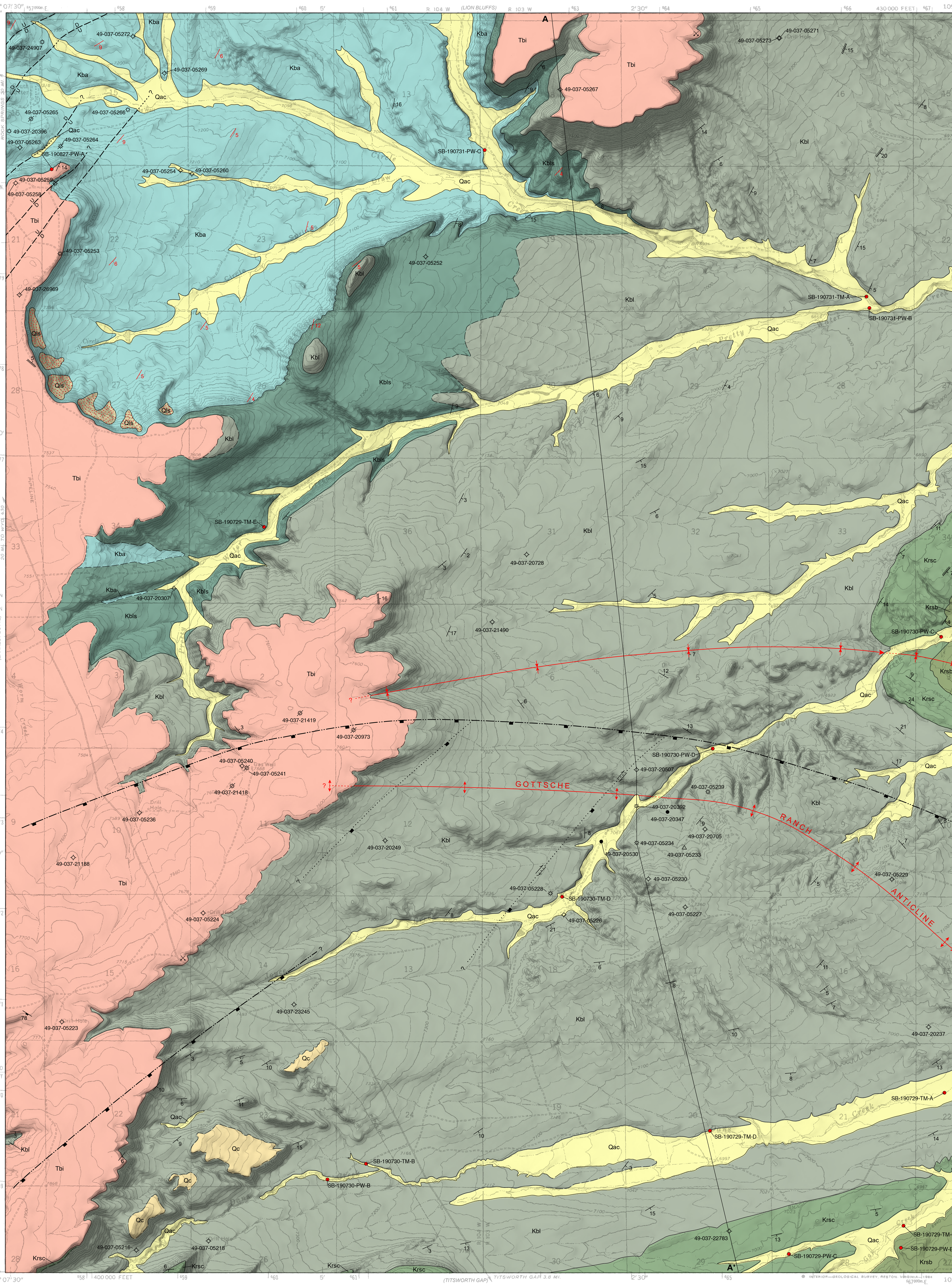
WYOMING STATE GEOLOGICAL SURVEY
Erin A. Campbell, Director and State Geologist
Laramie, Wyoming

Interpreting the past, providing for the future

OPEN FILE REPORT 2020-4
South Baxter 1:24,000-scale
Bedrock Geologic Map



Base map from U.S. Geological Survey 1:24,000-scale topographic map of the South Baxter, Wyoming Quadrangle, 1968, photoinspected 1976

Base hillshade derived from United States Elevation Data (NED), 10-meter Digital Elevation Model (DEM), 2000; azimuth 315º, sun angle 45º, vertical exaggeration 2.7

Projection: Universal Transverse Mercator (UTM), zone 12
North American Datum of 1927 (NAD 27)
1,000-meter grid ticks: UTM, zone 12
10,000-foot grid ticks: Wyoming State Plane Coordinate System, west central 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

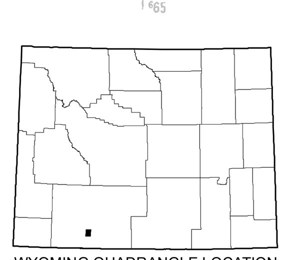
MN
GN
1°17'
10°10'

UTM grid and 2020 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 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



WYOMING QUADRANGLE LOCATION

Digital cartography by Patricia M. Webber and Thomas I. Martin

Map edited by Suzanne C. Luhr

Prepared in cooperation with and research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G19AC00142. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

EXPLANATION

CORRELATION OF MAP UNITS
(* indicates a formation shown only in cross section)

Qac, Qc, Qls	Holocene, Pleistocene	QUATERNARY	CENOZOIC
Unconformity			
Tbi	Oligocene	PALEOGENE	CENOZOIC
Unconformity			
Mesaverde Group: Krsb, Krsc, Kbl, Kbls; Kba	Upper Cretaceous	CRETACEOUS	MESOZOIC
Ku*	Lower Cretaceous	CRETACEOUS	MESOZOIC
Ju*	Jurassic	JURASSIC	MESOZOIC
Ꞧu*	Triassic	TRIASSIC	MESOZOIC

MAP SYMBOLS

Definitions: *Certain—Estimated location <25 m (82 ft)*
Approximate—Estimated location 25–100 m (82–330 ft)

Formation contact—Continuous where certain, long dash where approximate

Fault—Continuous where certain, long dash where approximate, dotted where concealed, queried where uncertain; rectangles on upper (tectonically higher) plate of reverse fault, arrows indicate relative motion of oblique fault, upthrown (U) and downthrown (D) blocks designated when fault type is unknown

Blind fault—Concealed; rectangles on upper (tectonically higher) plate of reverse fault; mapped by Besse (1999) from seismic data

Reverse fault with oblique slip (in cross section)—Arrows indicate relative motion; circle with minus, away from observer; circle with plus, toward observer

Anticline—Continuous where certain, dotted where concealed, queried where uncertain; arrow on end indicates direction of plunge

Syncline—Continuous where certain, dotted where concealed, queried where uncertain; arrow on end indicates direction of plunge

A A' **Line of cross section**

17 **Strike and dip of inclined bedding**

5 **Strike and dip of inclined bedding**—derived from Sears (1926)

