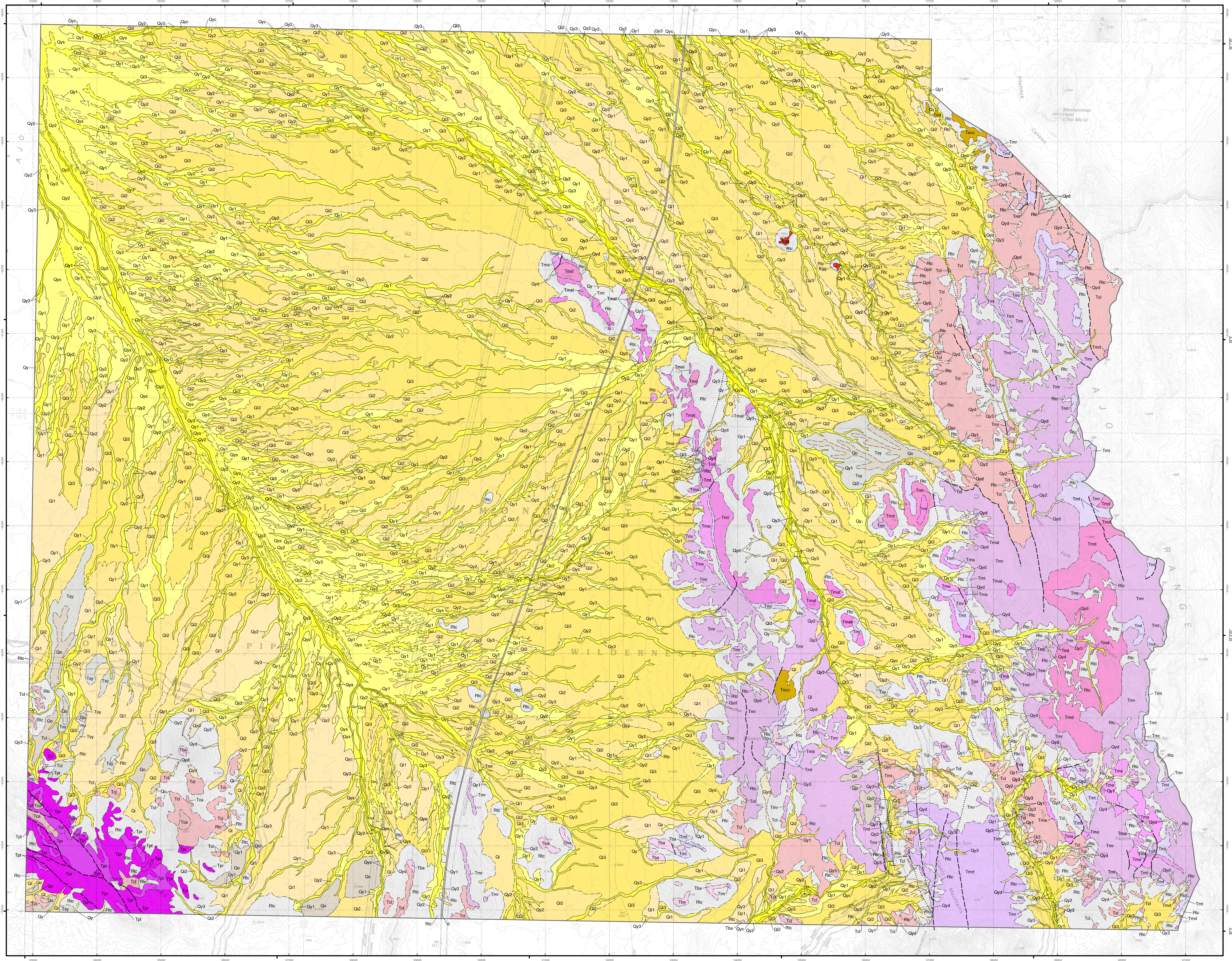

Projection Information:
North American Datum of 1983.
1000-meter Universal Transverse Mercator grid tics, zone 12, shown in blue.

Topographic base from USGS 1:24,000 Quadrangle Series.
Seamless basemap generated using iGage All Topo Pro software.
Hillshade generated from NED 10m Digital Elevation Model.

