Surficial Geology and Geomorphology of Central Sauceda Valley, Barry M. Goldwater Air Force Range, Maricopa County, Arizona

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Includes 12 pages of text and one 1:24,000-scale geologic map

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Introduction

This report summarizes the surficial geology and geomorphology of the central Sauceda Valley, on the East Tactical Range of the Barry M. Goldwater Air Force Range (Figure 1). The purpose of these investigations was to describe the general geologic and geomorphic framework for an archaeological survey of the central Sauceda Valley that was conducted for the Air Force by SWCA, Inc, and Arcadis Geraghty and Miller (Lyon, 2000). A 1:24,000-scale map showing the surficial geology of the survey area is included with this report (Plate 1). Interpretation of aerial photographs was done primarily by K. Demsey, with field checking and final mapping by A. Meglioli of Geraghty and Miller, with field assistance from P. Pearthree. Map compilation and final map preparation was done by T. Biggs. Report preparation was done primarily by P. Pearthree.

Several previous geologic investigations have been conducted in this area. Kirk Bryan explored this area as part of a project to locate and evaluate potential water sources (Bryan, 1925). He described the general geology and physiography of this area, and made many observations about the processes that have shaped this landscape. This portion of Arizona was mapped on a reconnaissance basis by E.D. Wilson and R.T. Moore as part of their efforts to develop a 1:500,000-scale geologic map of Arizona (Wilson and others, 1969). The bedrock geology of the Ajo 1:250,000-scale sheet, which includes the project area, was subsequently mapped in somewhat more detail (Gray and others, 1988). Much of the bedrock of the project was also mapped by Gray and others (1985) at 1:62,500. The generalized surficial geology of the Ajo sheet was mapped by Morrison (1983) at 1:250,000 scale. Bull (1991) developed a conceptual framework for understanding the impacts of climatic changes on arid region fluvial systems of the lower Colorado River region.

Acknowledgments

Numerous individuals contributed to these geomorphologic investigations. In particular, we thank Jerry Lyon and Heidi Roberts, who oversaw the field efforts, coordinated our field investigations with those of the archaeological survey, provided lots of information about the archaeology of the region, and generally kept us from getting into too much trouble. We also benefited substantially from discussions with Rick Ahlstrom of SWCA, who provided useful insights into the archaeology of this part of the world. Tim Orr and Sean Kneale assisted with layout of the geologic map (Plate 1).

