DIGITAL MAPPING TECHNIQUES 2023

The following was presented at DMT'23
May 21 - 24, 2023

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2023)

http://ngmdb.usgs.gov/info/dmt/

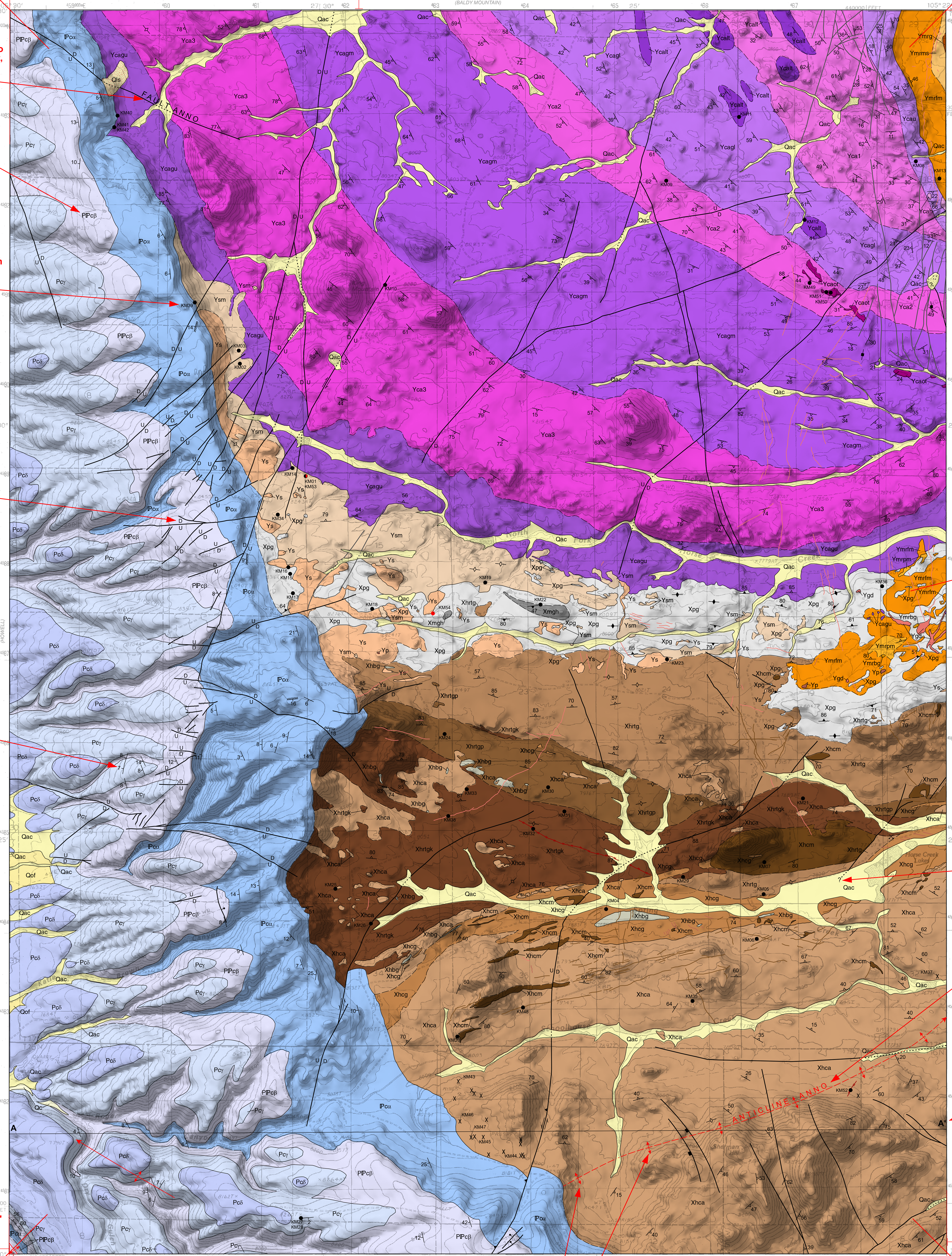
Wyoming State Geological Survey
1:24,000-scale Bedrock Map Standards
UPDATED AUGUST 2022

NOTE:
Vertical and horizontal map dimensions should always be whole numbers

WYOMING STATE GEOLOGICAL SURVEY
Erin A. Campbell, Director and State Geologist
Laramie, Wyoming

Interpreting the past, providing for the future

MAP SERIES 107
King Mountain 1:24,000-scale
Bedrock Geologic Map

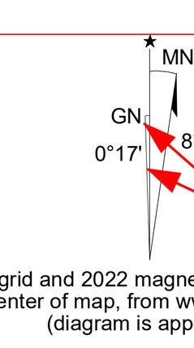


Base map from U.S. Geological Survey 1:24,000-scale topographic map of the King Mountain, Wyoming Quadrangle, 1987

Base hillshade derived from United States Elevation Data (NED), 10-meter Digital Elevation Model (DEM), 2013; azimuth 315º, sun angle 45º, vertical exaggeration 2.7

Projection: Universal Transverse Mercator (UTM), zone 13
North American Datum of 1927 (NAD 27)
1,000-meter grid ticks: UTM, zone 13
10,000-foot grid ticks: Wyoming State Plane Coordinate System, east zone

Wyoming State Geological Survey
P.O. Box 1347 - Laramie, WY 82073-1347
Phone: 307-766-2286 - Fax: 307-766-2605
Email: wsgs-info@wyo.gov