MN 10.8°
2011 MAGNETIC NORTH DECLINATION

SCALE 1:24 000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER
CONTOUR INTERVAL 20 FEET

GEOLOGIC MAP OF THE TILLOTSON PEAK 7 ½'QUADRANGLE AND PART OF THE MOUNT AJO 7 ½' QUADRANGLE, ORGAN PIPE CACTUS NATIONAL MONUMENT, PIMA COUNTY, ARIZONA

Arizona Geological Survey Digital Geologic Map DGM-73

By
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Pima County, Arizona: Arizona Geological Survey Digital Geologic Map DGM-73, version 1.0, scale 1:24,000.

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Introduction

This geologic map covers the southern part of the Valley of the Ajo and the western flank of the Ajo Mountains, within Organ Pipe Cactus National Monument in southwestern Arizona. The map depicts the late Cenozoic surficial deposits in the valleys and the middle Cenozoic volcanic rocks that are predominant in the mountains. Production of this new geologic map is the product of a cooperative research agreement between the National Park Service and the Arizona Geological Survey, and was funded primarily by the National Park Service. All surficial geologic mapping is new for this project. Bedrock geology is modified from Skinner et al (2008) and Gray et al (1985). Mapping was compiled digitally using ESRI ArcGIS software, over a digital orthophoto base (National Agricultural Imagery Program, 2007).

Organ Pipe Cactus National Monument is located in the Basin and Range Province of southwestern Arizona, on the U.S. – Mexico border. Most of the area covered by this map is underlain by late Cenozoic, valley-filling clastic sedimentary deposits that are as much as 1600 feet thick in the northern part of the map area (Richard et al., 2007). These consist mostly of sandstone and conglomerate in alluvial fans that flank the valley and fine-grained deposits in the valley axis. The valley is covered by relatively thin surficial deposits ranging in age from late Pliocene to modern. The Valley of the Ajo is part of the Gila River drainage and has undergone very little incision during the Quaternary, and thus the valley topography is relatively smooth. In general, upper piedmont areas are dominated by moderately coarse, incised Pleistocene alluvial fan deposits; young, relatively fine-grained deposits are prevalent on the lower piedmonts and along Cherioni Wash. Extensive, complex distributary drainage systems in middle piedmont areas are outlined by the extent of late Holocene deposits. In these areas, this geologic map indicates areas of potential flood hazards due to complex flow paths and widespread sheetflooding. Small areas in the extreme southern portions of the map that drain south to the Rio Sonoyta are much more deeply dissected. This reflects the gradual northward migration of the drainage divide through drainage capture during the Quaternary.

Bedrock of the map area is dominated by suites of Miocene volcanics and associated volcaniclastic rocks, with limited exposures of Cretaceous granitic rocks. Miocene volcanics were erupted as part of the Oligo-Miocene volcanism that swept across Arizona from east to west, and are predominantly felsic to intermediate lavas, dikes and pyroclastic rocks with associated breccia and conglomerate. These units are faulted and moderately tilted. The youngest volcanic rocks in the map area are basaltic andesites, which cap Tillotson Peak and are exposed in low hills in the southern part of the Valley of the Ajo. Resistant layers within several of the volcanic units form the prominent cliffs of the Ajo Range, but much more erodible volcanic units are also widespread in the mountain and adjacent hills and ridges. These erodible units commonly are covered by colluvium or talus derived from upslope, or in situ weathered regolith.

References

Gray, F., Miller, R.J., Peterson, D.W., May, D.J., Tosdal, R.M, Kahle, K., 1985, Geologic map of the Growler Mountains, Pima and Maricopa Counties, Arizona: U.S. Geological Survey, MF-1681, 1:62,500 scale.

Richard, S.M., Shipman, T.C., Greene, L.C., and Harris, R.C., 2007, Estimated Depth to Bedrock in Arizona, v 1.0: Arizona Geological Survey Digital Geologic Map DGM 52, 9 p. text, scale 1:1,000,000.

Skinner, L.A., Haxel, G., and Umhoefer, P.J., 2008, Geological Reconnaissance at Organ Pipe Cactus National Monument, Arizona: Northern Arizona University, Unpublished Digital Data, 1:24000 scale.

