BUREAU OF ECONOMIC GEOLOGY
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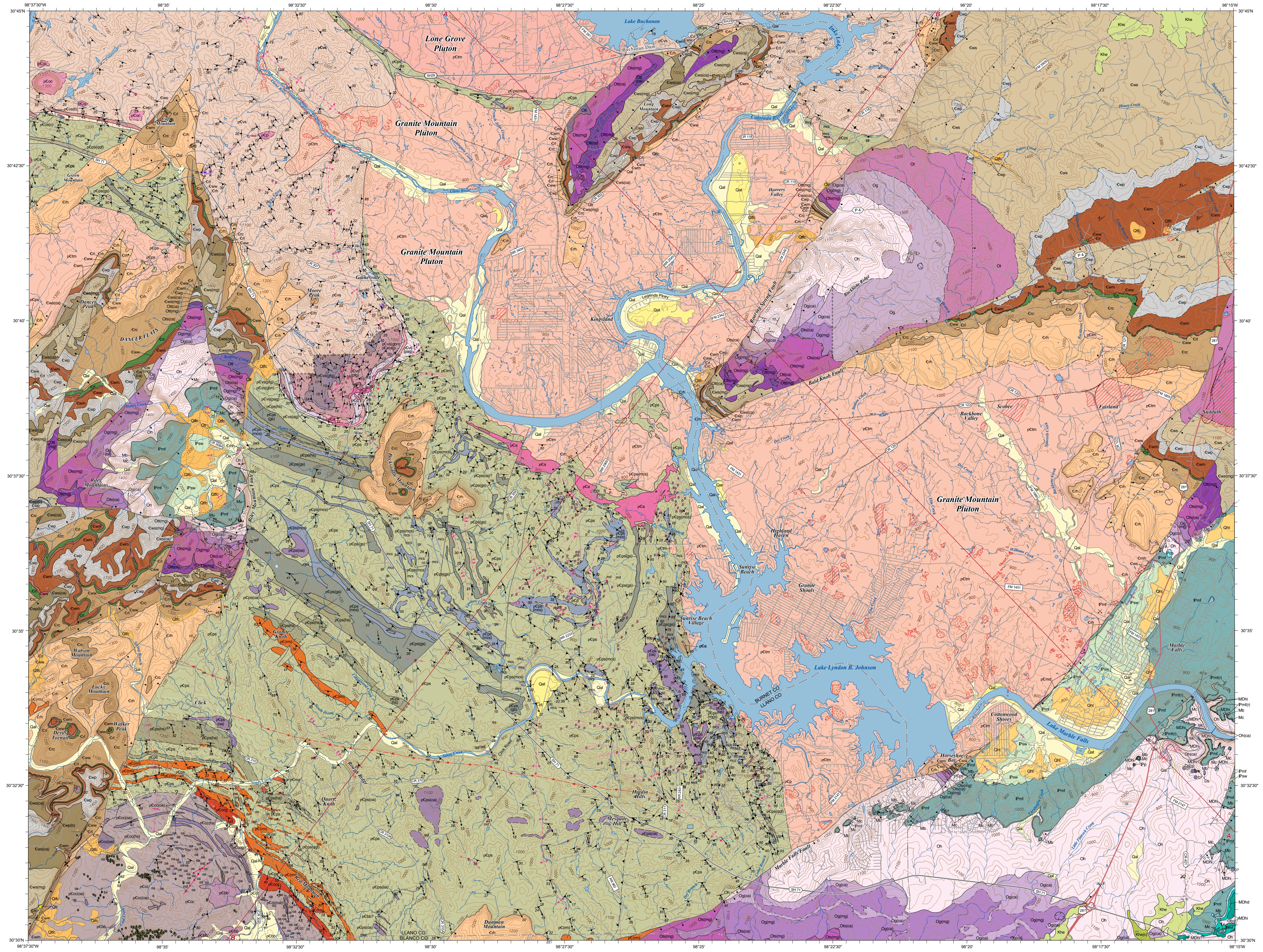
THE UNIVERSITY OF TEXAS AT AUSTIN

In cooperation with the State of Texas Advanced Resource Recovery (STARR) Program
and the U.S. Geological Survey National Cooperative Geologic Mapping Program
under STATEMAP award number G22AC00495, 2022.



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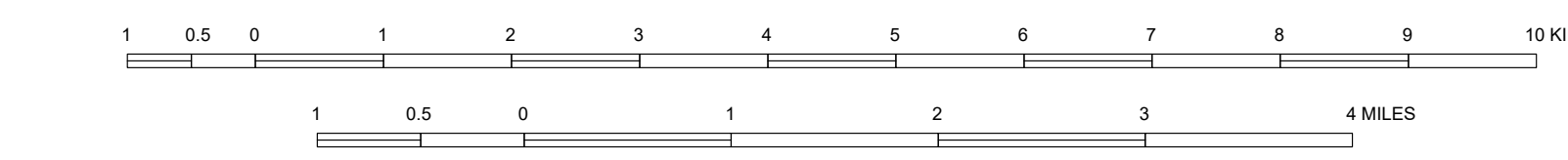
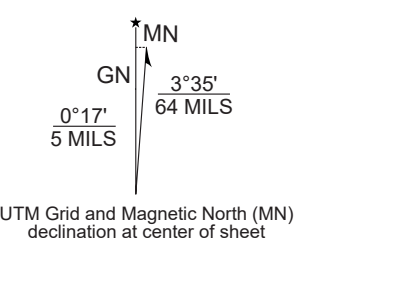


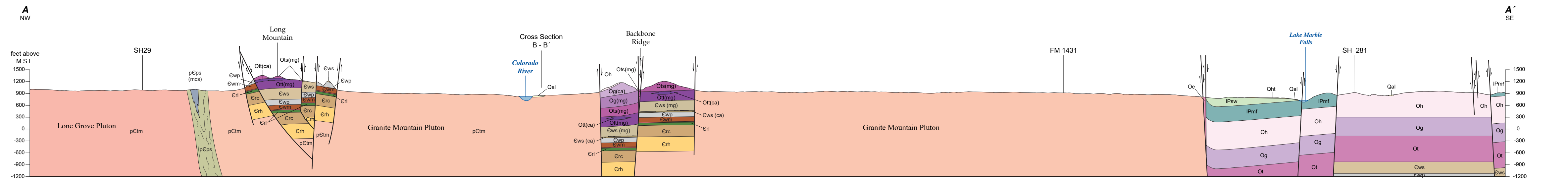
UNIVERSAL TRANSVERSE MERCATOR ZONE 14N, NAD 83
CONTOUR INTERVAL 20 FT
VERTICAL DATUM IS MEAN SEA LEVEL



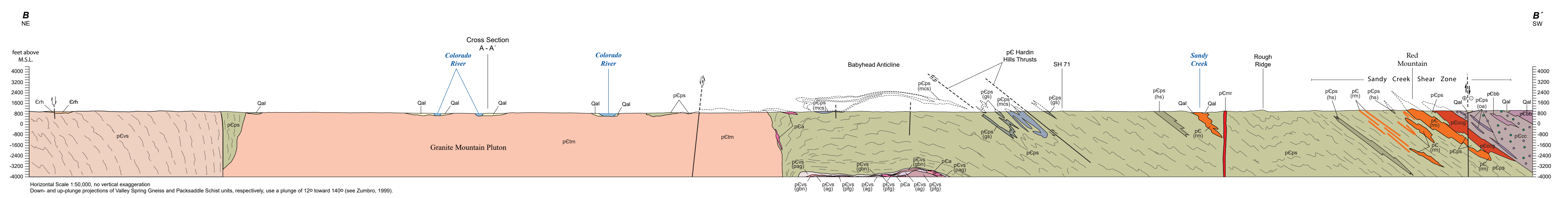
UTM Grid and Magnetic North (MN) declination at center of sheet

