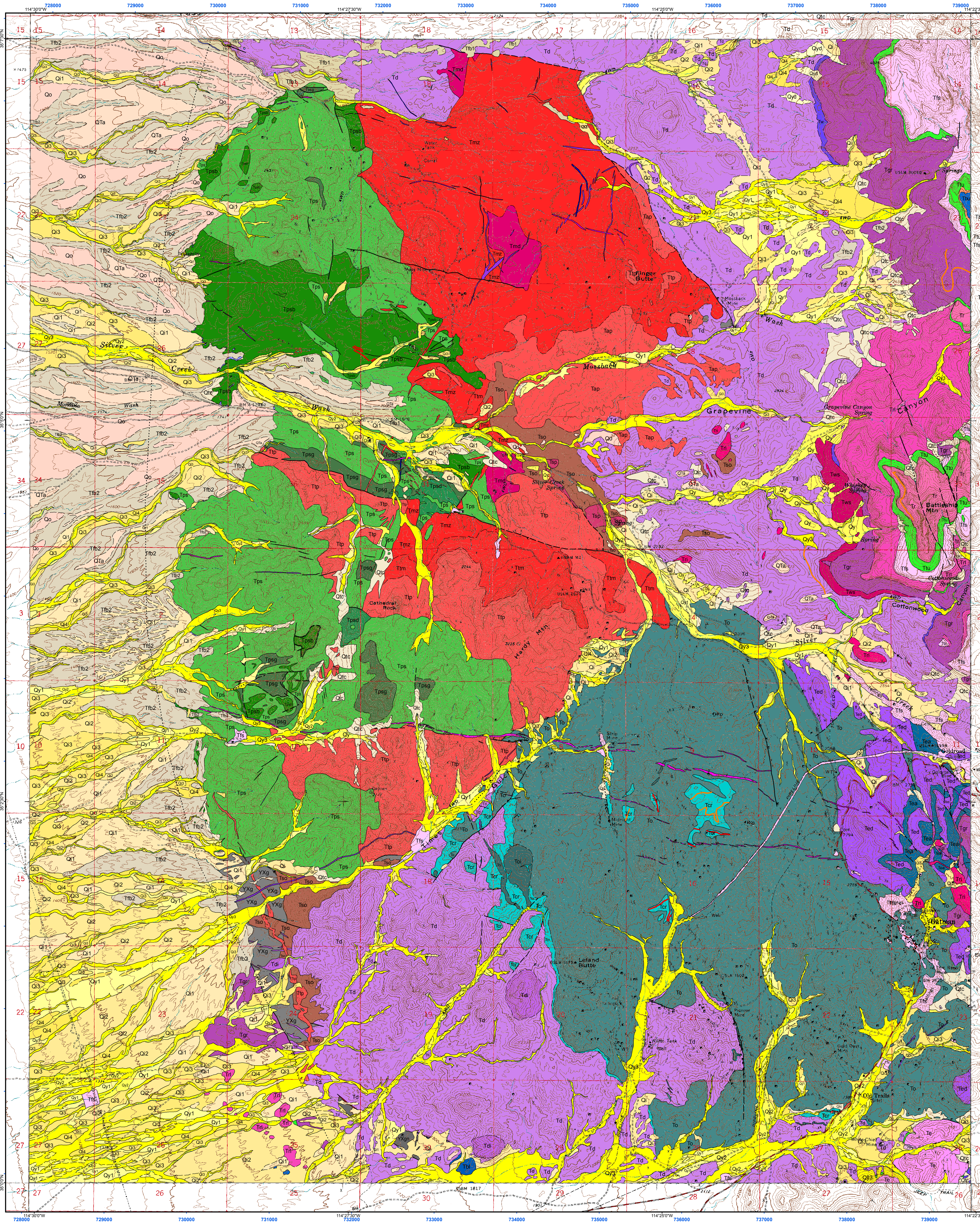

Geologic map of the Oatman 7 ½' Quadrangle, Mohave County, Arizona

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Introduction

This map depicts the bedrock and surficial geology of the Oatman quadrangle in the Black Mountains and Mohave Valley, Mohave County, Arizona. The geologic mapping is original but was informed by previous mapping in the lower Colorado River Valley. This geologic map complements previous AZGS mapping in this area, including the Davis Dam SE (DGM-45, Pearthree and House, 2005), Boundary Cone (DGM-54, Spencer et al., 2007), and Mount Nutt (DGM-118, Ferguson and Cook, 2016) quadrangles, and a geologic strip map (DGM-65, Pearthree et al., 2009) that covered the western part of the Oatman quadrangle. This geologic mapping was funded by the USGS National Cooperative Geologic Mapping Program under cooperative agreement number G15AC00519 (awarded for federal fiscal year 2015).

Bedrock geology is dominated by the Silver Creek caldera, source volcano of the early Miocene Peach Spring Tuff (Young and Brennan, 1974), and post-caldera plutonic rocks that intrude the caldera's eastern margin. The caldera is defined by outcrops of the intracaldera ignimbrite (Tps) which contains numerous, large expanses of lithic breccia (Tpsb, Tpsg, Tpsd) derived from the west-facing wall of the caldera. Pre-caldera rocks consist of Proterozoic granitic basement (YXg) overlain by a thick pile of dacitic lavas (Td) that includes a northwest-southeast trending graben filled with a distinctive, dark, dacitic lava called the "Oatman Andesite" (To). These rocks host many of the epithermal, low-sulfidation, quartz-calcite-adularia gold veins in the Oatman mining district (Clifton et al., 1980; DeWitt et al., 1991), which has produced over 2 million ounces of gold, and over 1 million ounces of silver since 1863 (Keith et al., 1983) – making it Arizona's largest gold district. Many features of the Silver Creek caldera, including its great thickness of intracaldera trachytic ignimbrite, and many of the megabreccia lenses contained within it where documented by Thorson (1971), but largely because the caldera is deeply eroded with no preserved rim, and because the rhyolitic outflow sheet of the Peach Spring Tuff is absent from the immediate vicinity of the caldera, the caldera was not recognized as the source of the Peach Spring Tuff until recently (Ferguson et al., 2013). Post-caldera volcanic rocks form the crest of the Black Mountains along the eastern edge of this map area, and the Peach Spring Tuff's outflow can be found at the base of this sequence a few kilometers to the south (Spencer et al., 2007), east (Ferguson and Cook, 2016), and north (Murphy et al., 2004) of this map area.