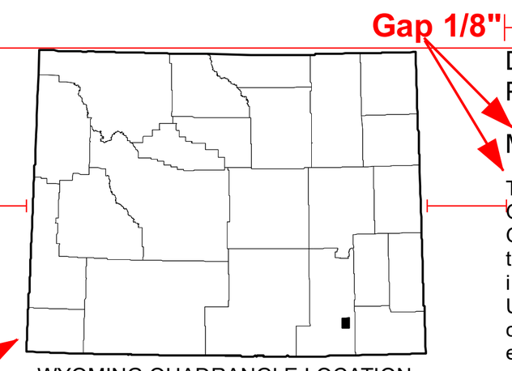


UTM grid and 2022 magnetic north declination at center of map, from www.ngdc.noaa.gov (diagram is approximate)

SCALE 1:24,000

1 — 0.5 — 0 — 1 Mile
1,000 — 0 — 1,000 — 2,000 — 3,000 — 4,000 — 5,000 — 6,000 — 7,000 Feet
1 — 0.5 — 0 — 1 Kilometer

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



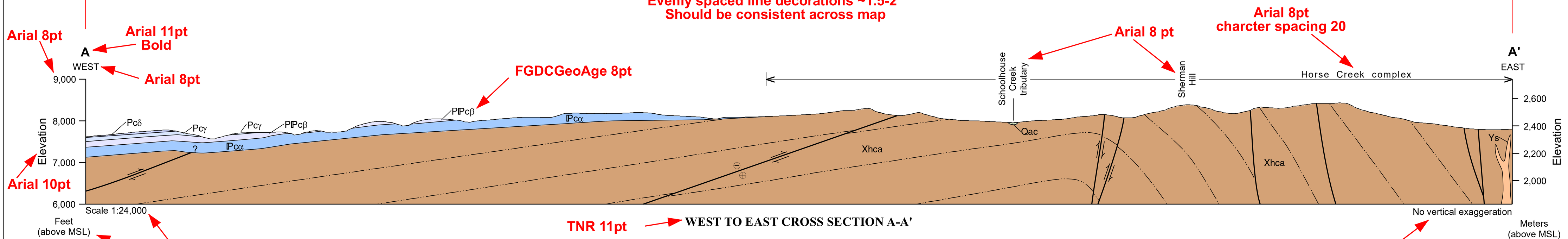
WYOMING QUADRANGLE LOCATION

Digital cartography by Ranie M. Lynds, Patricia M. Webber, and Jon M. Krupnick

Map edited by James A. Amato

This material is based upon work supported by the U.S. Geological Survey under Cooperative Agreement No. G20AC00159. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.

Suggested citation: Webber, P.M., Lynds, R.M., Stotter, S.V., Lindsley, D.H., and Frost, B.R., 2022, Geologic map of the King Mountain quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 107, scale 1:24,000.



WEST TO EAST CROSS SECTION A-A'

GEOLOGIC MAP OF THE KING MOUNTAIN QUADRANGLE, ALBANY COUNTY, WYOMING

by

Patricia M. Webber, Ranie M. Lynds, Sara V. Stotter, Donald H. Lindsley, and B. Ronald Frost

2022

CORRELATION OF MAP UNITS

Qac, Qls, Qc, Qof — Holocene, Pleistocene — QUATERNARY — CENOZOIC

Unconformity

Pcδ, Pcγ — PERMIAN — PALEOZOIC
PPcβ, Pcα — PENNSYLVANIAN

Unconformity

Ygd, Yp, Ym
Sherman batholith: Ys, Ysm
Laramie Anorthosite Complex — Maloin Ranch pluton: Ymrbg, Ymrg, Ymrms, Ymrpm, Ymrfm
Chugwater anorthosite pluton: Ycalt, Ycagu, Yca3, Ycagm, Yca2, Ycagl, Yca1, Ycaot, Ycau, Ycah
— Mesoproterozoic

Horse Creek complex: Xhcm, Xhca, Xhcg, Xhrtgk, Xhrtgp, Xhrtg
Xhbg
Horse Creek metamorphic suite: Xpg, Xmgh
— Paleoproterozoic

— PROTEROZOIC — PRECAMBRIAN

MAP SYMBOLS

Definitions: *Certain—Location known <25 m*
Approximate—Estimated location 25–100 m

Formation contact—Continuous where certain, long dash where approximate

Fault—Continuous where certain, dotted where concealed; queried where uncertain, upthrown (U) and downthrown (D) blocks designated when fault type is unknown, ball and bar on downthrown block of normal fault, triangle on upper plate of thrust fault, rectangles on upper plate of reverse fault, arrows indicate relative motion

Fracture or possible fault—Continuous where certain, dotted where concealed

Structural boundary—Separates layered from unlayered Chugwater anorthosite, after Lindsley and others (2010)

Anticline—Continuous where certain, long dash where approximate, dotted where concealed; arrow on end indicates direction of plunge

Line of cross section

Oblique fault—Circle with minus, toward observer; circle with plus, away from observer; arrows indicate relative motion; in cross section only

Trace of foliation in subsurface—Cross section only

Inclined metamorphic foliation—Showing strike and dip

Vertical metamorphic foliation—Showing strike

Inclined magmatic foliation and lamination—Showing strike and dip

Vertical magmatic foliation and lamination—Showing strike

Inclined bedding—Showing strike and dip

Inclined bedding in cross-bedded rocks—Showing strike and dip

Inclined jointing—Showing strike and dip

Vertical jointing—Showing strike

KM11 **Sample, geochemistry**

KM54 **Sample, geochronology**

KM53 **Sample, geochemistry and geochronology**

KM37 **Prospect pit**—Labeled if sampled for geochemistry

Aggregate pit

REFERENCES

Benniran, M.M., 1970, Casper Formation limestones, southwestern Laramie Mountains, Albany County, Wyoming: Laramie, University of Wyoming, M.S. thesis, 95 p.

