Geologic Map for DGM-999a (TontoNF 24K generalized Units)
Map Unit Legend

w — **Water**

Water

d — **Disturbed ground (recent)**

Heavily disturbed ground due to agriculture, extensive excavation, or construction of earth dams

Qtc — **Colluvium and talus (Holocene to Pliocene)**

Unconsolidated to weakly consolidated, very poorly sorted angular rock debris on hill slopes

Qal — **Quaternary sedimentary deposits**

Sand and gravel deposits along valley and canyon floors

Qyr — **Holocene River alluvium**

Unconsolidated, rounded to subangular, moderately sorted to poorly sorted, clast-supported sand, cobbles, and small boulders. Low terraces typically covered by sand and silt. Minimal carbonate accumulation. Little vegetation in channels, bars and terraces may have abundant riparian vegetation

Qir — **Pleistocene River alluvium**

Older terrace deposits along major rivers, consist of rounded cobble-gravels and sandy sediment, typically poorly to moderately consolidated.

Qy — **Holocene Piedmont alluvium**

Gravelly sediment capping basin fill on surface or forming surface deposits along drainages. Unconsolidated sandy and gravelly sediment, typically coarser grained in proximity to bedrock source areas.

Qi — **Pleistocene Piedmont alluvium**

Relatively planar, reddish terraces mantled by angular to sub-angular pebbles to cobbles

Qls — **Landslides (Quaternary)**

Landslides and other mass-movement or rock-avalanche deposits. May include some late Tertiary landslide deposits. Age of movement generally poorly constrained.

Tsyf — **Fine-grained and lacustrine sedimentary deposits (Miocene)**

Mudstone, some carbonate rock and evaporite deposits, deposited in low-energy lacustrine or playa environments, generally weakly to moderately indurated, and buff or tan colors. Locally interbedded with basaltic lava flows.

Tsy — **Gravelly sediment and sedimentary rocks (Pleistocene to Miocene); younger basin fill**

Conglomeratic and sandy sedimentary deposits accumulated in Middle Miocene to Pliocene basis, now undergoing dissection in modern drainages. Ranges from weakly to well consolidated. Clast assemblages generally heterogeneous, reflecting local bedrock sources. Boulder conglomerate in many places, particulary near sources areas, also some sedimentary breccia. Generally light gray or buff-colored; may be cut by faults, but bedding is typically subhorizontal except very close to faults cutting the unit.

Tvs — **Mixed volcanic and epiclastic breccia, clastic and tuffaceous rocks (Miocene)**

A mixed unit consisting of volcanic and epiclastic, monolithic to heterolithic breccia, conglomerate, and bedded, unwelded tuff. The breccia and conglomerate is typically massive or thick-bedded, and the tuff medium- to thin-bedded. The unit is preserved along a south-dipping erosional unconformity between pre-caldera rocks (Superstition Group) and post-Apache Leap Cauldron lava (Coffee Flat Mountain Formation).

Tvx — **Monolithic felsic volcanic rock breccia (Miocene)**

Largely monolithologic breccias composed of felsic volcanic rocks, in the vicinity of Saddle Mountain and in the northern Superstition Mountains. May be pyroclastic or rock avalanche deposits.

Tts — **Tuff and volcanic-lithic sandstone (Miocene)**

Tuff and tuffaceous sandstone interbedded. White to very light grey color, typically with well defined bedding and generally sand-size constituent particles. Distinction of epiclastic and pyroclastic origin not clear on a bed to bed basis. Generally represents accumulations adjacent to volcanic centers where reworked tuffs are interbedded with distal pyroclastic deposits.

Tbc — **Basaltic pyroclastic deposits and volcanic lithic sediment (Middle Tertiary)**

Accumulations of scoria and agglomerate probably associated with cinder cones. Locally interbedded with basalt flows. Good exposures are located north of Alder Creek and between Maverick Mountain and Alder Creek. Matrix is locally very fine-grained (ash?) and strongly cemented with calcite. The deposits locally contains basalt bombs up to about 30 cm long.

Tb **Basalt lava flows (Pliocene to late Oligocene)**

Basalt lava flows of uncertain affinity or in areas where lower and upper units are not differentiated. In northern part of compilation area, includes basaltic rocks associated with the Hickey and Chalk Canyon formation. These are medium- to dark-gray olivine basalt, consisting of flows 2-40 m thick that contain olivine phenocrysts 1-2 mm long, commonly altered to iddingsite and, in some flows, conspicuous phenocrysts of a dark-green pyroxene in an intergranular groundmass. Deeply embayed quartz phenocrysts and large blocky plagioclase crystals locally are abundant in some areas. Vesicles are common and locally are partly-lined with a zeolite; calcite amygdules and veins are abundant. Contains locally conspicuous interbeds of basaltic sand and scoria. Forms cliffs and steep slopes.

Tby **Younger basalt lava flows (Pliocene to Miocene)**

Relatively thin (less than 10 meters thick) basalt flows containing 5-15% phenocrysts of olivine, pyroxene, and rare plagioclase. Quartz- and calcite-filling amygdules are also very common in these lavas. Includes dark gray to dark greenish-brown, massive to vesicular flows in the valley of the Verde River. Mostly olivine basalt but includes minor amounts of andesite. Vesicular basalt is common and generally is light- to medium-gray and deuterically altered. Olivine phenocrysts are ubiquitous but are mostly converted to iddingsite. Pyroxene phenocrysts are rare. Red scoriaceous basaltic sands form rare but conspicuous interbeds. May forms steep slopes and cliffs in which individual flows are fairly distinct. Typically separated from older basalt (Tbo) by sandstone or conglomerate units. Onlaps onto Proterozoic rocks in some areas. Deposited on complex topography.

Tbo **Older basalt lava flows (Miocene)**

Basaltic lava flows that are in the lower part of thick volcanic sequences in the Goldfield Mountains, where they are highly faulted and tilted, also includes lava flows in the lower parts of less deformed sequences to the east and north, especially in the area between the Verde River and Mazatzal Mountains. Typically distinguished from younger basalt (Tby) mostly based on stratigraphic superposition. Lithology is very similar to younger basalt lava flow unit.

