GEOLOGIC MAP OF THE ARTESIA 7 ½' QUADRANGLE AND THE NORTHEASTERN CORNER OF THE MOUNT GRAHAM 7 ½' QUADRANGLE, GRAHAM COUNTY, ARIZONA

Arizona Geological Survey Digital Geologic Map DGM-106,
Version 1.0
Scale 1:24,000

By
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Introduction

Quaternary geology was mapped in three 7 ½ minute quadrangles in the Safford Basin, Graham County, Arizona: Artesia (Cook), Safford (Cook and Youberg), and Thatcher (Youberg). The geologic mapping is original but informed by previous works in the Gila River Valley (Gootee, 2012; Houser, 1990; Houser et al., 1985, 2004; Lanphere et. al., 2002; Richter et al., 1983). Holocene geomorphic boundaries of the Gila River were based on work by Klawon et al. (2004), and the bedrock geology was derived from Thorman and Naruk (1987). Quaternary faults incorporated in these maps are from the AZGS Quaternary fault database developed by P.A. Pearthree from previous work (Menges and Pearthree, 1983). These geologic maps were funded in part by the USGS National Cooperative Geologic Mapping Program under cooperative agreement number G11AC20455 (awarded for federal fiscal year 2011).

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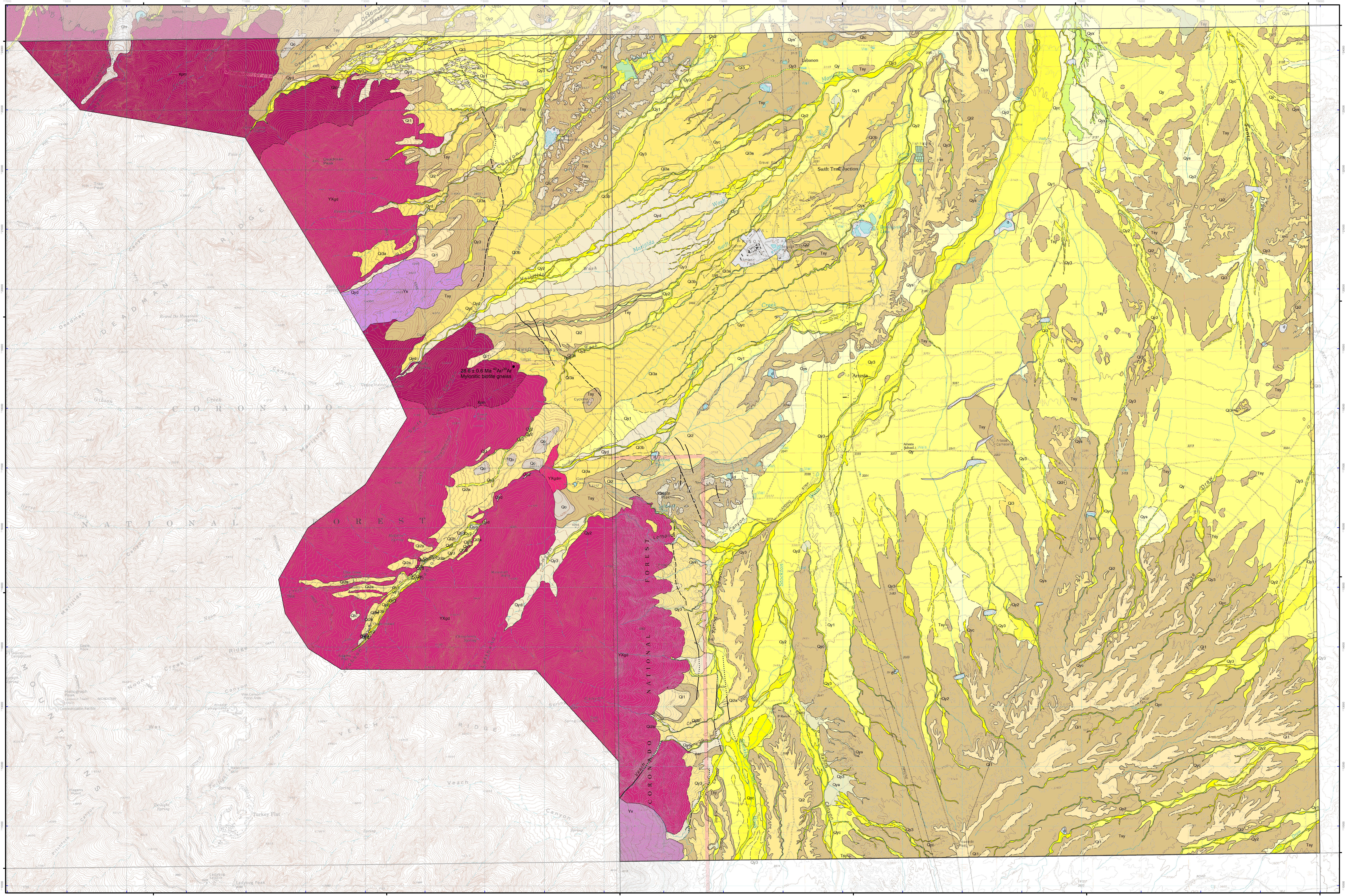


