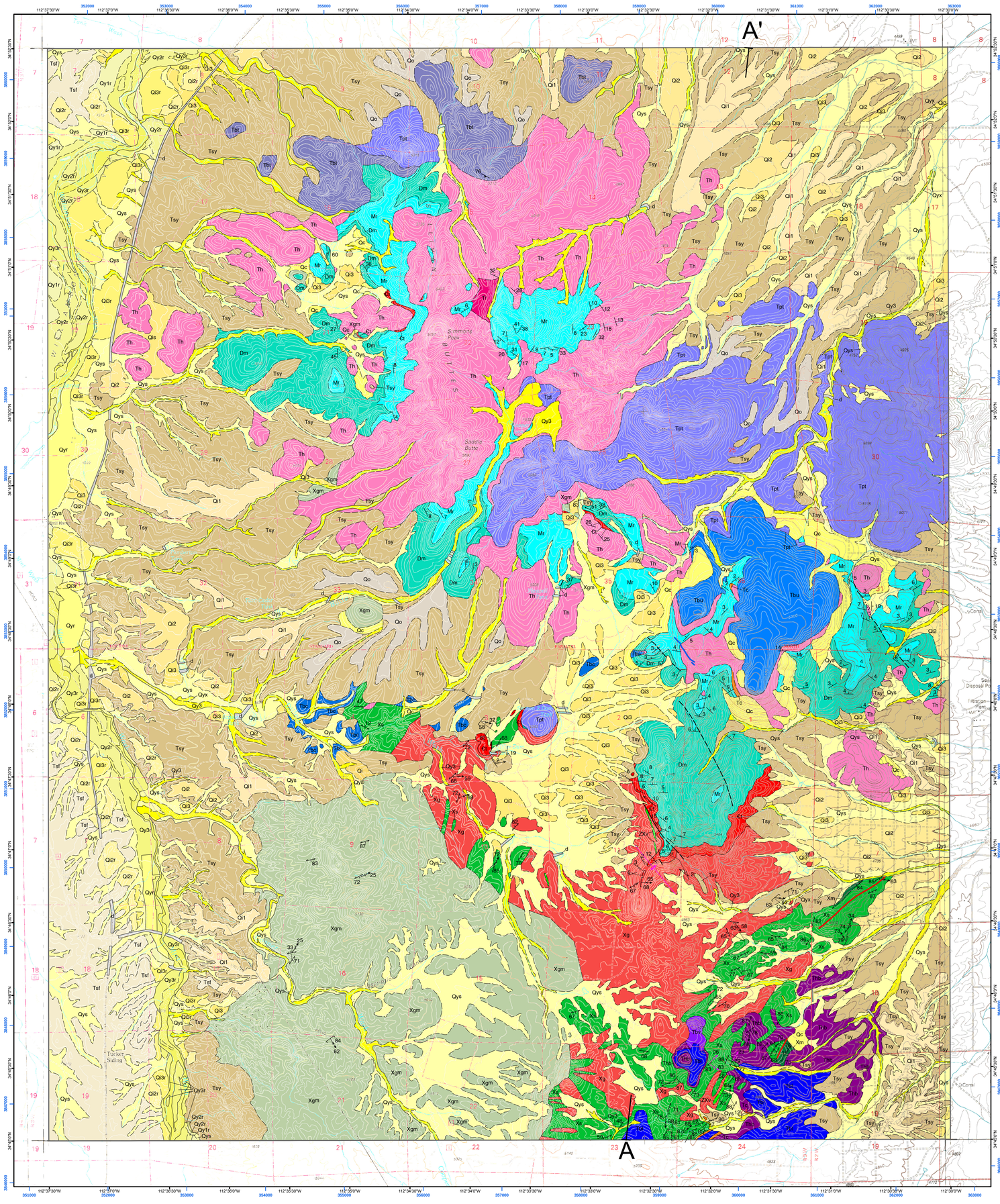

Topographic base from USGS 1:24,000 Quadrangle Series; generated using iGage All Topo Pro software
Contour interval: 10 feet (low relief areas), 40 feet (high relief areas)

Projection: UTM Zone 12N
Datum: NAD83

scale 1:24,000

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Feet

1 0.5 0 1 Miles

1 0.5 0 1 Kilometers

GEOLOGIC MAP OF THE SULLIVAN BUTTES 7 ½' QUADRANGLE, YAVAPAI COUNTY, ARIZONA

Arizona Geological Survey Digital Geologic Map DGM-102, Version 1.0
Scale 1:24,000

by
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October 2013

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Geologic Map Units

d — **Disturbed ground** - Areas profoundly disturbed by human activities. Includes gravel pits, earthen berms for stocktanks, substantial road berms, and railroad grades.