Tsm **Middle sedimentary basin-fill deposits (Miocene)**

Generally light tan to light grey, moderately consolidated sandstones and conglomerates. Bedding is typically better defined that in the younger basin fill deposits. Clast and matrix supported conglomerate may be present. These strata are commonly interbedded with basalt of units Tb, Tbo and Tby, and may be composed almost entirely of basalt clasts in these areas. Clast composition reflects adjacent bedrock source areas. Unit is cut by faults, and may be tilted in some areas. Typically crumbles easily and forms rounded hills. The matrix is commonly carbonate rich and locally forms well-consolidated caliche laminae. Similar to older conglomerate unit, but is generally lighter colored, lacking reddish hues, and is associated with basaltic lavas of the younger part of the middle Tertiary volcanic section. This unit is assigned if distinction between subunits has not been mapped.

Tlc **Carbonate sedimentary rocks (Miocene)**

White to light-gray, finely laminated, porous limestone and minor medium-gray to light-brown, thin-bedded chert. In some areas, the limestone contains laminated stromatolite-like mounds a few centimeters across. Limestone beds locally are broken into small overlapping slabs or brecciated into angular, centimeter size fragments separated by voids partly lined with secondary calcite. Contains sparse, silt-size quartz grains. The finely laminated limestone beds accumulated as micritic lime mudstone, possibly as algal mats. The stromatolite-like mounds consist of bladed calcite deposited as coatings on mud lumps or pieces of fragmented limestone. Probably accumulated in shallow lake or playa subjected to frequent wave action and periods of desiccation. Forms prominent cliffs and steep slopes. May correlate with part of the Pliocene and Miocene Verde Formation of the Jerome area (Nations and others, 1981, p. 143-148).

Tss **Sandy clastic rocks (Miocene)**

Pale brown to light-gray, medium- to thin-bedded sandstone, pebbly sandstone, silty mudstone, and minor medium- to thick-bedded cobble conglomerate. The unit also includes some limestone sequences up to a few meters thick and some nonwelded tuff beds. Includes sandy facies of the Whitetail formation, sandstone in the Superior Basin, and at Ister Flat along the Verde River.

Tcs **Sandstone and conglomerate (Miocene)**

Sandstone, conglomerate, mudstone, calcareous in some areas. Includes sandstone and conglomerate facies of the Chalk Canyon Formation, and units in the Sunflower area.

Tc **Conglomeratic clastic rocks (Miocene)**

Miocene conglomerate-dominated clastic rocks. Commonly massive or crudely bedded.

Tcsv — **Volcaniclastic conglomerate and sandstone (Miocene)**

Volcanic-lithic conglomerate, pebbly sandstone, sandstone, silty mudstone, and sedimentary breccia. These strata range from plane-bedded and cross-stratified to massive, and from thin- to thick-bedded. Most of the strata are clast-supported, and the beds internally stratified; and these are interpreted as fluvial deposits derived from juvenile volcanic source areas. Locally, thin- to medium-bedded laminated siltstones and mudstones are abundant, some of which may be lacustrine deposits. Massive, matrix supported, medium and thick-bedded diamictites are locally abundant, and these rocks are interpreted as debris-flow and hypoconcentrated flood flow deposits. Sedimentary breccia deposits are locally present.

Tx — **Sedimentary Breccia (Early Miocene to Eocene)**

Shattered rock and monolithologic breccia depositss.

Tv — **Volcanic rocks, undivided**

Undivided volcanic rocks of late Oligocene to Miocene age.

Tvf — **Felsic volcanic rocks (Miocene)**

Felsic lava flows, with associated vitrophyre, autobreccia, and tuff. Colors vary from dark gray to black for massive vitrophyre to white, light gray, or yellow in devitrified or deuterically altered parts of flows. Flow banding, amygdule, and brecciated zones are common. Rocks typically have phenocrysts of quartz, two feldspars, and sparse biotite or hornblende; tiny magnetite crystals are a common accessory. Quartz ranges from euhedral to resorbed. Phenocrysts make up to ~40% of rock in some units. Contacts with associated hypabyssal intrusions or endogeneous dome complexes are difficult to locate.

Tft — **Felsic pyroclastic rocks (Miocene)**

Pyroclastic rocks consisting of tuff, lapilli tuff, and tuff-breccia. Mostly these are associated with silicic volcanic centers in the area. Typcially the tuffaceous pyroclastic rocks are light colored, and range from massive to more commonly thin to thick bedded. Crystals of biotite, quartz, K-feldspar and plagioclase are typical, forming 1-15% of the rock, and some tuffs are lithic rich.

Talt — **Apache Leap Tuff**

Crystal-rich (40-50%), plagioclase, embayed quartz, sanidine, biotite-bearing ash-flow tuff. The tuff ranges from unwelded to densely welded, and it rarely contains more than a few percent lithic fragments. Pumice fragments are also sparse and generally difficult to see in outcrop. The base and top of this unit are locally, crudely thick-bedded, but the unit generally appears massive. A lower vitrophyre is present in the Boulder Canyon area. Flow-banding is recognized in a few places along Boulder Canyon trail just south of Canyon Lake. Locally near the top, especially in the Willow Springs and Tortilla Flat areas, accretionary lapilli-rich intervals are present. Includes rocks previously known as Superstition Tuff.

Talz — **Mesobreccia, megabreccia, and bedded breccia, Apache Leap tuff**

heterolithic, Apache Leap Tuff matrix, clast- and matrix-supported tuff breccia. Maximum clast size is about 5 meters, except for one >15m block of dacite lava which was mapped as a separate block. The clasts are composed of a wide variety of mafic to felsic lava, including basalt, crystal-rich dacite, porphyritic dacite, and rhyodacite (Td, Tdp, Trd), crystal-poor and crystal-rich rhyolite (Trp, Trx), and Whitlow Canyon type rhyodacite (Tw). The phenocryst mineralogy of these lava clasts can be matched directly with those of the older lava flows which crop out below Apache Leap Tuff to the north of the cauldron margin

Tfa — **Felsic to intermediate volcanic rocks (Miocene)**

Wide variety of rhyolitic to andesitic lava, includes some associated breccias and pyroclastic rocks.

