Geologic map of the Bouse and Ibex Peak 7 ½' Quadrangles, La Paz County, Arizona

Arizona Geological Survey
Digital Geologic Map 107 (DGM-107), version 2.0

by

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Introduction

The Bouse and Ibex Peak 7 ½' Quadrangles are located approximately 40 km south-southeast of the town of Parker in La Paz County, western Arizona. The Quadrangles encompass the northern Plomosa Mountains and flanking piedmonts, as well as part of upper Bouse Wash, the town of Bouse, and the southern edge of Cactus Plain. Geologic mapping was done under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992, and was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under STATEMAP assistance award #G12AC20464. Mapping was compiled digitally using ESRI ArcGIS software.

Version 2 of DGM-107 includes two days of new mapping east and southeast of Four Peaks, along the southeasternmost extent of the Plomosa detachment fault, and north of Ibex Peak.

Surficial geology

Surficial geologic units were mapped using field observations, stereo aerial photographs, digital orthophotographs and/or georeferenced satellite imagery, and digital elevation models (DEMs). Relative ages of alluvial deposits were estimated using characteristics of clast weathering, soil development, carbonate accumulation, and position in the landscape (Gile and others, 1981; Machette, 1985; Bull, 1991; Birkland, 1999). Soil development and carbonate accumulation begin once a deposit is isolated from active alluvial processes. As a result, the degree of soil development and carbonate accumulation are one of the criteria used to identify the approximate ages of surficial units. Younger alluvial deposits have little to no soil development, retaining the original grey or brown color of the alluvial sediments, and no carbonate accumulation. Clasts in these deposits have no weathering rinds or surface patinas and thus appear brighter and fresher than older clasts. Young alluvial surfaces often retain original depositional characteristics such as bars and swales. Conversely, older alluvial deposits have better developed soils that appear orange or red in color, with soil horizons reflecting clay and carbonate accumulations. Clasts in older alluvial deposits often exhibit darkened weathering rinds or some degree of oxidation (orange surface patina), and thus appear darker on the ground and in aerial photographs. Preserved alluvial surfaces may be smooth and flat (Qi3), becoming more rounded and coarser with age (Qi2). The oldest alluvial surfaces (Qi1) are often eroded, rounded ridges with no soils preserved and the carbonate horizon exposed.

Numerous northeast-trending, linear troughs are located on the west side of the northernmost Plomosa Mountains in older Quaternary to Pliocene alluvial deposits. Field examination did not identify any other features associated with these troughs except in a small number of locations where they were associated with faults, which are shown on the map.

Bedrock geology

The northern Plomosa Mountains are a southward tilted fault block bounded above and to the north by the Oligocene(?)-Miocene extensional Plomosa detachment fault (Scarborough and Meader, 1983; Spencer and Reynolds, 1991). Displacement on the fault was sufficient to uncover mylonitic crystalline rocks that make up a metamorphic core complex. Farther south in the detachment-fault footwall block, the Plomosa Pass thrust zone consists of multiple thrust faults and folded tectonites derived primarily from Paleozoic and Mesozoic sedimentary rocks (Stoneman, 1985; Steinke, 1996). Rocks of this complex thrust zone are displace northward in fault blocks above the Plomosa detachment fault. Apatite and zircon fission-track ages indicate that exhumation and cooling of footwall rocks below the Plomosa detachment fault occurred at about 15-23 Ma (Foster and Spencer, 1992). The southern part of the map area consists largely of upper Oligocene(?) to lower Miocene hornblende-dacite extrusions and shallow intrusions.

Extensional faulting and basin genesis, and elevated geothermal gradients associated with magmatism and crustal thinning, produced conditions that caused extensive oxidative alteration and mineralization in rocks near and above the detachment fault, including barite veins and deposits of hematite, specular hematite, and manganese oxides, with associated secondary copper minerals (Harrer, 1964; Duncan, 1990). At least one rock avalanche deposit includes breccia that was derived from rocks previously subjected to argillic alteration, presumably in the Jurassic, and then metamorphosed during Cretaceous thrust burial (Reynolds et al., 1987). Electron microprobe analysis of four samples from 3 localities identified quartz, hematite, kaolinite, rutile, alunite, diaspore, pyrophyllite, topaz, and svanbergite (Ken Domanik, Univ. Arizona, written comm., 2014; sample locations: 3760720 UTMN, 770759 UTME; 3760753 UTMN, 770791 UTME; 3760529 UTMN, 770531 UTME, NAD83, zone 11N).

Oligocene(?)-Miocene sedimentary and volcanic units are positioned on the Stratigraphic Correlation Diagram so that their inferred tectonic setting is indicated by the “Extensional tectonic stage”, as follows: (1) Initial normal faulting resulted in subsidence and deposition of basal arkose and limestone on crystalline rocks that previously formed a highland. (2) This was followed by deposition of rock-avalanche breccias and mafic lavas. The breccias are interpreted to indicate development of high relief, with breccias derived from a big normal fault scarp at the southern or southwestern margin of a half-graben basin. (3) This was followed by fragmentation of the half-graben basin into multiple small tilt-block half grabens, with increasing differentiation of stratigraphic sections between basins.

Description of Map Units

d	**Disturbed ground** - Heavily disturbed or covered ground associated with mine dumps, excavation, and municipal development that has obscured or cocealed original geologic features.
Qoc	**Pedogenic carbonate** - Extensive, thick (2-4 m), cliff exposures of pedogenic carbonate found high on mountain slopes. These units are typically formed on hillslope colluvium and are covered by thin, discontinuous layers of colluvium.

