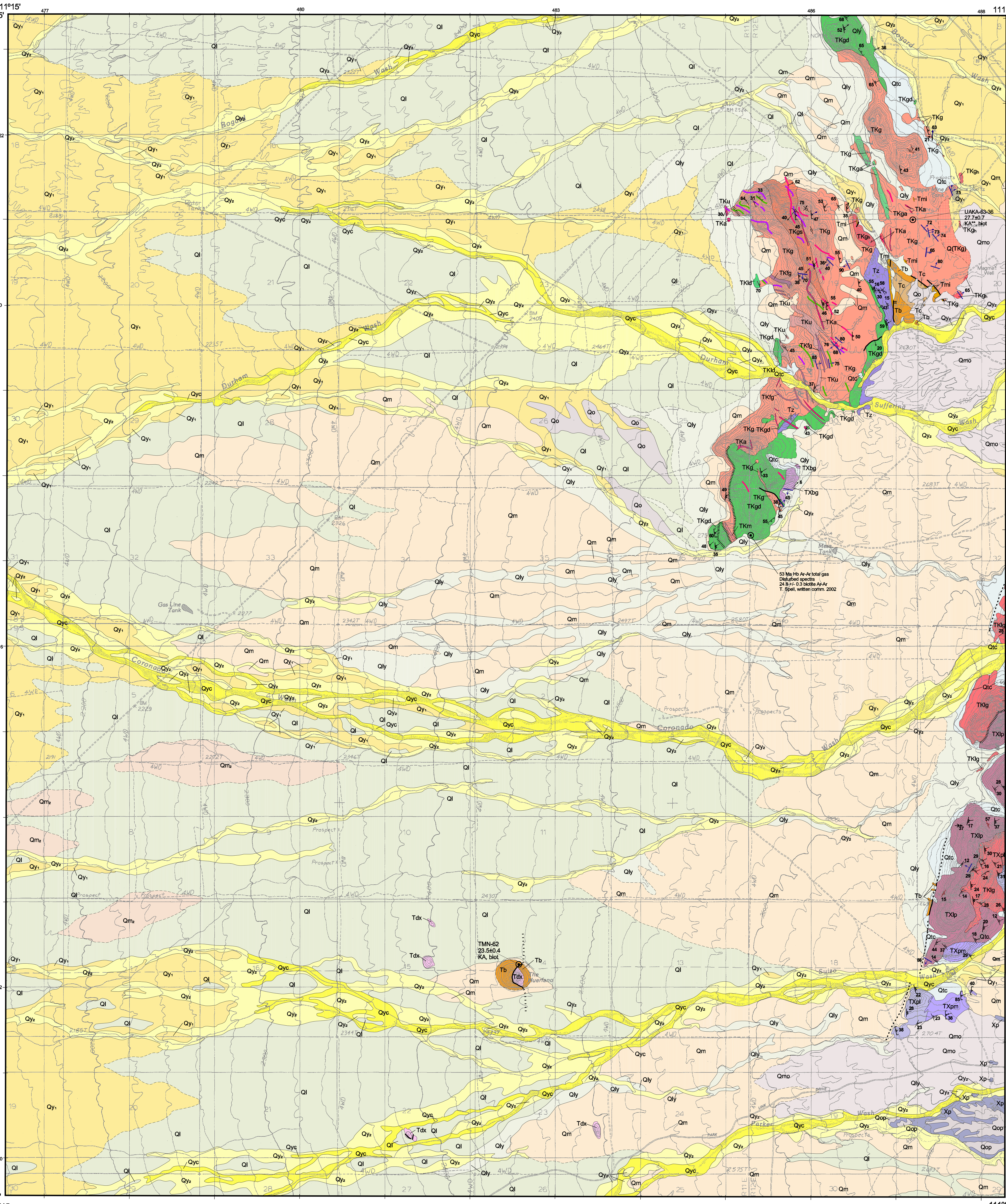


Topographic base U.S. Geological Survey Durham Hills 7.5' quadrangle, Provisional Edition, 1988; UTM zone 12, NAD 27.

Research partially supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number #01HQAG0098. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Geologic map of the Durham Hills 7.5' Quadrangle, Pinal County, Arizona

by Stephen M. Richard, Ann Youberg, Jon E. Spencer, and Charles A. Ferguson

Arizona Geological Survey Digital Geologic Map 19
December, 2002

Citation for this map: Richard, S.M., Youberg, Ann, Spencer, J.E., and Ferguson, C.A., 2002, Geologic map of the Durham Hills 7.5' Quadrangle, Pinal County, Arizona: Tucson, Arizona Geological Survey, Digital Geologic Map 19 (DGM-19), 1 sheet, layout scale 1:24,000, (1 CD-ROM with 1 Adobe Acrobat (pdf) file).