Surficial deposits in the western portion of the map record the late Miocene and younger geologic history of this region. Alluvial fan deposits dating to the latest Miocene are disconformably overlain locally by limestone, travertine or tufa, calcareous sandstone and carbonate-cemented local gravel of the Bouse Formation. This unit represents a dramatic departure from alluvial fan sedimentation and hillslope erosion and deposition and records the relatively brief but deep inundation of Mohave Valley sometime after 5.6 Ma (House et al., 2008; Pearthree and House, 2014). The highest Bouse outcrops found anywhere are exposed near the mouth of Silver Creek valley (Metzer and Loeltz, 1973; Pearthree and House, 2014), with bedded limestone or marl, sandstone and local gravel found up to 555 m asl, and a thin bed of calcareous sandstone between local fan gravel deposit found as high as 560 m asl. Bouse deposits are unconformably overlain by more local fan deposits. Small outcrops of travertine/tufa deposits of the Bouse Formation have been found at numerous localities along the bedrock mountain front, where they encrust or are draped over paleohillslope deposits or bedrock outcrops. Farther downslope to the west of the quadrangle boundary, the fan deposits that overlie the Bouse Formation interfinger with deposits of Bullhead Alluvium, a major phase of river aggradation in the early Pliocene (House et al., 2008). The early to middle Pliocene Tuff of Artists Drive has been found in these deposits at a number of localities, including in the map area. Multiple inset alluvial fans and terraces record subsequent periods of piedmont aggradation and incision through the late Pliocene and Quaternary. Some of these processes were likely driven by changes in base level due to river aggradation and incision.

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Map Unit Descriptions

Piedmont Alluvium

Qy_3 — **Sand and gravel deposits associated with active channels of tributary washes** - Very poorly sorted sand, pebbles, cobbles, boulders and minor silt deposits in active channels, bars, and low overbank areas along tributary washes. Gravel clasts consist of mixed, locally-derived volcanic rocks. Topography is smooth to undulating, with coarse gravel bars and sandy channels. Soil development is minimal.

Qy_2 — **Deposits in bars, low terraces, and active alluvial fans** - Very poorly sorted sand, pebble, cobble, boulder, and silt deposits in small stream channels, low terraces, and active or recently alluvial fans. Topography typically undulates between channels, terraces, and gravel bars. No desert pavement or soil development.

Qy_1 — **Deposits on low terraces and inactive alluvial fans** - Very poorly sorted sand, pebble, cobble, boulder, and silt deposits in gravel bars, low terraces, and inactive alluvial fans. Surfaces are typically are undulating, with coarse gravel bars and relict channels. Channels are covered by open to moderately closely packed fine gravel lags, gravel bars are weakly to moderately varnished. Soil development is weak, with some carbonate accumulations.

Qyd — **Young debris flow deposits** - Bouldery very poorly sorted, angular to subangular deposits associated with small, relatively steep watersheds. Deposits typically form lateral, curvilinear levees along active drainages, or more amorphous snouts. Rock varnish on gravel is weak to strong, indicative of a range of ages of deposition.

Qy — **Young channel and terrace deposits, undivided** - Sand and gravel deposits associated with active tributary wash systems, including channels, bars and low terraces. This unit is applied primarily to small tributaries where differentiating Holocene deposits by age is not practical.

Qi_4 — **Young intermediate alluvial fan and terrace deposits** - Very poorly sorted gravel and sand deposits in low intermediate terraces and relict alluvial fans, typically 1-3m above active washes. Moderate to dark brown and light orange rock varnish, moderate desert pavement development where relatively fine gravel. Bar and swale topography is obvious but slightly subdued. Very slight soil reddening, visible carbonate accumulations.

Qi_3 — **Young intermediate alluvial fan and terrace deposits** - Poorly sorted mixtures of silt, sand, pebbles, cobbles and boulders on relict alluvial fans and terraces. Surface topography varies from gently undulating relict bars and swales to quite smooth. Soil development is weak but desert pavement development is moderate to strong, with relatively smooth surfaces and brown to dark brown rock varnish.

Qi_2 — **Intermediate alluvial fan deposits** - Relict alluvial fan and moderately high terrace deposits consisting of poorly sorted sand, pebbles, cobbles, and boulders, with minor silt and clay. Soil development is moderate, with some soil reddening and weak clay accumulation and obvious carbonate accumulation. Rock varnish is dark brown to black; desert pavement development is variable, with tight, darkly varnished patches on well-preserved, smooth surfaces.

Qi — **Intermediate piedmont alluvium** - Undivided Pleistocene alluvial fan and terrace deposits, generally including Qi2, Qi3, and Qi4 deposits.

Qi_1 — **Oldest intermediate alluvial fan deposits** - Moderately to deeply eroded relict alluvial fan deposits consisting of poorly sorted sand, pebbles, cobbles, and boulders, with minor silt and clay. Soil development and pavement development variable depending on local surface preservation, with stage III-IV calcic horizons associated with well-preserved surfaces.