Piedmont units

Qy_c	**Deposits in modern channels** - Recently active channel deposits that are dominantly unconsolidated, very poorly sorted sandy to cobbly beds exhibiting bar and swale microtopography, but can range from fine silty beds to coarse gravelly bars in meandering reaches based on position within the channel. Clasts range from sub-rounded to angular. Qycr deposits are typically unvegetated to lightly vegetated and exhibit no soil development.
Qy_3	**Active channels, low terraces and bars** - Piedmont alluvial deposits located along active drainages including small channels, adjacent low terraces, or floodplain areas. Qy3 deposits are composed of unconsolidated, unvarnished sand, gravel, and silt deposits.
Qy_2	**Broad drainages and piedmont terrace deposits** - Qy2 deposits consist of terrace deposits located primarily along the flanks of incised drainages and low-relief terraces inset into Pleistocene age fan deposits. Some Qy2 deposits comprise extensive low relief alluvial fans where unconfined by older piedmont alluvium. These deposits consist of predominantly fine grained unconsolidated to weakly consolidated sediments with sub-rounded to sub-angular pebble to cobble bars on the surface and beds and lenses in cross section.
Qy_1	**Piedmont terraces and isolated alluvial fan deposits** - Qy1 deposits consist of planar terraces along larger piedmont drainages and remnant alluvial fan deposits on lower piedmont areas. Qy1 deposits are composed of sandy to pebbly swales with coarser unvarnished to very lightly varnished pebble to cobble bars, and partially overlie Pleistocene deposits in some areas.
Qy	**Young deposits, undifferentiated** - Primarily fluvial deposits, with small eolian dunes and sand sheets
Qya	**Young alluvial fan deposits** - Young, active alluvial fan deposits that are laterally extensive and composed of gravel, sand, silt associated with distributary drainages and broad sheetflood areas.
Qi	**Intermediate alluvial fan and terrace deposits, undifferentiated** - Undifferentiated middle and late Pleistocene alluvial fan and terrace deposits.
Qi_4	**Young intermediate alluvial fan and terrace deposits** - Pebble, cobble, and sand deposits in low terraces and alluvial fans. Moderate varnish on clasts, moderate gravel lags to weak pavements, but pavements not was well developed as Qi3. Soil development is weak to moderate.
Qi_3	**Intermediate fan and terrace deposits** - Gravel and sand deposits with moderate to tight desert pavements, dark rock varnish, forming relict alluvial fans and intermediate terraces. Soil development is moderate, with slight reddening, minor clay accumulation, calcic horizon development II-III.
Qi_2	**Older intermediate fan and terrace deposits** - Gravel and sand deposits, with minor silt and clay, associated with moderately eroded relict alluvial fans and intermediate terraces. Rock varnish and pavement development is variable, quite strong on well-preserved surfaces and moderate to weak on more eroded surfaces. Incision of modern washes below Qi2 surfaces ranges from 1-3 m.
Qi_1	**Higher dissected alluvial fan and terrace deposits** - High dissected gravelly alluvial fan deposits and dissected terrace deposits. Alluvial fans are deeply eroded, with limited preserved fan surface remnants. Soil development ranges from strong on well-preserved surfaces to weak to moderate on eroded slopes. Qi1 terrace deposits are up to 15 m above Osborne Wash.
Qo	**Very high old alluvial fan deposits** - Coarse gravelly high rremnant alluvial fans with very strong calcic soil development where surfaces are reasonably well preserved. Cobbles and boulders are common. Planar surfaces are typically supported by carbonate cementation and coarse grain size, but are also deeply eroded and high above active washes.
Qyd	**Debris-flow deposits and chutes** - Bouldery debris-flow levees and snouts, and erosional scars associated with debris flow activity higher on hillslopes.
Qtc	**Hillslope talus and colluvium - Hillslope talus and colluvium**

Deposits of Bouse Wash

Qy_cr	**Active main and side channels of Bouse Wash**
Qy_3r	**Active high-flow channels and terraces along Bouse Wash**
Qy_2r	**Terraces along Bouse Wash** - Terraces along Bouse Wash that are only active during the highest flows.
Qy_1r	**Terraces along Bouse Wash** - Abandoned terraces along Bouse Wash. Open creosote fields.
Qi_3r	**Intermediate terrace deposits - Bouse Wash** - Gravel and sand deposits with a mix of crystalline rocks, volcanics, and minor reworked rounded Colorado River pebbles and cobbles. Terraces up to 15 ft above the active channels.
Qi_r	**Older deposits - Bouse Wash** - Older, highly dissected terrace gravel and sand along Bouse Wash. Gravel is primarily crystalline and volcanic lithologies, but locally contains substantial rounded gravel reworked from older Colorado River deposits (Bullhead alluvium).

Deposits of Cactus Plain

Qys	**Sandy deposits in active drainages** - Reworked sand and fine gravel in and along active drainages in Cactus Plain, where source deposits are predominantly sand. Locally includes gravelly deposits in proximity to bedrock or older fan deposits.
Qe	**Dune sand deposits** - Quartz-rich dune sand deposits, with lesser amounts of silt and clay associated with more stable parts of dunes. Most areas in western Cactus Plain are dominated by linear dunes that trend generally NE; these dunes are up to 40 ft high. Some portions of Cactus Plain are dominated by much smaller crescent dunes.
Qsi	**Sand surface mantle** - Interdune and near dune areas covered primarily by sand, with minor gravel, silt and clay; not spatially associated with drainages. Percent coverage of sand is variable, but typically is >50 percent, Includes small areas of gravel lag, and eroded fine-grained deposits.
Qgi	**Gravel-mantled erosion surfaces** - Open gravel lag deposits on erosion surfaces. Most erosion surfaces are formed on older fine-grained deposits in interdune areas; some are formed on eroded older fan deposits around the margins of the dune field
Qgs	**Gravel and sand surface lag** - Erosion surfaces with open gravel lag and common, small-scale sandy eolian deposits. Complex spatial relationships between gravel and sand-dominated patches.

Miocene to Quaternary units

QTcgr	**Regolith derived from Miocene conglomerate** - Disaggregated rubble derived from conglomerate of map unit Tcg. In many areas this map unit is identified from aerial imagery, and probably includes substantial areas of conglomerate (map unit Tcg) that is not greatly disaggregated.
QTr	**Regolith, undivided** - Deeply weathered and disaggregated debris derived from unspecified older units.
QTa	**Deeply incised fans without preserved surfaces.**
QTf	**Silt, clay, minor sand** - Fine-grained deposits, some are likely poorly exposed Bouse Formation, others are almost certainly old eolian deposits
Tcb	**Bullhead alluvium** - Quartz-rich sand and rounded pebbles and cobbles of Bullhead alluvium; some finer-grained deposits locally; in a few outcrops, rests over erosional unconformity on Bouse deposits
Tcb?	**Bullhead alluvium?** - Quartz-rich sand and rounded pebbles and cobbles of Bullhead alluvium; some finer-grained deposits locally; in a few outcrops, rests over erosional unconformity on Bouse deposits. Unit is probably correlative with Bullhead alluvium.
Tbs	**Bouse Formation - fine siliciclastic deposits** - Green, tan, to reddish brown clay, silt, sand, and minor limestone and tufa.
Tcy	**Pebble conglomerate** - Reddish weakly to moderately consolidated pebble conglomerate with lenses of less consolidated reddish sand layers. Unit is mainly exposed along the lower banks of washes under Pleistocene fan surfaces but fan remnants are also present. May be slightly tilted.
Tsy	**Fanglomerate** - Poorly sorted, poorly consolidated, tan to light brown fanglomerate. Unit is not tilted by faulting except in a few exposures where it appears to be slightly tilted.