7 **Strike and dip of inclined bedding in cross-bedded rocks**

78 **Strike and dip of joint**

Gravel pit

49-037-20347 **Oil well**—Showing API number

49-037-05228 **Gas well**—Showing API number

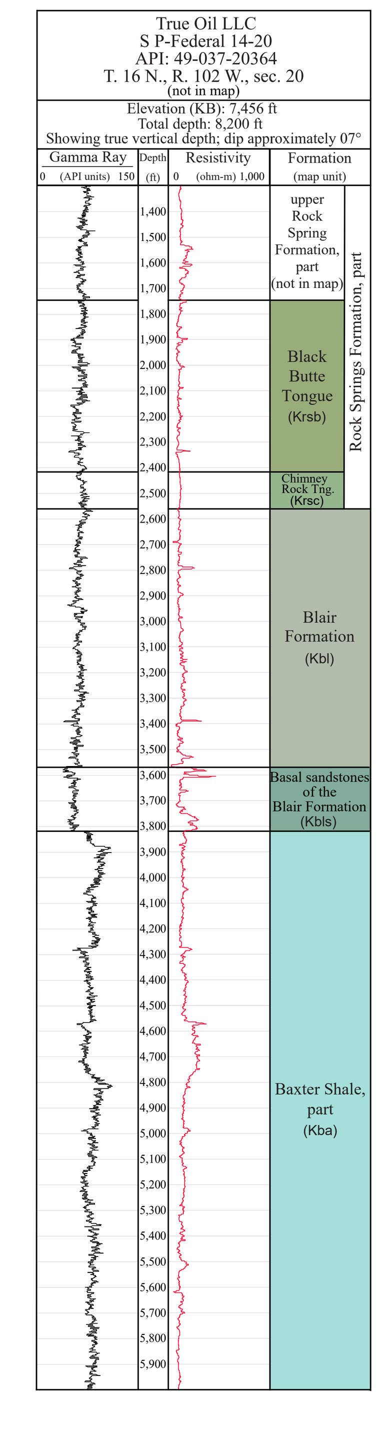
49-037-05241 **Gas well, plugged and abandoned**—Showing API number

49-037-05229 **Dry hole, plugged and abandoned**—Showing API number

49-037-05233 **Disposal well**—Showing API number

3-Krsb-SB **Sample**—Showing sample number; see report for analytical results

TYPE LOG



DESCRIPTION OF MAP UNITS
(* indicates a formation shown only in cross section)

Cenozoic

Qac **Alluvium and colluvium (Holocene and Pleistocene)**—Unconsolidated to poorly consolidated, subangular to subrounded clay, silt, sand, gravel, cobbles, and boulders mixed with clay-rich soil; derived from local geologic units. Comprises alluvium, slope wash, debris flows, and alluvial fan deposits. Thickness locally undetermined but typically less than 12 m (39 ft)

Qc **Colluvium (Holocene and Pleistocene)**—Unconsolidated silt, sand, gravel, cobbles, and boulders; derived from local geologic units. Combination of slope wash, debris flows, and alluvial fan deposits. In the southwestern corner of the quadrangle material predominantly derived from Bishop Conglomerate. Thickness less than 6 m (20 ft)

Qls **Landslide debris (Holocene and Pleistocene)**—Blocks and slumps of locally derived detritus from steep and unstable slopes. Thickness undetermined

Tbi **Bishop Conglomerate (Oligocene)**—Poorly consolidated to well-cemented, matrix- to clast-supported, subrounded to subangular, poorly to moderately sorted, pebble to boulder conglomerate. Conglomerate in northern map area consists of green, gray, brown, and black quartzites, green-gray andesite, and various dark volcanics. Conglomerate in southern map area consists of red-brown quartzites and sandstones of the Uinta Mountain Group, gray limestone, tan to brown Paleozoic sediments, white quartzite, chert, and minor metamorphic and igneous rocks. Fine- to coarse-grained, quartz-rich matrix with locally calcareous cement. Imbrication, tabular and trough cross-bedding, and channel scours common. Interbedded with lenses of medium- to coarse-grained, moderately sorted, subangular to subrounded, cross-bedded sandstone. Unconformably overlies all older units. Approximately 31 m (100 ft) thick

Mesozoic

Rock Springs Formation (Upper Cretaceous)

Krsb **Black Butte Tongue**—Poorly exposed, drab to gray, soft, sandy shale interbedded with thin intercalated lenses of siltstone and gray, very fine to fine-grained, subangular to subrounded, well sorted, calcareous, slope-forming sandstone composed of quartz, feldspar, chert, and iron oxides. Ripples, flaser and wavy bedding, parting lineations, and *Thalassinoides* ichnofossils common. Lower 135 m (440 ft) exposed in map area; total unit thickness approximately 213–221 m (700–720 ft)

Krsc **Chimney Rock Tongue**—Red-brown to light-gray, friable, very fine to fine-grained, moderately sorted, subangular to subrounded, lightly calcareous sandstone composed of quartz, iron oxides, chert, glauconite, and various mafic minerals; interbedded with gray siltstone and shale. Bioturbation, soft sediment deformation, horizontal lamination, and parting lineations common. Occasional *Scaphites hippocrepis* fossils (Roehler, 1990). Thickness approximately 46 m (150 ft)

Blair Formation (Upper Cretaceous)

Kbl **Blair Formation (main body)**—Gray to brown siltstones and shales interbedded with tan, reddish-tan, brown, and gray, fine- to medium-grained, well sorted, subangular to subrounded, quartz- and iron oxide-rich, thinly bedded, locally calcite-cemented sandstones. Dark gray, calcareous, fossiliferous siltstone with orange weathering surface common in upper part. Oscillation and current ripples, flaser and wavy bedding, low-angle trough cross-bedding common throughout, with *Baculites* sp. and *Inoceramus* sp. fossils and *Thalassinoides*, *Nereites*, and *Aulichnites* ichnofossils. Thickness approximately 475 m (1,560 ft)

Kbls **Basal sandstones**—Lowermost member of the Mesaverde Group in this quadrangle. Yellow-brown to gray, very fine to medium-grained, moderately sorted, subangular to subrounded, quartz- and iron oxide-rich, gypsiferous, variably calcite-cemented, cliff-forming sandstone interbedded with gray silty to sandy shale. Flaser and wavy bedding, current and oscillation ripples, low-angle trough cross-bedding, and *Thalassinoides* ichnofossils common. Thickness approximately 56 m (180 ft)

Kba **Baxter Shale (Upper Cretaceous)**—Poorly exposed, drab and gray to black, fissile, calcareous, gypsiferous, silty to sandy shale with popcorn weathering texture; occasionally interbedded with yellow and brown banded, fine to medium-grained, moderately sorted, lightly calcareous, rippled sandstone and concretionary limestone. Occasional ichnofossils including *Thalassinoides* and *Aulichnites*. Only uppermost 442 m (1,450 ft) exposed within the map area; thickness in nearby type logs is 893–914 m (2,930–3,000 ft)

Ku* **Older Cretaceous units, undivided**—Only in cross section

Ju* **Jurassic units, undivided**—Only in cross section

Ꞧu* **Triassic units, undivided**—Only in cross section

REFERENCES

Besse, R.E., 1999, Structural interpretation for the southern extent of the Rock Springs Uplift: Arlington, The University of Texas at Arlington, M.S. thesis, 81 p., 6 pls.

Hallberg, L.L., and Case, J.C., 2009, Preliminary surficial geologic map of the Firehole Canyon 30' x 60' quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 09-2, scale 1:100,000.

Hansen, W.R., 1986, Geomorphology of the eastern Uinta Mountains in Utah, Colorado, and Wyoming: U.S. Geological Survey Professional Paper 1365, 78 p.

Kehoe, K.S., Hoppes, K.L., and Webber, P.M., 2020, Preliminary geologic map of the Lion Bluffs quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 2020-3, 15 p., scale 1:24,000.

Kirschbaum, M.A., 1986, Geologic map of the Kappes Canyon quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1607, scale 1:24,000.

Luft, S.J., 1985, Generalized geologic map showing distribution and basal configuration of the Browns Park Formation and Bishop Conglomerate in northwestern Colorado, northeastern Utah, and southern Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1821, scale 1:250,000.

