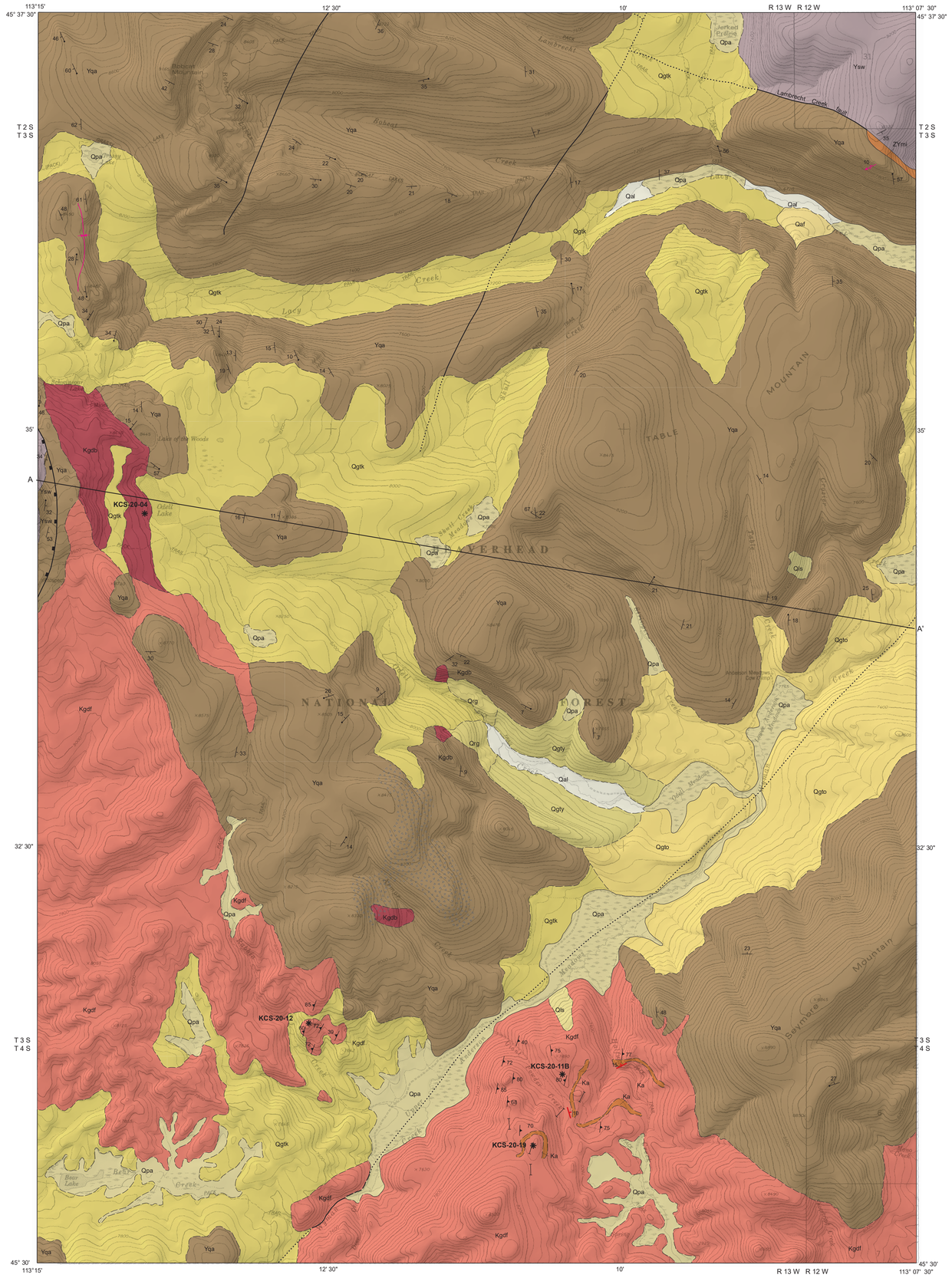
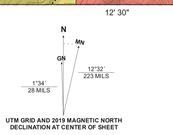
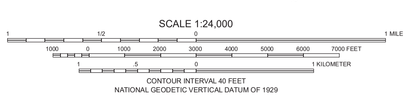


Odell Lake 1:24,000-scale quadrangle map
Base map produced by the United States Geological Survey
Topography compiled 1967. Planimetry derived from imagery taken 1995 and other sources. Public Land Survey System and survey control current as of 1999.
Projection: Lambert conformal conic
Grid:1000 meter Universal Transverse Mercator Zone 12
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

Shaded relief created from 10 meter digital elevation model from U.S. Geological Survey National Elevation Dataset.





