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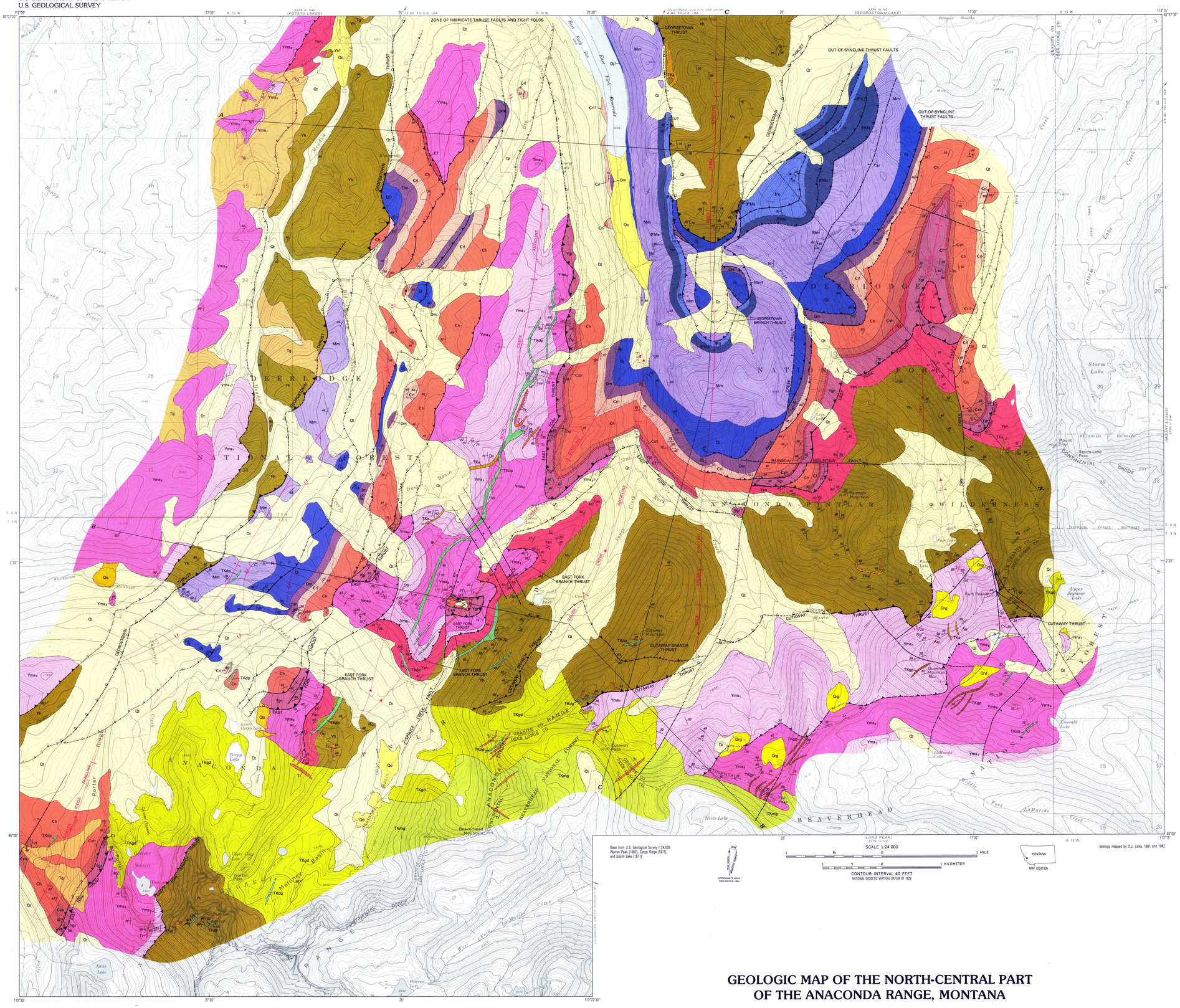
PLATE 1
SHEET 1 OF 2