Lynds, R.L., Webber, P.M., Kragh, N.A., Martin, T.I., Hoppes, K.L., and Taboga, K.G., 2020, Preliminary geologic map of the Earnest Butte quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 2020-2, 15 p., scale 1:24,000.

Rich, J.L., 1910, The physiography of the Bishop Conglomerate, southwestern Wyoming: The Journal of Geology, v. 18, no. 7, p. 601–632.

Roehler, H.W., 1973a, Geologic map of the Potter Mountain quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1082, scale 1:24,000.

Roehler, H.W., 1973b, Geologic map of the Titsworth Gap quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1083, scale 1:24,000.

Roehler, H.W., 1977, Geologic map of the Rock Springs Uplift and adjacent areas, Sweetwater County, Wyoming: U.S. Geological Survey Open File Report 77-242, scale 1:250,000.

Roehler, H.W., 1978, Geologic map of the Mud Springs Ranch quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1438, scale 1:24,000.

Roehler, H.W., 1990, Stratigraphy of the Mesaverde Group in the central and eastern Greater Green River Basin, Wyoming, Colorado, and Utah: U.S. Geological Survey Professional Paper 1508, 57 p.

Schultz, A.R., 1920, Oil possibilities in and around Baxter Basin, in the Rock Springs Uplift, Sweetwater County, Wyoming: U.S. Geological Survey Bulletin 702, 107 p., 17 pls.

Sears, J.D., 1926, Geology of the Baxter Basin gas field, Sweetwater County, Wyoming, *in* Contributions to economic geology (short papers and preliminary reports), 1925; Part 2, Mineral fuels: U.S. Geological Survey Bulletin 781-B, p. 13–29, 2 pls.

WOGCC, 2019, Wyoming Oil and Gas Conservation Commission, accessed November 2019, at http://wogcc.state.wy.us/.

WSEO, 2019, Wyoming State Engineer's Office, accessed May 2019, at https://sites.google.com/a/wyo.gov/seo/.

NOTICE TO USERS OF INFORMATION FROM THE WYOMING STATE GEOLOGICAL SURVEY

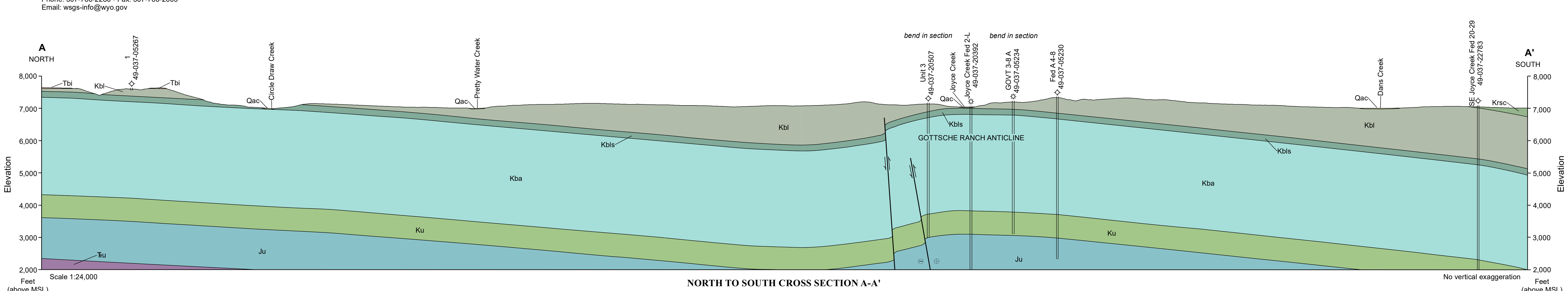
The WSGS encourages the fair use of its material. We request that credit be expressly given to the "Wyoming State Geological Survey" when citing information from this publication. Please contact the WSGS at 307-766-2286, or by email at wsgs-info@wyo.gov if you have questions about citing materials, preparing acknowledgments, or extensive use of this material. We appreciate your cooperation.

Individuals with disabilities who require an alternative form of this publication should contact the WSGS. For the TTY relay operator, call 800-877-9975.

For more information about the WSGS or to order publications and maps, go to www.wsgs.wyo.gov, call 307-766-2286, or email wsgs-info@wyo.gov.

NOTICE FOR OPEN FILE REPORTS PUBLISHED BY THE WSGS

Open File Reports are preliminary and usually require additional fieldwork and/or compilation and analysis; they are meant to be a first release of information for public comment and review. The WSGS welcomes any comments, suggestions, and contributions from users of the information.



NORTH TO SOUTH CROSS SECTION A-A'

PRELIMINARY GEOLOGIC MAP OF THE SOUTH BAXTER QUADRANGLE, SWEETWATER COUNTY, WYOMING

by

Patricia M. Webber, Thomas I. Martin, Jesse R. Pisel, and Kara L. Hoppes

2020

Interpreting the past, providing for the future

Preliminary Geologic Map of the South Baxter Quadrangle, Sweetwater County, Wyoming

Patricia M. Webber, Thomas I. Martin, Jesse R. Pisel, and Kara L. Hoppes

Open File Report 2020-4
May 2020

Wyoming State Geological Survey

Erin A. Campbell, Director and State Geologist

Preliminary Geologic Map of the South Baxter Quadrangle, Sweetwater County, Wyoming

Patricia M. Webber, Thomas I. Martin, Jesse R. Pisel, and Kara L. Hoppes

Layout by Christina D. George

Open File Report 2020-4
Wyoming State Geological Survey
Laramie, Wyoming: 2020

This Wyoming State Geological Survey (WSGS) Open File Report is preliminary and may require additional compilation and analysis. Additional data and review may be provided in subsequent years. For more information about the WSGS, or to download a copy of this Open File Report, visit www.wsgs.wyo.gov. The WSGS welcomes any comments and suggestions on this research. Please contact the WSGS at 307-766-2286, or email wsgs-info@wyo.gov.

Citation: Webber, P.M., Martin, T.I., Pisel, J.R., and Hoppes, K.L., 2020, Preliminary geologic map of the South Baxter quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 2020-4, 11 p., scale 1:24,000.

Table of Contents

List of Figures

List of Tables

INTRODUCTION

The South Baxter 7.5-minute quadrangle is located in southwestern Wyoming (fig. 1), along the southeastern flank of the Rock Springs Uplift. The axis of the Rock Springs Uplift extends along the western boundary of the map area, exposing southeast-dipping Upper Cretaceous rocks at its core that are unconformably capped by subhorizontal Paleogene strata.

