Surficial Geology of the Apache Junction Area, Northern Pinal and Eastern Maricopa Counties, Arizona.

by

Gary Huckleberry

Arizona Geological Survey
Open-File Report 94-10

June, 1994

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

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

Introduction

The eastern Phoenix Basin has experienced tremendous population growth and urban development withn the last 50 years. Some of this development has occurred in and near Apache Junction on the piedmont of the Superstition and Goldfield Mountains. Because of increased development in this area, there is a pressing need to understand the nature and distribution of surficial deposits. Although an environmental geologic study of the Apache Junction 7.5'-quadrangle was performed in the early 1970's (Turek, 1974), detailed mapping of basin deposits in this region has only recently been performed (Huckleberry, 1993a). Reduced vegetation, gully erosion, and earth fissures are some of the nascent evidence of land degradation due to improper land use and management of the natural resources. Surficial geologic mapping provides a spatial data base for age estimation of landforms and the characterization of physical properties of unconsolidated deposits. This information in conjunction with soil survey data can be used to facilitate sound land-use decisions.

This report presents the results of surficial geologic mapping in the Apache Junction and Desert Well 7.5-minute quadrangles (Figure 1). It is a supplement to previous surficial geologic mapping performed in the Superstition Mountain piedmont area (Huckleberry, 1993a).

Methods

Surficial geologic mapping is based on the premise that alluvial surfaces of different ages can be distinguished based on time-dependent physical characteristics. These physical characteristics include topographic position, degree of stream dissection, desert pavement development, and soil formation (Bull, 1991; Christensen and Purcell, 1985).

Surficial geologic mapping of the Apache Junction area was accomplished in four stages. The first stage was the analysis of aerial photography to help distinguish geological surfaces. Black and white stereo photography (1:42,000 scale) was used to trace geologic boundaries onto 1:24,000-scale orthophotos.

The second stage involved field reconnaissance and checking map unit boundaries delineated from aerial photography. Fieldwork was performed January through May, 1994. Soils were described for age estimation and correlation of surfaces. Because much of the lower piedmont is not dissected and lacks natural soil exposures, a backhoe was used to excavate a series of soil pits. Soils were described according to guidelines established by the Soil Survey Manual (Guthrie and Witty, 1981; Soil Survey Staff, 1951). Calcium carbonate development was characterized by the morphogenetic system of and Machette (1985).

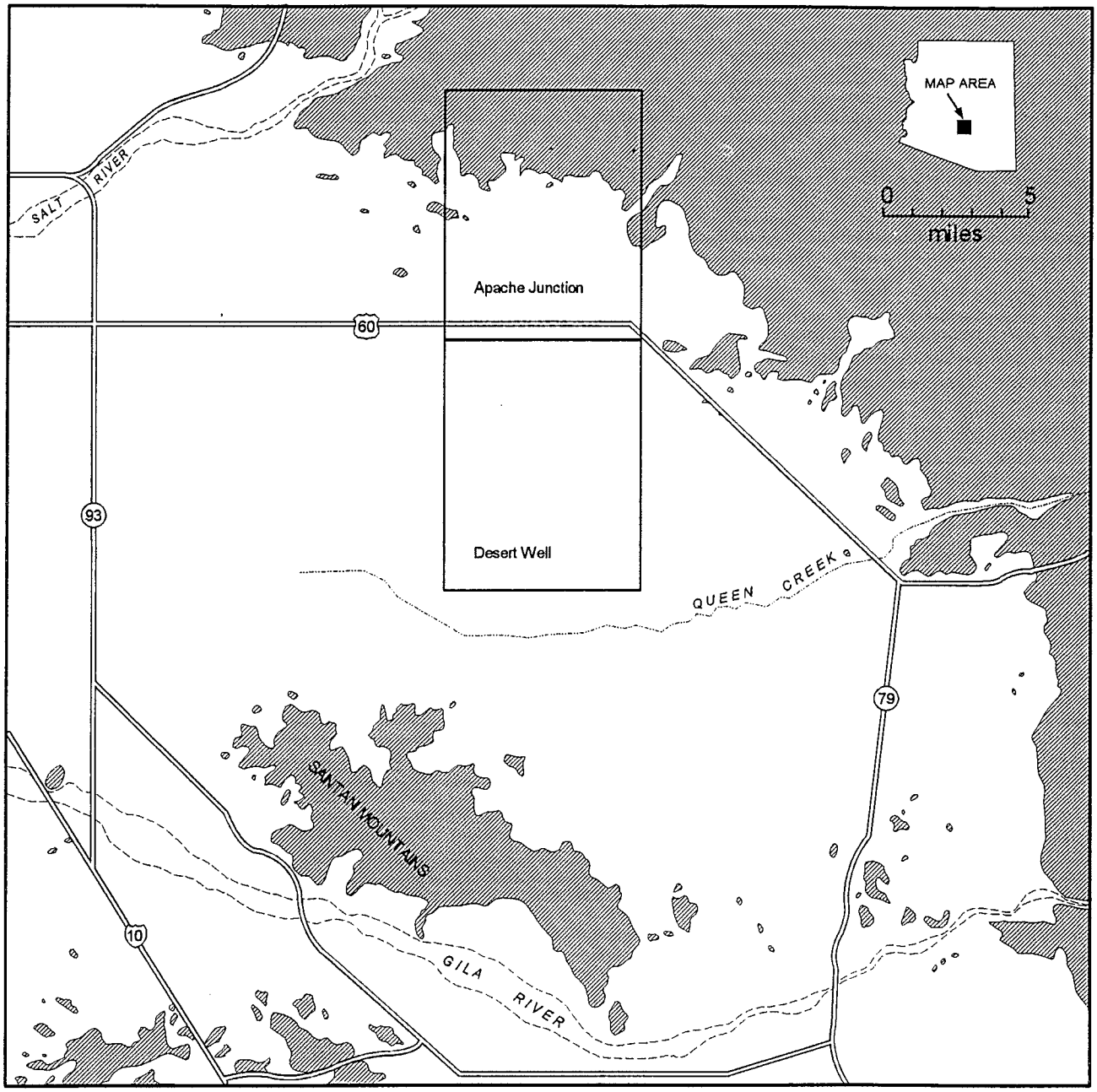

Figure 1. Eastern Phoenix Basin area and Apache Junction and Desert Well quadrangle locations.