GEOLOGIC MAP OF THE NORTH-CENTRAL PART OF THE ANACONDA RANGE, MONTANA

By

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CORRELATION OF MAP UNITS

Qls, Qg, Qo, Qt	Holocene and Pleistocene	QUATERNARY	
Unconformity			
Tg		TERTIARY(?)	
Unconformity			
Tr, TKgp, TKdp, TKa, TKmg, TKgd		TERTIARY OR UPPER CRETACEOUS	TERTIARY
Unconformity			
IPq		PENNSYLVANIAN	
Unconformity			
IPMs	Lower Pennsylvanian and Upper Mississippian(?)	PENNSYLVANIAN AND MISSISSIPPIAN	
Unconformity			
Mm, Dj, Dm		MISSISSIPPIAN	
Unconformity			
Dm	Upper Devonian	DEVONIAN	
Unconformity			
Crl, Ch, Cash, Cf	Upper Cambrian, Middle Cambrian	CAMBRIAN	
Unconformity			
Ygr	Missoula Group	Belt Supergroup	MIDDLE PROTEROZOIC
Thrust fault[1]			
Yms2, Yms1			
Thrust fault[1]			
Ysn, Yh			

[1] Thrust faulting occurred during the Cretaceous.

DESCRIPTION OF MAP UNITS

QUATERNARY AND TERTIARY UNCONSOLIDATED DEPOSITS

Qls **Landslide (Holocene)**—Poorly sorted, pebble- to boulder-sized rock fragments in a matrix of sand and finer material, weathered rock fragments, or till. Occur in drainage basin of Carpp Creek.

Qrg **Rock-glacier (Holocene and Pleistocene)**—Angular cobbles and boulders that form mounds and benches below cirque headwalls

Qo **Outwash (Pleistocene)**—Mainly glacio-fluvial deposits of bouldery to pebbly gravel, sand, and silt. Generally exhibit braided channel pattern on surface. Locally includes younger Holocene alluvium. Present in the drainages of Carpp Creek, Meadow Creek, and East Fork Rock Creek

Qt **Till (Pleistocene)**—Poorly sorted, poorly stratified, bouldery, sandy, silty, and clay-rich gravel. Consists of an older till occurring mainly as erosional remnants mantling sides and tops of ridges, and a younger, hummocky till deposited in many of the modern drainage basins; tills not separated on map. Locally includes outwash, protalus ramparts, younger alluvium, and talus

Tg **Gravel (Tertiary?)**—Moderately to poorly stratified and poorly sorted sandy and silty gravel. Clasts are rounded to subrounded, and size ranges from pebble to boulder; cobbles most abundant. Occurs in west part of area along valley of Meadow Creek and along west side of Porter Ridge

TERTIARY AND CRETACEOUS INTRUSIVE ROCKS[1]

Dikes and sills

Tr **Rhyolite porphyry (Tertiary)**—Pinkish-brown (altered) and light-gray (nonaltered). Commonly contains about 20–40 percent phenocrysts of plagioclase and smoky quartz and lesser amounts of biotite and potassium feldspar; phenocrysts range from about 0.02 to 0.2 in. (0.5 to 5 mm) in length; microgranular to felty groundmass is mainly quartz, plagioclase, and potassium feldspar. Accessory minerals include sphene, allanite, apatite, zircon, and opaque minerals. Some quartz and potassium feldspar phenocrysts have conspicuous resorption features. Locally contains two types of potassium feldspar; one shows simple Carlsbad twinning (orthoclase), the other shows faint grid twinning and zonation (zoned microcline?). Smoky quartz crystals characteristic of unit. Plagioclase slightly altered to sericite; biotite slightly altered to chlorite or to aggregates of muscovite, biotite, and goethite. Associated with pods of aplite and vein quartz near Beaverhead Mountain, in south-central part of area. Tertiary age assignment based on probable correlation with rhyolite dikes about 10 mi (16 km) southwest of the area, from which Desmarais (1983) obtained radiometric ages of about 43 Ma. Present in southwest to south-central part of area and in core of Rock Creek anticline