GEOLOGIC MAP OF A PORTION OF THE SOUTHEASTERN LLANO UPLIFT, BURNET, LLANO, AND BLANCO COUNTIES TEXAS

Mark A. Helper, Brian B. Hunt, and Virgil E. Barnes
2023

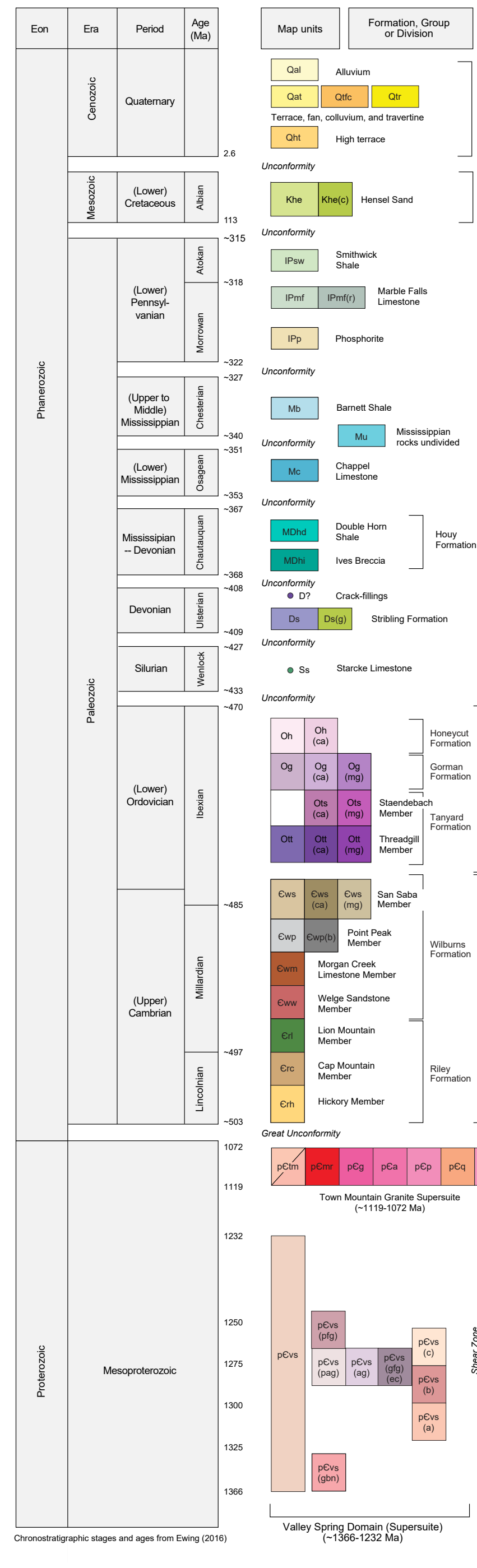


Horizontal scale is 1:50,000, 3X vertical exaggeration



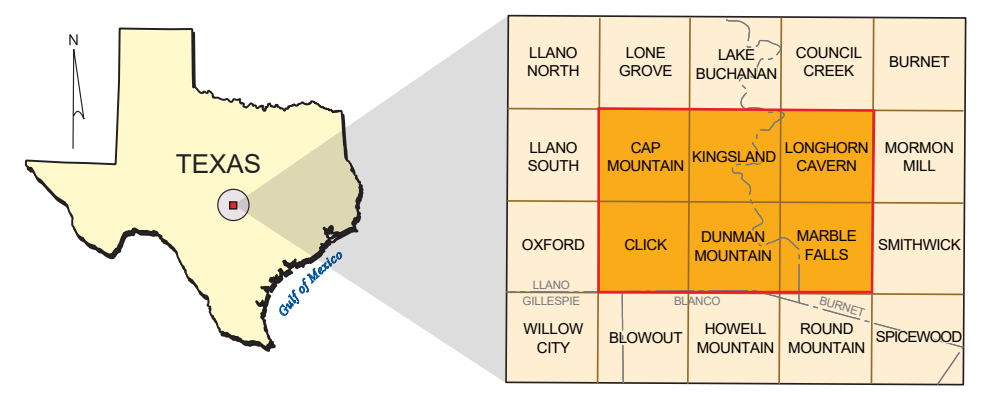
Horizontal Scale 1:50,000, no vertical exaggeration
Down- and up-plunge projections of Valley Spring Gneiss and Packsaddle Schist units, respectively, use a plunge of 12º toward 140º (see Zumbro, 1999).

CHRONOSTRATIGRAPHY AND CORRELATION OF MAP UNITS



Chronostratigraphic stages and ages from Ewing (2016)

- Topographic contour (20 ft interval)
- Intermittent stream
- County road
- Local road
- Railroad
- Pipeline (TRRC)
- Waterline



EXPLANATION

SURFICIAL DEPOSITS, QUATERNARY

Qal	**Qal—Alluvium**. Gravel, sand, and silt along and within stream courses.
Qat	**Qat—Alluvium, floodplain, and low terrace**. Sand, silt, and clay. Unconsolidated sediments on flat, broad treads within floodplains slightly above and adjacent to active stream channels. Flat surface represents recent overbank deposits commonly covering older alluvial channel deposits. Contains well-developed soils, locally cultivated. Consisting of granite grus and sandstone colluvium near Town Mountain Granite and Hickory Sandstone, respectively.
Qtr	**Qtr—Travertine**. Spring- and stream-deposited calcium carbonate. Occurrences are mostly associated with springs near faults in the Riley Mountains, at Long Mountain and at Backbone Ridge.
Qtfc	**Qtfc—Terrace, fan and colluvial deposits**. Colluvium and fan deposits, in part localized along and across fault line scarps in the Riley Mountains and along Backbone Ridge, passing downward into terrace deposits and alluvium along streams.
Qht	**Qht—High terrace**. Remnant broad, flat alluvial surfaces elevated above the incised channel of the Colorado River.

LOWER CRETACEOUS

Khe	**Khe—Hensel Sand**. Conglomerate, sand, silt, and clay. Reddish to yellow gray, poorly sorted, poorly consolidated to weakly calcite-cemented boulder to granular conglomerate, arkosic to quartz arenitic sand, silt and clay. Occurs as a thin mantle on Paleozoic rocks in the southeast and northeast portions of the map. Where not cultivated, sandier portions support a growth of broad leaf oak (Barnes, 1982). Well drained, recessive unit.
Khe(c)	**Khe(c)—Hensel Sand Conglomerate Facies**. Conglomerate. Poorly sorted, poorly bedded, containing clasts of Paleozoic and Precambrian rock from the Llano uplift. Occupies a fluvial paleochannel within Honeycut and Gorman Formation limestones near Flatrock Creek in the southeast corner of the map (Barnes, 1982a).