Geologic Map Units

Other units

d **Disturbed ground** - Heavily disturbed or altered ground due to extensive excavation, construction of earth dams, and municipal development.

Qtc **Talus and Colluvium** - Unconsolidated to weakly consolidated, locally derived, very poorly sorted angular rock debris deposited on and at the base of bedrock slopes and on the flanks of high-standing basin fill (Tsy) deposits below coarser alluvial capping sediments. Qtc deposits in the latter setting often stand out in positive relief relative to adjacent more easily eroded Tsy deposits to form colluvial "flatirons".

Piedmont alluvium

Qyc **Active stream channel deposits** - Qyc deposits are composed of unconsolidated, very poorly sorted sand to cobbles in lightly-vegetated piedmont channels. Channels may be flat-bottomed or exhibit bar and swale microtopography with bars composed of coarser sediments. Qyc deposits are generally devoid of vegetation and exhibit no soil development although small shrubs and grasses may be found on slightly elevated in-channel bars. Qyc deposits are lined by cottonwood and oak in near mountain reaches and mesquite, acacia, creosote, and desert broom farther from the mountain front. Qyc deposits commonly become submerged during moderate to extreme flow conditions and can be subject to deep, high velocity flow and lateral bank erosion. Channels are generally incised .25 - 1.5 m (1 - 5 ft) below adjacent Holocene alluvium and may be incised into adjacent Pleistocene alluvium by 2 m (6.5 ft) or more.

Qyx **Active arroyos** - Areas where valley-bottom deposits are being eroded due to arroyo development. Includes flat-bottomed to undulating channels with sand and gravel deposits, and eroded, typically fairly steep slopes. Arroyos are developing almost entirely in relatively fine-grained Holocene deposits, and are up to 3 m (10 ft) deep. Many arroyo areas are too small to depict at the map scale.

Qy3 **Low swales, tributary drainages, and weakly incised channels** - Piedmont alluvium located along active drainages including small channels, adjacent low terraces, or floodplain areas. Qy3 deposits are composed of unconsolidated, unvarnished sand, gravel, and silt deposits. Qy3 deposits may also exhibit significant cobble and boulder accumulations reworked from adjacent Qyd levees and splays. Qy3 drainages are often wider, lower energy, and more heavily vegetated than the Qyc channels they drain into. The gradient of some Qy3 channels draining high standing Tsy deposits may be significantly steeper than similar channels lower in the piedmont yet incision is generally absent or mild. Surface flow likely only occurs after soil saturation has been achieved. In upper piedmont areas Qy3 includes active stream channels where Qyc cannot be broken out at the map scale. Soil development is generally absent or incipient on Qy3 deposits which exhibit pale buff to light brown (10 YR) surface coloration.

Qya **Active alluvial fan deposits** - Low relief splays, fine-grained distributary alluvial fan deposits comprising the active portion of alluvial fans where channel flow becomes unconfined, and steeper depositional cones below abrupt incision at the edge of higher-standing older alluvium. Qya deposits are typically found at the downstream outlet of ephemeral channels and gullies. Qya deposits are extremely prone to flooding and channel migration. Sediments are unconsolidated and consist of very poorly sorted sand to small cobbles. Vegetation on Qya deposits consists of small shrubs, weeds, and cacti.

