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Preliminary Geologic Map
of the
Jeffrey City 7.5' Quadrangle
Fremont County, Wyoming

by

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This report is preliminary and has not been reviewed for conformity with Wyoming State Geological Survey editorial standards or with the North American Stratigraphic Code.

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INTRODUCTION

Recent economic interest in the Jeffery City 7.5' quadrangle showed a need for remapping parts of the quadrangle and detailed mapping of the entire quadrangle. This map was completed in cooperation with the U.S. Geological Survey 2015 StateMap grant award #G15AS00006 to the Wyoming State Geological Survey.

Mapping was conducted through on-the-ground examination and measurement of rock units, aerial imagery interpretation, and compilation of previous mapping and written reports. Initial mapping of the quadrangle began with aerial photographic interpretation and limited ground reconnaissance by Robert W. Gregory and Nick R. Jones during 2010 and 2011, which was incorporated into the 1:100,000 scale Bairoil 30' x 60' quadrangle (Jones and others, 2011). Initial Cenozoic interpretations were based on Love's (1970) 1:125,000-scale map and Stephens' (1964) 1:48,000-scale map. Field work encompassed more than 24 days, nearly 500 man-hours, and more than 100 miles walked by the authors between May and mid-August, 2016. Photos are by Robert W. Gregory and Katherine L. Rhode.

Although no economic rare earth or metals deposits were encountered, this investigation provided geologic details, including more accurate mapping of faults and greater detail to potentially ore-bearing geologic rock units. This helps to better understand central Wyoming's geology and structure. Mapping also clarified the relationships between Tertiary formations near the South Granite Mountains Fault.

We wish to gratefully acknowledge the following land-owners for access to their private lands to complete this map: Lonnie and Yvonne Claytor, Robert and Karina Peterson, Energy Fuels, Inc., Western Nuclear, Inc., Casper Heavenly Views, LLC, Beaver Valley, LLC, and Pan Green Mountain, LLC. Without their cooperation projects such as this would not be possible.

LOCATION

The Jeffrey City 1:24,000 scale quadrangle in central Wyoming (fig. 1) is approximately 74 air km (46 mi) southeast of Riverton, and includes the former uranium boomtown of Jeffrey City at the north edge of the map area. Elevations range from about 1,920 m (6,300 ft) above sea level in the northeastern corner of the quadrangle to more than 2,590 m (8,500 ft) near the southeastern corner. The climate within the quadrangle is high desert; grasses and sage represent the majority of vegetation. Isolated pine and juniper trees are found at the higher elevations, with wetter environment vegetation growing along Crooks Creek, Sheep Creek, and their branches.

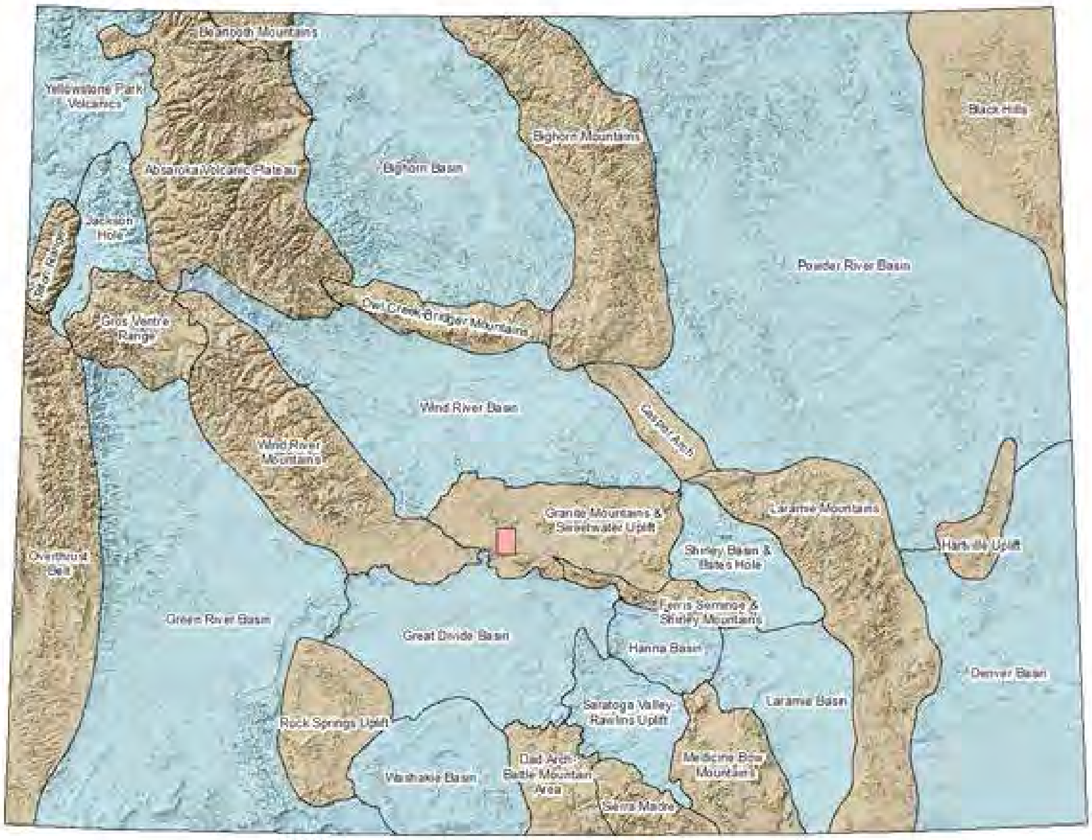

Figure 1. Approximate location of the Jeffrey City quadrangle.

Access to the area is from U.S. Highway 287 (Wyoming State Highway 789), which runs east-west, through Jeffrey City, across the very northern portion of the quadrangle. Crooks Gap Road runs south out of Jeffrey City and provides access to most of the quadrangle and to several side roads of varying condition. The eastern portion of the quadrangle can also be accessed via ranch roads from Green Mountain Road (BLM Road 2411), an improved gravel road which intersects U.S. Highway 287 about 6 miles east of Jeffrey City

GEOLOGIC SETTING

The Jeffrey City 1:24,000-scale geologic map, is located in the southern Granite Mountains, within the ancient Precambrian craton known as the Wyoming Province (Condie, 1976; Houston, 1983). Geologic units within the quadrangle represent a wide time frame of geologic time, from Quaternary units, represented by alluvium and slope wash; through in situ Tertiary units, and faulted Mesozoic and Paleozoic sedimentary units, all resting on Precambrian igneous and metamorphic rocks.

