Geologic Map of the Green Valley 7 ½' Quadrangle, Pima County, Arizona

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Arizona Geological Survey

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Introduction

This map describes the surficial geology, geomorphology, and geologic hazards of the Green Valley 7 ½'quadrangle on the southern fringe of the Tucson metropolitan area. The whole map area is within the drainage basin of the Santa Cruz River, a major, nor th-flowing regional drainage. This map covers a substantial part of the western piedmont of the Santa Rita Mountain and part of the Santa Cruz River channel and floodplain. There are several potentially conflicting land use issues in this area. The southern fringe of the Tucson metropolitan area is experiencing development and population growth. Much of the eastern part of map area is within the Santa Rita Experimental Range and Wildlife Area, a government-owned preserve that is undeveloped and will remain that way for the foreseeable future. Intense urban development has occurred and is continuing in the Green Valley area. This map is primarily intended to enhance our understanding of the surficial geology of the Green Valley area and to aid in assessing and understanding geologic hazards. This new mapping complements previously published mapping that focused on the bedrock exposed in the southeastern corner of the quadrangle (Drewes, 1971).

This surficial geologic mapping is part of continuing efforts by the AZGS to map the geology of the Phoenix – Tucson urban corridor. Mapping was originally conducted as part of the STATEMAP Program of the U.S. Geological Survey. Mapping was revised and the geodatabase transformed into an NCGMP09 compatible format with funding from the National Geologic and Geophysical Data Preservation Program.

The surficial geology of the project area was mapped originally using black-and-white aerial photographs taken in 1998 and color aerial photos taken in 1979. Unit boundaries were spot-checked in the field, and mapping was supplemented by observations and descriptions of soils and stratigraphy. The physical characteristics of Quaternary alluvial surfaces (channels, alluvial fans, floodplains, stream terraces) evident on aerial photographs and in the field were used to differentiate their associated deposits by age. Mapping was revised in 2019 using digital color orthophotography in ArcGIS. Surficial deposits of this quadrangle were then correlated with similar deposits in this region in order to roughly estimate their ages. Original mapping was done on aerial photos and compiled on 7 ½' quadrangle maps. The map compilations were then digitized and the final maps were generated from the digital data.

In this map, Quaternary surficial deposits are subdivided based on their source (axial valley stream and smaller tributary washes on piedmonts) and estimated age of deposits. Surface and soil characteristics were used to correlate alluvial deposits and to estimate their ages. Surface pits and exposures along cut banks were used to assess soil characteristics associated with deposits of different ages and from different sources. Soils and surfaces documented in the map area were generally correlated with soils and surfaces described in Quaternary mapping studies of adjacent; these correlations were also used to estimate the ages of surficial deposits in the map area.

Landscape evolution

The highest levels of alluvial deposits (unit QTa and Qo) in the Green Valley quadrangle were graded approximately to the ancestral Santa Cruz River before it was significantly entrenched. They are probably approximately correlative with QT deposits mapped in the Catalina foothills on the north side of the Tucson basin (Klawon and others, 1999), Qo and QT deposits mapped in the Tucson Mountain foothills on the west side of the Tucson basin (Pearthree and Biggs, 1999), and other high remnant deposits throughout southeastern Arizona (Menges and McFadden, 1981). It is likely that in the late Pliocene to early Quaternary, the surfaces of the Sierrita and Santa Rita piedmonts were fairly planar, undissected piedmonts that graded downslope to the floodplain of the th rough-flowing ancestral Santa Cruz river system. During the past 2 M.y., the Santa Cruz River and its tributaries have downcut substantially into the late Cenozoic deposits of the Santa Cruz Valley. The high remnant fan surfaces of the Santa Rita piedmont attest to the amount of stream erosion that has occurred since the highest levels of alluvium were deposited. Episodes of downcutting of the Santa Cruz River caused erosion of the toes of alluvial fans on both sides of the valley, and resulted in much of the stream downcutting in the piedmonts east and west of the river. Streams that head in the Santa Rita Mountains flow across the piedmonts and eventually join the Santa Cruz River. The lower ends of these streams are linked with the river, so if the Santa Cruz downcuts, the slopes of its tributary stream channels steepen and they tend to downcut as well. The ultimate cause of the Santa Cruz River downcutting is not certain. It is may have occurred a delayed response of the integration of the Tucson basin streams into the larger regional drainage system, or it may have been driven by some broad regional upwarping of southeastern Arizona (Menges and Pearthree, 1989).

