GEOLOGIC MAP OF THE MINNESOTA RIDGE QUADRANGLE, SOUTH DAKOTA

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State of South Dakota
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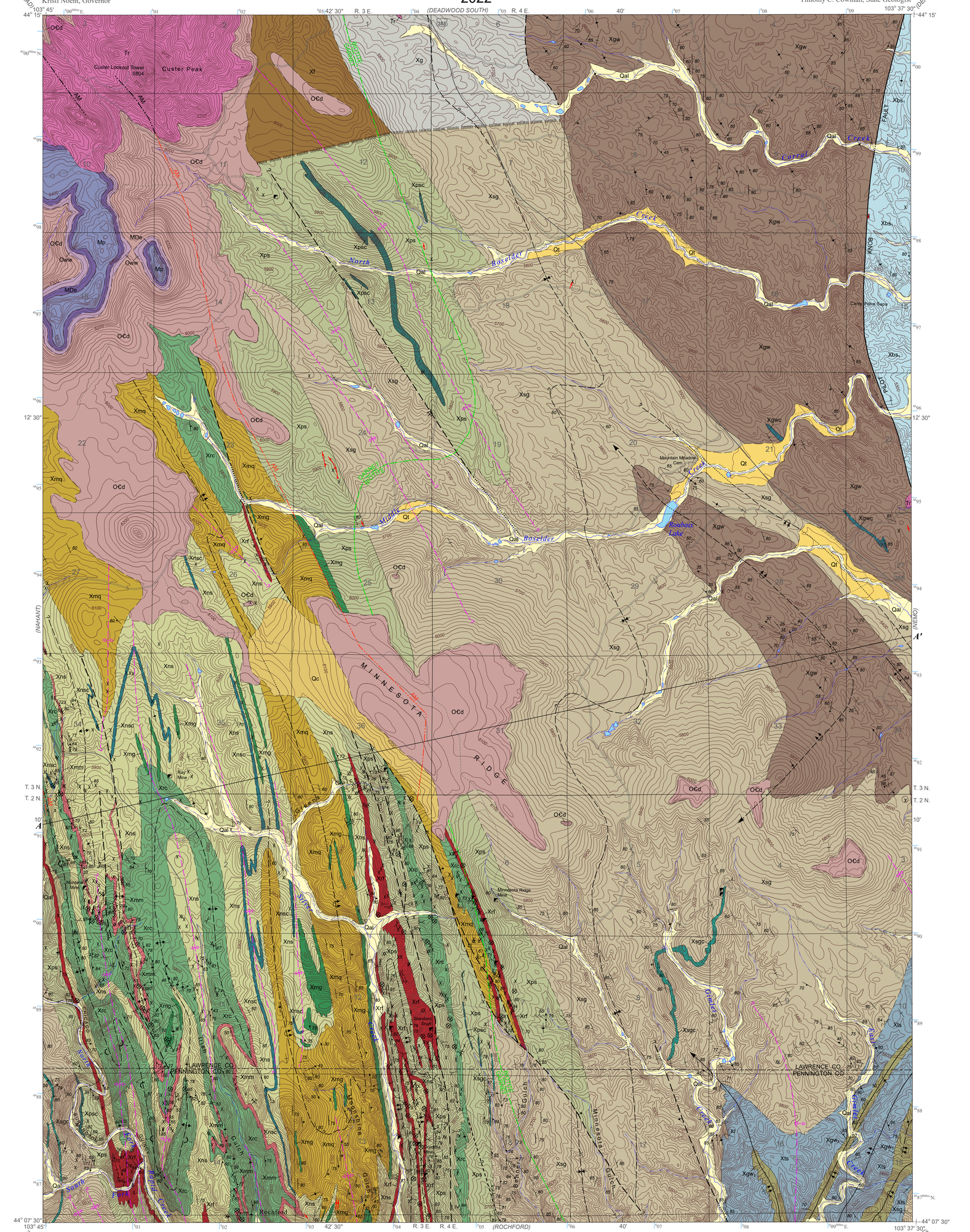
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
DIVISION OF FINANCIAL AND TECHNICAL ASSISTANCE
GEOLOGICAL SURVEY PROGRAM
7.5 MINUTE SERIES GEOLOGIC QUADRANGLE MAP 35



Map base modified from U.S.G.S. 1:24,000-scale Minnesota Ridge digital line graph.
Projection is Universal Transverse Mercator, Zone 13N.
Datum is 1983 North American.
UTM grid information generated from the ArcMap ™ layout grid function.