Blackstone, D.L., Jr., 1996, Structural geology of the Laramie Mountains, southeastern Wyoming and northeastern Colorado: Wyoming State Geological Survey Report of Investigations 51, 28 p., 3 pls., scale 1:500,000.

Darton, N.H., Blackwelder, Eliot, and Siebenthal, C.E., 1910, Geologic atlas of the United States, Laramie-Sherman folio, Wyoming: U.S. Geological Survey Folio 173, 17 p., 7 pls., scale 1:125,000.

Fowler, K.S., 1930, The anorthosite area of the Laramie Mountains, Wyoming: American Journal of Science, v. 19, p. 305–315 and 373–403, 3 pls., scale variable.

Frost, B.R., Bauer, R.L., Scoates, J.S., and Ingram, J.S., 2013, The Laramie Anorthosite Complex and its contact metamorphic aureole, *in* Abbott, L.D., and Hancock, G.S., eds., Classic concepts and new directions—Exploring 125 years of GSA discoveries in the Rocky Mountains Region: Geological Society of America Field Guide 33, p. 237–258.

Frost, C.D., Chamberlain, K.R., and Frost, B.R., 2000, The 1.76 Ga Horse Creek anorthosite complex, Wyoming—A massif anorthosite emplaced late in the Medicine Bow orogeny: Rocky Mountain Geology, v. 35, p. 71–90.

Frost, C.D., Frost, B.R., Bell, J.M., and Chamberlain, K.R., 2002, The relationship between A-type granites and residual magmas from anorthosite—Evidence from the northern Sherman batholith, Laramie Mountains, Wyoming, USA: Precambrian Research, v. 119, p. 45–71.

Frost, C.D., Frost, B.R., Chamberlain, K.R., and Edwards, B.R., 1999, Petrogenesis of the 1.43 Ga Sherman batholith, SE Wyoming, USA—A reduced rapakivi-type anorogenic granite: Journal of Petrology, v. 40, no. 12, p. 1,771–1,802.

Frost, C.D., Frost, B.R., Lindsley, D.H., Chamberlain, K.R., Swapp, S.M., and Scoates, J.S., 2010, Geochemical and isotopic evolution of the anorthositic plutons of the Laramie Anorthosite Complex—Explanations for variations in silica activity and oxygen fugacity of massif anorthosites: The Canadian Mineralogist, v. 48, p. 925–946.

Kolker, Allan, 1989, Petrology and geochemical evolution of the Maloin Ranch pluton, Laramie Anorthosite Complex, Wyoming: Stony Brook, State University of New York at Stony Brook, Ph.D. dissertation, 211 p., 1 pl., scale 1:24,000.

Lindsley, D.H., Frost, B.R., Frost, C.D., and Scoates, J.S., 2010, Petrology, geochemistry, and structure of the Chugwater anorthosite, Laramie Anorthosite Complex, southeastern Wyoming: The Canadian Mineralogist, v. 48, p. 887–923.

Lundy, D.A., 1978, Hydrology and geochemistry of the Casper aquifer in the vicinity of Laramie, Albany County, Wyoming: Laramie, University of Wyoming, M.S. thesis, 76 p.

Mitchell, J.N., Scoates, J.S., and Frost, C.D., 1995, High-Al gabbros in the Laramie Anorthosite Complex, Wyoming—Implications for the composition of melts parental to Proterozoic anorthosite: Contributions to Mineralogy and Petrology, v. 119, p. 166–180.

Newhouse, W.H., and Hagner, A.F., 1957, Geologic map of anorthosite areas, southern part of Laramie Range, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map 119, scale 1:63,360.

Ramarathnam, Sethurama, 1962, Geology and petrology of the southern portion of the Laramie anorthosite mass, Albany County, Wyoming: Golden, Colorado School of Mines, Ph.D. dissertation, 131 p., 3 pls.

Scoates, J.S., and Chamberlain, K.R., 1995, Baddeleyite (ZrO_2) and zircon ($ZrSiO_4$) from anorthositic rocks of the Laramie Anorthosite Complex, Wyoming—Petrologic consequences and U-Pb ages: American Mineralogist, v. 80, p. 2,475–2,480.

Scoates, J.S., and Chamberlain, K.R., 1997, Orogenic to post-orogenic origin for the 1.76 Ga Horse Creek anorthosite complex, Wyoming, USA: Journal of Geology, v. 105, p. 331–343.

Scoates, J.S., and Chamberlain, K.R., 2003, Geochronologic, geochemical and isotopic constraints on the origin of monzonitic and related rocks in the Laramie Anorthosite Complex, Wyoming, USA: Precambrian Research, v. 124, p. 269–304.

Speece, M.A., 1992, Geophysical studies in Precambrian regions—The Laramie Mountains, Wyoming, and the Godthabsfjord area, southern West Greenland: Laramie, University of Wyoming, Ph.D. dissertation, 120 p.

Ver Ploeg, A.J., 2007, Geologic map of the Howell quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 75, scale 1:24,000.

Ver Ploeg, A.J., and McLaughlin, J.F., 2009, Geologic map of the Pilot Hill quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 89, scale 1:24,000.

Xirouchakis, Dimitrios, 1996, Contact metamorphism adjacent to the Laramie Anorthosite Complex, Albany County, Wyoming: Duluth, University of Minnesota, M.S. thesis, 92 p.