Maps may be obtained from:
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Montana Bureau of Mines and Geology
1300 West Park Street
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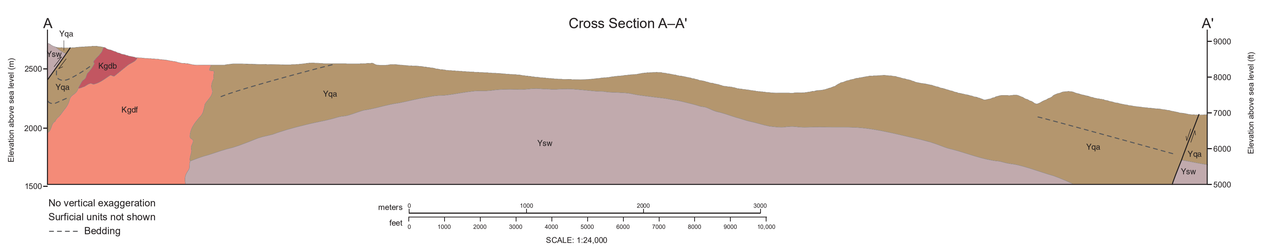
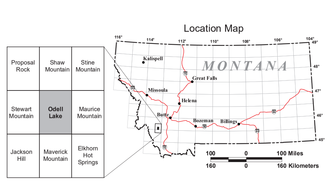
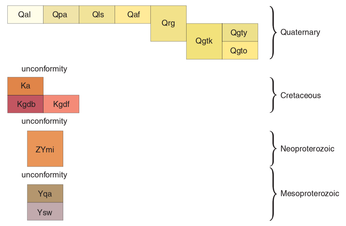
Phone: (406) 496-4174
http://mbmg.mtech.edu





Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award G20AC00270.
GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG. Editing: Susan Barth, MBMG.

CORRELATION DIAGRAM



MAP SYMBOLS

- Contact: dashed where approximately located
- Normal fault: dotted where concealed
- Reverse fault: identity and existence certain, location accurate. Rectangles on upthrown block
- Syncline: showing trace of axial plane
- 15 — Bedding, showing strike and dip
- 10 — Strike and dip of igneous dikes
- 10 — Upright bedding, where top direction of beds is known from sedimentary features, showing strike and dip
- 48 — Overturned bedding, where top direction of beds is known from sedimentary features, showing strike and dip
- 50 — Inclined cleavage, showing strike and dip
- Vertical cleavage, showing strike
- 68 — Inclined foliation, showing strike
- 10 — Small-scale fold axis
- KCS-20-11 — Sample point
- Breccia

INTRODUCTION

The Odell Lake 7.5' quadrangle map continues detailed geologic mapping in the Wisdom 30' x 60' quadrangle, a long-term Montana Bureau of Mines and Geology STATEMAP program goal to fill remaining gaps in the 1:100,000-scale geological coverage of Montana. The Odell Lake quadrangle is located in the West Pioneer Mountains, which contain Mesoproterozoic Belt Supergroup strata, Cretaceous high-grade migmatitic metamorphic rocks, and extensive Cretaceous through Tertiary plutons. This map area was chosen to further our understanding of regional Mesoproterozoic stratigraphic relationships and to provide insight into the tectonic regime that produced and emplaced the high-grade metamorphic rocks.

Previous Work

The entire quadrangle was mapped at the 1:50,000-scale by Berger and others (1983) and at the 1:250,000 scale by Ruppel and others (1993). Neither map included orientation data, structural data, or formation correlations with Mesoproterozoic Belt Supergroup strata.