Map Unit Descriptions

Piedmont deposits

Qyc — **Active channel deposits** - Deposits in active, open channels of washes that are large enough to depict at the map scale. This unit is composed of moderately-sorted sand and silt, with common pebbles and some cobbles in the lower piedmont areas, to poorly-sorted sand, pebbles, cobbles and boulders in the upper piedmont areas. Channels are incised less than 2 m below adjacent late Holocene terraces and alluvial fans. Channel morphologies generally consist of a single-thread, deep, high-flow channel or multi-threaded, shallow, low-flow channels with adjacent gravel bars. There is no soil development in these deposits.

Qyx — **Areas of active arroyo development** - Areas of fine-grained deposits undergoing erosion due to arroyo development. Includes flat-bottomed, steep-sided channels with sand and fine-gravel deposits, and eroded slopes; also includes some areas between gullies where remnants of the pre-incision deposits are preserved. Arroyos are generally developing in Qys or Qy3 deposits.

Qy3 — **Smaller active channels, bars, and low terraces** - Deposits associated with active channels, and bars and low terraces along washes and adjacent, recently active sheetflood areas. In upper piedmont areas, channel sediment is generally poorly-sorted to very poorly-sorted sand and pebbles, but may include cobbles and boulders. Terrace surfaces commonly are mantled with silt, sand, and gravel. On lower piedmont areas, young deposits consist predominantly of moderately-sorted silt, sand, and fine gravel, including some pebbles and cobbles in channels. Channels typically 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 single, moderately deep high-flow channel or multi-threaded, shallow, low-flow channels with adjacent gravel bars and finer floodplain deposits. Terraces and sheetflood areas commonly have planar to gently undulating surfaces and are covered primarily with fine-grained deposits with minor gravel concentrations. Soil development is minimal.

Qy2 — **Young terrace deposits** - Deposits found on floodplains and low terraces adjacent to active channels, or drainageways that receive occasional inundation. On middle and lower piedmonts, deposits typically consist of sand, silt, and clay, with local channel gravel deposits. On upper piedmonts, deposits typically consist of sand to small boulders capped with sand and finer deposits on terraces and other areas subject to overbank flooding. Qy2 surfaces are gently undulating where fine-grained, but have up to 1 m of local topography between gravel bars and adjacent, finer-grained swales. Surfaces typically are light brown to gray in color, and surface gravel has very weak to no desert varnish. Soil development associated with Qy2 deposits is weak with no clay accumulation and minimal to stage I carbonate accumulation.

Qys — **Young sheetflood deposits** - Laterally extensive sand and silt with minor fine gravel and clay deposits. Soil development is weak to none. Channels or swales are small, uninicised or minimally incised, and discontinuous. Vegetation consists of creosote and other small bushes, with some small trees locally along swales.

Qy1 — **Young terrace and alluvial fan deposits** - Terrace and alluvial fan deposits with weak but evident soil development. Qy1 deposits are generally poorly sorted sand, pebbles, cobbles, silt and boulders. Qy1 surfaces are typically 0.5 to 3 m higher than adjacent younger surfaces. Qy1 surfaces are generally planar where fine-grained, but undulate between coarse gravel bars and adjacent swales in the middle and upper piedmont, with local surface relief up to 1 m. Surfaces typically are mantled with a loose to moderately packed, moderately varnished pebble lag. Surface color is brown to slightly reddened (10 to 7.5 YR), and is darker than fresh fluvial deposits of younger units. Carbonate is present throughout the soil profile, but in some exposures gravel coatings are thin but continuous at about 0.5 m depth (stage II).

Qyd — **Young debris flow deposits** - Coarse, very poorly sorted deposits on steep hillslopes and along some washes within and near the mountains. Deposits consist primarily of small to medium 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. This unit also includes areas of erosion (debris flow scars) on hillslopes that are spatially associated with debris flow deposits.

Qy — **Holocene deposits, undivided** - This unit is mapped where it is not feasible to subdivide Holocene alluvium at 1:24,000 scale. It probably includes mainly Qy2 and Qy1 deposits.