DISCLAIMERS

Users of this map are cautioned against using the data at scales different from those at which the map was compiled. Using these data at a larger scale will not provide greater accuracy and is a misuse of the data. The Wyoming State Geological Survey (WSGS) and State of Wyoming make no representation or warranty, expressed or implied, regarding the use, accuracy, or completeness of the data presented herein, or of a map printed from these data. The act of distribution shall not constitute such a warranty. The WSGS does not guarantee the digital data or any map printed from the data to be free of errors or inaccuracies. The WSGS and State of Wyoming disclaim any responsibility or liability for interpretations made from, or any decisions based on, the digital data or printed map. The WSGS and State of Wyoming retain and do not waive sovereign immunity. The use of or reference to trademarks, trade names, or other product or company names in this publication is for descriptive or informational purposes only, or is pursuant to licensing agreements between the WSGS or State of Wyoming and software or hardware developers/vendors, and does not imply endorsement of those products by the WSGS or State of Wyoming.

EXPLANATION

DESCRIPTION OF MAP UNITS

Cenozoic

Qac **Alluvium and colluvium (Holocene)**—Unconsolidated to poorly consolidated, subangular to subrounded sand, gravel, cobbles, and boulders mixed with silt- and clay-rich soil; locally derived. Includes alluvium, slopewash, debris flows, and alluvial fan deposits. Older alluvial deposits locally contain boulders up to 2 m across. Thicknesses generally less than 15 m

Qls **Landslide debris (Holocene)**—Blocks and slumps of locally derived bedrock from steep and unstable slopes. Thickness less than 5 m

Qc **Colluvium (Holocene)**—Unconsolidated clay, silt, sand, gravel, cobbles, and boulders, typically in clay-rich soil matrix; locally derived. Combined alluvial fans, minor debris flows, and slopewash, typically at or near base of steep slopes. Thickness not determined

Qof **Older alluvial fan deposits (Holocene and Pleistocene)**—Poorly sorted clay, silt, sand, and gravel; crudely bedded to massive with some debris flow component. Limestone cobbles common. Currently inactive and dissected, often occurring as erosional remnants. Up to 3 m thick (Ver Ploeg, 2007)

Paleozoic

Casper Formation and Fountain Formation, undivided—Subdivided into five informal members based upon local, confined aquifer packages by Lundy (1978), following Benniran (1970); uppermost epsilon member not exposed on quadrangle. Upper contact of all members mapped on top of uppermost limestone. Underlying Fountain Formation included with basal Casper Formation. Thicknesses and descriptions from Benniran's (1970) measured section in Timber Canyon, T. 17 N., R. 72 W., secs. 27, 28, 29, and 30; total thickness approximately 166 m excluding epsilon member

Pcδ **Delta member (Permian)**—Top not exposed on quadrangle. Capped by white-gray to pink, massive, fractured, stylolitic 3-m-thick limestone underlain by 9-m-thick tan and pink, very fine-grained, subrounded, calcareous sandstone. Underlying 3-m-thick calcilutite and calcarenite is pink to light-gray and massive; crinoid columnals common, brachiopods and gastropods rare. Basal unit is tan, fine-grained, calcareous, moderately to well-sorted, cross-bedded, 12-m-thick sandstone interbedded with red silty shale. Thickness 27 m

Pcγ **Gamma member (Permian)**—Capped by extensive, ridge-forming, pink to white-gray, fine- to medium-grained crystalline, 9-m-thick calcarenite and calcilutite with abundant ooids, crinoid columnals, and gastropods; silicified at top; tan to buff and dolomitic at base. Underlain by 18-m-thick, yellowish-gray to grayish-orange, medium- to fine-grained, rounded to subrounded, moderately to well-sorted sandstone. Thickness 27 m

PPcβ **Beta member (Permian and Pennsylvanian)**—Capped by 11-m-thick white-gray to pink, massive calcarenite and calcilutite with chert concretions, ooids, crinoid columnals, brachiopods, gastropods, and fusulinids; equivalent to limestone 4 of Benniran (1970). Underlain by red to tan, fine-grained, subangular, moderately sorted, cross-bedded, 30-m-thick sandstone. Member mapped on top of limestone 4 of Benniran (1970). Thickness 41 m

Pcα **Alpha member and Fountain Formation, undivided (Pennsylvanian)**—Composed of three distinct limestone units underlain by sandstones; grades into and mapped with underlying Fountain Formation. Upper unit is prominent 17-m-thick calcarenite and calcilutite with dolomite at base; dense and recrystallized; brachiopods, gastropods, ooids, and crinoid columnals common; underlain by 15-m-thick buff and red, medium- to fine-grained sandstone with interbedded red shale. Middle unit is 5-m-thick, light-tan to light-purple, sandy calcarenite containing brachiopods, gastropods, and crinoid columnals; underlain by 11-m-thick reddish-brown to light-tan, medium- to fine-grained, cross-bedded sandstone. Lower unit is 4-m-thick, sandy, pink to tan to purple, finely crystalline calcarenite and calcilutite with few fossil fragments; underlain by 18-m-thick pink and tan, medium- to fine-grained calcareous sandstone. Alpha member total thickness is 70 m. Fountain Formation composed of poorly exposed, coarse-grained, pink to red to purple sandstone and arkose, interbedded with conglomerate, siltstone; less than 9 m thick

Precambrian

Ygd **Granite dike (Mesoproterozoic)**—Several varieties of granitic dikes associated with Laramie Anorthosite Complex and Sherman batholith. White, light-pink, pink-orange, or mottled maroon and white; aplitic to coarse-grained; locally porphyritic; can be pegmatitic. May contain pink microcline, perthite, plagioclase, quartz, biotite, and hornblende. Muscovite and epidote present in zones of mineralization. Includes multiple lithologies described under Sherman Granite and Maloin Ranch pluton. East of map area, individual feldspar megacrysts up to 60 cm. Dikes frequently host quartz veins, which are locally heavily mineralized and have been mined for copper, gold, and tungsten. Width ranges from 1 to 10 m, length up to several hundred meters; typically trend north–northwest. Crosscuts all units within Chugwater anorthosite, Maloin Ranch pluton, and Sherman batholith