Tertiary rock unit exposures are dominated by the Miocene Split Rock Formation, Eocene Battle Spring Formation and Crooks Gap Conglomerate. Minor exposures of the Paleocene Fort Union Formation occur in the southwest portion of the map area, near Crooks Gap.

Also prominent in the southern portion of the quadrangle is the Cretaceous Cody Shale, with minor exposures of the Frontier Formation, and Thermopolis Shale. The Cloverly Formation forms

prominent ridges outlining a Laramide asymmetric anticline east of Crooks Gap. Jurassic rocks include small discontinuous exposures of the Morrison Formation and more widespread outcrops of the Sundance Formation. Triassic rocks are chiefly represented by the Chugwater Group with thin but pervasive outcrops of the Alcova Limestone serving as a reliable marker bed.
Paleozoic rocks include minor exposures of the Permian Phosphoria, and the Pennsylvanian Tensleep and Amsden Formations, which are underlain by prominent, mostly continuous exposures of the Mississippian Madison Limestone and to a lesser extent the Cambrian Gros Ventre Formation and the Flathead Sandstone. With the exception of the Tensleep-Amsden contact, all Paleozoic contacts are unconformable.

The Archean rocks of the Granite Mountains were accreted onto the Wyoming Craton from approximately 2.65 to 2.63 Ga (Grace and others, 2006). They comprise a metamorphic complex of gneisses, schists, and fragments of supracrustal rocks that have been metamorphosed to amphibolite grade, intruded by medium- to coarse--grained granites, and subsequently intruded by diabase dikes (Peterman and Hildreth, 1978). The Granite Mountain batholith, also referred to as the Wyoming Batholith (Bagdonas, 2014), intruded the area around 2.62 Ga (Frost and others, 1998). East- to northeast-trending mafic dikes intruded during two intervals at approximately 2.4 to 2.6 Ga (Langstaff, 1995) and 1.47 to 1.45 Ga (Chamberlain and Frost, 1995; Chamberlain and others, 2000; 2003). Only minor exposures of granitic rocks of the Wyoming Batholith occur in the very northern portions of the quadrangle.

STRUCTURE

The Precambrian-cored Granite Mountains are a 137 km (85 mi) long by 48 km (30 mi) wide, west-trending, anticlinal uplift that developed during the Laramide orogeny, beginning in latest Cretaceous time. The north flank of the uplift is gently sloping, whereas the south and west flanks are steeper and thrust-faulted. The 80 km (50 mi) long Emigrant Trail Thrust Fault, active during earliest Eocene time, marks this boundary. It slopes upward at 20-35 degrees to the south and west and has a throw of more than 4,570 m (15,000 ft) in some places. The western part of the thrust remained static after its movement, but extensive normal faulting modified the southern part of the thrust plate, particularly east of Crooks Gap, near the end of early Eocene time (Love, 1970).

The South Granite Mountains Fault, as described by Love (1970), is one of the largest and most easily recognized structural features on aerial imagery within the Jeffrey City quadrangle. It generally separates the in situ Split Rock Formation in the northern part of the quadrangle from Mesozoic, Paleozoic, and Precambrian units to the south. The on-the-ground fault trace is mostly obscured by residuum from these formations, with only a few definitive outcrops marking it. The trace of the fault hosts scattered springs, while earlier fluid movements along it are marked by areas of iron staining, brecciation, and local occurrences of dogtooth spar in some fractures. Many of the faults indicated on the quadrangle are highlighted by linear features seen in aerial imagery paired with slight changes in ground cover appearance.

The first phase of uplift in the area caused nearly a 2,250 m (7,500 ft) vertical increase of the Granite Mountains arch and subsidence of basins to the north and south. Uplift of the arch continued through the Paleocene and into the early Eocene. The compressional force causing the uplift also produced thrust faults, reverse faults, and subsidiary anticlines and folds. Near the end of the early Eocene (49-55 Ma), the Granite Mountains block, was uplifted as much as 915 m (3,000 ft) along the South Granite Mountains Fault System, and a lesser amount along the North Granite Mountains Fault System on their north side, about 24-32 km (15-20 mi) to the north. Both of these faults cross-cut pre-existing structures and appear to be unaffected by rock types.

During Miocene time, the 129 km (80 mi) long west-northwest-trending Split Rock syncline began to form along the Granite Mountains trend. This 48 km (30 mi) wide down-warp, with its axis cutting east-west across the northern quarter of the Jeffrey City quadrangle, affected all earlier structures, subsided more than 610 m (2,000 ft), and is apparently still active (Love, 1970). Sedimentation into the syncline included the Miocene Split Rock Formation and the Pliocene Moonstone Formation to the northeast of the quadrangle. During Pliocene time, both the North and South Granite Mountains fault systems reactivated with a reversal of movements along normal faults, dropping the Granite Mountains downward by as much as 305 m (1,000 ft) along the northern fault and 610 m (2,000 ft) along the southern fault (Love, 1970).

TECTONIC SETTING

Late Cretaceous deformation during the Laramide orogeny formed a series of generally northwest-southeast trending folds and some accompanying faults in the map area as part of a regional northwest-southeast trend stretching from southeastern tip of the Wind River Range to the central Laramie Range in southeastern Wyoming. Subsequent erosion of uplifted Precambrian and Paleozoic rocks formed additional deposits in the early Tertiary, primarily to the south and west of the map area.

The youngest Cretaceous unit present in the southern portion of the quadrangle (Crooks Gap and areas to the east) is the Cody Shale. Although younger Cretaceous rocks including the Mesaverde Group, the Lewis Shale, and the Lance Formation are present in significant thicknesses (verified in oil field well logs) to the southeast, they do not appear in the Crooks Gap vicinity. During and after Laramide deformation in the Crooks Gap region these units were removed by erosion prior to and during deposition of the Paleocene Fort Union Formation. Paleocene erosion of rock units as old as the Cloverly Formation is evidenced by their fragments in the lower Fort Union Formation (Stephens, 1964).