The third stage was to check map-unit boundaries with previous environmental geology maps (Turek, 1974) and soil surveys (Adams, 1974; Camp, 1986). Substantial previous mapping has been performed in the Apache Junction quadrangle; most of the surficial geology and soils of the Desert Wells quadrangle have previously not been systematically studied.

The fourth stage involved the correlation and age-estimation of surfaces. Correlating surficial deposits that vary in lithology, grain-size, and elevation can be problematic, because landforms with unique climatic/tectonic histories may have similar surficial properties. Likewise, surfaces that share a similar environmental history may appear different. In lieu of chronological control, topographic position and weathering characteristics were used to assign relative ages and correlate surfaces within the project area to those mapped in the Superstition Mountain piedmont area (Huckleberry, 1993). Approximate ages were assigned to surfaces based primarily on comparison of soil development to areas where soils are radiometrically dated (Bull 1991).

Geomorphic Context

The project area is located in the eastern margin of the Phoenix Basin (Péwé, 1978) near the transition between the Sonoran Desert and Mexican Highland subdivisions of the Basin and Range physiographic province (Fenneman, 1931). Here the valley floor meets the Superstition and Goldfield Mountains. These mountains rise abruptly above the valley floor and are composed predominantly of mid-Tertiary volcanics that rest unconformably on Precambrian granite (Stuckless and Sheridan, 1971). These mountains are bounded by steeply-dipping normal faults (Figure 2) produced during the Basin and Range disturbance approximately 8-15 Ma[1] (Shafiqullah et al., 1980).

The upper piedmont in this area is mostly composed of a pediment formed in granite. Pediments are relatively smooth, gently sloping erosional surfaces commonly found in granitic terrains of southern Arizona (Bull, 1984; Moss, 1977). These landforms require millions of years of relative tectonic quiescence to form. The pediment flanking the Goldfield Mountains extends west beyond the Usery Mountains and is known as the Spook Pediment (Moss, 1977; Péwé, 1978). At Usery Pass, pediments merge from both the north and south side of the Goldfield and Usery Mountains forming a pediment pass (Figure 2). The pediment near Apache Junction is generally covered with thin alluvial fan deposits less than 3 m thick as revealed in occasional streamcuts and gravel quarries. This alluvial cover thickens downslope to the south. The point where the landform changes from pediment to alluvial fan is uncertain without detailed subsurface information. In reality, the buried pediment abruptly ends at a range-bounding fault, but trying to locate this boundary without geophysical information is problematic. In this study, the boundary between pediment and alluvial fan is placed where bedrock is not visible in streamcuts, or

[1] 1 My = 1,000,000 years, 1 Ma = 1 My before present; 1 ky = 1,000 years; 1 ka = 1 ky before present; (North American Commission on Stratigraphic Nomenclature, 1983).

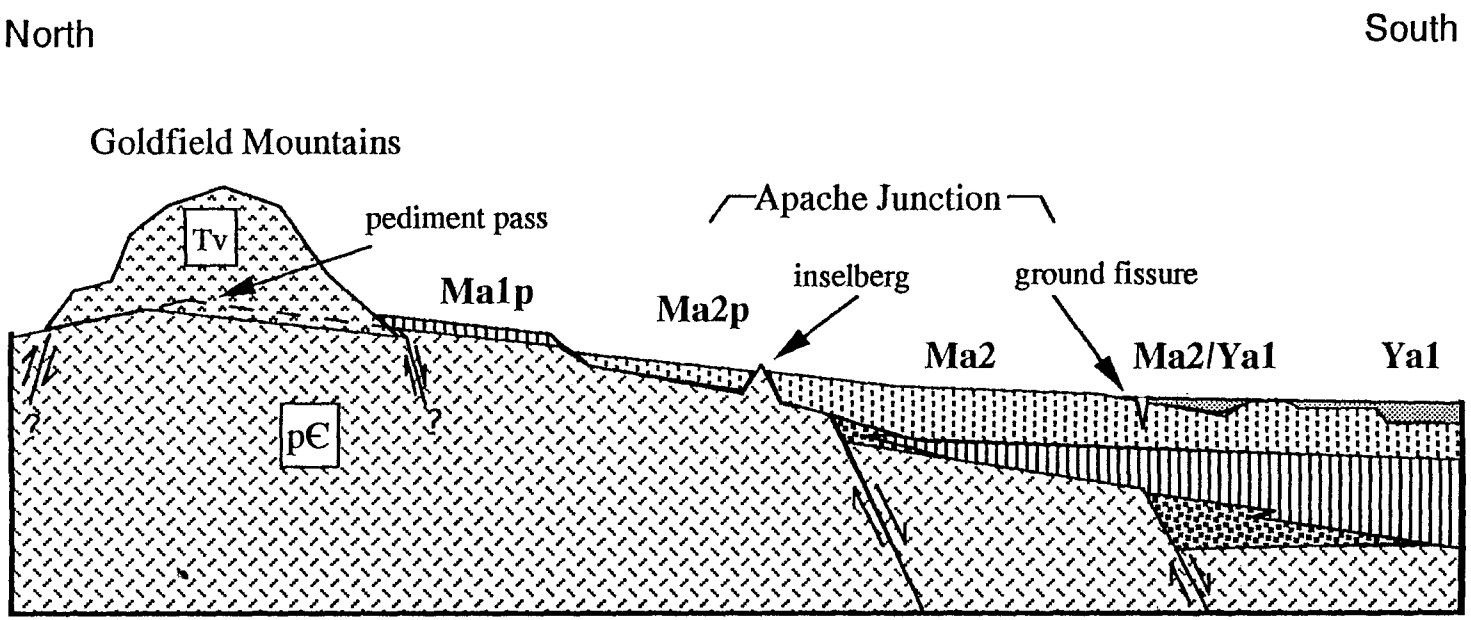

Figure 2. Schematic cross-section of Apache Junction area.

where there are few inselbergs, i.e., bedrock knobs poking through the alluvium. The farthest downslope inselberg is Hawk Rock, a small protusion of quartzite surrounded by late Quaternary alluvium located approximately 1 km south of the Apache Junction-Desert Well quadrangle boundary. Hawk Rock is a most unusual inselberg given its small size (< 1500 m^2) and isolation; the distance to the nearest inselberg is 7 km. Drilling and geophysical tests indicate that the pediment does not extend this far south and that Hawk Rock is the small tip of a buried mountain (Péwé et al., 1987).