Piedmont Deposits

Qyo — **Active tributary alluvium** - Deposits in channels, bars, low terraces, and small active alluvial fans. This unit is composed of moderately-sorted sand, silt, pebbles and cobbles. Channels typically are incised less than 6 ft (2 m) below adjacent late Holocene terraces and alluvial fans. Channel morphologies consist of single-thread, deeper channels and multi-threaded, shallower channels.

Qyx — **Areas of active arroyo development** - Areas where valley-bottom deposits are being eroded due to arroyo development. Includes flat-bottomed to undulating channels with sand and gravel deposits, and eroded, typically fairly steep slopes. Arroyos are developing almost entirely in fine-grained Qys deposits. Many arroyo areas are too small to depict at the map scale.

Qys — **Fine-grained valley deposits** - Laterally extensive, unconsolidated fine-grained alluvium in valley bottoms and manting the lower parts of adjacent slopes. These sediments are dark brown to light gray in color and consist of sand, silt, clay and gravel. In valley axes, these deposits are primarily silt and sand beds, and dark, weakly developed buried soils are common. Gravel makes up a small percentage of these deposits and typically gravel beds are thin and discontinuous. Along a few larger washes, thicker and more extensive gravel beds were observed. Qys deposits mantle the toes of slopes formed on bedrock and eroded older basin deposits. In these areas, Qys deposits are commonly more gravel-rich.

Qis — **Intermediate fine-grained deposits** - Unconsolidated to weakly consolidated fine-grained deposits derived primarily from fine-grained basin deposits. Deposits are primarily sand, silt and clay, with minor gravel clasts of limestone. Surfaces are smooth ti gently undulating, and orange to reddish brown. Soil development is moderate, with some clay accumulation and stage II-III calcic horizons.

Qio — **Younger intermediate alluvial fan and terrace deposits** - Gravelly alluvial fan and terrace deposits 3 to 20 ft (1 - 6 m) above active washes. Qi3 deposits are unconsolidated fine to coarse alluvium consisting of pebbles, cobbles, sand, and silt, with minor clay. Clasts include predominantly granite, metasedimentary, latite, limestone, and basalt, depending on the dominant lithologies upslope. Clasts are angular to subrounded. Soils typically are reddish-brown with moderate calcium carbonate accumulation (stage II-III). Soil color varies from orange to white due to differences in parent material.

Qio — **Older intermediate alluvial fan deposits** - Unconsolidated to weakly cemented coarse-grained alluvium forming moderately dissected alluvial fans and intermediate terraces. Clast lithologies include granite, metasediments, latite limestone, dolomite, and basalt. These deposits generally exhibit reddish-brown soils and moderate to strong calcium carbonate accumulation (stage II to IV). Varnish and pavement development are variable, ranging from none to moderately strong, but gravel lags are common. These surfaces are typically 20 to 50 ft (6-15 m) above active channels.

Qi — **Intermediate terrace and fan deposits** - Intermediate gravelly terrace and alluvial fan deposits, undivided

Qir — **High relict alluvial fan deposits** - Alluvial fan deposits forming relatively narrow planar surfaces to broadly rounded ridges. Qi1 fans are between 40 to 100 ft (10-30 m) above active washes. Qi1 deposits are unconsolidated to poorly cemented, coarse-grained alluvium consisting of cobbles, pebbles, sand, boulders with minor silt and clay. Clasts are generally subangular to subrounded. Rock varnish and desert pavement are weak to moderate. Qi1 deposits exhibit moderate to strong calcium carbonate accumulation (stage III to IV).

Qo — **Very high relict alluvial fan deposits** - Highest preserved alluvial fan deposits preserved on the uppermost piedmonts around Sullivan Buttes, capping the highest basin-fill deposits. Deposits typically are poorly exposed, but surface gravel consists of cobbles, boulders, pebbles and fines. Surfaces are planar to moderately rounded, with well-rounded edges. Preserved fan surfaces exhibit variable rock varnish and is grayish brown to reddish brown in color.