During the Eocene, southwest directed thrusting continued, further exposing Mesozoic, Paleozoic and Precambrian strata, from which debris was incorporated into the Battle Spring Formation. Stephens (1964) suggests that in addition to being partially eroded, the Fort Union was likely deformed to a minor extent prior to, and during Battle Spring deposition. The Battle Spring Formation was also deposited unconformably on the Cody Shale in parts of the map area. Battle Spring deposition was far more extensive in the Great Divide Basin south of the map area, reaching thicknesses in excess of 5,000-6,000 ft (Pipringos and Denson, 1970; Love, 1970).

The Crooks Gap Conglomerate (Battle Spring member B of Stephens, 1964) unconformably overlies the Battle Spring Formation and is approximately 400 ft thick. This unit was deposited during a time of extensive erosion of the uplifted Granite Mountains blocks of Precambrian and younger pre-Tertiary strata, leaving large boulders of granite up to 40 ft across (Love, 1970) interbedded with arkosic conglomerate and sandstone. Large pediment and alluvial fan surfaces also developed more distal to the uplifted blocks during this time. While there was significant volcanic activity to the northwest and northeast in the Absaroka and Rattlesnake Hills districts, respectively, the map area does not contain fluvial sediments derived from those magmatic centers. However, these sources, contributed large amounts of tuffaceous material to both the Wagon Bed and Split Rock Formations.

Between the Eocene and the Pliocene, extensive erosion of Eocene tuffaceous rocks in both the Absaroka and Rattlesnake Hills districts resulted in an extensive blanket of fluvial and eolian influenced sediments of the Oligocene White River and the Miocene Split Rock Formations. The map area has been largely stripped of any White River Formation that may have been deposited there, but the Split Rock Formation is notably present, primarily in the northern half of the quadrangle.

During the Pliocene, subsidence of the Granite Mountains block was controlled by normal faulting along both the South and North Granite Mountains Fault Systems. These two normal fault systems were probably most active during the Pliocene, but associated normal faulting has probably continued into the Quaternary.

ECONOMICS

Mineral resources that potentially may occur within the map area include uranium, gemstones, and aggregate. Oil has also been produced in the southern portion of the map for several decades.

Uranium

In the early 1950s, ore-grade uranium was discovered in the Crooks Gap area. Development and claim staking rapidly followed, and Western Nuclear, Inc. applied to the Atomic Energy Commission for construction of the Split Rock Mill, which was completed in July, 1957. Development continued and flourished until the downfall in the uranium industry in 1980. Since this peak, many of the past mines have been reclaimed, dewatering was discontinued, and the mines have been allowed to flood. Some development still occurs on Sheep Mountain, with a 2015 proposal for surface pit development and the reopening of the existing Sheep Underground mine.

The Battle Spring Formation is an important uranium host rock in the Great Divide Basin south of the Jeffrey City map area, and it crops out within the map's boundaries. Uranium is currently produced from the Battle Spring Formation in the Lost Creek area, approximately 25 mi south of Jeffrey City. The source rock for uranium in the Great Divide Basin is believed to be the Granite Mountains to the north, so fluids transporting uranium may have passed through the rocks in the Crooks Gap area, just south of Jeffrey City.

Gemstones

Abundant agates and small amounts of opal have been found around the Jeffrey City quadrangle. Detrital nephrite jade that originated in the Granite Mountains to the north has been reported from within the area, although none was found during the course of mapping. The majority of the jade float has been reworked multiple times by erosional processes. Detrital nephrite jade, the most likely type to be found within the quadrangle, is found within Tertiary conglomerates, and Quaternary colluvial, eluvial, and alluvial materials. The oldest known host units in the area for detrital nephrite are the Eocene Wind River and Battle Spring Formations. Detrital nephrite also occurs within the

Oligocene White River Formation in areas to the north, the Miocene Split Rock Formation, and in Quaternary lag gravels (Love, 1970).

Petroleum Resources

Oil was discovered in Crooks Gap and on Sheep Mountain north of Western Nuclear, Inc. permit area in the 1930s with oil fields constructed in the 1940's. There are currently two operating fields; the Sheep Creek oil field in the southeast corner of the map area is currently producing from the Phosphoria Formation (Stewart, 1979), and the Crooks Gap oil field in the southwest, which is producing mainly from the Muddy, Dakota, and Lakota Formations. Minor production has also occurred from the Nugget and Frontier Formations (Wyoming Oil and Gas Conservation Commission website, 2014).

DESCRIPTION OF MAP UNITS

Quaternary deposits

Holocene

Disturbed ground (d) **–** Areas that have been reshaped by human earth moving activities related to surface pit uranium mines, quarries, dams, or gravel pits.

Alluvium (Qa) **–** Unconsolidated clay, silt, sand, gravel, and cobbles located in and along most drainages, and may include minor eluvial deposits, slope wash, and small alluvial and colluvial fans along drainages.

Alluvial fan deposits (Qf) **–** Boulders, cobbles, pebbles, sand, gravel, and silt deposited as part of a sequence of alluvial fans; mostly unconsolidated.

Colluvium (Qc) **–** Unconsolidated weathered bedrock, slope wash and soil, at or near the base and lower parts of steep slopes.

Eolian dunes (Qs) **–** Mixed active and stabilized windblown dunes and sand; fine- to medium-grained with scattered coarser material; unconsolidated, fair to moderately sorted; vegetative cover dependent on active deposition, sparse grass at margins of active deposition with annual vegetation on more stable deposits.

Landslide deposits (Qls) **–** Angular blocks of bedrock and boulder and cobble-sized loose slope debris; largely unconsolidated and poorly sorted, with hummocky topography.

Holocene-Pleistocene

Terrace deposits (Qtg) **–** Cobbles, pebbles, sand, and silt, of fluvial origin; unconsolidated, poorly sorted, and largely unstratified; forms broad, near flat to gently sloping surfaces between drainages along mountain flanks; these merge in places with eluvial, alluvial, and colluvial deposits.

Tertiary

Miocene Split Rock Formation (Tsr) – Cross-bedded to massive, well-sorted, white to gray and tan, fine-grained tuffaceous sandstone, coarse arkosic sandstone and conglomerate, and cream to tan silty tuff and minor pumicite; conglomerate beds contain angular to rounded pebbles and cobbles dominated by Precambrian rocks; conspicuous well-rounded and frosted grains (Love, 1970); minor chert nodules. Regionally, the Split Rock Formation ranges in thickness from 46 m (150 ft) to more than 305 m (1000 ft); however, its thickness within the Jeffrey City quadrangle has not been measured.