Quaternary faulting

The surficial geology of the Santa Rita piedmont provides information that has been used to evaluate the behavior of the Santa Rita fault zone, which extends along the Santa Rita Mountains for about 35 miles (60 km) from Tubac to Corona de Tucson (Pearthree and Calvo, 1987). Along the fault zone, a discontinuous zone of fault scarps offset Pleistocene alluvium. Scarps trend northeast to north-south and are 1 to 6 km west of the base of the Santa Rita Mountains. Scarps range up to about 5 m in height and have maximum slope angles up to about 10°. Surficial deposits as young as late Pleistocene (unit Qi3) are displaced, but Holocene and latest Pleistocene deposits (units Qi4 and younger) are not faulted, which brackets the age of youngest faulting between 10-20 ka and 75-130 ka. Quantitative analysis of fault scarp morphologies indicates that the youngest surface rupture occurred between about 60-100 ka. Fault displacement of late Pleistocene (Qi3) surfaces averages about 2 m, in contrast to 4 to 5 m of displacement of middle and early Pleistocene surfaces (units Qi2 and Qo). Displacement of middle and early Pleistocene surfaces is similar, implying that the fault zone was not active during the early Pleistocene between the deposition of unit Qo and unit Qi2. The evidence of low frequency Quaternary fault activity combined with the existence of broad bedrock pediments on the west side of the Santa Rita Mountains indicates that the long-term slip rate on the Santa Rita fault zone is very low. The very long recurrence intervals between surface ruptures and evidence for very low long-term slip rates are consistent with other Quaternary fault zones that have been studied in southeastern Arizona, southwestern New Mexico, and northern Sonora (i.e., Bull and Pearthree, 1988).

Flood hazards

Hazards related to flooding in the Green Valley area may be subdivided into two broad categories. Along the Santa Cruz River, flood hazards consist mainly of channel and floodplain inundation and lateral erosion of unprotected channel banks. The most widespread flood hazards in the map area are those associated with smaller tributary drainages on piedmonts, where the extent of flood-prone area varies with the size of the stream and local topographic confinement of floodwater. This latter category of flood hazard is particularly difficult to assess in areas where channel networks are distributary and topographic relief is low. These areas may be subject to alluvial fan flooding.

The largest floods on the Santa Cruz drainages have resulted from regional storms in the winter and late summer - early fall, although summer storms have generated fairly large flows as well. At the Santa Cruz River gage near the village of Continental, the 45,000 cubic feet per second (cfs) discharge in October, 1983 is the peak of record (Pope and others, 1998). Other large floods occurred in January, 1993 (32,400 cfs) and October, 1977 (26,500 cfs). The channel of the Santa Cruz is entrenched one to several meters below the historical floodplain in most places. The channel capacity in not large enough to convey large flood discharges through this area, however, and floodplain inundation has occurred in the larger historical floods. Lateral bank erosion has been a significant hazard during, with hundreds of feet of erosion occurring during several floods (Wood and others, 1999). The bank s of some short reaches of the Santa Cruz River have been stabilized with soil cement, but the potential for serious bank erosion exists along extensive, unprotected banks formed in weakly consolidated Qyr deposits.

Smaller tributaries that drain the mountain ranges and the piedmonts are subject to flash floods. Floods on these drainages result from intense, localized thunderstorms that occur during the summer or early autumn, and stream stages typically rise and fall rapidly during floods. Flood hazards are relatively easy to manage where topographic relief contains floodwater to channels and adjacent low terraces. In these situations, the area that may be impacted by flooding is restricted and should be easy to avoid. It is much more difficult to assess and manage flood hazards associated with alluvial fan flooding. This type of flooding occurs where topographic relief is minimal and floodwater can spread widely. In these areas, channels may or may not be well defined, and their positions may shift during floods, and inundation is likely to be widespread during floods.

Surficial geologic mapping provides important information about the extent of flood-prone areas on the piedmonts, and it is the best way to delineate areas that may be prone to alluvial fan flooding. Floods leave behind physical evidence of their occurrence in the form of deposits. Therefore, the extent of young deposits on piedmonts is a good indicator of areas that have been flooded in the past few thousand years. These are the areas that are most likely to experience flooding in the future. Following this logic, the extent of potentially flood-prone areas on the piedmont varies with the extent of young deposits (units Qy2, Qy1, Qy, and possibly Qiy).