Qi3 — **Younger intermediate alluvial fan and terrace deposits** - Weakly to moderately dissected alluvial fan and terrace deposits with moderate soil and desert pavement development. Deposits consist of poorly sorted cobbles, pebbles, and sand, with lesser amounts of silt, clay and boulders. Qi3 surfaces typically are planar but relict gravel bars are evident and stand slightly higher than surrounding surfaces. Surfaces commonly are covered with loose to moderately packed desert pavements with weak to moderate varnish. Soils are slightly reddened (7.5YR) but clay accumulation is minimal (cambic horizons); underlying calcic horizons include thin to moderately thick, discontinuous to continuous carbonate coatings on gravel and soft carbonate nodules (stage II to III). Some Qi3 soils are not reddened and may represent a somewhat younger set of deposits that were not mapped separately. Qi3 surfaces are generally less than a few meters above active channels, but near the mountains may be as much as 10 m higher than active channels..

Qi2 — **Intermediate alluvial fan deposits** - Moderately dissected alluvial fan and terrace deposits with moderate to strong soil development and strong but variable desert pavement development. Deposits typically consist of poorly sorted cobbles, pebbles, and sand, with lesser amounts of silt, clay and small to medium boulders. Well-preserved planar Qi2 surfaces typically have well-varnished, tight pebble and cobble pavements, although areas without desert pavements are common. Surface carbonate fragments from underlying soil horizons are uncommon. Soils are reddish brown to brown (5 to 7.5YR), with obvious clay accumulation in strong cambic or weak argillic horizons up to 0.5 m thick. Calcic horizon development ranges from carbonate nodules, thick gravel coatings (stage III), and weakly cemented petrocalcic horizons with incipient laminar horizons (stage IV). Near the mountains Qi2 deposits are dominated by cobbles and boulders, and surfaces may be up to 5 m above active channels. On the lower piedmont, deposits are sandy with substantial gravel, locally including small boulders, and surfaces are typically less than 2 m above active channels.

Qi — **Intermediate deposits, undivided** - This unit is mapped in mountain valleys and on the fringes of bedrock ridges where it was not feasible to subdivide Pleistocene alluvial surfaces. It includes elements of Qi2 and Qi3, but probably not Qi1.

Qi1 — **Older intermediate alluvial fan deposits** - Moderately to deeply dissected relict alluvial fans with strong calcic horizon development. Deposits are poorly sorted, containing cobbles, pebbles, sand and boulders with minor silt and clay. Landforms are moderately to deeply eroded, and typically form gently rounded ridges with relatively limited planar remnants approximating the original fan surface. Carbonate fragments derived from underlying petrocalcic horizons are common on surfaces, giving them a light color on the ground and on aerial photographs. Active channels are incised up to 10 m below these surfaces. Soils are brown to yellowish red (7.5 to 5YR), with weakly to moderately cemented petrocalcic horizon development and some laminar carbonate (stage IV to V).

Qo — **Old alluvial fan deposits** - High-standing, deeply dissected relict alluvial fans with strong but variable calcic horizon development. Qo fan surfaces are preserved only near the mountains. Deposits are very poorly to poorly sorted gravel and sand. Some surface cobbles and boulders are darkly varnished, but varnish is variable due to rock weathering. Fragments from underlying petrocalcic horizons are common, giving the surface a very light color on the ground and on aerial photographs. Soils substantially eroded but are very calcareous with cemented petrocalcic horizons and laminar carbonate layers are exposed at the surface in some areas (stage IV to V).

Tsy — **Very old alluvial fan deposits** - Weakly to moderately indurated, interbedded conglomerate and sandstone, and very poorly sorted, weakly bedded conglomerates and breccias. Deposits are very calcareous and are cemented by calcium carbonate and possibly silica. The color of this unit typically is grayish or reddish, depending on clast lithologies. This unit is exposed primarily in or near the mountains, but is also exposed beneath thin surficial deposits at many localities in the middle and upper piedmont.

Bedrock

Rtc — **Hillslope deposits and regolith** - This unit includes several different types of weathered bedrock, including granite, Oligo-Miocene felsic volcanic rocks and associated volcanoclastic sediments, and basalt. It also includes extensive areas of locally derived hillslope colluvium and coarse boulder and cobble talus.