Map Units

Surficial Geologic Units: Map units consisting of variably consolidated clay, sand, and gravel, differentiated based on soil development, depositional environment, and outcrop morphology

Qyc Modern stream channel deposits (< ~1 ka) -- Active channel deposits composed of well-sorted sand and gravel to poorly-sorted sand, gravel and cobbles in the steeper channels. Channels are generally incised less than 1 m below adjacent terraces and bars, but locally incision may be as much as 2 m. Channel morphologies generally consist of a single-thread high flow channel or multi-threaded low flow channels with gravel bars. Channels are extremely flood prone and are subject to deep, high velocity in moderate to large flow events, and severe lateral bank erosion.

Qy₂ Late Holocene alluvium (< ~2 ka) -- Channels, low terraces, and small alluvial fans composed of gravel, cobbles, sand, silt, and boulders recently deposited by modern drainages. Includes Qyc where not mapped separately. Near mountain fronts, channel sediment is generally sand and gravel, but may include cobbles and boulders; terraces typically are mantled with sand and finer sediment. On piedmont areas, young deposits are mainly sand and silt, with some gravels and 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 consist of a single-thread high flow channel or multi-threaded low flow channels with gravel bars adjacent to low flow channels. Downstream branching distributary channel patterns - small, discontinuous, well-defined channels alternating with broad expansion reaches where channels are very small and poorly defined - are typical on the western piedmont. Local relief varies from fairly smooth channel bottoms to the undulating bar-and-swale topography that is characteristic of coarser deposits. Channels are flood prone and may be subject to deep, high velocity flows in moderate to large flow events. Potential lateral bank erosion is severe. Flood flows may significantly change channel morphology and flow paths. Terraces have planar surfaces, but small channels are common. Soil development associated with Qy2 deposits is minimal. Vegetation along Qy2 channels includes ironwood, mesquite and palo verde, along with several shrub species.

Qy₁ Holocene alluvium (~2 to 10 ka) -- Low terraces found at scattered locations along incised drainages and broad alluvial fans on the western edge of map area. Qy1 terraces are 1 to 2 m above adjacent active channels and less subject to inundation than adjacent Qy2 terraces. Qy1 surfaces are generally planar but fans may be incised up to 2 m. Deposits typically are sandy but locally have unvarnished, open, fine gravel lags. Soil development is minimal with weak subangular blocky structure and no to weak (stage 1) carbonate accumulation (see Machette, 1985, for description of stages of calcium carbonate accumulation in soils). Yellow brown (10YR) soil color is similar to original fluvial deposits. Qy1 surfaces support mainly creosote bush.

Qly Holocene to Late Pleistocene alluvium (~2 to 130 ka) -- Terraces and broadly rounded alluvial fan surfaces approximately 2 m above active channels. Qly is composed of mixed late Pleistocene (Ql) and Holocene (Qy1 and Qy2) alluvium. Qly areas are covered by a thin veneer of light brown, fine- grained Holocene alluvium and scattered fine gravel lag, with reddened late Pleistocene alluvium exposed in patches on low ridges, in roads and wash cut banks. Drainage networks are a mix of distributary channel networks on the lower piedmonts and tributary channels on the upper piedmonts. Vegetation includes triangle leaf bursage, creosote bush, cholla, prickly pear, barrel cacti, saguaros, ironwood and palo verde trees.

Ql Late Pleistocene alluvium (~10 to 130 ka) -- Broadly rounded to rounded and moderately dissected relict alluvial fans and terraces. Surfaces are 1 to 2 m of active channels with relict bar and swale morphology preserved. Deposits consist of gravel, cobbles, and fine-grained sediments. Ql surfaces commonly have loose, open lags of pebbles and cobbles; surface clasts may exhibit weak rock varnish. Ql soils are brown to strong brown (7.5YR), weakly to moderately developed, small to moderate subangular blocky structure and stage I-II calcium carbonate accumulation. Vegetation includes triangle leaf bursage, creosote bush, cholla, prickly pear, barrel cacti, saguaros, ironwood and palo verde trees.

