sandy loam	fan terraces, relict basin floors	Typic Haplargids	lite brown 7.5 YR	red brown 5 YR	clay loam	wk m sbk	few soft masses 15-35%	mid- to late Pleistocene
Mohall loam	fan terraces	Typic Haplargids	lite brown 7.5 YR	red brown 5 YR	clay loam	wk m sbk	few soft masses 15-35%	mid- to late Pleistocene
Pleistocene basin floor								
Casa Grande fine sandy loam	relict basin floors	Typic Natrargids	lite brown 7.5 YR	red brown 5 YR	sandy clay loam	mod m sbk - prismatic	lime masses 15-25%	mid- to late Pleistocene
Casa Grande clay loam	relict basin floors	Typic Natrargids	lite brown 7.5 YR	red brown 5 YR	sandy clay loam	mod m sbk - prismatic	lime masses 15-25%	mid- to late Pleistocene
Laveen loam	stream terraces, fan terraces	Typic Calciorthids	lite brown 7.5 YR	pink 7.5 YR	loam	wk m sbk	lime nodules 15-40%	mid- to late Pleistocene
Momoli very gravelly fine sandy loam	fan terraces	Typic Camborthids	lite brown 7.5 YR	brown 7.5 YR	sandy loam	ma	few masses and gravel coatings	late Pleistocene
Mohall clay loam	fan terraces, relict basin floors	Typic Haplargids	lite brown 7.5 YR	red brown 5 YR	clay loam	wk m sbk	few soft masses 15-35%	mid- to late Pleistocene

Table 1. Summary of soil map units in the Maricopa area. All data is extracted from Hall et al. (1991) except the age estimates in the last column.

Map Unit Descriptions

Piedmont Alluvium

These deposits cover the gently sloping, low relief plains (piedmonts) in the southern and western parts of the map area. Washes that head in the mountains and hills to the west or on the piedmont and drain to the east and northeast across the piedmont deposited all of this sediment. Deposits range in age from modern to middle to late Pleistocene, but are predominantly of Holocene age. The lower margins of the piedmonts intersect with the planar, very gently north- to northwest-sloping basin-floor deposits associated with the Santa Cruz River and Santa Rosa Wash.

Qy_c – Active channel deposits of Vekol Wash. Sand, gravel, and minor silt deposits in the channel of Vekol Wash. Vekol Wash is a moderately large drainage that heads in Vekol Valley southwest of the map area, crosses through low bedrock hills, and drains north to Santa Rosa Wash and the Santa Cruz River. Artificial berms confine the Vekol Wash channel north into the Maricopa – Ak Chin Indian Reservation, beyond which it is no longer recognizable as a distinct channel. The channel position has been altered in some locations since 1937. In these areas, the former channel is included in the Qy_2 map unit.

Qy_2 - Late Holocene alluvium. Unit Qy_2 consists of relatively fine deposits in small channels, and on low terraces, alluvial fans and other sheet flood areas. Deposits consisting of sand and silt with minor gravel and clay are associated with drainages that were active prior to major anthropogenic landscape alteration in the 20th century. In undisturbed areas on the western and southern margin of the map area, sediment is generally sand and silt with pebbles and few cobbles. On lower piedmont areas, young deposits consist predominantly of sand, silt, and clay. Channels are incised less than 1 m below adjacent terraces and fans. Channels are weakly developed and may have single, anastomosing, or distributary patterns. Qy_2 surfaces generally appear darker than surrounding areas on aerial photos, probably due to slightly greater vegetative color and minor organic content in the surface soil horizon. Local relief varies from fairly smooth channel bottoms to the gently undulating bar-and-swale topography. Soil development is minimal to weak; soils are classified as Torrifluvents or Camborthids. Vegetation density is moderate to locally high.

Qy_1 - Holocene alluvium. Unit Qy_1 consists of relatively fine deposits on low terraces, alluvial fans and other sheet flood areas surfaces that are broadly rounded and somewhat isolated from the active flow regime. Surfaces typically are covered with sand or fine, unvarnished open gravel lags. Surfaces appear lighter-colored on aerial photos compared with adjacent Qy_2 surfaces. Channels and swales are incised <1 m below Qy_1 surfaces; the lower areas of Qy_1 may be inundated during large flow events. Channels very small, weakly developed and commonly are discontinuous; tributary and distributary patterns are common. Vegetation density is low; surfaces support creosote and other small bushes.