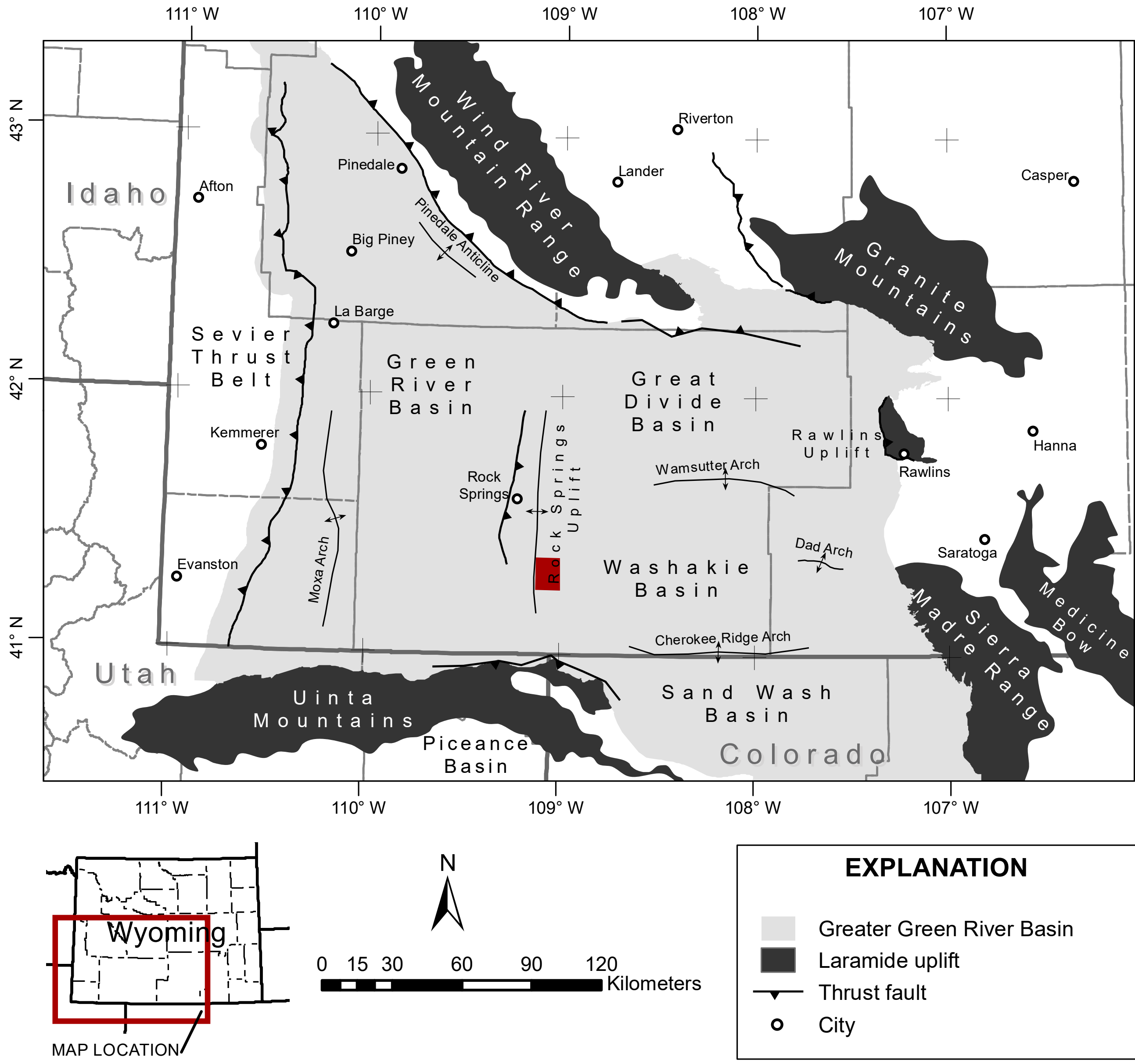


Figure 1. Map showing location of study area in Greater Green River Basin. Extent of the South Baxter quadrangle is shown as solid red rectangle, positioned along the southern end of the Rock Springs Uplift. Major structural features, basins, and uplifts are named; counties are outlined in gray.

While the South Baxter quadrangle has not previously been mapped at the 1:24,000 scale, extensive regional mapping at various scales has covered portions of the map area. Schultz (1920) produced a general 1:250,000-scale map that served as a basis for Sears's (1926) 1:62,500-scale map of the Baxter Basin gas field and Roehler's (1977) 1:125,000-scale map of the Rock Springs Uplift. Numerous structural maps of the Baxter Basin and Joyce Creek gas fields have been produced as well, including those by Fidlar (1950) and Reese (1968). Adjacent 1:24,000-scale bedrock maps include Titsworth Gap (Roehler, 1973) to the south, Mud Springs (Roehler, 1978) to the east, and Camel Rock (Roehler, 1979) to the northeast.

Field mapping and sample collection occurred from June to October 2019. Whole rock and sediment samples were gathered for geochemical analysis, while detrital zircon and fossil samples were collected to constrain geochronology.

Interpretation of field data, satellite imagery, and previous mapping aided in the final creation of the map and report. This project was completed in cooperation with the U.S. Geological Survey StateMap grant award G19AC00142.

Location

The Rock Springs Uplift spans 96 km (60 mi) north to south and 64 km (40 mi) east to west within the central portion of the Greater Green River Basin of southwestern Wyoming (fig. 1). This structural high separates the Green River Basin to the west from the Great Divide Basin and the Washakie Basin to the northeast and southeast, respectively. The South Baxter 1:24,000-scale quadrangle (Tps. 15–16 N. and Rgs. 103–104 W.) is in south-central Sweetwater County, Wyoming, on the southeastern flank of the Rock Springs Uplift.

The northern border of the quadrangle is approximately 23 km (14.3 mi) south of Rock Springs, Wyoming. The field area is best accessed from County Road 27 (Aspen Mountain Road). County roads 32 (Mud Springs Road), 73 (Brooks Ranch Road), and 30 (South Baxter Road) also allow access to the quadrangle, along with numerous two-track roads.

GEOLOGY

Upper Cretaceous sedimentary rocks dominate the outcrops of the South Baxter quadrangle and dip shallowly to the southeast off the southern flank of the Rock Springs Uplift. In the western side of the map area, Oligocene Bishop Conglomerate unconformably overlies the Upper Cretaceous units. During the Late Cretaceous, the majority of Wyoming was covered by the Western Interior Seaway (WIS), an epicontinental sea that longitudinally spanned across the center of North America (Steidtmann, 1993). Resulting sediment deposition during the Coniacian to early Campanian (Upper Cretaceous) formed the Baxter Shale, a deep marine sequence primarily composed of shale with minor sandstones in the upper extent of the formation (fig. 2). The sand content gradually increases toward the top of the unit and grades into the coarser sediments of the overlying Mesaverde Group (fig. 3), which represents a period of shoreline regression (Rudolph and others, 2015). The minimum depositional age is constrained to be lower Campanian by the index fossil *Scaphites hippocrepis* found in the upper part of the Baxter Shale (Cobban and others, 1994).

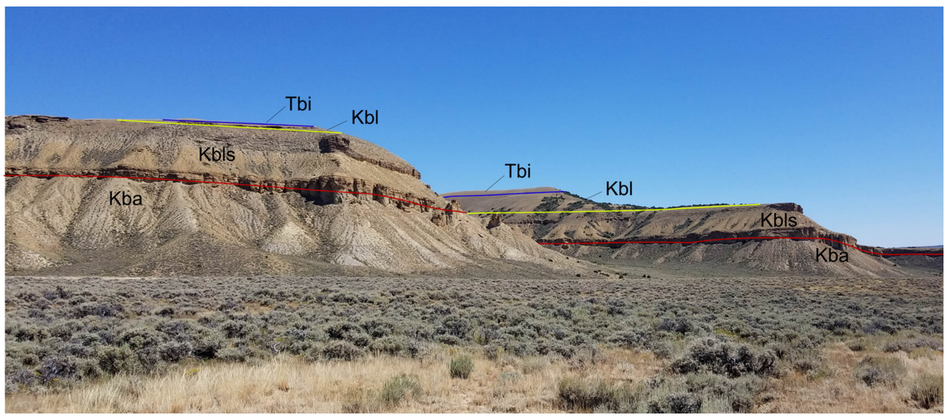


Figure 2. (Left) Photograph of outcrop of gray silty shale of the upper part of the Baxter Shale (Kba) exposed in badger hole in Circle Basin. Hammer in photograph is 35 cm (13.5 in) long.

Figure 3. (Above) Photograph showing contacts between overlying Bishop Conglomerate (Tbi), Blair Formation (Kbl), basal sandstones of the Blair Formation (Kbls), and the Baxter Shale (Kba). Baxter Shale often well exposed below upper contact with the basal sandstone of the Blair Formation, which is typically cliff-forming.