Qo — **Old alluvial fan deposits** - High, dissected relict alluvial fan deposits consisting of poorly sorted sand, pebbles, cobbles, and boulders, with minor silt. Soil development typically is variable, with moderately cemented petrocalcic horizon development (stage IV) on well-preserved surfaces.

QTa — **Very old alluvial fan deposits** - High, deeply dissected relict alluvial fan deposits, consisting of poorly sorted cobbles, sand, pebbles, and boulders, with minor silt. Soil development is strong, consisting of strongly cemented petrocalcic horizons at or near the surface. Cemented carbonate fragments reworked from underlying petrocalcic horizons are very common on QTa surfaces.

Late Miocene to Middle Pliocene Basin Deposits - Local gravel, fine-grained Colorado River deposits, and ash-fall deposits

Tta — **Tuff of Artists Drive** - Ash-fall tuff found in small pockets in locally derived gravel (Tfb2), but also found in association with high levels of Colorado River gravel and sand in adjacent areas. Geochemically correlated with the **Tuff of Artists Drive** in the Death Valley region, dated at 3.6-4.2 Ma.

Tfb_2 — **Local fan gravel, post-Bouse Formation** - Poorly sorted, weakly to moderately lithified conglomerate and sandstone exposed in the middle and lower portions of high, eroded ridges. Clasts consist largely of subangular to angular locally derived Tertiary volcanic rocks. Deposits overlie Bouse deposits in Silver Creek exposures, and probably are in part coeval with deposition of Bullhead Alluvium closer to the valley axis.

Tbc — **Bouse Formation basal carbonate** - Basal carbonate deposits of the Bouse Formation, including marl, calcareous sandstone, and minor travertine (tufa), Deposits unconformably overlie alluvial fan deposits (unit Tfb1), but locally are include local gravel lenses or are interbedded with local gravel beds. Commonly unconformably overlain by younger gravel (unit Tfb2).

Tbct — **Bouse Formation travertine/tufa** - Travertine or tufa deposits or encrustations, with algal and microbial forms, some hemispherical shapes, and massive, less structured carbonate drapes of pre-Bouse landforms.Travertufa encrusted bedrock paleohillslopes, and is commonly found along the interface between bedrock and somewhat younger fan gravel (unit Tfb2). Paleohillslopes range from gentle to moderately steep. Color of travertufa ranges from light to dark gray. This unit varies from a few cm thick up to 1 m thick.

Tfb_1 — **Pre-Bouse alluvial-fan deposits** - Very old tributary-fan, deposits exposed in a few localities along the mountain front and over bedrock pediments farther into the mountains. Poorly to very poorly sorted, moderately lithified, generally undeformed, locally-derived conglomerate and sandstone. Clasts consist largely of subangular to angular volcanic rocks. Deposition generally pre-dates Bouse deposition, but in some areas farther into the mountains this relationship is less clear. Locally Bouse inundation resulted in reworking of these deposits into the basal Bouse gravel.

Miocene and older bedrock units - Bedrock units consist of a Miocene (20-10 Ma) volcanic field and its associated plutonic rocks overlying and intruding granitic and gneissic crystalline basement.

Tbu — **Basaltic lava** - Mafic lava and dikes containg 0-10% <3mm iddingsite (after olivine?) phenocrysts in a finely crystalline matrix with sparse <2mm plagioclase phenocrysts.

Tq — **Quartz porphyritic rhyolitic dikes** - Rhyolitic, quartz-phyric dikes containing 1-15%, 1-7mm quartz phenocrysts generally subequal or subordinate to 2-30%, 1-12mm feldspar and 0-3% 1-4mm mafics, mostly biotite, but also hornblende and lesser pyroxene. Many dikes are composite, generally with more mafic, darker matrix phases that commonly form the walls of the main dike. In most cases, the darker, apparently more mafic phase also contains quartz phenocrysts.

Tm — **Feldspar porphyritic mafic dikes** - Dark, mafic mineral (biotite-hornblende-pyroxene)-rich crystalline matrix, 5-15%, <10mm feldspar porphyritic dikes that intrude the Moss monzonite and monzodiorite (Tm, Tmp).

Tk — **Feldspar porphyritic dikes** - **Feldspar porphyritic dikes** containing 1-30% 1-15mm feldspar (k-feldspar and plagioclase) with <1-5% <5mm mafics, mostly biotite > hornblend +/- pyroxene, and little or no quartz. Typically, these dikes have greenish, fine- to medium-grained matrix. The dikes are similar to and may be correlative to the Silver Creek porphyry (Tsp).

Ts — **Sandstone and conglomerate** - Generally thick-bedded, volcaniclastic conglomerate and sandstone containing clasts of intermediate and felsic volcanic rocks. The strata overlie a thick succession of nonwelded tuff at Sitgreave's Pass and drape over steeply north-facing buttress unconformities in the same area that overlap northeast-side down faults.

Ttu — **Nonwelded tuff** - Nonwelded, generally phenocryst-poor felsic tuff, typically medium- to thick-bedded. The unit is associated with numerous felsic lava units and is locally interbedded with minor volcaniclastic sedimentary rocks. A great thickness of this unit at Sitgreave's Pass is the Sitgreave's Pass of Ransome (1923). The unit, as mapped, is not a stratigraphic marker since it includes several other intervals of tuff at lower and higher stratigraphic levels.

Tap — **Altered porphyry (hypabyssal)** - Strongly argillic altered porphyry whose original lithology (Times granite, Moss monzonite, or dacitic / intermediate lava) is unknown. The unit is thought to be mostly intrusive in origin with relatively coarse-grained matrix and a lack of remnant breccia texture. The porphyry south of Mossback Canyon is probably mostly leucogranitic.