Surficial deposits in the project area are largely alluvial and derived from the Superstition and Goldfield Mountains. These deposits contain clasts of granite, quartz latite, dacite, and basalt that coarsen upslope towards the mountain front. Turek (1974) divided the alluvium within the Apache Junction quadrangle into three categories based on size. "Coarse grain alluvium" contains clasts that range 10-30 cm in diameter with a sandy matrix with a mean diameter greater than 0.5 mm. These deposits extend approximately 1-2 km from the mountain front. "Medium grained alluvium" contains clasts 5-10 cm in diameter and a mean matrix grain size greater than 0.5 mm. Turek mapped these deposits as extending 1-4 km downslope from the coarse grained alluvium south of the Goldfield Mountains and approximately 6 km downslope from coarse grained alluvium west of the Superstition Mountains. Most of the southern one-third of the Apache Junction quadrangle was mapped as "fine grain alluvium" characterized by clasts less than 5 cm in diameter and with a mean matrix size less than 0.5 mm. Farther south in the Desert Well quadrangle, much of the alluvium is derived from the Queen Creek fan system (Graf, 1988; Huckleberry, 1994, 1993a). Here the alluvium is generally fine textured and forms a series of gentle ridges and swales. The ridges are constructional landforms created by Queen Creek aggradation during the Holocene. This ridge and swale topography contrasts with the upper piedmont near Apache Junction where alluvial fans are dissected and the ridge tops are older relict surfaces.

Map Units

Three primary symbols are used to distinguish geomorphic surfaces in the Apache Junction piedmont area based on relative age: Y (young), M (middle or intermediate), and O (old). A lower case "a" following one of these primary symbols denotes alluvial fan surfaces and channels. Pediments are denoted with the symbol "Op". A lower case "p" is added to alluvial fan surfaces where a pediment is shallowly buried. Primary symbols may be subdivided (e.g., Ma1 and Ma2) where there are distinct differences in topographic position and weathering. If a landform has characteristics transitional between two map units, then both are presented and separated by a slash (e.g., Ma2/Ya1). Steeply sloping bedrock surfaces are denoted by "b". A solid line is used to delineate distince geologic boundaries. Where surface characteristics change gradually, a dashed line is used to mark the approximate location of the boundary. A dotted line is used to demarcate agricultural fields and other disturbed areas.

Ya2 (< 0.5 ka)

Modern ephemeral streams draining the piedmont are labeled Ya2. The two largest drainages are Weekes Wash and Siphon Draw, two ephemeral streams that originate in the Superstition Mountains. Many Ya2 channels are developed into fan surfaces, have relatively small catchment areas, and only flow during or immediately after rainfall events. Small Ya2 channels are lined with palo verde (*Cercidium*), mesquite (*Prosopsis*), and ironwood (*Olneya*) whereas larger channels also contain desert willow (*Chilopsis*) and tamarisk (*Tamarix*). Grain sizes range from sand to cobbles and the alluvium is highly permeable.

Drainage patterns for Ya2 channels are generally dendritic (Table 1), however within the larger Ya2 channels and on the lower piedmont where streamflow is less contained, drainage patterns are distributary. In the Desert Well quadrangle, some of the Ya2 channels have rectilinear drainage patterns that have formed along two-track roads and earth fissures. Much of the natural drainage has been disrupted by several flood protection diversion dams and the Central Arizona Project canal. These features divert runoff into a few concrete-lined floodway channels that carry the water to the Gila River.

Ya2 channels are flood-prone and contain a mixture of modern and historic sediments. Ya2 alluvium is stratified and lacks any appreciable soil formation. Most of the channel surfaces are modern in age, but there are also vegetated bars that may be several hundred years old.

Ya2' (< 0.5 ka)

Ephemeral stream channels associated with the Queen Creek fan system have been effaced by agricultural fields in the southern part of the Desert Well quadrangle. However, these former channels can still be identified on aerial photographs as swales and on soil maps (Adams, 1974) as sandy ribbons. These disturbed Ya2 channels are labeled Ya2' and are of comparable age and sedimentology as Ya2 channels (Table 1).

Ya1 (< 10 ka)

Holocene alluvial surfaces that have incipient soil development are labeled Ya1 (Table 1). Ya1 surfaces cover relatively broad areas at the distal ends of alluvial fans but are more restricted in area along washes in the upper piedmont. In the upper piedmont alluvial grain sizes range from coarse sand to boulders but decrease in size downstream. Ya1 soils are weakly developed and often contain primary fluvial bedforms. Pedogenesis is generally limited to surface enrichment of silt from eolian sources, slight oxidation, and weak calcification. These soils contain cambic, calcic (Stage I or less), and Cox horizons (Birkeland, 1984; Soil Survey Staff, 1975:45; Appendix A: Soil Profiles AJ3, DW1, DW2, and DW9b) and classify as Torrifluvents, Camborthids, and Calciorthids (Soil Survey Staff, 1975:168, 170, 189). Although Ya1 soils are relatively immature, they commonly

Table 1. Physical characteristics and age estimates of Apache Junction area geological surfaces.

Surface	Stream Dissection	Soil Horizons	Maximum Carbonate Stage	Pavement and Varnish Development	Surface Age Estimate	Correlative Surface (Bull, 1991)	Representative Soil Profile Description
Ya2	-	C	0	none	< 0.5 ka	Q4b	-
Ya2'	-	C	0	none	< 0.5 ka	Q4b	-
Ya1	> 1m	Bw, Bk, CBk, C	I	none	< 10 ka	Q4a	AJ1, AJ2a, AJ3, DW1, DW2, DW6
Ma2	1-4 m	Av, Bk, Bt	II+	weak-moderate	10-100 ka	Q2c, Q2b	DW4, DW8
Ma2/Ya1	< 1 m	Av, Bw, Bk, Bt, CBk, C	II+	weak-moderate	< 100 ka	-	-
Ma2/Ya	-	Av, Bw, Bk, Bt, CBk, C	II+	disturbed	< 100 ka	-	-
Ma1	> 2m	Av, Bt, Bk, Bkm, Bkqm	IV	poor-strong	100-500 ka	Q2a	AJ2b
Op	> 1m	Bt, Bk, Bkm, Bkqm	IV+	none	> 1 Ma	-	-

overlie older, well developed, Pleistocene soils (e.g., Appendix A: Soil Profile AJ2a and DW7). These buried soils limit infiltration in otherwise highly permeable Ya1 soils.

