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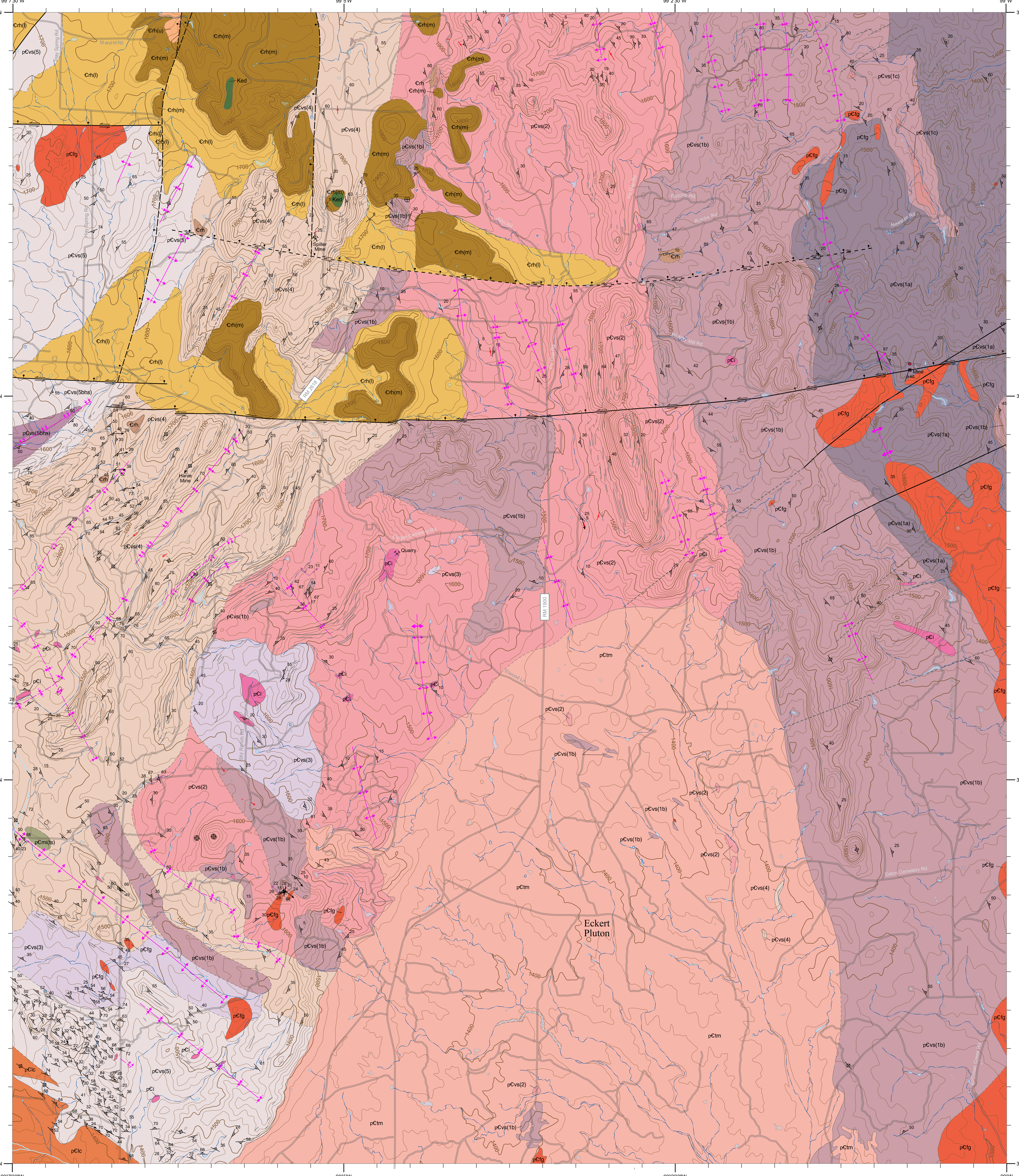
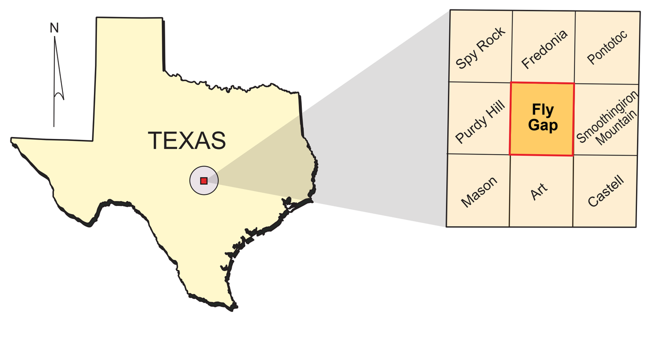
LORENA G. MOSCARDELLI, DIRECTOR
JACKSON SCHOOL OF GEOSCIENCES, THE UNIVERSITY OF TEXAS AT AUSTIN