Between the early Campanian and the early Maastrichtian, sea level fluctuations and the initiation of the Laramide orogeny resulted in the deposition of the Mesaverde Group and the formation of the Rock Springs Uplift (Roehler, 1990). Only the oldest two formations of the Mesaverde Group are present in the map area: the Blair Formation and the Rock Springs Formation. The Blair Formation is primarily composed of interbedded ripple-bedded sandstones and shales, with a thick package of cliff-forming basal sandstones (figs. 3 and 4). The basal sandstones formed in a fluvial-deltaic environment, and are topped by a thick shale-dominated sequence deposited during a minor transgression of the WIS (Hale, 1950; Rudolph and others, 2015). The shales, thin siltstones, and sandstones that comprise the Blair Formation's upper extent were likely deposited in distal delta-front and prodelta environments by low-density sediment gravity flows during a regressive period of the WIS. The prevalence of sandstone beds and coarser sediment increases toward the top of the formation, which intertongues with the base of the overlying Rock Springs Formation. Within the Blair Formation, the ubiquitous presence of the index fossil *Scaphites hippocrepis* restricts the formation's depositional age to lower Campanian (Smith, 1961).

Figure 4. Photograph of outcrop of the basal sandstones of the Blair Formation (Kbls) showing ripple-bedded sandstone interbedded with thin horizons of shale. Geologist for scale is 1.75 m (69 in) tall.

Only the Chimney Rock Tongue and the lower part of the Black Butte Tongue of the Rock Springs Formation are present within the South Baxter quadrangle. The Chimney Rock Tongue (fig. 5) is largely composed of sandstone interbedded with thin shales that accumulated in nearshore environments ranging from lagoon to shallow marine (Keith, 1965). Shoreline regression occurred due to subsequent basin subsidence, resulting in a sharp transition to the shale-rich Black Butte Tongue (fig. 6; Hale, 1955). WIS ammonite zone correlation constrains the Rock Springs Formation to early Campanian (Gill and others, 1970). U-Pb detrital zircon geochronology of a Black Butte Tongue sample (SB-190729-PW-B1) collected in the map area yields a maximum depositional age of 82.4 ± 9.9 Ma (weighted mean age at 95 percent confidence; Appendix 3).

Growth of the Rock Springs Uplift continued into the late Eocene and early Oligocene, during which a period of crustal stability fostered the development of the Gilbert Peak erosional surface (fig. 6). Alluvium and colluvium primarily derived from the Uinta Mountains accumulated on this pediment and eventually lithified to form the Bishop Conglomerate (Bradley, 1936; Hansen, 1986). In the western part of the South Baxter quadrangle, Bishop Conglomerate caps plateaus of Upper Cretaceous rocks (figs. 6 and 7). U-Pb detrital zircon studies of multiple facies within the greater Firehole Canyon area yielded maximum depositional ages ranging from 35.5 ± 0.6 Ma to 31.2 ± 0.6 Ma (Aslan and others, 2017). Near Diamond Mountain Plateau, Utah, K-Ar analysis of biotite within Bishop Conglomerate tuff beds yielded ages of 29.50 ± 1.08 Ma to 26.2 ± 0.7 Ma (Winkler, 1970; Hansen, 1986).

Figure 5. Photograph of an outcrop of the Blair Formation (Kbl), overlain by the Chimney Rock Tongue of the Rock Springs Formation (Krsc) in the southern part of the map area. The upper portions of the Blair Formation are dominated by recessive shale with thin sandstone layers, while the thin but more resistant sands of the Chimney Rock Tongue tend to cap ridges and form low hills.

A conglomeratic sample (LB-190802KK-C) with similar lithology and appearance to the Bishop Conglomerate was gathered in the adjacent Lion Bluffs quadrangle for U-Pb detrital zircon geochronology. The youngest cluster of grains yields a maximum depositional age of 43.5 ± 1.2 Ma (weighted mean age at 95 percent confidence; Kehoe and others, 2020).

Figure 6. Photograph of an outcrop of a sandier layer (foreground) in the Black Butte Tongue of the Rock Springs Formation (Krsb) dipping to the south and unconformably overlain by the relatively flat-lying Bishop Conglomerate (Tbi). The mesa in the background is a typical example of the Gilbert Peak erosion surface that dominates the topography in the southern Rock Springs Uplift. The basal contact of the Bishop conglomerate, which caps the mesa, is marked by a line of vegetation.

Figure 7. Photograph of an outcrop of Bishop Conglomerate (Tbi) showing poorly sorted clasts, ranging from 1 cm (0.4 in) to 30 cm (12 in), with trough cross-bedding in finer-grained, matrix-dominated layers. Hammer in photograph is 40.6 cm (16 in) long.

However, the youngest single grain in the sample is 25.9 ± 2.3 Ma, younger than other regional Bishop samples (Aslan and others, 2017). Further, the positioning of the outcrop, which is 182 m (600 ft) below the typical Bishop conglomerate samples and on the valley floor, suggests that this may be a sample of the Miocene Browns Park Formation instead. See Kehoe and others (2020) for further discussion.

Bedrock units of the South Baxter quadrangle have since been eroded, reworked, and deposited as alluvium, colluvium, and landslide debris.

Structure

The South Baxter quadrangle is positioned along the southern end of the Rock Springs Uplift, which is a basement-cored, low-amplitude, asymmetric, doubly plunging, generally north–south-trending anticline. The crest of the anticline does not intersect the map area, but crosses sec. 29, T. 16 N., R. 104 W. through sec. 16, T. 15 N., R. 104 W in the adjacent Earnest Butte quadrangle to the west (Lynds and others, 2020). As a result, the rocks within the quadrangle generally dip toward the southeast.

Offset within the southern Rock Springs Uplift is primarily controlled by several extensive, north–northeast-trending, west-vergent reverse faults with significant right-lateral oblique motion (Besse, 1999). The uplift's major axis lies within the hanging wall of the easternmost of these faults, which is the primary structure exposed within the adjacent Earnest Butte (Lynds and others, 2020) and Lion Bluffs quadrangles (Kehoe and others, 2020). This easternmost fault, which has been verified at depth from seismic data and geophysical well log correlation, has more than 1,200 m (4,000 ft) of vertical displacement within the Paleozoic section (Besse, 1999). Numerous smaller faults break the surface in the northwestern part of the South Baxter map area, and are generally conjugate to the major regional subsurface faults and vary in lateral extent as well as amount and orientation of displacement.

Regional seismic lines and geophysical well log correlation show a series of subsurface, east–west-trending, north-vergent, high-angle reverse faults on the southeastern flank of the uplift (Besse, 1999). The northernmost of these crosses the center of the South Baxter quadrangle and is associated with the low-amplitude, east-plunging Gottsche Ranch Anticline-Syncline pair (Roehler, 1978; Besse, 1999). Several other northeast-trending, west–northwest-vergent subsurface reverse faults occur south of this fault; the northernmost of these faults appears to terminate at the main east–west-trending fault. However, as a result of limited subsurface data, the continuity and extent of these is not known.

ECONOMICS

Oil and Gas

Several oil and gas fields overlap the South Baxter quadrangle, including the Circle Basin portion of the South Baxter Basin field, and the Joyce Creek, Salt Wells, and Little Worm Creek fields. Since 1915, forty-nine wells have been drilled on the quadrangle (table 1). Nine of these wells have produced oil, and 17 have produced natural gas. Currently, 2 wells are producing oil and 8 are producing natural gas. From 1978 through 2019, 54,022 barrels of oil, 10.73 billion cubic feet of natural gas, and 343,412 barrels of water were produced from wells within the quadrangle. Target formations include the Permian-age Phosphoria Formation and the Cretaceous-age Dakota and Frontier formations (WOGCC, 2020).