Eocene Crooks Gap Conglomerate (Tcg) – Very large, sub-rounded granitic boulders, up to 12 m (40 ft) across (Love, 1970) in a pink to orange-gray arkosic sandstone matrix; abundant iron oxide stained rinds on most boulders; occurs largely as remnants of fan deposits shed from the Granite Mountains. Thicknesses of up to 122 m (400 ft) based on fragmentary well records in the South Happy Springs oil field area, about 5 km (3 mi) west of the quadrangle (Stephens, 1964), but thickness can vary due to unconformable, erosional base. Previously called Member B of the Battle Spring Formation by Stephens (1964).

Eocene Battle Spring Formation (Tbs) – Conglomeratic arkose; light-gray, buff to light yellowish-gray, commonly stained with rusty-orange and yellow iron oxide (local iron concretions up to several inches across); mostly unconsolidated, permeable, cross-laminated with common cut-and-fill structures; noncalcareous, fine to coarse (up to several inches across); angular-sub-angular grains composed primarily of quartz, feldspar, and mica; poorly sorted; conglomerate lenses composed chiefly of boulders and cobbles of predominantly granite and to a lesser extent Paleozoic fragments of limestone, sandstone, and conglomerate that are interbedded with the above described arkose and lenticular carbonaceous siltstone beds. Siltstones are variegated tan, yellowish-brown, reddish-purple, and drab-brown; poorly sorted with fine to coarse quartz and feldspar grains in a predominantly silty and clayey matrix (Stephens, 1964); some lenses are calcareous cemented. This unit unconformably overlies the Fort Union Formation or older units where the Fort Union is absent. The carbonaceous horizons of the Battle Spring Formation host roll front uranium deposits on the south side of Green Mountain immediately south of the quadrangle and at Crooks Gap in the southwestern part of the quadrangle. Thicknesses range up to approximately 670 m (2200 ft) in the Crooks Gap vicinity (Stephens, 1964).

Paleocene Forth Union Formation (Tfu) – Complexly interbedded, commonly lenticular or discontinuous sequence of beds; predominately mudstone, shale, and carbonaceous shale, light- to dark-gray, locally maroon; lenticular, discontinuous sandstone, light-brown to gray, argillaceous, very fine- to medium-grained, commonly contains ferruginous concretions; locally contains numerous vertebrate and common invertebrate fossils, and plant fossils; coal beds are generally thin and discontinuous with lenticular thickenings to as much as 3 m (9 ft). Commonly eroded during Battle Spring deposition; contact between the two formations is mostly concealed by arkosic debris of Battle Spring rocks; thickness of the Fort Union varies up to 293 m (960 ft) (Stephens, 1964).

Cretaceous

Cody Shale (Kc) – Marine shale, soft, dark-gray to olive-gray with numerous bentonitic shales and siltstones; partly sandy, with limestone concretions; sandstone, very fine- to fine-grained, laminated gray to orangish gray, and light-tan to buff, glauconitic, thin-bedded, with trace fossils; Formation thickness ranges from 1,200–1,800 m (3,940–5,900 ft).

Frontier Formation (Kf) – Dark–gray shale and siltstone interbedded with gray and brown, fine- to coarse-grained sandstone; white to yellow bentonite; porcellanite; thin impure coal beds are found in the lower part (Love and others, 1979). The Wall Creek Sandstone Member may form a distinctive ridge of tan to rusty brown fine-grained sandstone within the Frontier Formation. Pekarek (1977) listed the thickness of the Frontier at about 204 m (670 ft).

Mowry Shale – combined with the Thermopolis Shale as one mappable unit (Kmt)

Mowry Shale – Hard, gray to black, weathering to silver gray-white, commonly iron-oxide stained, siliceous and tuffaceous shale containing abundant fish scales and common bentonite beds (Love and others, 1979); approximately 100 m (330 ft) thick.

Thermopolis Shale—Consists of 30–76 m (100–250 ft) of dark-gray to black, soft shale; locally hosts thin bentonite layers near the top and bottom; and is interrupted in the middle by a thin silty sandstone (Pekarek, 1977; Love and others, 1979). Observed thicknesses range from 9–40 m (30–130 ft).

Cloverly Formation – combined with the Jurassic Morrison Formation as one mappable unit (KJcm)

Cloverly Formation – Upper part of formation is light-gray to brown, fine- to coarse-grained, sparkly sandstone underlain by tan, yellowish-gray, pale-orange, angular to sub-rounded, fine- to coarse-grained conglomerate, with pebbles of quartz, chert, shale, and sandstone, in a matrix of fine- to medium-grained sandstone; well-indurated, locally siliceous, cross-bedded, and slabby, with interbedded variegated shale, claystone, and carbonaceous shale; forms prominent ledges and dip slopes; conglomeratic at base, which some geologists have mapped as the Lakota Conglomerate (Stewart, 1979). Thickness ranges from 23–30 m (75–100 ft; Jones and others, 2011).

Morrison Formation – Pale-green, blue-green, maroon, buff to brown, chalky white, interbedded mudstones and sandstones; mudstones are olive-green, gray, maroon, blocky, loosely consolidated to competent beds; with scattered chert and carbonate nodules, and local bentonite and ash beds; sandstone is generally gray, grayish-yellow to grayish-orange and thinly bedded; local dark-gray to black, discontinuous chert beds; local thin drab limestone beds with scattered chert nodule inclusions. Variable thickness 15–46 m (50–150 ft).

Jurassic

Sundance Formation (Js) – Interbedded sandstone, siltstone, limestone, and shale. Sandstone is grayish yellow to tan, calcareous, slightly glauconitic, and platy; siltstone, olive-gray, glauconitic, with numerous marine fossils; shale is greenish to maroon; limestone is brown, with abundant marine fossils of pelecypods and cephalopods. Thickness ranges from 61-76 m (200-250 ft).

Triassic

Nugget Sandstone (J ! n) – Cream to buff and salmon-red, massive to cross-bedded, fine- to medium-grained, friable, calcareous sandstone; extensively cross-bedded in the upper part and contains abundant frosted, rounded quartz grains (Love, 1970; Keefer, 1970). Thickness ranges from 61–122 m (200–400 ft).

Chugwater Group (! c) – Red and gray shale and siltstone with interbedded red to salmon to buff, fine-grained sandstone and gray limestone. Units within the Chugwater Group are as follows:

> Popo Agie Formation – Reddish-brown to maroon mudstone, with scattered yellow to orange pebbles near base, blocky, and locally calcareous. Thicknesses observed range 30–60 m (100–200 ft).