Yp **Pegmatite dike (Mesoproterozoic)**—Pegmatitic, white to pink quartzofeldspathic dikes and quartz veins; composed of pink microcline, perthite, plagioclase, translucent gray to opaque white quartz, with accessory biotite, amphibole, rare amazonite and garnet. Muscovite and epidote present in zones of mineralization. Feldspar megacrysts up to 60 cm. Width ranges from 1 to 10 m, length up to several hundred meters; typically trend north–northwest

Ym **Mafic dike (Mesoproterozoic)**—Fine-grained, locally porphyritic, inequigranular, gray-green to black mafic dikes composed of acicular, randomly oriented plagioclase laths, green to brown hornblende, and biotite with oxides and chlorite. Plagioclase extensively sericitized. Forms thin (less than 10 m) but laterally extensive dikes (up to 1.6 km) that cut Horse Creek intrusive units

Sherman batholith (Mesoproterozoic)

Ys **Sherman Granite**—Medium- to coarse-grained, orange-pink to reddish-gray, subequigranular granite composed of microcline, plagioclase, quartz, hornblende, biotite, and ilmenite with accessory magnetite, zircon, allanite, apatite, titanite, and fluorite. Rare fayalite, clinopyroxene, and pigeonite may be present (Frost and others, 2002). Weathers to coarse-grained arkosic soil; common alteration products include sericite, clay, and hematite (Ramarathnam, 1962). Textural and compositional variations common; main body subporphyritic to equigranular with subhedral feldspar phenocrysts. Local variations include coarse-grained, red-orange, ovoid, porphyritic perthitic microcline surrounded by hornblende, biotite, and possible pyroxene; coarse-grained, light-gray, granodiorite composed of light-pink potassium feldspar megacrysts (1.5–5 cm) in gray-white granodioritic matrix with magmatic foliation. Contact with Maloin Ranch pluton east of map area marked by series of gradational to intermingled granites that are difficult to distinguish from Sherman Granite. Age constrained south of map area to between 1,434 ± 1.7 Ma (Frost and others, 1999) and 1,433.0 ± 1.5 Ma (Frost and others, 2002); Mule Creek lobe of Sherman batholith, north of map area, constrained to 1,437.7 ± 2.4 Ma (Frost and others, 2002)

Ysm **Monzosyenite**—Coarse-grained to porphyritic, dark-red-brown to dark-gray syenite to monzosyenite composed of feldspar phenocrysts, clinopyroxene, green and brown amphibole, biotite, titanomagnetite with other oxides, apatite, trace quartz, and possible inverted pigeonite. Feldspar phenocrysts up to 4 cm; plagioclase and perthite with myrmekite on grain boundaries; heavily fractured. Amphibole occurs as pseudomorphs or as rims on pyroxene; mafic minerals constitute 20–40 percent of rock. Forms highly recessive and rounded outcrops, often only visible in drainages. Contacts with Sherman Granite poorly exposed but locally gradational; some areas may represent earlier phase of Sherman Granite. Age constrained to 1,440.3 ± 2.7 Ma

Laramie Anorthosite Complex

Maloin Ranch pluton (Mesoproterozoic)

Ymrbg **Biotite gabbro**—Fine- to medium-grained, gray-brown, unfoliated, subequigranular gabbro dominated by interlocking plagioclase, clinopyroxene, orthopyroxene, and biotite with accessory composite ilmenite-magnetite, olivine, brown hornblende, and minor apatite. Plagioclase is subhedral to tabular, appears translucent in hand sample; fine-grained variants exhibit lath-like plagioclase as subophitic intergrowths. Contains xenocrysts of Chugwater anorthosite plagioclase up to 0.5 cm (Kolker, 1989). Occurs primarily as minor conformable or cross-cutting bodies in southern portion of Maloin Ranch pluton; most occurrences too small to map

Ymrg **Granite**—Several discrete varieties of granite exist within Maloin Ranch pluton; also occurs as extensive dikes that cross-cut older units. Porphyritic granite: coarse-grained, porphyritic, pink; composed of perthitic microcline, ferrohornblende, biotite, and quartz; typically exposed on ridges near monzosyenite and quartz syenite. Medium-grained granite: medium-grained, subequigranular; composed of subequant perthitic microcline, ferrohornblende, biotite, and up to 35 percent quartz; gradational transition from monzosyenite, hornblende syenite, and quartz syenite. Southern porphyritic granite: coarse-grained, porphyritic; composed of tabular, zoned microcline, hornblende, plagioclase, and minor quartz; resembles portions of Sherman batholith (Kolker, 1989). In southeastern exposure of pluton, east of map area, contacts with Sherman granite interlayered to gradational; locally impossible to differentiate in field

Ymrms **Monzosyenite**—Coarse-grained, deep red-brown, two-feldspar cumulate composed of interlocking megacrystic feldspar in matrix of finer-grained ferromagnesian minerals, plagioclase, and quartz; magmatic foliation defined by alignment of mafic minerals. Feldspar megacrysts (1–3 cm) primarily composed of perthite and lesser plagioclase, with partial replacement by microcline; myrmekite common along megacryst grain boundaries. Ferromagnesian minerals in matrix include ferroaugite, inverted pigeonite, and fayalite, which occur in clots surrounded by green ferrohornblende and grunerite. Trace minerals include ilmenite, zircon, and apatite; quartz content variable. Forms low, spheroidal outcrops. Gradational contact with overlying porphyritic granite; underlying fine-grained monzonite is typically interlayered with sharp contacts but is locally gradational to intermixed (Kolker, 1989). Age constrained to 1,434.3 ± 1.2 Ma (Scoates and Chamberlain, 2003)