The location of most well sites were confirmed through either aerial imagery or physical location in the field. Field-confirmed well locations were recorded with handheld GPS. The confirmed positions were subsequently compared to well site locations reported by the Wyoming Oil and Gas Conservation Commission (2020) and corrected on the final map when necessary.

Table 1. Records and field-verified locations and status for wells within the South Baxter quadrangle (WOGCC, 2020).

API Number	Well name	Company	Latitude (NAD27)	Longitude (NAD27)	Year	Status	Total depth (ft)	Gas produced (Mcf)	Oil produced (Bbl)	Water produced (Bbl)	Producing or target formation(s)
49-037-05216	GOVT 1	Benedum Interests	41.25222	-109.10775	1964	DH	5,002	-	-	-	DAKOTA
49-037-05218	GOVT 2-26	Caulkins Oil CO	41.25314	-109.09828	1957	DH	5,074	-	-	-	MORRISON
49-037-05223	GOVT 1	Kramer Huff Drlg CO	41.27487	-109.11756	1961	DH	5,216	-	-	-	UNKNOWN
49-037-05224	GOVT 1-14	Caulkins Oil CO	41.28568	-109.09898	1959	DH	4,946	-	-	-	UNKNOWN
49-037-05226	JOYCE CREEK 31-18A	US Natural Gas CO	41.28552	-109.05156	1963	DH	4,011	-	-	-	DAKOTA
49-037-05227	RJ COOK 1	Skelly Oil Company	41.28626	-109.03560	1960	DH	4,698	-	-	-	MORRISON
49-037-05228	UNIT FEDERAL 24-7A	Crown O&G CO INC	41.28762	-109.05334	1962	PG	4,855	242,652	433	17	FRONTIER
49-037-05229	DAN'S CREEK 1	Davis Oil CO	41.28902	-109.00844	1963	DH	5,004	-	-	-	MORRISON
49-037-05230	FEDERAL 4-8A	Caulkins Oil CO	41.28906	-109.04045	1958	DH	5,055	-	-	-	DAKOTA
49-037-05233	UNIT 23-8A	Crown O&G CO INC	41.29745	-109.03268	1964	AI	4,075	-	-	-	DAKOTA
49-037-05234	UNIT 3-8A	Crown O&G CO INC	41.29264	-109.04198	1960	PG	4,100	726,075	425	17	FRONTIER
49-037-05236	CAPITOL COMPANY 1 1	Mountain Fuel Supply	41.29563	-109.10736	1951	DH	4,365	-	-	-	MORRISON
49-037-05239	UNIT 32-8A	Crown O&G CO INC	41.29769	-109.03263	1962	PG	4,440	365,001	406	-	FRONTIER
49-037-05240	*CAPITOL -GOV'T 1	Ibex Resources Operg	41.30028	-109.09389	1955	DH	7,230	-	-	-	UNKNOWN
49-037-05241	GREAT WESTERN 1-11	Ibex Resources Operg	41.30007	-109.09327	1962	PA	3,800	80,878	-	-	FRONTIER
49-037-05252	GOVT 1	Pray Max	41.35080	-109.06974	1959	DH	4,709	-	-	-	UNKNOWN
49-037-05253	A J POSTON 3	North Shore E & P	41.35108	-109.11787	1933	PG	2,732	874,060	-	362	FRONTIER
49-037-05254	E08341 A 1	Marathon Oil Company	41.35936	-109.10201	1924	DH	2,610	-	-	-	UNKNOWN
49-037-05258	UPRR PATENTED 1	Wexpro Company	41.35809	-109.12371	1922	DH	2,950	-	-	-	DAKOTA
49-037-05259	UNIT POSTON E-08341 2 AJ	Wexpro Company	41.35805	-109.11854	1928	PA	2,869	100,734	-	55	FRONTIER, DAKOTA
49-037-05260	SOUTH BAXTER 1	Petrol Oil & Gas INC	41.35900	-109.10051	1915	DH	100	-	-	-	UNKNOWN
49-037-05263	STATE LAND 2	Mountain Fuel Supply	41.36160	-109.12314	1930	DH	2,190	-	-	-	FRONTIER
49-037-05264	UNIT UPRR 2	Wexpro Company	41.36173	-109.11781	1930	PA	2,200	41	-	-	FRONTIER
49-037-05265	BAXTER BASIN SO UNIT 1	Mountain Fuel Supply	41.36445	-109.12169	1922	PA	2,693	7,700	-	-	DAKOTA
49-037-05266	ADAM COOPER PATENTED 1	North Shore E & P	41.36536	-109.10894	1936	PG	2,222	1,937,134	-	696	FRONTIER
49-037-05267	1	Montana Power Company	41.36738	-109.05203	1924	DH	30	-	-	-	UNKNOWN
49-037-05269	UPRR PATENTED 3	Wexpro Company	41.36898	-109.10415	1937	DH	2,322	-	-	-	FRONTIER
49-037-05271	BURNT CANYON UNIT 2	Pray Max	41.37248	-109.02313	1960	DH	1,403	-	-	-	BAXTER
49-037-05272	J H BROOKS PATENTED 1	Mountain Fuel Supply	41.37264	-109.10830	1935	DH	2,195	-	-	16	FRONTIER
49-037-05273	BURNT CANYON UNIT 2-X	Pray Max	41.37248	-109.02324	1960	DH	4,822	-	-	-	UNKNOWN
49-037-20237	OCONNELL-GOVT 1	Chandler & Assoc INC	41.27435	-109.00361	1970	DH	4,885	-	-	-	MORRISON
49-037-20249	FEDERAL-GRYNBERG 1	Grynberg Jack J	41.29287	-109.07509	1970	DH	4,687	-	-	-	UNKNOWN
49-037-20307	BROOKS 1	Occidental Petr	41.31787	-109.10285	1971	DH	4,285	-	-	-	UNKNOWN
49-037-20347	GOVT 1	Crown O&G CO INC	41.29572	-109.03792	1972	PO	8,290	54,102	33,842	306,732	DAKOTA
49-037-20392	JOYCE CREEK 2	Crown O&G CO INC	41.29628	-109.04200	1972	PG	6,720	1,174,510	475	75	FRONTIER, DAKOTA
49-037-20396	BAXTER BASIN UNIT 15	North Shore E & P	41.36322	-109.12457	1973	PG	7,130	2,002,383	-	257	DAKOTA
49-037-20507	JOYCE CREEK 3	Hilliard O&G INC	41.29990	-109.04201	1973	DH	4,150	-	-	-	DAKOTA
49-037-20530	JOYCE CREEK 4	Crown O&G CO INC	41.29280	-109.04664	1973	PO	4,725	43,451	6,497	29,746	DAKOTA
49-037-20705	*JOYCE CREEK 11-8	Devon Corporation	41.29401	-109.03301	1975	DH	7,012	-	-	-	UNKNOWN

