Surficial Geology Around the White Tank Mountains, Central Arizona

by

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Arizona Geological Survey
Open-File Report 91-8

November, 1991

Arizona Geological Survey
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Prepared in cooperation with
the U.S. Geological Survey COGEOMAP Program,
the Flood Control District of Maricopa County,
and the Arizona Department of Water Resources

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

Introduction

These nine maps depict the distribution and general ages of Quaternary geomorphic surfaces and associated alluvial deposits surrounding the White Tank Mountains, on the western margin of the Phoenix metropolitan area. The White Tank Mountains are one of many mountain ranges in the Basin and Range physiographic province of Arizona. The Basin and Range province in the vicinity of the study area is characterized by relatively small mountain ranges of modest topographic relief separated by wide, gently sloping piedmonts and basin bottom river drainages. The study area is drained by the Gila River. By indicating the age of alluvial surfaces and deposits, these maps provide a basis for evaluating the Quaternary geologic history of the area and assessing potential geologic hazards.

Alluvial surfaces and deposits differentiated for this map are assigned to Quaternary and Upper Tertiary geologic units primarily on the basis of the estimated timing of cessation of major deposition on each geomorphic surface. Relative topographic positions of each surface, surface characteristics, and degree of soil development in underlying deposits are the principal criteria used to assess surface age. The geomorphic surfaces and associated deposits were formed during discrete time intervals ranging from the Late Tertiary to the late Holocene. Six categories of alluvial surfaces are differentiated and mapped on the basis of surface age. Alluvial surfaces are further subdivided into piedmont and basin axis units. The characteristics of each map unit are described in detail below. The estimated ages of the units are inferred by correlation with similar surfaces and soils radiometrically dated elsewhere in the southwestern United States (Gile and others, 1981; Bull, 1991; Menges and McFadden, 1981).

The mapping is based primarily on interpretation of natural-color (1:24,000 scale) aerial photographs. Initial unit designations were later field checked throughout the map area. In extensive agricultural tracts where natural surface characteristics are altered, published soil surveys (Soil Conservation Service, 1977; 1986) were used to evaluate soil development and to delineate boundaries between surfaces of different ages. The nine 1:24,000 scale maps of this series represent a more detailed survey over a small portion of regions mapped on a reconnaissance basis (1:100,000 scale) by Demsey (1988, 1989).

This project was supported by the Arizona Geological Survey, U.S. Geological Survey Cooperative Geologic Mapping (COGEOMAP) Program, the Maricopa County Flood Control District, and the Arizona Department of Water Resources. Aerial photographs were provided by the U.S. Bureau of Land Management.

Description of Map Units

Piedmont Units

Y2 - Late Holocene alluvial fans, low terraces, and active stream channels, < 3 ka.

Alluvial fan deposits on the lower piedmont are fine silts and sands. Middle piedmont surfaces and active channels extending into the White Tank Mountains are very gravelly sands and

silts. Surfaces are typically undissected and display distributary drainage patterns, although 1.5 m arroyo cuts occur locally on the lower piedmont. Surfaces are typically smooth, but bar and swale topography is present on the middle piedmont. Desert pavement and desert varnish are absent. Minimal to no soil development has occurred. Soil great groups are Torrifluvents and Torriorthents. These areas are subject to occasional to frequent flooding.

Y1 - Late to early Holocene alluvial fans and terraces, 1 to 10 ka.