Qm, Qm₂ Middle Pleistocene alluvium (~130 to 750 ka) - Moderately dissected relict alluvial fans drained by well-developed, moderately to deeply incised tributary channel networks. Channels are incised 1 to 4 meters with channel dissection increasing towards the mountains. Well-preserved, planar Qm surfaces are smooth with moderately to strongly varnished, loose to moderately packed gravel and cobble pavements. More eroded, rounded Qm surfaces are characterized by scattered cobble lags and broad ridge-like topography. Qm alluvium derived from granitic rocks tend to have smooth gravel surfaces with little to no varnish on surface clasts, and lesser amounts of carbonate accumulation through the soil profile. Qm surfaces have a distinctive dark red color on color aerial photos, reflecting reddening of the surface soil and surface clasts. Soils typically contain reddened, clay argillic horizons, with obvious clay skins and subangular to angular blocky structure. Underlying soil carbonate development is typically stage II- III, with abundant carbonate through at least 1 m of the soil profile; included petrocalcic horizons are rare. Qm alluvium derived from granitic rocks contain lesser amounts of carbonate accumulation through the soil profiles. Qm2 surfaces are found on the lower western piedmonts. They are typically incised two to four meters and form isolated, well rounded ridges with coarse gravel and cobble lags. These surfaces are typically higher and more incised than surrounding Ql surfaces, with coarser lag and redder soil. However, soil development is not as strong as a typical Qm soil. Qm surfaces generally support mesquite, palo verde, ironwood, creosote, cholla, prickly pear, and sometimes ocotillo.

Qmo Middle to Early Pleistocene alluvium (~500 ka to 1 Ma) - Moderately to deeply dissected relict alluvial fans. Qmo forms broadly rounded ridges that are higher than adjacent Qm surfaces but not as high or eroded as Qo surfaces. Tributary drainage networks are incised 3 to 6 m, increasing towards the mountains. Qmo soils are very well developed with a distinct dark red (5-2.5 YR), heavy clay argillic horizon and subangular blocky to prismatic structure. Carbonate accumulations are 2-4 m thick and range from stage III -V. Qmo surfaces support sparse vegetation including palo verde, mesquite, ocotillo, cholla and prickly pear cacti.

Qo, Qop Early Pleistocene alluvium (~750 ka to 2 Ma) - Early Pleistocene alluvium (~750 ka to 2 Ma) -- Moderately to deeply dissected relict alluvial fans remnants in the southeastern map area. Qo surfaces are highly eroded, rounded ridges with up to 10 m of active channel incision. Qo deposits consist of cobbles, boulders, and sand and finer clasts with soil development similar to Qmo soils. Qo surfaces vary from red where the argillic horizon is preserved, to light colored where carbonate-rich fragments derived from the underlying petrocalcic horizon litter the surface. Qop is a thin veneer of well-preserved Qo alluvium over bedrock pediment. Qo surfaces record the highest levels of aggradation in the area surround the Tortolita Mountains, and are probably correlative with other high, remnant surfaces found at various locations throughout southern Arizona (e.g. Skotnicki, 2000). Qo surfaces support sparse vegetation including palo verde, mesquite, ocotillo, cholla and prickly pear cacti.

Other Quaternary Map Units

Qtc Talus and colluvium (< 2 Ma) - Qtc consists of gravity-transported, unconsolidated talus and colluvium on steep hillslopes where it is sufficiently thick to obscure underlying bedrock. Deposits consist of angular to subangular boulders to fine sand, composed mainly of adjacent bedrock rock types. Vegetation is generally not found on these deposits due to the frequent movement of material.

Q(TKg) Holocene alluvium and residuum over TKg (<~10 ka) - Thin, discontinuous Holocene alluvium and residuum derived from underlying bedrock Unit TKg. Deposits are silts and sands with angular to subangular gravel and cobles composed of Unit TKg. Vegetation is sparse and consists mostly of creosote.

Tertiary map units

Zone of hematitic alteration and fracturing.

Tdx Dacite lava flows (Oligocene to early Miocene) - Dacite lava flows on inselbergs southwest of Durham Hills. Rock has very fine-grained crystalline matrix, and contain 20-25% 2-6mm diameter plagioclase phenocrysts, 2-5mm biotite phenocrysts. Dacite is dark red in color, and strongly potassium metasomatized, includes massive and autobrecciated zones. Overlies basalt lava included in unit Tm.

Tb Mafic lava (Oligocene to early Miocene)- Undivided basalt to basaltic andesite, mostly scattered outcrop on flats, difficult to place in stratigraphic context. In outcrops above detachment fault in east-central Durham Hills, consists of very finely crystalline, dark tan weathering, variably vesicular mafic lava flows. Contains 1-5% olivine and clinopyroxene phenocrysts, but small (12mm) crystal size and extensive oxidation and alteration make identification uncertain. One 20 cm thick sandstone bed within volcaniclastic debris probably overlies or underlies a lava flow autobreccia. Scoriaceous, vesicular basaltic lavas on inselbergs southwest of Durham Hills contain 5-7% mafic phenocrysts 1-2 millimeter in diameter, and in some places about 3% 1-3 millimeter diameter plagioclase phenocrysts.

Tc Conglomerate of Magma Well (Oligocene to early Miocene) -- Conglomerate in hanging wall of detachment fault in Central Durham Hills. Pebble to cobble conglomerate with >90% clasts of porphyritic biotite granite with 5-8% dark (mostly biotite) minerals in one area, abundant mafic volcanic debris in another. Heterogeneity and poor sorting indicate probable local derivation.