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 No. G24AC00508, 2024





SCALE 1:24,000

0 1 2 MILE

0 1 2 KILOMETER

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

N
0°0.02'GN
4°MN
True North
Magnetic North

Approximate Magnetic North (MN) declination, November 2020

BEDROCK GEOLOGIC MAP OF THE FLY GAP QUADRANGLE, MASON COUNTY, TEXAS

Mark A. Helper, Brian B. Hunt, and Marvin J. Droddy, Jr.

2025

ACKNOWLEDGMENTS AND DISCLAIMERS

This map compiles previously unpublished and published geologic mapping from the listed sources, augmented by limited new mapping. New mapping employed 2022, 0.6 m per pixel natural color digital aerial imagery from the National Agriculture Imagery Program distributed through the Texas Geographic Information Office Texas Imagery Service, a 0.7 m per pixel digital terrain model derived from 2019 USGS Lidar data and three short field visits. Mapping was supported by the STATEMAP program of the US Geological Survey (award No. G24AC00508, 2024, Jeffrey G. Paine, Principal Investigator) and by Bureau of Economic Geology STARR funds for geologic mapping and geologic hazards. The topographic base was created from U.S. Geological Survey digital files of the Fly Gap 7.5' quadrangle. Place names and other base map labels are from the 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. We express our sincere gratitude to Mason County landowners who provided access for mapping, including Hal Zesch, Harry W. Greene, John Thomas, and David Hillis. We also acknowledge the important work of Droddy (1978), other students and the many researchers whose efforts have collectively advanced the understanding of Llano Uplift geology, particularly to Virgil Barnes for his numerous geologic contributions to the region.

Jason Suarez directed and coordinated the graphics and editing. Layout and computer graphics were done by Francine M. Mastrangelo and M. Helper. Editing was by Alyssa Naley.

CRETACEOUS SEDIMENTARY ROCKS

Fredericksburg Division

Ked

Ked—Edwards Formation (Cretaceous)—Thinly bedded micritic limestone with gray and brown chert nodules. Only present as poorly exposed, thin (less than 20 feet thick) erosional remnants that cap two hills above an elevation of about 1940 feet in the northwest part of the quadrangle.

UNCONFORMITY

PALEOZOIC SEDIMENTARY ROCKS

Moore Hollow Group
Riley Formation

Ꞓrh

Ꞓrh—Hickory Sandstone Member (Late Cambrian)—Quartz sandstone. From Hunt and Helper (2024): "Subdivided into three informal units (upper, middle, and lower) based upon variations in color, grainsize, porosity, bedding thickness, cementation, and topographic expression (Mutis-Duplat, 1982; Becker, 1985). Where not differentiated, the unit generally consists of brown to red quartz sandstones. Diagenetically there is little to no calcite and glauconite. Locally there is a major aquifer in the subsurface. The contact with the overlying Cap Mountain is placed at the first resistant calcareous cemented sandstone, which is often expressed as a topographic scarp and heavily vegetated break in slope. About 400 ft thick (Becker, 1985)."

Ꞓrh(u)

Ꞓrh(u)—Upper Hickory (Late Cambrian)—Sandstone. Hematitic quartz arenite. From Hunt and Helper (2024): "Massive to thinly-bedded, red, medium- to coarse-grained, well-rounded, moderately sorted, friable, hematite and limonite cement, and glauconitic with calcite cement toward the top. Hematite locally forms ooid-like coatings around quartz grains. Poorly exposed recessive unit, forms topographically low benches that develop deep red soils often used for cultivation or agricultural purposes. Unit grades into overlying Cap Mountain, marked by calcite-cemented sandstone with increased resistance and relief in landscape. The unit is locally an aquifer. About 75 ft thick (Becker, 1985)."