Based primarily on soil development, Ya1 surfaces are age-estimated to be younger than 10 ka. These surfaces are still prone to flooding during rare storm events that generate prolonged or heavy rainfall. Ya1 surfaces correlate in age with Bull's (1991) Q4a, Q3b, and Q3c surfaces in the lower Colorado River Valley.

Ya (< 10 ka)

In many places south of Siphon Draw in the Desert Well quadrangle, it is not possible to distinguish Ya2 and Ya1 surfaces. These areas are either agriculturally disturbed surfaces or relatively low areas with indistinct channel boundaries. These surfaces are labeled Ya (Table 1).

Ma2 (10-100 ka)

Late Pleistocene alluvial fan surfaces labeled Ma2 are common in both the proximal and distal portions of alluvial fans where stream dissection is < 3 m (Table 1). Alluvial sediment sizes range from sand to cobbles, but surface soils are rich in pedogenic clay. Ma2 soils display considerable morphological variability but most contain moderate argillic (Soil Survey Staff, 1975:26) and calcic horizons with Stage I-II+ development (Appendix A: Soil Profiles DW4 and DW8). These soils classify as Calciorthids and Haplargids (Soil Survey Staff, 1975:159). The argillic and calcic horizons limit the rate of infiltration into these surfaces, and thus they are not primary areas of groundwater recharge.

Ma2 surfaces correlate in age with Bull's (1991) Q3a, Q2b and Q2c surfaces. A reasonable age estimate for Ma2 surfaces is 10-100 ka (Table 1). This is a considerable wider and older age range than previously presented for Ma2 surfaces along the Gila River (Huckleberry, 1993b). This revised age estimate reflects observations of older soils on Ma2 surfaces in the Superstition Mountain piedmont area (Huckleberry, 1993a).

Ma2/Ya1 (< 100 ka)

There is little relief in the western and southwestern parts of the project area, thus topographic position cannot be used to distinguish surfaces. These areas are flat, contain mostly fine gravel and finer sediments, and contain a variety of young and old soils. The symbol Ma2/Ya1 is used to mark these surfaces with nondescript surface morphometry that contain both argillic and younger alluvial soils. Ma2/Ya1 soils classify as Camborthids, Calciorthids, and Haplargids (Appendix A: Soil Profile SP-12). Ma2/Ya1 surfaces are only marginal areas of groundwater recharge due to the fine-textured nature of the soils. Several Ma2/Ya1 surfaces located on the upslope side of the Magma Diversion Dams are now prone to flooding.

Ma2/Ya (< 100 ka)

Surfaces of Holocene or late Pleistocene age that have been agriculturally developed in the middle piedmont are labeled Ma2/Ya (Table 1).

Ma1 (100-500 ka)

Geomorphic surfaces developed on middle to late Pleistocene alluvial fan sediments are labeled Ma1 (Table 1). These surfaces are most common in the upper piedmont. Alluvial grain sizes range from sand to boulders, but the surfaces are enriched in pedogenic clay. Ma1 surfaces are heavily dissected and contain mature soils with argillic, calcic, and petrocalcic (Stage II-III+) horizons (Appendix A: Soil Profile AJ2b). These soils classify as Calciorthids, Paleorthids, Haplargids, and Paleargids (Soil Survey Staff, 1975:165, 176). Because of their relatively impermeable argillic and petrocalcic horizons, Ma2 surfaces are not areas of significant infiltration and groundwater recharge. Ma1 surfaces correlate to Bull's (1991) Q2a surface (400-730 ka); their age is estimated to be 100-500 ka (Table 1).

Op (> 1 Ma)

Pediment surfaces with little alluvial cover are mapped as Op. Op surfaces are generally restricted to the Usery Pass area. They are commonly mantled in grus, i.e., granule-sized clasts of quartz and feldspar, and may contain remnants of old soils such as truncated petrocalcic horizons. The depth of weathering is greater than 2 m, and thus Op surfaces have been mined for gravels. Quartz and feldspar mineral grains weathered from granitic rock are used for gravel. Op surfaces are areas that generate considerable runoff since there is little infiltration storage. Op surfaces are greater than 1 My old.

Earth Fissures

As previously mentioned, alluvial deposits in the Apache Junction piedmont area thicken to the south. In the southern part of the Desert Well quadrangle beyond the range-bounding faults, the alluvium is greater than 600 m deep (Oppenheimer and Sumner, 1980). These deposits store vast quantities of groundwater and are important aquifers for the eastern Phoenix Basin. Most of the groundwater has been used for agriculture although municipal demands for water have increased significantly in the last 30 years. As is often the case, the rate of groundwater withdrawal has exceeded the rate of groundwater recharge. Moreover, diversion dams and floodways have reduced infiltration in the local area. As a result, water tables have dropped throughout much of the eastern Phoenix Basin. Within the project area, water tables have fallen 30-90 m (Schumann and Genualdi, 1986). The lowering of the water table has caused aquifer compaction and land subsidence in the Apache Junction piedmont area. A series of vertical extensometers and repeated surveys have demonstrated a compaction rate of approximately 6 cm/yr between 1978 and 1987 within the Hawk Rock area (Péwé et al., 1987).

As the ground subsides, various tensile forces are generated at the surface. This often leads to earth fissure development within surficial alluvium. Several earth fissures have developed near Hawk Rock; some of these exceed 3 m in depth and extend over 100 m. That they are clustured near Hawk Rock suggests that the subsurface bedrock which is shallow here influences their development. It is believed that buried bedrock ridges and changes in thickness of alluvium contribute to differential compaction in dewatered aquifers (Péwé et al., 1987). This helps generate the tensile forces at the surface that create earth fissures. Once started, earth fissures may capture runoff and expand by gully erosion. Because the Hawk Rock earth fissures are located close to the Central Arizona Project Canal, ironically, a project designed to reduce Arizona's dependence on groundwater, local land subsidence and fissures are being monitored by the Bureau of Reclamation, U.S. Geological Survey, and Arizona Geological Survey.