UNCONFORMITY

PENNSYLVANIAN

ℙcb	**ℙcb—Unnamed solution collapse breccia**. Blocks of Marble Falls Limestone and Houey Formation that occupy an approximately 200 x 250 m collapse structure in Ordovician Honeycut and Pennsylvanian Marble Falls formations at a single locality north of Marble Falls.
ℙsw	**ℙsw—Smithwick Shale**. Claystone and sandstone. Black to greenish-gray to yellowish-gray claystone (non-fissile shale) containing thin (<2 m) layers and lenses of medium- to fine-grained sandstone. Poorly exposed; weathering produces sparsely vegetated (grasses, mesquite), clay-rich, yellow-brown soil. Contacts with interlayered Smithwick sandstone lenses marked by change to slightly steeper slopes and denser vegetation. Sandstone lenses: medium- to very fine-grained, moderately- to well-sorted, quartz cemented, green-gray quartz sandstone (sublitharenite) weathering to various tones of reddish brown, interbedded with lesser amounts of Smithwick claystone. Resistant, hill-capping, commonly densely vegetated by oak, mesquite, cactus and grasses. Sandstone locally structureless, but commonly has abundant sole marks (small flute casts, tool marks), horizontal burrows, low-angle cross stratification, grading, and plant fragment impressions. Claystone-sandstone contacts are gradational, marked by increased amounts of sandstone float, slighter steeper topography and denser vegetation.
ℙmf	**ℙmf—Marble Falls Limestone**. Limestone. Dark gray to black, mudstone to wackestone with thin interbeds of light gray or brownish gray grainstone containing crinoid debris. Contains bedding-parallel nodules and branching networks of black, gray and brown chert, commonly spiculiferous. A 117-m-thick type section (Barnes, 1952b), now beneath Lake Marble Falls downstream of Marble Falls, contains a lower reef facies (r) that grades laterally to dark gray, hard spiculite and associated fine-grained highly spiculiferous gray to dark gray limestone. Above the reef and spiculite facies is light yellowish brown to light olive gray mudstone with interbedded oolitic- and allochem-rich grainstones. Ridge forming unit covered by dense growth of juniper and oak. Supports steep topography.
ℙmf(r)	**ℙmf(r)—Marble Falls Limestone, reef facies**. High calcium limestone. Very fine-grained, massive, medium olive gray to light brownish gray, about 35 m thick (Barnes, 1952b).
ℙp	**ℙp—Unnamed Phosphorite**. Phosphorite. Well-bedded, pale yellowish brown to dark yellowish brown, weathering dark yellowish orange containing phosphatic fossil debris, 0.1–0.6 mm ooids and structureless pellets (Barnes, 1954). Up to 3.4 m thick, occurring only atop two small hills southeast of Marble Falls.

MISSISSIPPIAN

Mu	**Mu—Missipian Rocks, undivided**. Barnett Shale and Chappel Limestone, undivided.
Mb	**Mb—Barnett Shale**. Shale. Dark gray to black, weathering brownish gray, oil-bearing, with limestone concretions about 0.6 m by 15 cm in dimension, locally includes chert. Poorly exposed in discontinuous isolated outcrops beneath Marble Falls Limestone. Averages 4.6 m thick.
Mc	**Mc—Chappel Limestone**. Limestone. Fine-grained, medium-dark gray with brownish-olive cast, crinoid-debris wackestone. In thin, discontinuous outcrops beneath Barnett Shale or Marble Falls Limestone. Contains conodonts, brachiopods and trilobites. 0–0.9 m thick.

MISSISSIPPIAN AND DEVONIAN
HOUY FORMATION

MDhd	**MDhd—Double Horn Shale**. Shale. Black, fissile, locally containing silicified wood (*Callixylon*). Poorly exposed, of unknown thickness.
MDhi	**MDhi—Ives Breccia**. Chert. Rounded-to-angular chert clasts in chert matrix appearing to surround boulders of Ellenburger Limestone up to 1.5 m in size. Areas mapped MDhi are soils containing chert clasts from either Ives Breccia or Stribling Formation. Poorly exposed, up to 0.75 m thick.

UNCONFORMTY

DEVONIAN

● D?	**D?—Unnamed crack-filling carbonate**. Dolomite and limestone. Crack fillings of dull yellow to dark brown carbonate, containing Devonian conodonts, in post-Ellenburger units and upper Honeycut Formation. In Houey or Chappel formations, fills may be Mississippian or Pennsylvanian. Crack fillings denoted by points labeled D?
Ds	**Ds—Stribling Formation**. Limestone and dolomite. Yellowish gray to pinkish and olive gray, microgranular to coarse-grained with chert lenses. Poorly exposed at only two localities, less than 3 m thick.
Ds(g)	**Ds(g)—Stribling Formation, glauconitic facies**. Limestone. Brownish, sandy, with glauconite, phosphatic pellets, and conodonts.

UNCONFORMITY

SILURIAN

● Ss	**Ss—Starcke Limestone**. Limestone. Medium- to coarse-grained, pinkish gray, massive, locally brecciated. Soil covered, with neither top nor bottom exposed. Abundant fossils of probable Wenlock age.

UNCONFORMITY

ORDOVICIAN
ELLENBURGER GROUP

Oe	**Oe—Ellenburger Group, undivided**. Limestone and dolomite. Cherty, non-glauconitic, thick- to thin-bedded, sparingly fossiliferous. Limestones generally fine-grained, light gray; dolomites varied colors, microgranular to very coarse crystalline. Aggregate thickness 495–555 m.
Oh	**Oh—Honeycut Formation**. Cherty limestone and dolomite. Thin- to thick-bedded, with sparse interbeds of light green shale near top. Upper contact an erosional unconformity with karstic topography filled in part by remnants of Upper Ordovician, Silurian, and Devonian rocks above. Gradational lower contact locally collapsed into underlying Gorman Formation. Average thickness 112–206 m.
Oh(ca)	**Oh(ca)—Honeycut Formation, upper unit, limestone facies**. High purity limestone. Aphanitic, brownish yellow-gray with "cannonball" chert. Mined and quarried near Marble Falls (Barnes et al., 1972). Up to 67 m thick.
Og	**Og—Gorman Formation**. Limestone and dolomite. Upper limestone and lower dolomite units, with lateral variations common. Upper unit: limestone and lesser dolomite, thin- to thick-bedded, cherty, light gray to yellowish gray, microcrystalline; dolomite microcrystalline to fine-grained. "*Diaphelasma* zone" brachiopod (Ogd). Lower unit: dolomite and lesser limestone. Pink, yellow, brown, medium gray, fine-grained dolomite with less chert than upper. Top of the lower unit defined below "*Archaeoscyphia* zone" sponge (Oga) in chert. 142–147 m thick.
Og(ca)	**Og(ca)—Gorman Formation, upper unit, limestone facies**. Limestone and lesser dolomite. Thin- to thick-bedded, cherty, light gray to yellowish gray, microcrystalline limestone. Dolomite microcrystalline to fine-grained. 74–80 m thick.
Og(mg)	**Og(mg)—Gorman Formation, lower unit, dolomite facies**. Dolomite with lesser limestone. Pink, yellow, brown, medium gray, fine-grained dolomite. Less cherty than calcitic (ca) upper unit. Top immediately below the cherty *Archaeoscyphia* sponge zone (Oga). 65–67 m thick.
Ot	**Ot—Tanyard Formation**. Dolomite. Predominantly medium- to coarse-grained. In contrast to overlying units, generally coarser grained, lighter in color, without sand or sponge (*Archaeoscyphia*) zones. Total thickness 168–198 m.
Ots(ca)	**Ots(ca)—Staendebach Member, calcite facies**. Limestone. Fine-grained, light gray, well-bedded, smooth weathering with trilobites in upper 30 meters. 0–37 m thick.
Ots(mg)	**Ots(mg)—Staendebach Member, dolomite facies**. Dolomite. Fine - to medium-grained, light gray to brownish and yellowish gray, medium- to thickly-bedded cherty dolomite. Forms uneven medium to dark gray ledges. Up to 71 m thick. Contact with overlying calcitic facies locally laterally gradational over 30+ m.
Ott	**Ott—Threadgill Member**. Dolomite. Medium- to coarse-grained, light-colored, non-cherty, locally containing a mappable limestone (ca) facies gradational to surrounding dolomite. Limestone aphanitic, noncherty, massive to indistinctly bedded, weathering to massive irregular, rough ledges. Fossils include sparse gastropods and cephalopods. Absence of glauconite, chert, and sand distinctive compared to underlying San Saba Member carbonate. Grades upward into overlying Staendebach Member dolomite that is distinctively chertier. Lower contact with San Saba is time transgressive (spanning Cambrian-Ordovician boundary) and lithologically indistinct. 28–76 m thick.
Ott(ca)	**Ott(ca)—Threadgill Member, calcite facies**. Limestone. White to light gray, aphanitic non-cherty limestone grading laterally and vertically into dolomite. Calcite facies locally more resistant to weathering, standing in relief compared to dolomite facies.
Ott(mg)	**Ott(mg)—Threadgill Member, dolomite facies**. Dolomite. Medium- to coarse-grained, chert-poor. White to light gray color contrasts strongly with darker tones of the San Saba carbonate beneath.