Geologic Summary

Rocks in the Odell Lake quadrangle and throughout the entire West Pioneer Mountains are interpreted to lie within the hanging wall of the Grasshopper thrust system (Ruppel and others, 1993). Most of the Odell Lake quadrangle is underlain by gently folded, low-grade metasedimentary rocks of the Mesoproterozoic Belt Supergroup intruded by late Cretaceous granodiorite. Quaternary glacial deposits are extensive, covering much of the bedrock. Although Cretaceous high-grade metamorphic rocks occur in the north-adjacent Shaw Mountain quadrangle (Lonn, 2020), none are exposed in the Odell Lake quadrangle.

STRATIGRAPHY

The Mesoproterozoic strata of the Odell Lake quadrangle are correlated with rocks of the Lemhi subbasin, a southern arm of the Belt basin characterized by sandy strata (Burmester and others, 2016) that are equivalent to the Missoula Group of the central Belt Basin. Two Mesoproterozoic units are identified: coarse-grained quartzite of the Swauger Formation (Ysw), and a thinner bedded, finer-grained quartzite and argillite unit (Yqa). Along the western border of the quadrangle, in the hanging wall of a reverse fault, Ysw appears to grade up into a thin sliver of Yqa. In addition, the abundant spherical medium quartz grains common in Yqa are are unknown from formations below the Swauger Fm (Burmester and others, 2016). Therefore, Yqa is tentatively correlated with the Lawson Creek Fm of the Lemhi subbasin (Burmester and others, 2016). Confirmation of this stratigraphic relationship awaits future mapping.

The map area was extensively glaciated during the Quaternary, and glacial till and organic-rich paludal deposits cover large areas of bedrock.

IGNEOUS ROCKS

Generally undeformed Late Cretaceous granite to granodiorite in the southern and southwestern parts of the quadrangle are part of the large batholith that underlies much of the East and West Pioneer Mountains. Four samples of granodiorite collected during this study range in composition from 64.20 to 70.83 wt. percent SiO_2 (table 1). The granodiorite formed during widespread Mesozoic magmatism that affected much of southwestern Montana (e.g., Scarberry and others, 2020).Granitic rocks exposed in the southern part of the quadrangle are cut by aplite dikes and related small bodies of alaskite and pegmatite. Precious- and base-metal-bearing quartz veins and porphyry-type molybdenum deposits in the region formed during the latest phases of Cretaceous igneous activity (Berger and others, 1983).

STRUCTURE

Across most of the map, unit Yqa is deformed into broad, gentle folds with north to northwest axes. The east–west Lambrecht Creek fault in the northeastern part of the map is interpreted to be Proterozoic in age based on a minimum age of 660 Ma (Pearson and Zen, 1985) for a dike (ZYmi) that intrudes the fault zone. Near the western border, a north–south, east-directed reverse fault brings up steeply dipping, older Ysw and a thin section of overlying Yqa. It is interpreted as a reverse fault because strata are steeply dipping to overturned near its trace. The Mesoproterozoic strata are also cut by a few minor north–northeast faults continuous with those mapped in the north-adjacent Shaw Mountain quadrangle (Lonn, 2020). A prominent northeast lineament in the southeastern part of the map appears to be controlled by a fault with apparent left-lateral offset that extends, with apparent down-to-the northwest offset, into the east- adjacent Maurice Mountain 7.5' quadrangle (Lonn, 2015) and the south-adjacent Salmon 30' x 60' quadrangle (Lonn and others, 2019).

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene)**—Gravel, sand, silt, and clay in modern stream channels and floodplains. Modern stream and floodplain deposits. Thickness as much as 40 m (130 ft).

Qpa **Paludal deposit (Holocene)**—Sand, silt, and organic matter deposited in swamp, marsh, pond, or lake. The upper meter or more is usually comprised of organic-rich soil derived in place from decayed plants. Thickness less than 10 m (33 ft).

Qls **Landslide deposit (Holocene and Pleistocene)**—Unsorted mixture of silt, clay, sand, gravel and boulders. Typically characterized by hummocky topography. Thickness probably less than 30 m (100 ft).

Qaf **Alluvial fan deposit (Holocene and Pleistocene)**—Angular to subrounded, poorly sorted, cobble to boulder gravel fans. Thickness probably less than 20 m (66 ft).