Summary

This report and accompanying maps provides further information on the age and physical characteristics of surficial geologic materials in the eastern Phoenix Basin. The Apache Junction piedmont area consists of pediments that grade downslope into thick alluvial fan sequences. The upper piedmont is relatively dissected and contains mostly Pleistocene surfaces. In contrast, the lower piedmont is less dissected and is an area of overall Holocene aggradation. Here streams are shallow, and large areas were prone to inundation before the construction of flood protection works. Many of the Holocene alluvial deposits are highly permeable and good zones for groundwater recharge. Groundwater levels have declined in this region due to decades of groundwater withdrawal for agricultural and municipal needs. This has resulted in regional land subsidence and the development of earth fissures. Future development of the eastern Phoenix Basin should take into account the age and nature of geologic materials in order to best utilize and manage the area's natural resources.

References Cited

Adams, E.D., 1974, Soil Survey of Eastern Maricopa and Northern Pinal Counties Area, Arizona: Washington D.C., U.S. Government Printing Office, 61 p.

Birkeland, P.W., 1984, Soils and geomorphology: New York, Oxford University Press, 372 p.

Bull, W.B., 1991, Geomorphic responses to climatic change: New York, Oxford University Press, 326 p.

Camp, P., 1986, Soil survey of Aguila-Carefree area, parts of Maricopa and Pinal counties, Arizona. U.S. Department of Agriculture, Soil Conservation Service: Washington D.C., U.S. Goverment Printing Office.

Christenson, G.E., and Purcell, C.R., 1985, Correlation and age of Quaternary alluvial-fan sequences, Basin and Range Province, southwestern United States, *in* Weide, D.C., ed., Soils and Quaternary geology of the southwestern United States, Geological Society of America Special Papers 203, p.115-122.

Fenneman, N., 1931, Physiography of western United States: New York, McGraw-Hill Book Company, Inc., 534 p.

Graf, W.L., 1988, Fluvial processes in dryland rivers: New York, Springer-Verlag, 346 p.

Guthrie, R. and Witty, J., 1981, New designations for soil horizons and layers and the new Soil Survey Manual: Soil Science Society of America Proceedings, v. 46, p. 443-444.

Huckleberry, G.A., 1994, Surficial geology of the Santan Mountains Piedmont area, northern Pinal and eastern Maricopa counties, Arizona: Arizona Geological Survey Open-File Report 94-7, 30 p., 2 sheets (1:24,000).

_____ 1993a, Surficial geology of the Superstition Mountain piedmont area, northern Pinal and eastern Maricopa counties, Arizona: Arizona Geological Survey Open-File Report 93-15, 33 p., 4 sheets (1:24,000).

_____ 1993b, Surficial geology of the Middle Gila River area, north-central Pinal County, Arizona: Arizona Geological Survey Open-File Report 93-4, 51 p., 4 sheets (1:24,000).

Machette, M.N., 1985, Calcic soils of the southwestern United States, *in* Weide, D.C., ed., Soils and Quaternary geology of the southwestern United States, Geological Society of America Special Papers 203, p.1-21.

Moss, J.H.,1977, The formation of pediments: scarp backwearing or surface downwasting?, *in* Doehring, D.O., ed., Geomorphology in arid regions, 8th Annual Geomorphology Symposium: Binghampton, State Univesity of New York, p. 51-78:

North American Commission on Stratigraphic Nomenclature, 1983, North American stratigraphic code: American Association of Petroleum Geologists Bulletin, v. 67, pp. 841-875.

Oppenheimer, J.M., and Sumner, J.S., 1980, Depth-to-Bedrock Map, Basin and Range Province, Arizona: Laboratory of Geophysics, University of Arizona, Tucson. (1:1,000,000).

Péwé, T.L., 1978, Terraces of the lower Salt River Valley in relation to the late Cenozoic history of the Phoenix Basin, Arizona, *In* Burt, D., and Péwé, T., eds., Guidebook to the geology of central Arizona: State of Arizona, Bureau of Geology and Mineral Technology, Special Paper 2, p. 1-45.

Péwé, T.L., Raymond, R.H., and Schumann, H.H., 1987, Land subsidence and earth-fissure formation in eastern Phoenix metropolitan area, Arizona, *in* G.H. Davis and E.M. VandenDolder (eds), Geologic diversity of Arizona and its margins: excursions to choice areas: Arizona Bureau of Geology and Mineral Technology Special Paper 5, p. 199-204.

Schumann, H.H., and Genualdi, R.B., 1986, Land subsidence, earth fissures, and water-level change in southern Arizona: Arizona Bureau of Geology and Mineral Technology Map 23, 1:1,000,000.

Shafiqullah, M., Damon, P.E., Lynch, D.J., Reynolds, S.J., Rehrig, W.A., and Raymond, R.H., 1980, K-Ar geochronology and geologic history of southwestern Arizona and adjacent areas, *in* Jenney, J.P., and Stone, C., eds, Studies in western Arizona, Arizona Geological Society Digest, v. 12, p. 201-260.

Soil Survey Staff, 1975, Soil taxonomy: U.S. Department of Agriculture Handbook 436, 754 p.

_____ 1951, Soil survey manual: U.S. Department of Agriculture Handbook 18, 503 p.

Stuckless, J.S, and Sheridan, M.F., 1971, Tertiary volcanic stratigraphy in the Goldfield and Superstition Mountains, Arizona: Geological Society of America Bulletin, vol. 82, p. 3235-3240.

Turek, F., 1975, Environmental geology of the Apache Junction quadrangle, Arizona: Tempe, Arizona State University unpublished MS thesis, 58 p., scale 1:48,000.

Appendix A: Soil Descriptions

Geologic Surface: Ya1
Soil Profile: AJ1
Classification: Camborthid
Location: Pinal County, Arizona; SW 1/4, NE1/4, SW 1/4, Sec. 10, T. 1 N., R. 8 E.
Physiographic Position: Alluvial fan; elevation 567 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*), palo verde (*Cercidium*), cholla (*Opuntia*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil profile located approximately 50 m southeast of Bulldog Mine Rd. Surface soil (A and C horizons) are modified by silt enrichment. Few clasts of Bkm horizon are found in gravels of C2 horizon. 2Bkb2 horizon contains seams of calcium carbonate up to 1 cm thick, but no laminar cap. Bw horizon doesn't meet qualifications for a cambic horizon according to the Soil Survey Staff (1975) due to too coarse texture; it is defined as cambic here based on structure and carbonate leaching. Soil colors are for dry conditions.

A 0-8 cm. Brown to strong brown (7.5YR 5/5) gravelly loamy sand; moderate, fine, subangular blocky structure; soft (dry), not sticky and not plastic (wet); noneffervescent; clear smooth boundary.

