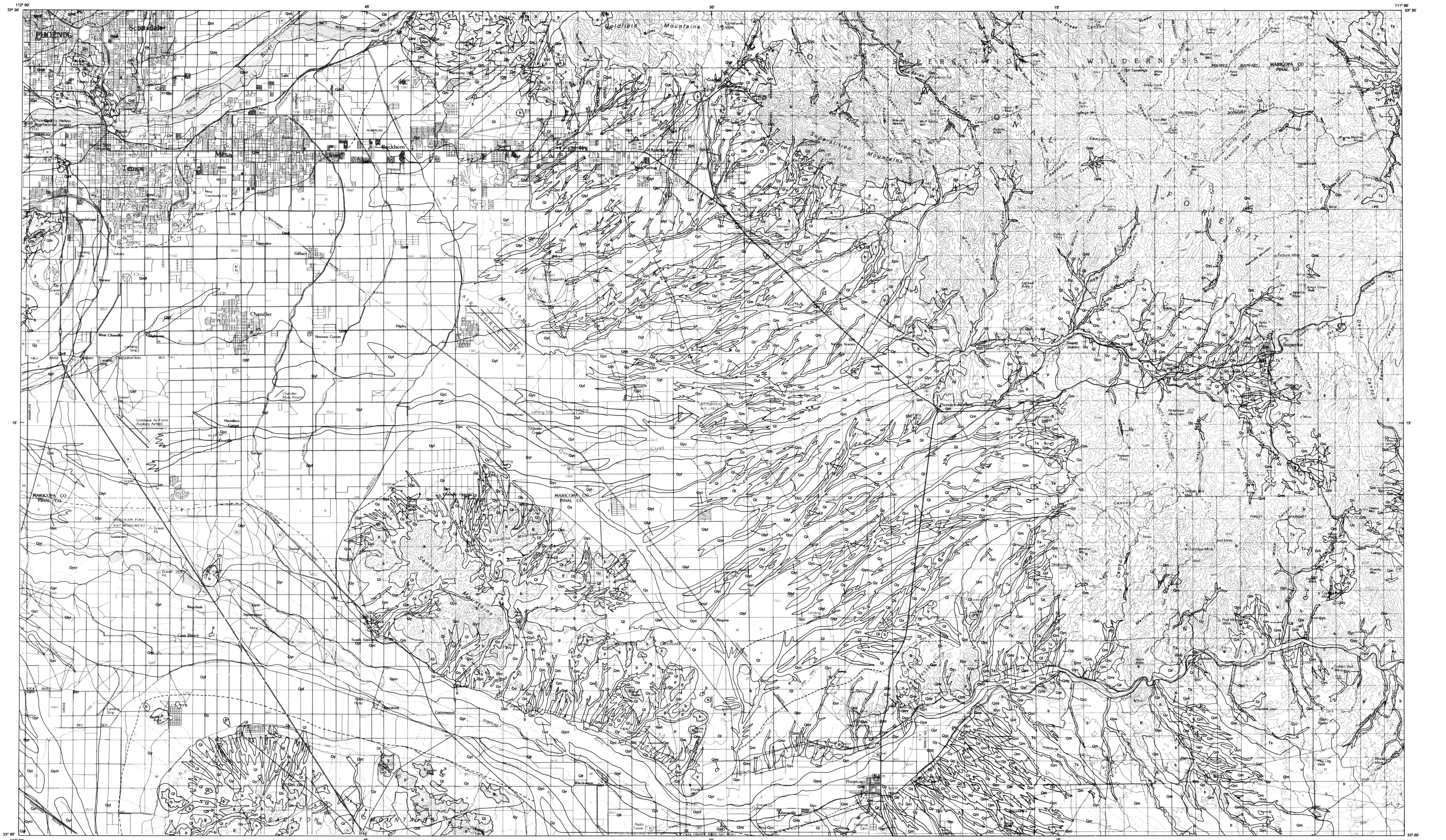

Surficial Geologic Map of the Mesa 30' x 60' Quadrangle, Arizona

by
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Introduction

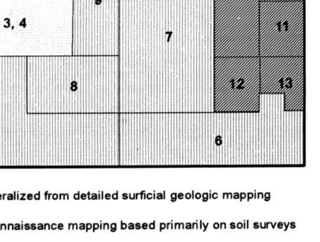
This map summarizes the surficial geology of the Mesa 30' x 60' Quadrangle in central Arizona. Approximately 65 percent of the Mesa Quadrangle, including the rapidly growing eastern and southeastern Phoenix metropolitan area, is covered with Quaternary and Tertiary surficial deposits. On this map, we differentiate surficial deposits based on their position in the regional landscape (piedmont, basin-floor, and river deposits) and their ages. The distribution and physical characteristics of different surficial geologic units have environmental and engineering implications. For example, areas covered by young deposits of the major rivers generally are flood prone and have the greatest potential for ground-water recharge. Old river and piedmont deposits typically have strongly developed, clay- and calcium carbonate-rich soils, whereas young deposits have sandy soils with minimal calcium carbonate accumulation. The distribution of deposits of different ages provides information about areas that might be flood prone (areas covered with young deposits) and areas where excavation might be challenging (areas covered with old deposits). In addition, the distribution and character of surficial deposits of different ages provides information regarding the recent geologic history of the Mesa Quadrangle.