Qys **Sheetflood deposits and swales, reworked basin fill deposits** - Laterally extensive, unconsolidated fine-grained alluvium in valley bottoms and mantling the lower parts of adjacent slopes. These sediments are light brown to light tan to white in color and consist of sand, silt, clay, and gravel. In valley axes, these deposits are primarily silt and sand beds, and weakly developed buried soils are common. Gravel makes up a small percentage of these deposits and typically gravel beds are thin and discontinuous. Along a few larger washes, thicker and more extensive gravel beds were observed. Qys deposits mantle the toes of slopes formed on eroded basin fill (Tsy) deposits. In these areas, Qys deposits are commonly more gravel-rich and sandy to pebbly calcium carbonate aggregate nodules litter slopes. Occasionally weakly channelized flow occurs but minor gradient changes or vegetation cause aggradation that leads again to sheetflow or infiltration. Surface soil development is weak.

Qe **Eolian sand sheets and dunes** - Vegetation mounds and evidence for eolian deposition and transport are observable throughout the mapped area but some regions are dominated by these processes at the surface. Qe deposits consist of fine sandy dunes within depressions in laterally extensive Qy deposits in the Safford and Artesia quadrangles and vegetation banded eolian depocenters on extensive planar early Pleistocene Gila River deposits north of the Gila River in the Safford, San Jose, and Lone Star Mountain quadrangles. Coppice dunes or nebkhas in the Safford and Artesia quadrangle are topped by creosote, mesquite, and soaptree yucca. The dunes are located in a depression within Qy deposits immediately north of higher standing Tsy deposits. This depression serves as a depositional sink for saltating grains transported by southern winds, leading to dune formation. The extensive Qe deposits on the wide planar Pleistocene Gila River terraces north of the Gila River appear distinctly banded on aerial photos. On the ground these areas are low relief, fine grained sandy deposits with subtle interconnected vegetation mounds or very low relief vegetation mounds. Vegetation is dominated by creosote and grasses. Vegetated mounds are generally less than 15 cm (6 in) high but the increase in roughness on an otherwise planar surface from the interconnected mounds traps eolian grains leading to continued aggradation. Between the vegetation bands the surface is comprised of sand and silt with a discontinuous pebble to small cobble cover. Desiccation cracks are evident in the finer fraction; pebbles are lightly to moderately varnished.

Qy2 **Broad drainages and piedmont terrace deposits** - Qy2 deposits consist of terrace deposits located primarily along the flanks of incised drainages and low-relief terraces inset into Pleistocene age fan deposits. Some Qy2 deposits comprise extensive low relief alluvial fans where unconfined by older piedmont alluvium. These deposits consist of predominantly fine grained unconsolidated to weakly consolidated sediments with sub-rounded to sub-angular pebble to cobble bars on the surface and beds and lenses in cross section. Where inset into older alluvium, Qy2 deposits are planar with remnant bar and swale microtopography. Planar Qy2 terraces are typically elevated from 30 cm - 1.5 m (1 - 5 ft) above active channels. Soil development on Qy2 deposits is minor, characterized by no to incipient stage I-II calcium carbonate accumulation in the form of small filaments and medium brown (10 YR) surface coloration. Vegetation on Qy2 surfaces consists of small shrubs, weeds, bunch grass, yucca, Mormon tea, prickly pear, desert broom, and the occasional cholla. These surfaces are subject to inundation during moderate to extreme flow conditions when channel flow exceeds capacity or due to channel migration on low-relief portions of broad distal fan deposits.

Qy1 **High standing broad piedmont terraces** - Qy1 deposits consist of planar terraces along larger piedmont drainages that are 1 - 2 m (3 - 6 ft) higher in the landscape than adjacent Qy2 terraces. In the Safford and Thatcher quadranges, Qy1 deposits also consist of eroded, remnant alluvial fan deposits on lower piedmont areas. Qy1 deposits are composed of sandy to pebbly swales with coarser unvarnished to very lightly varnished pebble to cobble bars, and partially overlie Pleistocene deposits in some areas. Bar and swale microtopography is somewhat muted by vegetation mounding. Pebbles and cobbles exposed in cross section exhibit stage I-II calcium carbonate accumulation within a medium brown matrix of fine sand to silt. Some reddened clay rich aggregate and calcium carbonate coated clast inclusions have been reworked from older deposits. Qy1 surfaces are generally isolated from flooding associated with the modern drainage system although inundation may be possible during extreme precipitation and runoff events. Vegetation on Qy1 deposits is similar to that found on Qy2 deposits with the addition of creosote, whitethorn and catclaw acacia.