Bw 8-15 cm. Brown to strong brown (7.5YR 5/5) gravelly loamy sand; weak, medium, subangular blocky structure; soft (dry), not sticky and not plastic (wet); noneffervescent; clear smooth boundary.

CBk 15-28 cm. Brown to strong brown (7.5YR 5/5) gravelly loamy sand; single grain; loose (dry), not sticky and not plastic (wet); slightly effervescent; carbonates occur as segregated filaments and discontinuous rinds on clasts (Stage I); gradual smooth boundary.

C 28-62 cm. Strong brown (7.5YR 4/6) very gravelly sand; single grain; loose (dry), not sticky and not plastic (wet); noneffervescent; abrupt smooth boundary.

2Bwb 62-85 cm. Strong brown (7.5YR 4/6) gravelly sandy clay loam; massive; slightly hard (dry), sticky and plastic (wet); noneffervescent; clear smooth boundary.

2Bkb1 85-97 cm. Strong brown (7.5YR 4/6) gravelly sandy clay loam; massive; slightly hard (dry), very sticky and plastic (wet); strongly effervescent; common, medium, carbonates occur as irregular segregated soft masses (Stage I+); abrupt smooth boundary.

2Bkb2 97-124 cm. Strong brown (7.5YR 4/6) gravelly sandy clay loam; weak, very coarse, platy structure; extremely hard (dry), sticky and plastic (wet); violently effervescent; carbonates occur as many, coarse, irrigular segregated soft masses and filaments (Stage III); clear smooth boundary.

2Bkb3 124-150+ cm. Pink (7.5YR 7/4) sandy loam; massive; slightly hard (dry), sticky and slightly plastic (wet); violently effervescent; carbonates disseminated and occur as many, medium, irregular segregated soft masses and filaments (Stage II).

Geologic Surface: Ya1
Soil Profile: AJ2a
Classification: Camborthid
Location: Pinal County, Arizona; SE 1/4, NE1/4, SW 1/4, Sec. 10, T. 1 N., R. 8 E.
Physiographic Position: Alluvial fan; elevation 570 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), palo verde (*Cercidium*), cholla (*Opuntia*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil is located approximately 50 m west of a mid-section, two-track road. A horizon is good example of eolian silt enrichment in gravelly soils. Channel cut into petrocalcic horizon. Profile is only 30 m north of soil AJ2b in a slight swale. Soil colors are for dry conditions.

A 0-10 cm. Light brown (7.5YR 6/4) silty loam; moderate, medium, subangular blocky structure; soft (dry), not sticky and plastic (wet); noneffervescent; clear smooth boundary.

Bw 10-18 cm. Brown (7.5YR 5/4) gravelly sandy loam; single grain; loose (dry), slightly sticky and slightly plastic (wet); noneffervescent; gradual smooth boundary.

Bk 18-70 cm. Brown (7.5YR 5/4) very gravelly loamy sand; single grain; loose (dry), not sticky and not plastic (wet); strongly effervescent; carbonates are disseminated; abrupt irregular boundary.

2Bkm 70-130+ cm. Pinkish white (7.5YR 8/2) gravelly loamy sand; massive; extremely hard (dry), not sticky and not plastic (wet); violently effervescent; carbonates indurate horizon (Stage III).

Geologic Surface: Ya1
Soil Profile: AJ3
Classification: Camborthid
Location: Maricopa County, Arizona; NE 1/4, NE1/4, SW 1/4, Sec. 36, T. 1 N., R. 7 E.
Physiographic Position: Alluvial fan; elevation 476 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil profile located approximately 50 m west of Meridian Road near the overpass over U.S. 60. C horizon still contains faint fluvial bedforms. Soil colors are for dry conditions.

A 0-5 cm. Light yellowish brown (10YR 6/4) loamy fine sand; moderate, medium to coarse, subangular blocky structure; soft (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bk 5-19 cm. Light yellowish brown (10YR 6/4) loamy fine sand; weak, coarse, subangular blocky structure; soft (dry), slightly sticky and slightly plastic (wet); slightly effervescent; carbonates are disseminated; abrupt wavy boundary.

CB1 19-50 cm. Light yellowish brown (10YR 6/4) very gravelly medium to coarse sand; single grain; loose (dry), not sticky and not plastic (wet); noneffervescent; abrupt wavy boundary.

CBk2 50-130+ cm. Light yellowish brown (10YR 6/4) gravelly sandy loam; single grain; loose (dry), slightly sticky and slightly plastic (wet); strongly effervescent; carbonates are disseminated.

Geologic Surface: Ya1
Soil Profile: DW1
Classification: Camborthid
Location: Pinal County, Arizona; NW 1/4, SW 1/4, Sec. 14, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 496 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*), palo verde (*Cercidium*).
Described by: Gary Huckleberry, January 11, 1994.
Remarks: Soil pit excavated 40 m south of retention dam. Coarse stratification still evident in C and 2C. Cambic horizon based on textural modification (enrichment of silt). Modern alluvium in adjacent channel is light yellowish brown to very pale brown (10YR 6-7/4). Parent material derived from largely felsic volcanics and schist. Soil colors are for dry conditions.

Bw 0-8 cm. Light yellowish brown (10YR 6/4) gravelly sandy loam; single grain to weak, medium, platy structure; slightly hard (dry), sticky and plastic (wet); noneffervescent; abrupt wavy boundary.

C 8-50 cm. Light yellowish brown (10YR 6/4) very gravelly loamy coarse sand; single grain; loose (dry), nonsticky and nonplastic (wet); noneffervescent; abrupt smooth boundary.

2C 50-80+ cm. Light brown to brown (7.5YR 5.5/4) silty clay loam; massive; slightly hard (dry), sticky and plastic (wet); noneffervescent.

Geologic Surface: Ya1
Soil Profile: DW2
Classification: Camborthid
Location: Pinal County, Arizona; NE 1/4, NE 1/4, Sec. 22, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 493 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), bursage (*Franseria*), palo verde (*Cercidium*).
Sampled by: Gary Huckleberry, January 11, 1994.
Remarks: Soil pit excavated 30 m south of fence (section line). Parent material derived from largely felsic volcanics and schist. Soil colors are for dry conditions.