Tmi Mafic dike with biotite (Oligocene to early Miocene?) -- Dark, medium to fine grained mafic dike, in some areas with biotite, in other areas appears to be a fine-grained plagioclase-hornblende mafic dike. Moderate to severe fracturing with fracture-filling hematite and chloritic alteration are common. Dike apparently intrudes detachment fault in western exposure of dike, and is faulted by post-detachment, high-angle, southwest-dipping normal fault in eastern exposure.

Tertiary mylonitic rocks

Tz Mylonitic rocks (Oligocene to early Miocene)-Heterogeneous mylonitic rocks, derived from porphyritic granodiorite unit (TKg), Pinal Schist, Diorite to granodiorite of Durham Hills (TKgd), and possibly other units. Characterized by well developed mylonitic fabric that obscures the exact nature of the protolith. Rock is typically drab gray-green very fine-grained quartz-feldspar-chlorite mylonite. Transposed quartz veins are common.

TXpm Pinal Schist with mylonitic overprint (Middle Proterozoic and Cretaceous or Tertiary)- Pinal schist with strongly planar fabric. Lenses of leucocratic granitoid concordant to foliation are apparently the transposed remnants of muscovite granite and pegmatite dikes. Floating isoclinal fold hinges in millimeter to cm-scale dif- ferentiated foliation are commonly visible. Mylonitic stretching lineation is poorly developed in mica-rich rock, but is easily seen in transposed quartz veins and granitoid dikes. The stretching lineation is typically parallel to prominent intersection lineation formed between older laminated differentiated foliation and mylonitic foliation.

TKgₓ Hematitic mylonitic porphyritic biotite granodiorite (Cretaceous and Oligocene to early Miocene) - moderately to strongly mylonitic porphyritic biotite granodiorite (TKg), strongly fractured with common hematite staining on fracture surfaces. The rock is affected by chloritic and hematitic alteration with local fracture-filling secondary copper minerals (chrysocolla(?), malachite(?)). Structural thickness of mylonitic zone is generally greater than alteration zone. Mylonitic rocks are typically strongly mylonitic, with some rocks so transposed by shearing that they have been converted to a thinly layered gneiss, with layers 2-10 mm thick. Contact into weakly foliated porphyritic granodiorite in NW NE Sec. 19 is very abrupt.

Intrusive complex of the Durham Hills (Cretaceous or Tertiary)

TKa Aplite. Fine-grained, equigranular dikes consisting of quartz and feldspar, with 1-2% biotite, 5-10 millimeter diameter potassium feldspar phenocrysts are present in some areas. Some dikes have pegmatitic zones. Garnet rarely present. Aplite dikes frequently have mylonitic foliation internal to dikes that is more strongly developed than foliation in rock that dike intrudes. Internal foliation typically sub-concordant with dike margins. Some aplites have gradational contacts over 5-15 cm into unit TKg.

TKg Porphyritic granodiorite of the Durham Hills. Contains 1-2 cm pinkish white K-feldspar that are sufficiently abundant and visible, with dark, biotite-rich matrix, that rock has a distinctive, porphyritic appearance in the field. Content of large K-feldspar phenocrysts (1-2 cm) is highly variable, and ranges from 0% to perhaps 40%. Full range of content visible over distances of as little as 1.5 m. Rock commonly weathers to form large rounded boulders littering the surface.

TKgs Slightly porphyritic granodiorite of the Durham Hills. Seriate-texture granodiorite, grain size from 0.5 to 3 millimeter, with scattered 1 cm potassium feldspar phenocrysts. Rock contains 30-40% quartz, 60-70% feldspar, mostly plagioclase, and 5-7% biotite. Contact with porphyritic granodiorite is sharp to gradational; the two rocks appear to be phases of the same pluton.

TKga Aplite and porphyritic granodiorite of the Durham Hills. This unit consists of abundant thin to very thick aplite dikes intruding porphyritic granodiorite of the Durham Hills.

TKgd Diorite to granodiorite of Durham Hills. Texturally variable diorite to granodiorite. Ranges from medium-grained (3-5 mm), equigranular hornblende-plagioclase diorite to fine-grained biotite-hornblende- plagioclase granodiorite. Potassium feldspar content difficult to estimate, mostly seems sparse to absent, but 0.5-1 cm diameter potassium feldspar phenocrysts are present in some areas. Mostly medium-gray color. Irregular intrusive contacts separate phases. Strain highly variable, rock ranges from mylonite to non- foliated. Medium-grained granitoid dikes, pegmatites and some aplite dikes cut the unit, and locally cut across mylonitic fabric in the granodiorite. One porphyritic granodiorite dike intruding the diorite-granodiorite unit in the southern Durham Hills was observed to have stoped blocks of diorite-granodiorite in the porphyritic granodiorite, demonstrating that at least locally the porphyritic granodiorite is younger. Sphene is a common accessory mineral.