Upper Miocene volcanic units of north Cactus Plain

Miocene sedimentary and volcanic units

Tcgm	**Conglomerate with mylonitic clasts** - Tan to brown, moderately to poorly sorted conglomerate with diverse clast compositions including mylonitic and chloritic breccia derived from below the Plomosa detachment fault. Lack of oxidative alteration indicates that alteration did not affect strata at this high stratigraphic level in Miocene upper-plate strata or that alteration had ended when these strata were deposited and tilted by faulting.
Tcr	**Rounded-clast conglomerate** - Conglomerate with rounded to subrounded cobbles. Clasts are approximately 80% granitoids, 15-20% intermediate composition volcanics, and 1-2% quartzite. These are inferred to be river deposits.
Tiu	**Intermediate to felsic intrusions, undivided** - In most exposures, this unit forms crystal-poor felsite dikes or irregular intrusions, with 0-4%, <2mm quartz, 1-5%, <1mm biotite, and up to 2%, <1mm hornblende. Quartz is absent in most exposures. Mafic minerals are typically oxidized and unidentifiable in the field. This unit includes crystal-poor, flow-banded rhyolite with 1-2%, locally up to ~4%, <2mm quartz. This unit possibly includes extrusions (domes?). In the southern part of the Ibex Peak 7.5' Quadrangle, most exposures of this unit consist of crystal-poor feldspar porphyry with up to 2%, <2mm feldspar, and locally includes a porphyry intrusion(?) with 10-15%, <2mm feldspar, and 1-2%, <1mm biotite, and a dike with 4-8% mafics consisting of <1mm biotite and <<1mm hornblende. At Ibex Peak this unit consists of a hornblende dacite intrusion with 5-9%, <1mm hornblende. At one locality (UTMN 3747519, UTME 769899, NAD 83, zone 11), this unit consists of volcanogenic breccia with clasts that contain ~20%, <1mm sanidine, and ~20%, <<1mm biotite and possible hornblende. The breccia matrix has the same composition as the breccia clasts. This is potential sample site for argon geochronology.
Tdh	**Hornblende dacite** - – Intermediate-composition lava flows, extrusive masses, dikes, and irregular shallow intrusions. This rock unit is typically brecciated, with 1-100 mm breccia fragments of dacite in a similar dacite matrix. The unit typically contains up to 3%, <1mm feldspar, and 2-4%, <1mm iron oxides derived from mafic minerals. Contains no quartz and no vesicles. Rocks fracture as if fairly siliceous. In the southern part of the Ibex Peak 7.5' Quadrangle, this unit consists of pale gray volcanogenic breccia with 1-5%, <1mm hornblende, up to 2%, <1mm biotite, some fresh, and 2-9%, <1mm feldspar. Locally near the base of the unit (UTMN 3740511, UTME 771995, NAD 83, zone 11), it contains up to 30%, <2mm pyroxene(?). Rock unit here looks like autobreccia, with slightly different color fragments of dacite with different abundance of crystals - some fragments are crystal poor. At the highest stratigraphic levels, near the southern edge of the Ibex Peak 7.5' Quadrangle, this unit includes vitrophyre with 2-4%, <1mm, fresh biotite and hornblende, and 7-10%, <1mm feldspar. Also in this area (UTMN 3741064, UTME 772041, NAD 83, zone 11), this unit is a pale greenish white, bedded pyroclastic unit with volcanic-lithic fragments up to 20 cm in tuffaceous matrix. Planar bedding is apparent for beds 1-10 cm thick. Fragments contain 2-3%, <2mm biotite, 4-6%, <2mm feldspar, some of which is sanidine.
Tdhv	**Hornblende dacite vitrophyre**
Tbp	**Bedded pyroclastic rocks** - Beds up to 2m thick with angular, volcanic-lithic clasts up to 30 cm. Clasts are typical hornblende dacite of map unit Tdh.
Tt	**Tuff** - In the Ibex Peak 7.5' Quadrangle, tuff of this unit contains 1-5 cm, irregular and elongate pits inferred to be relict pumice fragments. Unit contains up to 3%, <1mm biotite, some fresh, ~5%, <1mm feldspar, some of which might be sanidine, and 2-4% volcanic-lithic fragments up to 5 cm. ~5% of rock is <1mm voids that are inferred to be primary. The top of the tuff unit is thinly bedded over a thickness of ~1m.
Tm	**Mafic volcanic rocks** - **Mafic volcanic rocks**, dark gray, with up to 8%, <3mm plagioclase, and up to 4% iron oxides as alteration products of mafic phenocrysts. Rare sandstone or bedded conglomerate reveals orientation of bedding. In the southern Ibex Peak 7.5' Quadrangle, this unit consists of mafic lava with up to 20%, <5mm plagioclase, 2-4%, <2mm pyroxene, and 1-4%, <1mm iron oxides after olivine. Locally this unit contains up to 15%, <2mm iron oxides after pyroxene(?). In the northern part of the Bouse 7.5' Quadrangle, these rocks are rarely quartz bearing, but severe oxidative alteration obscures variations in the original composition of volcanic rocks, and these rare quartz-bearing rocks were not differentiated. Also in this area, rocks of this unit locally include massive to poorly sorted volcanic-lithic conglomerate with variably rounded volcanic clasts with sparse quartz and feldspar grains in an indurated matrix. Quartz and feldspar grains in matrix may not be volcanogenic.
Tx	**Rock avalanche breccia** - Massive breccia composed of angular fragments derived from diverse rock types. Most are monolithologic, and are derived from granitoids, quartzite, and carbonate. Some contain mixed-clast compositions. In the southern part of the Ibex Peak 7.5' Quadrangle, this unit includes blocks of unshattered carbonate at least 100m across. Map label with parenthetical term after “Tx”, such as “Tx(gr)”, indicates protolith composition of breccia, as follows: Tx(gr) – granitic protolith; Tx(Jv) – Jurassic metavolcanic protolith; Tx(md) – fine-grained mafic dike protolith; Tx(Mzcg) – Mesozoic conglomerate protolith; Tx(Mzss) – Mesozoic sandstone protolith; Tx(Mzsv) – Mesozoic metasedimentary and metavolcanic protolith, including hydrothermally altered rocks; Tx(PPs) – Supai Group calcareous metasiltstone and metasandstone; Tx(Pzc) – Paleozoic carbonate protolith; Tx(Pzq) – Paleozoic quartzite protolith; Tx(Pzs) –Paleozoic sedimentary protolith, undivided; Tx(q) – quartzite protolith, undivided; Tx(Tm) – Tertiary mafic volcanic protolith; Tx(YXg) – porphyritic biotite-granite protolith.
Tcx	**Conglomerate and breccia, undivided** - Massive conglomerate with clasts up to 1m of granite, quartzite, weakly schistose metavolcanic and/or metasedimentary rocks, and rock-avalanche breccia derived from porphyritic, coarse-grained granite.
Tss	**Sandstone** - Tan to medium brown to reddish brown to red, medium to fine grained sandstone, rare siltstone, and silty fine-grained sandstone, locally coarse to pebbly. Red colors in some areas are possibly due to potassium metasomatism.
Tssl	**Sandstone, lower unit** - Tan to medium brown to reddish brown, commonly thin bedded to laminated, medium to fine grained sandstone, rare siltstone, and silty fine-grained sandstone, locally coarse to pebbly. Rocks of this unit are distinguished from rocks of map unit Tss by their association with mafic and intermediate volcanic rocks (map units Tm and Tdh) and rock-avalanche breccias (map unit Tx).
Tsc	**Sandstone and conglomerate** - Sandstone, pebbly sandstone, and conglomerate. Clasts are typically subrounded to subangular and derived from Tertiary volcanic rocks, granitoids, and metasedimentary rocks.
Tscl	**Sandstone and conglomerate, lower unit** - Sandstone, pebbly sandstone, and conglomerate. Clasts are typically subrounded to subangular and derived from Tertiary volcanic rocks, granitoids, and metasedimentary rocks, without gneissic or mylonitic clasts like those derived from the footwall block of the Plomosa detachment fault.
Tscm	**Manganiferous sandstone and conglomerate** - Sandstone and conglomerate with pervasive manganese oxides filling pore space.
Tscc	**Sandstone and conglomerate with secondary calcium carbonate** - Sandstone and conglomerate with secondary calcium carbonate filling pore space. Rocks of this unit are exposed in the Ibex Peak 7.5' Quadrangle adjacent to the Plomosa detachment fault. Secondary calcium carbonate is thought to be derived from hydrothermal fluids the circulated along the detachment fault when it was active.
Tcg	**Conglomerate** - This unit typically consists of brown to reddish brown, moderately to strongly cemented, poorly sorted, weakly stratified conglomerate. Clasts are dominantly gneissic and granitic, with significant basaltic clasts, some vesicular. Clasts are typically subangular, 1-10 cm, locally to 50 cm. At one location east of “Plomosa” Peak north of Quinn (Plomosa) Pass (UTMN 3747949, UTME 769984, NAD 83, zone 11), conglomerate clasts include chloritic breccia and gneiss like that of the lower plate, and form bold, rounded outcrops like those farther north in the Bouse 7.5' Quadrangle that contain mylonitic debris from the lower plate (map unit Tcgm).
Tcgl	**Conglomerate, lower unit** - This unit typically consists of brown to reddish brown, moderately to strongly cemented, poorly sorted, weakly stratified conglomerate. Clasts commonly include mafic volcanics and are typically subangular. Rocks of this unit are distinguished from conglomerate of map unit Tcg by their association with mafic volcanic rocks (map unit Tm) and rock-avalanche breccia (map unit Tx), and by greater degrees of oxidative alteration and lithification.
Tl	**Limestone** - Thin to medium bedded, gray and tan, variably siliceous limestone, commonly slightly to moderately silty and with silty beds.
Tls	**Limestone, silty limestone, and less common calcareous siltstone and sandstone** - Diverse limestone, silty and sandy limestone, calcareous siltstone and calcareous sandstone, with diverse colors. This unit includes the following: (1) Limestone and silty limestone, in some areas platy weathering in 1-10 cm beds, (2) calcareous siltstone and calcareous fine to medium to locally coarse grained sandstone, (3) gray, yellow, and pale red limestone, siliceous limestone, and silty limestone, ~2-20 cm thick beds (locally to 40 cm) defined by variations in color and resistance to weathering, and containing tan and brown siliceous layers up to 10 cm thick, probably of calcareous siltstone but could be diagenetic silica or silicified tuff, and (4), southeast of Four Peaks this unit consists of tuffaceous and silty carbonate and tuff.
Ths	**Massive hematite-silica rock** - Hematite-silica rock that is massive, black to reddish black to dark brown, hard, dense rock. This unit is stratigraphically below lacustrine carbonate west of Four Peaks. To the east it forms replacements of lacustrine silty carbonates.
Tba	**Basal arkose** - Generally arkosic sandstone and conglomerate, with dominantly subrounded granitoid clasts up to 30 cm. In the southern part of the Ibex Peak 7.5' Quadrangle, this unit includes (1) volcanic-lithic sandstone, (2) siltstone, laminated silty limestone, and thick bedded sandy limestone, and (3) massive to very crudely bedded, angular- to subangular-clast conglomerate, with 1-100cm clasts. Many clasts are derived from green siltstone and fine grain sandstone that looks like Mesozoic McCoy Mountains Formation. In the northern part of the Bouse 7.5' Quadrangle, this unit consists coarse to fine, dark reddish brown to pale gray arkosic sandstone. Conglomerate forms 5-10% of unit at lower stratigraphic levels, and consists of beds up to 1m thick with subrounded cobbles of granitoids and sparse quartzite up to 30 cm diameter.