A 0-2 cm. Brown (10YR 5/3) gravelly sandy loam; weak, fine, granular structure; soft (dry), slightly sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

Bw 2-20 cm. Light brown (7.5YR 6/4) gravelly sandy loam; weak, fine, granular structure; soft (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bk1 20-38 cm. Light brown (7.5YR 6/4) gravelly sandy loam; weak, massive; soft (dry), slightly sticky and plastic (wet); strongly effervescent; carbonates are disseminated; clear smooth boundary.

Btk2 38-70 cm. Light brown (7.5YR 6/4) sandy clay loam; massive; soft (dry), sticky and plastic (wet); strongly effervescent; carbonates are disseminated; common, fine, clay skins on ped faces; clear smooth boundary.

Bk3 70-90+ cm. Light brown (7.5YR 6/4) gravelly sandy loam; massive; soft (dry), sticky and plastic (wet); strongly effervescent; carbonates are disseminated.

Geologic Surface: Ya1
Soil Profile: DW6
Classification: Torrifluvent
Location: Pinal County, Arizona; SE 1/4, SE1/4, Sec. 6, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 474 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), ironwood (*Olneya*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Located approximately 50 m west of Ironwood Road near Apache Jct. city limits sign. Soil colors are for dry conditions.

A 0-3 cm. Light yellowish brown (10YR 6/4) sandy loam; weak, coarse to very coarse, platy and subangular blocky structure; soft (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

C 3-64 cm. Brown to strong brown (7.5YR 5/5) gravelly sandy loam; single grain; loose (dry), slightly sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

2Bkb1 64-100 cm. Brown (7.5YR 5/4) very gravelly sandy loam; massive; slightly hard (dry), slightly sticky and slightly plastic (wet); strongly effervescent; carbonates are disseminated and occur as continuous coatings on clasts (Stage II); gradual smooth boundary.

2Bkb2 100-140+ cm. Brown to light brown (7.5YR 5.5/4) gravelly sandy loam with pinkish white (7.5YR 8/2) mottles; massive; hard (dry), slightly sticky and slightly plastic (wet); strongly effervescent; carbonates are disseminated and occur as common, fine, filaments and continuous coatings on clasts (Stage II).

Geologic Surface: Ya1
Soil Profile: DW7
Classification: Camborthid
Location: Maricopa County, Arizona; SE 1/4, SW1/4, SE 1/4, Sec. 2, T. 1 S., R. 7 E.
Physiographic Position: Alluvial fan; elevation 448 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), ironwood (*Olneya*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil profile located approximately 100 m east of abandoned cattle tank. Few, faint, manganese oxides on ped faces in 3Btkb horizon. Soil colors are for dry conditions.

A 0-2 cm. Light brown (7.5YR 6/4) loam; weak, coarse, platy structure; slightly hard (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bt 2-32 cm. Brown (7.5YR 5/4) sandy clay loam; weak, very coarse, angular blocky structure; hard (dry), sticky and plastic (wet); noneffervescent; few, faint, clay skins on ped faces; clear smooth boundary.

C 32-47 cm. Brown to strong brown (7.5YR 5/5) very gravelly coarse sand; single grain; loose (dry), not sticky and not plastic (wet); noneffervescent; abrupt smooth boundary.

2Btkb1 47-65 cm. Strong brown (7.5YR 5/6) sandy clay loam; weak, medium, angular blocky structure; very hard (dry), sticky and plastic (wet); slightly effervescent; carbonates are disseminated and occur as few, fine, filaments (Stage I); common, faint, clay skins on ped faces; clear smooth boundary.

2Btkb2 65-92 cm. Strong brown (7.5YR 5/6) clay loam with pinkish white (7.5YR 8/2) mottles; weak, medium, angular blocky structure; extremely hard (dry), very sticky and plastic (wet); violently effervescent; carbonates are disseminated and occur as common, fine, filaments (Stage I+); many, distinct, clay skins on ped faces; clear smooth boundary.

2Bkb3 92-106 cm. Light brown (7.5YR 6/4) clay loam; massive; very hard (dry), sticky and plastic (wet); violently effervescent; carbonates are disseminated; clear smooth boundary.

3Btkb 106-130+ cm. Yellowish red (5YR 4/6) clay with pinkish white (5YR 8/2) mottles; massive; very hard (dry), very sticky and very plastic (wet); violently effervescent; carbonates are disseminated and occur as common, fine, filaments (Stage I+); many, prominent, clay skins on ped faces.

Geologic Surface: Ya1
Soil Profile: DW9a
Classification: Camborthid
Location: Pinal County, Arizona; NE 1/4, NE1/4, NW 1/4, Sec. 33, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 468 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil profile located approximately 150 m east of cattle tank and 100 m south of barbed wire fence. Lens of mottled soil and charcoal occurs at 35-45 cm depth; charcoal sampled for 14C analysis. A single large cobble (18cm x 7cm x 6cm) occurs at base of Bk2. Soil colors are for dry conditions.

Bw1 0-20 cm. Light yellowish brown (10YR 6/4) sandy loam; weak, very coarse, angular blocky structure; very hard (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bw2 20-72 cm. Brown to strong brown (7.5YR 5/5) gravelly sandy loam; massive; loose (dry), slightly sticky and slightly plastic (wet); noneffervescent; abrupt smooth boundary.

Bk 72-95 cm. Brown to strong brown (7.5YR 5/5) gravelly sandy loam; massive; slightly hard (dry), slightly sticky and slightly plastic (wet); strongly effervescent; carbonates are disseminated; abrupt wavy boundary.

2Btkb1 95-112 cm. Strong brown (7.5YR 4/6) very gravelly sandy clay loam; single grain; loose (dry), sightly sticky and plastic (wet); strongly effervescent; carbonates are disseminated and occur as common, fine filaments and continuous rinds on clasts (Stage II); common, fine, distinct, clay skins form bridges between sand grains; clear smooth boundary.

2Btkb2 112-130+ cm. Strong brown (7.5YR 4/6) gravelly sandy clay loam; massive; hard (dry), sightly sticky and plastic (wet); strongly effervescent; carbonates are disseminated and occur as common, fine filaments and few, medium, irregular, soft masses (Stage I).

Geologic Surface: Ya1
Soil Profile: DW9b
Classification:Camborthid
Location: Pinal County, Arizona; NE 1/4, NE1/4, NW 1/4, Sec. 33, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 468 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Located on top of low rise approximately 60 m southwest of soil profile DW9a. Soil colors are for dry conditions.