Tba — **Basaltic andesite flows and flow breccias** - Porphyritic, medium-gray to black basaltic andesite with reddish, oxidized flow margins. Individual flows are approximately 2-10 m thick and are usually separated by an oxidized basal flow breccia and a vesicular, glassy upper margin; minor lenses of pyroclastic rocks occur between flows and at the basal contact of the unit; thick soil horizons exist between some flows. Phenocrysts compose about 5 to 15% of the rock and consist of subhedral olivine (0.5-2.5 mm), partially- or completely-altered to iddingsite (prominent in hand specimen), minor euhedral to subhedral plagioclase, twinned clinopyroxene, and rare orthopyroxene. A glomeroporphyritic texture is common. The groundmass is pilotaxitic to intergranular composed of plagioclase feldspar, clinopyroxene, magnetite, and occasional, slightly devitrified brown glass. Basaltic andesite is the youngest bedrock unit in the Growler Mountains and forms minor dikes observed intruding all other units; whole-rock K-Ar ages of 14.4±0.7 Ma (Miller, written comm., 1981) and 15±2.2 Ma (Eberly and Stanley, 1978) have been determined for samples collected at or near the exposed top of this unit.

Tmat — **Ash-flow tuff** - Brown to orange, poorly- to densely-welded. Vapor-phase recrystallization and devitrification is variable. Composed of angular basalt and andesite lithic fragments (< 3 cm, locally as much as 15 cm across). Unconformably overlies varyingly zeolitized tuff (Tmt) near Tillotson Peak.

Tmr — **Rhyolite, rhyodacite, and minor dacite flows** - Fresh surfaces are red, purple, brown, gray, or black. Weathered surfaces are tan, brown, or maroon and may be stained with manganese. Rhyolite flows are short and stubby, and in places can be traced to domes. Dacite flows are thin and sheet-like. Flow margins are locally zeolitized. Flow banding occurs on all scales and is commonly contorted; more mafic compositions exhibit microscopic fluxion-banding in the groundmass. Flow textures range from aphyric to moderately porphyritic. Phenocrysts are subhedral to euhedral and commonly fragmental. Phenocryst composition includes common plagioclase and biotite, less common augite, diopsidic augite, oxyhornblende, sanidine, and primary bi-pyramidal quartz (plagioclase and quartz comprise ~30% of some rhyodacites and dacites). Biotite is ubiquitous, partially oxidized, and locally rimmed by augite and quartz. The groundmass is vitrophyric to hyalopilitic. In glassy rocks, matrix is black or gray perlitic glass-bearing lath-shaped crystallites and tan to brown spherulites. Where strongly recrystallized or felsitic, the groundmass consists of interlocking quartz, alkali feldspar, and magnetite (commonly altered to brown limonite). Forms massive, nearly vertical cliffs, steep slopes, flat benches, and ledge. Flows from this member have K- Ar ages on biotite ranging from 17.1-15.9 Ma (Tosdal, unpub. data, 1983) and 17.4 Ma on whole-rock samples (Shafiqullah et al., 1980).

Tmt — **Tuff and tuff breccia** - Buff, yellow, greenish, and white crystal-vitric and lithic-lapilli tuff, tuff-breccia, agglomerate, and tuffaceous sandstone. Individual beds range from < 5 cm to 5 m thick. Forms continuous horizons or lenses within rhyolite flows (Tmr). Massive or stratified with well-developed internal stratification and cross-bedding; may be complexly contorted or folded by younger or contemporaneous rhyolite flows. Composed of fragmented phenocrysts and angular lithic fragments in a matrix of pumice lapilli and glass shards. Phenocrysts of strongly embayed plagioclase and quartz are common. Feldspar has bleb-like inclusions of diopsidic augite, augite, brown glass, and apatite prisms. Pumice fragments and shards are partly devitrified or varyingly recrystallized to quartz, alkali feldspar, iron oxides, and ubiquitous brown clay minerals. Diagenetic zeolite alteration is common.

Tmrt — **Felsic volcanic rocks, undivided** - Rhyolite, rhyodacite, tuff, tuff breccia, and minor dacite, undivided, because detailed mapping appears to be suspect.