Qc — **Colluvium and talus** - Poorly to very poorly sorted, moderately bedded, angular to subangular cobble and pebble deposits colluvium on steep slopes. Most deposits are derived from adjacent bedrock outcrops, but some are derived from high ridges of gravelly basin-fill deposits.

Tsy — **Younger siliciclastic rocks** - Poorly exposed conglomerate with some finer-grained beds. Deposits are typically weakly indurated and form low hills and ridges flanking bedrock uplands. The relative abundance of conglomerate to fines depends on the proximity to bedrock uplands. Subangular to sub-rounded clasts match bedrock outcrops in nearby uplands. Exposed thickness ranges from 0 to 100 feet (0 to 30 m). In the north, the unit is strongly volcaniclastic. In the south it is composed chiefly of Proterozoic schist and granite, and Paleozoic sedimentary clasts.

Axial Valley Deposits Associated with Williamson Valley and Mint Washes

Qyr — **Active river channel deposits** - Unconsolidated, very poorly sorted sandy to cobbly beds exhibiting bar and swale microtopography. Clasts are subangular to well-rounded. Clast lithologies include granite, metasediments, metavolcanics, latite and basalt, limestone and chert. Qyr deposits are typically unvegetated to lightly vegetated and exhibit no soil development. Qyr deposits are entrenched from 3 to 15 ft (1-5 m) below adjacent historical floodplain deposits, and are subject to inundation in most flow events.

Qyr — **Low terrace deposits** - Very young terrace deposits that occupy elevations from 3 to 6 ft (1-2 m) above active channels, are inset below the pre-incision historical floodplain, and form most of the modern floodplain. These surfaces are planar to rounded, and locally exhibit bar and swale microtopography. Deposits are poorly sorted silt, sand, pebbles and cobbles, but commonly are fine-grained at the surface. Pebbles and cobbles are well-rounded to sub-angular. These surfaces are subject to inundation in moderate to large floods.

Qyr — **Valley bottom deposits** - Floodplain deposits that formed valley floors prior to recent entrenchment of the larger washes in the valley. Qy2r deposits form broadly planar surfaces that locally retain the shape of historical river meanders and abandoned channels. Qy2r surfaces are 5 to 15 ft (1.5-5 m) above modern channels and are quite extensive. These deposits are predominantly fine grained at the surface, but exposures along incised channels reveal interfingering coarse sandy to pebbly braided channel and fine sand layers within predominantly fine sand, silt and clay deposits. Buried, moderately organic-rich soils were observed in many exposures. Where Qy2r deposits are moderately to deeply incised they not subject to inundation by river floods, but they may be flood-prone in areas with less channel incision.

Qyr — **Young river alluvium, undivided** - Young river terrace deposits that have been altered and partially obscured by human activity. These deposits generally consist of Qy3r and Qy2r deposits, but may include some young tributary fan deposits.

Qyr — **Older valley-bottom deposits** - Sand, silt, and gravel deposits associated with slightly higher terraces that are remnants of older Holocene aggradation periods. Soil development is moderate and surface color is gray to brown. Weak calcium carbonate accumulation is evident on the undersides of some buried clasts. Qy1r surfaces are commonly 1 to 6 ft (0.3-2 m) higher than adjacent Qy2r surfaces.

Qior — **Younger intermediate terrace deposits** - Weakly consolidated, gravell river terrace deposits 10 to 30 ft above active channels. Gravel clasts are fairly diverse lithologically, including granite, metasediments and metavolcanics, limestone, basalt and latite. Clasts are subangular to well-rounded. Deposits also include sand, silt and minor clay. Soil development consists of Stage II calcic horizon development and reddened cambic or weak argillic horizons. Surface color typically is light orange.

Qior — **Older intermediate terrace deposits** - Reddish to orange gravelly terrace deposits that occupy higher positions in the landscape. Terrace surfaces are slightly to moderately rounded. Clast composition is diverse. Well-rounded pebbles to cobbles with stage calcium carbonate accumulation commonly litter Qi2r surfaces. Qi2r soils are moderately well developed, with reddened (5YR) argillic horizons, obvious clay skins and subangular to angular blocky structure where surfaces are well-preserved. Underlying soil carbonate development is typically stage II to III, with abundant carbonate through at least 1 m of the soil profile.