Deposits on the middle piedmont are a coarse poorly sorted, angular to subangular admixture of silt, sand, and gravel. On the lower piedmont, deposits are typically fine silt and sand. Surface relief is typically less than 0.5 m above active channels. Lower piedmont surfaces are smooth and flat with an incipient dendritic drainage pattern. Middle piedmont surfaces have well preserved bar and swale topography with very little tributary drainage development. A poorly developed pebble to granule desert pavement (cobble to granule on middle piedmont) exists over 50 to 85 percent of the surface. Surface cobbles, when present, are lightly and incompletely varnished along the base of the cobble to brownish black (10 YR 2/2). An orange (7.5 YR 7/6) to dull yellowish brown (10 YR 5/4) color is rarely observed on cobble undersides. Minimal soil development has occurred in the underlying deposits -- the most strongly developed profiles contain cambic horizons (hue 7.5 YR) above stage I to II calcic horizons. Soil great groups are Torrifluvents, Torriorthents, and Camborthids. Most Y1 areas are not subject to flooding at present. However, because typically there is little topographic relief between active channels and Y1 surfaces, they could potentially become subject to flooding through minor shifts in the present depositional patterns.

Y - Undifferentiated Holocene alluvial surfaces, 0 to 10 ka.

In some places this designation is used where the Y1 and Y2 surfaces are too intricately intermingled to map separately at this scale. In other areas on the lower piedmont the designation is used where surface characteristics are not distinctive of either Y1 or Y2 surfaces but are clearly of Holocene age. These areas may be subject to occasional to frequent flooding.

M2 - Latest to late Pleistocene alluvial fans, 10 to 150 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand, and gravel. The surfaces are moderately dissected with typically < 1 m to 3 m relief above active channels. Interfluve areas are broad and flat with original gravel bar and swale topography typically moderately to well preserved. A poorly to moderately developed cobble to granule desert pavement is found over 50 to 80 percent of the surface. Surface cobbles are incompletely varnished to very dark brown (7.5 YR 2/3) on top and reddish brown (2.5 YR 4/6) to more commonly dull orange (5 YR 6/4) on undersides. M2 surfaces are not widespread and are predominantly restricted to the middle piedmont. Underlying soils typically contain cambic horizons (hue 7.5 YR), above a stage I to II calcic horizon. Soil great groups are Camborthids and Haplargids. Most areas are free from flooding, although those areas of low relief could become susceptible to flooding with relatively minor shifts in depositional patterns.

M1b - Middle to late Pleistocene alluvial fans, 150 to 300 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand, and gravel. The surfaces are moderately dissected on the upper piedmont with 1-6 m of relief above active channels.

On the lower and middle piedmont relief may be less than 1 m. Interfluve areas are broad and flat with original gravel bar and swale topography poorly preserved. A moderately to well developed cobble to pebble desert pavement is found over 50 to 75 percent of the surface. Surface cobbles are incompletely varnished to black (5 YR 1.7/1) on top and reddish brown (2.5 YR 4/6) to less commonly dull orange (7.5 YR 7/4) on undersides. Underlying soils are characterized by weakly developed argillic horizons (hue 5 YR), typically above a stage II calcic horizon. Soil great groups are Haplargids and Calciorthids. Most areas are isolated from flooding except in entrenched channels, but areas of low relief on the middle and lower piedmont could become susceptible to flooding with relatively minor shifts in depositional patterns.

M12 - Middle or late Pleistocene distal alluvial fans, 10 to 300 ka.

Undifferentiated M1b and M2 surfaces. This designation is used mostly in agricultural areas where surface characteristics are destroyed and available soil descriptions do not enable differentiation of the two surfaces. This designation is locally used elsewhere in areas not field checked. Only areas of low relief may be susceptible to flooding.

M1a - Middle to early Pleistocene alluvial fans, 300 to 1,000 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand and gravel. The surfaces are moderately dissected with typically 1-6 m of relief above active channels but less than 0.5 m of relief above Unit M1b. Interfluve areas are broad, flat, and smooth; bar and swale topography is typically absent or poorly preserved. A well developed cobble to pebble desert pavement is found over the entire surface. Surface cobbles are completely varnished black (5 YR 1.7/1) on top and reddish brown (2.5 YR 4/8) on undersides. Surfaces are typically well preserved and are the darkest surfaces on the White Tank Mountains piedmont. Underlying soils are characterized by moderately to very strongly developed argillic horizons (hue 5 to 2.5 YR), commonly overlying a stage IV calcic horizon. (May locally be composed of river terraces west of the Hassayampa River). Soil great groups are Haplargids. These areas are isolated from active fluvial processes, and only entrenched channels are subject to flooding.