The surficial geology and geomorphology of the Mesa Quadrangle are fascinating because of their diversity. The Mesa Quadrangle straddles the boundary between the Basin and Range physiographic province of southern and western Arizona and the Transition Zone physiographic province of central Arizona. Thus, the eastern part of the Mesa Quadrangle has the rugged topography and deep dissection typical of the Transition Zone, whereas the central and western parts of the quadrangle have broad, minimally dissected valleys and low mountain ranges typical of the Arizona Basin and Range. The transition between these disparate landscapes is quite abrupt, occurring along the western edge of the Superstition Mountains and continuing south through the area east of Florence. The Gila and Salt rivers also traverse the Mesa Quadrangle. The deposits left by these rivers add to the complexity of the surficial geology and provide hints about the nature of regional landscape evolution.

Methods

This map was developed through compilation of existing, large-scale surficial geologic maps and original reconnaissance mapping of areas that have not been previously mapped. The central, southern, and northwesternmost parts of the Mesa Quadrangle are covered by published large-scale (1:24,000) surficial geologic maps (figure 1). In these areas, detailed

Figure 1. Data Sources Used in Compilation



Generalized from detailed surficial geologic mapping

Reconnaissance mapping based primarily on soil surveys

Reconnaissance mapping and USGS quadrangle maps

Sources Used in Map Compilation

1. Péwé and others, 1986.
2. Péwé, 1978.
3. Adams, 1974.
4. Camp, 1986.
5. Huckleberry, 1992.
6. Huckleberry, 1993a.
7. Huckleberry, 1993b.
8. Huckleberry, 1994a.
9. Huckleberry, 1994b.
10. Peterson, 1960.
11. Peterson, 1969.
12. Theodore and others, 1978
13. Creasey and others, 1983

surficial geologic mapping was generalized and modified slightly in order to represent it at a smaller scale. The remainder of the Mesa Quadrangle was mapped on a reconnaissance basis. In the eastern part of the Mesa Quadrangle, reconnaissance mapping involved review and compilation of alluvial deposits shown on existing geologic maps (the primary emphasis of these maps was bedrock geology), interpretation of surficial geologic units utilizing aerial photographs, and limited field-checking of surficial geologic relationships. Most of the surficial geology of the northwestern quarter of the Mesa Quadrangle has been obscured by agricultural cultivation or urban development. In this area, however, published detailed soil surveys provide information about the distribution of soils of different types. Using soils information, we inferred the distribution of alluvial deposits of different ages on a reconnaissance basis.

Map Units

The surficial geologic units of this map are defined by their age and their location in the landscape. Surficial deposits are differentiated based on soil development, surface characteristics, and topographic position in the landscape. Age estimates of surficial deposits are based on correlation with other dated soil/deposit chronosequences in the southwestern United States. Age categories used in this map are as follows: Qy, Holocene (<10 ka; ka stands for thousands of years before the present); Ql, late Pleistocene (10 to 250 ka); Qm, middle Pleistocene (250 to 750 ka); Qo, early Pleistocene (750 ka to ~2 Ma; Ma stands for millions of years before the present); and Tertiary (> 2 Ma). The three landscape categories used here are (1) intramontane and piedmont deposits (no letter added; e.g., Ql); (2) fine-grained basin-floor deposits (letter f added; e.g., Qyf); and (3) deposits of major rivers (letter r added; e.g., Qmr). Deposits in modern channels and very young bars and terraces are indicated by the letter c (Qyc and Qyrc), and eolian deposits are labeled Qye. Areas of exposed bedrock are subdivided into bedrock mountains and hills (b) and low-relief, fairly planar bedrock erosion surfaces or pediments (p).

Piedmont and Intramontane Deposits

Surficial deposits that mantle the piedmonts of this region and the limited deposits in the mountains are described in this section. Intramontane surficial deposits consist primarily of narrow stream channels and stream terraces and high, deeply dissected remnants of Tertiary basin-fill deposits. Piedmonts, the broad plains that slope gently down from mountain ranges toward basin floors or axial drainages, are predominantly covered by thin Quaternary surficial deposits. These deposits typically are poorly sorted, containing particles ranging in size from silt or clay to cobbles or boulders. Subangular gravel-sized clasts are generally an important component of these deposits. Piedmont channels, alluvial fans, and terraces range in age from modern to middle to early Pleistocene. Dissected Tertiary basin-fill deposits and bedrock pediments are quite extensive on the upper piedmonts of the eastern and northern parts of the Mesa Quadrangle. Piedmont alluvial deposits grade or interfinger downslope into finer-grained basin-floor deposits or terraces of the Gila and Salt rivers.