TKgp **Granite porphyry (Tertiary or Upper Cretaceous)**—Light-gray, fine-grained, porphyritic phenocrysts and groundmass composed of plagioclase, potassium feldspar, quartz, and biotite; contains about 50–70 percent phenocrysts that range from about 0.04 to 0.2 in. (1 to 5 mm) in length. Accessory minerals include sphene, apatite, zircon, opaque minerals, and rare allanite. Contains smoky quartz and zoned microcline(?), suggesting possible comagmatic relationship with the rhyolite porphyry dikes and sills (Tr). Present near, and probably derived from, the monzogranite stock (TKmg) in the south-central to southeast part of area

TKdp **Granodiorite porphyry and dacite porphyry (Tertiary or Upper Cretaceous)**—Light-gray to gray, porphyritic and both phaneritic and aphanitic groundmass textures. Contains about 20–60 percent phenocrysts of plagioclase, quartz, biotite, and rare hornblende and orthoclase in microgranular to felty groundmass of plagioclase, quartz, biotite, and potassium feldspar. Quartz phenocrysts commonly rounded and embayed with halos of groundmass quartz in optical continuity. Phenocrysts of potassium feldspar strongly embayed and rimmed by plagioclase (rapakivi texture). Northerly trending dikes in core of Rock Creek anticline vary from dacite to granodiorite along trend. Scattered through southwestern part of area with two occurrences in southeast corner; may be derived from nearby granodiorite stock (TKgd)

TKa **Porphyritic quartz diorite and andesite (Tertiary or Upper Cretaceous)**—Light- to dark-gray and weakly porphyritic, characterized by about 0–35 percent phenocrysts of plagioclase and hornblende. Groundmass is dominantly quartz, plagioclase, and minor potassium feldspar. Quartz diorite, light-gray, intergranular to felty textured, andesite generally dark gray, felty textured. Plagioclase phenocrysts show faint, normal zonation, reaction rims, and minor myrmekite; plagioclase highly altered to sericite and saussurite. Hornblende occurs interstitially and as prismatic phenocrysts, and commonly is altered to epidote, chlorite, sericite, calcite, and opaque minerals. Secondary quartz and calcite occur interstitially and in vugs. Exposed in each part of area, and along southwest flank of Rock Creek anticline; one larger exposure in north-central part. May be derived from a quartz diorite stock present just east of study area

Stocks

TKmg **Biotite monzogranite (Tertiary or Upper Cretaceous)**—Porphyritic, medium-grained, hypidiomorphic granular. Contains essential plagioclase, quartz, and orthoclase, varietal green and brown biotite, and accessory allanite, sphene, zircon, apatite, and opaque minerals. Plagioclase has average compositional range of An_{32} (core) to An_{17} (rim) and commonly shows resorption borders, reaction rims, and some myrmekite adjacent to orthoclase. Orthoclase contains blebs, wisps, and irregular patches of perthite. Microcline present in minor amounts. Distinctive phenocrysts of pink, subhedral orthoclase as much as 1 in. (2.5 cm) in length occur near Cutaway Pass, in the south-central part of the study area. Plagioclase slightly to pervasively altered to sericite; some locally altered to epidote. Biotite altered to chlorite along cleavage and edges; epidote or clinozoisite, sphene, feathery opaque minerals, and fluorite commonly accompany chlorite alteration. Exposed in southwest to south-central part of area