TKld Leucogranodiorite of Durham Hills. Medium-grained equigranular granodiorite with sparse but ubiquitous hornblende prisms and sparse potassium feldspar phenocrysts. Locally grades to seriate monzogranite with quartz-feldspar groundmass 1 -10mm in diameter, with scattered hornblende prisms and 2-3% biotite. Weak internal foliation generally present, defined by aligned hornblende, biotite, and potassium feldspar crystals. Rock distinguished from slightly porphyritic granodiorite by lighter color, and sparsity of phenocrysts and presence of hornblende prisms.

TKu Mixed porphyritic granodiorite, leuco-granodiorite, fine-grained granodiorite. Mixed zone of porphyritic granodiorite, leucocratic granodiorite in dikes with variable orientations, aplite to aplite-fine-grained granitoid and fine-grained biotite quartz diorite. Mixed phases seem to be irregular blobs in general. Rock variations occur on 1-10 meter scale. May be zones of magma mixing.

TKfg Fine-grained diorite to granodiorite (late Cretaceous or Tertiary) - medium gray, fine-grained to very fine-grained, equigranular diorite to granodiorite. Rock consists of approximately 70% feldspar, with some quartz; remainder is biotite and hornblende. 1-2 millimeter prismatic mafic crystals locally present. Forms dikes and lenses in porphyritic granodiorite and slightly porphyritic granodiorite, rock is lithologically quite similar to locally abundant enclaves in porphyritic granodiorite.

TKm Mafic dikes (late Cretaceous or Tertiary) - fine to very fine-grained dark greenish gray dikes, generally very poorly exposed, forms swales with sparse float of dike rock. Aphanitic to very fine-grained chilled margins exposed rarely. Rock is plagioclase + chloritized mafic minerals. Hornblende phenocrysts and mafic phenocrysts altered to very fine-grained biotite present in some dikes.

Leucogranite complex of the Suizo Mountains

TKlg Leucogranite of the Suizo Mountains (Late Cretaceous or Tertiary) - Leucocratic muscovite-biotite granitoid, consists of about 20% quartz 1-3 millimeter in diameter, weakly to moderately sericitized plagioclase, and generally less than about 7% muscovite + biotite. Locally contains 2-3%, 0.1 to 3 mm garnet, and up to 7% muscovite. The unit consists of pegmatite and pegmatitic quartz veins in some areas Rock is generally resistant and forms ridge tops in Suizo Mountains. Foliation is generally very weakly developed in the northern part of the Suizo Mountains. The leucogranite is transformed to strongly lineated mylonite and flinty ultramylonite in a mylonite zone on the southeast side of Suizo Mountains. Mylonitic fabric is progressively less developed structurally downward on west side of range.

Mixed Pinal Schist and leucogranite

TXlp Mixed unit, leucogranite predominant over Pinal Schist (Early Proterozoic and Late Cretaceous or Tertiary) -- Heterogeneous pegmatitic muscovite leucogranite with screens of muscovite-biotite schist, and schist with concordant veinlets and sheets of leucogranite. This unit mapped where leucogranite is the predominant phase present, and schist forms > 10% of rock volume. Garnet is only locally present in the schist phase. Leucogranite dikes can locally be observed to cross cut laminated differentiated foliation in schist, interpreted to represent the Proterozoic fabric in the schist. Includes some lenses of medium-grained equigranular to slightly porphyritic, texturally variable diorite that strongly resembles unit TKgd.

TXpl Mixed unit, Pinal Schist predominant over leucogranite (Early Proterozoic and Late Cretaceous or Tertiary) - Identical to TXlp, but schist is predominant, and leucogranite forms > 10% of rock.

TXbg Biotite granodiorite (Tertiary, Cretaceous or Early Proterozoic) - Light gray, medium-fine grained, recrystallized biotite granodiorite. Rock is generally equigranular with granoblastic texture. Aligned biotite clots define a moderately developed l-fabric. Recrystallized texture of rock suggests that this is an older granitoid phase than unit TKgd, and has been subjected to a pre-TKgd metamorphic event.

Xp Pinal Schist (Early Proterozoic) - Gray to silvery fine-grained psammite, schist and phyllite, in hanging wall of detachment fault, exposed in washes and on pediment in southeastern corner of map area. Locally contains 1-2 millimeter diameter dark spots, siliceous laminations, and sandy lenses. Fabric is very variable.