Ymrpm **Porphyritic monzonite**—Coarse-grained, red-brown to gray, massive, porphyritic monzonite composed of feldspar megacrysts hosted in fine-grained, monzonitic matrix. Feldspar megacrysts (0.5–4 cm) include both microperthite and plagioclase, typically subhedral to euhedral, randomly oriented, and locally exhibit prominent twinning. Monzonitic matrix composed of plagioclase, microperthite, and minor quartz (less than 5 percent), with clots of inverted pigeonite and clinopyroxene. Majority of area mapped as porphyritic monzonite includes interlayered fine-grained monzonite, biotite gabbro, and monzosyenite. Contacts with fine-grained monzonite and monzosyenite are sharp (Kolker, 1989)

Ymrfm **Fine-grained monzonite**—Fine- to medium-grained, equigranular to locally porphyritic monzonite composed of interlocking plagioclase, microperthite, augite, inverted pigeonite, biotite, and minor quartz (Kolker, 1989); localized, weak magmatic foliation defined by alignment of feldspar phenocrysts. Deep-red iron staining common; fresh surfaces gray. Porphyritic variants dominated by 2–3 cm feldspar megacrysts with minor mafic minerals in matrix. Includes fine- to medium-grained ferrodiorite dikes and inclusions intruded along basal contact with Chugwater anorthosite; composed of plagioclase, augite, inverted pigeonite, composite ilmenite-titanomagnetite, and apatite (Kolker, 1989). Numerous unmapped xenoliths of pelitic gneiss near Lake Hill

Chugwater anorthosite pluton (Mesoproterozoic)—Main body subdivided into upper, middle, and lower layered zones composed of a leucogabbroic zone overlying an anorthositic zone, with centimeter- to meter-scale interlayering within each zone

Ycalt **Leucotroctolite**—Fine- to medium-grained, light-gray plagioclase, fayalite (up to 40 percent), augite, and orthopyroxene, with accessory biotite, ilmenite, titaniferous magnetite, and trace pyhrrotite, pentlandite, and chalcopyrite. Olivine commonly weathers out leaving pitted surface. Leucotroctolite bodies typically 2–20 m wide and both cut and lie parallel to regional layering; sharp contacts with anorthosite and diffuse contacts with leucogabbro. Areas mapped as leuctroctolite are generalized regions of leucotroctolite outcrops intermixed with anorthosite and leucogabbro (Newhouse and Hagner, 1957; Frost and others, 2010; Lindsley and others, 2010)

Ycagu **Upper leucogabbroic layered zone**—Medium-grained, dark-blue to black, subequigranular to inequigranular leucogabbro. Composed of 80–90 percent anhedral to tabular plagioclase ($An_{45\text{-}60}$), up to 15 percent iron-rich augite, inverted pigeonite, and orthopyroxene; minor phases include olivine, ilmenite, and titanomagnetite; biotite only present with olivine; trace sulfides include pyrrhotite, pentlandite, and chalcopyrite. Forms poorly exposed topographic lows (Lindsley and others, 2010)

Yca3 **Upper anorthositic layered zone (King Mountain anorthosite)**—Medium-grained, blue-gray, subequigranular to inequigranular anorthosite. Composed of tabular labradorescent plagioclase phenocrysts ($An_{42\text{-}63}$; 2–3 cm) with rare megacrysts (larger than 5 cm), inverted pigeonite, and orthopyroxene with accessory ilmenite and magnetite (2–4 percent); contains trace quartz and secondary muscovite, epidote, and sericite. Plagioclase phenocrysts contain inclusions of magnetite, ilmenite, biotite, and rutile; inverted pigeonite present in upper stratigraphic levels of unit. Distinctive lamination and magmatic foliation defined by alignment of plagioclase phenocrysts (Lindsley and others, 2010). Age constrained to 1,436 ± 0.7 Ma (Frost and others, 2010)

Ycagm **Middle leucogabbroic layered zone**—Medium- to coarse-grained, dark-blue to black, subequigranular to inequigranular, locally megacrystic leucogabbro, weathers dark-brown. Composed of 80–90 percent anhedral to tabular plagioclase ($An_{46\text{-}55}$), up to 15 percent iron-rich augite, and orthopyroxene; minor phases include olivine, ilmenite, and titanomagnetite; biotite only present with olivine; trace sulfides include pyrrhotite, pentlandite, and chalcopyrite. Forms poorly exposed topographic lows (Lindsley and others, 2010)

Yca2 **Middle anorthositic layered zone**—Medium- to coarse-grained, dark-blue to dark-gray, subequigranular to inequigranular, locally megacrystic anorthosite. Composed of anhedral to tabular labradorescent plagioclase phenocrysts ($An_{46\text{-}55}$; 1 mm–3 cm) with minor green amphibole, rutile, accessory muscovite (less than 5 percent); secondary biotite, chlorite, sericite, epidote, and muscovite present. Plagioclase phenocrysts contain inclusions of magnetite, ilmenite, biotite, and rutile; white to light-gray plagioclase neoblasts present on phenocryst grain boundaries due to high-temperature deformation. Weak magmatic foliation defined by alignment of plagioclase phenocrysts. Forms topographic highs. Contains meter-scale characteristic intrusions of leucotroctolite as described above

Ycagl **Lower leucogabbroic layered zone**—Coarse-grained to megacrystic, dark-blue to black, subequigranular to inequigranular leucogabbro. Composed of 80–90 percent tabular plagioclase ($An_{47\text{-}52}$), up to 15 percent iron-rich augite, and orthopyroxene with minor olivine, ilmenite, and titanomagnetite; biotite only present with olivine; trace sulfides include pyrrhotite, pentlandite, and chalcopyrite. Forms topographic lows, poorly exposed (Lindsley and others, 2010)