The Geological Survey Program, South Dakota Department of Agriculture and Natural Resources, engages in an ongoing data collection and interpretation process. An outcome of that process is to reflect those interpretations on maps such as this one. Reasonable efforts have been made to ensure that this map accurately reflects the source data used in its preparation. As additional data become available, geologic interpretations may be revised and the map may be updated by the Geological Survey Program. This map should not be enlarged or otherwise used in an attempt to interpret more detail than can be seen at the 1:24,000 scale.

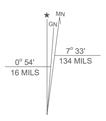
SCALE 1:24,000

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

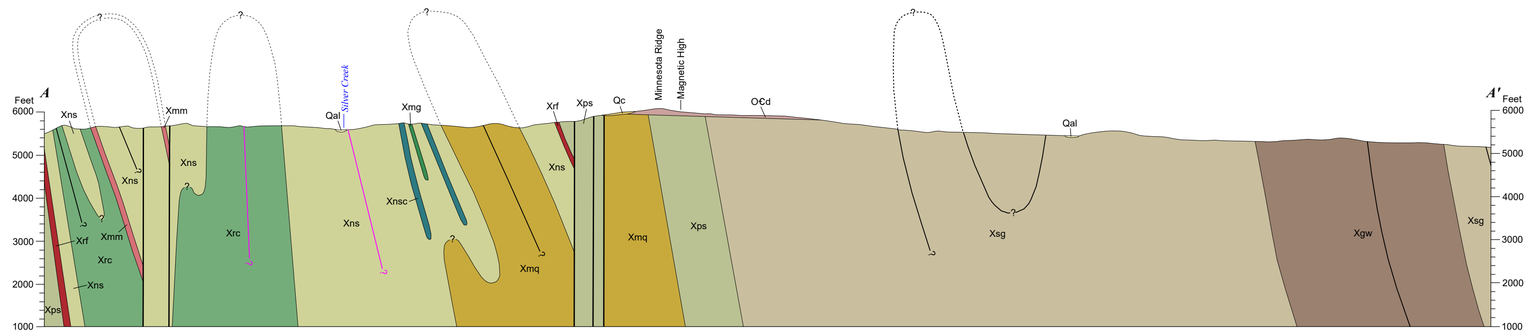
CONTOUR INTERVAL 20 FEET



UTM GRID AND 2021 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

Digital Cartography by M.D. Fahrenbach

QUADRANGLE LOCATION



EXPLANATION

QUATERNARY

Qal — **Alluvium** - Unconsolidated to poorly consolidated, clasts to boulder-size. May include adjacent terrace deposits. Deposited in present day stream drainages. Maximum thickness approximately 40 ft (12.2 m)

Qt — **Terrace deposit** - Unconsolidated to poorly consolidated, clasts to boulder-size dominantly of vein quartz, quartzite, metachert, and minor schist. Deposited adjacent to present-day streams. Only larger deposits are shown. Maximum thickness approximately 20 ft (6.1 m)

Unconformity

TERTIARY

Tr — **Rhyolite** - Finely crystalline to aphanitic groundmass dominantly of potassium feldspar. Leucocratic, white, tan, to pinkish-white where fresh, weathering gray to yellowish-brown. Iron- and manganese-stained, locally with prominent flow banding. May have sericitic or argillic alteration

Nonconformity

MISSISSIPPIAN — Lower Mississippian

Mp — **Pahasapa Limestone** - Limestone to dolomitic limestone. Grayish-white to gray. Finely to medium crystalline, thin- to thick-bedded in the lower portion of the formation, becoming massive in the upper portion. Karstic, with dissolution dominantly in the upper third. Forms prominent cliffs. Contains rugose corals and spiriferid brachiopods, especially near the upper contact. Exposed thickness approximately 430 ft (131.1 m)

DEVONIAN — Upper Devonian

MDe — **Englewood Formation** - Limestone, dolomitic limestone, and shale. Pink, purple-gray, to gray. Thinly laminated to thin-bedded with abundant stylolite surfaces and bioturbation. Limestones are very finely to medium crystalline and typically argillaceous. Thickness 40-55 ft (12.2-16.8 m)