Ta — **Intermediate composition lava flows (Miocene)**

Andesitic to dacitic lava and associated breccia. Locally includes related pyroclastic or hypabyssal intrusive rocks.

Tba — **Mafic to intermediate volcanic rocks**

mafic and intermediate lava, and associated non-welded tuff, tuff breccia, and volcaniclastic rocks. In the southwestern Superstition Mountains and Goldfield Mountains, includes the Government Well Formation that ranges in thickness from 0 to 1,500 meters. This unit overlies and locally interfingers with non-volcaniclastic sedimentary rocks of the Whitetail Formation (older clastic sedimentary rocks) and is overlain by rhyolitic lava and tuff of the Tule Canyon Formation. The lower contact is defined as the first appearance of volcanic rocks that dominate (>70%) the stratigraphic sequence, and in most areas, these rocks are basaltic. The upper contact is defined as the first appearance of crystal-poor rhyolite lava or tuff, and this contact appears to be isochronous throughout the main part of the field. The lower part of the unit consists mostly of basaltic lava, but basalt is also present sparingly in the upper division. The upper part of the Government Well Formation is characterized by crystal-rich dacitic lava containing phenocrysts of plagioclase and biotite, + hornblende, pyroxene, and quartz. Sanidine phenocrysts are notably absent throughout the formation. At its type section along the Apache Trail near Government Well in the northern Superstition Mountains, the formation is 1570 meters thick.

Tm

Mafic volcanic rocks (middle Tertiary)

Dark to medium grey fine-grained volcanic rocks containing 1-3 mm nonhedral to subhedral phenocrysts of olivine and/or pyroxene mostly altered to iddingsite, clear quartz, and various amounts of biotite and/or hornblende in a dark aphanitic matrix. The abundance and occurance of phenocryst types is quite variable between outcrops. A few contain almost exclusively olivine and/or pyroxene. Some contain all four phases. Most contain at least olivine and/or pyroxene and quartz. Several outcrops are clearly intrusive and others are clearly depositional. Some exposures are both and for others it is not clear. Therefore all of these rocks were mapped together. Generally, this unit forms resistant knobs and hills, though locally the rock is crumbly. Distinguished from basalt lava units (Tb, Tbo, Tby) in that the rock is more altered and faulted and original lava-flow layering and morphology has been obscured. Includes basalts of Government Well formation in the Goldfield and southeastern Superstition Mountains.

Tcbb

Biotite basalt (Late Oligocene or Miocene)

Vuggy, dark gray basalt (biotite lamprophyre) with up to 25% biotite that is only moderately resistant to weathering and form low, rounded outcrops (Conway, 1995). Includes lava flow and associated breccia. Crustal xenoliths present in some places.

Twm

Older fine-grained clastic sedimentary rocks (Miocene to Eocene)

Light gray to red brown laminated mudstone with interbedded, very thin beds of fine-grained sandstone. In southwestern part of map area contains lenses of pebble to cobble conglomerate; some of these contain only angular clasts of Pinal schist, others contain granite (Yg and TKtc), Pinal schist, and carbonate or quartzite clasts from the Apache Group or Paleozoic section. Contacts are gradational into other facies of Whitetail formation.

Tw

Whitetail formation (Late Oligocene to Early Miocene)

Poorly sorted, crudely bedded to massive conglomerate containing subrounded to subangular clasts up to 40 cm diameter of Apache Group rocks and Paleozoic carbonates and quartzites. Reddish brown sandy matrix is poorly cemented.

Tch

Chaos (Miocene or Oligocene)

Rock bodies in which superposed faulting has mixed units on a 5-50m scale with such complexity that relationships cannot be shown on the map. One area of this unit mapped in north-trending fault zone NE NW SW sec. 25, T2S R12E consists of Apache Group, diabase, and lower Paleozoic units. Contacts with more intact rock bodies are faults.

Ti

Felsic hypabyssal intrusive rocks (late Oligocene to Miocene)

Intrusive, rhyolite to rhyodacite, locally grading into extrusive lava flow and/or dome equivalent rocks. Also as discrete fine-grained intrusive masses.

Tii

Intermediate composition hypabyssal intrusive rocks (late Oligocene to Miocene)

Various dacitic to andesitic hypabyssal intrusive rocks, commonly porphyritic.

Tbi

Intrusive basalt

Dikes of basaltic rock. May include some late Cretaceous dikes. Generally associated with Tertiary volcanic rocks

TKs

Granitic intrusive rock (Early Tertiary or Late Cretaceous)

Includes Solitude Granite, a distinctive light-colored granite of Late Cretaceous or Early Tertiary age that crops out 3 miles south of Miami, near the head of Solitude Gulch (Ransome, 1903, p. 65). The outcrop of the Solitude granite is almost white, with a faint yellowish tinge; it is so much lighter in color than the neighboring, grayish-yellow Schultze granite, that the two rocks are readily distinguishable, even when viewed from several miles away.

The Solitude granite within the mapped area is largely muscovite granite. Southeastward it grades into true granite, containing about as much biotite as muscovite. Surfaces of the broken rock are rough and granular. Quartz, feldspar, and silvery white muscovite are readily recognized with the unaided eye. Brownish alteration halos commonly surround the muscovite grains. The texture is characteristically nonporphyritic, medium grained, and equigranular. The minerals seen in thin sections are quartz, turbid orthoclase, albite, muscovite, and a little microcline. The feldspars tend to be intergrown in anhedral clusters, which are interspersed with clusters of anhedral quartz grains. Muscovite occurs as aggregates of large ragged flakes and also as minute flakes scattered , through the feldspar clusters. The very sparse accessory minerals are rutile, sphene, bluish prisms of tourmaline, and occasional grains of limonite that probably are pseudomorphs after pyrite. The rock south of the mapped area, contains biotite in addition to muscovite. In general, the minerals of the rock show very little or no alteration by weathering.