Qy **Alluvium, undivided** - Qy deposits comprise broad, low relief, alluvial landscapes located primarily east of Stockton Wash in the Artesia quadrangle, on the lower piedmont areas of the Thatcher quadrangle, and on lower piedmont areas along Stockton Wash in the Safford quadrangle. These deposits are composed of material reworked from eroded late Tertiary basin fill sediments and associated capping Pleistocene gravels located to the south. Qy deposits are generally fine grained, composed of mostly silt and sand with a thin pebble cover and occasional remnant cobble bar at the surface. Drainages within Qy deposits are unincised to weakly incised (< 10 - 15 cm (4 - 6 in)), and sheetflow across Qy surfaces between channels appears common based on observation of abundant piled flood debris on the upslope side of vegetation and vegetation mounds throughout the mapped area. Vegetation on Qy surfaces consists of whitethorn and catclaw acacia, mesquite, Mormon tea, yucca, small grassy ground cover, shrubs, and cacti.

Qyd **Debris flow deposits** - This unit consists of coarse, very poorly sorted deposits on steep hillslopes and along washes within and proximal to the Pinaleño mountains. Deposits consist primarily of small to very large (diameters > 2 m/6 ft) boulders, cobbles, pebbles and sand. Typically, the coarse deposits form linear levees paralleling small washes or irregularly shaped piles representing debris-flow snouts. Surface boulders and cobbles have minimal to moderate rock varnish suggesting deposit ages of Holocene to latest Pleistocene. This unit also includes areas of erosion (debris-flow scars) on hillslopes that are spatially associated with debris flow deposits. Numerous debris flow deposits comprise much of the deposits south of and along Marijilda Wash and along Jacobson Creek in the Artesia quadrangle, and along all of the major drainages in the Thatcher quadrangle. A USGS stream gage in Marijilda Canyon was destroyed by extreme flooding and debris flow transport in 2004 indicating debris flow activity is ongoing along the Pinaleño mountain front.

Qi3 **Low-intermediate terraces and alluvial fan deposits, undivided** - Broadly planar terrace and fan deposits elevated up to 3 m (10 ft) above adjacent Holocene (Qyc, Qy3, Qyd, and Qys) deposits. Surface soil on Qi3 deposits is mildly reddened (7.5 YR 5/4). Cobbles and boulders dominate Qi3 deposits in cross section where exposed by incised channels or roadcuts. Qi3 deposits proximal to the Pinaleño mountain front are likely partially composed of numerous debris flow deposits. On broad planar Qi3 surfaces farther from the mountain front surface soil is composed of sand, silt, and small pebbles with partially buried cobbles to boulders creating remnant bar and swale microtopography. Some Qi3 deposits appear to overlie highly eroded Tsy deposits and are likely less than several meters thick. Some Qi3 deposits are offset by Quaternary faulting. Faulted Qi3 surfaces are typically offset by a single scarp or narrow fault zone by 1 - 2 m (3 - 6 ft). Vegetation on Qi3 deposits is dominated by creosote but includes prickly pear, barrel, and cholla cactus; bunch grasses, small shrubs, whitethorn and catclaw acacia, mesquite, agave, yucca, and mormon tea. Locally, Qi3 deposits are subdivided into two members with similar morphology that occupy different positions in the landscape.

Qi3b **Low-intermediate terraces and alluvial fan deposits, younger member** - Qi3b deposits closely resemble Qi3a deposits in morphology but occupy slightly lower positions in the landscape.

Qi3a **Low-intermediate terraces and alluvial fan deposits, older member** - Qi3a deposits closely resemble Qi3b deposits in morphology but occupy slightly higher positions in the landscape.