Qyi - Late Pleistocene to Holocene alluvium. Broadly rounded surfaces approximately 1 m above active channels composed of mixed alluvium of late Pleistocene and Holocene age. Drainage networks consist of distributary channel networks associated with larger drainages and tributary channels associated with smaller drainages that head on Qyi surfaces. Slightly reddened Pleistocene alluvium (unit Qi or Qif) is exposed in patches on low ridges and in roads and cut banks of washes, but it is mainly covered by a thin veneer of Holocene fine-grained alluvium (unit Qy). The Holocene surfaces usually are light brown in color and soils have weak subangular blocky structure and minor carbonate accumulation.

Qi – Middle to late Pleistocene alluvium. Qi alluvial surfaces are rounded and moderately dissected relict alluvial fans that are 1 to 2 m above adjacent active channels. In the map area, they are found only around the southernmost bedrock hills. Qi deposits consist of sand, silt, clay, pebbles, and some cobbles. Qi surfaces commonly have loose, open pavements of pebbles and cobbles; surface clasts exhibit weak to moderate rock varnish. Qi soils are gravelly sandy loams with subangular blocky structure, weak clay skins, and Stage II to III calcic horizons (Table 1). The moderate soil development associated with Qi surfaces suggests that they are of late Pleistocene age.

Qif – Middle to late Pleistocene fine-grained alluvium. Qif alluvial surfaces are broadly rounded, weakly dissected distal alluvial fan remnants. Weakly incised tributary and distributary channel networks are common. Qif deposits consist of sand, silt, clay and minor fine gravel, with minimal gravel surface lags. Qif soils are moderately to well-developed, with sandy loam to clay loam textures, obvious reddening, and stage II to III calcic horizon development.

Axial Valley Deposits

Deposits laid down by Santa Rosa Wash and the Santa Cruz River cover the broad, very low-relief basin-floor areas. These areas have been almost completely altered by human activities. Most deposits are fine-grained; however, those that are gravelly exhibit mixed lithologies reflecting the large drainage areas of these streams. Deposit descriptions are derived in part from soil descriptions are taken from Hall et al (1991).

Qy_cr - Modern axial wash channel deposits. Sand, fine gravel and silt in the confined channel of Santa Rosa Wash. The channel is confined between artificial berms from where it enters the south-central part of the map to near the northern end of the map. At that location, the artificial channel ends in a golf course / park area. In 1937, there was no clearly defined channel associated with Santa Rosa Wash.

Qy_2r – Late Holocene floodplain deposits. This unit encompasses active channels and low terraces composed of sand, silt, and clay. Natural channel patterns are braided, but modern channels in much of the map area are contained within berms. Soils are classified as Torrifluvents; they are weakly developed and have clay loam or sandy loam textures with little or no evidence of clay movement or carbonate accumulation. These areas are prone to inundation in moderate to large flow events, unless they have been protected by artificial diversion structures.

Qy_sr - Holocene striped floodplain deposits. This distinctive unit is characterized by fine-grained surfaces with pronounced dark stripes that trend approximately perpendicular to surface flow directions. The dark stripes consist of alternating vegetation and soil lineations. The stripes have little or no topographic expression, and are not associated with obvious eolian features such as low dunes. Qy_sr surfaces are generally are adjacent to Qy_2r surfaces and are not much if any higher than these surfaces, which suggests that Qy_sr areas have experienced shallow flow during large floods. The areal extent of this unit is inferred primarily from historical aerial photos, because all of these areas are currently under cultivation or urban development. Comparing the distribution of Qy_sr unit with the soils maps of Hall et al (1991), the distinctive striped pattern that characterizes Qysr overprints several different fine-grained soils of Holocene and Pleistocene age. This suggests that the stripes are a surface phenomenon that has developed during the late Holocene.

Qy_1r - Holocene floodplain and terrace deposits. The Qy_1r unit consists of low terraces that are slightly higher than and spatially separated from the main axial channel and swale network. Qy_1r deposits consist of sand, silt, and clay. Soils are classified as Torrifluvents and Camborthids, which are deep, weakly developed soils with some carbonate filaments and fine masses and weak soil structure in near surface horizons. Qy_1r surfaces which may experience sheetflooding during large flow events.