TKq

fine-grained granitoid dikes, sills, border zones (Early Tertiary or Late Cretaceous)

Fine grained granitic composition intrusive rock. Contains 5-10 volume percent biotite. Generally porphyritic, lack aplitic texture and contain more biotite than aplite dikes.

Tgm

Hypabyssal porphyritic granitoid (Early Tertiary or Late Cretaceous)

Texturally variable equigranular granodiorite to granite porphyry. Typically, groundmass is holocrystalline, phanerocrystalline, finegrained, and aplitic, and is sprinkled with black shiny biotite crystals to produce light salt-and pepper effect. Grain size of groundmass increases in the central part of the stock, and texture changes to seriate with medium to coarse grain size.

TKsg

Porphyritic granite (Early Tertiary or Late Cretaceous)

TKsg, stock of porphyritic biotite-quartz monzonite grading locally into porphyritic granite
TKgp granite porphyry dikes and sills not obviously connected with the main stock may include some unrelated dikes in the southeastern part of the quadrangle

TKgg

Granodiorite (Early Tertiary or Late Cretaceous)

biotite granodiorite. South of Castle Dome mine, body is bounded by Pinal schist on the south and by a large mass of quartz monzonite and small bodies of granite porphyry on the north. At the west end of the body along Gold Gulch, south of the Castle Dome mine is an intrusive breccia composed of small blocks of granodiorite included in quartz monzonite porphyry. The character of the breccia seems adequate proof that the granodiorite is older than the quartz monzonite.
Typical granodiorite is light-gray medium-grained almost equigranular rock. Plagioclase, quartz, and black biotite are the only minerals that can be recognized. A facies with noticeably porphyritic texture occurs in some places near the margins of the body.

TKd

Dioritic intrusive rocks (Early Tertiary or Late Cretaceous)

Medium- to fine-grained, generally hypidiomorphic granular, locally grades to panidiomorphic granular dioritic rock. Consists mostly of euhedral to subhedral plagioclase and variable amounts of euhedral hornblende, pyroxene, and biotite; interstitial quartz ranges from trace to 15 percent. There are two major but intergradational rock types: one is medium grained and contains 10-20 percent mafic minerals and 10-15 percent quartz; the other is fine grained and contains 20-40 percent mafic minerals and trace to 10 percent quartz. Common in both types are irregular masses of coarse-grained rock containing euhedral hornblende as much as 4 cm long or euhedral pyroxene as much as 2 cm wide. Plagioclase shows slight to moderate alteration to sericite and clay, and mafic minerals are altered to uralite, epidote, biotite, and chlorite.

TKdp

Hypabyssal dioritic rocks (Early Tertiary or Late Cretaceous)

Diorite porphyry occurs as thin sills, dikes, and small irregular masses intruding Apache Group and Paleozoic strata from Superior to the Globe Hills, but is most common in the western part of the Inspiration quadrangle. The rock is generally deeply weathered and crops out only in the most favorable places. The most extensive outcrops are in the lower part of the Pioneer formation or along the base of the Scanlan conglomerate. Contacts between diabase and the Pioneer formation are a common locus of diorite porphyry intrusions. Color is very light-gray to medium-gray. The phenocrysts are white or yellowish-gray plagioclase, as much as 5 mm long. The only other mineral recognizable in hand specimens is hornblende, in minute greenish-black prisms.
The diorite porphyry is clearly younger than the diabase. Several fragments of it have been found in the Whitetail conglomerate northwest of Continental Spring. The dike in diabase north of the Old Dominion "A" shaft is mineralized with pyrite and chalcopyrite on the tenth level of the mine.

TKap

Aplite or pegmatite dikes (Early Tertiary or Late Cretaceous)

Aplite to pegmatite dikes associated with Laramide plutons

Kbx

Breccia (Late Cretaceous)

Locally flow-banded breccia composed of fragments of volcanic rocks, diorite, Pinal Schist, and Middle Proterozoic coarse-grained granite in a semicircular mass about 1.2 km east of The Spine (UTM 497000E, 3665500N). Quartz and feldspar crystals in volcanic rock clasts are generally rounded (comminution?). Matrix is medium to dark gray and very fine-grained to aphanitic, with scattered 1-4 mm diameter xenocrysts(?) of quartz and feldspar. Matrix is similar to very-fine-grained phases in diorite core (Kd) of breccia. Lenses and pods of marble present in breccia are partially or completely altered to epidote-actinolite skam; sparse vitreous quartzite clasts are also present. The marble and quartzite association suggests derivation from Paleozoic or Apache Group units, but some of the carbonate may be secondary. Sulfide mineralization (pyrite) is associated with the skam inclusions. Interpreted as intrusive breccia [Creasey et al., 1983] associated with diorite (Kd). Laramide dikes cut breccia. Intruded into or overlies Proterozoic coarse-grained granite (Yg), contact appears sharp. Contact with diorite (TKd) is gradational.

Pzs

Paleozoic strata (Paleozoic)

Undivided sandstone, dolostone, and limestone of Paleozoic age.

Pn

Naco Formation (Pennsylvanian)

Light-gray, tan, and yellow, thin bedded, non-resistant shale limestone and shale. Fusulinids and brachiopods are common. Local terra rosa weathering residuum 0-30 m thick at base of section consists of red silty clay and a chaotic mixture of red clay and limestone blocks. Incomplete section exposed in upper Pine Creek. Thickness about 30 m

Me

Escabrosa Limestone (Mississippian)

Gray to blue-gray massive crystalline limestone in beds up to 3 m thick. Crinoid columnals abundant; corals abundant in some beds. Forms prominent, cliffy outcrops. Some parts contain abundant chert. Black chert bands prominent near base of formation. Minor interbedded silty or marly limestone. Top is variably developed karst zone with clasts of limestone in a red-brown clay matrix. Keith [1983] describes an upper unit he named the Eskimin-zin formation that overlies karsted horizon at the top of the Escabrosa Limestone; this unit (0-110 feet thick) consists of pink to yellowish orange unfossiliferous fine-grained to aphanitic dolomite. -Lower contact with thinner bedded, generally slope-forming Martin Formation is sharp and usually clear. Upper contact with Naco formation is subtle change to more ledgy outcrop.