Qi2 **Intermediate-high terrace and remnant alluvial fan deposits, undivided** - Broadly planar to moderately rounded cobble to boulder dominated terrace and fan deposits capping underlying Tsy deposits. Qi2 deposits are elevated up to 45 m (150 ft) above Holocene piedmont deposits near the Pinaleño mountain front and 12 m (40 ft) farther out in the valley. Qi2 deposits commonly cap Tsy basin filling sediments. Broadly planar to gently rounded caps exhibit clay rich reddened (2.5 - 5 YR 4/6) soils with calcium carbonate rinds and matrix between clasts (Stage III) where exposed in cross section. Quaternary faulting has displaced Qi2 deposits by up to 5 m (16 ft) in numerous locations along the mountain front (Menges and Pearthree, 1983). Quaternary fault scarps offsetting middle to late Pleistocene alluvium parallel the north to northwest trend on the east side of the Pinaleño Mountains (Houser et al., 2004). Middle Pleistocene (Qi2) deposits are offset by more faulting events than younger late Pleistocene (Qi3) deposits. Often, Qi2 deposits are offset by multiple fault scarps within a short distance (less than 300 m (1000 ft)) while Qi3 surfaces are offset by fewer scarps or a single scarp. Nearby Holocene deposits are not noticeably offset but a vegetation trace across these deposits between offset Pleistocene fan remnants can sometimes be observed in aerial photos. In some areas where the contact between Qi2 and underlying Tsy deposits is exposed, an erosional unconformity is evident. Vegetation on Qi2 deposits is similar to that found on Qi3 deposits although creosote is less abundant and more widely spaced. Vegetation includes prickly pear, barrel, and cholla cactus; bunch grasses, small shrubs, whitethorn and catclaw acacia, mesquite, agave, yucca, mormon tea, and ocotillo near carbonate-rich eroded edges. Locally, Qi2 deposits are subdivided into two members with similar morphology that occupy different positions in the landscape.

Qi2b **Intermediate-high terraces and alluvial fan deposits, younger member** - Qi2b deposits closely resemble Qi2a deposits in morphology but occupy slightly lower positions in the landscape.

Qi2a **Intermediate-high terraces and alluvial fan deposits, older member** - Qi2a deposits closely resemble Qi2b deposits in morphology but occupy slightly higher positions in the landscape.

Qi1 **High standing relict alluvial fan remnants** - Qi1 deposits are relict alluvial fan remnants overlying Tsy sediments or bedrock that stand higher in the landscape than Qi2 and younger deposits. Qi1 surfaces are planar to well rounded near eroded edges. Where extensively preserved, Qi1 deposits exhibit deeply incised mature tributary drainage networks and clay rich, reddened (2.5 - 5YR 3/6) soils. Qi1 deposits commonly cap and preserve underlying finer grained Tsy deposits. Coarse cobble to boulder lag derived from erosion of the Qi1 cap also covers the flanks of underlying Tsy deposits, shielding them from erosion. Vegetation on Qi1 deposits consists of mesquite, grasses, small shrubs, prickly pear, barrel, creosote, agave, ocotillo, and oak near incised drainages.

Qo **Alluvial fan deposits** - Early Pleistocene alluvial fan deposits, undivided. these are the highest fan surfaces in the Safford basin, and were mapped only in the Thatcher quadrangle. Frye Mesa is the most extensively preserved Qo surface. The remanat Qo surface on Frye Mesa is planar with well rounded, eroded edges. Other smaller remnant Qo surfaces are well rounded. All Qo surfaces are found near the mountain front capping coarse (Tcs) to finer-grained (Tsf) basin fill deposits (Tsy). Where preserved, Qo deposits exhibit deeply incised mature tributary drainage networks and clay rich, reddened (2.5 YR 3/6) soils. Coarse cobble to boulder lag derived from erosion of the Qo cap also covers the flanks of underlying Tsy deposits, shielding them from erosion. Vegetation on Qo deposits consists of mesquite, grasses, small shrubs, prickly pear, barrel, creosote, and agave.