Ꞓrh(m)

Ꞓrh(m)—Middle Hickory (Late Cambrian)—Quartz arenite. From Hunt and Helper (2024): "Thick- to thin-bedded, with laterally continuous beds, quartz and hematite cement (increasing upward), fine- to coarse-grained, rounded to subrounded, poorly sorted, smaller scale trough cross-bedding, light brown to orangish brown, with phosphatic brachiopods, and abundant trace fossils. Locally silty laminations and interbeds. Laterally continuous mudstone and siltstone interbeds. This unit is indurated and forms ridges, outcrops and low hills owing to a weathering-produced, near-surface lithification process (Brann Johnson, personal communication). The unit is often thickly vegetated. Little to no agriculture and is considered an aquitard (Brann Johnson, personal communication). Up to 145 ft thick (Becker, 1985)."

Ꞓrh(l)

Ꞓrh(l)—Lower Hickory (Late Cambrian)—Sandstone. Quartz arenite. From Hunt and Helper (2024): "Massive and discontinuous beds, large amplitude trough cross-bedding, very coarse- to medium-grained, quartz and hematite cement, poorly sorted, rounded to subrounded, light to dark brown, friable, locally conglomeratic with feldspar grains, granitic and metamorphic pebbles at the base. Ventifacts described and mapped near the base (Alexander, 1952). Very porous and permeable and is a locally major aquifer unit. A recessive and poorly exposed unit that forms topographically low benches with well-developed soils often in agricultural use. The top of the unit is the first resistant, well-cemented sandstone. Unit rests unconformably on the Precambrian surface and has variable thickness, ranging from 0 to about 55 ft thick (Becker, 1985)."

UNCONFORMITY

MESOPROTEROZOIC IGNEOUS ROCKS (SUPERSUITE)

Syn- to Post-Kinematic Granites (Suite)

pꞒtm

pꞒtm—Town Mountain Granite (Mesoproterozoic)—From Hunt and Helper (2024): "Porphyritic to equigranular, pink, fine- to coarse-grained granite. Composed of pink microcline (up to 3 cm), vitreous gray quartz, cloudy white plagioclase, biotite and hornblende, and containing aplitic to pegmatitic granite dikes and milky quartz veins. Locally topaz-bearing (White, 1960). Undeformed microcline phenocrysts locally define a flow foliation and/or lineation, especially near pluton margins. Granite occurs in plutons up to 13 miles in size which tend to be circular vertical cylinders with concentric textural variations. Boundaries range from sharp and regular to highly irregular with wide zones of mixed rock; U/Pb zircon ages for these bodies are 1119–1070 Ma (Walker, 1992; Reed, 1999). Weathers to form grus aggregate; where granite is deeply weathered and grus well developed it locally underlies areas in cultivation. The large granite body in the south-central portion of the quadrangle is known as the Eckert pluton (Barker and Reed, 2010). Although the Eckert Pluton has not been dated, however the nearby Katemcy Pluton located to the northwest is reported to be 1070 ± 2 Ma, based on U/Pb zircon dating; (Walker, 1992)."

pꞒfg

pꞒfg—Fine-grained granite (Mesoproterozoic)—Fine-grained gray and pink granites, often foliated or migmatitic, thought to be derived from partial melting of Valley Spring Gneiss (Salyapongse, 1978).

pꞒi

pꞒi—Pegmatite or aplite (Mesoproterozoic)—Small bodies of pegmatite or aplite consisting of quartz and feldspar.

pꞒq

pꞒq—Quartz vein (Mesoproterozoic)—Vein quartz. Milky white, monomineralic veins of quartz, most too small to map but up to 1.5 m wide, that cut across gneissic foliation or schistosity.