Qrg **Rock glacier deposit (Holocene and Pleistocene)**—Angular rock debris and boulders with lobate forms. Active and inactive rock glaciers not distinguished. Thickness less than 18 m (60 ft).

Qgtk **Glacial till and kame deposits, undivided (Pleistocene)**—Primarily unsorted silty to clayey boulder till with subangular to subrounded clasts. Characterized by hummocky terrain scattered with large subangular to subrounded boulders. Includes Qgty and Qgto where they are not divided. Also includes minor outwash, fan, kame, and esker deposits. Thickness as much as 100 m (330 ft).

Qgty **Glacial till and kame deposits, younger (Pleistocene)**—Primarily unsorted silty to clayey boulder till with fresh subangular to subrounded clasts, characterized by hummocky terrain scattered with large subangular to subrounded boulders. Also includes minor outwash, fan, kame, and esker deposits. Thickness as much as 100 m (330 ft).

Qgto **Glacial till and kame deposits, older (Pleistocene)**—Primarily unsorted silty to clayey boulder till with more weathered subangular to subrounded clasts than Qgty. Hummocky topography is less obvious than Qgty. Also includes minor outwash, fan, kame, and esker deposits. Thickness as much as 100 m (330 ft).

Ka **Aplite Dikes (Late Cretaceous)**—Tan, fine-grained, equigranular silicic dikes and associated smaller masses of alaskite and pegmatite. The pegmatite consists mainly of potassium feldspar and smoky quartz crystals that average >5 cm in length, and sparse fine magnetite. These rocks cut granodiorite (Kgdf) and form recessive ledges within massive, blocky, rock towers in Halfway Creek and Giant Powder Creek in the southern part of the map.

Table 1. Bulk Rock geochemical data.

Sample I.D.	KCS-20-04	KCS-20-12	KCS-20-11B	KCS-20-19
Map Unit	Kgdb	Kgdf	Kgdf	Kgdf
Lattitude	45.57517	45.52389	45.51868	45.51186
Longitude	-113.23518	-113.21184	-113.17578	-113.17987
Major elements (wt. % oxide)				
SiO_2	70.83	64.98	64.20	68.68
TiO_2	0.29	0.55	0.45	0.31
Al_2O_3	15.46	16.53	17.08	16.25
FeO*	1.75	4.51	4.29	2.42
MnO	0.03	0.10	0.11	0.06
MgO	0.52	1.80	1.65	0.75
CaO	2.36	4.66	4.69	3.25
Na_2O	4.21	3.37	3.57	3.86
K_2O	3.35	2.77	3.00	3.52
P_2O_5	0.10	0.18	0.16	0.12
Total	98.89	99.44	99.21	99.24
LOI	0.62	0.45	0.48	0.50
Trace elements (ppm)(XRF)				
Ni	4	5	4	4
Cr	4	8	7	4
V	21	79	69	32
Ga	19	18	18	18
Cu	35	4	3	1
Zn	41	64	68	55
Trace elements (ppm)(ICP-MS)				
La	37.3	28.4	28.7	35.8
Ce	68.1	55.2	53.0	61.1
Pr	7.3	6.7	6.1	6.7
Nd	25.6	29.5	22.8	23.1
Sm	4.0	4.8	4.3	3.7
Eu	0.9	1.3	1.2	0.1
Gd	2.7	4.1	3.6	2.7
Tb	0.4	0.7	0.6	0.4
Dy	1.9	3.6	3.1	2.1
Ho	0.4	0.7	0.6	0.4
Er	0.9	2.0	1.8	1.1
Tm	0.1	0.3	0.3	0.2
Yb	0.9	2.0	1.8	1.2
Lu	0.2	0.3	0.3	0.2
Ba	1,386	1,022	1,093	1,168
Th	10.5	7.1	7.9	9.3
Nb	11.4	11.7	10.7	11.8
Y	10.6	20.8	18.3	12.3
Hf	4.8	5.2	4.7	4.5
Ta	0.7	0.9	0.8	0.8
U	1.9	1.8	1.8	2.0
Pb	19.1	17.3	20.1	24.0
Rb	94.8	83.4	82.2	102.3
Cs	2.6	1.9	1.7	1.6
Sr	497	441	470	483
Sc	2.4	8.8	8.2	3.3
Zr	176	197	178	166