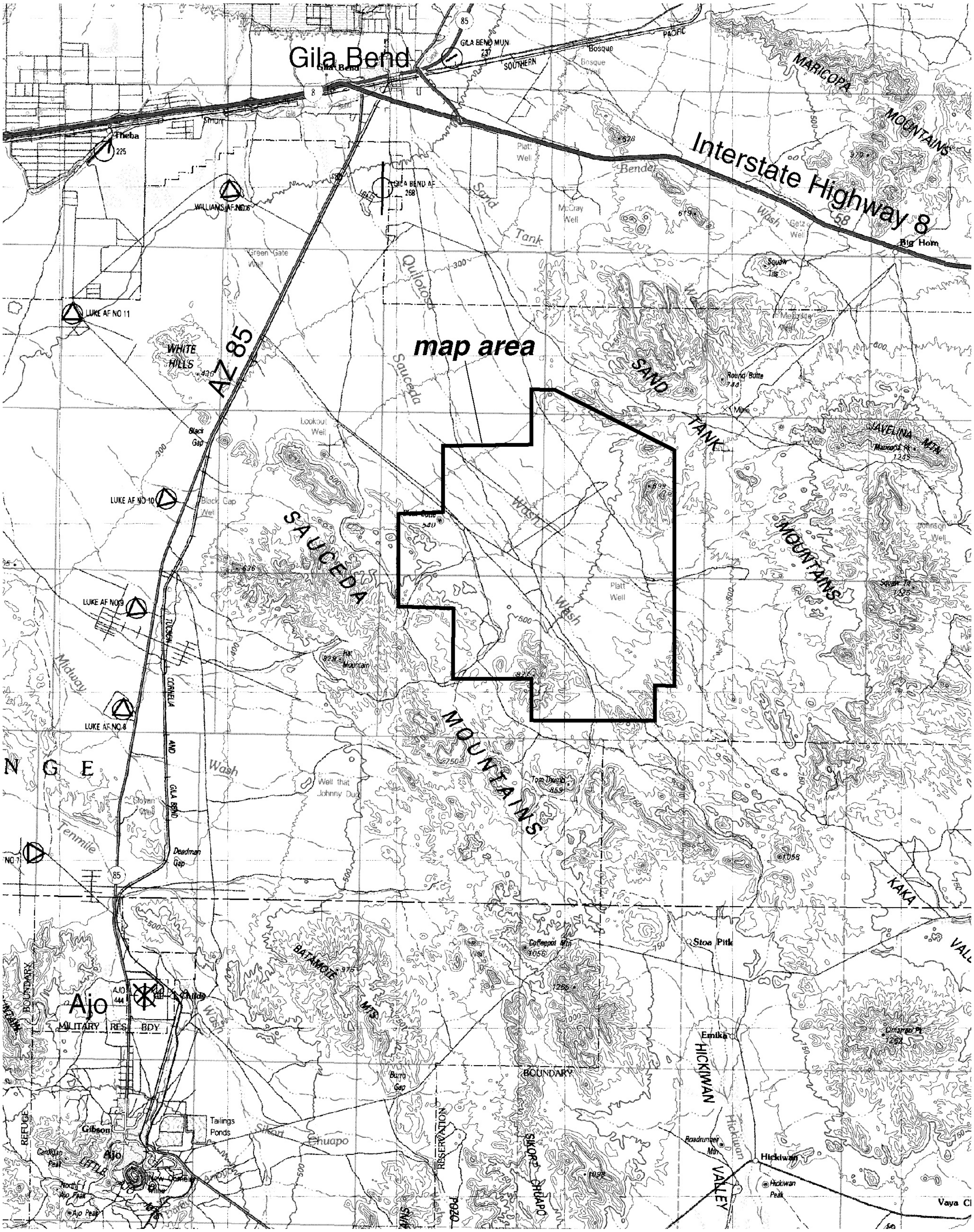

Figure 1. Location of study area in central Sauceda Valley.

Quaternary (0 to 1.8 Ma)	Holocene (0 to 10 ka)	late Holocene (0 to 4 ka) early to middle Holocene (4 to 10 ka)
	Pleistocene (10 ka to 1.8 Ma)	late Pleistocene (10 to 150 ka) middle Pleistocene (150 to 750 ka) early Pleistocene (750 ka to 1.8 Ma)
Tertiary (1.8 to 65 Ma)	Pliocene (1.8 to 5.5 Ma) Miocene (5.5 to 22 Ma)	
Proterozoic (570 Ma to 2.5 Ga)		

Table 1. Time intervals as used in this report. "Thousands of years before present" is abbreviated as **ka**; "millions of years before present" is abbreviated as **Ma**; "billions of years before present" is abbreviated as **Ga.**

Climate

The climate of the study area is currently hot and dry, with extreme seasonal temperature variations and two distinct seasons of rainfall. The nearest weather stations to the central Sauceda Valley are Ajo and Gila Bend. At Ajo (elevation 1747 feet asl), the average August high temperature is 103° F, and the average January low temperature is 42° F. Average annual precipitation at Ajo is 8.7 in. At Gila Bend (elevation 742 feet asl), which is closer to the map area, the average August high temperature is 109° F, and the average January low temperature is 38° F. Average annual precipitation at Gila Bend is about 6 in. Occasional freezing temperatures are recorded at both stations during most winters, but snow is rare. Slightly less than one-half of the annual precipitation at both weather stations falls between July and September. Late summer rainfall occurs as heavy thunderstorms when moist air sweeps northwards from the Gulf of California and the Gulf of Mexico. Occasionally, the area may be affected by moisture derived from dissipating tropical storms in late summer or early autumn.Winter precipitation generally is caused by cyclonic storms originating in the Pacific. It is usually less intense and therefore infiltrates into the soil more deeply than summer rainfall.