Basin fill alluvium

Tsy **Basin Fill Deposits, undivided** - Weakly to moderately consolidated silt, clay, sand, and gravel deposited in basins during and after late Cenozoic faulting. Tsy deposits are generally light to medium brown to tan (7.5 YR 6/4) in color. They commonly form high rounded hills and ridges in modern basins, and locally form prominent bluffs when overlain by more consolidated, erosion resistant deposits (unit Qi2r, Qi2, Qi1, and others). Where uncapped, these deposits form gently rolling, low relief hills throughout the map area, with broadly dissected by tributary drainage networks (unit Qy3, Qyx, and Qys). Exposures are generally poor, but locally a sand to silt member is subdivided (Tsf), as is a coarser, silt to boulders, alluvial fan compent adjacent to the mountain front. Everywhere else, broadly rounded basin fill hills and swales were mapped as unit Tsy. Vegetation on Tsy deposits ranges from bunch grass ground cover, small shrubs, acacia, desert broom, and mesquite in lowlands to yucca, prickly pear, barrel, larger mesquite, oak, and agave on high standing Tsy deposits. Tsy deposits were subdivided into 111 Ranch and Bear Springs Wash deposits based on provenance by Houser, 1990. These deposits are interfingering and include sediments from both the Pinaleño Mountains and Bonita Creek prior to the establishment of a through-flowing Gila River around 2 Ma. The 111 Ranch and Bear Springs Wash beds record a time when the Safford Basin was closed and Tertiary Lake Graham existed. For the purposes of this map we group these members together as Tsy deposits.

Bedrock

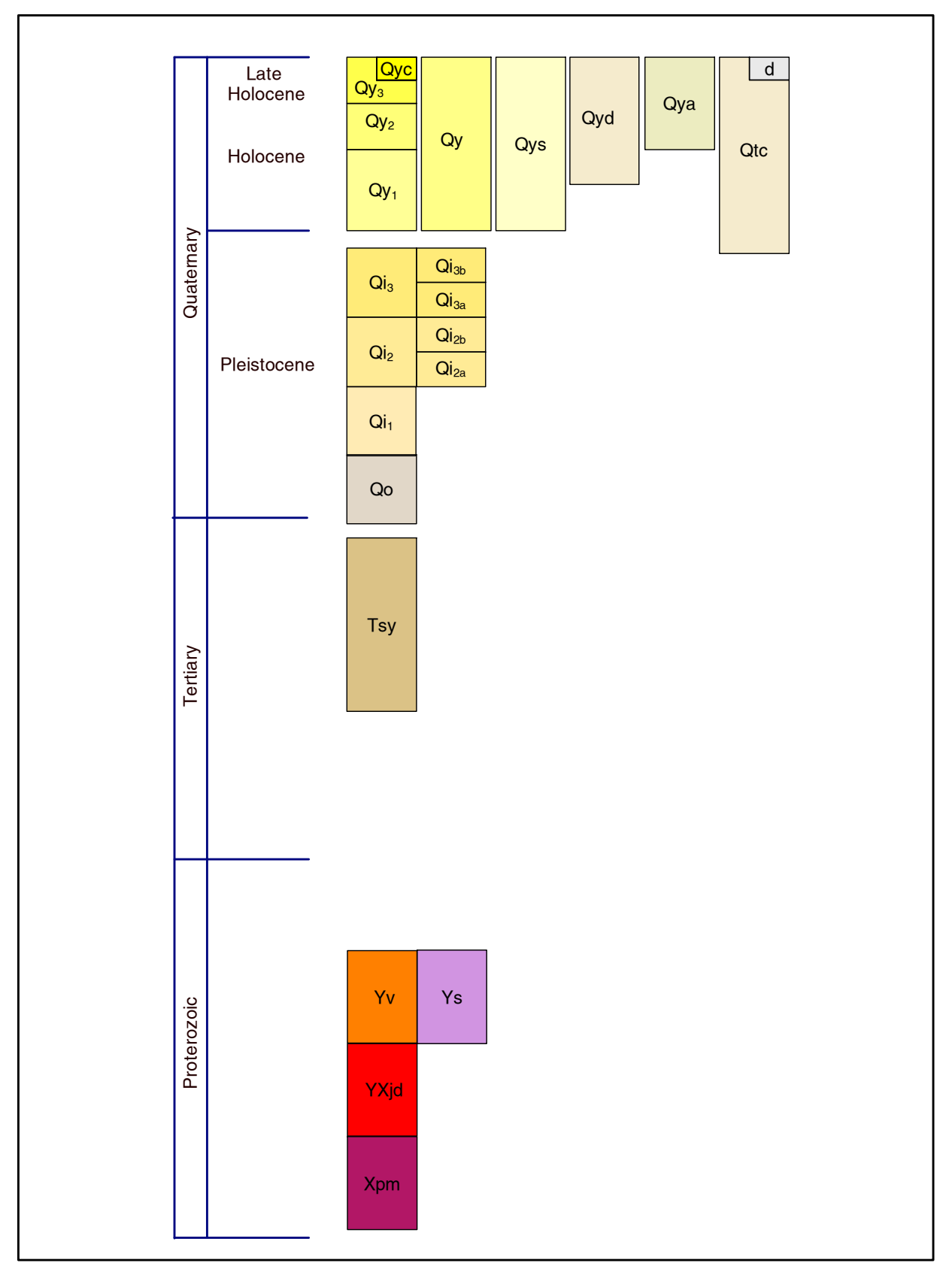
Ys **Slick Rock granite** - Medium-grained, two mica granite, crosscuts foliation of Pinaleno Mountains gneiss. From Thorman and Naruk, 1987.