CAMBRIAN
MOORE HOLLOW GROUP

Єmh	**Єmh—Moore Hollow Group, undivided**. Limestone and sandstone. Fault slivers of Cambrian rock along the Marble Falls and Riley Mountain faults.

WILBURNS FORMATION

Єws	**Єws—San Saba Member**. Dolomite and limestone. Limestone, generally basal, fine- to medium-grained, thin- to thick-bedded, glauconitic and stromatolitic, locally oolitic, light gray or grayish orange where dolomitic. Dolomite, generally above limestone but locally laterally and vertically gradational with it, fine-grained to microgranular, cherty, yellowish to brownish gray commonly mottled with pinkish and purplish hues, medium-bedded to massive. Total thickness 67–88 m. Upper boundary gradational, placed at the top of fine-grained dolomite but above Cambrian fossils, and beneath coarse-grained dolomite bearing Ordovician fossils (Barnes, 1982a). Generally more resistant than underlying Point Peak.
Єws(mg)	**Єws(mg)—San Saba Member, dolomite facies**. Dolomite. Coarse- and fine-grained, cherty, medium-bedded grading upward into thicker, cherty, massive beds; weathers to rounded, solution-pitted boulder-like masses. Yellow to brownish gray, commonly mottled to pinkish to purplish gray to mottled gray.
Єws(ca)	**Єws(ca)—San Saba Member, stromatolite facies**. Limestone. Fine- to medium-grained, thin- to thick-bedded, gray, glauconitic and stromatolitic (*Girvanella* genus). Gradational with underlying Point Peak Member.
Єwp	**Єwp—Point Peak Member**. Siltstone and limestone. Lower portion, up to 33 m, typically poorly exposed, composed of 1) yellowish brown weathering, calcareous and glauconitic, thinly-bedded argillaceous siltstone, and 2) fine-grained, medium gray to greenish gray, thinly-bedded, silty, intraformational limestone conglomerate. Upper portion, up to 35 m, stromatolitic (biohermal) limestone; greenish gray, fine-grained massive, with beds and septae between stromatolites of fine- to coarse-grained glauconitic limestone. Thickness highly variable, with as little as 16–33 m in Marble Falls quadrangle. Grades upward where upper biostromal facies is absent to overlying San Saba Member, with contact placed above the first resistant limestone beds.
Єwp(b)	**Єwp(b)—Point Peak Member, Bioherm facies**. Limestone. Stromatolitic, mottled greenish to brownish gray; light brownish yellow where dolomitic and pale greenish gray where argillaceous films are present.
Єwm	**Єwm—Morgan Creek Limestone Member**. Limestone and calcareous sandstone. Basal sandstone well-cemented, calcareous, thick-bedded, coarse- to medium-grained, glauconitic, light olive gray to reddish gray, up to 8 m thick. This grades upward into thin- to medium- bedded, less sandy, fine- to coarse-grained limestone (wackestone to grainstone) with patches of brownish yellow dolomite. The upper portion contains alternating reddish argillaceous calcareous siltstone, coarse-grained, thick-bedded greenish gray to olive gray glauconitic limestone, with intervals of pale brown stromatolitic limestone near the top. Total thickness 34–40 m. The upper boundary is marked by an abrupt change in topographic slope to the less resistant and recessive weathering Point Peak Member. Morgan Creek Member forms ridges and steep hillslopes.
Єww	**Єww—Welge Sandstone Member**. Quartz sandstone. Yellowish brown, slightly to non-glauconitic, coarse- to medium-grained, with well-rounded and well-sorted grains cemented by quartz overgrowths. Grades into overlying Morgan Creek Member. 3–5 m thick. Forms a very narrow low sandstone scarp easily visible in high resolution digital terrain models. Aerial photographs show a thin line of vegetation marking its presence, usually above a sparsely vegetated bench underlain by Lion Mountain Sandstone.

RILEY FORMATION

Єrl	**Єrl—Lion Mountain Member**. Sandstone. Highly glauconitic, green to dark brown, fine- to coarse-grained and cross-bedded, containing white, oblate, decimeter- to meter-scale cross-bedded limestone lenses rich in phosphatic brachiopods and trilobite coquina. A recessive unit, forming benches or valleys between more resistive overlying and underlying units. Develops dark reddish soil that is locally cultivated. 10-20 meters thick.
Єrc	**Єrc—Cap Mountain Member**. Limestone and sandstone. Dark tones of yellowish brown, brown, red, and gray, fine- to medium-grained, moderately to poorly sorted, glauconitic, very sandy limestone, calcareous sandstone, calcareous siltstone, and oolitic limestone. Coarse-grained trilobite coquinite at top. Changes in hill slopes and vegetation density mark upper and lower contacts, which are otherwise gradational. Highly resistant, scarp forming, densely vegetated with juniper, live oak, yucca, and cacti. 88–125 m thick.
Єrh	**Єrh—Hickory Sandstone Member**. Sandstone. Brown to red, arkosic to quartz arenitic. Basal portion massive to trough cross-bedded, coarse-grained, poorly sorted, conglomeratic, quartz, and hematite cemented. Middle portion: thick- to thin-bedded, fine- to coarse-grained, poorly- to moderately well-sorted, light brown, silty; locally hematite cemented, containing phosphatic brachiopods and abundant trace fossils, up to 44 m thick. Upper portion: medium to coarse, very well-rounded grains, red, friable, hematite cemented, becoming more argillaceous and glauconitic upward. Upper contact is below first resistant bed of Cap Mountain Limestone, generally coincident with a marked change is slope. Lower contact is a nonconformity. 84–143 m thick.

NONCONFORMITY

pЄmd md	**pЄmd—Mafic dike**. Diabase. Dark gray to black, weathering dark yellowish brown, 0.3–6 m thick dikes, up to about 1.6 km long. Aphanitic to fine-grained and porphyritic, zoned to unzoned, ophitic to diabasic textures. 15–65% plagioclase, 40–80% hornblende, with accessory biotite and magnetite. Hornblende commonly partially replaced by chlorite. Those found along the Marble Falls Fault are of indeterminate age (Barnes, 1982), others are clearly Precambrian.

MESOPROTEROZOIC
TOWN MOUNTAIN GRANITE (SUPERSUITE)