The climate of the Sonoran desert has not remained constant over the time period represented by the alluvial deposits and surfaces of Sauceda Valley. The transition from the relatively warm and stable Pliocene climate to the dramatic glacial-interglacial cycles of the Pleistocene resulted in major aggradation and erosion events recorded as alluvial fans and fan remnants in the study area. Analysis of packrat middens, collections of vegetation stored by packrats in crevices and preserved for tens of thousands of years, indicates that the climate similar to today has only existed since about 4 ka (Van Devender, 1990). Middle to late Pleistocene midden samples from the western Sonoran Desert contain fragments of juniper, pinyon pine, and Joshua tree, indicating cooler summers and a greater proportion of winter precipitation than today. However, precipitation probably reached a maximum during the late Pleistocene (30 to 10 ka), and the coexistence of frost-sensitive Whipple yucca and barrel cactus with juniper and pinyon pine suggests that late Pleistocene seasonal temperature extremes were less than those of today (Van Devender, 1990). Precipitation falling during winter months would have infiltrated more deeply than summer moisture due to lowered evaporation rates. Due to the increased effectiveness of leaching and equable temperatures, as well as the increased proportion of winter rain, late Pleistocene climate was likely more conducive to weathering of soil minerals than today's interglacial moisture regime.

General Geology and Geomorphology

Sauceda Valley is located in the middle of the Sonoran Desert subprovince of the Basin and Range physiographic province. The Basin and Range province includes southern, central, and western Arizona, all of Nevada, parts of California, New Mexico, Oregon, Texas, and Utah, and much of northwestern Mexico. The physiography of the Basin and Range province is characterized by alluvial basins and intervening mountain ranges that formed as a result of normal faulting related to extension of the crust during the past 30 million years or so (Shafiqullah and others, 1980). Relatively narrow and not very high, north- to northwest-trending ranges and broad, minimally dissected basins are typical of the Sonoran Desert subprovince. These characteristics imply that significant normal faulting has not occurred during the past 5 to 10 million of years in this area (Shafiqullah and others, 1980; Menges and Pearthree, 1989).

The bedrock geology of the project area has generally been mapped on several scales. Bedrock lithologies in the Sauceda Mountains on the southwest side of the valley consist primarily of silicic volcanic rocks (rhyolite and rhyodacite), with lesser amounts of mafic volcanic rocks (basalt and basaltic andesite) (Gray and others, 1985). Based on radiometric age estimates obtained for these rocks, they were erupted in the Miocene around 20 Ma. Tertiary basalt is common in the Sand Tank Mountains northeast of the valley as well, but much older Proterozoic schist and granite are the predominant lithologies in the southern Sand Tank Mountains (Gray and others, 1985; Gray and others, 1988).

The landscape of this part of Arizona may be divided into three main elements:

(1) Rugged, but not very lofty mountain ranges. The topographic fronts of the mountains are very embayed and sinuous, and outlying bedrock hills (inselbergs) are common. The very steep mountain slopes with minimal cover of colluvium attest to the predominance of erosional processes (Bryan, 1925). Erosion is facilitated by uncommon but intense rainfall and runoff, steep slopes, and sparse vegetative cover. It is likely that significantly more hillslope colluvium covered bedrock slopes in the mountains during glacial pluvial intervals of the Quaternary, especially in mountains composed of granitic or metamorphic rocks (Bull, 1991).

(2) Broad valley floors covered by deposits of larger axial washes. The larger washes in this region generally flow down the axes of the valleys about midway between the adjacent ranges. Floodplains associated with these washes are composed mainly of sand, silt and clay, with local gravelly channel deposits. Multiple small, discontinuous channels are typical, and well-defined channels are unusual. One or a few larger, well-defined channels exist along limited reaches of the axial drainages. Locally, alluvial fans exist along these washes where floodplains are very wide and increase in width substantially downstream.

(3) Piedmonts with minimal topographic relief. Piedmonts are the broad plains that slope gently from the mountains to the axial washes. They are covered primarily by alluvial deposits, which range in age from Holocene to early Pleistocene. Upper piedmont areas typically have tributary (converging downstream) drainage systems. Middle and lower piedmonts have weakly integrated, complex distributary (diverging downslope) drainage networks. Topographic relief is not great; channels are entrenched as much as 2 to 3 m below adjacent relict fan surfaces on upper piedmonts, but less than 1 m of relief between channels and adjacent alluvial surfaces is typical of middle and lower piedmonts.

The archaeological survey covered the central Sauceda Valley and the flanks of the Sauceda and Sand Tank mountains. Although the area covered by the survey and this map is fairly small, it includes each of these three landscape units. In the map area, the axial washes (Sauceda and Quilotosa washes) head in the southern Sauceda and Sand Tank mountains. The axial washes drain similar source lithologies as the smaller piedmont washes, and the axial washes are not very large, so the deposits associated with the axial washes and piedmont washes are generally similar in clast composition and particle rounding. Because of these similarities, deposits of axial washes and piedmont streams are not differentiated on this map, as they have been on some recent maps of other portions of the Barry M. Goldwater Air Force Range (Pearthree, Freeman, and Demsey, 2001; Pearthree, Klawon, and Demsey, 2001; Klawon and Pearthree, 2001).