Metaigneous Rocks (Suite)

pꞒmi(ts)

pꞒmi(ts)—Tremolite schist (Mesoproterozoic)—Tremolite schist (Droddy, 1978). Slightly foliated, dark green, non-resistant, composed nearly entirely of tremolite with secondary chlorite and opaque oxides (Droddy, 1978).

pꞒmi(md)

pꞒmi(md)—Metadiorite (Mesoproterozoic)—Metadiorite. Black and white, fine- to medium-grained, poorly exposed xenolith(?) within Town Mountain Granite of the Eckert Pluton. About 70% zoned and altered plagioclase, 25% amphibole and biotite (replacing amphibole) and 5% quartz and opaque oxides (Droddy, 1978).

pꞒmi(mb)

pꞒmi(mb)—Metabasalt (Mesoproterozoic)—Metabasalt (Droddy, 1978). Hydrothermally altered basaltic breccia containing dark green chlorite (~50%) and plagioclase (An01; ~20%) with light green epidote (20%) and quartz veins. Known only from a shaft astride the trace of the E-W fault near the eastern edge of the map.

MESOPROTEROZOIC METAMORPHIC ROCKS

Valley Spring Gneiss (VSG) Supersuite

pꞒvs(5)

pꞒvs(5)—Unit 5-calc-silicate-bearing gneiss and quartz-feldspar gneiss (Mesoproterozoic)—Mainly fine-grained foliated calc-silicate-bearing gneiss and quartz-feldspar gneiss with minor quartzite, biotite and hornblende schist, amphibolite and plagioclase-pyroxene rock (Droddy, 1978). Foliated calc-silicate-bearing gneiss has mm-scale green calc-silicate-rich laminae that alternate with light pinkish to grayish feldspar bands. Microcline and plagioclase predominate (up to 70%; oligoclase more abundant than microcline), quartz is highly variable (6–52%, commonly 28–40%). Calc-silicates are actinolite (up to 22%), green clinopyroxene (up to 12%), occasional brown andraditic garnet (intergrown with clinopyroxene; up to 10%) and epidote (up to 18%), with accessory calcite, titanite, and Fe oxides. Forms rounded knobs. Lacks green calc-silicate patches common to Unit pꞒvs(4) and is fine-grained. Gradational to pꞒvs(3) over hundreds of meters by decrease in amphibole, with a resultant lighter color. Relative increase in amphibole and epidote marks pꞒvs(2) contacts. Equivalent to Mutis-Duplat (1982) unit VS2 and contains layers of unit VS1(4). Approximately 550 m thick in the SW corner of the map.

pꞒvs(5bhs)

pꞒvs(5bhs)—Unit 5-biotite-hornblende schist (Mesoproterozoic)—Biotite-hornblende schist (Droddy, 1978). Dark gray, fine-grained, interlayered with quartz-feldspar gneiss. Equivalent to VS2(2) of Mutis-Duplat (1982).

pꞒvs(4)

pꞒvs(4)—Unit 4-quartz-feldspar gneiss (Mesoproterozoic)—Mostly pink quartz-feldspar gneiss with either accessory mica or calc-silicates (Droddy, 1978). Forms prominent NE- to NW-trending ridges. Contact with pꞒvs(1b) and pꞒvs(2) is marked by a micaceous or hematitic horizon in the west-central part of the quadrangle, but it is less well defined elsewhere. Contact with pꞒvs(3) is characterized by an increase in amphibole content and, hence, a transition from pink to dark green over a few tens of meters. Unit pꞒvs(2) gneiss is slightly lighter with fewer calc-silicates, and pꞒvs(2) has parallel feldspar bands that are largely absent or poorly developed in pꞒvs(4). Equivalent to unit VS1 of Mutis-Duplat (1982) but includes parts of his units VS2 and VS3. Approximately 1220–1280 m thick (Droddy, 1978).

pꞒvs(3)

pꞒvs(3)—Unit 3-actinolite-rich gneiss (Mesoproterozoic)—Actinolite-rich gneiss (Droddy, 1978). Calcium-rich, slightly foliated, fine- to medium-grained, pink and green, with abundant green amphibole, albite, microcline and lesser quartz (10%). Comprises discontinuous outcrops not confined to a stratigraphic horizon—most lie near or at the top of pꞒvs(2), but biggest is at the pꞒvs(4)-pꞒvs(5) contact. In both cases, it is found near pꞒvs(1b). Distinctive for abundance of green amphibole (21–36%; tremolite-ferrotremolite). Plagioclase (An2) is more abundant than microcline; quartz about 10%; contains rare pale green clinopyroxene. Locally overlain by unit pꞒvs(5).