Qyc (< 0.5 ka)

Very young deposits in the channels of ephemeral streams draining piedmonts, mountain areas, and basin floors are labeled Qyc. Qyc deposits are composed of minimally oxidized sand, silt, pebbles, cobbles, and boulders. Qyc deposits are typically coarse and very poorly sorted within mountain areas and on upper piedmonts, with particles ranging from silt to cobbles or boulders; in areas subject to overbank flooding, however, Qyc deposits are primarily sand and silt. Qyc deposits are typically composed of sand, silt, and pebbles on lower piedmonts, and are primarily sand on basin floors. Drainage patterns of Qyc channels are generally dendritic in the mountains and on upper piedmonts. Within the larger Qyc channels and on the lower piedmonts and basin floors distributary and anastomosing channel patterns are common. Many Qyc channels on lower piedmonts have discontinuous entrenched and unentrenched reaches. Some of the Qyc channels on piedmonts have rectilinear drainage patterns that suggest anthropogenic causes, such as railroad tracks, diversion ditches and dams, or channels that have developed out of two-track roads and cattle trails. Most Qyc channels on basin floors have been obscured or obliterated by agricultural cultivation. These former channels are identified by broad, shallow swales and young, sandy soils.

Qyc alluvium is generally well-stratified and lacks any appreciable soil formation. Qyc soils are classified as Torrifluvents or Torriorthents. Most of the channel surfaces are modern in age, but vegetated bars may be several hundred years old.

Vegetation tends to be concentrated along modern drainages because of the relatively greater supply of moisture. Some of the larger drainages that originate in the mountains support streamflow in the mountains and upper piedmont areas during the winter and spring. These drainages may sustain relatively large and lush riparian vegetation, such as cottonwood, sycamore, desert willow and tamarisk. Most Qyc channels on piedmonts only flow during or immediately after rainfall events. These channels typically are lined with palo verde, mesquite, or ironwood. Qyc surfaces are prone to flooding unless structures have been constructed to divert water from them. Areas mapped as Qyc on lowermost piedmonts and basin floors were formerly quite flood prone, but have for the most part been protected by flood-control structures. Due to relatively frequent wetting and high permeability, areas mapped as Qyc have high potential for ground-water recharge.

Qy (<10 ka)

Holocene alluvial deposits that have incipient soil development are mapped as Qy. Unit Qy consists primarily of low terraces along active washes in the montane and upper piedmont areas and broad alluvial fans on lower piedmonts. Active channels are also included in unit Qy where they could not be consistently differentiated from slightly older deposits, primarily on active alluvial fans and in some montane stream reaches. In the mountains and on upper piedmonts particle sizes range from fine sand to boulders; on lower piedmonts, sand, silt, and pebbles predominate. Qy deposits typically are associated with narrow stream channels and low terraces on upper piedmonts and within the mountains. In contrast, Qy alluvial fans cover much of the middle and lower piedmonts of the Mesa Quadrangle. Drainage networks on Qy alluvial-fan surfaces on middle and lower piedmonts typically are distributary or anastomosing, with discontinuous entrenched and unentrenched reaches. In upper piedmont and intramontane areas, Qy deposits are associated with dendritic drainage networks. Qy terraces and alluvial fans typically are about 1 to 2 m above modern channels.

Qy soils are weakly developed and commonly primary fluvial bedforms are preserved. Pedogenesis is generally limited to surface enrichment of silt from eolian sources, slight oxidation, and weak calcium carbonate accumulation. Surface colors typically are light brown to yellowish brown (10 YR), with minimal reddening deeper in the soil profile. Surfaces have minimal or no rock varnish or desert pavement development. Qy soils contain cambic, calcic (Stage I or less; morphologic stages of calcium carbonate accumulation are after Gile and others, 1981, and Machette, 1985), and Cox horizons (Birkeland, 1984), and classify as Torrifluvents, Torriorthents, Camborthids, and Calciorthids.

Based primarily on soil development, we estimate Qy surfaces to be younger than 10 ka. Unit Qy encompasses units Ya, Ya1, Ya1a, and Ya1b of Huckleberry (1992, 1993a, 1993b, 1994a, 1994b). We correlate Qy deposits with the Q4, Q3c, and Q3b surfaces (< 8 ka) in the lower Colorado River valley (LCR) (Bull 1991); and with the Fillmore alluvium (< 7 ka) in southern New Mexico near Las Cruces (SNM) (Gile and others, 1981).

Qy includes many active channels too small to map at this scale, relatively low stream terraces that may be inundated during large floods, and active alluvial fans on the middle and lower piedmont. All areas mapped as Qy should be considered as potentially flood prone unless geomorphologic/hydrologic/hydraulic analyses indicate they are not. Due to relatively high permeability and the variable potential for inundation, areas mapped as Qyc have moderate to high potential for ground-water recharge.

Ql (10 to 250 ka)

Late Pleistocene alluvial fan surfaces and terraces with moderate soil development are mapped as unit Ql. Ql units are typically alluvial fans on middle and lower piedmonts and terraces on upper piedmonts and in mountain areas. Alluvial sediment sizes range from sand to cobbles and boulders, coarser in upper piedmont and mountain areas. Drainage patterns on Ql surfaces are dendritic, with surface dissection varying from about 1 to 4 m. Desert pavement and rock varnish development is quite variable, ranging from nonexistent to moderate. Subdued depositional bar-and-swale surface topography is common.

Ql soils are more strongly developed than Qy soils, but their characteristics vary substantially. Ql surface colors typically are similar to or slightly redder than Qy surfaces (light brown to reddish yellow). Ql soils commonly contain argillic horizons (zones of clay accumulation) that are weakly to moderately strongly developed. These upper horizons of Ql soils are slightly (strong brown, 7.5 YR) to obviously (yellowish red, 5 YR) reddened relative to their parent material. Calcic horizon morphologies are also quite variable, ranging from Stage I-III development. Ql soils classify as Haplargids, Camborthids, and Calciorthids.