Paleozoic and Mesozoic sedimentary units

Mzcg	**Conglomerate, breccia, and sandstone** - Conglomerate is the dominant lithology, with clasts up to 30 cm of limestone and fine sandstone. Clasts are variably flattened, at one locality reaching an aspect ratio of 10:1. Locally includes sandstone and breccia.
Mzss	**Sandstone** - Quartz-rich sandstone with no lithics or mica. Fine to medium grained, locally coarse, very locally with pebbles up to 1 cm. Layering (bedding?) in underlying Kaibab limestone is parallel to contact with this sandstone. Rounded quartzite cobbles up to 5 cm diameter are present at basal 10-20 cm of sandstone where contact with Kaibab is tight (UTMN 3754074, UTME 769698, NAD 83, zone 11). Bedding is not obviously transposed in sandstone but clast dimensions suggest flattening with aspect ratios as high as 2:1. Also includes strongly cleaved, pale maroon, quartzose siltstone. At higher stratigraphic levels (UTMN 3753861, UTME 769645, NAD 83, zone 11), unit includes carbonate- and quartzite-clast conglomerate with subrounded clasts up to 30 cm diameter in a silty to sandy and possibly calcareous matrix. Carbonate clasts are flattened more than quartzite clasts, with aspect ratios as high as 2:1.
Pk	**Kaibab Limestone** - Medium gray limestone mottled with irregular siliceous knots and stringers. Includes recrystallized and probably deformed limestone with chert stringers that may represent bedding. Also, differential weathering reveals thin beds (2-20 mm) that appear to be bedding. Approximately 20 m below top of unit is an ~3m thick gypsum bed (UTMN 3754125, UTME 769703, NAD 83, zone 11).
Pc	**Coconino Sandstone** - Orthoquartzite derived from medium to fine grain quartz sanstone.
PPs	**Supai Formation** - Thin- to medium-bedded, fine quartzose sandstone, silty sand, and calcareous siltstone and fine sandstone, generally metamorphosed to pale green calc-silicate and quartzite with layering defined in part by differential weathering.
MDc	**Martin Formation and Redwall Limestone, undivided** - Calcite and dolomite marble and silty marble, commonly cherty.
Cb	**Bolsa Quartzite**
Pzc	**Carbonate rocks, undivided** - Recrystallized and penetratively deformed carbonate and siliceous carbonate derived from Paleozoic carbonate units (Kaibab Limestone, Redwall Limestone, Martin Limestone).
Pzs	**Sedimentary rocks, undivided** - Recrystallized and deformed carbonate, calcareous siltstone, fine calcareous sandstone, and sandstone.