pЄ mr	**pЄmr—Melarhyolite dike**. Rhyolite. Dark gray to black, very fine-grained to porphyritic (quartz and feldspar phenocrysts with myrmekitic and graphic intergrowths) in an aphanitic matrix of potassium feldspar (~60%), quartz (5–20%), biotite (~20%), oligoclase (trace to 10%), and accessory amphibole, zircon, apatite, calcite and opaques. Very tough, with one 10–12-m-thick vertical flow-banded dike forming a prominent, ~12 km long ridge that cross-cuts fabrics and folds in the southern portion of the map but contains biotite aligned parallel to foliation in the country rock, suggesting it is late synkinematic in age (McGehee, 1963, 1979). U-Pb zircon crystallization date is 1098 +/- 3 Ma (Walker, 1992).
pЄ g	**pЄg—Granite dike**. Granite. Pink to light gray, medium-grained granite dikes, unfoliated, equigranular to porphyritic.
pЄa a	**pЄa—Aplite dike and aplogranite**. Granite. Aplite dikes, sills or bodies of very fine- to fine-grained granite (aplogranite) that intrude Valley Spring Gneiss and Packsaddle Schist. Pink, resistant, standing out in relief. Weakly foliated or unfoliated at margins, unfoliated interiors, granoblastic to sparsely porphyritic. Dominantly microcline and quartz, with lesser plagioclase and biotite. Accessory garnet, amphibole, chlorite, and apatite have been noted (Zumbro, 1999). Field relationships indicate a late syn- to post-tectonic origin.
pЄp p	**pЄp—Pegmatite dike**. Granite. Pink, very coarse-grained, quartz- and feldspar-rich dikes and bodies within Packsaddle Schist, Valley Spring Gneiss and granite, thought to be late-stage derivatives of Town Mountain Granite magmatism (McGehee, 1963). Mainly tabular, straight, and steeply inclined, many forming low, linear, resistant ridges (visible in high resolution DTMs) up to ~1500 m long, commonly parallel to regional joint sets. Up to 20 m thick, containing pink perthitic microcline, milky white, colorless, rose or smoky quartz, with or without muscovite, biotite, albite, and black tourmaline; more rarely containing topaz, garnet, fluorite, beryl, apatite, titanite, corundum, stilpnomelane, cassiterite, molybdenite, bismuth, and bismuthinite (White, 1960). McGehee (1963) noted that large pegmatites with complex mineralogies occur only in Packsaddle Schist and Town Mountain Granite, and with greatest abundance proximal to Town Mountain Granite plutons; most elsewhere are simply quartz and feldspar, regardless of size.
pЄ q	**pЄq—Vein quartz**. Quartz. Resistant, milky white, monomineralic masses and veins within granite, Packsaddle Schist and Valley Spring Gneiss, most too small to be mapped. Veins are both cut across and aligned, folded, and boudinaged with the foliation in schist and gneiss, indicating veins of different ages, some likely associated with hydrothermal activity during granite intrusion and others produced synkinematically during earlier regional metamorphism.
pЄtm	**pЄtm—Town Mountain Granite**. Granite. Pink to light gray, coarse- to medium-grained, commonly rapikivi and/or antirapikivi textured, with coarse pink perthitic, inclusion-rich, microcline, zoned, mantled, and inclusion-rich white plagioclase, gray quartz, black biotite, and amphibole, and accessory titanite, zircon, allanite, apatite, fluorite, hematite, magnetite and ilmenite. Porphyritic to equigranular. Forms circular to ovoid, post-to late-synkinematic, texturally zoned (Keppel, 1940) plutons with mafic schlieren, felsic enclaves, xenoliths and flow foliation common near margins. Granite Mountain and Lone Grove plutons within the map area have U-Pb crystallization ages of 1091 +/-4 and 1091 +/-2 Ma (Barker and Reed, 2010). Exfoliation domes (some mapped), up to ~1 km across, are locally quarried for building stone; elsewhere grus, an *in-situ* granite weathering product, attaining thicknesses up to 10 meters, is quarried and facilitates mapping where granite is not exposed.
pЄoc	**pЄoc—Sandstone Mountain Granite.** Granite. Pink fine-grained, resistant, comprising Sandstone Mountain pluton and smaller satellite bodies in the Cap Mountain quadrangle. Approximately 25% microcline, 37% plagioclase, 37% quartz, 1% biotite. Originally classified as Oatman Creek Granite, a name now deprecated (Barker and Reed, 2010). Undated, but by circular form and discordant contacts, it is here considered a post-kinematic granite of the Town Mountain Supersuite, which have ages of 1093–1072 +/-6 Ma (Barker and Reed, 2010).

ORTHOGNEISS AND METAINTRUSIVE ROCKS

pЄ(rm) rm	**pЄ(rm)—Red Mountain Gneiss**. Granitic orthogneiss. Dark red sills up to ~150 m thick forming resistant ridges parallel to the regional foliation of Packsaddle Schist and locally coincident with its southern boundary. Composed of roughly 50% microcline, 40% quartz, 4% oligoclase, 5% biotite, 1% magnetite with accessory muscovite, apatite, titanite and zircon, commonly with secondary epidote and chlorite. Fine- to medium-grained, strongly lineated; well-foliated and mylonitic to poorly foliated. Lineation defined by stretched quartz and feldspar, locally forming rods up to 2 cm long, and by streaks of biotite. Flattened quartz and feldspar define the foliation, which is absent to less well-developed in the center of the thickest sills. Igneous crystallization dated by U-Pb zircon at 1239 +5/-3 Ma (Walker, 1992). Xenoliths and locally discordant contacts indicate Red Mountain Gneiss intruded Packsaddle Schist prior to regional deformation and dynamic metamorphism.
pЄma	**pЄma—Meta-aplite**. Aplitic granite, metamorphosed. Pink, equigranular, in sills or elongated irregular masses. Weakly foliated to granoblastic with granophyric and myrmekitic textures locally preserved. Approximately 50% untwinned albite-oligoclase, 25% microcline, 15% quartz, 5% biotite with accessory zircon, apatite and magnetite. Restricted in occurrences to Red Mountain Gneiss area.
pЄccg	**pЄccg—Comanche Creek Gneiss**. Quartz monzonitic orthogneiss. Pink and white, medium- to coarse-grained, with pink microcline augen to 2 cm; 30–45% microcline, 10–20% oligoclase, 30–50% quartz, 5-10% biotite. Strongly lineated and variably foliated with smaller augen and recrystallized quartz ribbons associated with more strongly foliated rock. Occupies a concordant sill that intrudes and shares a common deformational history with Red Mountain Gneiss (Carter, 1989; Reese et al., 2000) to the north and east, and is in tectonic contact with Coal Creek Domain rocks to the south and west (Roback, 1996; Reese et al., 2000). U-Pb igneous crystallization date of 1238 +8/-6 Ma. Name introduced by Reese et al. (2000); formerly considered metasomatized Big Branch Gneiss (Clabaugh and Boyer, 1961).