ORDOVICIAN — Upper Ordovician

Oww — **Whitewood Limestone and Winnipeg Formation (undifferentiated)** - **Whitewood Limestone** - Dolomitic limestone and dolomite. Variegated yellowish-brown, brownish-orange, to gray. Thin- to thick-bedded with thin shale partings; bioturbated. **Winnipeg Formation** - Greenish-gray fissile shale and tan calcareous siltstone. Combined thickness of units approximately 40-50 ft (12.2-15.2 m)

Disconformity

ORDOVICIAN — Lower Ordovician

CAMBRIAN — Upper Cambrian

OCd — **Deadwood Formation** - Basal conglomerate and conglomeratic sandstone containing rounded to well-rounded quartz pebbles as much as 3 in (7.6 cm) in diameter derived from quartz veins. Overlain by tan, brown, to reddish-brown, medium-grained, moderately sorted, medium- to thick-bedded sandstone and orthoquartzite. Locally cross bedded. Includes thin- to medium-bedded greenish glauconitic sandstone, intraformational conglomerate, siltstone, and shale. Formation is typically covered by colluvium and poorly exposed. Thickness approximately 200-250 ft (61.0-76.2 m)

Unconformity

PRECAMBRIAN — Lower Proterozoic

Xg / Xsg / Xsgc — **Grizzly Formation** - **Xg** - Slate, phyllite, mica schist, and minor metagraywacke. Gray, dark gray, to bluish-gray. Some beds are carbonaceous. Gradational into the Swede Gulch Formation (Xsg). Protolith of formation is dominantly shale and siltstone
Swede Gulch Formation - **Xsg**- Slate, phyllite, schist and metagraywacke. Gray to black. Composed of 35-70% to as much as 90% biotite, and 25-50% angular 0.01-0.05 mm quartz grains. Pale red to black garnets with graphite inclusions occur at higher metamorphic grades. Laminated to medium-bedded. Bedding is indicated by 0.5-2.0 in (1.3-5.1 cm) thick garnetiferous layers and light-dark layering. Contains chloritic layers and accessory magnetite, ilmenite, and pyrite. Lower carbonaceous and graphitic portion probably grades into the Poverty Gulch Slate (Xps). Gradational into the Grizzly Formation (Xg) (Bayley, 1972a). Poorly exposed. Protoliths of formation are carbonaceous shale and shale, minor siltstone, and chert. **Xsgc** - Metachert, medium- to thick-bedded and massive, having light-dark layering. Typically ferruginous and iron-stained. One to several beds occur with graphitic slate and schist about 100 ft (30.5 m) above the base of the formation (Bayley, 1972a)

Xgw / Xgwc — **Metagraywacke** - **Xgw** - Quartz-mica schist, quartzose schist, and phyllite. Tan to gray. Fine- to very-fine grained, thin- to thick-bedded. Quartz-rich Bouma A beds locally contain calcareous and calc-silicate concretions and are resistant to erosion. May be equivalent in part to metagraywacke units Xgw_1, Xgw_2, and Xgw_3 on adjacent quadrangles. Initially mapped as part of the Roubaix Formation by Bayley (1972c). Protolith is distal to proximal turbidite deposits of graywacke with minor shale interbeds. **Xgwc** - Metachert, finely to medium crystalline with light-dark layering, ferruginous

Unconformity ?

Xgw_3 — **Metagraywacke unit 3** - Quartzite, quartzose schist, and phyllite. Tan to gray. Fine- to coarse-grained, thin- to thick-bedded. Quartz-rich Bouma A beds locally contain calcareous and calc-silicate concretions and are resistant to erosion. Protolith is proximal turbidite deposits having sandstone and graywacke with minor shale interbeds

Xmg — **Metagabbro** - Amphibolite and chloritic amphibole schist. Grayish-green to greenish-black. Medium crystalline except where sheared or well foliated and schistose. Composed of plagioclase, hornblende, biotite, and calcite. Locally with chloritic alteration. A sill on the Pactola Dam quadrangle has a Pb-Pb zircon age of 1,883 +/- 5 Ma (Redden and others, 1990). It is uncertain that all bodies shown as Xmg are of the same age. Protolith is gabbro