Mapping Techniques and Ground Control

We employed standard surficial geologic mapping techniques to produce geologic maps of the project area. We developed a 1:24,000-scale surficial geologic map of the project area. Mapping was based primarily on interpretation of approximately 1:24,000-scale color photographs flown in 1985 that were supplied by the Air Force. Field surveys were conducted to verify geologic relations in the map area.

Surficial geologic units in the project area were differentiated by the source and process of emplacement of the deposits and their relative age. Surficial deposits were subdivided based on their ages, using criteria described below. The physical characteristics of alluvial surfaces (alluvial fans, floodplains, stream terraces) may be used to differentiate their associated deposits by age. The initial surface features of alluvial surfaces are shaped by large-scale depositional processes. When surfaces are isolated from further deposition or reworking by large streams, they

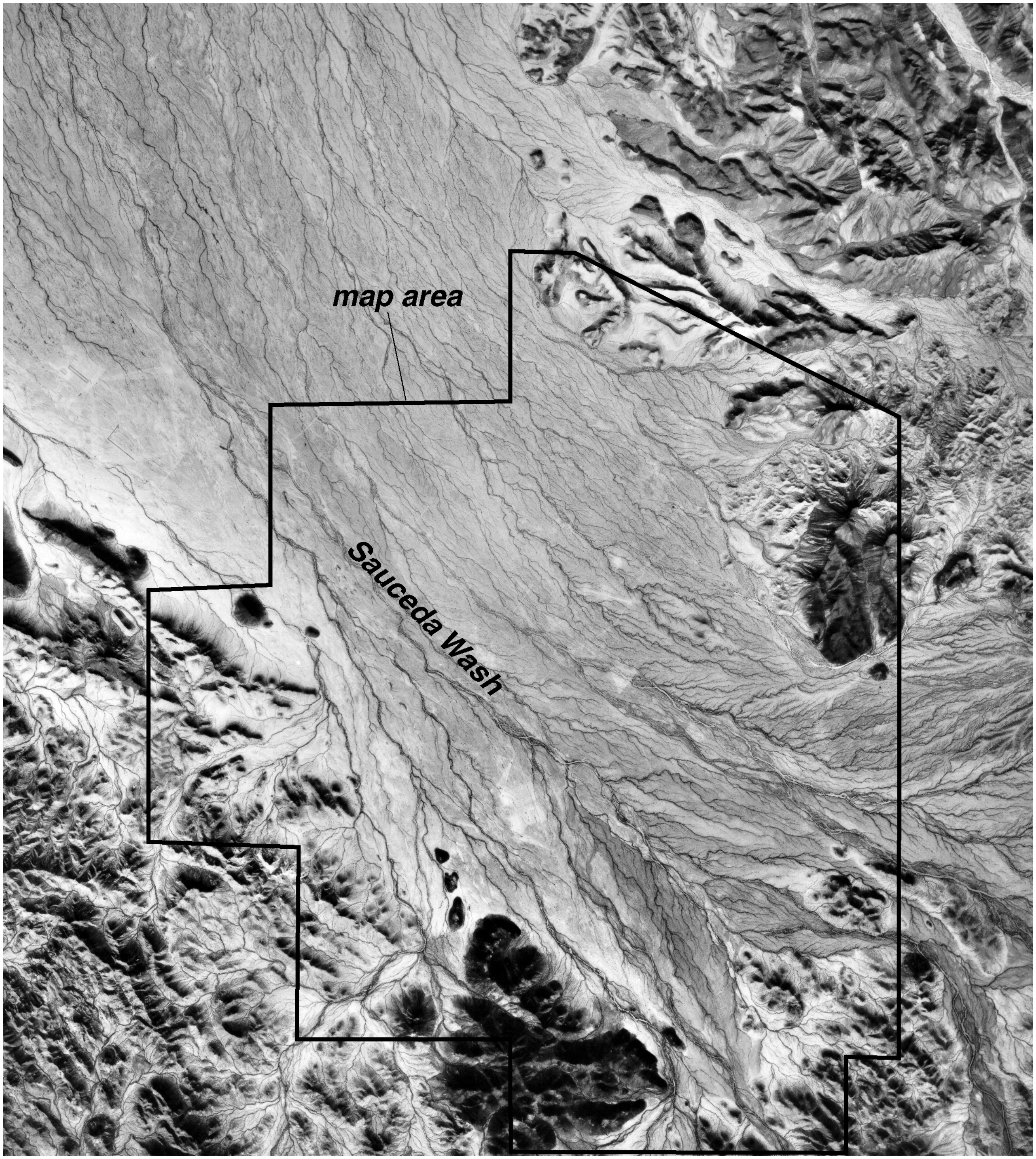

Figure 2. High-altitude aerial photograph of central Sauceda Valley.

are gradually modified over thousands of years by other processes, which operate very slowly and on a smaller scale. Modifying processes include (1) small-scale erosion and deposition that smooth the original surface topography; (2) bioturbation, the churning of sediments by organisms, which obliterates depositional structures; (3) development of soils, primarily through accumulation of silt, clay, and calcium carbonate; (4) development of surficial gravel pavements (desert pavements) above zones of accumulated silt and clay; (5) accumulation of rock varnish on surface gravel clasts; (6) development of tributary dendritic (treelike) stream networks on surfaces; and (7) entrenchment of these stream networks below original depositional surfaces and subsequent dissection of these surfaces.

Alluvial surfaces of similar age have a characteristic appearance because they have undergone similar post-depositional modifications, and they are distinctly 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 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. Very old fan surfaces, in contrast, have been isolated from substantial fluvial deposition or reworking for hundreds of thousands of years. These surfaces are characterized by strongly developed soils with clay- and calcium-carbonate-rich horizons, well-developed tributary stream networks that are entrenched 1 to 10 m below the fan surface, and strongly developed varnish on surface rocks. Old alluvial-fan surfaces may also have smooth, closely packed desert pavements between the entrenched drainages. The ages of alluvial surfaces in the southwestern United States may be roughly estimated based on these surface characteristics, especially soil development (Gile and others, 1981; Bull, 1991).