Paleoproterozoic to Tertiary granitic and gneissic rocks

Tgrm	**Mudersback Granite** - Medium-grained, equigranular, light-colored biotite granite named Mudersbach granite (after the Mudersbach mine) by Scarborough and Meader (1983). A sample of this granite yielded a U-Pb isochron date, on three zircon fractions, of 20.4 +1.8 -2.1 Ma (dated by Mark Martin, personal communication (1996), and reported by Steinke (1996)).
TKgd	**Unfoliated mafic granitoids** - Northwest of Round Mountain in the Bouse 7.5' Quadrangle, rocks of this unit consists of dark, equigranular, medium to fine grained granitoids that intrude chloritic breccia and mylonitic leucogranite at the base of Round Mountains in the upper plate of the Plomosa detachment fault. Mafic minerals were not identified due to extensive alteration.
Jic	**Jurassic igneous complex of Plomosa Pass** - Diverse intrusive rock types that are variabley foliated, including hornblende diorite, porphyritic granodiorite (166.4 +/- 1.0 Ma U-Pb, Steinke, 1996), and porphyrytic leucogranite locally deformed into mylonitic gneiss.
KJg	**Southern Cross granite** - Fine to medium grained, generally equigranular to weakly porphyritic granitoid with up to 20% mafic minerals including biotite and hornblende. Named the Southern Cross granite by Stoneman (1985).
Mzgl	**Weakly genissic leucogranite** - Fine-grained (0.1 -1.0 mm) leucogranite with weakly gneissic, 3-30 mm layering defined by variable quartz-feldspar ratios and by weak variation in mafic mineral content. The leucogranite superficially resembles a metapsammite. This unit is interpreted as Mesozoic because it intrudes Paleozoic carbonates. Although forming part of the upper plate of the Plomosa detachment fault, rocks of this unit are mylonitic on the northwest side of Round Mountain in the Bouse 7.5' Quadrangle.
TXmd	**Fine to very fine grained diorite to intrusive basalt** - Generally gray, dark gray, greenish gray, and black basaltic dikes and intrusions and very fine grained dioritic rocks.
TXgd	**Mafic granitoid** - Medium to fine grained, biotite-hornblende mafic granitoid, with ~20%, <1mm hornblende. Unit is exposed northwest of the Tough Nut mine in the southeastern Ibex Peak 7.5' Quadrangle and east of the Little Butte mine at the northern end of the Plomosa Mountains.
TXgb	**Biotite granitoid** - Biotite granitoid in the Bouse 7.5' Quadrangle is medium to fine grained, with 8-15% biotite. Unit is dark, altered, and intruded by mafic dikes.
TXc	**Crystalline rocks, undivided** - This unit consists of crystalline rocks in the Ibex Peak 7.5' Quadrangle that are structurally above the Plomosa Pass thrust zone. In the Tough Nut mine area, rocks of this unit consist primarily of dark, fine-grained, biotite granodiorite and less abundant, similar appearing rock with 1-2 cm K-feldspar phenocrysts. Unit is highly fractured to shattered, but not as much as a typical rock-avalanche breccia. Minor constituents are sparse, small intrusions of fine-grained leucogranite, very sparse pegmatites, and sparse, dark, muscovitic, quartzose metasedimentary rocks of suspected early Proterozoic age.
TXgn	**Gneissic, granitic, and metamorphic rocks, undivided** - These diverse crystalline rocks forming the lower plate of the Plomosa detachment fault are commonly mylonitic, especially near the detachment fault. Mylonitic foliation and lineation are typically recrystallized, but not so much that quartz ribbons are completely obscure. Protolith is commonly thinly layered, fine-grained quartzo-feldspathic biotite gneiss and dark, fine-grained mafic gneiss, with rare pegmatites and local hornblendite. Gneiss is at least locally (canyon at UTMN 3748915, UTME 768331, NAD 83, zone 11) deformed into an L-tectonite with isoclinal fold axes parallel to lineation. A variety of structural and alteration phenomena have affected this rock unit near the Plomosa detachment fault. Severe brecciation has affected rocks of this unit for tens to hundreds of meters below the detachment fault. Rocks within a few meters of the detachment fault, and in some areas within tens of meters, are typically altered with green color due to abundant fine chlorite. This chloritic alteration is commonly associated epidote and earthy hematite. Within several tens of meters of the detachment fault, lower plate gneissic rocks locally include carbonate tectonite with probably Paleozoic sedimentary protoliths.
YXg	**Porphyritic biotite granite** - Coarse- to fine-grained biotite granite with K-feldspar phenocrysts mostly less than 1 cm but locally up to 4 cm. Mafic minerals, dominantly biotite, make up as much as 10% of rock unit. Locally unit is weakly foliated where associated fine-grained leucogranite (map unit YXgl).