Tsf — **Slopes formed on fine-grained basin-fill deposits** - Slopes underlain by fine-grained basin-fill deposits. Deposits commonly are sand, silt and clay, with scattered clasts of reworked carbonate and gravel derived from old river terraces and alluvial fans. Soil development is generally weak.

Bedrock units

Tbu — **Upper basalt** - Basalt lava containing up to 10% <3 mm olivine phenocrysts, with <5% <2 mm pyroxene, and minor <2mm plagioclase.

Tbc — **Basalt of Crossroads Ranch** - Basaltic lava containing up to 10% <2 mm olivine (altered to iddingsite) phenocrysts with sparse pyroxene and plagioclase <1 mm. The lava occurs in the Crossroads Ranch area in the west-central part of the map area.

Tpt — **Pyroxene-porphyritic volcanic rocks** - Pyroxene-porphyritic trachyte and trachyandesite lava, lava breccia and related pyroclastic rocks. Based on the petrography and geochemistry of Tinnin (2009) the lavas contain 10-20% clinopyroxene up to 4mm with up to 10% biotite (<1.5mm), minor orthopyroxene (<0.5mm), plagioclase (<0.5mm), opaque oxides (<<0.5mm), and in the trachyte, minor quartz (<0.5mm). The lavas contain xenoliths of amphibolite, garnet pyroxenite, and eclogite (Schulze, 1977; Tinnin, 2009). Xenoliths are typically <5cm and consitute 1-5% of the rock, but locally are up to 50cm.

Tbt — **Biotite-trachyte lava** - Trachyte lava containing, based on the petrography of Tinnin (2009), 7% <1mm biotite phenocrysts with abundant <<0.5mm matrix biotite, and minor plagioclase (<0.2mm), clinopyroxene and orthopyroxene (<1mm), hornblende (<0.5mm), and opaque oxides (<<0.5mm). The lavas contain sparse (<1%) small (<2cm) xenoliths of amphibolite, garnet pyroxenite, and eclogite (Schulze, 1977; Tinnin, 2009).

Th — **Hornblende-porphyritic volcanic rocks** - Hornblende-porphyritic lavas and pyroclastic rocks were erupted from discrete volcanic centers that vary, based on the geochemistry of Tinnin (2009), in composition from trachyte (Tht), through dacite (Thd), to andesite (Tha). Based on the petrography of Tinnin (2009), the dominant phenocryst phase is hornblende (5-15% <2mm), with lesser amounts of biotite (2-10% <1.5mm), plagioclase (1-3% <1.5mm), clinopyroxene and orthopyroxene (<2% <2mm), opaque oxides (<1%, <0.5mm), and quartz (<<1%, <0.5mm). The lavas contain xenoliths of amphibolite, garnet pyroxenite, and eclogite (Schulze, 1977; Tinnin, 2009). Xenoliths are typically <5cm and consitute 1-5% of the rock, but locally are up to 50cm. The unit consists mostly of lava breccia, block and ash flows and related pyroclastic rocks that coalesce into a widely distributed apron that constitutes the bulk of the Sullivan Buttes volcanic field. Although it may be possible to differentiate the individual source volcanoes (Tinnin, 2009), which are shown as sub-units Tht, Thd, and Tha on his map, the strong petrologic similarity of each compositional variety makes it virtually impossible to differentiate the distal portions of the flows. The distal portions of the hornblende-porphyritic lavas were mapped as a single unit (Thbx) by Tinnin (2009).

Tr — **Rhyolite lava** - Phenocryst-poor rhyolite lava containing, based on the petrography of Tinnin (2009), ~10% <1.5mm phenocrysts of biotite, with minor clinopyroxene and orthopyroxene (<1.5mm), plagioclase (<0.5mm), quartz (<0.5mm) and opaque oxides (<<0.5mm). The rhyolite had been interpreted as younger than the hornblende-porphyritic lavas that surround it (Tinnin, 2009), but we recognize a contact along the north flank of the dome where hornblende-porphyritic lava breccia and tuff overlies the rhyolite.

Tbv — **Older basaltic rocks, undifferentiated** - Hornblende basalt (Thb), and lower basaltic rocks (Tbl) are not differentiated on the northern part of a hill in the NW/4 of section 24, Township 16N, Range 3W.