Description of Map Units

Surficial deposits on the accompanying map (Pocket Map 1) are classified by inferred age. Deposits are divided by age into late Holocene (Qy2; less than about 4 ka), early to middle Holocene (Qy1; about 4 to 10 ka), late Pleistocene (Ql; 10 to 150 ka), middle Pleistocene (Qm; 150 to 500 ka), middle to early Pleistocene (Qmo; 500 to 1000 ka), and early Pleistocene (Qo; ~1 to 2 Ma). As was noted above, ages of all of these deposits are roughly estimated by correlation with other similar areas, because no useful constraints have been developed for most of the deposits in these valleys. Age estimates given here are based on correlation with the surface chronosequences developed in the lower Colorado River valley by Bull (1991) and the Table Top Mountain area by Pendall (1994); see Table 2.

Surficial Geologic Units

Qy2 - late Holocene alluvium (< 4 ka)

Channels, undissected floodplains, low terraces, and active or recently active alluvial fans. On middle and lower piedmonts, deposits typically consist of sand, silt, and clay, with local channel gravel deposits; channels are small, shallow, and discontinuous. On upper piedmonts, deposits typically consist of sand to small boulders in well-defined channels, with sand and finer deposits on terraces and other areas subject to overbank flooding; braided or distributary channels networks are common. Vegetation is generally sparse, with low desert shrubs and annuals; vegetation density is higher with larger shrubs and some palo verde, ironwood, and mesquite along and near channels. Limited, open gravel lags on surface, but there are no pavements and rock varnish is minimal; surface color is light brown, but may be darker during seasons with above-average moisture because of growth of annuals and other ground covering plants. **Qy2** is probably correlative with units Q4 and Q3c of Bull (1991; see Table 2), which are of late Holocene age.

Qy1 - middle to early Holocene alluvium (4 to 10 ka)

Undissected terraces and alluvial fans somewhat isolated from active fluvial systems. Alluvial surfaces typically are < 1 m above adjacent washes and are partially covered by weak pavements or residual gravel deposits composed of pebbles and few cobbles with minimal rock varnish, although deposits are predominantly sand and finer. Vegetation on lag surfaces is very sparse. Locally, there is some eolian overprint consisting of linear to semicircular coppice dunes associated with more vegetation, mainly creosote; dunes crests less than 1 m above adjacent surfaces with gravel lags. Surface color is light brown, typically somewhat lighter than **Qy2** surfaces. **Qy1** deposits are probably correlative with unit Q3b and possibly unit Q3a of Bull (1991), which are middle to early Holocene in age.