> Alcova Limestone ***(! a)*** – Limestone, gray to light-purple, thinly laminated from presence of fossil stromatolites; blocky, forms prominent ridges up to 4 m (13 ft) thick; weathered surfaces appear orange to rusty brown from lichen growth.

> Red Peak Formation – Red to orange, laminated, platy siltstone; common ripple marks, slightly calcareous, interbedded with very fine-grained silty sandstone grading into siltstone; partly calcareous; Thickness is approximately 150–200 m (49–660 ft).

Permian

Phosphoria Formation (Pp) – Red to yellow-brown sandy siltstone, interbedded with gray dolomite and various nodules and lenses of black and gray chert; minor exposures along thrust fault zone in southeast portion of map area; less than 15 m (50 ft) thick.

Pennsylvanian

Tensleep Formation - combined with the Amsden Formation as one mappable unit ($Mta) – These units, particularly the Amsden, are largely absent from the study area, but where present they are extensively deformed and their thicknesses are minimal; as such they are combined for mapping purposes:

> Tensleep Formation – Tan to grayish-white, fine- to medium-grained, cross-bedded sandstone with a few thin gray cherty limestones and dolomites in the lower part (Keefer and Van Lieu, 1966; Pekarek, 1977; Love and others, 1979); weathers brown to rusty brown and locally iron stained; generally poor exposures typically concealed by talus. Thicknesses observed average 3–8 m (10–26 ft).

> Amsden Formation—Light-rusty red-brown to gray siltstone; contains sparse iron oxide nodules and concretions toward its erosional contact with the underlying Madison Limestone (Keefer and Van Lieu, 1966); interbedded with thin beds of light-gray sandy and silty limestone (Reynolds, 1968). Observed thicknesses less than 6 m (20 ft).

Mississippian

Madison Limestone (Mm) – Massive to thin-bedded bluish-gray crystalline limestone and dolomitic limestone, locally accompanied by massive to bedded chert and abundant chert nodules. This represents only the lower part of the formation as described farther north. Regionally, the

Madison thins from the northwest to the southeast and unconformably overlies the Cambrian formations; this contact often exhibits several feet of relief (Keefer and Van Lieu, 1966). Exposed primarily in a northwest-southeast trend along the South Granite Mountains Fault System in the southern portion of the map area as ridges or partially buried knobs. Observed thicknesses range 25–80 m (80–260 ft).

Cambrian

Gros Ventre Formation (^gv) – Nonresistant, generally poorly exposed, reddish-orange to red, brown, dark-olive-green and gray interbedded, bioturbated, very fine-grained sandstone and shale accompanied in upper half by numerous thin limestone beds and layers of flat pebble conglomerate (Keefer and Van Lieu, 1966). The Gros Ventre Formation conformably, and in places gradationally overlies the late Middle Cambrian Flathead Sandstone; approximately 150 m (500 ft) thick.

Flathead Sandstone (^f) – Resistant reddish-brown to yellow, pink, gray, and tan, fine- to coarse-grained, often thinly-laminated, and occasionally cross-bedded quartzitic sandstone; commonly contains glauconite and hematite; upper part more shaly and softer than lower; base is commonly conglomeratic and arkosic with angular fragments of mica, feldspar and quartz, and some granitic pebbles up to 2.5 cm (1.0 in) across (Keefer and Van Lieu, 1966); silicification may be intense, turning it into a hard, dense quartzite in some areas near the South Granite Mountains Fault; unconformably overlies Precambrian igneous and metamorphic rocks. Observed thicknesses about 46-137 m (150-450 ft).

Precambrian

Granite Mountains (Wyoming) Batholith – Gray, yellowish-gray, pinkish-orange, medium- to coarse-grained granite, with some fine-grained variations; locally pegmatitic and marked by milky quartz and coarse feldspar; highly fractured and chemically altered nearer South Granite Mountains Fault System; overlain unconformably by Flathead Sandstone and younger strata. Biotite locally defines weak foliation and less common strong foliation; some moderate foliation also occurs, defined by orientation of feldspar. Regionally, the granite generally consists of 30–40 percent microcline, 25–35 percent quartz, 25–35 percent plagioclase, and 1–7 percent biotite (which may form lenses), accompanied by accessory epidote, sphene, magnetite, apatite and zircon (Bagdonas, 2014). Mafic dikes, pegmatites, and minor metamorphic outcrops were not mapped separately from the batholith.