Qir - Middle to late Pleistocene fine-grained river terrace deposits. Late or middle Pleistocene river terraces on the basin floor with moderately to strongly developed soils. In areas that have not been cultivated, Pleistocene terraces are slightly higher (a few meters or less) than adjacent Holocene floodplain and terraces. In cultivated areas, topographic differences may have been obliterated, but on historical aerial photos Pleistocene surfaces appear to be higher than surrounding younger surfaces. In addition to topographic relief, Qir soils are substantially more developed than younger soils. Qmlr soils are classified as Calciorthids, Haplargids and Natrargids; they are fine-grained, and generally have well developed structure and reddened argillic horizons and common soft carbonate nodules.

<u>Eolian Deposits</u>

Qye - Holocene sand dunes. Unit Qye consists of relatively small eolian dunes found in several places on the basin floor. Dunes consist of well-sorted sand. They partly stabilized by creosote, grasses, and bursage vegetation. They appear as irregular topography on topographic maps and may reach a height of 5 m above adjacent Qy_2r surfaces. In some areas, the topographic expression of dunes has been removed to facilitate agricultural land uses. In these areas, Qye deposits were delineated based on soil survey maps (Hall et al, 1991).

d – disturbed areas. Areas that have been profoundly altered by large irrigation canals, railroad embankments, or aggregate operations are mapped as “disturbed”.

Bedrock units

TYm - Cenozoic to Mesoproterozoic fine-grained mafic dikes. Mafic dikes with sparse <2mm mafic phenocrysts in a dioritic matrix with 30-50% mafics (probably pyroxene) and plagioclase, that locally resembles diabase texture

Ylg - Mesoproterozoic leucogranite and pegmatite dikes. Banded fine- to medium-grained leucogranite to coarse-grained pegmatite dikes with <5% muscovite, and sparse sphene up to 3mm.

Yg - Mesoproterozoic granite. Medium- to coarse-grained, equigranular to potassium feldspar porphyritic granite with 5-10% biotite. Sparse schlieren of fine- to medium-grained 20-60% biotite granite are locally present.

TXg - Cenozoic to Paleoproterozoic granodiorite. Fine- to medium-grained granodiorite to quartz monzodiorite with 10-20% biotite. Locally contains up to 10% fine- to medium-grained leucogranite dikes.

TXm – Cenozoic to Paleoproterozoic mafic complex. Fine- to medium-grained granodiorite to quartz monzodiorite and diorite with up to 35% mafics (mostly biotite) mixed with very fine-grained to fine-grained diorite with up to 60% mafics (biotite and pyroxene?). The complex is typically strongly altered with abundant epidote-rich fine-grained leucogranite dikes, some of which are strongly mylonitic. Mylonitic texture occurs on discrete, gently dipping bands oriented parallel to contact with overlying granodiorite (TXg) map unit.

Geologic/Geomorphic Framework

The Maricopa area is located in the northeastern part of the Sonoran Desert subprovince of the Basin and Range physiographic province. The physiography of the Basin and Range province in Arizona is characterized by alluvial basins and intervening mountain ranges that formed as a result of normal faulting related to extension of the crust between about 30 and 6 Ma (Shafiqullah et al, 1980; Menges and Pearthree, 1989). The landscape of this area consists of small, low-lying mountain ranges and broad, minimally dissected basins that are typical of the Sonoran Desert subprovince. Bedrock exposures are limited to these mountain ranges and a few outlying hills (inselbergs) that rise above the basin floors and broad plains surrounding the mountain ranges. Nearly all of the map area is covered by late Quaternary alluvium that was deposited by Santa Rosa Wash and the Santa Cruz River (northeastern part of the map) and Vekol Wash and many smaller, poorly defined tributary washes that trend from southwest to northeast toward the valley floor. The surficial geology and geomorphology of this area record the gradual transfer of material from the mountains to the surrounding piedmonts and basin floors during the past few million years in the absence of significant tectonic activity. Pre-Quaternary plutonic rocks are exposed in a few hills and isolated inselbergs in the southern and southwestern parts of the map area.