pꞒvs(2)

pꞒvs(2)—Unit 2-calc-silicate-bearing gneiss and quartz-feldspar gneiss (Mesoproterozoic)—Well-foliated, pink, fine-grained quartz feldspar gneiss, with or without foliation-parallel calc-silicate (actinolite, andradite, and epidote) (Droddy, 1978). Forms broad ridges over 120 m high. Locally overlain by Unit pꞒvs(3); in direct contact with pꞒvs(4) or pꞒvs(1b). Contact with pꞒvs(1b) is gradational and poorly exposed. Pink, resistant, gneissic bands up to 2 cm thick are composed of quartz and microcline alternating with less resistant light pink to white bands of quartz and plagioclase. Biotite, muscovite, and opaque oxides are common at levels up to a few percent. Calc-silicate -bearing gneiss, most common near the base, contains abundant, distinctive greenish patches of elongate brown andradite, actinolite, and epidote (replacing plagioclase and actinolite) with accessory titanite and opaque oxide. Ca-silicates comprise 15–25% in these gneisses that otherwise contain 25–40% quartz, 12–25% microcline and 24–40% albite (An2).

pꞒvs(1c)

pꞒvs(1c)—Unit 1c-chlorite-rich gneiss (Mesoproterozoic)—Chlorite-rich gneiss (Droddy, 1978). Lenses of fine-grained greenish gneiss containing chlorite (replacing amphibole), quartz, and albite. No potassium feldspar. Lenses are localized to pꞒvs(1b).

pꞒvs(1b)

pꞒvs(1b)—Unit 1b-biotite gneiss, migmatite, muscovite schist or hematite schist (Mesoproterozoic)—Biotite gneiss, migmatite, muscovite schist or hematite schist (Droddy,1978). Abundant biotite and Fe-Ti oxide; complexly interlayered with pꞒvs(1a); contacts, gradational over 20-30 m, are marked by an increased grain size and mica content. Gneisses form rounded ridges and knobs, schist, and migmatites weather to flatter terrain. This unit is not restricted to a single stratigraphic horizon but is within, or in contact with, units pꞒvs(1a), pꞒvs(2), pꞒvs(3), pꞒvs(4) and pꞒvs(5). Heterolithic, coarser- grained and more mica-rich than pꞒvs(1a). Microcline 30–50%, quartz 30–40%, plagioclase 10–20%, mica 10–20%, Fe-Ti oxides 5%. Granoblastic gray to red and black biotite gneiss is the most common subtype containing quartz (up to 68%, commonly30–40%), microcline (up to 60%, commonly 30–50%), plagioclase (up to 44%, commonly10–20%), biotite (up to 25%), muscovite (to 5%; replacing sillimanite) and Fe-Ti oxide (to 5%), with both magnetite and ilmenite present. More foliated gneiss of this variety contains ovoid quartz-muscovite-sillimanite pods that weather out in relief. These are microcline-deficient; a few contain almandine-spessartine garnet.

pꞒvs(1a)

pꞒvs(1a)—Unit 1a-microcline-rich gneiss (Mesoproterozoic)—Microcline-rich gneiss (Droddy, 1978). Pink, fine-grained, weakly foliated with an appearance that resembles fine-grained granite. 60–70% microcline, 25–30% quartz, 10% opaques, with minor albite and biotite. Two varieties: 1) a moderately foliated, compositionally layered fine-grained gneiss with abundant microcline porphyroblasts up to 1–2 mm in size; 2) poorly foliated, relatively quartz-rich (to 40%) gneiss with elongate quartz up to several mm long.