Tma — **Andesite** - Red-brown, gray, black, or purple augite andesite flows, lahars, tuff breccias, agglomerate, and minor black hypersthene-hornblende andesite flows. **Andesite** may be layered: white rhyolite tuff-breccia succeeded upward by red-brown, partially-oxidized andesite lava, dense, black andesite vitrophyre, and then gray, platy andesite. **Andesite** contains phenocrysts or microphenocrysts of subhedral to fragmental augite and weakly-zoned plagioclase. Groundmass is hyalopilitic, with moderately-oriented plagioclase microlites, sparse clinopyroxene, magnetite, and glass. Hypersthene-hornblende andesite flows are composed of subhedral to euhedral phenocrysts of hypersthene, hornblende, and plagioclase in brown glassy matrix. Unconformably overlies Childs Latite (Tcl) or is interbedded with rhyolite (Tmr). Likely contemporaneous with dacite flows (Tmd).

Tmb — **Porphyritic basalt** - Fine-grained, holocrystalline, weakly porphyritic basalt that weathers red. Phenocryst composition includes olivine (generally iddingsitized) and plagioclase (normally-zoned from labradorite to andesine) in a pilotaxitic groundmass of plagioclase microlites, clinopyroxene, olivine, and Fe-Ti oxides. Unit occurs as a single flow intercalated with tuff (Tmt).

Tmd — **Dacite** - Brown, gray, and black porphyritic dacite flows interbedded with rhyolite (Tmr); locally includes sparse yellow tuff-breccia (Tmt). Phenocrysts of subhedral to euhedral or fragmental plagioclase, augite, and sparse hypersthene, hornblende, and biotite. Mafic phenocryst mineralogy varies between flows. Brown clay minerals are locally pervasive and commonly surround oxidized mafic phenocrysts. Groundmass is composed of flow-banded crystallites. Flattened red-brown pumice may be present. Although generally fissile and friable, exposures locally form distinct prominences, such as the reddish-brown ledges and cliffs in the Ajo Range.

Tsvu — **Sedimentary and volcanic rocks** - Complex mixture of poorly-stratified, semi-consolidated red conglomerate, breccias, brown, fluvial conglomerate, sandstone, and minor gray and yellow tuff. Conglomerate (20- to 100-m-thick) is composed of moderately- to poorly-indurated, crudely-bedded, poorly-sorted debris flows and fluvial gravel. Conglomeratic clasts (pebble- to boulder-size) are angular to subrounded and are derived from Miocene volcanic rocks: Childs Latite (Tcl) (dominant), basalt, andesite, and rhyolite. The matrix is brown, pebbly, moderately-sorted and generally ranges from tuffaceous mudstone to sandstone. The unit unconformably overlies Childs Latite (Tcl) and underlies or is locally interbedded with rhyolite.

Tcl — **Latite** - Augite latite flows, flow breccia, flow agglomerate, minor hypabyssal, and more silicic tuffaceous rocks characterized by megacrystic plagioclase phenocrysts. Fresh surfaces are gray to black, or maroon in iron-oxide stained; weathered surfaces are tan, brown, or purple. Stratigraphically lower flows are thicker, more massive, and less weathered, whereas higher flows are typically thinner and more oxidized. Although flow sequences can vary rapidly in texture and appearance over short vertical and lateral distances, lower flows are typically darker and tend toward blue or gray hues, whereas higher in the section red or brown hues are common. Individual flows are evenly bedded, vesicular to (less commonly) massive and dense, and generally lack internal flow features. Outcrops are typically craggy to blocky. K-Ar isotopic dates from rocks above and below this unit indicate that it was deposited over a very short time in the Early Miocene (~18 Ma) (Tosdal and Miller, unpub. data, 1983).

Tca — **Augite andesite** - **Augite andesite** flows and flow breccia interbedded with Childs Latite (Tcl). Laterally discontinuous, individually 5- to 15-m-thick. Lighter colored and notably less porphyritic than surrounding Childs Latite flows. Fresh surfaces are generally weathered gray to mottled tan, brown, gray, and maroon. Flows are generally massive and display local weak flow-banding, vesiculated tops, and brecciated bases, with minor autobrecciated and scoriaceous flows. Flow sequences typically rest on a thin (<2-m-thick) poorly-sorted, pebble- to cobble-size conglomerate composed exclusively of Childs Latite (Tcl) clasts.
Flows are porphyro-aphanitic with < 2-cm-long phenocrysts comprising 15% of rock. Most abundant phenocrysts are euhedral laths of zoned plagioclase (labrodorite) and subhedral to euhedral, usually glomeroporphyritic, augite. Oxyhornblende and biotite (partially to completely oxidized to magnetite and hematite) are minor constituents, and euhedral apatite is an accessory phase. Pilotaxitic groundmass consists of plagioclase microlites, clinopyroxene, disseminated magnetite, hematite, and interstitial cryptofelsite. Vesicles and microveinlets are lined or filled with calcite or cristobalite and tridymite.