Table 1 Continued

API Number	Well name	Company	Latitude (NAD27)	Longitude (NAD27)	Year	Status	Total depth (ft)	Gas produced (Mcf)	Oil produced (Bbl)	Water produced (Bbl)	Producing or target formation(s)
49-037-20728	NORTHWEST JOYCE CREK 1	Davis Oil CO	41.32125	-109.05646	1975	DH	4,977	-	-	-	UNKNOWN
49-037-20973	POLUMBUS 1-1	Ibex Resources Operg	41.30384	-109.07923	1977	PA	7,165	2,002,508	6,982	3,540	PHOSPHORIA
49-037-21188	CITIES-FEDERAL 1-10	Great Western Drl CO	41.29118	-109.11607	1978	DH	7,385	-	-	-	UNKNOWN
49-037-21418	PRETTY WATER CREEK 3-11	Ibex Resources Operg	41.29829	-109.09519	1979	PA	7,179	612,542	3,786	1,859	PHOSPHORIA
49-037-21419	FEDERAL 1-2	Ibex Resources Operg	41.30552	-109.08627	1981	PA	7,130	429,140	1,176	-	PHOSPHORIA
49-037-21490	FEDERAL 1-6	Great Western Drl CO	41.31455	-109.06098	1979	DH	4,993	-	-	-	DAKOTA
49-037-22783	SE JOYCE CREEK 20-29	Pacific Entpr Oil CO	41.25411	-109.02986	1990	DH	5,419	-	-	-	MORRISON
49-037-23245	NOZZLENOB 2-14	Anadarko E&P Onshore LLC	41.27659	-109.08706	1993	DH	4,542	-	-	-	DAKOTA
49-037-24907	SOUTH BAXTER UNIT 21	North Shore E & P	41.37207	-109.12022	2001	PG	2,552	73,531	-	40	FRONTIER
49-037-26969	SOUTH BAXTER 30	Wexpro Company	41.34699	-109.12320	2006	DH	3,437	-	-	-	DAKOTA

Uranium

There are no active or historic uranium mines or prospect pits on the South Baxter quadrangle. However, in the 1970s and 1980s, the Department of Energy's National Uranium Resource Evaluation (NURE) program collected 19 sediment samples from locations within the map area in an effort to identify uranium occurrences across the United States (U.S. Geological Survey, 2004). Thirteen of these sites were resampled in 2019. Results from the geochemical analysis of these samples are reported in Appendix 2.

Aggregate

Historically, aggregate was mined from the Bishop Conglomerate in two locations within the South Baxter quadrangle. The Joyce Creek sand and gravel pit, in the southwestern part of the map area along County Road 27, operated from 1986 to 2016. The second mine is unnamed and exists along the northern boundary of the quadrangle (fig. 8).

Figure 8. Photograph of small aggregate pit in Bishop Conglomerate (Tbi) near northern boundary of quadrangle. Hammer in photograph is 40.6 cm (16 in) long.

Although no active mines exist on the South Baxter quadrangle, development potential for aggregate resources is favorable. The Bishop Conglomerate often weathers into unconsolidated colluvium surfaces that are typically less than 0.6 m (2 ft) thick but laterally extensive, such as those found in the southwestern portion of the map (Sutherland and others, 2018).

REFERENCES

Aslan, Andres, Boraas-Connors, Marisa, Sprinkel, D.A., Becker, T.P., Lynds, Ranie, Karlstrom, K.E., Heizler, Matt, 2017, Cenozoic collapse of the eastern Uinta Mountains and drainage evolution of the Uinta Mountains region: Geosphere, v. 14, no. 1, p. 115–140.

Besse, R.E., 1999, Structural interpretation for the southern extent of the Rock Springs Uplift: Arlington, The University of Texas at Arlington, M.S. thesis, 81 p., 6 pl.

Bradley, W.H., 1936, Geomorphology of the north flank of the Uinta Mountains: U.S. Geological Survey Professional Paper 185-I, p. 163–199.

Cobban, W.A., Merewether, E.A., Fouch, T.D., and Obradovich, J.D., 1994, Some Cretaceous shorelines in the Western Interior of the United States, *in* Caputo, M.V., Peterson, J.A., and Franczyk, K.J., eds., Mesozoic systems of the Rocky Mountain Region, USA: Rocky Mountain Section, SEPM (Society for Sedimentary Geology), p. 393–414.

Dickinson, W.R., and Gehrels, G.E., 2009, Use of U-Pb ages of detrital zircons to infer maximum depositional ages of strata—A test against a Colorado Plateau Mesozoic database: Earth and Planetary Science Letters, v. 288, p. 115–125.

Fidlar, M.M., 1950, Baxter Basin gas fields Sweetwater County, Wyoming: Wyoming Geological Association, 5th Annual Field Conference, Guidebook, p. 109–110.

Gehrels, G.E., Valencia, V.A., and Pullen, Alex, 2006, Detrital zircon geochronology by laser-ablation multicollector ICPMS at the Arizona LaserChron Center: The Paleontological Society Papers, v. 12, p. 67–76.

Gehrels, G.E., Valencia, V.A., and Ruiz, Joaquin, 2008, Enhanced precision, accuracy, efficiency, and spatial resolution of U-Pb ages by laser ablation-multicollector-inductively coupled plasma-mass spectrometry: Geochemistry, Geophysics, Geosystems, v. 9, no. 3, 13 p.

Gill, J.R., Merewether, F.A., and Cobban, W.A., 1970, Stratigraphy and nomenclature of some Upper Cretaceous and lower Tertiary rocks in south-central Wyoming: U.S. Geological Survey Professional Paper 667, 53 p.

Hale, L.A., 1950, Stratigraphy of the Upper Cretaceous Montana Group in the Rock Springs Uplift, Sweetwater County, Wyoming: Wyoming Geological Association, 5th Annual Field Conference, Guidebook, p. 49–58.

Hale, L.A., 1955, Stratigraphy and facies relationship of the Montanan Group in south-central Wyoming, northeastern Utah, and northwestern Colorado: Wyoming Geological Association, 10th Annual Field Conference, Guidebook, p. 89–94.

Hansen, W.R., 1986, Neogene tectonics and geomorphology of the eastern Uinta Mountains in Utah, Colorado, and Wyoming: U.S. Geological Survey Professional Paper 1356, 78 p.

Kehoe, K.S., Hoppes, K.L., and Webber, P.M., 2020, Preliminary geologic map of the Lion Bluffs quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 2020-3, 15 p., scale 1:24,000.

Keith, R.E., 1965, Rock Springs and Blair formations on and adjacent to the Rock Springs Uplift, Sweetwater County, Wyoming: Wyoming Geological Association, 19th Annual Field Conference, Guidebook, p. 42–53, 2 pls.

Lynds, R.L., Webber, P.M., Kragh, N.A., Martin, T.I., Hoppes, K.L., and Taboga, K.G., 2020, Preliminary geologic map of the Earnest Butte quadrangle, Sweetwater County, Wyoming: Wyoming State Geological Survey Open File Report 2020-2, 15 p., scale 1:24,000.

Pecha, Mark, 2019, Lynds Jan 2019 Element 2 Final Report—Report to Ranie Lynds, WSGS: Arizona LaserChron Center, final report.

Reese, D.L., 1968, Gas fields of Rock Springs Uplift, Sweetwater County, Wyoming—Wyoming Geological Association, Memoir 9: Natural gases of North America, v.1, p. 803–816.

Roehler, H.W., 1973, Geologic map of the Titsworth Gap quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map 1083, scale 1:24,000.

Roehler, H.W., 1977, Geologic map of the Rock Springs Uplift and adjacent areas, Sweetwater County, Wyoming: U.S. Geological Survey Open File Report 77-242, scale 1:250,000.

Roehler, H.W., 1978, Geologic map of the Mud Springs Ranch quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map 1438, scale 1:24,000.

Roehler, H.W., 1979, Geology and mineral resources of the Mud Springs Ranch quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Professional Paper 1065-C, 35 p.

Roehler, H.W., 1990, Stratigraphy of the Mesaverde Group in the central and eastern Greater Green River Basin, Wyoming, Colorado, and Utah: U.S. Geological Survey Professional Paper 1508, 57 p.