Tri — **Rhyolite porphyry** - Hypabyssal rhyolite containing up to 15% 2-10mm felspar (sanidine and plagioclase), 3-7% 1-4mm, typically embayed quartz phenocrysts, and 1-2% <2mm mafics, mostly biotite. The rock is typically strongly argillic altered and the mafic phenocryst sites are commonly altered beyond recognition. This porphyry can be differentiated from the Times leucogranite porphyry by its ubiquitous and conspicuous phenocrysts of quartz.

Tr — **Rhyolitic lava** - **Rhyolitic lava** containing 5-20%, 1-12mm phenocrysts of feldspar (plagioclase and sanidine), 5-10%, <6mm quartz, and <2%, <3mm biotite. Correlates with the Cottonwood Rhyolite of Ransome (1923).

Tfs — **Trachytic lava of Flag Spring** - Phenocryst-poor, light-gray matrix lava containing 3-10%, <4mm felspar (mostly plagioclase), and <2% <3mm biotite and sparse, <4mm hornblende. Named for exposures at Flag Spring in the easterly adjacent Mt Nutt map area (Ransome, 1923). In most areas, this lava occurs as a 20-50m thick flow dominated by coherent facies, massive, cliff-forming lava, but in the northeast corner of the map area, a large vent complex is present consisting of at least 200m of clast-supported lava breccia.

Trl — **Lower rhyolite lava** - Rhyolitic lava containing 5-10% 1-10mm feldspar,1-3% <4mm quartz, and<<1% <1mm biotite and hornblende phenocrysts. Correlates loosely with the Meadow Creek Trachyte of Ransome (1923).

Tgi — dacitic intrusions - Dikes and irregular stocks of dacitic porphyry containing 10-20% 2-10mm plagioclase, 1-2% <3mm mafics of biotite, and hornblende with sparse pyroxene. Numerous dikes of this unit occur in the cliffs east of Oatman, and a large stock of the unit is intruded by the Elephant's Tooth stock. In some areas, the intrusions merge upward into flows of the Gold Road dacite (Tgr).

Tgr — **Gold Road dacitic lavas** - Dacitic lavas containing 15-35% 2-15mm feldspar (mostly plagioclase), 1-4mm bitote, and +/- hornblende and pyroxene. The lavas overlie the the Black Eagle or Whiskey Spring lava sequences and are thought to post-date eruption of the Peach Spring Tuff. The name Gold Road is inherited from the Gold Road Latite of Ransome (1923).

Tmd — **Moss monzodiorite** - Medium- to coarse-grained monzodiorite porphyry containing 15-25% mafics of biotite, hornblende and pyroxene. The monzodiorite occurs as a small body in the core of the Moss porphyry of Ransome (1923), that appears to intrude the Moss monzonite porphyry.

Tsp — **Silver Creek Porphyry** - Porphyry containing up to 60% phenocrysts of K-feldspar (up to 2cm) and plagioclase (up to 8mm), commonly rimmed with K-feldspar in a fine-grained phaneritic matrix with 1-5% <3mm mafics, mostly biotite. The porphyry occurs as stocks and dikes along Silver Creek, and to a lesser degree along Times Gulch. An intrusion breccia (Thorson, 1971) of the porphyry constitutes most of the northernmost outcop of this unit in Silver Creek.

Ttp — **Times leucogranite** - The Times porphyry of Ransome (1923) is a fine- to medium-grained leucogranite, locally with feldspar phenocrysts up to 8mm. Matrix is commoly granophyric, and quartz, although abundant in the matrix is rarely present as phenocrysts. Sparse biotite and / or hornblende is also present. The Times occurs mostly as an irregular shaped pluton that intrudes the southeastern part of the Silver Creek caldera. Dikes of **Times leucogranite** are found in many areas; in the northern part of the caldera, dikes appear to cut bodies of Moss monzonite porphyry, and in the south, across the bedrock mouth of Times Gulch, a 10-50m wide dike cuts across all older units and can be traced for several km to the south where it preferentially intrudes, locally as a gently east-dipping dike, along the basement-Tertiary volcanic contact. Ransome (1923) interpreted the Times to post-date the Moss and Thorson (1971) considered theTimes to be older than the Moss. There is clear evidence of intermingling of the two porphyries on the north slope of Hardy Mountain (Ttm) and in other areas, The issue is confused by the presence of many dikes that intrude both porphyries that may or may not be akin to either porphyry. Leucogranite porphyry dikes clearly intrude the Moss porphyry, but monzodiorite porphyry dikes also clearly intrude leucogranite dikes.

Ttm — **Hybrid Times-Moss** - Zones of complexley intermingled Times leucogranite and Moss monzonite in which it is not clear which phase is older. Conflicting relationships are present in nearly all outcrops of this unit whose contacts with the main parts of theTimes leucogranite and the Moss monzonite are gradational.

Tmz — **Moss monzonite** - Medium-grained monzonitic porphyry containing 7-15% mafics of biotite, +/- hornblende and pyroxene. Named the Moss porphyry by Ransome (1923).