M1 - Middle Pleistocene alluvial fans, 150 to 1,000 ka.

Undifferentiated M1b and M1a surfaces. (May locally be composed of river terraces of the same age immediately north of and adjacent to Wagner Wash and Trilby Wash). On the middle piedmont this designation is used where the two surfaces are too intricately intermingled to map separately at this scale. In other areas this designation is used where surface characteristics are destroyed (agricultural areas) or where extensive field checking was not conducted (north of Wagner Wash and Trilby Wash). Only entrenched channels dissected into the surface are subject to flooding in undisturbed areas.

O - Early Pleistocene to late Pliocene alluvial fans, > 1,000 ka.

Alluvial fan surfaces and deposits of inferred early Pleistocene to late Pliocene age. This unit occupies the highest topographic positions on the White Tank Mountains piedmont and occurs only on the upper piedmont. The deposits are characteristically poorly sorted subangular gravels containing minor amounts of finer material. Deposits range in thickness from greater than 15 m to only a thin veneer (<2 m) over bedrock pediments. The surfaces are deeply dissected (10-15 m). Interfluve

areas are well-rounded ridges with intervening swales or ravines; original depositional surfaces are rarely preserved. Degraded surfaces are typically covered with abundant fragments of pedogenic carbonate derived from exposed brecciated laminar petrocalcic horizons. The petrocalcic fragments commonly impart a light colored appearance to these surface remnants as observed on aerial photographs. Soils are generally stripped by erosion down to exposed remnants of stage IV to VI petrocalcic horizons. Soil great groups are Durorthids. Flooding is restricted to entrenched channels, although hillside slope wash is probable.

Axial Drainage Units

Y2r - Active channels and low terraces along axial drainages, < 3 ka.

Basin axis river channels and deposits of the Gila River, Hassayampa River, Wagner Wash, and Trilby Wash. Active channels on the present river bottoms were not separately mapped as channel positions frequently shift across the entire surface. Deposits range from silt to coarse sands but well rounded cobble bars are common along the Gila River and Hassayampa River. Flooding occurs frequently in basin axis channels.

Y1rt - Late to early Holocene terraces along axial drainages, 1 to 10 ka.

Deposits are typically fine silt and sand with common gravel lenses of well rounded cobbles. Terrace surfaces are smooth and typically less than 1.5 m above the active basin axis drainages (Y2r). These areas could potentially be flooded during very large flow events or after an extended period of aggradation in the active basin axis channels (Y2r).

M1bt - Middle to late Pleistocene river terraces, 150 to 300 ka.

High terrace of the Hassayampa River. This surface is mapped in only one area along the eastern edge of the Hassayampa River at the northern end of the Daggs Tank quadrangle. The terrace surface is flat and dissected up to 30 m by small tributaries flowing into the Hassayampa. The surface is inset 10 m below the adjacent Org deposits. Flooding may occur in entrenched channels and locally along the margin with the topographically higher Org deposits.

Ort - Early Pleistocene to late Pliocene river terraces, > 1,000 ka.

Highest terrace along the Hassayampa River. The well rounded gravel found at the surface is typically darkly varnished. In small localized areas, much of the surface is covered by petrocalcic fragments derived from underlying petrocalcic horizons. The terrace surfaces are dissected up to 30 m by small tributaries flowing into the Hassayampa River. Elsewhere the surface is very flat with a wide spacing between broad shallowly dissected (<2 m) drainages developed on the surface. Flooding restricted to entrenched channels.

Org - Early Pleistocene to late Pliocene river deposits, > 1,000 ka.