Active alluvial fans may be recognized by both distributary (downstream-branching) channel networks and laterally extensive young deposits between channels. Unconfined flow during floods occurs along both the western and eastern margins of the Santa Cruz floodplain, where tributaries debouch from the topographically confined foothills onto the Qyr terrace. On the Santa Rita piedmont, drainages in the upper piedmont are topographically confined and flood hazards are of limited extent. In the southern part of the map, drainages are topographically confined to very near the Santa Cruz floodplain. Farther north, however, most drainages have unconfined middle piedmont reaches that are subject to broad sheetflooding and possibly alluvial-fan flooding. Flood hazards are greatest at the upslope end of these areas, at the transition from confined to unconfined flow, because of fairly deep flow, high flow velocities, and the potential for significant changes in channel position during floods.

Soil problems

Soils in the Tucson area present a number of problems to homeowners. Cracking of foundations, walls, driveways and swimming pools causes headaches and costs millions of dollars each year in repairs. Severe or recurring damage can lower the value of a house or commercial property. Leading in the list of potential soil properties that can cause structural failures are expansive soils and collapsing soils. Properties of problem soils are generally related to the type and amount of clay, and to the conditions under which the clay originated. Clay minerals can form in-place by weathering of rocks, or by deposition from water or wind. Potential soil problems in middle and upper piedmont areas consist of shrink-swell potential, low infiltration rates, and hard substrate. Shrink-swell problems may exist on clay-rich soils of unit Qi2 and Qo, although the gravel that is common in these deposits likely decreases the severity of unstable soil problems. Excavation may be difficult and near-surface infiltration rates low on the oldest piedmont units (Qo, and QTa) due to the existence of carbonate- and silica-cemented hardpans (petrocalcic and duric horizons). Excavation and infiltration problems may be encountered on all surficial units in the uppermost piedmont areas because of the existence of bedrock at shallow depths.

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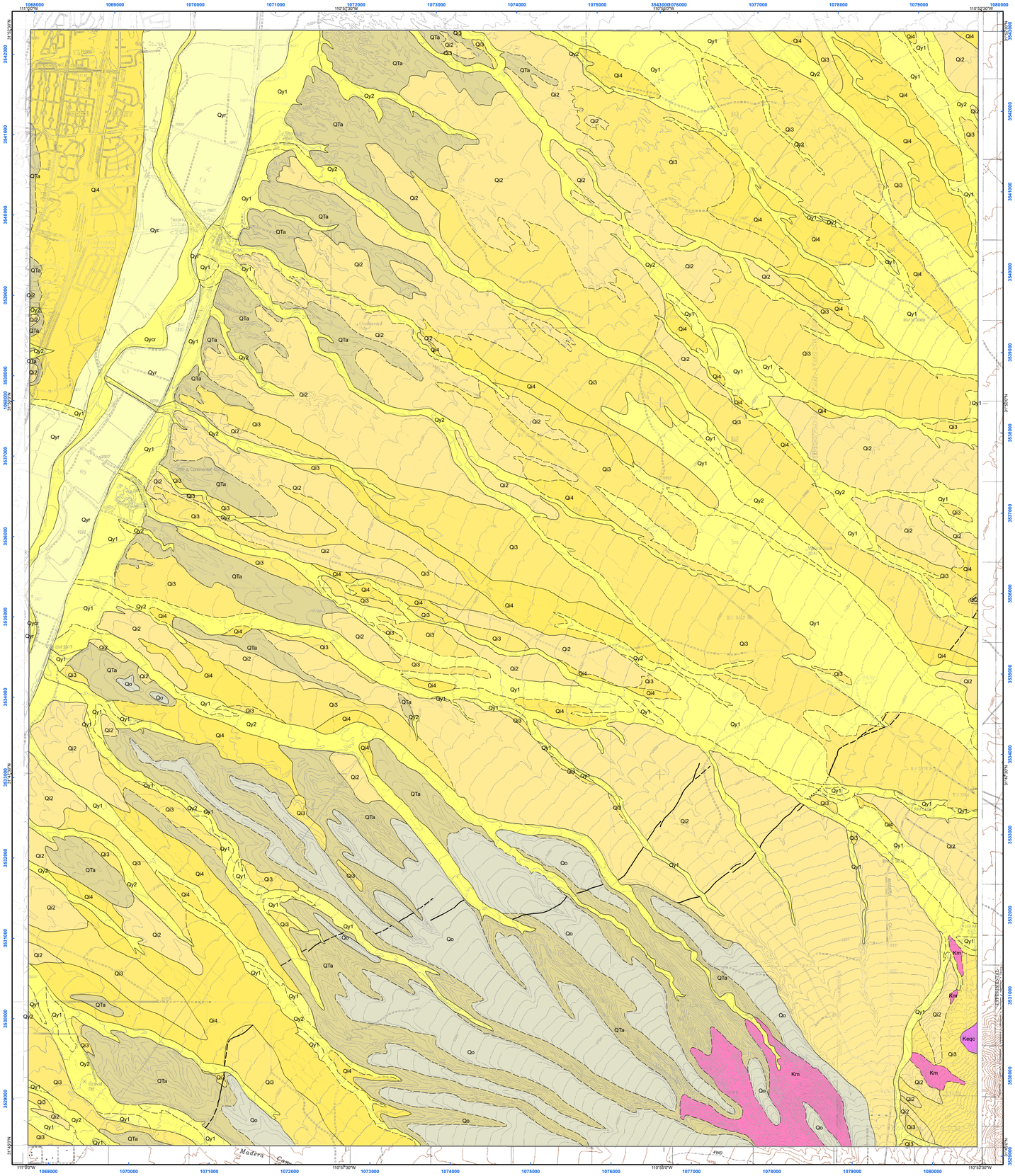