Tps — **Peach Springs Tuff** - Densely welded ignimbrite containing >25% and <35% phenocrysts of<6mm K-feldspar, <3mm plagioclase, and <1%, 1-3mm biotite, with trace sphene, hornblende, and pyroxene. Pumice lapillii, difficult to identify due to intense, high-temperature recrystallization of the matrix in most areas, are up 30cm and make up 5-25% of the ignimbrite. Pumic lapilli are best preserved directly adjacent to megabreccia clasts where rapid chilling of the matrix apparently better preserves their texture. Lithic lapilli of intermediate volcanics, porprhyry, and granite up to 10cm generally constitute <5% of the rock. Lithic swarms of mesobreccia and megabreccia with >15% lithics are mapped separately (Tspb, Tspd, Tspg). The ignimbrite is pervasively weakly altered, and its feldspar phenocrysts, with K-feldspar typically at least twice as abundant as plagioclase, are cloudy or chalky in most areas, but along the western edge of the range north of Times Gulch, clear sanidine (K-feldspar) phenocrysts are present (Ransome, 1923), that have yielded an Ar/Ar date of 18.80 +/- 0.07 Ma (Ferguson et al., 2013). Outflow Peach Spring Tuff (with an average age of 18.78 +/- 0.02 Ma (ibid.) is not present in this map area. The Peach Spring Tuff's stratigraphic position, based on geochronology of younger and older strata, and phyiscal stratigraphic constraints, is thought to occur at the top of the Whiskey Spring / Black Eagle Mine volcanic sequences (Tws, Tea), and below the Gold Road and/or lower rhyolite lava units (Tgr, Trl). Since the intracaldera ignimbrite is compositionally a trachyte, and not a rhyolite as the Peach Spring Tuff is throughout most of its outflow sheet, the two ignimbrites were previously considered to be different units largely because Peach Spring Tuff was thought to be unzoned compositionally based on its known outcrops when it was defined (Young and Brennan, 1974). More recent mapping identified a phenocryst-rich upper trachyte zone capping the proximal rhyolite outflow sheet (Ferguson et al., 2013), which is a near perfect match, geochemically, petrologically, and mineralogically to the intracaldera trachyte of this map area (Pamucku et al., 2013).

Tpsb — **Lithic breccia** - Clast-supported and matrix-supported mesobreccia (clasts <1m) and megabreccia (clasts >1m) within Peach Spring Tuff. The breccias contain between 15% to nearly 100% lithic clasts, and have ash-flow tuff matrix similar to the encassing densely welded Peach Spring Tuff. Llithic blocks are good matches to volcanic units found (mostly but not always) in the wall of the Silver Creek caldera: granite and gneiss (YXg, YXgn), dacitic lava (To, Td), trachyte lava (Te), and volcaniclastic conglomerate, sandstone, breccia, and carbonate (Tcr). Where lithic blocks are in excess of 50 meters, the blocks are typicallly mapped as enclaves within the ignimbrite. Many of these breccias have sharp, distinct contacts with the encassing, lithic-poor, densely welded Peach Spring Tuff. and other, monolithic, clast-supported megabreccias.

Tpsg — **Granitic megabreccia** - **Granitic megabreccia**s within the Peach Spring Tuff are composed of nearly 100% coarse-grained granite with lesser gneiss boulders, cobbles, and pebbles within dark green non-volcanic matrix. Ash-flow tuff matrix is generalyy present only along the edges of the megabreccias. The breccias occur as tabular bodies interleaved with densely welded Peach Spring Tuff and other types of megabreccia. Contacts between some granite megabreccia and dacite megabreccia bodies may represent intact contacts between granite basement and the dacite of Alcyone Mine preserved in very large blocks floating within the Peach Spring Tuff.

Tpsd — **Dacitic megabreccia** - Dacitic megabreccia within the Peach Spring Tuff consist of nearly 100% dacitic lava with little or no ash-flow tuff matrix. The dacite is plagioclase-phenocryst-rich (15-30%) with maific phenocrysts dominated by biotite suggesting that the main source is the dacite of Alcyone Mine (Td). Pyroxene-dominant phenocryst dacite similar to the Oatman Andesite (To) are also present. Ash-flow tuff matrix is generaly present only along the edges of the megabreccias. The breccias occur as tabular bodies interleaved with densely welded Peach Spring Tuff or other megabreccia. Very large masses of dacitic lava mapped as dacitic megabreccia north of Silver Creek have no obvious exposed base and might be substrate of the dacitic rocks of Alcyone Mine)Td) underlying intracaldera Peach Spring Tuff.

Black Eagle Mine lava sequence - A sequence of alternating pyroxene-dominant (andesitic), and biotite-dominant (dacitic), moderately plagioclase phenocryst-rich lavas that overlie the Oatman Andesite. Geochemically, the rocks are probably no more andesitic than the Oatman Andsite, but since so many of the flows have been referred to as andesite for so long, the misnomer is retained. Flows of this unit ranging in thickness from <10m to <50m occur along the western edge of the map area; their base is defined as the base of the oldest biotite-dominant lava, and the top as the top of the youngest pyroxene-dominant flow. The lavas are dominated by massive, cliff-forming coherent facies and contain 15-25% <8mm plagioclase along with 1-3% mafics, typically <4mm.

Tw — **Wrigley Mine Andesite** - Dark matrix, commonly vesicular, basaltic trachyandesitic lava (Spencer et al, 2006) containing 5-10% <4mm black (ortho) and dark green (clino) pyroxene phenocrysts that are more abundant than 3-10% <5mm plagioclase phenocrysts. The lava is named for a conspicuous sequence of mafic lavas at the Wrigley Mine about 7km south of Oatman which overlie the Esperanza Trachyte. In the Oatman area, flows of truly andesitic composition are rare, and are only known to occur at or near the top of the Black Eagle Mine sequence. To the south of the White Cheif Mine fault, the unit directly overlies the Esperanza Trachyte and is fairly thick (up to 150m). To the north of the White Chief Mine fault, the unit caps the Black Eagle succession in the easterly adjacent Mt Nutt map area. North of the Silver Creek fault zone, a thin flow of the unit is present just to the south of Grapevine Canyon near Whiskey Spring and another one near the base of the steep west-facing ridge in the northeast corner of the map area. The lava is known to directly underlie the outflow sheet of the Peach Spring Tuff in the southerly adjacent Boundary Cone map area (Spencer et al, 2006), and in the northerly adjacent Union Pass quadrangle directly underlies a regional unconformity corresponding to a hiatus that is thought to represent regional uplift and erosion just prior to formation of the Silver Creek caldera, and eruption of the Peach Spring Tuff.