PACKSADDLE DOMAIN SUPERSUITE

pЄps	**pЄps—Packsaddle Schist, undivided**. Feldspathic amphibole and mica schists, amphibolite, quartzite, marble and felsic gneiss. Originally divided into four now-deprecated formations (McGehee, 1963, 1979; Reese et al., 2000), it is shown here undivided and coextensive with the Packsaddle Domain of Mosher (1998), but with mappable, particularly distinctive, and/or resistant lithologies (marble/calc-silicate rock, orthoamphibolite, graphite schist, quartzite, and fine-grained hard quartz-rich rock [leptite] and hornblende schist) indicated. Supracrustal rocks of the Packsaddle Domain uplift here consist of 1274–1243 Ma, metamorphosed volcanic, volcaniclastic, and sedimentary rocks interpreted to represent a marine basinal sequence (Reese et al., 2000), with a shallow-water, continental-margin depositional environment for the rocks closest to the Valley Spring Domain (Mosher, 1998). Rocks nearest to and within the Sandy Creek Shear Zone (roughly co-extensive with southern-most Red Mountain Gneiss) have undergone complete transposition, precluding determination of many protoliths and of any original contact relationships. Deformation intensity (but not complexity) decreases northward away from the zone. More units have apparent igneous protoliths in the south near the boundary with the Coal Creek Domain, and metasedimentary units (marbles, calc-silicate rocks, graphitic schists, and quartzites) become dominant northward near the Valley Spring Domain. Granitic sills, ranging in age from 1255 to 1238 Ma, intrude the supracrustal rocks and are affected by the polyphase deformation; an undeformed to late-synkinematic, regionally extensive 1098 Ma melarhyolite dike crosscuts all structures (Walker, 1992; Roback, 1996). At the northern boundary of the Packsaddle Domain, a ductile shear zone places Packsaddle metasedimentary and metavolcanic rocks on granitic gneiss of the Valley Spring Domain (Reese et al, 1999; Zumbro, 1999; Mosher et al., 2004). In the western uplift, rocks of the Packsaddle Domain consist of interlayered amphibolites, felsic gneisses, pelitic schists and minor calc silicates, and the few dated units yield similar ages (e.g., 1253 +5/-3 Ma; Roback et al., 1999).
pЄps(hs)	**pЄps(hs)—Amphibole schist**. Amphibole schist. Medium green, dark green, gray, black; very fine-grained, schistose to phyllitic, highly fissile. Composed of amphibole (15–85%, average 45%), feldspar (both plagioclase with lesser to no microcline), and quartz (in subequal amounts). Millimeter- to centimeter-scale compositional layers of alternating hornblende- and feldspar-quartz-rich laminae are variably developed; a weak to strong lineation by alignment of amphibole is commonly evident. Both are locally folded on a small scale. Black amphibole (hornblende) predominates in amphibole schist in the northern ~2/3 of the Packsaddle domain; amphibole schist in the southern ~1/3 proximal to the Sandy Creek Shear Zone is instead predominantly pale green (actinolite), but otherwise similar in texture and fabric. These schists are lighter in color and richer in quartz and feldspar (some having undergone grain size reduction; McGehee, 1963a), with some containing appreciable biotite. Interlayered black amphibole schist occurs infrequently. Basaltic lava flows and mafic tuffs are possible protoliths (McGehee, 1963a).
pЄps(qqf) qqf	**pЄps(qqf)—Quartzite and quartz-feldspar schist**. Quartzite and quartz-feldspar schist. Gray, pale-brown to pink, fine- to medium- grained, granoblastic to weakly foliated by slightly elongate quartz and feldspar, which also define a stretching lineation on foliation surfaces. With the presence of minor aligned biotite, these rocks become gradational to quartz mica schist and felsic gneiss. Resistant, forming low ridges and ledges. Average mineralogy, difficult to define, generally 90% quartz and feldspar (subequal amounts, with plagioclase more common than potassium feldspar), with or without small amounts of biotite, muscovite, chlorite, epidote, garnet, amphibole, pyrite, apatite, staurolite, titanite and iron-oxide, and sillimanite and/or andalusite locally present near Town Mountain Granite contacts and elsewhere.
pЄps(mcs) mcs	**pЄps(mcs)—Marble and calc-silicate rock**. Marble and calc-silicate rock. Marble is gray-, white- and black-banded, very fine- to very coarse-grained, granoblastic, composed of calcite (35–95%, rarely pure), and subordinate, variable amounts of tremolite, plagioclase, quartz, mica (phlogopite and muscovite), graphite, iron-oxide and titanite. Tremolite, diopside, microcline, talc, and pyrite occur within calc-silicate rocks, and very coarse-grained calc-silicate rock near granite and pegmatite contacts locally contain scapolite, vesuvianite, wollastonite, and calcic garnet (McGehee, 1963). Marble occurs in lenticular decimeter- to decameter-thick layers, lenses and bodies up to ~100 m thick interlayered and associated with graphite and amphibole schists at both map and outcrop scale in the lower (northern) Packsaddle Schist. At map scale, complex patterns are a consequence of tight folding and refolding, a characteristic feature also visible at smaller scales; marker beds (mapped as lines where marble layers are less than 10 m thick) and thicker layers outline early tight to isoclinal, shallowly reclined to upright folds that are, in large areas, refolded by later, shallowly SE-plunging, upright antiforms and synforms, as recorded by mapped axial traces in northeastern Packsaddle Schist.
pЄps(gs) gs	**pЄps(gs)—Graphite schist**. Graphite schist. Dark gray to black, very fine-grained, fissile to blocky. Commonly interlayered or associated with marble, and locally gradational into fine-grained graphite-amphibole and amphibole schist and phyllite. Graphite content, from a few percent up to 30% (McGehee, 1963), is generally subsidiary to quartz and muscovite, with lesser amounts of biotite, pyrite, and microcline. Andalusite (chiastolite) and tourmaline are common near granite and pegmatite contacts, and cordierite is present at a few localities (McGehee, 1963). Usually foliated and schistose on a fine scale, with alternating compositional layers of lesser and greater amounts of quartz (both as flattened and boudinaged veins and as very fine-grained layers), graphite, and muscovite, with graphite and mica defining one or more foliations, and stretched quartz a lineation on foliation surfaces. Compositional layering and graphite-mica foliation are commonly tightly to isoclinally folded and refolded on a centimeter to meter scale, with one or more axial planar foliation developed in fold hinges (Reese and Mosher, 2004).
pЄps(oa) oa	**pЄps(oa)—Orthoamphibolite**. Amphibolite. Black, medium- to coarse-grained, in discordant to concordant irregularly-shaped bodies, folded sheets, and lenses, all with borders parallel to foliation in surrounding schist. Granoblastic to weakly foliated (aligned hornblende) to gneissic (hornblende- and feldspar-rich bands). Composed of hornblende (20–65%), plagioclase (0–40%) and microcline (average 19%), with variable amounts of quartz (15%), secondary chlorite and accessory titanite, iron-oxide and apatite. Thought to be of intrusive origin (orthoamphibolite, either metagabbro or metadiabase) as sills, dikes, or stocks (McGehee, 1963). Generally resistant, forming hills and topography higher than surrounding rocks. Poorly exposed but mappable by the presence of reddish-brown blocky amphibolite rubble and dark red soil.