Qy - Holocene alluvium (< 10 ka)

Undifferentiated Holocene alluvium, typically in upper piedmont areas and valleys in the mountains.

Ql - late Pleistocene alluvium (~10 to 150 ka)

Weakly to moderately dissected alluvial fans and terraces that are higher and either lighter-colored or grayer than surrounding **Qy** surfaces. In lower and middle piedmont areas, **Ql** surfaces typically have tributary drainage networks that are incised less than 1 m; in upper piedmonts, **Ql** surfaces may be as much as 2 m above active channels. Surfaces have weak to moderate pavements composed of angular to subangular pebbles and some cobbles; rock varnish typically is weak; surface color is white to gray. Soils associated with this unit are somewhat enriched in clay and silt, and are slightly reddened. **Ql** deposits are probably correlative with unit Q2c of Bull (1991), which is of late Pleistocene age.

Qm - middle Pleistocene alluvium (~150 to 500 ka)

Older relict fans with moderate to strong soil development and well-developed, entrenched tributary drainage networks. Modern channels are incised up to 3 m below **Qm** surfaces. Between modern channels, surfaces typically are very planar, with subdued bar-and-swale topography, moderate to strong pebble to cobble pavements, and gray to black rock varnish. Underlying soil is reddened and enriched in clay and has moderate to strong carbonate accumulation. These deposits are exposed in middle and upper piedmont areas and cover much of the floor of Sauceda Valley. They are probably correlative with units Q2b and Q2a of Bull (1991), which are middle Pleistocene in age.

Qml – middle and late Pleistocene alluvium, undivided (~10 to 500 ka)

Qmo - middle to early Pleistocene alluvium (~500 to 1,000 ka)

Middle to early Pleistocene relict alluvial fans surfaces are typically 3 m to 5 m above active wash bottoms. Dissection by streams has apparently been limited by petrocalcic horizons that armor the surface. Clasts on the **Qmo** surfaces are predominantly basalt and rhyolite cobbles, and smaller gravel size quartz and caliche fragments mantle the surface between basalt cobbles. Desert pavement exist but are fairly open; they probably been disrupted by erosion. Surface cobbles are moderately darkly varnished. Carbonate soil horizon development is very strong, with a hard laminated zone. **Qmo** deposits are exposed in middle and upper piedmont areas, and cover portions of the floor of Sauceda Valley. They are probably correlative with unit Q1 of Bull (1991), which is of early Pleistocene age.

Qo - early Pleistocene alluvium (~1 to 2 Ma)

Oldest, deeply eroded relict fans with moderate to strong soil development. Surfaces have moderate cobble to boulder pavements, rock varnish varies from very strong to weak; surface color is lighter than most **Qm** surfaces because of fragments derived from petrocalcic soil horizons litter **Oa** surfaces. Tributary drainage networks are strongly developed and moderately to deeply entrenched; areas between channels are rounded by erosion; **Oa** surfaces are only preserved in a few upper piedmont areas where bedrock is resistant fine-grained volcanic rocks. They are probably correlative with unit Q1 of Bull (1991), which is of early Pleistocene age.

Age Range	**Table Top Mountain chronosequence (Pendall, 1994)**	**Lower Colorado River chronosequence (Bull, 1991)**	**Growler chronosequence (this report)**
late Holocene (0-4 ka)	Y2	Q3c	Qy2
middle Holocene (4-7 ka)	Y1	Q3b	Qy1
early Holocene to latest Pleistocene (7-15 ka)	MY	Q3a	Qy1?, Ql?
late Pleistocene (15-150 ka)	M2	Q2c, Q2b	Ql, Qml
middle Pleistocene (150-750 ka)	M1, Mo	Q2b, Q2a	Qm, Qml, Qmo
early Pleistocene (750 ka to 1.6 Ma)	O2	Q1	Qo

Table 2. Tentative correlation table for deposits of the lower Colorado River Valley, the Table Top Mountain area between Gila Bend and Casa Grande, and the central Sauceda Valley.