Yca1 **Lower anorthositic layered zone**—Coarse-grained to megacrystic, dark-gray, inequigranular to semiequigranular anorthosite composed of tabular, labradorescent plagioclase phenocrysts ($An_{48\text{-}56}$). Minor mineral constituents include augite, low-Ca pyroxene, ilmenite, magnetite, and local quartz. Olivine present in proximity to troctolite. Troctolite inclusions: medium-grained to megacrystic, undeformed, composed of olivine (up to 50 percent), plagioclase, minor orthopyroxene, and biotite, with accessory ilmenite and titaniferous magnetite; exhibits sharp boundaries when injected; forms recessive outcrops. Lower anorthositic layered zone distinctly stratified; compositional layering defined by varying abundance of mafic minerals. Age constrained between 1,435.4 ± 0.5 Ma and 1,435.2 ± 0.9 Ma (Scoates and Chamberlain, 1995; Frost and others, 2010; Lindsley and others, 2010; Frost and others, 2013)

Ycaot **Oxide troctolite**—Medium- to coarse-grained, black, oxide-rich troctolite composed of titaniferous magnetite and ilmenite with plagioclase, olivine, alkali feldspar, augite, and apatite. Most outcrops in map area composed exclusively of Fe-Ti oxides. Occurs as inclusions and dikes within Chugwater anorthosite (Mitchell and others, 1995; Frost and others, 2010)

Ycau **Anorthosite, unlayered**—Coarse-grained to megacrystic, dark-gray, inequigranular to semiequigranular massive anorthosite composed of labradorescent plagioclase with minor augite, low-calcium pyroxene, olivine, ilmenite, magnetite, and local quartz. Occupies lowest stratigraphic position in Chugwater anorthosite pluton and is separated from lower anorthositic layered zone by structural boundary and is equivalent to undivided anorthosite of Lindsley and others (2010). Both units are petrographically and compositionally identical but unlayered anorthosite lacks traceable layering and lamination and exhibits evidence of different structural and deformational history than layered anorthosite zones (Lindsley and others, 2010). Age constrained between 1,435.7 ± 1.1 Ma and 1,435.5 ± 0.3 Ma (Frost and others, 2010)

Ycah **High-calcium anorthosite**—Fine-grained, light-gray to white, locally porphyritic, highly deformed anorthosite. Primarily composed of interlocking, subhedral to anhedral plagioclase ($An_{67\text{-}75}$) and minor (5–10 percent) pyroxene, with trace epidote and quartz (Lindsley and others, 2010). Local red to blue labradorescent plagioclase megacrysts (3–10 cm). Only observed along structural boundary separating layered Chugwater anorthosite from unlayered Chugwater anorthosite (Lindsley and others, 2010)

Horse Creek complex (Paleoproterozoic)

Xhcm **Horse Creek quartz monzonite**—Fine- to medium-grained, subequigranular, orange-pink quartz monzonite of Scoates and Chamberlain (1997); composed of oligoclase, microcline, hornblende, biotite, and minor quartz with accessory titanite, ilmenite, magnetite, apatite, and zircon. Oligoclase and microcline occur in approximately equal proportions (Ramarathnam, 1962; Frost and others, 2000). Well exposed and highly resistant; forms extensive but narrow, east- to northeast-trending dikes in Horse Creek anorthosite and porphyritic granite with primary intrusion at Dirty Mountain. Magmatic foliation defined by alignment of mafic minerals and localized quartz ribbons. Age constrained to 1,754.5 ± 2.2 Ma (Scoates and Chamberlain, 1997)

Xhca **Horse Creek anorthosite**—Medium- to coarse-grained, light-gray to blue-gray, strongly recrystallized equigranular anorthosite of Scoates and Chamberlain (1997); composed of interlocking plagioclase ($An_{44\text{-}68}$; Ramarathnam, 1962), primary clinopyroxene and olivine with secondary hornblende, biotite, chlorite, and epidote. Accessory phases include ilmenite, titanite, zircon, and apatite (Frost and others, 2000). Plagioclase phenocrysts range from subhedral to tabular. Anorthosite is gabbroic to dioritic in proximity to porphyritic granite and granodiorite. Includes small (less than 30 m across), very fine to fine-grained, dark-brown to black dioritic bodies spatially associated with white quartz intrusions. Diorite composed of approximately equal parts randomly oriented, subhedral hornblende replacing pyroxene, tabular plagioclase laths, oxides, and trace biotite. Age constrained to 1,761.5 ± 2 Ma (Scoates and Chamberlain, 1997)

Xhcg **Porphyritic granite**—Coarse-grained to porphyritic, pink-orange to black, semiequigranular to porphyritic granite; composed of 1–3 cm microcline phenocrysts in matrix of finer-grained quartz, oligoclase, microcline, and biotite with accessory hornblende, magnetite, titanite, ilmenite, and zircon (Frost and others, 2000). Microcline is commonly zoned. Contains xenoliths of hornblende-biotite gneiss and dioritic schist. Fine-grained variants occur in proximity to Dirty Mountain. Produces distinctive coarse-grained soil composed of feldspar phenocrysts. Locally strong magmatic foliation defined by alignment of mafic minerals. Contacts with potassium feldspar- and plagioclase feldspar-bearing porphyritic granodiorites and Ragged Top granodiorite typically gradational. Porphyritic granite makes up part of unit mapped by Frost and others (2000) as Horse Creek granite