Structure Symbols

Contacts
- Accurately located
- Approximately located
- Concealed
- Nature uncertain
- Gradational contact

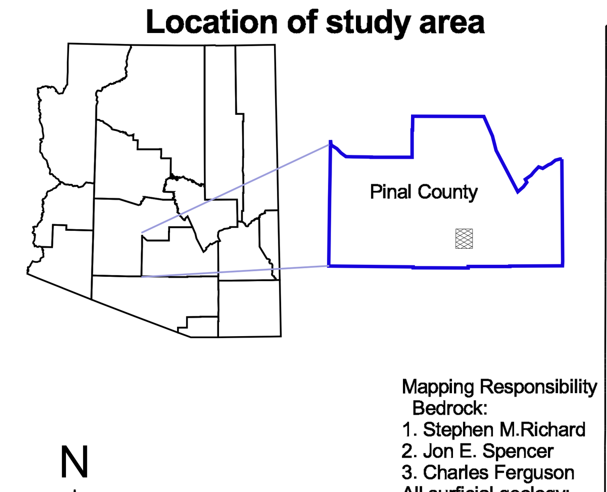
Faults
- Accurately located
- Approximately located
- Concealed
- Nature uncertain
- Detachment fault

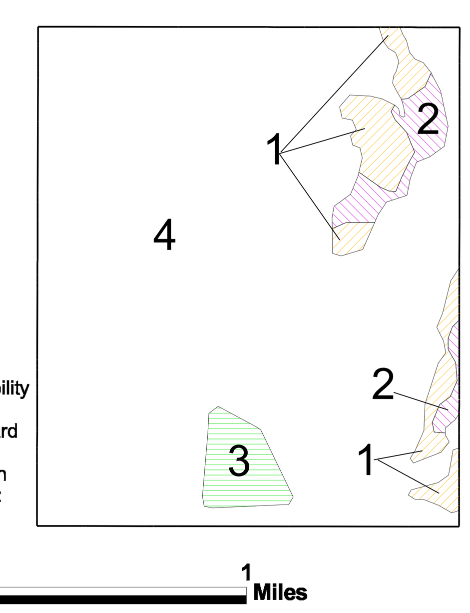
Bedding and Foliation, number indicates dip
- Inclined planar bedding
- generic inclined foliation
- gneissic foliation
- axial surface of continuous crenulation
- weak shape fabric, incipient mylonitic foliation
- moderately developed mylonitic foliation
- mylonitic foliation
- inclined joint
- vertical joint

Fault orientation
- Dip direction and magnitude
- minor fault
- quartz-hematite mineralized vein/fracture

Lineation, number indicates plunge
- mylonitic stretching lineation with sense of shear
- mylonitic lineation with up-dip sense of shear
- crenulation fold in mylonite
- slickenside striation

Location of study area

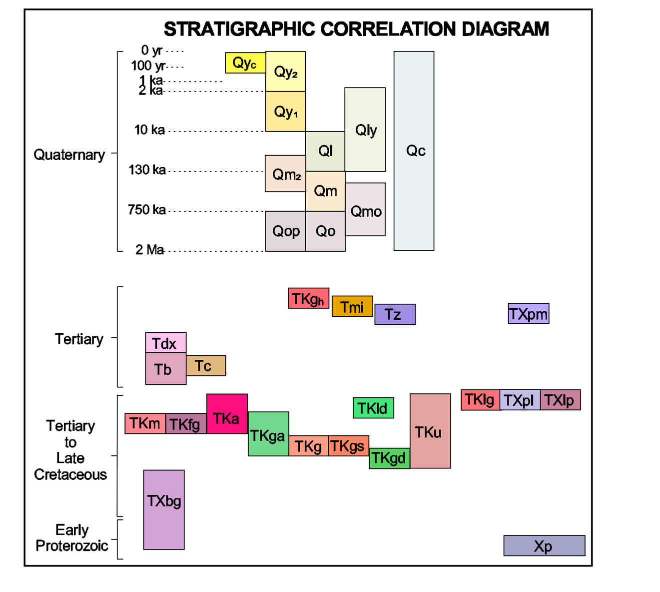




Mapping Responsibility
Bedrock:
1. Stephen M.Richard
2. Jon E. Spencer
3. Charles Ferguson
All surficial geology:
4. Ann Youberg

1 0 1 Miles
1000 0 1000 2000 3000 4000 5000 6000 7000 Feet
1 0 1 Kilometers

STRATIGRAPHIC CORRELATION DIAGRAM



INTRODUCTION
This digital geologic map and report describes the bedrock and surficial geology of the Durham Hills 7 1/2' Quadrangle. The study area is located approximately 60 km northwest of downtown Tucson. It includes the Durham Hills, western Suizo Mountains, and the piedmont areas extending west and south of these hills with sparse outcrops of Tertiary volcanic rock. Elevations in the study range from approximately 3360' in the Suizo Mountains on the eastern edge of the map area to 2760' on the western edge.