The broad, undissected basin-floor areas record the slow, long-term aggradation of the Santa Cruz River and Santa Rosa Wash. Santa Rosa Wash flows from the south and joins the Santa

Cruz in the map area. Nearly all of the basin-floor areas are mantled with deposits of these regional drainages. Wide floodplains of these drainages are composed of Holocene deposits of sand, silt and clay, with minor gravel. Multiple small, discontinuous channels and swales were typical, and well-defined channels were probably unusual, prior to human alteration of the floodplain for agricultural purposes (Figure 3). In the modern environment, channels have been artificially confined between earthen berms to contain low and moderate flows through the area (Rhoades, 1991). During large historical floods of the latter part of the 20th century, however, broad portions of the basin floor were inundated (see Roeske et al., 1989; Wood et al., 1999).

The broad piedmont of the southern and western part of the map area is covered by alluvial deposits, nearly all which are quite young. Upper piedmont areas south and west of the map area typically have tributary (converging downstream) drainage systems. This map are includes only middle and lower piedmonts, where natural drainage networks were complex and commonly poorly defined. Channel patterns included distributary (diverging downslope) and tributary patterns, and channels typically were very small and discontinuous (see Figure 2 for example). Topographic relief was minimal prior to development; all channels were entrenched less than 2 m below adjacent alluvial surfaces and in most areas local relief was much less. Holocene deposits cover middle and lower piedmont areas, although Pleistocene deposits are shallowly buried and locally exposed in these areas.

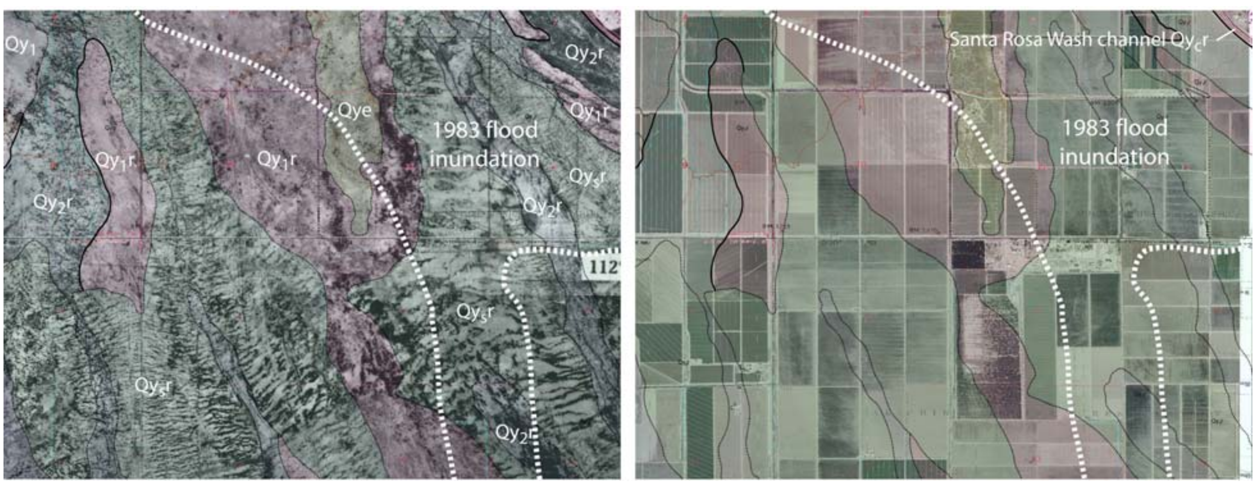

Figure 3. A portion of the Santa Rosa Wash floodplain on the basin floor, in the northeastern corner of the Antelope Peak NE quadrangle and the southeastern corner of the Maricopa quadrangle. This part of the map area has been completely altered by agricultural activity, and the natural flow paths evident in the 1937 aerial photo have been disrupted. The 1983 flood on the Santa Cruz River inundated much of the floodplain of Santa Rosa Wash as well (from Roeske et al., 1989). Some basin floor areas that were probably topographically higher prior to human modification (mapped as Qy_1r and Qye) were inundated in 1983.