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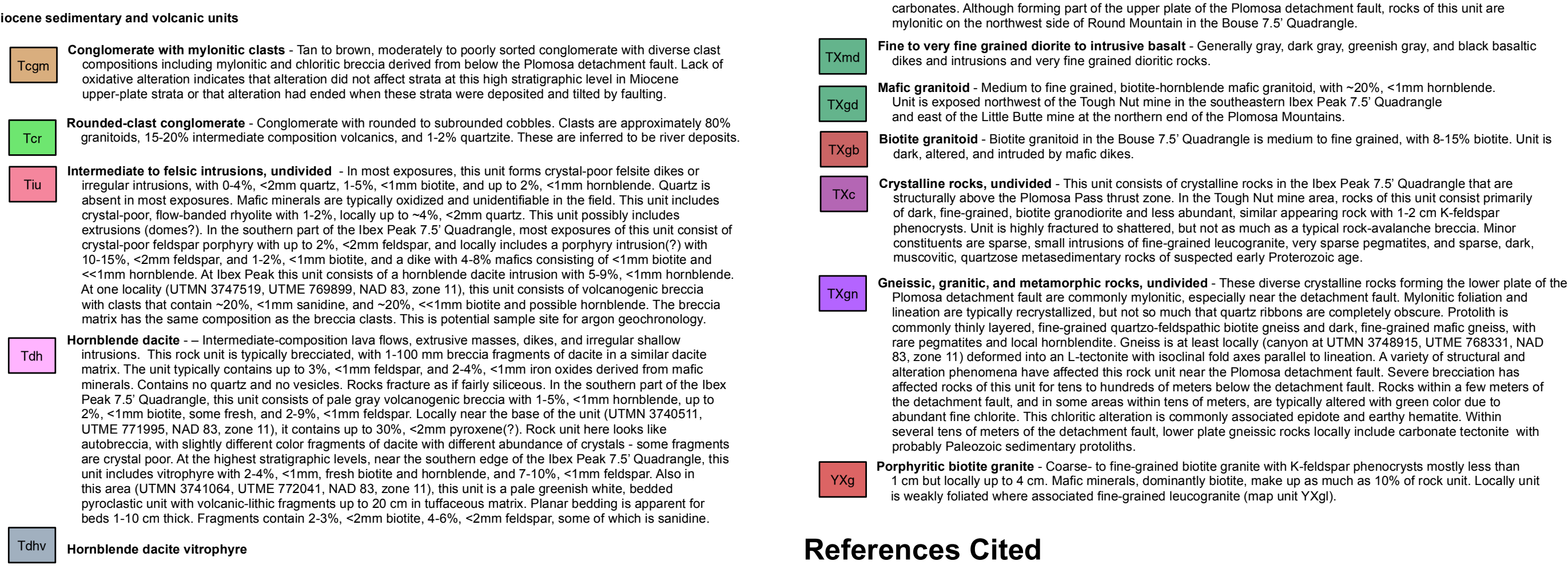
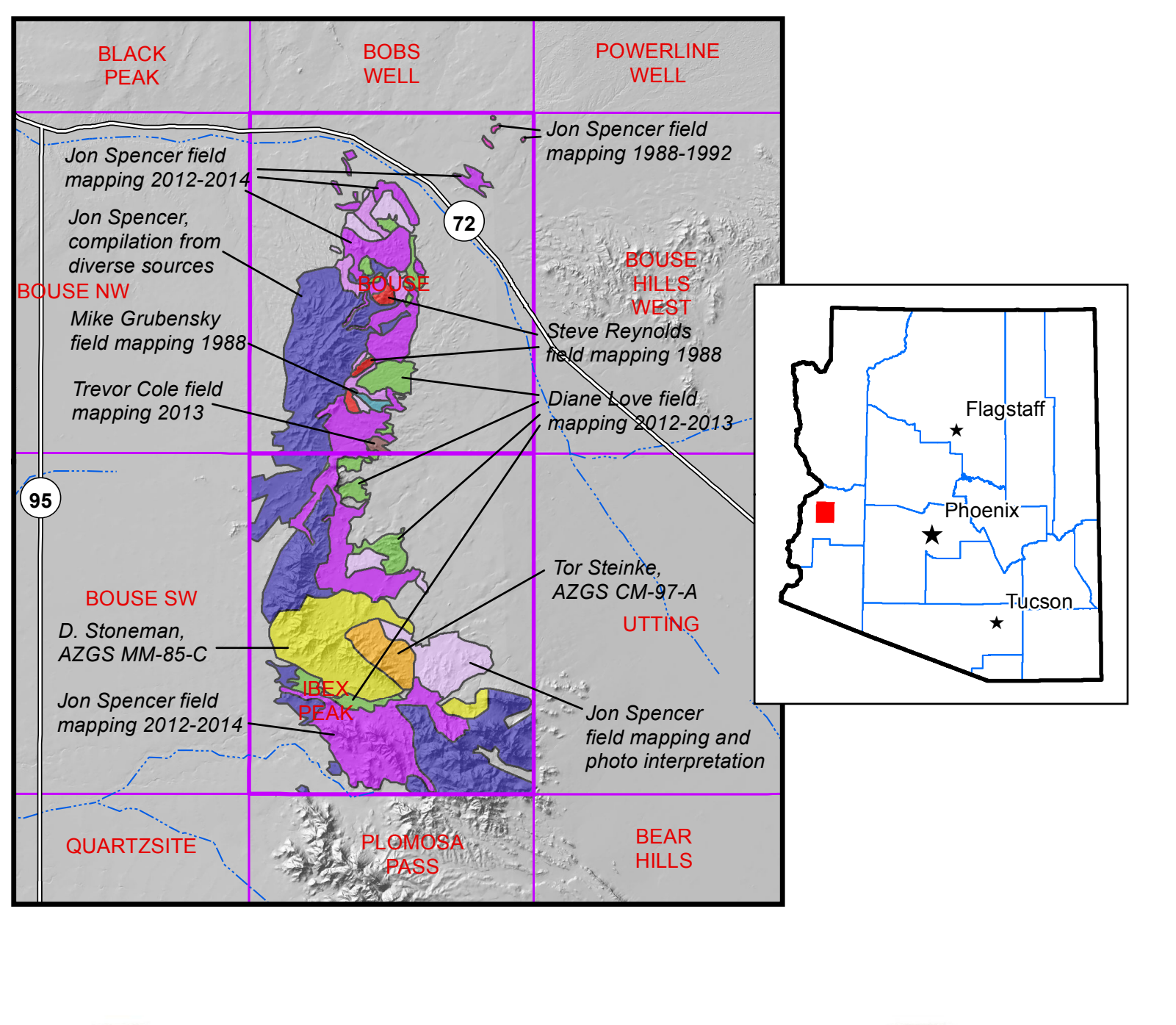
Stratigraphic Correlation Diagram



Sources of bedrock mapping

Surficial mapping by Ann Youberg



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Structure symbols

- bedding, inclined
- bedding, inclined, approximate
- bedding, horizontal
- apparent dip of bedding
- bedding, inclined, transposed
- tectonic foliation, parallel to bedding
- tectonic foliation
- gneissic layering
- joint
- mylonitic foliation
- mylonitic foliation and lineation
- mylonitic foliation and lineation with normal sense-of-shear
- mylonite foliation, recrystallized
- mylonitic lineation without foliation
- eutaxitic foliation
- flow banding
- dip of fault