VALLEY SPRING DOMAIN SUPERSUITE

pЄvs	**pЄvs—Valley Spring Gneiss, undivided**. Felsic gneiss, amphibolite, schist, quartzite, marble and granite. Dominantly poor- to well-foliated quartz-feldspar gneisses, with lesser amphibole and biotite gneisses, mica schists, quartzite, and calc-silicate gneiss (Zumbro, 1999; McGehee, 1979; Barnes, 1952) not continuously exposed or laterally continuous enough to map separately. Includes Unit A of McGehee (1979). Within the Cap Mountain Quadrangle, Zumbro (1999) interpreted the structurally lowest package of Valley Spring Gneiss as a heterogeneous sequence of mostly paragneiss (meta-arkose, metapelite, metamorphosed sandy carbonate, amphibole, and biotite-rich gneiss) intruded by granitic gneisses and younger, lesser to undeformed melarhyolite, aplite, pegmatite, and coarse-grained granite. U-Pb zircon crystallization dates for metaigneous rocks of the Valley Spring Gneiss span 1366–1232 Ma (Reese et al., 2000) with the youngest date from foliated (but not gneissic) granite at Inks Lakes State Park (Rougvie et al., 1999).
pЄvs(pag)	**pЄvs(pag)—Mylonitic syenogranitic augen gneiss**. Felsic augen gneiss. Quartz-microcline-plagioclase mylonitic augen gneiss of the uppermost Valley Spring Gneiss. Pink to purple-gray, fine-grained, well-banded, with foliation defined by biotite and 0.5–3 cm microcline augen. Microcline augen and stratigraphic position are diagnostic. 6–52 m thick. In thrust contact with overlying Packsaddle Schist. Sharp to gradational contact with underlying amphibole-biotite gneiss, containing thin augen gneiss boudins cited as evidence of an intrusive relationship (Zumbro, 1999). Partially equivalent to Valley Spring Gneiss Unit C of McGehee (1979). U-Pb zircon igneous crystallization age of 1272 +8/-5 Ma (Reese et al., 2000).
pЄvs(c)	**pЄvs(c) - Unit C: pink augen gneiss**. Felsic augen gneiss. Quartz-microcline-plagioclase augen gneiss of the uppermost Valley Spring Gneiss (McGehee, 1979) partially equivalent to the syenogranitic augen gneiss of Zumbro (1999) where mapped in Honey Creek and vicinity.
pЄvs(ag)	**pЄvs(ag)—Amphibole gneiss and biotite-amphibole-gneiss**. Amphibole and biotite-amphibole-gneiss. Fine-grained, dark gray and dark greenish gray, plagioclase (34%)-sericitized feldspar (26%)-amphibole (14%)-microcline (14%) gneiss with minor quartz (2%), biotite, titanite (1.2%), iron-oxide, epidote, apatite and zircon. Locally slightly banded on mm- to cm-scale with poorly organized felsic and mafic bands. Monzodioritic in composition, highly variable thickness, ranging 10–82 m. Locally interlayered with 0.5–1.5 m thick sill-like layers of amphibole-biotite gneiss and rare schist; is intruded by, or intrudes, other pCvs subunits. U-Pb zircon igneous crystallization age of 1275 +/-3 Ma (Roback, unpublished, in Zumbro, 1999). Lies within both Unit A and B of McGehee (1979).
pЄvs(gbn)	**pЄvs(gbn)—Gray banded gneiss**. Banded felsic gneiss. Uniformly, continuously and conspicuously well-banded, gray weathering, with 1–3 cm thick black-green, light pink, dark pink and yellow-green gneissic banding. Well lineated and less boudinaged than subunits above and below. 5–55 m thick, monzogranitic in composition, composed of amphibole, elongate microcline, elongate quartz, subhedral epidote and minor plagioclase, with accessory iron-oxide, apatite, zircon, biotite, and titanite. U-Pb zircon igneous crystallization age of 1366 +/-3 Ma with metamorphic zircon of 1325 Ma (Reese et al., 2000). Dominantly within Unit B but overlapping Unit A of McGehee (1979).
pЄvs(b)	**pЄvs(b)—Unit B: gray biotite-quartz-feldspar gneiss**. Biotite Gneiss. Finer grained and better foliated than underlying Unit C, with layer-parallel pods of epidote up to 0.3 m long. Averages 63% microcline, 25% quartz, 8% biotite, and 3% hornblende with accessory titanite, iron-oxide, apatite, and zircon.
pЄvs(pfg)	**pЄvs(pfg)—Pink felsic gneiss**. Felsic gneiss. Pink to pinkish gray, light purple-pink where fresh, poorly to moderately well-foliated microcline-rich syenogranitic gneiss (Zumbro, 1999). Darker brown appearance with increasing biotite content. Gneissic banding defined by light and darker pink, mm- to cm-thick layers. Composed of elongate microcline (42%), elongate quartz (35%) and plagioclase (18%) with accessory iron-oxide, biotite, garnet, titanite, amphibole, zircon, epidote, muscovite, and chlorite. Locally boudinaged, but not as extensively as amphibole gneiss or underlying gray gneiss. Contains asymmetric microcline augen (1–3 cm in diameter) and red-black oxidation spots from weathering of iron-oxide and garnet. Very fine-grained biotite locally defines a foliation, and with microcline augen and muscovite, can define a knobby appearance on foliation surfaces. 45–200 m thick, showing intrusive relationships with all other Valley Spring Gneiss subunits (mylonitic augen gneiss [pЄpag], gray banded gneiss [pЄgbn], amphibole gneiss [pЄvs(ag)] and gray felsic gneiss [pЄvs(gn)], commonly as layer-parallel, sill-like bodies. Includes McGehee's (1979) slightly foliated metagranite and is entirely within his Unit A.
pЄvs(gfg)	**pЄvs(gfg)—Gray felsic gneiss**. Felsic gneiss with retrogressed eclogite (garnet pyroxenite) boudins. Medium purple-gray, biotite-rich, strongly boudinaged syenogranitic gneiss typically darker in tone than the adjacent pink felsic gneiss. Outcrops are undulatory and hummocky from boudinage in several directions. Well foliated, with alternating, ubiquitous light pink, coarser grained, unfoliated pegmatitic layers, and finer grained dark purple-gray, biotite-rich foliated layers of 0.25 cm to several cm wide. Where pegmatitic layers are abundant the gray gneiss is pinker and takes on the appearance of a migmatite with asymmetric pink microcline augen and isoclinal to open folds with axial plane gneissic foliation. 47% microcline, 18% plagioclase, 28% quartz, 2.4% biotite. Plagioclase and microcline augen are likely relict igneous porphyroclasts within a finer-grained groundmass of the same with quartz. Contains accessory amphibole, titanite, zircon, apatite, rutile, rare garnet, and secondary chlorite. Hosts retrogressed relict eclogite facies garnet clinopyroxenite and orthoamphibolite bodies (boudinaged sills; points labeled pЄvs(e)) within gray and pink felsic gneiss near the structural top of this subunit. U-Pb zircon igneous crystallization date of 1273 +/-2 Ma (Zumbro, 1999). Includes part of Unit A of McGehee (1979).
◎	**pЄvs(e)—Garnet pyroxenite**. Garnet pyroxenite. Black, cm- to m-scale (up to 4x6 m), ellipsoidal to spherical, highly tapered to equant, isolated to connected lenses and pods, both as intrafolial isolated layers that have experienced chocolate tablet boudinage and as nested boudins within more strongly foliated gneiss with foliation boudinage. Boudins have a foliation at their margins that is parallel to surrounding gneiss. In larger lenses and spheres, the foliation dies out into a weakly foliated to unfoliated interior. Margins are commonly rimmed or intersected by vein quartz, aplite, and/or pegmatite. Smaller bodies are completely or partially retrogressed to an amphibolite facies mineralogy of amphibole-oligoclase-quartz-biotite; symplectic or coronal texture garnet pseudomorphs are the only relicts of the earlier mineralogy. Larger bodies still contain garnet that is rimmed by symplectite coronas of amphibole, magnetite, oligoclase and clinopyroxene (Zumbro, 1999).

COAL CREEK DOMAIN SUPERSUITE

pЄcc	**pЄcc—Coal Creek Domain, undivided**. Metadiorite, metatonalite, metagabbro (hornblendite and orthoamphibolite), mafic schist, metamafic dikes, minor talc, metaserpentinite, and other metasomatic rocks (soapstone). Comprises part of the former Packsaddle Schist Click Formation (McGehee, 1977, 1979) north of the Coal Creek Serpentinite and south of the Sandy Creek shear zone (Roback, 1996). Unfoliated to strongly foliated, cogenetic, mafic, metaigneous rocks that contain small bodies and larger sills of orthoamphibolite and hornblendite (pЄoa; metagabbro), small bodies of metaserpentinite, talc and soapstone (pЄs), and mafic dikes. The mapped distribution of metaserpentinite, soapstone, orthoamphibolite, and mafic schist bodies (e.g. Barnes, 1943a), though poorly exposed, resembles that of a mélange. Metatonalite and metadiorite have U-Pb zircon igneous crystallization dates of 1292-1275 Ma. These demonstrably intrude the oldest component of the Domain, the Big Branch Gneiss (see below; Roback, 1996). U-Pb zircon dates indicate metamorphism and foliation formation within these rocks at c.1256 Ma (Roback, 1996).
pЄcc(oa) ● oa	**pЄcc(oa)—Orthoamphibolite, hornblendite, metadiorite**. Amphibolite, hornblendite and metadiorite. Black, black and white, gray, medium- to coarse-grained, massive to layered and foliated. As arcuate, elongate, concordant sills (metagabbro and metadiabase, McGehee, 1963; diorite of Barnes, 1943a), some up to 3.5 km long and showing relict igneous texture, and as smaller, more discordant dikes and more equant masses that weather to rubbly, rusty, red piles of blocks, some of nearly pure hornblende (hornblendite).
pЄcc(hs)	**pЄcc(hs)—Hornblende schist**. Hornblende schist. Medium green, dark green, gray, black; very fine-grained, schistose to phyllitic. Composed of amphibole and feldspar (plagioclase with lesser to no microcline) with or without quartz. Millimeter- to centimeter-scale compositional layers of alternating hornblende- and feldspar-rich laminae are variably developed; a weak to strong lineation by alignment of amphibole is commonly evident. Both are locally folded on a small scale.
pЄs s	**pЄs—Metaserpentinite, soapstone and talc**. Metaserpentinite and allied metasomatic rocks. Isolated, elongate (up to 250m in length), narrow (less than 40 meters) lenses of metaserpentinite, talc, tremolite and chlorite rock (commonly with magnetite) (Gillis, 1989; Barnes, 1943a) that are concordant to the foliation in surrounding rocks. Poorly exposed but commonly erosionally resistant, forming small ridges and mounds or scatterings of blocks.
pЄbb	**pЄbb—Big Branch Gneiss**. Gneissic to migmatitic quartz metadiorite, metatonalite and amphibolite. Fine- to medium-grained, gray. Crops out predominantly south of the Coal Creek Serpentinite (south of map area) and comprises the oldest and structurally highest component of the Coal Creek Domain. U-Pb zircon igneous crystallization dates are 1326-1301 Ma (Roback, 1996). Xenoliths of Big Branch Gneiss within Coal Creek Domain metamafic igneous rocks, and cross-cutting relationships with the same, indicate early dynamothermal metamorphism and foliation formation between 1301 and 1292 Ma. A younger dynamothermal metamorphism has been directly dated at 1256 Ma (Roback, 1996).