Geologic Hazards

This section summarizes the character and distribution of the principal geologic hazards that exist in the Maricopa area. This information is fairly general in nature. Detailed site-specific geologic, engineering, hydrologic, or soils investigations would be required to thoroughly assess potential hazards at particular locations. More specific information on soil properties may be obtained from Hall et al. (1991), and information on mapped floodplain and flood-prone areas may be obtained from local floodplain management agencies.

Flooding hazards. Flooding hazards in the map area may be subdivided into those associated with major regional drainage systems and those associated with smaller tributary drainages. The largest channels in the study area are the Santa Cruz River and Santa Rosa Wash. Flooding on these large drainages has resulted from regional storms in the winter and late summer - early fall. Their smaller tributaries (including Vekol Wash) drain the piedmont in the southern and western part of the map area. Floods on these drainages typically result from intense, localized thunderstorms that occur during the summer or early fall.

The Santa Cruz River, the largest drainage in the map area, flows from southeast to northwest and poses the greatest flood hazard to basin-floor areas. The largest floods in the historical record occurred in 1905, 1914-1915, 1977, 1983, and 1993, with 1983 being the peak of record at gages in the upper Santa Cruz and at the confluence with the Gila River (Laveen gage). During the 1983 flood, broad areas of the Maricopa-Stanfield basin were inundated, including in a swath across the northeastern part of the map area (Roeske et al., 1989). This is in contrast to floods that occurred earlier in the century (1914-1915), when Santa Cruz River flooding was also widespread in the Picacho basin along the North Branch of the Santa Cruz (Smith, 1938). The primary cause for this change lies in channel modifications begun around the turn of the century upstream of the map area, when a diversion dam and canal were constructed in southeastern Picacho basin in order to direct flow from the Santa Cruz to a reservoir, and distribute to croplands. Floods of 1914-1915 destroyed the diversion dam and eroded the canal to a depth of 12 feet, and it became the new main channel for the Santa Cruz. Subsequent large floods in 1977, 1983, and 1993 have continued to entrench the canal so that channels in Picacho basin such as the North Branch of the Santa Cruz and McClellan Wash do not receive significant flow from the upper Santa Cruz River (Wood et al, 1999). Both Holocene and Pleistocene surfaces were inundated during 1983 and 1993 along the modern flow path in the Maricopa-Stanfield area. One large flood occurred on Santa Rosa Wash in the past 50 years in response to a dissipating tropical storm in 1962 (Lewis, 1963). Inundation on the basin floor was extensive, but probably less than during the 1983 flood. Tat Momlikat Dam was constructed on Santa Rosa Wash south of the map area in 1974, and there have been no large flows on Santa Rosa Wash since that time.

The basin floor in the map area is a broad alluvial plain with complex, discontinuous, branching and rejoining flow paths. This weakly defined channel pattern along with the low gradient in the area increases the potential for channel changes during large floods. In addition, human encroachment on the floodplain and constriction of channels using artificial berms contribute to widespread inundation of the basin floor during large floods. Because of the low relief between young and older surfaces and human alterations of the floodplain, current flooding hazards there cannot be confidently predicted by alluvial-surface age.

Surficial geologic mapping provides important information about the extent of flood-prone areas on the piedmonts, and it is the best way to delineate areas that may be prone to alluvial-fan flooding or other sheetflooding. Floods leave behind physical evidence of their occurrence in the form of deposits. Therefore, the extent of young deposits on piedmonts is a good indicator of areas that have been flooded in the past few thousand years. Geologically very young deposits cover almost all of the piedmont in the map area, and local topographic relief associated with these deposits is minimal. This implies that much or all of the piedmont may be prone to sheetflooding. Extensive sheetflooding almost certainly occurs in the piedmont areas on the southern and southwestern margins of the map area. Agricultural activities have substantially altered the local topography and natural drainage systems on most of the piedmont, however, and irrigation canals and ditches divert surface flow and presumably provide some flood protection to downslope areas.