A 0-5 cm. Brown to strong brown (7.5YR 5.5) gravelly sandy loam; weak, coarse, subangular blocky structure; soft (dry), not sticky and not plastic (wet); noneffervescent; clear smooth boundary.

Bw 5-20 cm. Brown to strong brown (7.5YR 5.5) gravelly sandy loam; weak, medium, subangular blocky structure; soft (dry), not sticky and not plastic (wet); noneffervescent; clear smooth boundary.

CBk1 20-58 cm. Strong brown (7.5YR 5/6) gravelly loamy sand; single grain; loose (dry), not sticky and not plastic (wet); slightly effervescent; carbonates occur as discontinuous rinds on clasts (Stage I); clear smooth boundary.

CBk2 58-140+ cm. Strong brown (7.5YR 5/6) gravelly loamy sand; single grain; loose (dry), not sticky and not plastic (wet); strongly effervescent; carbonates are disseminated and occur as discontinuous rinds on clasts (Stage I).

Geologic Surface: Ma2
Soil Profile: DW4
Classification: Haplargid
Location: Pinal County, Arizona; NE 1/4, SW 1/4, Sec. 2, T. 2 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 482 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), mesquite (*Prosopsis*).
Sampled by: Gary Huckleberry, January 17, 1994.
Remarks: Soil pit excavated approximately 50 m west of diversion dam. Surface contains gravel lag (ca. 10 % coverage). Adjacent creosote contain basal mounds 10-20 cm in height, sandy loam in texture, and 10YR in color. Parent material derived from largely felsic volcanics and schist. Soil colors are for dry conditions.

A 0-1 cm. Light yellowish brown (10YR 6/4) gravelly sandy clay loam; moderate, coarse, platy structure; slightly hard (dry), sticky and plastic (wet); noneffervescent; abrupt smooth boundary.

Bt1 1-20 cm. Strong brown (7.5YR 5/6) sandy clay loam; moderate, very coarse angular blocky structure; hard (dry), very sticky and very plastic (wet); noneffervescent; common, distinct, clay skins on ped faces; clear smoth boundary.

Bt2 20-46 cm. Strong brown (7.5YR 5/6) sandy clay loam; weak, medium to coarse angular blocky structure; hard (dry), very sticky and very plastic (wet); noneffervescent; common, distinct, clay skins on ped faces; abrupt smoth boundary.

Btk3 46-75+ cm. Strong brown (7.5YR 5/6) sandy clay loam with common, fine, prominent pinkish white (7.5YR 8/2) mottles; weak, medium to coarse angular blocky structure; very hard (dry), very sticky and very plastic (wet); strongly effervescent; carbonates occur as many fine filaments and medium masses on ped faces (Stage II); many, distinct, clay skins on ped faces.

Geologic Surface: Ma2
Soil Profile: DW8
Classification: Haplargid
Location: Pinal County, Arizona; SE 1/4, SE1/4, SE 1/4, Sec. 31, T. 1 S., R. 8 E.
Physiographic Position: Alluvial fan; elevation 451 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), mesquite (*Prosopsis*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: Soil profile located approximately 150 m west of Vineyard Road. Soil colors are for dry conditions.

A 0-2 cm. Brown to light brown (7.5YR 5.5/4) gravelly sandy loam; weak, very coarse, platy structure; slightly hard (dry), slightly sticky and slightly plastic (wet); noneffervescent; abrupt, smooth boundary.

Bt 2-40 cm. Yellowish red (5YR 4/6) sandy clay; strong, coarse, angular blocky structure; extremely hard (dry), sticky and very plastic (wet); noneffervescent; many, prominent, clay skins on ped faces; clear smooth boundary.

Btk1 40-65 cm. Yellowish red (5YR 4/6) sandy clay loam; strong, coarse, angular blocky structure; extremely hard (dry), sticky and very plastic (wet); strongly effervescent; carbonates occur as few, fine filaments (Stage I); many, prominent, clay skins on ped faces; clear smooth boundary.

Btk2 65-82 cm. Yellowish red (5YR 4/6) sandy clay loam with pinkish white (5YR 8/2) mottles; weak, medium, angular blocky structure; extremely hard (dry), sticky and very plastic (wet); strongly effervescent; carbonates occurs as common, fine filaments and coatings on ped faces (Stage I+); many, distinct, clay skins on ped faces; clear smooth boundary.

Bk3 82-130+ cm. Pink (7.5YR 7/4) sandy clay loam with common, coarse, irregular, pink (7.5YR 8/2) mottles; massive; extremely hard (dry), sticky and plastic (wet); violently effervescent; many, very coarse, irregular nodules and disseminated carbonates (Stage II+).

Geologic Surface: Ma1
Soil Profile: AJ2b
Classification: Paleargid
Location: Pinal County, Arizona; SE 1/4, NE1/4, SW 1/4, Sec. 10, T. 1 N., R. 8 E.
Physiographic Position: Alluvial fan; elevation 570 m.
Topography: Gentle 1% slope
Vegetation: Creosote (*Larrea*), palo verde (*Cercidium*), cholla (*Opuntia*).
Described by: Gary Huckleberry, April 26, 1994.
Remarks: This profile is only 30 m south of soil AJ2a but is on a slight rise. Grus and rhyolitic gravels create a variable surface lag (20-70% surface area covered). Soil colors are for dry conditions.

A 0-5 cm. Brown to strong brown (7.5YR 5/5) gravelly loam; moderate, fine to medium, platy and subangular blocky structure; soft (dry), slightly sticky and slightly plastic (wet); noneffervescent; clear smooth boundary.

Bw 5-12 cm. Brown to strong brown (7.5YR 5/5) gravelly loam; massive; slightly hard (dry), slightly sticky and plastic (wet); noneffervescent; clear smooth boundary.

Bt1 12-33 cm. Yellowish red (5YR 4/6) gravelly sandy clay; massive; hard to very hard (dry), sticky and plastic (wet); noneffervescent; common, distinct clay skins line interstitial pores and form colloidal stains on sand grains; gradual smooth boundary.

Bt2 33-60 cm. Yellowish red (5YR 4/6) gravelly sandy clay; massive; very hard (dry), sticky and very plastic (wet); noneffervescent; many, distinct clay skins line interstitial pores and form colloidal stains on sand grains; gradual smooth boundary

Bkm 60-100+ cm. Pinkish white (5YR 8/2), massive; extremely hard; violently effervescent; carbonates indurate horizon and have laminar morphology on top.