Map Unit Descriptions

Piedmont Alluvium

Qy_2 **Channel and low terrace deposits (Late Holocene)** - Unit Qy2 consists of channels, low terraces, and small alluvial fans composed of cobbles, sand, silt and boulders that have been recently deposited by modern drainages. In upper piedmont areas, channel sediment is generally sand, pebbles and cobbles, with some boulders; terraces typically are mantled with sand and finer sediment. On lower piedmont areas, young deposits consist predominantly of sand and silt, and some cobbles in channels. Channels generally are incised less than 1 m below adjacent terraces and fans, but locally incision may be as much as 2 m. Channel morphologies generally consist of a singlethread high flow channel or multi-threaded low flow channels with gravel bars adjacent to low flow channels. Downstream-branching distributary channel patterns are associated with the few young alluvial fans in the area. In these areas, channels typically are discontinuous, with small, well-defined channels alternating with broad expansion reach where channels are very small and poorly defined. Local relief varies from fairly smooth channel bottoms to the undulating bar-and-swale topography that is characteristic of coarser deposits. Terrace surfaces typically have planar surfaces, but small channels are also common on terraces. Soil development associated with Qy2 deposits is minimal (see Table 1 for more soils information). Terrace and fan surfaces are brown, and on aerial photos they generally appear darker than surrounding areas, whereas sandy to gravelly channels appear light-colored on aerial photos. Vegetation density is variable. Channels typically have sparse, small vegetation. The densest vegetation in the map area is found along channel margins and on Qy2 terraces along channels. Along the larger washes, tree species include mesquite, palo verde, and acacia; smaller bushes and grass may also be quite dense. Smaller washes typically have palo verde, mesquite, large creosote and other bushes along them.

Qy_1 **Young alluvial fan and terrace deposits (Holocene)** - Qy consists of deposits in low terraces adjacent to drainages <2m above active channels, and extensive, weakly incised young alluvial fans. Soil development consists of cambic horizons over weak to moderate (stage I to II) calcic horizons. This map unit approximately correlates with unit 3b of Pearthree and Calvo (1987).

Qiy **Young and young intermediate alluvial fan deposits (Holocene and Late Pleistocene)** - Broadly rounded alluvial fan surfaces approximately 1 m above active channels composed of mixed alluvium of late Pleistocene and Holocene age. Drainage networks consist of a mix of distributary channel networks associated with larger drainages and tributary channels associated with smaller drainages that head on Qiy surfaces. Qiy areas are primarily covered by a thin veneer of Holocene fine-grained alluvium (unit Qy), but reddened Pleistocene alluvium (unit Qi3 and rarely, Qi2) is exposed in patches on low ridges and in roads and cut banks of washes. The Holocene surfaces usually are light brown in color and soils have weak subangular blocky structure and minor carbonate accumulation. Qiy fans support palo verde and mesquite trees along washes and low shrubs and grass in interfluve areas. This unit is generally correlative with units 2d and 3a of Pearthree and Calvo (1987).