Dm

Martin Formation (Upper and Middle? Devonian)

Medium-gray, fine- to medium-grained, thin- to medium-bedded, commonly laminated dolomite and subordinate limestone. Contains scattered angular quartz silt. Basal beds emit fetid petroliferous odor when broken. Chert nodules occur throughout the member and are particularly common in the lower half. Abundant bryozoans, corals, and brachiopods locally in upper part of the member. Weathers medium- to light-gray locally with yellow, red, or brown hues. Forms slopes with ledges. Incomplete section in Limestone Hills is about 65 m thick Beckers Butte Member (Upper or Middle? Devonian)-Pale red-purple to pale red, locally reddish brownish-orange, dolomitic sandstone and minor medium-gray aphanitic dolomite at top-Sandstone is fine- to medium-grained, commonly containing 5-20 percent scattered rounded quartz grains 1-2 mm across. Bedding poorly expressed but generally thin and locally emphasized by lenticular laminations of very coarse quartz grains and chert fragments. Pebble conglomerate 2.5 m thick at base contains clasts of rhyolite, quartzite, and chert. Light-gray, medium-grained, well-indurated sandstone as much as 1.2 m thick occurs at top of sandstone part of the member. Aphanitic dolomite at top consists of thin beds and is about 1 m thick. Thickness 0-11m

Cba

Bolsa Quartzite and Abrigo Formation (Middle Cambrian)

Maroon-gray feldspathic sandstone. Grit and pebble conglomerate at the base grade up into medium- to fine-grained sandstone with siltstone partings up section. Planar tabular cross beds are common in quartzite beds in the lower part. Brick-red to light gray, fine- to medium-grained, well sorted and bedded sandstone. Abundant iron oxide gives rock red color. Commonly preserved in channels cut into underlying rock units. Lithologic distinction from Troy quartzite is cryptic; depositional contact on top of diabase is only sure way to distinguish units. Bolsa-Abrigo transition is a gradation into dark gray, maroon and gray-green sandy shale with a few thin, locally bioturbated siltstone beds. Disconformably overlies Precambrian rocks, typically on a deeply weathered zone. Unconformably on Proterozoic diabase (Ydb) or Troy Quartzite. Contact with Martin formation is abrupt transition to carbonate deposition.

_Ytb

Troy or Bolsa Quartzite (Middle Proterozoic or Cambrian)

Rusty-red, pink and tan, medium- to coarse-grained and grit-sized, moderately to poorly sorted, locally massive quartzite. Beds are 0.3 to 1.5 m thick. Conglomeratic unit typically is present at the base, and contains clasts of underlying units. Does not part prominently along bedding surfaces; bedding is delineated by grain size variation in sandstone. Troughy and planar tabular crossbedding is common. Sandstone lacks prominent pinkish feldspar grains characteristic of Dripping Spring Quartzite. In the Troy, pebbly conglomerate lenses and beds and individual pebbles of quartz or chert are present throughout the unit. Bolsa typically forms a more uniformly fining-upward sequence with thinner bedded and finer grained quartzite with more clearly defined bedding partings in the upper part. Lithologically, quartzites in the two units are very similar. Troy Quartzite is intruded irregularly by diabase sills (Ydb) and disconformably overlies basalt (Yb) or Mescal Limestone. Bolsa Quartzite disconformably overlies Troy, diabase, or older Proterozoic granitic or metamorphic rocks.

Ya

Apache Group, Troy Quartzite, and diabase (Middle Proterozoic)

Undivided in structurally complex zones.

Ydb

Diabase (Middle Proterozoic)

Dibased dikes, sills, and irregular intrusive bodies of greenish-black, fine- to medium-grained diabase that intrude Apache Group and Troy quartzite.

Yb

Basalt, Apache group (Middle Proterozoic)

Dark-gray to dark-brown aphanitic rock composed of microscopic plagioclase tablets partly altered to clay and calcite, and pyroxene and olivine largely altered to opaque oxides, serpentine, calcite, iddingsite, and other products. Locally vesicular and amygdaloidal. Some layers are volcanic breccia consisting of angular basalt blocks in a matrix of basaltic lava.

Ym

Mescal Limestone (Middle Proterozoic)

Medium-gray to light-brown to white dolomite and limestone; generally thin-bedded with undulating to even bedding planes. Texture generally aphanitic or fine grained, locally medium or coarse grained, crystalline. Black to light-brown variegated chert abundant in some beds as uneven layers alternating with carbonate or as irregular nodules. Near base is layer of poorly exposed breccia of angular cherty dolomite fragments in a matrix of silty, locally calcareous, dolomite. Near top an algal member contains abundant wavy concentric structures characteristic of stromatolites. Locally near intrusive bodies of diabase in southern part of quadrangle, seams of chrysotile asbestos occur parallel to bedding

Yds

Dripping Spring quartzite (Middle Proterozoic)

Light-gray to light brownish-gray, medium- to coarse-grained, feldspathic quartzite; shows distinct separation into beds which are thinly laminated and locally cross bedded only the lower part of the formation is present. Included with the Dripping Spring at its base, for convenience in mapping is the Barnes conglomerate which in this area ranges from a thin layer of coarse feldspathic sandstone containing a few scattered pebbles to a 6-foot-thick bed of closely packed ellipsoidal pebbles of hard vitreous quartzite, white vein quartz, and red jasper

Yp

Pioneer Formation (Middle Proterozoic)

Three members, from the base: Scanlan Conglomerate Member (generally 1-4 ft, locally as much as 18 ft)-Well-rounded to subangular pebbles of white quartz, locally abundant, and angular pebbles and granules of schist in a matrix of grayish-red-purple, very coarse grained, poorly sorted rock chips and arkosic sandstone.
Arkose member -- Arkose and feldspathic quartzite and sandstone, light-brown to dark-brown to dusky-red-purple, medium- to thin-bedded. Sandy beds separated by thin beds of siltstone and shale. Number and thickness of siltstone beds increase upward so that upper part of member contains equal amounts of arkose and siltstone.
Siltstone member--Thin-bedded siltstone, shale, and fine-grained arkose, dusky-purple and dusky-red, speckled by light-brown to greenish-yellow spots. Siltstone and shale are tuffaceous. Typically weathers to small, flat, angular flakes. Total thickness of unit is typically about 300 feet thick.