Tea — **Black Eagle andesite** - Andesitic lavas in the Black Eagle sequence containing pyoxene > biotite mafic phenocrysts.

Ted — **Black Eagle dacite** - Dacitic lavas in the Black Eagle seuence containing biotie > pyroxene mafic phenocrysts.

Tws — **lavas of Whiskey Spring** - A sequence of alternating dacitic lavas containing 10-20% 2-12mm plagioclase phenocrysts and 1-2% <3mm mafics dominated either by biotite (dacitic) or pyroxene (andesitic). The flows range in thickness between 5m and 40m and are too thin and complexly interbedded to map indivdually at 1:24,000 scale. In general, the biotite dominant (dacitic) lavas are more abundant, and the plagioclase phenocrysts tend to be rimmed either with k-feldspar, or albitic plagioclase.

Toi — **Intrusive Oatman Andesite** - Hypabyssal dikes and stock-like masses of dark gray, finely crystalline matrix Oatman Andesite containing 10-20% phenocrysts of <8mm plagioclase with 1-3%, <4mm mafics that are dominated by dark green pyoxene. Plagioclase tends to be strongly lath-shaped and euhedral. Biotite <2mm is rare to absent and is always subordinate to pyroxene. Elongate (<200m) thin (<30m) raft-like enclaves of the unit of Cooper Ranch (Tcr) carbonate are present in some areas.

To — **Oatman Andesite** - Dark, plagioclase phenocryst-rich lava with mafic phenocrysts dominated by clinopyroxene. The name is inherited from local terminology predating its assignment by Ransome (1923) for the dark, andesitic appearing lavas that stratigraphically overlie the dacite of Alcyone Mine, and host much of the gold mineralization in and around the town of Oatman. The name "andesite" is retained even though its average composition is dacitic (Thorson, 1971). The lavas contain 10-20% phenocrysts of <8mm plagioclase with 1-3%, <4mm mafics that are dominated by dark green pyoxene. Plagioclase tends to be strongly lath-shaped and euhedral. Trace to sparse biotite <2mm occurs in some of the flows, but is always subordinate to dark green pyroxene. The matrix is typically dark gray and flows are dominated by coherent facies, massive cliffy outcrops. Large raft-like enclaves up to several hundred meters wide of subaqueous ignimbrite, sandstone, marl, and carbonate derived from the underlying unit of Cooper Ranch (Tcr), are fairly common within the **Oatman Andesite**. The **Oatman Andesite**, despite being mapped over a fairly broad area of the Oatman district on some maps (Thorson, 1971), is, sensu stricto, confined to a 6-10 km wide, southeast-northwest trending graben centered on Oatman. The unit is not present south of the White Chief Mine fault or north of the Silver Creek fault zone.

Te — **Esperanza Trachyte** - Cliff-forming, mostly massive-coherent facies, phenocryst-poor trachyte lava containing <5% <3mm feldspar (mostly plagioclase), and up to 1% <2mm biotite. The lava is present only south of the White Chief Mine fault where it overlies the dacitic rocks of Alcyone Mine (Td) and is overlain by the Wrigley Mine basaltic trachyandesite (Tw). The unit was mapped as the unit of Wrigley Mine (Spencer, 2006) in the southerly adjacent Boundary Cone map area. The name, **Esperanza Trachyte**, is inherited from Ransome (1923).

Tcr — **Unit of Cooper Ranch** - Subaqueous ignimbrite and tephra deposits, sandstone, siltstone, mudstone, marl, and carbonate. The signature lithology of this unit is thin-bedded to laminated, dark gray, commonly fetid, micritic and/or recrystallized carbonate (limestone and dolostone) that is locally magnesite-bearing. The carbonate makes up less than 5% of the unit and occurs in sequences up to 5m thick, but typically <1m. Some carbonates serve as marker beds that can be traced for up to 1km, but mostly it occurs sproadically throughout the unit. Commonly, the top of the unit is defined by at least one major carbonate bed. Sandstone and siltstone units are typically only a few meters thick, but can be quite thick (10-15m), as are massive marls also up to 15m thick. Subaqueous, plagioclase-biotite phenocryst-rich ignimbrites1-30m thick, either welded or with stongly compacted, dark green pumice lapill are common, especially in the lower half of the unit. The ignimbrites are commonly faintly internally thin-bedded to laminated (typical of subaqueous deposition), and some of the thinner strata might be fallout tephra. The unit gradationally overlies the dacite of Alcyone Mine (Td), and is sharply overlain by dark, pyroxene-dominant dacitic lavas of the Oatman Andesite (To).

Tdi — **Dacitic intrusions of Alcyone Mine** - Massive, and flow-foliated, finely crystalline matrix porphyry containing 15-30% feldspar (mostly plagioclase) and 1-3% strongly hematite altered <3mm mafics. Body in NW/4 of section 20 near Leland Butte and two other bodies in the NE/4 of section 30 are interpreted as a dacitic domes. Dikes and irregular stock-like bodies in section 24 are probable feeders to flows and or domes in that area.