GEOLOGIC MAP OF A PORTION OF THE SOUTHEASTERN LLANO UPLIFT,
BURNET, LLANO, AND BLANCO COUNTIES, TEXAS
OPEN-FILE MAP NO. 277
2023

GEOLOGIC MAP SYMBOLS

▨	**Granite exfoliation dome**. Exfoliation dome, nearly all of Town Mountain Granite, some the site of building stone quarries.
▨	**Disturbed Land**. Ground that has been significantly disturbed by human activity, principally quarrying. Includes active or abandoned Town Mountain Granite, granite grus, or Paleozoic limestone quarries.
▭	**Shear Zone**. Ductile shear zone; high strain zone of mylonites, augen gneiss and phyllonite up to 4.5 km wide, localized to the upper and lower contacts of the Packsaddle Domain and affecting rocks in the overlying and underlying Valley Spring and Coal Creek Domains, respectively. The Sandy Creek shear zone (Roback, 1996) is the name given to the shear zone at the Coal Creek-Packsaddle Domain contact. Both shear zones display a reverse slip sense (Reese et al., 2000; Nelis, 1984).

- Contact
- Contact approximate
- Gradational contact
- Contact, inferred
- Contact, concealed
- Contact uncertain
- Fault, dip and slip sense unknown
- Fault, inferred, dip and slip sense unknown
- Fault, ball and bar on down side
- Fault, inferred, ball and bar on down side
- Fault, concealed
- Thrust fault, inferred
- Thrust fault, concealed
- Oblique slip fault, inferred, ball and bar on down side, arrows showing lateral motion
- Scratch boundary
- Sinkhole outline
- Fossil bed
- Axial trace of plunging syncline
- Axial trace of syncline, concealed
- Axial trace of plunging synform
- Axial trace of overturned synform
- Axial trace of plunging antiform
- Axial trace of overturned antiform
- Strike and dip of inclined bedding
- Strike and dip of inclined metamorphic foliation
- Strike and dip of vertical metamorphic foliation
- Trend and plunge of lineation
- Trend and plunge of inclined minor fold axis
- Gossan
- Gravel pit
- Mine shaft or adit, abandoned

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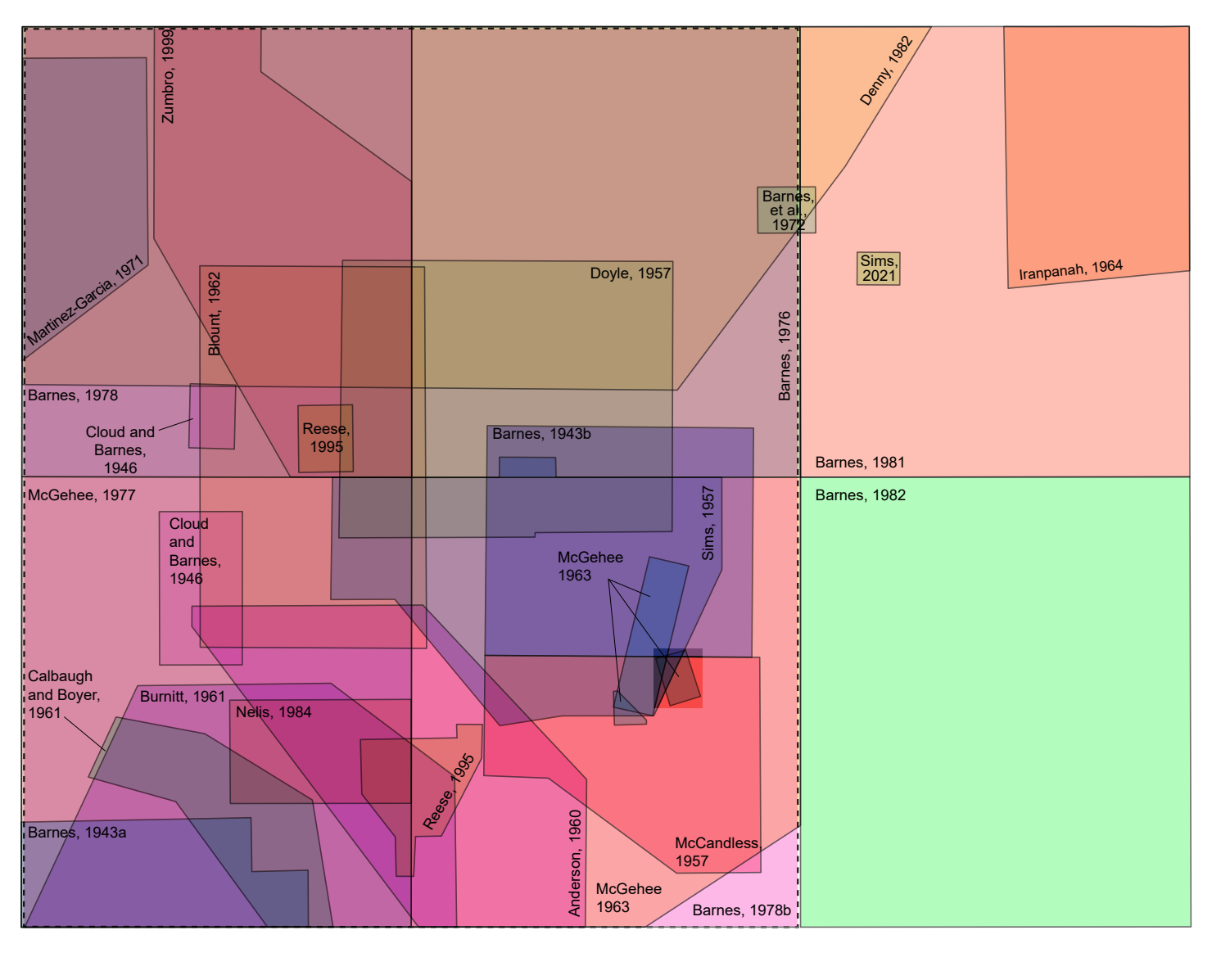
GEOLOGIC MAP DATA SOURCES



ACKNOWLEDGMENTS

This map compiles previously unpublished and published geologic mapping from the listed sources, augmented by new mapping principally within the Longhorn Caverns 7.5' Quadrangle. New mapping employed 2022, 0.6 m per pixel natural color digital aerial imagery from the National Agriculture Imagery Program distributed through theTexas Natural Resources Information System, a 1.7 m per pixel lidar-based digital terrain model derived from the 2007 Texas Strategic Mapping Program (StratMap) Lower Colorado River Lidar dataset and limited field work in Burnet and Llano Counties. The topographic base was created from U.S. Geological Survey digital files of the Marble Falls, Dunman Mountain, Click, Cap Mountain, Kingsland, and Longhorn Caverns 7.5' quadrangles. Place name and other base map labels come from an Environmental Systems Research Institute, Inc. World Terrain Reference layer (Esri, 2024). Map symbology conforms to the Federal Geographic Data Committee cartographic standard for geologic map symbolization (FGDC, 2006). Digital geologic data are contained within a GeMS-compliant database (USGS, 2020) created by M.Helper.

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