XYgp

Granite and schist (Middle Proterozoic and Early Proterozoic)

Zones of biotite granite (Oracle granite) with abundant, partially resorbed inclusions of Pinal schist. Mixed zones are common in contacts between these units. Gradational contacts into homogeneous granite.

Yi

Quartz-feldspar porphyry dikes (Middle Proterozoic).

These dikes contain subhedral cloudy- to clear-grey quartz and light grey K-feldspar from 2-8 mm wide in a light grey aphanitic matrix. Contains rare biotite locally. Feldspar is commonly sericitized and weathers chalky white. Forms resistant ridges. Intrudes quartz monzonite (map unit Xg) and is intruded by the medium-grained granite (map unit Ygf)

Ygrp

Pegmatite, two-mica granite (Middle Proterozoic)

No description given

Ygf

Fine- to medium-grained granite, locally with two micas (Middle Proterozoic)

This granite is mostly equigranular but locally sparsely K-feldspar porphyritic with light tan K-feldspar phenocrysts rarely up to 2.5 cm long. Contains anhedral to subhedral crystals of clear quartz, biotite, K-feldspar, and plagioclase. Typically weathers into smaller, angular blocks instead of large spheroidal boulders. Weathered surfaces have a sugary granular texture. The rock is cut by aplite dikes. Includes McDowell Pass Granite.

Yg

Coarse grained porphyritic granitoid (middle Proterozoic, Carefree, Oracle, Ruin, McDowell Pass)

Light brown to light gray porphyritic biotite granite; contains 2-8 cm diameter phenocrysts of K-feldspar in a coarse-grained groundmass of plagioclase, quartz, K-feldspar and biotite. Accessory apatite, zircon, magnetite and rare sphene are present. Weathers rapidly to grus. Thin aplite-pegmatite dikes are common. Intrudes Pinal Schist, and intruded by various Laramide plutons and dikes. Contact with Pinal Schist east of The Spine is a mixed zone with abundant screens and xenoliths of schist in granite near contact. Overlain by Apache Leap Tuff (Tal) and Whitetail conglomerate on erosional unconformity with significant relief.

YXrw

Equigranular granitic intrusive rock (Early Proterozoic)

Equigranular, unfoliated, medium to fine grained granite or granodiorite with local marginal aplitic zones. Generally contains 7-10% mica, including both biotite and muscovite, but their relative abundance varies greatly. More muscovite-rich granite appears to have assimilated more Pinal Schist and is generally associated with gradational assimilation zones and broader contact aureoles. The granite near the contacts in this pluton is slightly foliated. West of Reymert Wash, this phase contains abundant partially digested inclusions of Pinal Schist

YXfm

Granitoid (Middle or Early Proterozoic)

Medium-grained, equigranular quartz monzonite containing 1-5 mm phenocrysts of subhedral white feldspar (probably plagioclase), about 2% grey milky quartz, and abundant dark green clumps of biotite. Dark grey-green on fresh and weathered surfaces. Does not appear foliated. Forms lens-like bodies within map unit YXfg and probably intrudes it.

YXha

Hornblendite (Early or Middle Proterozoic)

Fine to coarse grained hornblendite, consisting of 70-90% hornblende with anhedral plagioclase, and common secondary(?) epidote. Rock is black. Interpreted to be related to Madera Superunit based on proximity to granitic rocks of Reymert Wash

Xgn — **Highly sheared felsic igneous rocks (Early Proterozoic)**

Highly deformed leucocratic gneiss, contains leucosomes of quartz and feldspar, and quartz and muscovite. Locally it is very fine-grained quartz-feldspar-sericite phyllite, and resembles deformed rhyolite. In other places it resembles deformed, interbedded rhyolite and quartzite.

Xbca — **Amphibolite**

Dark green amphibolite in thin screens in felsic metavolcanic rocks of Browns Cave.

Xmi — **Mafic to intermediate hypabyssal intrusive rocks (Early Proterozoic)**

Dark green lenticular intrusive rock containing phenocrysts of plagioclase and hornblende(?), in a dark green aphanitic matrix. Also includes basaltic rocks apparently intruding Mazatzal Quartzite and non foliated fine-grained diorite intruding Alder group in the Slate Creek Shear zone area.

Xqp — **Porphyritic granitic hypabyssal intrusive rocks**

A variety of porphyritic intrusive rocks with fine-grained granitic composition groundmass, typically with quartz, K-feldspar or plagioclase phenocrysts 1-4 mm. Generally pinkish color, dark grey in some areas.

Xvrg — **Pink to reddish mostly equigranular granitoid (Early Proterozoic)**

Pink to red fine to coarse-grained mostly equigranular granitoid, Verde River Red Granite Batholith of Anderson (1989). Includes Sheep Mountain Granophyre between Humboldt Mountain and the Verde River, and rocks mapped as Payson granite SE of Humboldt Mountain on the west side of the Verde River

Xg — **Granite (Early Proterozoic)**

Medium-grained granitoid, foliated or non-foliated. Includes Lost Gulch Quartz Monzonite. Mostly equigranular, slightly porphyritic in some areas.

Xtp — **Fine-grained leucocratic granitic rocks (Early Proterozoic)**

Quartz and potassium feldspar porphyritic, fine-grained leucogranite matrix porphyry.