Kgdf **Biotite Granodiorite (Late Cretaceous)**—Pale pink to pinkish gray, with conspicuous biotite pheonocrysts comprising about 5 percent of the rock. Plagioclase, potassium feldspar, quartz, and sparse sub-millimeter hornblende form the balance of the phenocryst assemblage in the biotite granodiorite. Well-exposed outcrops of the unit occur adjacent to Odell Lake. In the south-central part of the map, Kgdb and the surrounding Yqa country rocks are extensively brecciated. Berger and others (1983) interpreted this as intrusive breccia, and noted the occurrence of molybdenite-bearing quartz veinlets. Biotite granodiorite near Odell Lake, in the northwest map corner, yielded an age of 68.7 ± 0.5 Ma (table 1; J. Mosolf, written commun., 2022).

Kgdb **Granodiorite, foliated (Late Cretaceous)**—Gray, medium- to coarse-grained granodiorite, similar to granodiorite in the north-adjacent Shaw Mountain (Lonn, 2020) and Foolhen Mountain quadrangles (Elliott and Lonn, 2021), and apparently continuous with the large batholith that makes up most of the East Pioneer Mountains (Ruppel and others, 1993; Berger and others, 1983; Snee, 1978, 1982). In the Odell Lake quadrangle, the granodiorite varies from massive to weakly foliated, but to the north in the Foolhen Mountain quadrangle, it grades into gneiss (Elliott and Lonn, 2021). Contains biotite, hornblende, or both biotite and hornblende. Berger and others (1983) divided the unit based on the presence or absence of hornblende. They observed granitic rocks that lacked hornblende west of Giant Powder Creek in the southern part of the map, but our mapping did not distinguish these units. Zircons from a biotite-rich, unfoliated sample of Kgdf on the Foolhen Mountain have a U-Pb age of 73.89 ± 0.39 Ma (Elliott and Lonn, 2021).Two new U-Pb ages were obtained for the granodiorite (table 1). Granodiorite in the southwest map corner yielded an age of 71.8 ± 0.5 Ma, and graniodiorite in the southeast map corner yielded an age of 70.1 ± 0.4 Ma. (table 1; J. Mosolf, written commun., 2022).

ZYmi **Mafic dike (Neoproterozoic or Mesoproterozoic)**—Dark gray, altered dike containing olivine and/or augite, lath-shaped feldspar, pyroxene, and opaque minerals (Zen, 1988). Intrudes the Lambrecht Creek fault in the northeastern part of the map. Pearson and Zen (1985) reported a whole rock Ar^{40}/Ar^{39} thermal release minimum age of 660 Ma for the dike on the east-adjacent Maurice Mountain quadrangle. Maximum age is constrained by the 1,400 Ma country rocks.

Yqa **Quartzite and argillite, Belt Supergroup (Mesoproterozoic)**—Dominantly gray, flat laminated, very fine- to fine-grained quartzite in decimeter- to meter-thick beds separated by thin argillite skins. Convolute bedding, climbing ripple cross laminations, and mud rip-up clasts are common. Contains uncommon beds as much as 0.2 m thick of feldspar-poor, medium-grained quartzite with abundant well-rounded spherical grains. Contains intervals as much as 100 m thick dominated by centimeter-scale siltite–argillite couplets with abundant mud rip-ups, dessication cracks, load casts, and centimeter-scale lenses of feldspar-poor, medium-grained quartzite. Also contains rare calc-silicate intervals as much as a meter thick, black argillite beds as much as 0.2 m thick, and millimeter-scale siltite–argillite microcouplets. Near the west edge of the map in the hanging wall of a reverse fault, a 100- to 200-m-thick interval of similar lithologies grades down into thick medium- to coarse-grained quartzite of the Swauger Fm (Ysw). In addition, abundant spherical medium quartz grains were not observed in formations below the Swauger Fm (Burmester and others, 2016). Therefore, Yqa is tentatively correlated with the Lawson Creek Formation of the Lemhi subbasin (Burmester and others, 2016). At least 1,000 m (3,300 ft) is exposed on the north-adjacent Shaw Mountain quadrangle (Lonn, 2020).