TKgd **Hornblende-biotite granodiorite (Tertiary or Upper Cretaceous)**—Medium- and fine-grained, hypidiomorphic granular. Contains essential plagioclase, quartz, and orthoclase, varietal brown and green biotite and green hornblende, and accessory allanite, zircon, apatite, sphene, and opaque minerals. Plagioclase has average compositional range of An_{32} (core) to An_{22} (rim) and shows normal and oscillatory zoning, myrmekite, reaction rims, and resorption borders common where adjacent to orthoclase. Plagioclase slightly altered to sericite and less commonly epidote. Orthoclase commonly contains blebs and wisps of perthite. Biotite altered to chlorite along cleavages. Hornblende cores altered to biotite. Fine-grained, porphyritic, leucocratic phases common adjacent to contacts. Contacts with host rocks sharp; both concordant and discordant contact relations occur. Two granodiorite stocks exposed, one in southeastern part of study area and a small part of one in southeastern part of area. Locally faulted against, and probably intruded by the monzogranite stock (TKmg) in the south-central and southwestern parts of the study area; unfaulted contacts of the two stocks appear gradational but commonly are obscured by leucocratic or porphyritic rock

PALEOZOIC SEDIMENTARY ROCKS

IPq **Quadrant Quartzite (Pennsylvanian)**—White to tan, massive-weathering quartzite composed chiefly of fine- to medium-grained, subangular to rounded, well-sorted quartz sand; slightly lithic. Cemented by quartz and minor iron oxide. Weathers light red and yellow as a result of iron oxide stain. Prominent cliff-forming unit. Approximate thickness 300 ft (90 m). Occurs only in northeastern part of area

IPMs **Snowcrest Range Group (Lower Pennsylvanian and Upper Mississippian(?))**—Interbedded red, calcareous shale and siltstone, subordinate olive-green shale, white to gray limestone nodules, and thin, discontinuous beds of limestone. Lower 100 ft (30 m) contains a few lenticular beds of pale-red, fine-grained, dolomite-cemented sandstone as much as 2 ft (0.6 m) thick. Small yellow or green reduction spots common in red shale. Approximate thickness 330 ft (100 m). Occurs only in northeastern part of area

Mm **Madison Group (Upper and Lower Mississippian)**—Upper 1,500 ft (460 m) dominantly light bluish gray, thick-bedded, massive-weathering, crinoidal limestone; mainly biosparite and biosparmicrite; minor amounts of biomicrite and micrite. A paleokarstic zone common at the top of the Madison Group about 25 mi (40 km) to the north in the Flint Creek Range is absent. Lower 400–450 ft (120–135 m) is medium- to dark-gray, shaly and silty, fossiliferous limestone that contains crinoids, rugose corals, brachiopods, gastropods, and bryozoans in matrix of micrite and minor sparite. Flaggy partings and black chert stringers and nodules common in lower part. Total thickness about 1,900–2,000 ft (580–610 m). Largest exposures in the northeastern quarter of the area; also exposed in the west below Georgetown thrust

Dj **Jefferson Formation (Upper Devonian)**—Dark-gray to black, bituminous, porous, coarsely crystalline, thick-bedded dolomite containing some interbeds as much as 5 ft (1.5 m) thick of bluish-gray to cream limestone. Upper part contains more limestone interbeds and locally contains a pale-bluish-gray sedimentary breccia as much as a few feet (a couple of meters) thick containing dispersed limestone clasts as much as 2 in. (5 cm) in diameter. Where well exposed, alternating dark and light beds give unit a distinct striped appearance. Total thickness about 800–850 ft (245–260 m)

Dm **Maywood Formation (Upper Devonian)**—Light-red and yellow, thin-bedded, commonly dolomitic shale and siltstone; contains some interbeds of pink, sandy and shaly dolomite interbeds as much as 10 ft (3 m) thick, and sparse, thin beds of gray limestone. Upper part contains a pink to tan, medium-grained quartzite zone about 15–30 ft (4.5–9 m) thick, and some sparse, dark, coarsely crystalline dolomite interbeds similar to dolomite of the overlying Jefferson Formation. Beds of dolomite-cemented sandstone and siltstone common in lower part. Total thickness about 350 ft (107 m)