Deposits of well-rounded, well-sorted gravel and cross-stratified sand representing bedload material of major axial drainages. This unit is currently exposed along the margins of the

Hassayampa River. The deposits exhibit zones (> 1 m) strongly indurated with carbonate cement. The original depositional surface (Ort) is completely eroded in these areas exposing the underlying deposits (Org). Flooding restricted to entrenched channels, although hillside slope wash is probable.

Bedrock Units* -

T - Tertiary volcanics

TK - Tertiary or Cretaceous intrusive and volcanic rocks

X - Early Proterozoic gneiss and granite

* - Bedrock units are generalized to show lithologies and ages. Detailed lithologic contacts and structures are not shown. Rock ages from Reynolds (1988).

Key to Map Symbols

Surficial geologic contact (dashed where inferred)

Basinward pediment boundary

Upslope edge of agricultural fields

Distribution of Surficial Deposits and the Quaternary Evolution of the White Tanks Piedmonts

In general, relatively young alluvial surfaces become increasingly extensive downslope on the piedmonts of the White Tank Mountains. The oldest surfaces (O and M1a) are found along the mountain front while the youngest surfaces (Y) are dominant adjacent to the basin axis drainages. This distribution suggests a general tendency toward erosion throughout the Quaternary punctuated by periods of equilibrium or aggradation.

Thick alluvial-fan deposits associated with the early Pleistocene to late Tertiary (O) surfaces probably represent the final stage of basin-filling sedimentation associated with the Basin and Range disturbance. All of the younger surfaces are associated with thin veneers of sediment, typically several meters thick or less, overlying older deposits. As a result of erosion throughout the Quaternary, only small, deeply dissected remnants of the early Pleistocene to late Tertiary surfaces are exposed along the mountain front. The change from an aggradational to a primarily erosional phase is most likely related to the cessation of tectonic activity in the region, although integration of the major basin axis drainages and climate changes probably played a minor role.

Middle to late Pleistocene surfaces (M1a and M1b) extend from the upper to lower piedmont and cover much of the White Tank Mountains piedmonts. These relatively thin but areally extensive deposits represent pulses of deposition that punctuated the long-term tendency toward downcutting and erosion on the piedmonts. Distinct differences in surface characteristics and soil development between M1a and M1b indicate that the interval between deposition of these units was probably hundreds of thousands of years long. However, the amount of relief between M1a and M1b typically is negligible, so the net downcutting in the middle Pleistocene was minimal. As a result, distinguishing between these two surfaces is sometimes difficult and they remain undifferentiated in some areas (M1).

The younger surfaces (M2, Y1, and Y2) are found predominantly in the lower and middle piedmont areas. Associated deposits indicate these surfaces are largely the product of erosion of M1 surfaces. Most drainages supplying sediment to the younger surfaces on the lower piedmont head on M1 surfaces and do not extend into the mountains. Sediment thickness on the young surfaces is extremely thin and it is common to see small pods of older units poking through the younger surfaces.

The presence of relatively small, active distributary flow areas on the middle piedmont suggest that loci of deposition has not shifted significantly since the latest Pleistocene. Active distributary flow areas are alluvial fans that become reconfined between older deposits at their downstream ends. They are characterized by distributary channel networks and extensive, young (Y2 and Y1) deposits. Late Pleistocene surfaces (M2) are restricted for the most part to the middle piedmont, where they usually flank younger distributary flow areas.

Deep entrenchment of the Hassayampa River has occurred during the Quaternary, as the present river bottom (Y2r) is over 30 m below the early Pleistocene to Late Tertiary river terrace (Ort). Entrenchment evidently has preceded relatively continuously throughout the Quaternary as no major terraces of intermediate height are observed except for a small middle Pleistocene terrace (M1bt) in the northern portion of the study area. The piedmont surfaces appear largely unaffected by the entrenchment of the Hassayampa River as even the youngest surfaces are graded to the high river

terrace (Org). Only minor dissection has occurred along the downslope edges of the piedmont units as newly formed drainages graded to the present river bottom erode headward.

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