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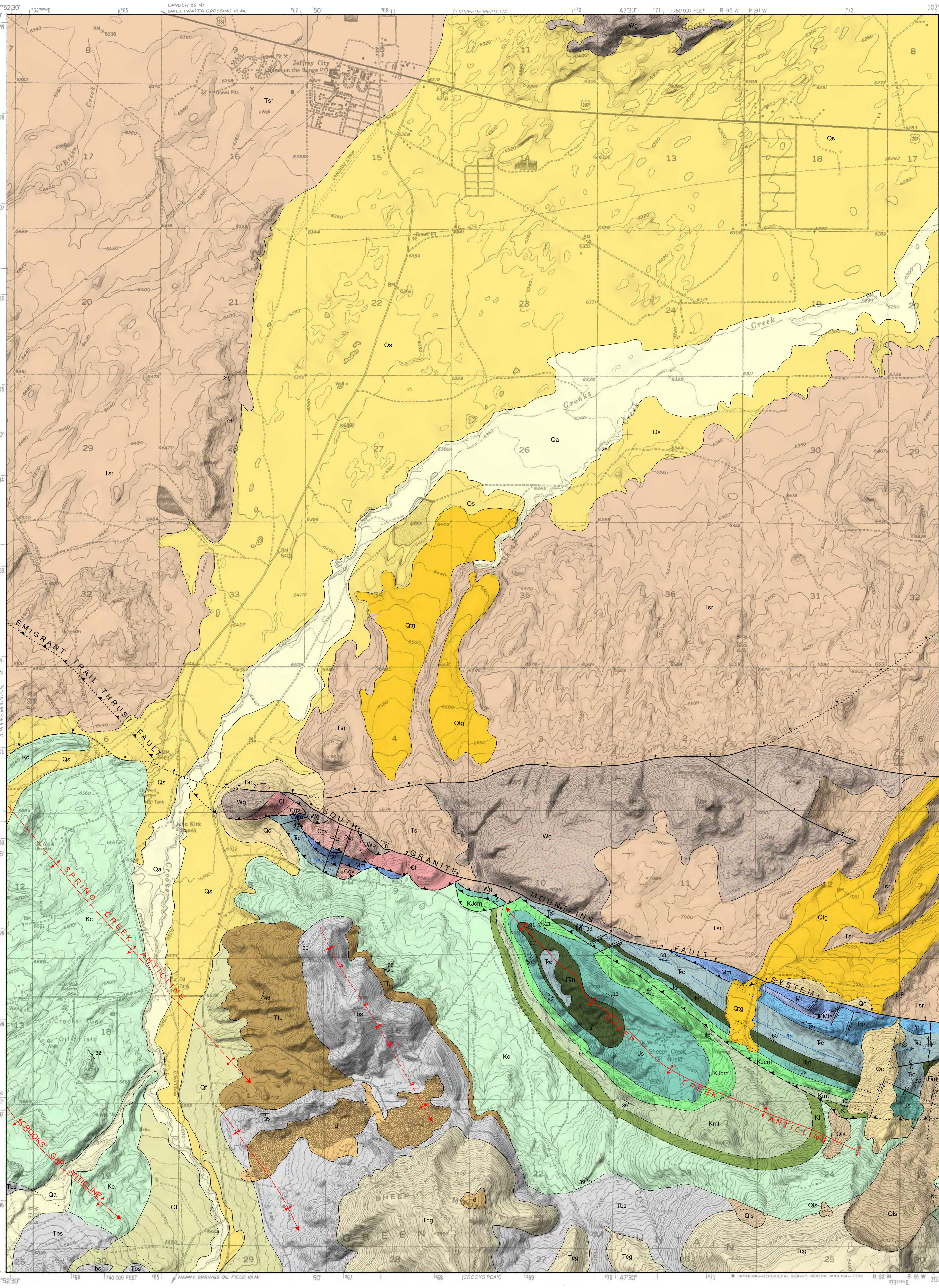
WYOMING STATE GEOLOGICAL SURVEY
Thomas A. Drean, Director and State Geologist
Laramie, Wyoming

Interpreting the past, providing for the future

OPEN FILE REPORT 2016-7
Jeffrey City 1:24,000-scale
Bedrock Geologic Map



Base map from U.S. Geological Survey 1:24,000-scale topographic map of the Jeffrey City, Wyoming Quadrangle, 1957, photorevised 1984

Base hillshade derived from a U.S. Geological Survey tile of the National Elevation Dataset (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, west central zone

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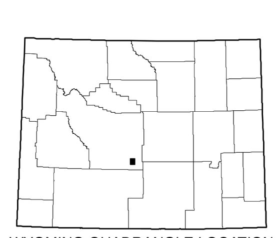
MN
GN
1°12'
10°3'
UTM GRID AND 2016 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929


WYOMING QUADRANGLE LOCATION

Digital cartography by Katherine L. Rhode
Map edited by Suzanne C. Luhr

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PRELIMINARY GEOLOGIC MAP OF THE JEFFREY CITY QUADRANGLE, FREMONT COUNTY, WYOMING

by
Robert W. Gregory, Katherine L. Rhode, and Wayne M. Sutherland
2016

EXPLANATION

DESCRIPTION OF MAP UNITS

Cenozoic

d — **Disturbed ground (Holocene)**—Areas that have been reshaped by human earth moving activities related to surface pit uranium mines, quarries, dams, or gravel pits

Qa — **Alluvium (Holocene)**—Unconsolidated clay, silt, sand, gravel, and cobbles located in and along most drainages; may include minor eluvial deposits, slope wash, and small alluvial and colluvial fans along drainages

Qf — **Alluvial fan deposits (Holocene)**—Boulders, cobbles, pebbles, sand, gravel, and silt deposited as part of a sequence of alluvial fans; mostly unconsolidated

Qc — **Colluvium (Holocene)**—Unconsolidated weathered bedrock, slope wash and soil, at or near the base and lower parts of steep slopes

Qs — **Eolian dunes (Holocene)**—Mixed active and stabilized wind-blown dunes and sand; fine- to medium-grained with scattered coarser material; unconsolidated, fair to moderately sorted; vegetative cover dependent on active deposition, sparse grass at margins of active deposition with annual vegetation on more stable deposits

Qls — **Landslide deposits (Holocene)**—Angular blocks of bedrock and boulder and cobble-sized loose slope debris; largely unconsolidated and poorly sorted, with hummocky topography

Qtg — **Terrace deposits (Holocene and Pleistocene)**—Cobbles, pebbles, sand, and silt, of fluvial origin; unconsolidated, poorly sorted, and largely unstratified; forms broad, near flat to gently sloping surfaces between drainages along mountain flanks; these merge in places with eluvial, alluvial, and colluvial deposits

Tsr — **Split Rock Formation (Miocene)**—Cross-bedded to massive, well-sorted, white to gray and tan, fine-grained tuffaceous sandstone, coarse arkosic sandstone and conglomerate, and cream to tan silty tuff and minor pumicite; conglomerate beds contain angular to rounded pebbles and cobbles dominated by Precambrian rocks; conspicuous well-rounded and frosted grains (Love, 1970); minor chert nodules. Regionally, the Split Rock Formation ranges in thickness from 46 m (150 ft) to more than 305 m (1000 ft); however, its thickness within the Jeffrey City quadrangle has not been measured

Tcg — **Crooks Gap Conglomerate (Eocene)**—Very large, subrounded granitic boulders, up to 12 m (40 ft) across (Love, 1970) in a pink to orange-gray arkosic sandstone matrix; abundant iron-oxide-stained rinds on most boulders; occurs largely as remnants of fan deposits shed from the Granite Mountains. Thicknesses of up to 122 m (400 ft) based on fragmentary well records in the South Happy Springs oil field area, about 5 km (3 mi) west of the quadrangle (Stephens, 1964), but thickness can vary due to unconformable, erosional base. Previously called Member B of the Battle Spring Formation by Stephens (1964)