Unit Ql includes deposits of several different ages, probably ranging from slightly greater than 10 ka to as much as 100 to 200 ka. Unit Ql is equivalent to unit Ma2 of Huckleberry (1992, 1993a, 1993b, 1994a, 1994b). We correlate Ql deposits with the Q2c (12-70 ka) and Q2b (70-200 ka) surfaces of the LCR (Bull, 1991) and the Isaac's Ranch (8-15 ka) and Jornada II (25-125 ka) surfaces of the SNM (Gile and others, 1981). The substantial time span covered by unit Ql helps to explain the considerable morphological variability displayed by Ql soils. All Ql soils have developed at least in part during times when the regional climate was wetter and cooler than the Holocene, but the oldest soils may be an order of magnitude older than the youngest soils. Although well developed, none of these soils have not yet reached the stage of pedogenic development when subsequent soil formation is impeded by plugged and indurated horizons. These late Pleistocene soils thus display greater morphological variability compared to older soils with strong argillic horizons or petrocalcic horizons.

Ql units generally are not flood prone, except immediately adjacent to active washes. In lower piedmont areas where topographic relief is minimal, some areas mapped as Ql may be subject to inundation during extreme floods or may become subject to inundation as a result of relatively minor changes in the stream systems. Areas mapped as Ql generally have low recharge potential because their soils have generally low permeability and they are isolated from major washes.

Qly (< 250 ka)

Qly is a composite map unit that contains both late Pleistocene (Ql) and Holocene (Qy and Qyc) deposits. Qly is used in a few piedmont areas in the northern part of the Mesa Quadrangle where it is difficult to distinguish surfaces of different ages because they have complex, interfingering spatial relationships. Unit Qly contains a variety of young (Camborthids) and older (Haplargids, Calciorthids) soils. Portions of the areas mapped as Qly may be prone to flooding in extreme events, but they are marginal areas of groundwater recharge due to limited inundation.

Qm (250 to 750 ka)

Dissected middle Pleistocene alluvial-fan and terrace deposits with strong soil development are mapped as Qm. Relict Qm alluvial fans cover much of the middle and upper piedmonts throughout the Mesa Quadrangle. Small Qm fans and terraces are also fairly common along streams and in small basins in mountain areas. Sediment grain sizes range from sand to boulders, fining downstream. Qm alluvial-fan surfaces typically have dendritic drainage and are heavily dissected by streams that head on them. Qm surfaces typically are 2 to 10 m above modern channels, with dissection decreasing downslope as Qm surfaces converge with younger surfaces. Desert pavement and rock varnish development are typically strong on stable Qm surfaces, but may be variable or weak on surfaces that have experienced significant erosion.

Qm soils typically exhibit strong soil development. Surface color range from strong brown to reddish brown. Qm soils typically contain reddened argillic horizons (strong brown to yellowish red, 7.5 YR to 5 YR) that are moderately to strongly enriched in pedogenic clay. Calcic horizon development typically is fairly strong (Stage II-IV); some Qm units have petrocalcic horizons (caliche). These soils classify as Calciorthids, Paleorthids, Haplargids, and Paleargids.

We estimate the age of Qm deposits to be at least 250 ka, and more likely 500 to 700 ka. Unit Qm is equivalent to unit Ma1 of Huckleberry (1992, 1993a, 1993b, 1994a, 1994b). Soils associated with the Qm unit are much more strongly developed than those associated with Ql, implying that Qm is substantially older than Ql. We correlate the Qm unit with Q2a surfaces (400-700 ka) of the LCR (Bull, 1991) the Jornada I (250-400 ka) and possibly Doña Ana (> 400 ka) surfaces of SNM (Gile and others, 1981).

Areas mapped as Qm are generally not flood prone except in and adjacent to washes. Because of their relatively impermeable argillic and petrocalcic horizons, Qm surfaces are not areas of significant ground-water recharge.

Qml (10 to 750 ka)

Qml is a composite map unit that contains both middle Pleistocene (Qm) and late Pleistocene (Ql) terrace and alluvial-fan deposits. Qml is used in montane areas that were mapped on a reconnaissance basis. In these areas, it is difficult to confidently distinguish between middle and late Pleistocene terraces without extensive field investigations and soil descriptions. Areas mapped as Qml are not prone to flooding except in and immediately adjacent to washes, and they are not areas of significant recharge.

Qo (750 ka to 2 Ma)

Deeply dissected remnants of very old Quaternary alluvial fans with strong soil development are mapped as Qo. These relict alluvial fans exist in some upper piedmont areas in the south-central and eastern parts of the Mesa Quadrangle. Qo surfaces commonly are deeply dissected into a series of alluvial-fan remnants that mark the highest stand of basin deposits along the upper piedmont. Qo surfaces typically are 6 to 25 m above modern channels. Older deposits underlying and downslope from preserved Qo surfaces are mapped as Tertiary basin-fill deposits (Ts). In the eastern quarter of the Mesa Quadrangle, however, basin-fill deposits exist at levels substantially higher than Qo surfaces. Qo deposits typically are coarse and very poorly sorted, with grain sizes ranging from sand to boulders. Desert pavement on Qo surfaces varies from none to moderate; rock varnish varies from none to strong.