Xf / Xpsc / Xps / Xts — **Flag Rock Formation** - **Xf** - Mica schist and laminated pyritic and carbonaceous phyllite. Light-gray to greenish-gray. Contains layered graphitic quartzite, metachert, metabasalt, and carbonate facies iron-formation. Protolith is dposits of siltstone, carbonaceous shale, chert, and iron carbonate with pillow basalt.
Poverty Gulch Slate - **Xps** - Slate, phyllite, and interbedded graphitic slate and schist. Dark brown to black. Laminated, with alternate laminae typically containing abundant small garnets (Bayley, 1972a). Laterally equivalent to the Tenderfoot Formation (Xts), and gradational into the Flag Rock Formation (Xf). Protolith is shale, siltstone, tuffaceous volcanic sediments, carbonate- and silicate-facies iron-formation, and chert beds. **Xpsc**- Metachert, with light-dark layering, ferruginous
Tenderfoot Formation - **Xts** - Micaceous phyllite and schist, laminated to thin-bedded. Greenish-gray to silver-gray. Includes some metagraywacke beds which increase in abundance to the north, and cannot be distinguished from metagraywacke units in adjacent quadrangles (Redden and DeWitt, 2008). Typically has accessory magnetite and ilmenite, and locally with malachite-stained muscovite-rich schist, and thin spessartine-bearing beds. Laterally equivalent to the Poverty Gulch Slate (Xps), and to ash flow tuffs in the Rochford area. Age approximately 1,880 Ma (Redden and others, 1990). Protolith is alumina-rich seafloor weathered alkalic volcanic tuff and shale

Xrf — **Rochford Formation** - Metachert, thick- to thin-bedded, ferruginous. Dark greenish-gray, weathering dark reddish-brown. Composition variable, averaging 77% cummingtonite-grunerite, 10% chlorite, 5% almandite garnet, 5% sulfide, 4% graphite, 4% carbonate, 3% biotite, and 2% quartz. Dominantly metachert on straight fold limbs, with rosettes of cummingtonite-grunerite on tight fold noses. Upper and lower contacts are conformable (Weissenborn, 1987). Lithologically similar to the Montana Mine Formation (Xmm), and the Homestake Formation of the northern Black Hills (Bayley, 1972a). Thickness approximately 50 ft (15.2 m) to as much as 375 ft (114.3 m). Age estimated less than 1,887 Ma (Frei and others, 2009). Protolith is likely submarine thermal spring deposits

Xns / Xnsc / Xrc — **Nahant Schist** - **Xns** - Slate and schist, graphitic. Dark gray to black. Bedding inconspicuous. A chert-grunerite unit is present at the base of the formation. Intertongues with the Rapid Creek Greenstone (Xrc) (Bayley, 1972a). Areas mapped as Irish Gulch Slate by Bayley (1972a) have been included with the Nahant Schist (Xns). Protolith of formation is shale and carbonaceous shale, tuffaceous volcaniclastic sediments, and chert beds. **Xnsc** - Metachert, ferruginous, with light-dark layering
Rapid Creek Greenstone - **Xrc** - Metabasalt, schistose calcareous mafic tuff, agglomerate, and weakly foliated amphibolite with abundant actinolite. Green, greenish-gray, to black. Dense, massive, forming ridges. Includes interbedded layered metachert. Intertongues with the Nahant Schist (Bayley, 1972a). Protolith is pillowed submarine basalt flows

Xmm — **Montana Mine Formation** - Metachert containing cummingtonite-grunerite and chloritic schist, and graphitic and volcaniclastic interbeds. Dark grayish-green to brown, weathering dark reddish-brown. Thin- to thick-bedded, ferruginous. Consists of approximately 43% quartz, 38% cummingtonite-grunerite, 13% chlorite, 4% sulfide, 1% biotite, and minor almandite garnet. Locally with poorly sorted angular chert fragments that increase in angularity and size up to 1.5 ft (0.46 m) south of the Montana Mine. Poorly exposed. Thickness 40-80 ft (12.2-24.4 m) (Weissenborn, 1987). Lithologically similar to the Rochford Formation (Xrf), and the Homestake Formation of the northern Black Hills (Bayley, 1972a). $^{207}Pb/^{206}Pb$ dating of zircon in an interbedded felsic tuff gave an age of 1,884 +/- 29 Ma (Redden and others, 1990). Protolith is likely submarine thermal spring deposits