Tpr — **Biotite rhyolite domes, flows, agglomerates, and tuffs** - Gray domes characterized by a massive interior and contorted flow banding along the margins. Commonly porphyritic with phenocrysts of subhedral red-brown biotite, euhedral sanidine, solitary or glomeroporphyritic plagioclase (commonly enclosing euhedral apatite or sphene), and quartz. Groundmass is composed of devitrified glass and spherulites. Agglomerate is composed of monolithologic angular to subangular cognate clasts in a gray, tuffaceous matrix, is poorly-sorted, and forms a carapace along flow and dome margins. Associated tuffs are lenticular and discontinuous. K-Ar sanidine dates yielded an age of 18.7 ± 0.5 Ma (Gray et al., 1984).

Tpt — **Lithic lapilli tuff** - White to yellowish-green, poorly-sorted massive to well-bedded, commonly cross-bedded. Individual beds are 1cm- to 1-m-thick. Composed of fragmental plagioclase and biotite phenocrysts, subrounded lithic fragments of augite andesite (Tpa), and pumice lapilli (<1-cm-long) in a vitroclastic matrix. Matrix and lapilli composed of devitrified to brown clay minerals, yellowish-green celadonite (?), and zeolite (?) minerals.

Kgg — **Granodiorite** - Gray to pinkish-gray or tan, medium-grained, hypidiomorphic-granular or porphyritic hornblende-biotite granodiorite, with subordinate biotite leucogranodiorite, biotite granite, and aplite. **Granodiorite** commonly exhibits microscopic recrystallization and deformation textures and contains phenocrysts of orthoclase/microcline or oligoclase. Phenocrysts include alkali feldspar, plagioclase, quartz, epidote, white mica, biotite, and hornblende. Alkali feldspar is pinkish-white, microperthitic, and varyingly altered to clay minerals. Plagioclase is white and commonly altered to white mica and epidote. Quartz is anhedral and interstitial, usually strained, and locally recrystallized near crosscutting veins. Biotite is locally kinked and varyingly altered to limonite or (less commonly) to chlorite, sphene, and white mica. Sparse euhedral hornblende is altered to limonite. Accessory minerals include sphene, apatite, and zircon. U-Pb ages from zircon indicate a late Cretaceous age (Tosdal, unpub. data, 1985) for the granodiorite (~67 Ma).

d — **Disturbed areas** - This unit depicts areas that have been profoundly disturbed by human activity and underlying geologic units cannot be observed. Mapped mostly along State Route 85. Distrubed areas include charcos, Highway 85 and dirt roads that significantly alter geologic units.

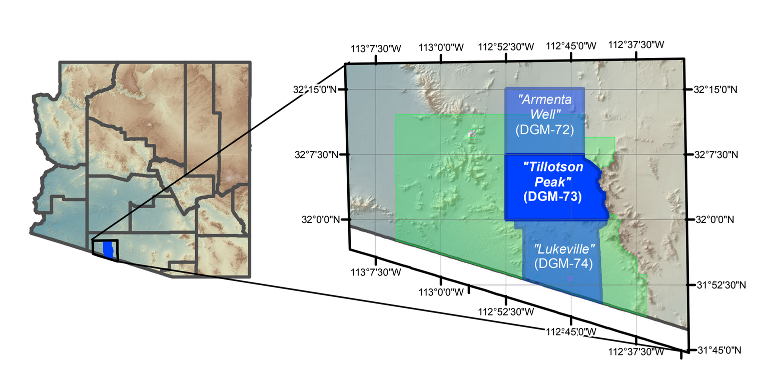
Line Symbol Descriptions

- contact, accurately located
- contact, approximately located
- fault, accurately located
- fault, approximately located
- fault, concealed

Location Map

Mapped area shown in blue

Organ Pipe Cactus National Monument shown in green



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