Contacts, faults, and geomorphic features

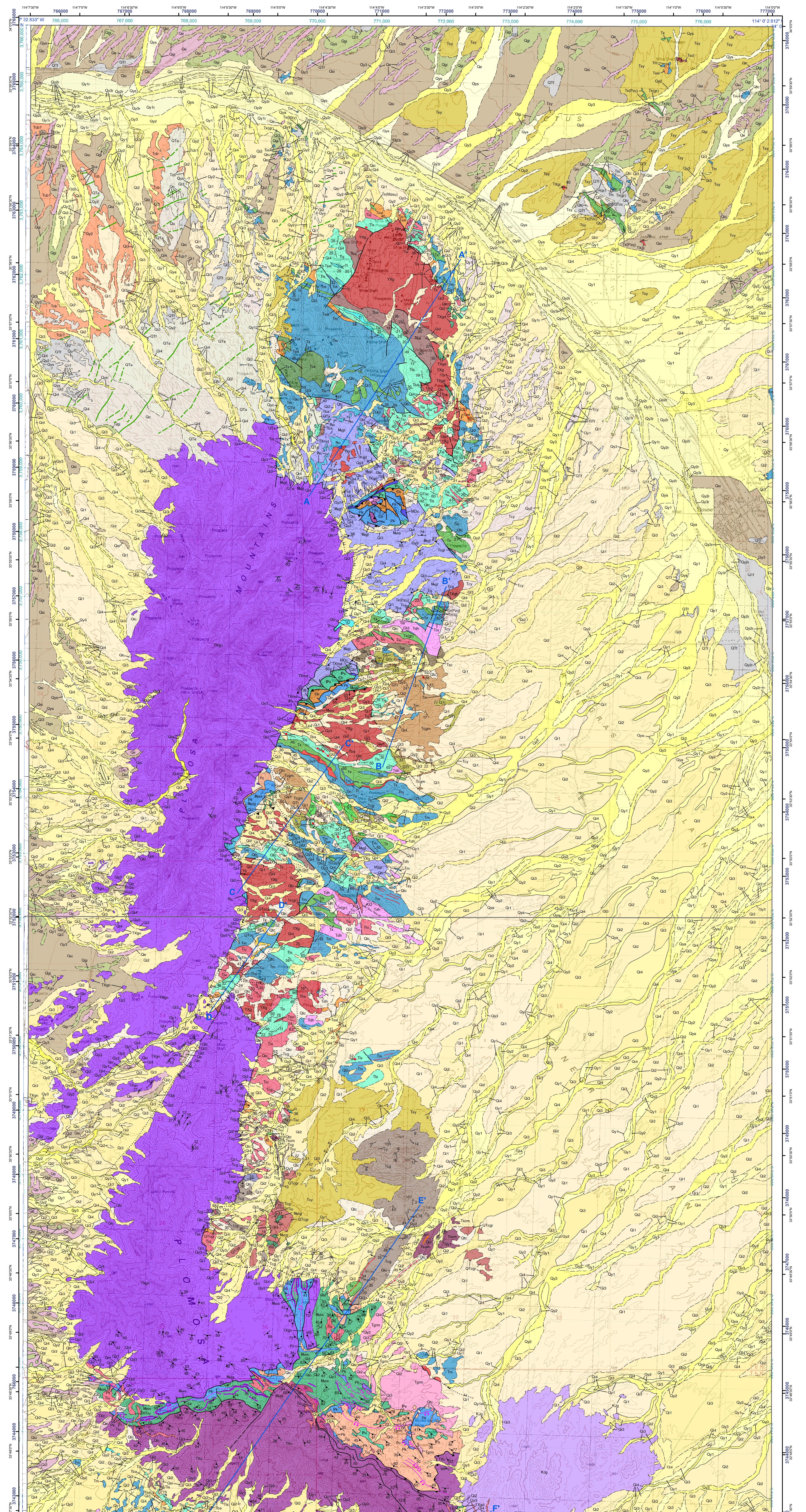
- contact, accurate
- contact, approximate
- contact, inferred
- fault, accurate
- fault, approximate
- fault, concealed
- detachment fault, accurate
- detachment fault, concealed
- low-angle fault, accurate
- low-angle fault, approximate
- thrust fault, accurate
- thrust fault, concealed
- shear zone
- linear geomorphic feature of uncertain origin
- linear geomorphic feature of uncertain origin, approximately located

Veins and marker beds

- marker bed
- tuff
- barite vein
- manganese-oxide vein
- conglomerate in Mesozoic metasedimentary rocks
- calcite vein

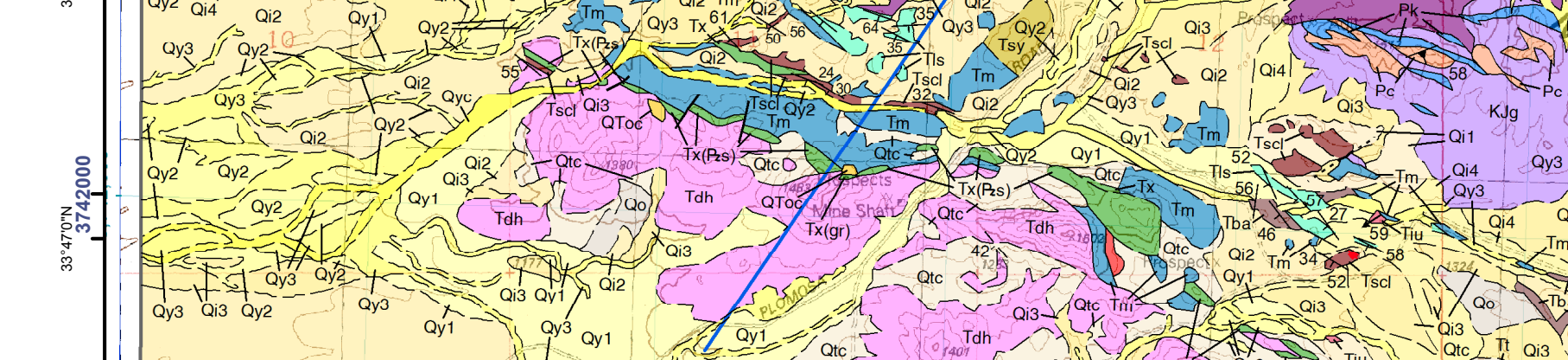
Folds

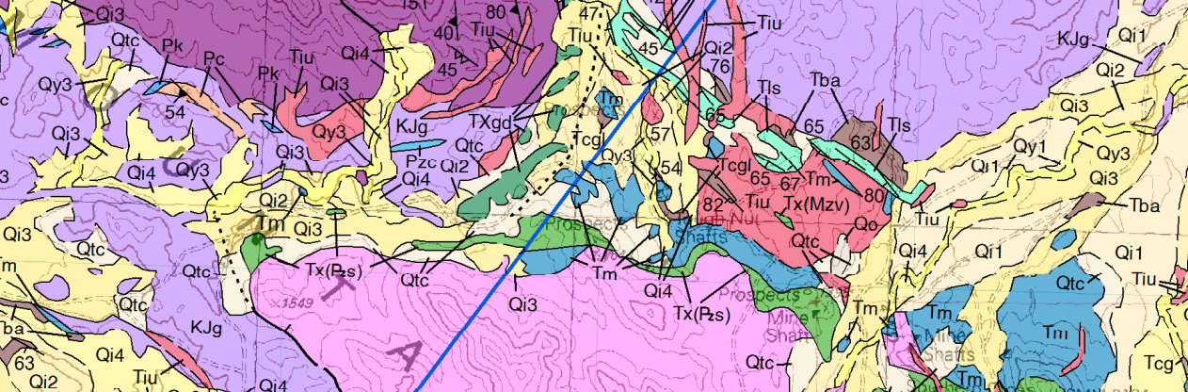
- overturned anticline, accurate
- overturned syncline, accurate

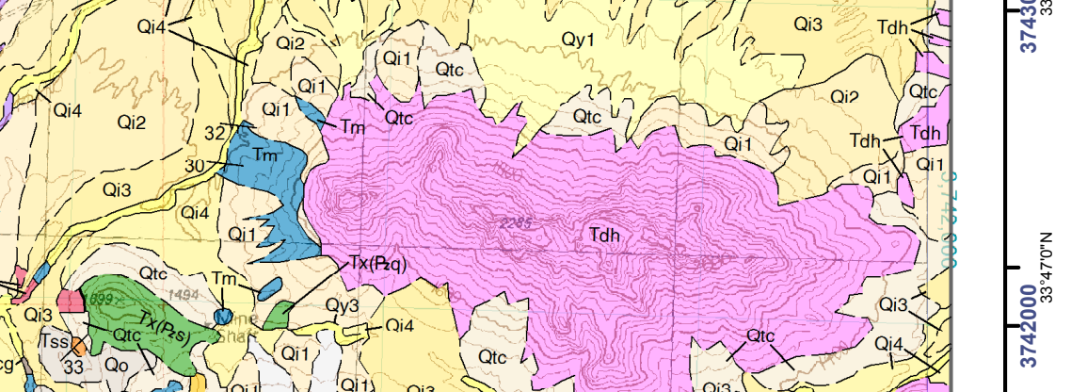


Projection: UTM Zone 11
Datum: NAD83

AllTopo V7 Pro Topographic Basemap with NAD83 grid. Topographic base map derived from Bouse and Ibex Peak 7.5' USGS topographic quadrangle maps originally with NAD27 datum.