Xhrtgk **Potassium feldspar porphyritic granodiorite**—Medium- to coarse-grained, porphyritic, black, white, and pink granodiorite composed of pink potassium feldspar phenocrysts (1–4 cm) hosted in finer-grained matrix of plagioclase, perthite, biotite, hornblende, and quartz with trace microcline, oxides, apatite, and zircon. Exhibits well-developed magmatic foliation defined by preferred orientation of feldspar phenocrysts and alignment of mafic minerals. Contains xenoliths of hornblende-biotite gneiss and dioritic schist. Contacts with plagioclase feldspar granodiorite and Ragged Top granodiorite gradational, defined by increase in feldspar phenocryst size relative to matrix and by introduction of pink potassium feldspar phenocrysts. Porphyritic granodiorite makes up part of unit mapped by Frost and others (2000) as Horse Creek granite. Age constrained to 1,770.9 ± 2.8 Ma (Frost and others, 2000)

Xhrtgp **Plagioclase feldspar porphyritic granodiorite**—Medium- to coarse-grained, porphyritic, black and white granodiorite to tonalite composed of white plagioclase phenocrysts (1–4 cm) hosted in finer-grained matrix of plagioclase, perthite, biotite, hornblende, and quartz with trace microcline, oxides, apatite, and zircon. Exhibits well-developed magmatic foliation defined by preferred orientation of feldspar phenocrysts and alignment of mafic minerals. Contains xenoliths of hornblende-biotite gneiss and dioritic schist. Contacts with potassium feldspar granodiorite and Ragged Top granodiorite gradational, defined by increase in feldspar phenocryst size relative to matrix and by loss of pink potassium feldspar phenocrysts. Porphyritic granodiorite makes up part of unit mapped by Frost and others (2000) as Horse Creek granite and Ragged Top granodiorite

Xhrtg **Ragged Top granodiorite**—Medium- to coarse-grained, semiequigranular, black and white granodiorite to tonalite of Frost and others (2000); composed of plagioclase, biotite, quartz, and hornblende, with accessory magnetite, titanite, apatite, chlorite, and microcline. Plagioclase weathers to gray-brown kaolinite and sericite (Frost and others, 2000). Magmatic foliation defined by alignment of mafic minerals and feldspar phenocrysts; locally strongly foliated to gneissic. Contains abundant xenoliths of hornblende-biotite gneiss and dioritic schist. Contacts with potassium feldspar and plagioclase feldspar porphyritic granodiorites typically gradational, defined by increase in feldspar phenocryst size relative to matrix and introduction or loss of pink potassium feldspar phenocrysts. Granodiorite along contact with pelitic schist is garnet bearing in Lake Hill region. Age constrained to 1,770 ± 4 Ma (Frost and others, 2000) and 1,762 ± 5 Ma

Xhbg **Hornblende biotite gneiss (Paleoproterozoic)**—Fine- to medium-grained, dark-green to brown, subequigranular, weakly foliated hornblende-biotite-andesine gneiss of Ramarathnam (1962). Occurs as xenoliths within porphyritic granite and granodiorite members of Horse Creek complex. Composed of plagioclase with hornblende, biotite, relict clinopyroxene, and magnetite, with minor quartz, accessory epidote, titanite, and sericite. Hornblende occurs as pseudomorphs of pyroxene and with biotite on rims of pyroxene. Poorly understood relative to other units

Horse Creek metamorphic suite (Paleoproterozoic)

Xpg **Pelitic gneiss and schist, undifferentiated**—Assorted pelitic gneisses and schists. Generally fine-grained, dark blueish-gray, red-brown, to dark-brown and black, foliated, compositionally layered to schistose; may contain potassium feldspar, plagioclase, perthite, quartz, cordierite, orthopyroxene, biotite, spinel, sillimanite, and garnet, with accessory ilmenite, titanomagnetite, zircon, monazite, and apatite. Retrograde minerals include andalusite, chlorite, muscovite, and rare calcite (Xirouchakis, 1996). Compositionally banded gneisses have alternating orthoclase-orthopyroxene-garnet and cordierite-biotite-sillimanite layers. Schistose units very fine to fine-grained, dark blueish-gray to black, foliated, and micaceous with garnet porphyroclasts. Biotite commonly occurs as overgrowths on pyroxene and garnet; sillimanite and green spinel form clots rimmed by cordierite, giving pelitic gneisses locally spotty appearance; garnet porphyroclasts most common in quartzofeldspathic layers. Leucocratic partial melt present in contact aureole of Laramie Anorthosite Complex (Xirouchakis, 1996). Compositionally banded brown pelitic gneiss and gray cordierite-rich gneiss most prevalent in western part of quadrangle, with more dark blueish-gray to black pelitic gneiss and schists present in southern extent of pelites near Lake Hill

Xmgh **Mafic gneiss and hornfels, undifferentiated**—Very fine to fine-grained, black, subequigranular to equigranular, massive hornfels; composed of clinopyroxene, orthopyroxene, plagioclase, and hornblende with accessory biotite, titanomagnetite, ilmenite, and spinel. Occurs as lenticular bodies within pelitic gneisses; forms topographic highs; most occurrences too small to map. Minor iron-rich compositionally banded mafic gneiss present in sec. 17, T. 17 N., R. 71. W.

NOTICE TO USERS

The Wyoming State Geological Survey (WSGS) encourages the fair use of its material. We request that credit be expressly given to the "Wyoming State Geological Survey" when citing information from this publication. Please contact the WSGS at 307-766-2286 or by email at wsgs-info@wyo.gov with questions about citing materials, preparing acknowledgments, extensive use of this material, or to order maps and publications. Individuals with disabilities who require an alternative form of this publication should contact the WSGS. For the TTY relay operator, call 800-877-9975. We appreciate your cooperation.

Add Notices and Disclaimers from Docs folder or: I:\Data\GIS\Tools\Cartography\Inserts\Disclaimer_Notices\

Column width should be consistent across all columns but will vary from map to map; usually between 6" to 6.5"

Place title where it looks best. Can go centered between cross sectionand map, or below both