Yv **Veach Ridge granite** - Biotite granite. Massive to weakly foliated pluton that crosscuts foliation of the Pinaleno Mountain gneiss. From Thorman and Naruk, 1987.

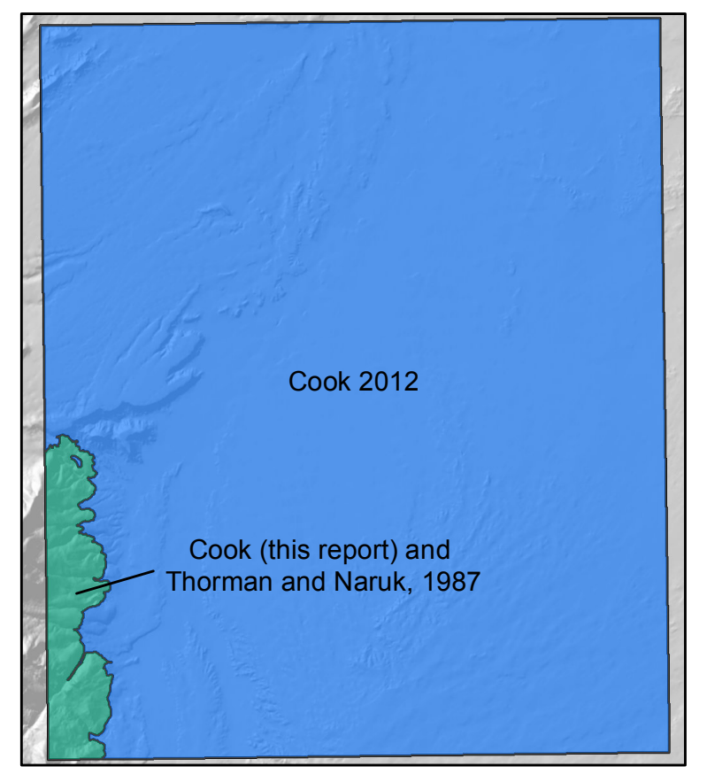
YXgd **John's Dam gneiss** - Intercalated granitic gneiss and gneiss of the Pinaleno Mountains. From Thorman and Naruk, 1987.

Xpm **Gneiss of Pinaleno Mountains** - Compositionally layered felsic, leucocratic gneiss and minor amphiblite that underlies most of the Pinaleno Mountains and is hte oldest unit in the range. From Thorman and Naruk, 1987.