Xdgv — **Granophyre (Early Proterozoic)**

Red, brown, and tan, leucocratic granophyre with miarolitic cavities. Has quartz and alkali feldspar phenocrysts in a micrographic groundmass. Mafic minerals are largely altered to hematite and muscovite. Contains red to brown, fine-grained, equigranular aplite bodies and masses that grade into granophyre.

Xgc — **Porphyritic granitoid (Early Proterozoic)**

Leucocratic, pink-weathering, medium-grained, equigranular to slightly K-spar porphyritic quartz monzonite. This pluton is completely post-kinematic with respect to the host rocks in the area, but it is considered early Proterozoic because of its similarity to the Verde Valley granites of the easterly adjacent Humboldt Mt. quadrangle (Gilbert and others, 1998), and other granitoids of this map area (Grays Gulch) which are clearly concordant with respect to bedding

Xagd — **Granodiorite (Early Proterozoic)**

Equigranular biotite granodiorite, grain size typically 2-4 mm. Contains 4-6%, locally up to 20%, biotite. Some phases contain hornblende in elongate prisms. Only locally foliated, especially near contacts where granodiorite intrudes Pinal Schist.

Xbd — **Dioritic intrusive rock (Early Proterozoic)**

Fine- to medium-grained weakly foliated to non-foliated diorite, small lenticular bodies spatially associated with Bland Tonalite.

Xct — **Dioritic to granodioritic intrusive rock (Early Proterozoic) tonalite**

Medium- to medium-coarse-grained hornblende-biotite diorite to granodiorite containing phenocrysts of hornblende (Anderson and Creasey, 1967). Includes tonalite of Cherry (DeWitt, 1989), and part of Cherry batholith (Anderson, 1989a). Newly named herein for exposures near Cherry. Undeformed in most outcrops, but mildly to strongly flow foliated in places. Strongly deformed along Shylock fault and Shylock high-strain zone in southwestern Black Hills. Hosts gold-bearing quartz veins in Cherry district that are genetically related to the tonalite (Clements, 1991).
Age of sample from near Cherry, from U-Pb zircon analyses, is 1,740 Ma (Anderson and others, 1971). Conflicting age (cuts 1,720-Ma Bland Tonalite but has U-Pb zircon age of 1,740 Ma) may be due to more than one tonalite body within a composite pluton (Anderson, 1989a)

Xcfg — **Gabbroic intrusive rock (Early Proterozoic)**

Medium- to coarse-grained, equigranular, hornblende-rich gabbro-norite, gabbro, and gabbro-diorite. Undeformed and only mildly metamorphosed in Black Hills. Unit mapped on USGS map 2996, no description provided.

Xbmm — **Intermediate to basic composition igneous complex (Early Protorozoic) diorite metabasite tonalite**

Mafic igneous complex consisting mostly of fine- to medium-grained diorite with lesser metabasite and tonalite.

Xu — **Supracrustal rocks (Early Proterozoic)**

Metamorphosed volcanic and sedimentary rocks undivided.

Xp — **Metasedimentary rocks (Early Proterozoic)**

Undivided generally very low to medium grade metasedimentary rocks, includes rocks mapped as Pinal Schist, and other sequences with mixed metasedimentary rock types.

Xcs — **Calc silicate or marble metasedimentary rocks (Early Proterozoic)**

Generally thin layers of marble or calcite-epidote-quartz rich calc silicate metamorphic rock. Marble typically gray to white.

Xsq — **Quartzose metasedimentary rocks (Early Proterozoic)**

Quartzite and quartz-rich units interpreted to be derived from quartzsose sandstone units. Generally fine grained, light gray with pink, tan, purple or bluish hue. Bedding may be visible, including in some cases cross bedding delineated by magnetite rich laminations. Some units are interlayered with fine grained meta-clastic rocks or grit/pebble sandstone.

Xct — **Chert and metachert (Early Proterozoic)**

Unit containing abundant very fine grained siliceous hornfels or gneiss interpreted to be derived from chert or siliceous exhalites. Interlayered with gray argillite and chert-pebble in argillite conglomerate in some areas. Chert various colors, usually dark, commonly jasperoid (dark red).

Xsc — **Conglomeratic metasedimantary rocks (Early Protoerozic)**

Metaconglomerate, arkose, and pebbly feldspathic arenite; these rocks display abundant primary sedimentary structures. Non-foliated in some areas, contrasting with strongly foliated metavolcanic rocks they overlie; also in some cases observe weak foliation, sub-parallel to that which is pervasively displayed in the country rocks along the edges of this rock unit. May include some interleaved rhyolite tuff and related volcaniclastic conglomerate and/or breccia, and more rarely, dark-gray, very fine-grained marble.

Xsf — **Pelitic or phyllitic metasedimentary rocks (Early Proterozoic)**

This unit includes slate, phyllite and schist with abundant mica minerals. In some cases the protolith may be fine-grained tuffaceous rock. Lithology varies in different assemblages and with metamorphic grade, but well developed, penetrative schistosity is characteristic. Typical variety is bluish gray, dark gray, or silvery, fine-grained, muscovite-biotite schist with numerous, variably folded hydrothermal quartz stringers. Foliation is defined by compositional layering, phyllosilicate orientation, and quartz segregations. Compositional layers in schist tends to be thin to very thin (2-15 mm). Quartz stringers are irregular but are commonly approximately parallel to fabric defined by phyllosilicate orientation. Quartz veins in thickened fold hinges locally form rods visible on foliation surfaces and may be parallel to crenulation fold axes. Weak lineation in some areas is an intersection between dominant foliation and axial surface cleavage of over-printing crenulation, and in other areas is a mineral lineation parallel to hinges of isoclinal folds. Interbedded sandstone layers are not unusual.