Qo soils range from moderately to very strongly developed, depending on their preservation. In areas where fairly extensive Qo surfaces are preserved, Qo soils typically include reddish brown to red (5 YR to 2.5 YR), clay-rich argillic horizons and petrocalcic horizons (caliche; Stage III-V). In areas where Qo remnants are of limited extent, or on slopes below planar fan surfaces, argillic horizons may have been removed by erosion leaving a calcic or petrocalcic horizon and caliche fragments at the surface. Qo soils classify as Paleargids (well-preserved argillic horizons), Durorthids, and Paleorthids. The common presence of petrocalcic fragments on Qo surfaces indicates erosion or bioturbation of the original surface.

We estimate the age of Qo alluvium to be 1 to 2 Ma. Unit Qo is generally equivalent to unit Oa of Huckleberry (1992, 1993a, 1993b, 1994a, 1994b). However, unit Qo is somewhat more restricted than unit Oa because it includes only those areas where some remnant of the original alluvial-fan surface is preserved; if no planar fan surface is preserved, deeply dissected surficial deposits are inferred to be of Tertiary age (unit Ts). Qo correlates with the Q1 surface (> 1.2 Ma) in the LCR (Bull, 1991) and possibly the Doña Ana surface (>400 ka) of the middle Rio Grande Valley (Gile and others, 1981). Qo also correlates with the Martinez unit (Menges and McFadden, 1981; Morrison, 1985), very high alluvial surfaces common to the basins of southeastern Arizona. Menges and McFadden (1981) estimate the age of the Martinez surface as 1-3 Ma based on very strong soil formation and magnetostratigraphy of underlying sediments.

Areas mapped as Qo are not flood prone. Impermeable argillic and petrocalcic horizons and relatively steep slopes associated with unit Qo limit the amount of groundwater recharge in these areas.

Ts (2 to 38 Ma)

Unit Ts includes late and middle Tertiary alluvial sediment that was deposited in basins formed during extensional tectonism. Dissection of these deposits is variable, but they typically are deeply dissected into ridges and intervening valleys with as much as 60 m of local relief between modern stream channels and the highest levels of unit Ts. In some portions of the Mesa Quadrangle, Ts sediment is capped by fan gravels of unit Qo. Generally, however, no original depositional surfaces are preserved at the highest levels of this unit. Ts deposits are poorly to extremely poorly sorted, subangular to subrounded pebbles, cobbles and boulders, with a sand, silt and clay matrix. Bedding ranges from crude to well-defined, and consolidation varies from weak to moderate. Unit Ts includes generally untilted Pliocene to middle Miocene deposits (unit Tsy of Reynolds, 1988), and generally tilted middle Miocene to Oligocene deposits (unit Tsm of Reynolds, 1988).

Basin-Floor Deposits

The fine-grained surficial deposits that mantle the undissected basin floors and lowermost piedmonts of the Mesa Quadrangle are described in this section. These deposits range in age from modern to middle Pleistocene, and their soil characteristics vary with age. The primary area covered by basin-floor deposits is a broad expanse extending from the Magma-Queen Creek area northwest through Chandler and Gilbert to the Salt River terraces, west nearly to South Mountain, and then south to near the Gila River. Fine-grained basin-floor deposits interfinger with distal piedmont deposits in lower piedmont areas. Mapping basin-floor deposits is exceedingly difficult due to the lack of topographic relief, similarity of surface characteristics between deposits of different ages, and especially the extensive agricultural tillage of these areas. We relied heavily on published soil surveys to assess soil development in order to interpret the extent of basin-floor deposits of different ages. In addition, we employ fewer map units and more dashed unit contacts, and more areas are mapped as composite units.

Qyf (<10 ka)

Unit Qyf comprises the young, fine-grained deposits with minimal soil development that mantle much of the lowermost piedmonts and the southern half of the undissected basin floor in the central part of the Mesa Quadrangle. Extensive Qyf deposits typically surround young channel deposits (Qyc), and they tend to increase in width downslope, indicating that they are fine-grained alluvial-fan/sheet-flood deposits associated with ephemeral drainages. Unit Qyf includes many small channels as well, and these commonly exhibit alternating entrenched and unentrenched reaches. Qyf deposits typically are composed of sand, silt and clay, with some fine gravel. Original depositional bedding may be preserved, but more typically bioturbation has obscured sedimentary structures.

Soil development associated with Qyf deposits is weak, consisting mainly of eolian silt and minor (stage I) carbonate accumulation. Soils are primarily Torrifluvents, except where Qyf deposits are thin (< 50 cm) over older soils. The minimal soil development associated with Qyf deposits implies that they are of Holocene age (< 10 ka). A Holocene age for Qyf deposits is also indicated by a conventional radiocarbon date of 1725 $\pm$ 120 years (University of Arizona, sample no. A-7910) obtained from charcoal buried at 40 cm depth in the cambic horizon of a Qyf soil.

Qyf is composed of young sheet-flood and overbank deposits, indicating that these areas have been subject to flooding fairly recently. All of these areas should be considered as potentially flood prone unless they have been protected by flood-control structures or geomorphologic/hydrologic/hydraulic analyses indicate they are not. Due to moderate permeability and the potential for widespread inundation during large floods, areas mapped as Qyc have moderate potential for ground-water recharge.