Td — **Dacitic volcanic rocks of Alcyone Mine** - Dacitic lava and minor ignimbrite containing 15-35% phenocrysts, mostly plagioclase (2-15mm), with up to 5% 1-4mm biotite, and <1% hornblende and/or pyroxene up to 5mm. Coherent facies lava dominates in resistant exposures while inchorent facies (autobreccia) typically crop out in swales and recessive areas. Intrebeds of similar composition pyroclastic rocks and minor dacitic volcaniclastic rocks are also present. Some of the pyroclastic rocks are welded (or have compacted pumice lapilli) and are very similar to pyroclastic rocks in the overlying unit of Cooper Ranch (Tcr). Prominent peaks in at least two areas represent probable hypabyssal intrusions that grade outward into lava (the 2681' peak southwest of Leland Butte, and the 2523' peak in the N/4 of section 30, R20W, T19N). The unit is named for the Alcyone Mine about 2 miles south of Oatman, and the place name is inherited from Ransome (1923) who recognized an "Alcyone Trachyte" as the oldest major volcanic unit in the area. The unit overlies and is interbedded with the lower conglomerate (Tso), and the lower basalt (Tbl), and is overlain, somewhat gradtionally, by the unit of Cooper Ranch (Tcr). The unit correlates broadly with a series of sub-Esperanza Trachyte dacitic lavas in the southerly adjacent Boundary Cone map area referred to as the upper and lower dacites of Cook Mine, and the dacites of Alcyone Mine (Spencer et al., 2006).

Tbl — **Lower basalt** - Basaltic lava, and possibly, locally, hypabyssal intrusions containing 1-10%, <0.5mm pyroxene phenocrysts in dense, finely crystalline matrix. The basalt is interbedded with dacitic lava near the base of the dacite of Alcyone Mine (Td) along the southern edge of the map area,

Tso — **Lower conglomerate** - Sandstone, conglomerate, breccia, siltstone, mudstone, and minor tuff. Dark weathering and strongly indurated sedimentary rocks either directly overlie granitic basement or occur interbedded with dacitic lavas of the dacite of Alcyone Mine. The strata are pervasively propylitically altered and dominated by clasts of granitic, and intermediate composition volcanic rocks. The granitic clasts are mostly phaneritic and probably derived from the underlying basement, but also include sparse, finely crystalline-matrix porphyritic plutonic rock clasts of probable Laramide (80-50Ma) age. Sparse pyroclastic strata are dacitic in composition, with feldspar and biotite phenocrysts. Bed thcknesses tend to increase with maximum grain size. Thick-bedded, sub-angular to sub-rounded clast conglomerate and breccia beds are mostly clast-supported and massive, whereas sandstone-siltstone-mudstone sequences are thin- to medium-bedded, with cross-stratification, and ripple lamination comon sedimentary structures. Channel and cut- fill features are not common. Instead, planar contacts between nearly all beds imply rapid depostion, and graded sandstone beds capped by ripple laminated zones and/or thin siltstone units suggest turbidite style lacustrine sedimentation. The rocks occur in two areas: the bedrock mouth of Times Gulch, and the confluence of Siler Creek with Grapevine and Mossback canyons. The rocks in Times Gulch were refered to as the Murdock Breccia by Lausen (1931) who placed them at the base of the volcanic pile. Thorson (1971) inpterpreted the same rocks along with the deeply weathered granitic rocks they overlie in Times Gulch as intracaldera breccia. We agree with Lausen (1931) and interpret the strata as the basal Tertiary supracrustal unit in the area, and place a caldera margin in this area just north of the gulch.

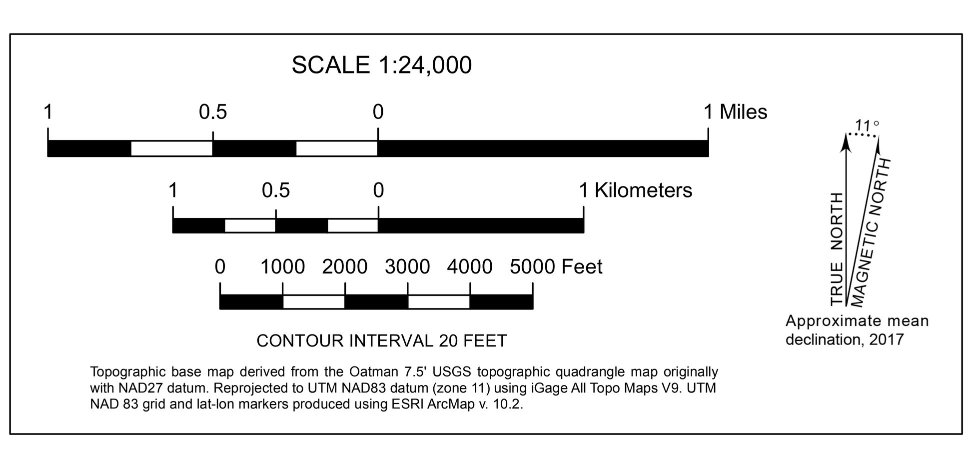
YXg — **Granite** - Medium to coarse-grained, locally K-feldspar porphyritic, granite containing up to 15% biotite. The granite locally includes undifferentiated enclaves of gneissic rock.

YXgn — **Gneiss** - Paragneiss, locally compositionally banded, containing 15-40% biotite and fine- to medium-grained orthogneiss containing less than 15% biotite

Other Units

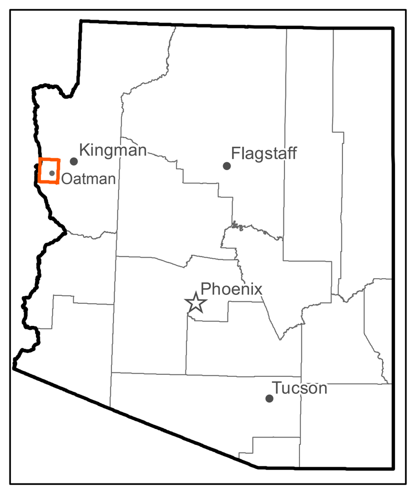
d — **Disturbed ground** - Mine dumps, mine tailings, pipelines, roads, and other man-made deposits.