Ysw **Swauger Formation, Belt Supergroup (Mesoproterozoic)**—Multicolored (pink, white, red, and purple), thick-bedded, poorly sorted, massive to cross-bedded, medium- to coarse-grained quartzite containing numerous pebble-bearing intervals as well as intervals of thin-bedded, flat-laminated, fine-grained quartzite and siltite. Coarse, floating, well-rounded quartz grains and chalky white feldspar grains are obvious in hand sample. Some quartz grains are well-rounded, but feldspar grains are angular, suggesting two source areas. Pink quartz grains, red jasper grains, detrital muscovite, and thick mud rip-ups are common. Rare argillite beds typically contain desiccation cracks. Feldspar content is variable, with potassium feldspar dominating a few percent of plagioclase (Calbeck, 1975; Lonn, 2015; Lonn and Elliott, 2017; Elliott and Lonn, in review). Equivalent to Zen's (1988) Boner Knob and Maurice Mountain quartzites, to Calbeck's (1975) Belt 1 and 2, to Lonn and McDonald's (2004b) Bonner Formation, and to Elliott and Lonn's (in review) unit Yq. Swauger Formation is a thick unit within the Lemhi subbasin strata of the Belt Supergroup (Burmester and others, 2016). Only the uppermost part is exposed in the Odell Lake quadrangle, but surrounding quadrangles contain extensive exposures, and Calbeck (1975) estimated a thickness of at least 1,600 m (5,200 ft) immediately to the northeast in the Wise River Valley.

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Table 2. U-Pb LA-ICPMS geochronology.

Sample I.D.	Map Unit	Latitude	Longitude	Age (Ma)	2 σ	MSWD
KCS-20-04	Kgdb	45.57517	-113.23518	68.7	0.5	1.70
KCS-20-12	Kgdf	45.52389	-113.21184	71.8	0.5	1.90
KCS-20-19	Kgdf	45.51186	-113.17987	70.1	0.4	0.81

Reported ages are the weighted mean of ^{206}Pb-^{238}U ages obtained for each sample. Zircon separates were prepared by Ethan Coppage in the rock laboratory at the Montana Bureau of Mines and Geology, and analyzed by Jesse Mosolf at the University of California-Santa Barbara. Courtesy of J. Mosolf (written commun., 2022).

Figure 1. Unit Yqa is dominated by gray, flat-laminated, fine-grained quartzite in beds from several decimeters to 1 m thick. Note the thin dark argillite beds above wristwatch.

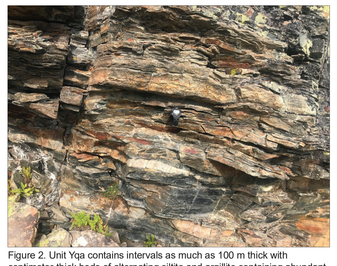

Figure 2. Unit Yqa contains intervals as much as 100 m thick with centimeter-thick beds of alternating siltite and argillite containing abundant dessication cracks and mud rip-ups. Below the watch, note the lenticular beds of white, feldspar-poor, coarse-grained quartzite and the thick black argillite bed; both commonly occur in these thinner-bedded intervals.

Figure 3. Unit Yqa also contains rare thin-bedded calc-silicate-rich intervals as much as 2 m thick. Note straight-sided desiccation cracks cutting bed in upper part. Wristwatch for scale.

Figure 4. The uppermost Swauger Formation is characterized by cross-bedded medium- to coarse-grained quartzite; some beds are conglomeratic. Note small white quartz pebbles in middle bed. Wristwatch for scale.

Figure 5. Stream channel cut in Qpa shows that a 1-m thickness of black organic-rich material comprises the uppermost part of unit Qpa. The overhanging banks suggest that this soil built up in place through decay of plant material. The gravelly streambed seen in the photo shows underlying fluvial deposits that have washed into the basin.

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Geologic Map 86

Geologic Map of the Odell Lake 7.5' Quadrangle, Southwestern Montana

Jeffrey D. Lonn and Kaleb C. Scarberry

2022