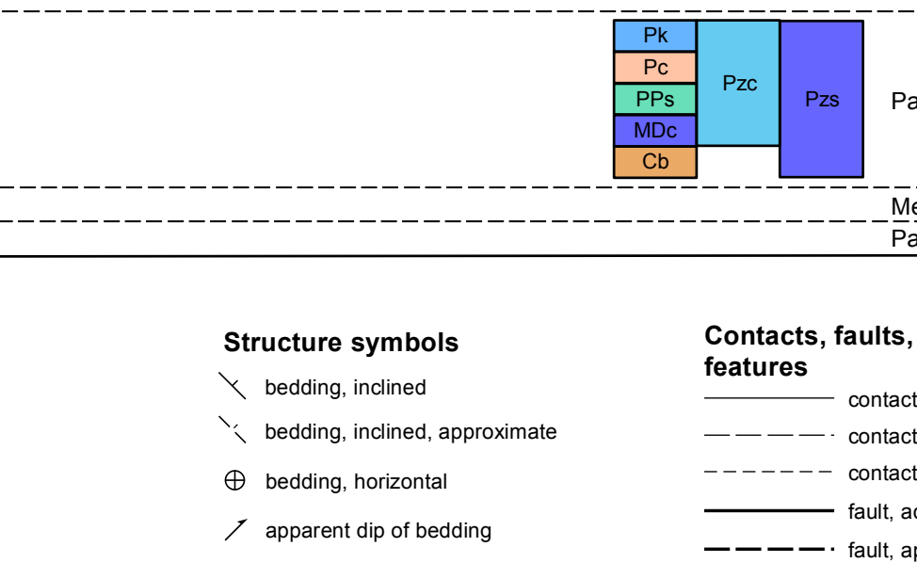




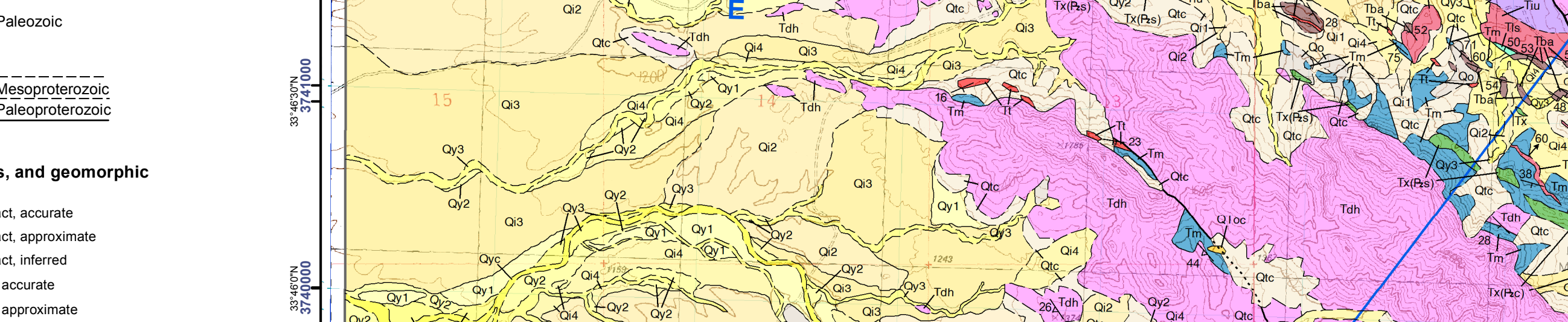


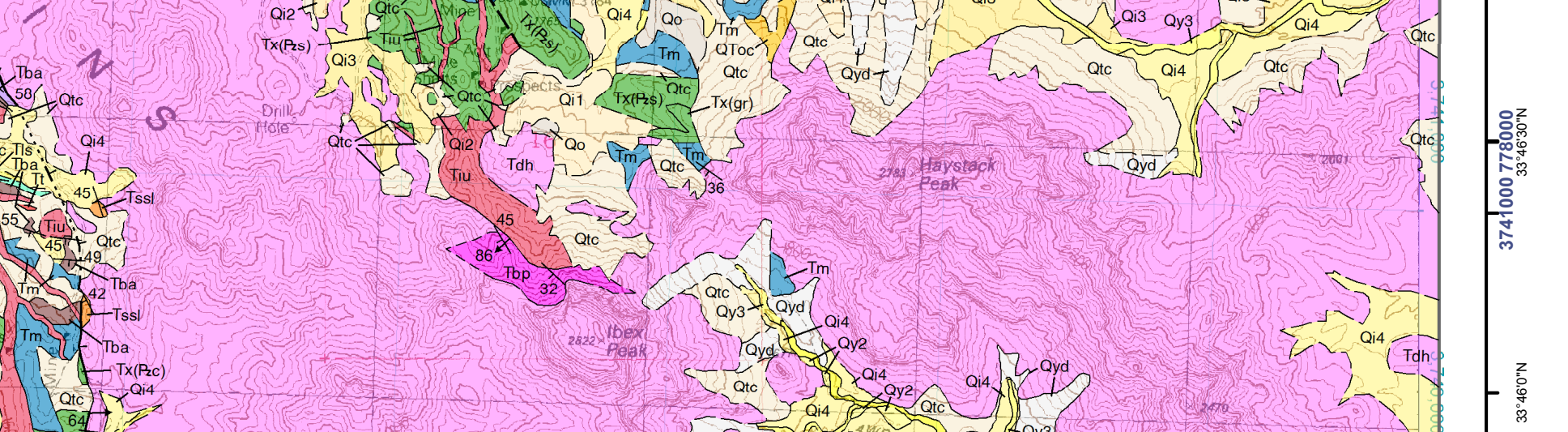
NO VERTICAL EXAGGERATION ON CROSS SECTIONS

Note - Quaternary units are not shown on cross sections.



Note: Dotted-line fault represents fault that was contested by intrusion (Tiu). This fault is inferred to have strike-slip displacement, juxtaposing dissimilar stratigraphic sequences.





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