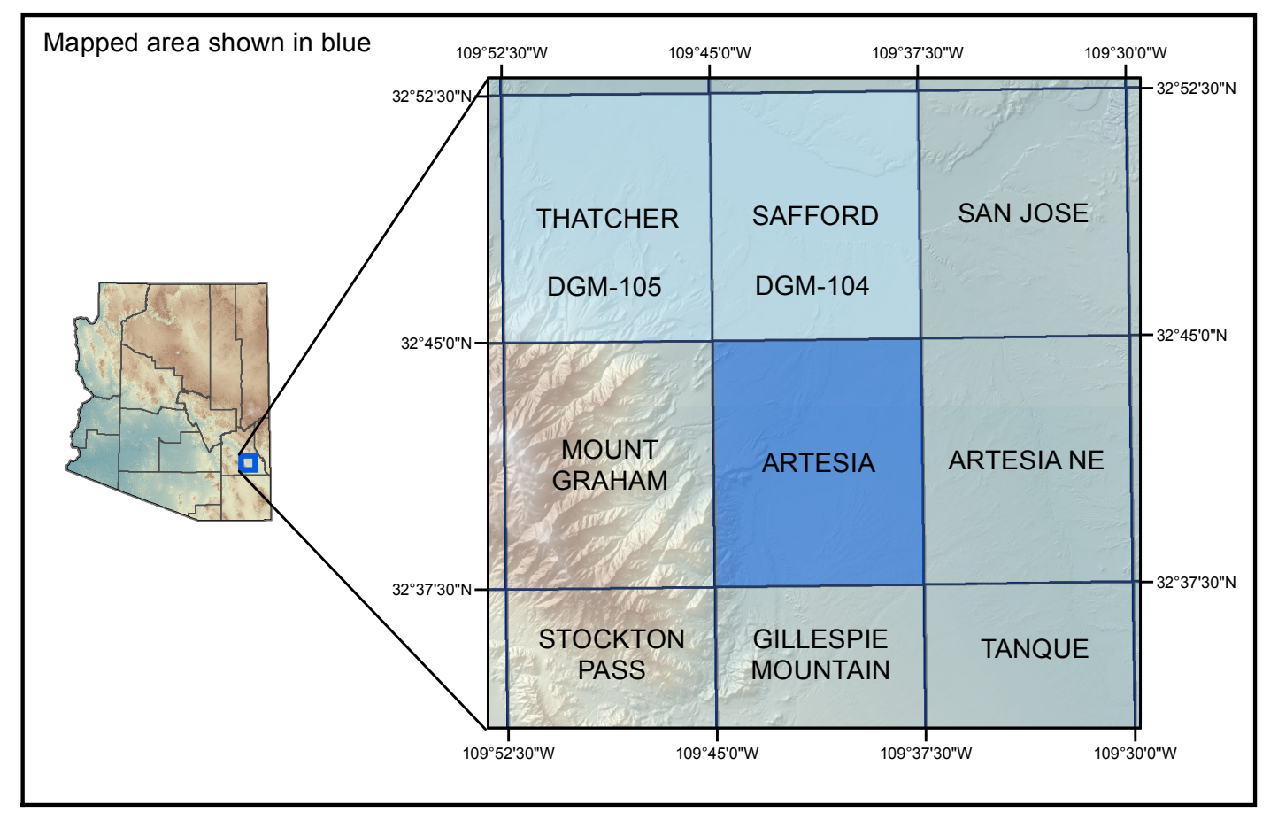
Map Unit Correlation Diagram



Mapping Responsibility



Location Map



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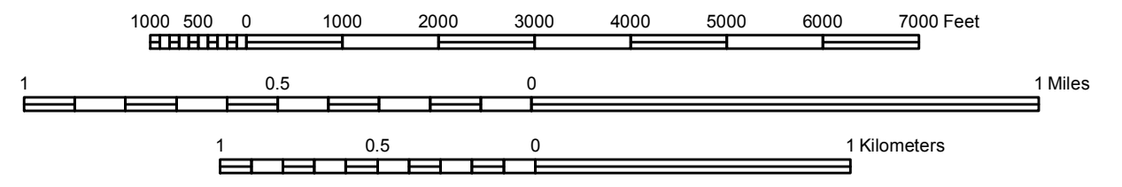

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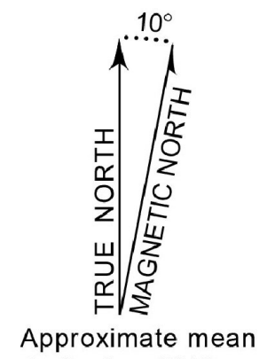
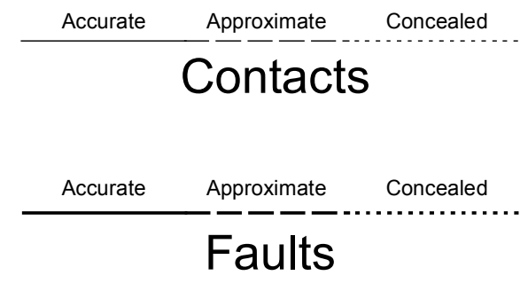


Approximate mean declination, 2013



Topographic base from USGS 1:24,000 Quadrangle Series; generated using iGage All Topo Pro software
Contour interval: 10 feet (low relief areas), 40 feet (high relief areas)

Projection: UTM Zone 12N
Datum: NAD83

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