Qlyf (< 250 ka)

Fine-grained Holocene and late Pleistocene deposits complexly interfinger in some basin floor and lowermost piedmont areas. In these areas, we utilize the composite map unit Qlyf. Little topographic relief and extensive agricultural development in these areas limit our ability to distinguish detailed relationships between young and old deposits. Because these are areas of sheetflooding, many of the deposits may be Holocene in age. However, soil survey maps and recent geologic mapping indicate that some soils within these low-relief areas have moderate development (Haplargids) indicative of a late Pleistocene age.

Qmlf (10 to 750 ka)

Unit Qmlf comprises fine-grained basin-floor deposits characterized by moderate to strong soil development indicative of substantial antiquity. Qmlf deposits cover much of the basin floor in the Mesa-Gilbert-Chandler area, implying that the northern basin floor has not received significant deposition during the Holocene. Virtually all of these areas have been disturbed by agricultural tillage, so the original surface morphology and drainage patterns have been obscured. Qmlf deposits are composed of sand, clay and silt, with some fine gravel. Areas mapped as Qmlf have minimal local topographic relief, generally less than 1 m and less than 3 m in all cases. These areas are not topographically distinct from areas covered by younger deposits (Qyf), and commonly grade into areas of younger deposits. The northern edge of Qmlf deposition grades very subtly onto the middle Pleistocene terrace of the Salt River (the Mesa Terrace of Péwé, 1978; Qmr on this map).

Soil development associated with unit Qmlf is moderate to strong, consisting of substantial clay and calcium carbonate accumulation. Qmlf soils are classified as Haplargids. They typically have fairly thick argillic horizons with clay loam or clay textures and moderate calcic horizon development (stage II to III). Surface colors typically are brown (7.5 YR), but argillic horizons are reddish brown (5 YR). The presence well-developed argillic horizons implies that Qmlf deposits are of middle to late Pleistocene age.

Eolian Deposits

Qye (< 4 ka)

Several small areas of eolian sand exist on the north side of the Gila River upstream from Florence. The sands are well sorted, probably derived from the flood plain of the MGR, and are situated on top of Pleistocene stream terraces. The presence of creosote, cholla, and various grasses on the dunes indicates that they are relatively stable. However, archaeological artifacts at the surface represent a deflated lag and suggest some surface erosion and redeposition. Overall surface instability is further supported by minimal pedogenesis. Soils classify as Torripsamments.

Qye sand dunes have existed in these locations since at least 1 ka, as indicated by the presence of Hohokam pottery sherds and possible Archaic (i.e., pre-Hohokam) lithic artifact clusters. Qye sediments are probably < 4 ka.

Major-River Deposits

Deposits of the major rivers that traverse the Mesa Quadrangle are described in this section. The Gila River heads in New Mexico and drains most of southeastern Arizona before winding across the southern portion of the Mesa Quadrangle. Its two largest tributaries, the Salt and Santa Cruz rivers, also flow across parts of the Mesa Quadrangle. Deposits of each of these rivers consist of active channels and one or more terraces that record former, higher positions of the stream channels. These river terraces, which range from Holocene to early Pleistocene in age, record the Quaternary evolution of the major rivers. The heights of river terraces of similar age increase relative to modern channels from west to east across the Mesa Quadrangle. This phenomenon has been interpreted by several authors as evidence for regional uplift of the Transition Zone of central Arizona relative to the Basin and Range province of south-central Arizona (Péwé, 1978; Menges and Pearthree, 1989; Huckleberry, 1993a).

Major river deposits are distinguished from piedmont and basin-floor deposits by their diverse lithologic composition, their clast rounding, and their landform morphology. These rivers drain large, geologically-complex areas, so their sediment is composed of many different lithologies. River sediment typically has been transported a long distance prior to its deposition in this area, so clasts generally are much more rounded than those of piedmont gravels. River terraces typically are elongate landforms that mimic the general trend of the modern rivers. Terraces are bounded on at least one side by a scarp (or riser) that either drops down to the next younger terrace or rises up to the next older terrace. Modern river channels and terraces of different ages are similar sedimentologically, and are distinctly different from piedmont gravels (Kokalis, 1971).

Qycr (< 0.1 ka)

Modern channels of the Gila, Salt, and Santa Cruz rivers are mapped as unit Qycr. The channels of these major rivers have been shaped primarily by large floods, with some modification by human activity. The form and extent of modern channels have varied substantially during the historical period (Kokalis, 1971; Huckleberry, 1992; 1993c). The locations of channels shown on this map are as they existed when original, large-scale geologic mapping was completed (see earlier section for data sources). Channel banks are commonly well-defined, ranging from 1 to 3 m in height. Along some stream reaches, however, channel depth decreases and the channel diverges into several smaller, anastomosing channels. Channel deposits consist primarily of sand and gravel, with local accumulations of silt. The Salt River channel has distinctly coarser sediment, dominated by rounded cobbles and small boulders. Deposits within Qycr channels are modern to historical in age.

Areas mapped as Qycr have been flooded one or more times during the historical period and should be considered flood prone. Even though upstream dams on the Salt and Gila rivers provide some protection from flooding, channel areas are likely to suffer serious inundation during large flow events. Due to the permeability of the sediment and the frequency of flow, major river channels are the areas with the greatest potential for ground-water recharge in the Mesa Quadrangle.