Lost Creek Gneiss Suite

pꞒlc

pꞒlc—Lost Creek Gneiss augen gneiss (Mesoproterozoic)—Granitic augen gneiss (Droddy, 1978; Hunt and Helper, 2024). Medium- to coarse-grained, pink, slightly foliated with elongate microcline augen (to 3 cm) and subparallel biotite-rich bands (up to 1 mm thick) that wrap augen. Sharp but interfingering contact with pꞒvs(5). Poorly exposed. A single sample contains 55% feldspar (subequal albite and microcline), 50% quartz, 4% biotite and <2% magnetite. Microcline augen are perthitic, twinned and contain albite inclusions. Albite (An4–13) is also present in myrmekite around microcline, and as anhedral grains.

MAP SYMBOLS

Geologic Points

- Strike and dip of bedding
- Horizontal bedding
- Strike and dip of foliation, undifferentiated
- Vertical foliation, undifferentiated
- Horizontal foliation, undifferentiated
- Trend and plunge of lineation, undifferentiated
- Trend and plunge of minor fold, undifferentiated
- Orientation of minor fault

Contacts and Faults

- Contact
- Contact, inferred
- 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
- Oblique slip fault, ball and bar on down side, arrows showing lateral motion
- Oblique slip fault, inferred, ball and bar on down side, arrows showing lateral motion

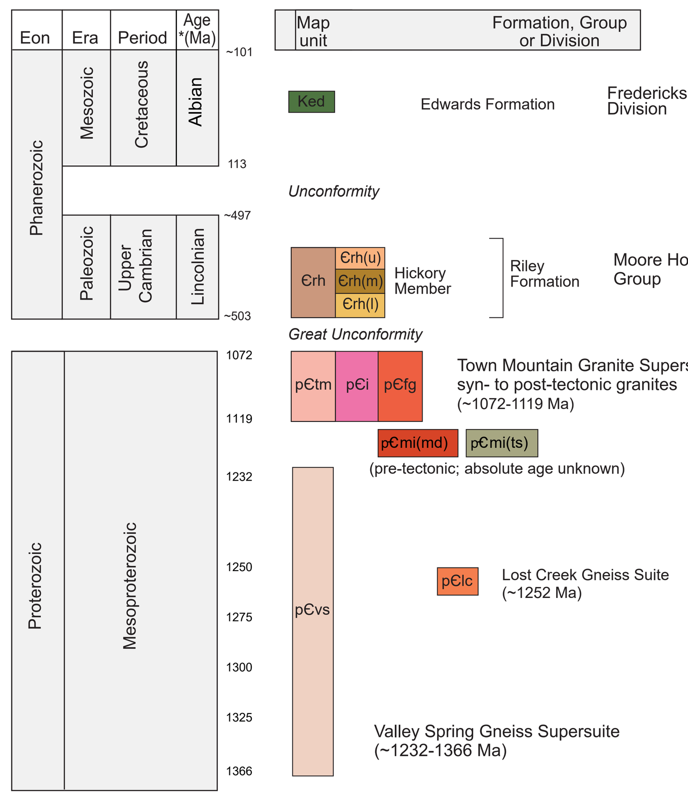
Geologic Lines

- Axial trace of antiform
- Axial trace of antiform-approximate
- Axial trace of overturned antiform
- Axial trace of overturned antiform-approximate
- Axial trace of synform
- Axial trace of synform-approximate
- Axial trace of overturned synform
- Axial trace of overturned synform-approximate
- Foliation trace

Basemap Symbols

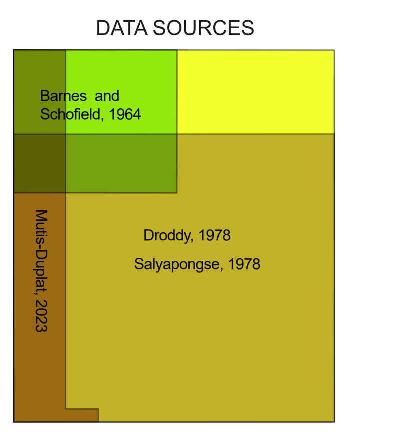
- Topographic contour (20 ft interval)
- Intermittent stream
- County road
- Local road
- Mine Shaft
- Quarry

CHRONOSTRATIGRAPHY AND CORRELATION OF MAP UNITS



Chronostratigraphic units and ages from Walker, 1992; Roback and others, 1999; Reese, and others, 2000; Barker and Reed, 2010, and Ewing, 2016. *Ma = Million years ago

DATA SOURCES



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