Thb — **Hornblende basalt** - Mafic lava containing up to 10% <2mm olivine (altered to iddingsite), and 2-5% conspicuous 2-5mm euhedral hornblende. The lava is interbedded with lower basaltic rocks (Tbl) in the southeastern corner of the map area.

Tbl — **Lower basaltic rocks** - Mafic lava and scoria. Basaltic lava and sparse scoria containing up to 10% <3mm phenocrysts of olivine (altered to iddingsite), pyroxene, and plagioclase. The flows are interbedded with the older conglomerate (Tc) and a hornblende basalt (Thb) in the southeast corner of the map area where the two types of lava cap a hill in the NW/4 of section 24, Township 16N, Range 3W. The hill appears to be the source of at least three flows, the upper and lower being olivine basalt, and the middle flow hornblende basalt.

Tc — **Conglomerate** - Conglomerate, pebbly sandstone, and lesser arkosic, lithic-rich sandstone. The conglomerate is rarely exposed, and is mapped primarily from float. Clasts consist of pink, medium-grained to granule quartz sandstone, granite, schist, and limestone/dolostone, and range in size from pebbles to cobbles, rarely boulders, and in shape from rounded to angular. Tertiary volcanic clasts (in rare exposures of outcrop) are absent and distinguish this unit from the younger, typically strongly volcaniclastic conglomerate and sandstone unit (Tcy) that overlies the Tertiary volcanics. In the southeast corner of the map area, non-volcaniclastic conglomerate is interbedded with the basal Mid-Tertiary volcanic units (Tbl).

Mr — **Redwall Limestone** - Cherty limestone, and minor dolostone. Medium- to thick-bedded, in mostly tabular, amalgamated sets. Carbonate of this unit is typically skeletal packstone and grainstone with abundant crinoid fragments and rugose coral. Chert typically occurs in rounded, bread-loaf shaped masses.

Dm — **Martin Limestone** - Dolostone, shale, and minor quartz sandstone. The unit is dominated by tabular sets of medium- to thick-bedded, variably recrystallized, light tan to brown and light gray to dark gray dolostone. The dolostone is commonly aglal laminated and cross-laminated. Interbeds of dark red to light green shale and medium-grained quartz sandstone make up as much as 20% of the unit. Quartz sandstone is most abundant in the lower part, particularly in transition downwards into the Tapeats Sandstone. The unit is characteristically devoid of recognizable fossils except for a sparsely preserved skeletal packstone near the base containing Atrypa brachiopods.

Ct — **Tapeats Sandstone** - Medium- to coarse-grained and locally granule and pebbly sandstone, typically cross-stratified in medium-bedded, tabular and wedge-shaped sets. Vein-quartz pebble conglomerate is abundant at the base of the formation. The vein quartz clasts are commonly angular to sub-angular, and at one locality occur as meter scale boulders in the hanging wall of an east-side-down normal fault in the NE/4 of section 11, Township 16N, Range 3W.

ZXv — **Quartz vein** - Massive white vein quartz and zones of concentrated quartz vein and quartz veinlet stockworks intruding light green to gray silicified schist. The veins and vein stockworks occur in north-striking masses up to 30m wide that intrude the metasedimentary rocks (Xs).

Xg — **Granite** - Medium- to coarse-grained equigranular granite with up to 15% biotite.

Xgm — **Granite and metasedimentary rocks** - Complexly intermixed granite and schist. Schist of the metasedimentary unit (Xs) becomes increasingly mixed with foliation-parallel granitic dikes to the west so that differentiation of the two units becomes problematic. Granite makes up 20-80% of the unit and occurs in medium- to coarse-grained concordant and discordant pegmatitic dikes with respect to foliation in the host coarse-grained sericite-biotite-quartz schist.

Xfe — **Ironstone and quartzite** - Thin-banded ironstone and quartzite occurs in a single 3-9 ft (1-3 m) thick bed typically associated with metavolcanic rocks (Xm).

Xs — **Metasedimentary rocks** - Quartz-sericite schist and psammitic schist that becomes coarser grained and increasingly more biotite-rich to the west. The rocks also increasingly include foliation-parallel granitic dikes to the west. To the east, compositional layering in these rocks is strongly reminiscent of relict bedding, and the schistosity is relatively fine-grained, and typically noticeably inclined with respect to the compositional layering. The schistosity is also axial planar with respect to minor folds of the compositional layering. The compositional layering is defined by alternations of mica-rich and quartz-rich (psammitic) bands typically in the cm range but also, rarely, up to a meter. Faint laminations are present in some of the bands reminiscent of parallel and ripple-laminations in turbidite sequences. Crenulation lineation(s) developed on schistosity surfaces is typically inclined with respect to the intersection of compositional layering and schistosity indicating multiple and/or progressive phases of deformation.