Generalized Bedrock Geologic Units

(descriptions of bedrock units are simplified from Gray and others, 1985)

Tb - Miocene basalt and basaltic andesite flows

Dark gray to black, mafic lava flows. Individual basalt flows range up to 25 m thick, but most are much thinner. Older basalt flows that date to about 20 Ma have been tilted up to 25° to the southwest by faulting. Younger basaltic rocks that date to about 15 Ma are relatively flat-lying and form mesas in both the Sand Tank and Sauceda mountains. These rocks are quite resistant to erosion; weathering of these rocks produces relatively coarse sediment.

Tr - Miocene rhyolite and rhyodacite flows and tuffs

This unit includes silicic lava flows, welded pyroclastic tuffs, and ash fall tuffs. Rocks included in this unit have a variety of colors, including gray, pink, yellow, and brown. Dates that have been obtained for these rocks range from about 19 to 21 Ma. These rocks generally have been tilted by faulting; dip directions vary. Some lava flows and welded tuffs are quite resistant to erosion and form cliffs; weathering of these lithologies produces relatively coarse sediment. Less welded tuffs and air fall tuffs are much more susceptible to erosion, and typically produce more, and finer, sediment.

pCg - Precambrian granite

Light gray to light brown, coarse porphyritic granitic rock. Structural deformation is pervasive in these rocks. The granitic rocks intrude the older Pinal Schist, described below. Granite is quite susceptible to weathering and erosion in this environment; weathering of this rock produces abundant sand to cobble-sized sediment.

pCs - Precambrian schist

The oldest rock unit in the map area is the Pinal Schist. This is a biotite rich, strongly foliated and lineated metasedimentary rock with abundant quartz veins. The schist is moderately susceptible to weathering and erosion.

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Surficial Geologic Map of Central Sauceda Valley, Barry M. Goldwater Air Force Range, Maricopa County, Arizona

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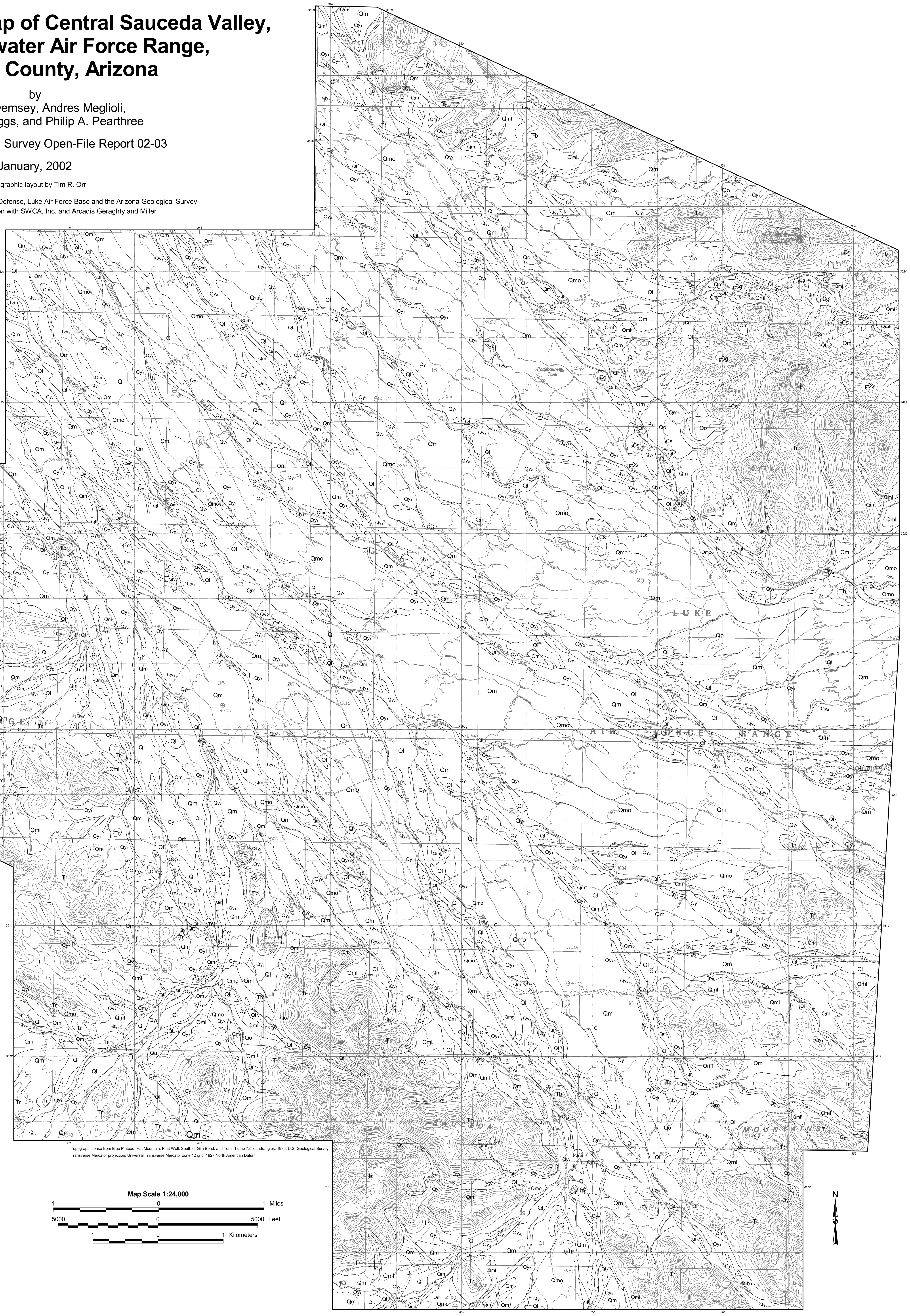