Qi_4 **Very young intermediate alluvial fan and terrace deposits (Latest Pleistocene)** - Unit Qi4 consists of slightly dissected relict alluvial fans and terraces found on the upper, middle and lower piedmont. Moderately developed, slightly incised tributary drainage networks are typical on Qi4 surfaces. Active channels are incised 1-2 m below Qi4 surfaces. Qi4 deposits consist of pebbles, cobbles, and finer-grained sediment. Qi4 surfaces have open lags of pebbles and cobbles; surface clasts exhibit weak rock varnish. Qi4 soils are moderately developed, with orange to reddish brown clay loam cambic to weak argillic horizons and stage II calcium carbonate accumulation. Dominant forms of vegetation include grasses, small shrubs, mesquite, and palo verde. Unit Qi4 is generally correlative with unit 2d of Pearthree and Calvo (1987).

Qi_3 **Young intermediate alluvial fan and terrace deposits (Late Pleistocene)** - Unit Qi3 consists of slightly to moderately dissected relict alluvial fans and terraces found on the upper, middle and lower piedmont. Moderately to well-developed, slightly to moderately incised tributary drainage networks are typical on Qi3 surfaces. Active channels are incised up to about 2 m below Qi3 surfaces, with incision typically increasing toward the mountain front. Qi3 fans and terraces are commonly lower in elevation than adjacent Qi2 and older surfaces, but the lower margins of Qi3 deposits lap out onto more dissected Qi2 surfaces in some places. Qi3 deposits consist of pebbles, cobbles, and finer-grained sediment. Qi3 surfaces commonly have loose, open lags of pebbles and cobbles; surface clasts exhibit weak rock varnish. Qi3 soils are moderately developed, with orange to reddish brown clay loam to light clay argillic horizons and stage II calcium carbonate accumulation. Dominant forms of vegetation include grasses, small shrubs, mesquite, and palo verde. Unit Qi3 is generally correlative with unit 2c of Pearthree and Calvo (1987).

Qi_2 **Intermediate alluvial fan and terrace deposits (Middle Pleistocene)** - Unit Qi2 consists of planar, moderately dissected relict alluvial fans and terraces with strong soil development found throughout the map area. Qi2 surfaces are drained by well-developed, moderately incised tributary channel networks; channels are typically several meters below adjacent Qi2 surfaces. Well-preserved, planar Qi2 surfaces are smooth with scattered pebble and cobble lags; surface color is reddish brown. Rock varnish on surface clasts is typically orange or dark brown. More eroded, rounded Qi2 surfaces are characterized by scattered cobble lags with moderate to strong varnish, broad ridge-like topography and some carbonate litter on the surface. Soils typically contain reddened, clay argillic horizons, with obvious clay skins and subangular to angular blocky structure. Underlying soil carbonate development is typically stage III, with abundant carbonate through at least 1 m of the soil profile; indurated petrocalcic horizons are rare. Qi2 surfaces generally support grasses, bursage, cholla, and small shrubs. Unit Qi2 is correlative with unit 2b of Pearthree and Calvo (1987).

Qo **Old alluvial fan deposits (Early Pleistocene)** - Unit Qo consists of very old, high, dissected alluvial fan remnants with moderately well preserved fan surfaces and variable, locally very strong soil development. Qo deposits and surfaces are extensive and exceptionally well preserved in the southern part of the Madera Canyon fan complex in the southeastern part of the map area. Qo surfaces range from fairly smooth to broadly rounded. Qo deposits consist of cobbles, boulders, and sand and finer clasts. Stage III to IV calcic horizons are typical. Where surfaces are planar and well-preserved, red, heavy clay argillic horizons are typical. Qo surfaces are dominated by grass, small shrubs, and ocotillo. Qo surfaces record the highest levels of aggradation in the Tucson basin and the Santa Cruz Valley, and are probably correlative with other high, remnant surfaces found at various locations throughout southern Arizona (Menges and McFadden, 1981; Helmick, 1986). Unit Qo is correlative with unit 2a of Pearthree and Calvo (1987).