Rudolph, K.W., Devlin, W.J., and Crabaugh, J.P., 2015, Upper Cretaceous sequence stratigraphy of the Rock Springs Uplift, Wyoming: The Mountain Geologist, v. 52, no. 3, p. 13–157.

Schultz, A.R., 1920, Oil possibilities in and around Baxter Basin, in the Rock Springs Uplift, Sweetwater County, Wyoming: U.S. Geological Survey Bulletin 702, 107 p.

Sears, J.D., 1926, Geology of the Baxter Basin gas field, Sweetwater County, Wyoming, *in* Contributions to economic geology (short papers and preliminary reports), 1925; Part 2, Mineral fuels: U.S. Geological Survey Bulletin 781-B, p. B13–B27, 2 pls.

Smith, J.H., 1961, A summary of stratigraphy and paleontology, upper Colorado and Montanan groups southcentral Wyoming, northeastern Utah, and northwestern Colorado: Wyoming Geological Association, 16th Annual Field Conference, Guidebook, p. 101–112.

Stacey, J.S., and Kramers, J.D., 1975, Approximation of terrestrial lead isotope evolution by a two-stage model: Earth and Planetary Science Letters, v. 26, p. 207–221.

Steidtmann, J.R., 1993, The Cretaceous foreland basin and its sedimentary record, *in* Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., eds., Geology of Wyoming: Geological Survey of Wyoming [Wyoming State Geological Survey] Memoir 5, p. 250–271.

Sutherland, W.M., Stafford, J.E., Carroll, C.J., Gregory, R.W., and Kehoe, K.S., 2018, Mines and minerals map of Wyoming: Wyoming State Geological Survey, accessed July 2019, at http://wsgs.maps.arcgis.com/apps/webappviewer/index.html?id=af948a51f4954a81adeae8935440cd28.

U.S. Geological Survey, 2004, National uranium resource evaluation (NURE) hydrogeochemical and stream sediment reconnaissance data: U.S. Geological Survey, Denver, Colorado.

Winkler, G.R., 1970, Sedimentology and geomorphic significance of the Bishop Conglomerate and Browns Park Formation, eastern Uinta Mountains, Utah, Colorado, and Wyoming: Salt Lake City, University of Utah, M.S. thesis, 115 p.

WOGCC, 2020, Wyoming Oil and Gas Conservation Commission, accessed March 2020, at http://wogcc.state.wy.us/.

Appendices

APPENDIX 1: GEOCHEMICAL ANALYSES—ROCK SAMPLES

ALS Chemex, in Reno, Nevada, analyzed one sample from the South Baxter quadrangle using complete elemental characterization package CCP-PCK01 for whole rock, trace elements, rare earths, and base metals. Analyses were conducted using inductively coupled plasma (ICP) atomic emission spectrometry, ICP mass spectrometry, and by infrared spectroscopy via induction furnace. The sample submitted for geochemical analysis was selected to collect baseline data of strata that has not undergone alteration observed elsewhere in the region. Data table A1 shows sample name, sampled formation, location, and the elemental results as reported by ALS Chemex. All sample locations are shown on the map.

APPENDIX 2: GEOCHEMICAL ANALYSES—STREAM-SEDIMENT SAMPLES

Stream-sediment samples were collected from the South Baxter quadrangle to test the reproducibility of geochemical results obtained from sediment samples collected in the late 1970s as part of the National Uranium Resource Evaluation (NURE) program (Smith, 1997). Sample locations were chosen to mimic those of the original NURE dataset. AGAT Laboratories, from Mississauga, Ontario, analyzed thirteen stream-sediment samples for 58 elements using sodium peroxide fusion followed by ICP-OES and ICP-MS finish (AGAT method code: 201 378; AGAT SOP: MIN-200-12001). Data table A2 shows sample name, location, and the elemental results as reported by AGAT Laboratories. All sample locations are shown on the map.

APPENDIX 3: DETRITAL ZIRCON GEOCHRONOLOGY

U-Pb Methodology

Detrital zircon geochronology analyses were carried out at the Arizona LaserChron Center at the University of Arizona, and the following text is modified from Pecha (2019). Zircon grains were extracted from bulk sample, including density separation using a Wilfley table and heavy liquids (methylene i). The resulting heavy mineral fraction then underwent separation using a Frantz LB-1 magnetic barrier separator to isolate the zircons. A representative split of the entire zircon yield of each sample was incorporated into a 1-inch epoxy mount along with multiple fragments of each of the three zircon standards (FC1, SL-mix, and R33). The mounts were sanded down approximately 20 microns, polished progressively using a 9-, 5-, 3-, and 1-micron polishing pads, and backscatter electron (BSE) imaged using a Hitachi S-3400N scanning electron microscope (SEM) equipped with a Gatan Chroma CL2 detector. Prior to isotopic analysis, the mounts were cleaned in an ultrasound bath of 1 percent HNO_3 and 1 percent HCl in order to remove any residual common Pb from the surface of the mount.

U-Pb geochronology of individual zircon crystals was conducted by laser ablation multicollector inductively coupled mass spectrometry (LA-ICPMS) at the Arizona LaserChron Center (Gehrels and others, 2006, 2008). The isotopic analyses involved ablation of zircon using a Photon Machines Analyte G2 excimer laser coupled to a Thermo Element 2 single-collector-ICPMS. Drill rate is approximately one micron per second, resulting in a final ablation pit depth of about 12 microns.

The errors in determining the $^{206}Pb/^{238}U$ and $^{206}Pb/^{204}Pb$ result in a final measurement error of approximately 1–2 percent (at 2σ level) in the $^{206}Pb/^{238}U$ age for each analysis. The errors in determining $^{206}Pb/^{207}Pb$ and $^{206}Pb/^{204}Pb$ also result in approximately 1–2 percent (at 2σ level) uncertainty in age for grains that are older than 900 Ma, however, they are substantially larger for younger grains due to the low intensity of the ^{207}Pb signal.

The common Pb correction is accomplished by using the Hg-corrected ^{204}Pb and assuming an initial Pb composition from Stacey and Kramers (1975). Uncertainties of 1.5 for $^{206}Pb/^{204}Pb$ and 0.3 for $^{207}Pb/^{204}Pb$ are applied to these compositional values based on the variation in Pb isotopic composition in modern crystalline rocks. Interference of ^{204}Hg with ^{204}Pb is accounted for measurement of ^{202}Hg during laser ablation and subtraction of ^{204}Hg, according to the natural $^{202}Hg/^{204}Hg$ of 4.35.

U-Pb Results

One sample was collected for detrital zircon geochronology from the Black Butte Tongue of the Rock Springs Formation. The location of the sample is shown on the map, and the sample location is summarized in data table A3.

The maximum depositional age was calculated by multiple methods following Dickinson and Gehrels (2009), with results summarized in data table A3. Youngest single grain (YSG) is the absolute youngest age measured in a sample. The probability density peak (PDP) age was calculated from the crest of the youngest discrete age peak on a probability density plot. Final age (FA), or age incorporating both internal analytical error accounted for with the weighted mean age and external systematic error, was calculated using the DZ Age Pick Program (version of September 1, 2009) of the Arizona LaserChron Center (www.geo.arizona.edu/alc). The weighted mean age at 2σ was determined from the youngest cluster of three or more grain ages ($i \geq 3$) overlapping in age by weighting each measurement by the square of its uncertainty. This method assumes the grains are cogenetic and is valid if the mean square weighted deviation (MSWD) of the set of grains is near one.

Compiled single zircon age results for the sample are summarized and reported in data table A3. Uncertainties shown in these results are at the 1σ level and include only measurement errors. Complete digital analytical data are available from the Wyoming State Geological Survey (www.wsgs.wyo.gov/).