Qtc — **Colluvium and talus, undivided** - Coarse, very poorly sorted, weeakly bedded, locally derived hillslope deposits. Primarily colluvium, but locally includes coarse, framework gravel talus deposits

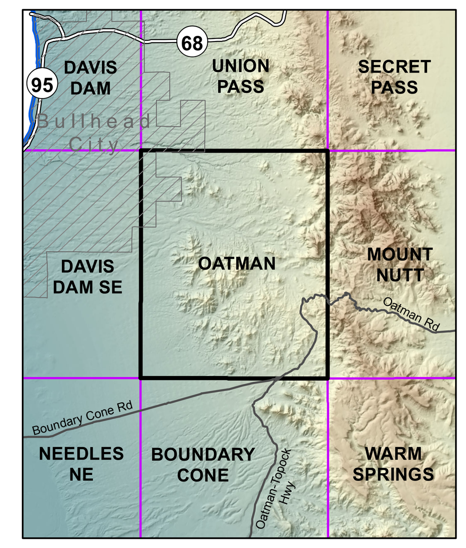


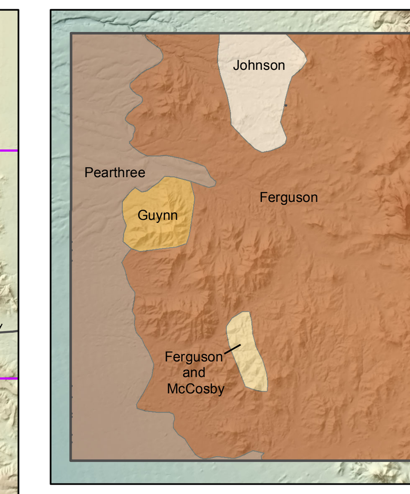
Contacts, faults, and marker beds

- Contact, accurate
- Contact, approximate
- Fault, accurate
- Fault, approximate
- Fault, concealed
- limestone marker bed
- volcanic marker bed



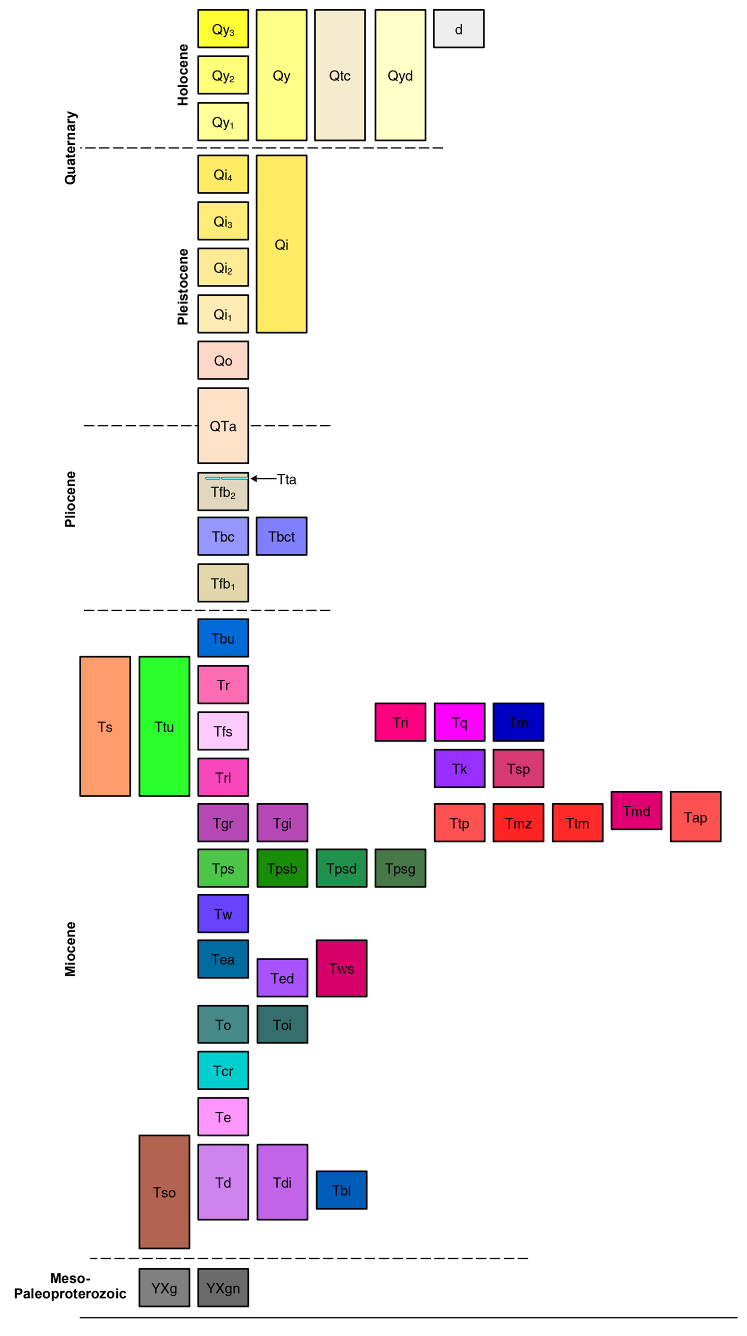
Location of map area





Mapping responsibility

Correlation of map units



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