Soil problems. Several types of soil/substrate problems may be encountered in the Maricopa area (see Hall et al., 1991, for more detailed soils information). Large parts of the basin floors may be susceptible to shrinking and swelling of soils during drying and wetting cycles. Areas with clay-rich Pleistocene soils at the surface (map unit Qir and Qif) are most likely to be affected, but other areas covered by young deposits have clay-rich Pleistocene soils in the near subsurface (Qy_sr and Qyi, for example) and may also be affected by shrink-swell activity. Soil collapse or compaction upon wetting or loading (hydrocompaction) may be an important geologic hazard on the basin floors and lower piedmonts. Hydrocompaction is a reduction in soil volume that occurs when susceptible deposits are wetted for the first time after burial. Deposits that are susceptible to hydrocompaction are typically relatively fine-grained, young sediments that are deposited in a moisture-deficient environment. Deposits in the map area that are the most likely candidates for hydrocompaction are the fine-grained alluvial fans of units Qy_1 and Qyi on the lower piedmonts, and Qy_1r on the basin floor.

Potential soil problems in piedmont areas consist of shrink-swell potential, low infiltration rates, and hard substrate. Shrink-swell problems may exist on clay-rich soils of unit Qif. Excavation may be difficult and near-surface infiltration rates low on surficial units and exposed bedrock pediments around the isolated bedrock hills because of the existence of bedrock at shallow depths.

Land subsidence and earth fissures. In the Maricopa area, agriculture has been a driving force in the local economy and has resulted in the heavy use of ground-water resources. Because recharge in the area is limited, ground-water withdrawal has resulted in subsidence of the land surface in basin areas and the development of earth fissures near the basin margins. In the map area, several earth fissures exist in Holocene alluvium in the southernmost part of the Antelope Peak NE quadrangle near isolated bedrock hills (Harris, 1995; this report; Figure 4). These fissures are not visible on the 1937 orthophotos, but several fissures were evident by 1971 when the orthophotos used for the soil survey mapping were taken.