Qyr (< 10 ka)

Low terrace deposits with weak soil development are mapped as unit Qyr. Several different levels of terraces are included in this map unit. The lowest and youngest of these terraces (terrace Y2/Y1 of Huckleberry, 1992; 1993a) are discontinuous and contain both channel (crudely bedded coarse sands, gravels, and cobbles) and overbank (finely laminated clays, silts, and fine sands) sediments. Soil development is limited to slight organic accumulation at the surface and some bioturbation; soils classify as Torrifluvents.

Somewhat older Holocene terraces comprise the majority of unit Qyr. Included in this subdivision are the Lehi terrace of the Salt River (Péwé, 1978) and the Adamsville (Y1) terrace of the Gila River (Huckleberry, 1993a). These terraces range from 1 to 5 m above modern channels. They are fairly continuous and broad and are largely covered by mosaics of agricultural fields and urban development (along the Salt River). Qyr terraces contain both channel and overbank deposits, with the latter dominating the upper 2 m of the terrace. Alluvial bedforms near the surface are absent or weakly expressed due to bioturbation. There is organic accumulation in uppermost soil horizons, and slightly oxidized horizons exist at deeper levels. In places, fine nodules of calcium carbonate have accumulated. Soils on the Qyr terraces are Torrifluvents and Camborthids. The age of the Adamsville Terrace is probably < 8 ka. Two samples of detrital charcoal collected from within 2 m of the surface of the Adamsville Terrace near Casa Grande National Monument have radiocarbon ages of 4.7 ka and 0.7 ka (Huckleberry, 1993a). Pleistocene alluvium underlies Qyr alluvium at fairly shallow levels, as evidenced by a Probicidean tusk found 7 to 9 m beneath the Qyr surface in a gravel quarry near Sacaton (Huckleberry, 1992).

Many areas mapped as Qyr may be subject to flood hazards. Portions of Qyr terraces have been inundated in large historical floods (Péwé, 1978; Huckleberry, 1993a), even after dams were constructed upstream. Lateral bank erosion during floods is also a major hazard, because major changes in channel form and position have occurred in large floods (Huckleberry, 1993c) and the weakly consolidated deposits of Qyr terraces typically are susceptible to erosion. Qyr terraces may be areas of significant ground-water recharge if they are inundated during large floods.

Qlr (10 to 250 ka)

Late Pleistocene river terraces with moderate soil development are mapped as unit Qlr. Terraces of this age include the Blue Point Terrace of the Salt River (Péwé, 1978) and the Bogart (M2) and Ms3 terraces along the Gila River (Huckleberry, 1993a). Qlr terraces are limited in extent in the Mesa Quadrangle, and Qlr terrace deposits typically are thin. Qlr terrace surfaces range from about 2 to 15 m above modern channels. In mountain areas along the Gila River, Qlr terraces are relatively narrow straths eroded into bedrock, with thin (< 3 m) caps of alluvial deposits. Qlr terrace surfaces have undergone some dissection by small streams that flow across them.

Based primarily on soil development, we believe that Qlr terraces are moderately old, but substantially younger than the next older river terraces described below. Soil development on Qlr terraces is moderate to fairly strong, with 5 to 7.5 YR reddening, minimal clay accumulation, and stage II to III calcium carbonate accumulation . Bogart Terrace soils are classified as Calciorthids; Ms3 soils are classified as Calciorthids or in some cases Paleorthids because of greater carbonate cementation. Qlr terraces probably range in age from 10 to 40 ka (M2) to 100 to 200 ka (Ms3)(Huckleberry, 1993a).

Qlr terraces are not prone to flooding from the major rivers, although minor flooding might occur along small drainages on the terraces. Lateral bank erosion could be a hazard where Qlr terraces abut the active river channels (unit Qycr), but Qlr terrace deposits generally have more cohesion and resist bank erosion more effectively than younger terraces. Qlr deposits are fairly permeable, but inundation is limited, so Qlr terraces are not areas of significant recharge.

Qlyr (< 250 ka)

This composite map unit is utilized in nondescript, low-relief areas along the Gila River in the western portion of the Mesa Quadrangle. In this area we have distinguished two sets of river terraces. The lower terrace is of Holocene age and is mapped as Qyr. The slightly higher terrace is probably composed of late Pleistocene and Holocene deposits, and thus is mapped as Qlyr. The higher river terraces are less than 6 m above the modern channel. The terrace surfaces have little topographic relief and minimal drainage-network development and dissection. Soils described on these terraces are fine-textured and are fairly well-developed (Calciorthids, Haplargids, and Natrargids; Camp, 1986; Hall, 1991), which suggests a late Pleistocene age for the terraces (Huckleberry, 1992). However, some Hohokam archeological sites situated on Qlyr terraces have been buried, indicating that portions of the terraces are covered by very young deposits.

Qlyr terraces are probably not prone to flooding from the Gila River, although minor flooding might occur along small drainages on the terraces. Lateral bank erosion could be a hazard where Qlyr terraces abut the active channel of the Gila River (unit Qycr). These deposits are fairly fine-grained and inundation is limited, so Qlyr terraces are not areas of significant recharge.