Xm — **Metavolcanic rocks** - Plagioclase-porphyritic lava, pillow lava, hyaloclastite breccia, and minor volcaniclastic rocks. Plagioclase phenocrysts up to 4mm, constitute up to 20% of the rock. Mafic phenocrysts are either altered or metamorphosed beyond recognition. Probable composition ranges from dacite to basalt.

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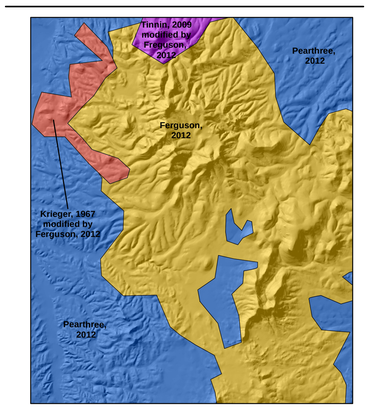
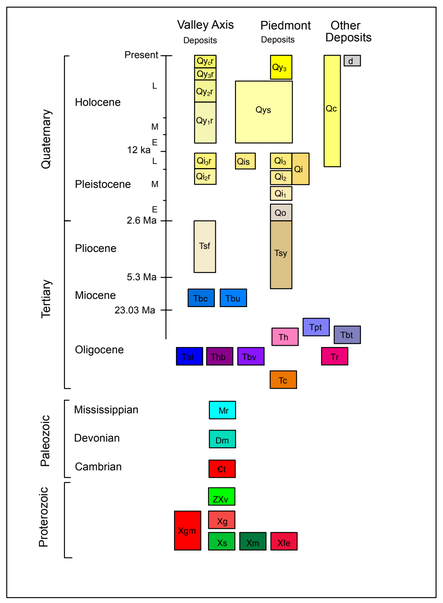
Mapping Responsibility



Map Unit Correlation Diagram



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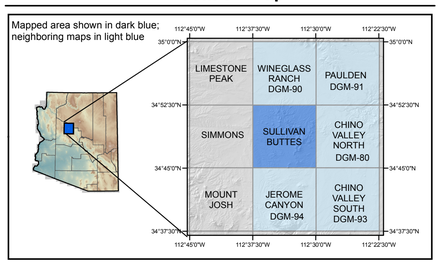
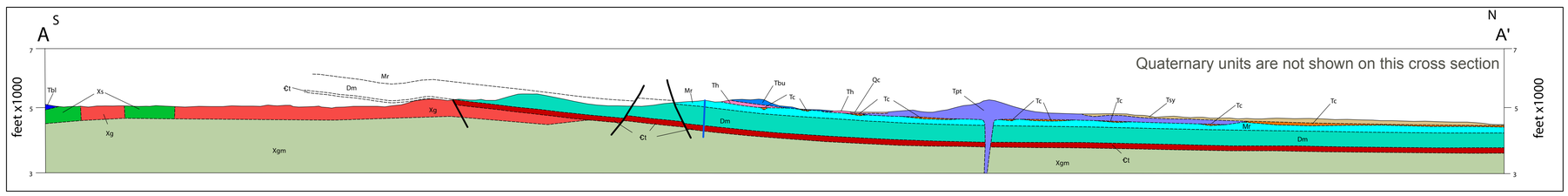
11°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2013

Location Map



Cross-Section



Line and Structure Symbol Descriptions

Contacts and Faults
- Accurate contact
- Approximate contact
- Accurate fault
- Approximate fault
- Concealed fault
- A — A' Cross-section line

Orientation Data
- 30 Inclined bedding, top direction unknown
- 30 Overturned bedding, top direction known
- 30 Inclined bedding, top direction known
- 30 Inclined cleavage
- 30 Inclined metamorphic or tectonic foliation
- Tectonic foliation
- Paleocurrent lineation
- Inclined lineation at intersection of bedding and cleavage
- Inclined lineation at intersection of two unspecified surfaces
- Asymmetirc crenulation lineation, (S-shaped)
- Asymmetric crenulation lineation, (Z-shaped)
- Basalt dike