Crl **Red Lion Formation (Upper Cambrian)**—Light-gray limestone containing conspicuous yellow-, red-, or orange-weathering, siliceous and argillaceous laminae that are thicker and more abundant in lower part. Locally, near top, is a 3- to 6-ft (1- to 2-m) thick tan-weathering sedimentary breccia composed of subangular clasts of limy shale in a limy silt and clay matrix. Basal part consists of about 15 ft (5 m) of reddish-maroon, limy and silty shale containing thin, gray limestone lenses about 0.5 in. (1 cm) thick. Total thickness about 350 ft (107 m)

Ch **Hasmark Formation (Upper Cambrian)**—As defined by Emmons and Calkins (1913), the Hasmark is a bluish-gray to light-gray, thick-bedded to massive, fine-grained dolomite that contains a 5- to 10-ft (1.5- to 3-m-) thick zone of brown shale interbeds in middle part, and some beds of brown shale as much as 3 ft (1 m) thick in lower part. The upper 330 ft (100 m) is mainly cream weathering, light-gray, thick-bedded, fine-grained dolomite; bedding generally well defined on weathered surfaces by white to very light yellow laminations that are slightly argillaceous and about 1 mm thick. The lower 650–700 ft (200–215 m) is primarily bluish gray, fine-grained, crystalline dolomite; weathered surfaces exhibit irregular, light- and dark-gray mottling, grainy texture, and white, twiglike protrusions. Contains an oolite and pisolite zone near base and locally near top. Total thickness about 1,000 ft (305 m)

Cash **Silver Hill Formation (Middle Cambrian)**—Upper part, about 100–150 ft (30–45 m) thick, consists mainly of bluish-gray limestone containing conspicuous purplish-red or orangish-yellow, carbonate-cemented, wavy, siliceous and argillaceous laminae. Upper part is similar in appearance to much of the Red Lion Formation. Lower part consists of about 50 ft (15 m) of olive-green and greenish-black shale and argillaceous siltstone containing thin interbeds of white to tan sandstone; flaser-structure common in shale. Not present in study area is about 15 ft (5 m) of dark-greenish-brown shale that is the uppermost unit of the formation north of the area (Emmons and Calkins, 1913). Total thickness about 150–200 ft (45–60 m)

Cf **Flathead Quartzite (Middle Cambrian)**—White- to tan-weathering, fine- to medium-grained quartzite consisting of rounded to well-rounded, well-sorted quartz sand grains cemented by quartz and minor sericite. Contains some very thin partings of light-green shale between quartzite beds. Ripple laminations and some moderate-angle, small- to medium-scale planar crossbeds occur locally. Basal, unconformable contact with underlying quartzite of Garnet Range Formation is discordant and appears to have negligible relief. Maximum thickness about 100 ft (30 m)

MIDDLE PROTEROZOIC SEDIMENTARY ROCKS (BELT SUPERGROUP)

Missoula Group

Ygr **Garnet Range Formation (Middle Proterozoic)**—Dominantly light green, dull-red, and white quartzite, red and pink, feldspathic and argillaceous quartzite, and lesser reddish brown, silty and sandy argillite. Ripple laminations and planar and trough crossbeds common in quartzite beds. Quartzite near top commonly shows splotchy white and light-green mottling. Contact with overlying Flathead Quartzite commonly marked by an abrupt decrease in mottled quartzite of the Garnet Range Formation. Only upper part of formation exposed in study area; in fault contact with underlying units. Thickness about 300–400 ft (90–120 m)

Mount Shields Formation (Middle Proterozoic)—Consists of three members in this region, the lower two of which occur in the study area. Principal sedimentologic characteristics of the Mount Shields Formation are rhythmic bedding, flat aggradational basal contacts of beds, and fining-upward cycles

Yms3 **Member two**—Dominantly pink to white, fine- to medium-grained, poorly to moderately sorted arkose, subarkose, and quartzite. Argillite partings define bedding units, about 1–10 ft (0.3–3 m) thick, that become finer grained upward. Planar laminations, ripple cross-laminations, and low-angle planar and tangential crossbeds common. Scattered red and green mudstone chips common in parts of unit. Some sequences of white to tan quartzite beds, 10–100 ft (3–30 m) thick, are lithologically similar to quartzite in the Flathead Quartzite and upper part of the Garnet Range Formation. Lower part has zones containing dispersed lenses of matrix-supported, quartzitic pebble and cobble conglomerate. Convolute bedding common in exposures along Continental Divide in the southeastern part of area. Commonly forms prominent ridges flanked and covered by talus. Thickness variable because of faulting; ranges from 0 to about 4,000 ft (0 to 1,220 m)