Mapping was conducted between October, 2001 and May, 2002 as part of continuing efforts by the Arizona Geological Survey (AZGS) to map the geology of the Phoenix-Tucson urban corridor. This map is part of a mapping project that encompasses several adjacent quadrangles including Fortified Peak (DGM 18), Desert Peak (DGM 20), Oro Valley (DGM 21), Chief Butte (DGM 22), North of Oracle (DGM 23), and the Tortolita Mountains including the northern portion of Ruelas Canyon (DGM 26). Bedrock mapping consists almost entirely of new mapping but locally incorporates past mapping by Banks and others (1977). The surficial geologic mapping builds on and complements previous efforts in the Tucson area (e.g. Klawon and others, 1999; Pearthree and Biggs, 1999; Skotnicki, 1999; Pearthree and Youberg, 2000; Skotnicki, 2000, and references cited on those maps). This mapping is part of the STATEMAP Program of the U.S. Geological Survey, administered under contract #01HQAG0098, and jointly supported by the AZGS and the U.S. Geological Survey National Cooperative Mapping Program.

The majority of the map area is a piedmont that slopes gently westward-from the Durham Hills and Suizo Mountains. The piedmont is mantled by Quaternary alluvium of varying ages. The two main ridges of the Durham Hills are separated by a northwest-trending high-angle fault. This fault is inferred to cut a gently east-dipping detachment fault exposed southward from about 487000N 3621000E (UTM, zone 12). Rock above and below the detachment fault is crushed for a distance of 20 to 200 cm. Footwall rocks are strongly mylonitic for several to 10 meters structurally beneath the fault, with some rocks so transposed by shearing that they have been converted to a thinly layered gneissic mylonite, with layers 2-10 mm thick. Hanging wall rock is reddish and oxidized, footwall rock is greenish gray and chloritic. The fault dips 40° to 45° to the east. No microbreccia or silicified fault surface was observed. This detachment fault is inferred to bound the east side of the Durham Hills, juxtaposing Tertiary volcanic and sedimentary rocks on foliated to massive granitic rocks exposed in the Durham Hills. These volcanic and sedimentary rocks are inferred to be continuous in the subsurface between the Durham Hills, The Huerfano, and the Suizo Mountains. A NNE-trending high-angle(?) fault along the west base of the Suizo Mountains juxtaposes Tertiary volcanic rock against granitic and metamorphic rocks of the Suizo Mountains. The Suizo Mountains are bounded on the east by an east-dipping detachment fault, which is inferred to continue southwest into the map area, separating mylonitic Pinal Schist invaded by leucogranite on the northwest from low-grade, phyllitic Pinal Schist along Parker Wash in the southeast corner of the map area.

MINERAL DEPOSITS
1. Copper Mine Tank mines-Mineralization characterized by abundant fractures in granite with pervasive hematite staining and chloritic alteration; green copper stain (probably chrysocolla and malachite) is common on fracture surfaces in some shafts and prospects.
2. Beneath the detachment fault in the central Durham Hills granitic rock is fractured with common hematite staining on fracture surfaces, and the rock is affected by chloritic and hematitic alteration with local fracture-filling secondary copper minerals (chrysocolla(?), malachite(?)). The mylonitic zone associated with the detachment fault generally extends structurally deeper than the alteration zone.
3. Numerous generally north-northwest-trending fracture zones are present on the east side of the western ridge of the Durham Hills. These are associated with weak silicification, hematite staining, and rare green copper oxide mineralization.

CLIMATE
Three weather stations near the map area have operated during intervals over the past century and provide climatological data for the study area. The weather station at Red Rock (Red Rock 6 SSW), west of the study site, has records from 1893 to 1973. Cortaro weather station (Cortaro 3 SW), south of the study site, has records from 1948 to 1976. Willow Springs Ranch weather station, east of the study area, operated between 1949 and 1978.

Throughout this region, most of the annual precipitation (50-60%) falls during the summer monsoon from June to September. Late summer rainfall occurs as heavy thunderstorms when moist air sweeps northwards from the Gulf of California and the Gulf of Mexico. Occasional intense late summer to early fall precipitation occurs in this region as a result of incursions of moist air derived from dissipating tropical storms in the Pacific Ocean. Winter precipitation generally is caused by cyclonic storms originating in the Pacific. It is usually less intense and may be more prolonged, and therefore infiltrates into the soil more deeply than summer rainfall (summarized from Sellers and Hill, 1974). Freezing temperatures are common during most winters, but snow is uncommon and not persistent.