Qmr (250 to 750 ka)

Qmr encompasses prominent high terraces with strong soil development along the Gila and Salt rivers. Terraces grouped in this map unit include the Mesa terrace along the Salt River (Péwé, 1978), the Florence (M1) aggradational terrace along the Gila River (Huckleberry, 1993a), and two high strath terraces farther upstream along the Gila River (terraces Ms2 and Ms3; Huckleberry, 1993a). Broad Qmr terraces exist on both sides of the Salt and Gila rivers after they exit the mountainous country in the eastern part of the Mesa Quadrangle; these terraces are major depositional landforms. Qmr terraces range in height above the modern channel from 5 to 10 m in the west to as much as 40 to 65 m in the east. Qmr alluvium is composed of sand, gravel, and cobble channel deposits with interfingered silty and clayey overbank sediments. Desert pavement and rock varnish development is weak to moderate. Qmr terraces commonly do not have a well preserved, planar morphology because they have been eroded by streams that head on them or that flow across them. Eroded Qmr landforms consist of series of low, rounded ridges and moderately incised stream channels. Eroded Qmr surfaces are typically littered with fragments of caliche and calcium carbonate nodules.

Soils associated with Qmr terraces are strongly developed where they have not been seriously eroded. Clay accumulation in Qmr soils is variable; typically, soils developed on aggradational terraces in the basin have only cambic horizons, whereas soils developed on strath terraces in the mountains have fairly strong, red argillic horizons. Qmr soils typically have strongly developed calcic or petrocalcic horizons (Stage III-V) (Péwé, 1978; Anderson and others, 1986; Huckleberry, 1993a) and classify as Calciorthids, Paleorthids and Paleargids. Strongly developed surface soils and the extent of surface dissection suggest that Qmr terraces are at least several hundred thousand years, and possibly as much as 1 million years old (see Péwé, 1978; Huckleberry, 1993). Using total carbonate accumulation in a Mesa terrace soil, Anderson and others (1986) estimated an age range of 350 to 775 ka for the terrace. Buried, strongly developed soils within Qmr deposits are exposed at several locations along the Gila River indicate that Qmr deposition occurred over at least 100,000 years (Huckleberry, 1993a).

Qor (750ka to 2 Ma)

Very old, high, degraded terrace remnants that exist along the Gila and Salt rivers are mapped as Qor. Unit Qor includes the Sawik terrace along the Salt River (Péwé, 1978) and the Target (O) terrace along the Gila River (Huckleberry, 1993a). Along the Salt River, Qor terraces exist as isolated remnants standing high above the Mesa (Qmr) terrace. Along the Gila River, deeply eroded Qor deposits are extensive upstream from Florence to North Butte. Because Qor terrace deposits have been exposed to erosion for most of the Quaternary, they seldom retain their original terrace form and instead form a series of deeply dissected hills and isolated ridges. Qor deposits are coarse, with clasts ranging in size from pebbles to boulders. Coarse-grained rocks at the surface are highly pitted, and fine-grained rocks are commonly fractured. There is no desert pavement development in areas that have undergone significant erosion, but in a few places where depositional surfaces are preserved desert pavement and rock varnish are moderately to strongly developed.

Qor soils are dominated by thick petrocalcic horizons with Stage IV-V morphology. Secondary silica incorporated within the petrocalcic horizons appears as light brown, thin laminae. These soils classify as Durorthids (Hall, 1991). Based on the extremely strong soil development and the height of Qor terraces above modern stream channels, their age is likely to be at least 1 million years old (Péwé, 1978; Anderson and others, 1986; Huckleberry, 1993a).

Bedrock Areas

Pediments (p)

Extensive bedrock pediments exist around and within many of the mountain ranges of the Mesa Quadrangle. Pediments surround the Papago Buttes and the Santan and Sacaton mountains; the Usury and Superstition mountains also have broad pediments in the Mesa-Apache Junction area. Bedrock pediments are low-relief erosion surfaces with minimal alluvial cover that have developed by erosional backwearing of mountain masses. On this map, we show pediments only where exposed bedrock predominates, and alluvial cover is scarce or nonexistent. Pediments mantled by thin alluvial cover undoubtedly are much more extensive than exposed pediments. Pediments probably form by a combination of deep chemical weathering of bedrock and lateral erosion by streams that flow across the pediment (see Huckleberry, 1993b, for more detailed review of processes of pediment formation). Pediments thus are commonly developed on lithologies that are susceptible to chemical weathering in the subsurface. In the Mesa Quadrangle, pediments are developed primarily on granitic rocks.

Bedrock (b)

Bedrock lithologies are not differentiated on this map. The most common bedrock lithologies in the Mesa Quadrangle are, in order of decreasing abundance, middle Tertiary fine-grained volcanic rocks, Precambrian metamorphic and granitoid rocks, and early Tertiary to late Cretaceous granitic rocks (Reynolds, 1988).

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SCALE 1:100,000

0 1 2 3 4 5 mi

0 1 2 3 4 5 km

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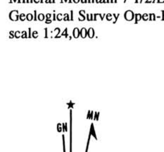

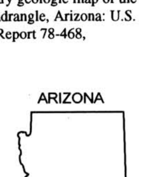

QUADRANGLE LOCATION