QTa **Very old alluvial fan deposits (Pliocene to Early Pleistocene)** - Unit QTa consists of very old, deeply dissected and highly eroded alluvial fan deposits. Probably includes old river deposits on the lowermost piedmont. Surfaces are alternating eroded ridges and deep valleys, with ridgecrests typically 10 to 30 meters above adjacent active channels. Thicknesses of QTa deposits are generally not known. QTa deposits are drained by deeply incised tributary channel networks, and original highest capping fan surfaces are not preserved. QTa deposits are dominated by gravel ranging from boulders to pebbles. Deposits are moderately indurated and are quite resistant to erosion because of the large clast size and carbonate cementation. Soils typically are dominated by carbonate accumulation, which may be as strong as stage V (cemented petrocalcic horizons with laminar cap) on ridgecrests. Carbonate litter is common on ridgecrests and hillslopes. QTa deposits support creosote, mesquite, palo verde, ocotillo, and cholla.

Axial Stream Deposits

Qy_{cf} **Modern river channel deposits (Holocene)** - This unit consists of river channel deposits of the Santa Cruz River. They are composed primarily of sand and gravel. Along the Santa Cruz River, modern channels are typically entrenched several meters below adjacent young terraces. The current entrenched channel configuration began to evolve with the development of arroyos in the late 1800's, and continued to evolve through this century (Betancourt, 1990; Wood and others, 1999). Channels have variable widths, but modern channels in much of the map area are relatively uniform within artificial dikes. Channels are extremely flood prone and are subject to deep, high velocity in moderate to large flow events. Banks along some portions of the Santa Cruz River have been protected with soil cement, but other reaches are unprotected and are subject to several lateral erosion during floods.

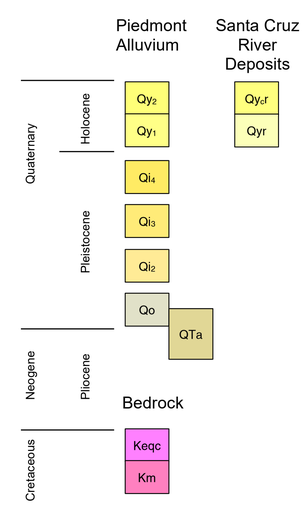
Qyr **Holocene floodplain and terrace deposits(Holocene)** - The Qyr unit consists of floodplains and low terraces flanking the main channel system along the Santa Cruz River. Most Qyr areas along the Santa Cruz River are part of the active floodplain and may be inundated in large floods. Terrace surfaces are flat and uneroded, except immediately adjacent to channels. Qyr deposits consist of weakly to unconsolidated sand, silt, and clay. Soils are weakly developed, with some carbonate filaments and fine masses and weak soil structure in near surface horizons. Locally, Qyr surfaces may experience sheetflooding during large floods in areas where the main channel is not deeply entrenched, and as a result of flooding on local tributaries that debouch onto Qyr surfaces. Unprotected channel banks formed in Qyr deposits are very susceptible to lateral erosion.

Bedrock

Keqc **Elephant Head Quartz Monzonite (Cretaceous)** - Coarse grained quartz monzonite (Drewes, 1971)

Km **Madera Canyon Granodiorite (Cretaceous)** - granodiorite

Correlation of Map Units



SCALE 1:24,000

1 0.5 0 1 Miles

1 0.5 0 1 Kilometers

0 1100 2200 3300 4400 5500 Feet

CONTOUR INTERVAL 40 FEET

TRUE NORTH

MAGNETIC NORTH

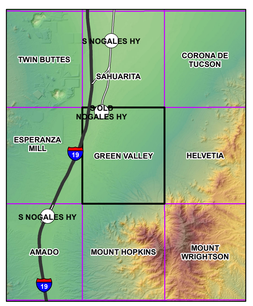
9.4°

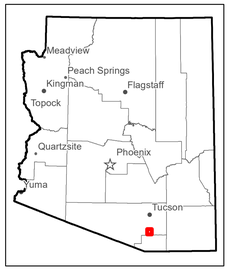
Approximate mean declination, 2019

Topographic base map derived from the Green Valley 7.5' USGS topographic quadrangle map originally with NAD27 datum. Reprojected to UTM NAD83 datum (zone 12) using iGage All Topo

Line Types

- Contact, accurate
- Contact, approximate
- Fault, accurate
- Fault, approximate
- Fault, concealed





Location of map area

Arizona Geological Survey Digital Geologic Map DGM-141
Geologic map of the Green Valley 7 1/2' Quadrangle

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