Tbs — **Battle Spring Formation (Eocene)**—Conglomeratic arkose, light-gray, buff to light-yellowish gray, commonly stained with rusty orange and yellow iron oxide (local iron concretions up to several inches across), mostly unconsolidated, permeable, cross-laminated with common cut-and-fill structures; noncalcareous, fine to coarse (up to several inches across); angular-subangular grains composed primarily of quartz, feldspar, and mica; poorly sorted; conglomerate lenses composed chiefly of boulders and cobbles of predominantly granite and to a lesser extent, Paleozoic fragments of limestone, sandstone, and conglomerate are interbedded with the above described arkose and lenticular carbonaceous siltstone beds. Siltstones are variegated tan, yellowish brown, reddish purple, and drab brown; poorly sorted with fine to coarse quartz and feldspar grains in a predominantly silty and clayey matrix (Stephens, 1964); some lenses are calcareous cemented. This unit unconformably overlies the Fort Union formation or older units where the Fort Union is absent. The carbonaceous horizons of the Battle Spring Formation host roll front uranium deposits on the south side of Green Mountain immediately south of the quadrangle and at Crooks Gap in the southwestern part of the quadrangle. Thicknesses range up to approximately 670 m (2200 ft) in the Crooks Gap vicinity (Stephens, 1964)

Tfu — **Fort Union Formation (Paleocene)**—Complexly interbedded, commonly lenticular or discontinuous sequence of beds; predominately mudstone, shale, and carbonaceous shale, light to dark gray, locally maroon; lenticular, discontinuous sandstone, light brown to gray, argillaceous, very fine to medium grained, commonly contains ferruginous concretions; locally contains numerous vertebrate and common invertebrate fossils, and plant fossils; coal beds are generally thin and discontinuous with lenticular thickenings to as much as 3 m (9 ft). Commonly eroded during Battle Spring deposition; contact between the two formations is mostly concealed by arkosic debris of Battle Spring rocks; thickness of the Fort Union varies from 0–293 m (960 ft) (Stephens, 1964)

Mesozoic

Kc — **Cody Shale (Upper Cretaceous)**—Marine shale, soft, dark-gray to olive-gray with numerous bentonitic shales and siltstones; partly sandy, with limestone concretions; sandstone, very fine to fine-grained, laminated gray to orangish-gray, and light-tan to buff, glauconitic, thin-bedded, with trace fossils; Formation thickness ranges from 1,200–1,800 m (3,940–5,900 ft)

Kf — **Frontier Formation (Upper Cretaceous)**—Dark gray shale and siltstone interbedded with gray and brown, fine- to coarse-grained sandstone; white to yellow bentonite, porcellanite; thin impure coal beds are found in the lower part (Love and others, 1979). Wall Creek Sandstone Member may form a distinctive ridge of tan to rusty brown fine-grained sandstone in the Frontier Formation. Pekarek (1977) listed the thickness of the Frontier at about 204 m (670 ft)

Kmt — **Mowry (Upper Cretaceous) and Thermopolis (Lower Cretaceous) Shales**—The Mowry Shale dominates poorly exposed outcrops of this unit in the map area. The Thermopolis Shale is mostly concealed or absent, except in a few localities, in close proximity to upper Cloverly outcrops

Mowry Shale—Hard, gray to black, weathering to silver gray-white, commonly iron-oxide stained, siliceous and tuffaceous shale containing abundant fish scales and common bentonite beds (Love and others, 1979); approximately 100 m (330 ft) thick

Thermopolis Shale—Consists of 30–76 m (100–250 ft) of dark-gray to black, soft shale; locally hosts thin bentonite layers near the top and bottom, and is interrupted in the middle by a thin silty sandstone (Pekarek, 1977; Love and others, 1979). Observed thicknesses range from 9–40 m (30–130 ft)

KJcm — **Cloverly (Lower Cretaceous) and Morrison (Upper Jurassic) Formations, Undivided**—The Cloverly Formation is a prominent ridge-forming unit in the map area, while the underlying Morrison Formation is mostly concealed by slope wash or valley fill, and as such the two are mapped as one combined unit

Cloverly Formation—Upper part of formation is light-gray to brown, fine- to coarse-grained, sparkly sandstone underlain by tan, yellowish-gray, pale-orange, angular to subrounded, fine- to coarse-grained conglomerate, with pebbles of quartz, chert, shale, and sandstone, in a matrix of fine- to medium-grained sandstone; well-indurated, locally siliceous, cross-bedded, and slabby, with interbedded variegated shale, claystone, and carbonaceous shale; forms prominent ledges and dip slopes; conglomeratic at base, which some geologists have mapped as the Lakota Conglomerate (Stewart, 1979). Thickness ranges from 23–30 m (75–100 ft) (Jones and others, 2011)

Morrison Formation—Pale-green, blue-green, maroon, buff to brown, chalky white, interbedded mudstones and sandstones; mudstones are olive-green, gray, maroon, blocky, loosely consolidated to competent beds; with scattered chert and carbonate nodules, and local bentonite and ash beds; sandstone is generally gray, grayish-yellow to grayish orange and thinly bedded; local dark-gray to black, discontinuous chert beds; local thin drab limestone beds with scattered chert nodule inclusions. Variable thickness range 15–46 m (50–150 ft)

Js — **Sundance Formation (Upper and Middle Jurassic)**—Interbedded sandstone, siltstone, limestone, and shale. Sandstone is grayish yellow to tan, calcareous, slightly glauconitic, and platy; siltstone, olive-gray, glauconitic, with numerous marine fossils; shale is greenish to maroon; limestone is brown, with abundant marine fossils of pelecypods and cephalopods. Thickness ranges from 61–76 m (200–250 ft)

JŦn — **Nugget Sandstone (Lower Jurassic and Upper Triassic)**—Cream to buff and salmon-red, massive to cross-bedded, fine- to medium-grained, friable, calcareous sandstone; extensively cross-bedded in the upper part and contains abundant frosted, rounded quartz grains (Love, 1970; Keefer, 1970). Thickness ranges from 61–122 m (200–400 ft)

Ŧc — **Chugwater Group (Triassic)**—Red and gray shale and siltstone with interbedded red to salmon to buff, fine-grained sandstone and gray limestone. Units within the Chugwater Group are as follows:

Popo Agie Formation—Reddish-brown to maroon mudstone, with scattered yellow to orange pebbles near base, blocky, and locally calcareous. Thicknesses observed range 30–60 m (100–200 ft)

Alcova Limestone (Ŧa)—Limestone, gray to light-purple, thinly laminated from presence of fossil stromatolites; blocky, forms prominent ridges up to 4 m (13 ft) thick; weathered surfaces appear orange to rusty brown from lichen growth