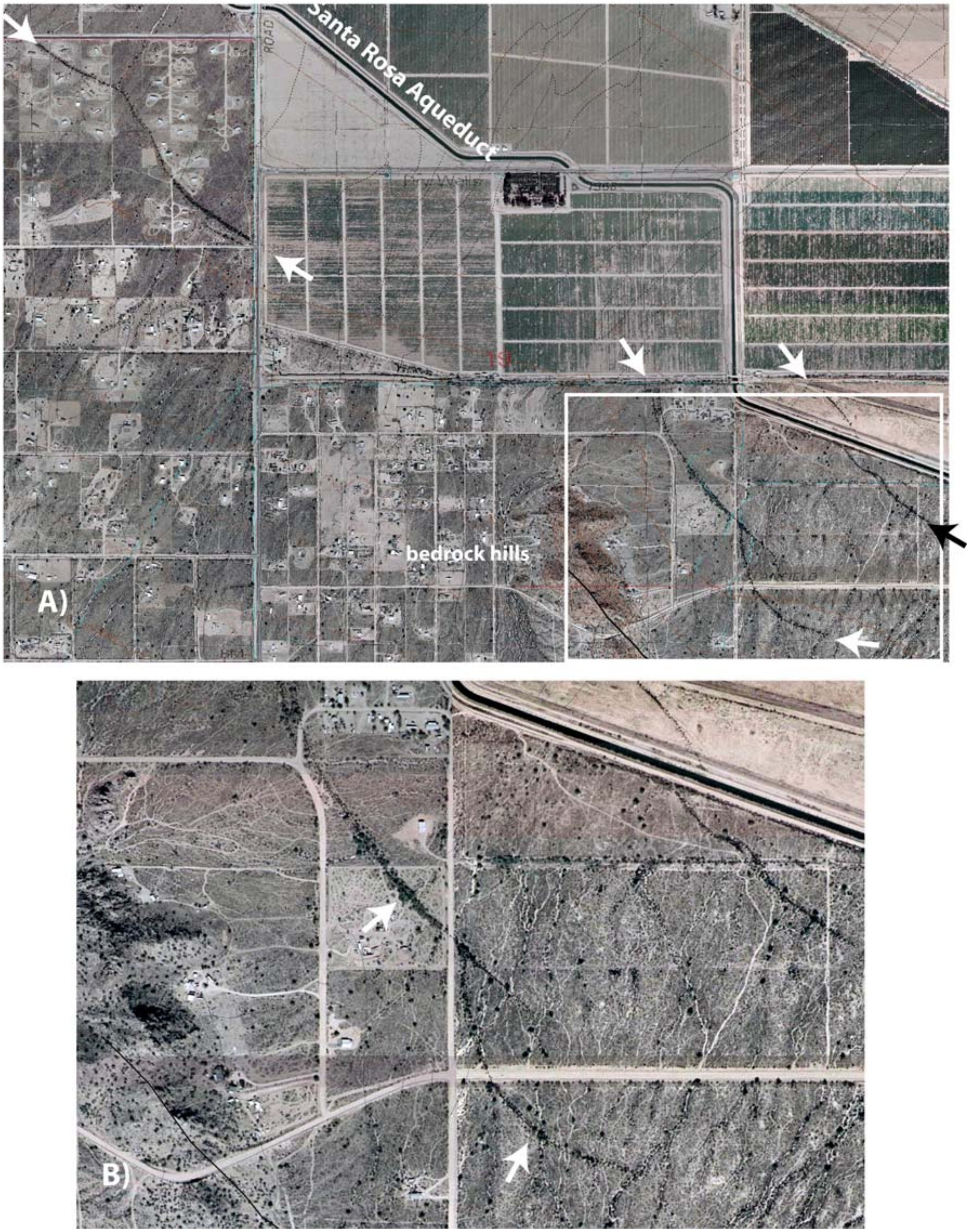

Figure 4. Aerial photographs of earth fissures near the southern margin of the map area. Arrows in Figure 4A point to the ends of several fissures. Bedrock is almost certainly shallowly buried around the low bedrock hills, and the fissures may well have developed where the basin alluvium thickens to the north. Figure 4B is a larger-scale view of the southeast corner of (4A) showing relatively mature vegetation along parts of the fissure network that existed prior to 1971.

Earth fissures are surface tension cracks caused by subsidence due to excessive withdrawal of ground water from underlying aquifers. As water is withdrawn from the interstices of aquifer sediment, the material compacts to fill in the empty pore space. If recharge rates are substantially less than withdrawal rates, aquifer compaction may be expressed on the surface as land subsidence and earth fissure development. Land subsidence occurs as a circular depression around areas of greatest ground water pumping (Slaff, 1993) and is usually greatest near the center of this depression. Earth fissures are formed on the edges of the "bowl" by differential compaction as areas of greater subsidence encounter those with less (Schumann and Genualdi, 1986). They begin as tension cracks in the subsurface, and enlarge as they capture surface runoff. As subsurface piping continues, they appear at the surface as small, aligned pits and cracks. When enough of the underlying soil is eroded, the roof over the fissure collapses, and reveals the underlying subsidence crack (Pewe, 1990). On the surface, these features are a preferred flow path for runoff and develop into gullies which may be as deep as 16 ft and wider than 50 ft (Schumann and Genualdi, 1986). Over time, material from the sides of the fissure and vegetation begin to fill in the fissure such that it becomes a linear depression in the landscape. Fissures may repeat part or all of this sequence if further lateral stresses are induced (Pewe, 1990)

Land subsidence and earth fissures pose a hazard to developed areas within the subsidence depression. Canals, highways and irrigation systems are affected more frequently than individual structures such as houses because they crosscut the area of subsidence and are more likely to experience the effects of differential compaction. Changes in the gradient of an agricultural area become problematic for canals and irrigation ditches which function most efficiently at their designed gradient. In addition, entire agricultural fields must be releveled, as was the case in the lower Santa Cruz valley (Schumann and Genualdi, 1986). Water wells become difficult or impossible to operate following subsidence; in many instances, the casing bottom is located below the zone of compaction such that the well itself does not lower with the ground but remains in its original position. This leaves the wellhead elevated above the ground surface and causes well casings which line the well to break or bend, rendering the well useless for the pumping and monitoring of ground water (Slaff, 1993).

Areas of subsidence may also affect the gradient and behavior of stream systems. As a stream enters the subsidence bowl, gradient increases and causes stream incison into previously stable subtrate; as the gradient decreases toward the center of the bowl, the stream loses its capacity to transport sediment and relinquishes its sediment load to the landscape. Changes in moisture availability, vegetation, and land use may accompany stream adaptations. In some areas the subsidence may be too great to allow streams to exit the depression, thus creating a new flood prone region.

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