Xmq — **Moonshine Gulch Quartzite** - Metagraywacke and quartzite. Gray to nearly black. Thin- to thick-bedded, with sub-rounded to rounded, medium- to coarse-grained, moderately to poorly sorted quartz grains with silica cement. Some beds are graded. Interbedded with alternating silver-gray and black layered carbonate, and sericitic to micaceous and graphitic slate and phyllite. Pyrite occurs as disseminated grains. Laterally equivalent to the Ellison Formation of the northern Black Hills (Bayley, 1972a). Protolith is proximal turbidite deposits having sandstone, graywacke, siltstone, and shale

Fault Contact

Xbs_1 — **Reausaw Slate** - Biotite phyllite, garnet schist, and graphitic slate and schist. Reddish-brown, dark gray, to black. Laminated to thin-bedded, very fine-grained, fissile, and carbonaceous. Includes units of magnetic cherty ferruginous schist with minor cummingtonite-grunerite. Contains sulfides, iron carbonate, and abundant thin veinlets of milky quartz. Poorly exposed (Bayley, 1972a; 1972c). Protolith is black shale with minor siltstone and thin chert beds

CONTACTS

Long dashed where approximately located; vertical lines where gradational and approximately located; queried where uncertain in cross section

FAULTS

Fault — Long dashed where approximately located; short dashed where inferred; dotted where concealed; queried where uncertain. Bar and ball on downthrown side

FOLDS (Early Proterozoic)

D_1 FOLDS

Anticline — Location of trace of axial plane. Long dashed where approximately located; queried where uncertain

Syncline — Location of trace of axial plane. Long dashed where approximately located; dotted where concealed; queried where uncertain

Overturned anticline — Location of trace of axial plane, dip direction of limbs, and direction of plunge. Long dashed where approximately located; dotted where concealed; queried where uncertain

Overturned syncline — Location of trace of axial plane, dip direction of limbs, and direction of plunge. Long dashed where approximately located; dotted where concealed; queried where uncertain

Minor fold (50) — Showing bearing and plunge

Minor synform (45) — Showing bearing and plunge

D_2 FOLDS

Antiform — Location of trace of axial plane. Long dashed where approximately located; dotted where concealed; queried where uncertain

Synform — Location of trace of axial plane. Long dashed where approximately located; dotted where concealed; queried where uncertain

BEDDING

Inclined (73)

Inclined (60) — Ball indicates top direction of beds known to be in dip direction

Overturned (56) — Ball indicates top direction of beds known to be opposite of dip direction

Vertical

Top of bed — Indicated by sedimentary structures

Top of basalt pillow

FOLIATION

Inclined (70)

Parallel to bedding (78)

Vertical

Crenulation (50)

LINEATION

Lineation (80) — Showing bearing and plunge

QUARTZ VEIN

METAMORPHIC ISOGRAD

BIOTITE / GARNET — First appearance of index mineral noted on side of isograd

MAGNETIC HIGH

AM — Located by aerial magnetic survey (Bayley, 1972a, 1972b). Shown in black when on rhyolite (Tr)

OTHER FEATURES

Open pit mine

Mine shaft

Mine adit

Trench

Group of prospect pits

Prospect pit

INDEX MAP OF SELECTED REFERENCES

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ACKNOWLEDGEMENTS

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Custer Peak on the right, elevation 6804 ft (2804 m), is the tallest of several peaks on a rhyolite (Tr) laccolith that intruded the Deadwood Formation (OCd). A fire lookout tower is visible on the summit.

Northeast trending quartz vein 8-10 ft (2.4-3.0 m) across in the Swede Gulch Formation (Xsg). Snow is in the background.

Thin-bedded Nahant Schist (Xns) along Co. 17. Hammer is 16 in (40.6 cm) long and parallel to the northeast dipping bedding.

Very resistant, thick-bedded and massive metachert (Xgwc). Bedding is nearly vertical and dips steeply to the right. Most large exposures of metachert are surrounded by angular blocks of talus.