Red Peak Formation—Red to orange, laminated, platy siltstone; common ripple marks, slightly calcareous, interbedded with very fine grained silty sandstone grading into siltstone; partly calcareous; Thickness is approximately 150–200 m (490–660 ft)

Paleozoic

Pp — **Phosphoria Formation (Permian)**—Red to yellow-brown sandy siltstone, interbedded with gray dolomite and various nodules and lenses of black and gray chert; minor exposures along thrust fault zone in southeast portion of map area; less than 15 m (50 ft) thick

IPMta — **Tensleep (Upper and Middle Pennsylvanian) and Amsden (Middle and Lower Pennsylvanian and Mississippian) Formations, Undivided**—These units, particularly the Amsden, are largely absent from the study area, but where present they are extensively deformed and their combined thickness is minimal; as such they are combined for mapping purposes:

Tensleep Formation—Tan to grayish-white, fine- to medium-grained, cross-bedded sandstone with a few thin gray cherty limestones and dolomites in the lower part (Keefer and Van Lieu, 1966; Pekarek, 1977; Love and others, 1979); weathers brown to rusty brown and locally iron stained; generally poor exposures typically concealed by talus. Thicknesses observed average 3–8 m (10–26 ft)

Amsden Formation—Light rusty red-brown to gray siltstone; contains sparse iron-oxide nodules and concretions toward its erosional contact with the underlying Madison Limestone (Keefer and Van Lieu, 1966); interbedded with thin beds of light-gray sandy and silty limestone (Reynolds, 1968). Observed thicknesses less than 6 m (20 ft)

Mm — **Madison Limestone (Mississippian)**—Massive to thin-bedded bluish-gray crystalline limestone and dolomitic limestone, locally accompanied by massive to bedded chert and abundant chert nodules. This represents only the lower part of the formation as described farther north. Regionally, the Madison thins from the northwest to the southeast and unconformably overlies the Cambrian formations; this contact often exhibits several feet of relief (Keefer and Van Lieu, 1966). Exposed primarily in a NW-SE trend along the South Granite Mountains Fault System in the southern portion of the map area as ridges or partially buried knobs. Observed thicknesses range 25–80 m (80–260 ft)

€gv — **Gros Ventre Formation (Upper and Middle Cambrian)**—Nonresistant, generally poorly exposed, reddish-orange to red, brown, dark-olive green and gray interbedded, bioturbated, very fine grained sandstone and shale accompanied in upper half by numerous thin limestone beds and layers of flat pebble conglomerate (Keefer and Van Lieu, 1966). The Gros Ventre Formation conformably, and in places gradationally overlies the late Middle Cambrian Flathead Sandstone; approximately 150 m (500 ft) thick

€f — **Flathead Sandstone (Middle Cambrian)**—Resistant reddish-brown to yellow, pink, gray, and tan, fine- to coarse-grained, often thinly laminated, and occasionally cross-bedded quartzitic sandstone; commonly contains glauconite and hematite; upper part more shaly and softer than lower; base is commonly conglomeratic and arkosic with angular fragments of mica, feldspar and quartz, and some granitic pebbles up to 2.5 cm (1.0 in) across (Keefer and Van Lieu, 1966); silicification may be intense, turning it into a hard, dense quartzite in some areas near the South Granite Mountains Fault; unconformably overlies Precambrian igneous and metamorphic rocks. Observed thicknesses about 46–137 m (150–450 ft)

Precambrian

Wg — **Granite (Neoarchean)**—Gray, yellowish-gray, pinkish-orange, medium- to coarse-grained granite, with some fine-grained variations; locally pegmatitic and marked by milky quartz and coarse feldspar; highly fractured and chemically altered nearer South Granite Mountains Fault System; overlain unconformably by Flathead Sandstone and younger strata. Biotite locally defines weak foliation and less common strong foliation; some moderate foliation also occurs, defined by orientation of feldspar. Regionally, the granite generally consists of 30–40 percent microcline, 25–35 percent quartz, 25–35 percent plagioclase, and 1–7 percent biotite (which may form lenses), accompanied by accessory epidote, sphene, magnetite, apatite and zircon (Bagdonas, 2014)

CORRELATION OF MAP UNITS

d, Qa, Qf, Qc, Qs, Qls, Qtg — Holocene, Pleistocene — QUATERNARY — CENOZOIC
Unconformity
Tsr — Miocene — TERTIARY — NEOGENE
Unconformity
Tcg, Tbs — Eocene — TERTIARY — PALEOGENE
Tfu — Paleocene
Unconformity
Kc, Kf, Kmt — Upper Cretaceous, Lower Cretaceous — CRETACEOUS — MESOZOIC
KJcm, Js — Upper Jurassic, Middle Jurrasic — JURASSIC
Unconformity
JŦn — Lower Jurrasic, Triassic
Unconformity
Ŧc — Triassic — TRIASSIC
Unconformity
Pp — Permian — PERMIAN — PALEOZOIC
Unconformity
IPMta — Pennsylvanian, Mississippian — CARBONIFEROUS
Unconformity
Mm
Unconformity
€gv — Upper Cambrian — CAMBRIAN
Unconformity
€f — Middle Cambrian
Unconformity
Wg — Neoarchean — ARCHEAN — PRECAMBRIAN

MAP SYMBOLS

Definitions
Certain—Location known <25 m (82 ft)
Approximate—Estimated location 25–100 m (82–330 ft)
Inferred—Estimated location >100 m (330 ft)

Formation contact—Continuous where certain; long dash where approximate; queried where identity or existence questionable

Marker bed, Alcova Limestone (Ŧa)—limestone marker bed in the Chugwater Formation; see DESCRIPTION OF MAP UNITS for explanation

Fault—Continuous where certain; long dash where approximately located; dotted where concealed; upthrown (U) and downtown (D) blocks designated where fault type is unknown; arrows indicate apparent direction of movement on oblique-slip fault

Normal fault—Continuous where certain; long dash where approximately located; dotted where concealed; bar and ball on downthown block of fault

Thrust fault—Continuous where certain; long dash where approximately located; dotted where concealed; sawteeth on upper (tectonically higher) plate

Anticline—Continuous where certain; long dash where approximately located; dotted where concealed; arrow on end of axis indicates direction of plunge; positioned using measured dips

Syncline—Long dash where approximately located; queried where positioned using previously published maps and not confirmed with surface expression; arrow on end of axis indicates direction of plunge

21 **Strike and dip of inclined bedding**

68 **Strike and dip of overturned bedding**

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