Xsv — **Volcanic lithic metasedimentary rocks, very low to low grade (Early Protoerozoic)**

Metamorphic rocks with relict texture and structure indicating derivation from volcanic-lithic protolith. Distinguished from volcanic protolith by compositional heterogeneity and relict sedimentary structure. Deformation and metamorphic grade variable, ranging from cleaved very low-grade rock with clear sedimentary bedding and structures to intensly foliated phyllite or schist with subtle relict structure and clastic texture, and greenschist to lower-amphibolite facies mineral assemblages. Protoliths interpreted as medium to coarse-grained, poorly sorted, faintly bedded volcanic sandstone, gravelly volcanic wackes, sedimentary breccias, cobble conglomerate, minor shale, and breccia, with occasional limestone, dolomite, or bedded chert.

Xsp — **Quartzo-feldspathic metasedimentary rocks (psammite) (Early Prototerozoic**

Fine grained, tan weathering psammitic schist in which bedding is locally visible. Grain size typically in sand range, with grains consisting primarily of quartz, minor feldspar, and sparse to very sparse lithic fragments. Protolith is inferred to have ranged from massive medium- to coarse-grained sandstone to interbedded thin- to medium-bedded, shale, siltstone, and sandstone, generally more quartz and feldspar-rich (compositionally mature) than protolith of volcanic-lithic metasedimentary unit (Xsv).

Xsh — **Very low-grade, fine-grained metasedimentary rocks (Early Proterozoic)**

Relatively undeformed fine-grained sedimetnary rock described on source maps as shale, siltstone, mudstone, argillite, fine-grained sandstone or similar terms. Laminated to, thin-bedded shale and sparse, thin siltstone or sandstone interbeds. Locally associated with volcanic breccia or conglomerate; interbedded sandstone is common.

Xvf

Felsic meta-volcanic rocks (Early Proterozoic)

Generally low-grade metamorphic rocks interpreted to be derived from felsic volcanic rocks, mostly based on relict quartz phenocrysts. Rock may be massive, flow-banded, fragmental, or have preserved eutaxitic foliation. In more deformed outcrops distinction of tectonic foliation from eutaxitic foliation may be difficult. Porphyroblasts (relict phenocryts) of subhedral, partially rounded light grey feldspar 2-4 mm, partially rounded quartz up to about 8 mm, smaller anhedral to subhedral biotite and minor muscovite in varying proportions are typical. Aphanitic matrix is the norm, may be altered to sericitic phyllite in deformed area. Crystals are more easily seen on weathered surfaces. Exhibits shades of pink, green, and grey. This unit includes mixed lava and welded tuff, or rocks for which lava or welded tuff origin is not determined. Generally resistant and forms steep hills with blocky, angular clasts where foliation is not well developed.

Xvft

Felsic metavolcanic pyroclastic rocks (Early Proterozoic)

This rock is mineralogically similar to the felsic metavolcanic unit (Xvf), but is distinguished by evidence for dominantly pyroclastic origin, in the form of fiamme, lithic fragments in tuff, or lithologic layering. The clasts are best seen on weathered outcrops.

Xvfe

Felsic meta-volcanic lava flows (Early Proterozoic)

Rock mineralogically identical to felsic metavolcanic unit (Xvf), distinguished by evidence for dominant origin as lava flows, including flow-banding, autobreccia textures, irregular lithosome boundaries, lack of fiamme.

Xva

Intermediate composition metavolcanic rocks (Early Proterozoic)

Metamorphic rock interpreted to be derived from dacitic to andesitic protolith, characterized by generally medium to dark grayish colors, relict plagioclase and mafic-mineral phenocrysts, with sparse or no phenocrystic quartz. Epidote and chlorite are pervasive metamorphic or alteration products. Rock is massive in some areas (Mount Ord), making distinction of hypabyssal or extrusive origin difficult. Observation of relict fragmental texture commonly requires a perfectly weathered surface. These rocks likely represent an assemblage of hypabyssal intrusions to extrusive flows

Xvb

Mafic to intermediate composition metavolcanic rocks (Early Proterozoic)

Mafic to intermediate composition lava flows, dacitic volcanic breccia, subaqueous lithic tuff, mafic flows and pillow lava, and bedded chert, all sheared and metamorphosed to low grade.

Xvm

Mafic metavolcanic rocks (Early Proterozoic)

Generally dark colored metamorphic rocks interpreted to be derived largely from mafic volcanic rocks. Includes dark gray-green,strongly foliated fine-grained biotite-amphibole schist containing 1-3 mm anhedral black amphibole porphyroblasts in the McDowell Mountains. In the Cave Creek area is less foliated, lower grade, generally massive, with zones preserving fragmental texture or even pillow structure.

Xme

Melange, pillow basalt, and chert complex (Early Proterozoic)

Blocks of carbonate and siltstone in a disrupted slate matrix. Cross-bedded quartz-arenite lenses and beds are enclosed this unit. Mixing of rocks types is considered to predate deformation and metamophism. Melange term is used in a non-genetic sense; mixing might be subduction related tectonic or related to slope failure forming olistrostromes.

Xcb

Chloritic or biotitic schist, locally with amphibolite, chert, or calcsilicate rock (Early Proterozoic)

Quartz-sericite schist, chloritic schist, and amphibolite schist, locally including zones of ferruginous chert, rusty calcareous schist and marble. Only outcrops along west side of Black Canyon in extreme NW part of compilation area

Xrh

Felsic hypabyssal rocks (Early Proterozoic)

Massive intrusive rhyolitic rocks, characterized by homogeneous textural and structural character.

Xdc

Mafic sheeted dike complex (Early Proterozoic)

Rock body consisting of coalescing aphanatic mafic dikes with parallel chilled margins with sparse granitoid screens between dikes.

Xam

Mixed amphibolite and metasedimentary rocks (Early Proteorozic)

Interlayered quartzo-feldspathic or micaceous schist and dark green to black fined-grained amphibolite, some layers of quartzite.

q

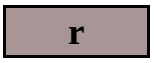
Hydrothermal quartz (Proterozoic, Laramide, or middle Tertiary)

White bull quartz forming prominent outcrops. No metallic minerals detected.

fe

Ferruginous alteration zone

Characterized by reddish or orange staining of rock by iron oxide minerals, typically associated with silicification of rock.



Bedrock (pre Quaternary)

Rock outcrop of uncertain age or affinity