Climate records from two of these stations illustrate the relatively warm and dry climate of the lower elevations in the Sonoran Desert. Cortaro, at about 2280 ft asl, has an average annual precipitation of 11.2 in., while Red Rock, at about 1860 ft asl, has an average annual precipitation of 9.8 in. (Western Regional Climate Center, 2002). Average annual maximum temperature for Cortaro is 85.7° F, with an average high temperature of 102.7° F in July and 67.0 ° F in January. Temperature data from Red Rock are typically within a degree of Cortaro. These conditions reflect those typically found on the piedmonts through out the map area. The higher, mountainous areas of Durham Hills and Suizo Mountains are more closely approximated by the Willow Springs Ranch weather station, located at 3690 ft asl. Average annual precipitation is 15.1 in, with an average annual total snowfall of 3.1 in. Average annual maximum temperature for Willow Springs is 77.1° F, with an average high temperature of 95.4° F in July and 58.6 ° F in January.

METHODOLOGY
Quaternary surficial geology was mapped and described by Youberg. Bedrock geology of the Durham Hills and Suizo Mountains was mapped and described by Richard and Spencer. Ferguson mapped Tertiary volcanic rocks exposed on inselbergs in the vicinity of The Huerfano. Bedrock geology was mapped by field observation using 1:24,000-scale USGS topographic base maps, and Garmin 12 GPS receivers to assist location of observation stations. Surficial geology was mapped using aerial photograph interpretation and direct field observation. Aerial photographs included 1984, 1:30,000 scale, USGS color photographs, supplemented by large-format, 1983, 1:24,000 scale, high altitude, false color photos provided by NRCS.

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. Surficial deposits of this quadrangle were then correlated with similar deposits in this region in order to roughly estimate their ages. Alluvial surfaces of similar age have a distinctive appearance and soil characteristics because they have undergone similar post-depositional modifications. Terraces and alluvial fans that are less than a few thousand years old still retain clear evidence of the original depositional topography, such as bars of gravel deposits, swales (troughlike depressions) where low flows passed between bars, and distributary channel networks, which are characteristic of active alluvial fans. Young alluvial surfaces have little rock varnish on surface clasts, little soil development, and are minimally dissected. Very old fan surfaces, in contrast, have been isolated from substantial fluvial deposition or reworking for hundreds of thousands of years. These surfaces are characterized by strongly developed soils with clay-rich argillic horizons and cemented calcium-carbonate horizons, well-developed tributary stream networks that are entrenched 1 to 10 m below the fan surface, and strongly developed varnish on surface rocks. The ages of alluvial surfaces in the southwestern United States may be roughly estimated based on these surface characteristics, especially soil development (Gile and others, 1981; Bull, 1991).

REFERENCES
Banks, N.G., Dockter, R.D., Briskey, J.A., Davis, G.H., Keith, S.B., Budden, R.T., Kiven, C.W., and Anderson, Phillip, 1977, Reconnaissance geologic map of the Tortolita Mountains quadrangle, Arizona: U.S. Geol. Surv. Map MF-864, 1 sheet, scale 1:62,500.
Bull, W.B., 1991, Geomorphic Response to Climatic Change, New York: Oxford University Press, 326 p.
Gile, L.H., Hawley, J.W., and Grossman, R.B., 1981, Soils and geomorphology in the basin and range area of southern New Mexico -- guidebook to the Desert Project: New Mexico Bureau of Mines and Mineral Resources Memoir 39, 222 p.
Klawon, J.E., Dickinson, W.R., and Pearthree, P.A., 1999, Surficial geology and geologic hazards of the northern Tucson basin, Tucson North and Sabino Canyon 7 1/2' quadrangles: Arizona Geological Survey Open-File Report 99-21, 21 p. 1 sheet, scale 1:24,000.
Pearthree, P.A., and Youberg, A., 2000, Surficial geology and geologic hazards of the Green Valley-Sahuarita Area, Pima County, AZ: Az. Geol. Sur. OFR 99-22, 12 p., scale 1:24,000.Skotnicki, S.J., 1999, Geologic map of the Ninetysix Hills, Pinal County, Arizona: Az. Geol. Sur. OFR 99-20, 4 plates, scale 1:24,000, with 14 p. text.
Reynolds, S. J., Florence, F. P., Welty, John W., and others, 1986, Compilation of Radiometric Age Determinations in Arizona, Arizona Bureau of Geology and Mineral Technology Bulletin 197, 258 pages.
Skotnicki, S.J., 2000, Geologic map of the Oracle 7.5' quadrangle and the eastern third of the Tortolita Mountains 7.5' quadrangle, Pima County, Arizona, Az. Geol. Sur. OFR 00-4, 19 p., scale 1:24,000, text and sheet.
Sellers, W.D., and Hill, R.H., 1974, Arizona Climate, 1931-72: Tucson, Univ. Az. Press, 616p.
Western Regional Climate Center, 2002, Arizona climate summaries, in Western U.S. historical climate summaries, WRCC Web Page, Desert Research Institute, University of Nevada.