Topographic base from Blue Plateau, Hat Mountain, Platt Well, South of Gila Bend, and Tom Thumb 7.5' quadrangles, 1986, U.S. Geological Survey
Transverse Mercator projection; Universal Transverse Mercator zone 12 grid; 1927 North American Datum

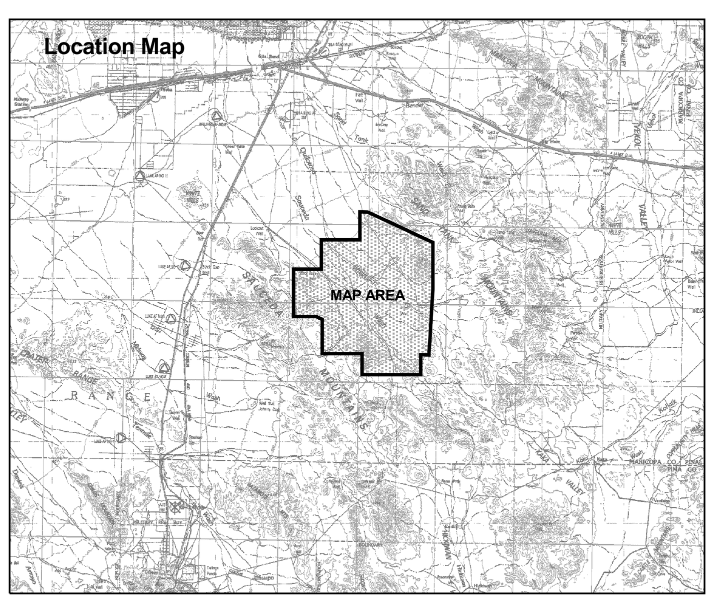
Map Units

Surficial Geologic Units

Unit	Description
Qy_2	Late Holocene alluvium in channels, and on undissected floodplains, low terraces, and active or recently active alluvial fans
Qy_1	Middle to early Holocene alluvium on undissected terraces and alluvial fans somewhat isolated from active fluvial systems
Qy	Undifferientated Holocene alluvium, typically in upper piedmont areas and valleys in the mountains
Ql	Late Pleistocene alluvium on weakly to moderately dissected alluvial fans and terraces
Qml	Middle to late Pleistocene alluvium on relict alluvial fans
Qm	Middle Pleistocene alluvium on relict, moderately dissected alluvial fans with moderate to strong soil development
Qmo	Middle to early Pleistocene alluvium on relict, moderately dissected alluvial fans with petrocalcic horizons
Qo	Early Pleistocene alluvium on deeply eroded relict fans with moderate to strong soil development

Bedrock Geologic Units

Unit	Description
Tb	Miocene basalt and basaltic andesite flows (15 to 20 Ma)
Tr	Miocene rhyolite and rhyodacite flows and tuffs (19 to 21 Ma)
pCg	Precambrian coarse porphyritic granite
pCs	Precambrian Pinal Schist



Map Scale 1:24,000

1 — 0 — 1 Miles
5000 — 0 — 5000 Feet
1 — 0 — 1 Kilometers