Yms1 **Member one**—Thick zones of rhythmically interbedded, maroon to red argillite, tan-weathering siltite, and fine-grained arkose, subarkose, and quartzite that alternate with zones of interbedded tan-weathering, poorly sorted to well-sorted, fine- to medium-grained arkose, subarkose, and quartzite. Individual zones range in thickness from about 25 to 200 ft (8 to 60 m). Zones of interbedded arkose, subarkose, and quartzite increase in thickness upward. Mud cracks, water-expulsion structures, ripple cross-laminations, and small-scale, low-angle planar and tangential crossbeds common in argillite-siltite-quartzite zones. Medium-scale crossbeds and ripple cross-laminations are common in arkose-subarkose-quartzite zones. Upper part of member has lenticular beds of pebble conglomerate along bedding in some argillite-siltite-quartzite zones in core of Rock Creek anticline. Coarser, arkosic conglomerate occurs in upper part just west of Meadow Creek, in westernmost part of area. Because of faulting, only incomplete sections present. Thickness as much as 3,000 ft (915 m)

Ysn **Snowslip Formation (Middle Proterozoic)**—Only lower part of formation present in area; upper part faulted away. Lower part consists of red and green, thinly laminated argillite, argillaceous siltite, siltite, and minor, lenticular, white quartzite beds and laminae consisting of medium- and coarse-grained, very well sorted, well-rounded quartz arenite that lacks matrix. Oolites, thin, lenticular, glauconite-bearing sandstone beds, and armored mudballs occur near the base. Argillite and siltite beds contain uneven laminae, mudcracks, fluid-escape structures, ripple marks, flaser-structures, and minor small-scale crossbeds. About 650 ft (200 m) exposed

Yh **Helena Formation (Middle Proterozoic)**—Dominantly comprises beds and laminae of tan-weathering, limy siltstone and gray, argillaceous limestone; lesser laminae and thin interbeds as much as 4 in. (10 cm) thick of white, fine-grained limy sandstone or quartzite. Proportion of mainly calcareous units to mainly argillaceous and siliceous units varies vertically across a few inches (several centimeters) of section in thinly interbedded and laminated zones, and varies across a few tens to several tens of feet (10–30 m) of section through thick-bedded zones; some parts of formation are dominantly impure limestone, other parts are mainly calcite cemented argillite, siltite, and quartzite. About 200 ft (60 m) of green limy argillite in uppermost part of formation is transitional into green and red argillite of the overlying Snowslip Formation, and contact between the Helena and Snowslip is placed above the green limy argillite and beneath the lowest red argillite zone of the Snowslip. Beneath upper green argillite is about 1,500 ft (450 m) of thin-bedded argillaceous limestone and tan limy siltite containing a zone of wavy, algal laminations about 500 ft (150 m) below top of zone. The thinly bedded rocks are underlain by about 4,000 ft (1,220 m) of pale-pink- and tan-weathering, thick-bedded, argillaceous limestone and dolomite that include a few to numerous interbeds of calcareous siltite and quartzite. Lower 300 ft (90 m) of the Helena Formation exposed near Quesner Mountain consists of green calcareous siltstone and pinkish-weathering silty limestone. Base of unit faulted away. Minimum thickness about 6,000 ft (1,830 m)

Contact—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed

High-angle fault—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed; ball and bar on apparent downthrown side. Barbs indicate relative direction of lateral movement

Thrust fault—Long-dashed where approximately located; short-dashed where inferred; dotted with open teeth where concealed; queried where uncertain; sawtooth on upper plate. Thicker line with larger teeth indicates sheet thrusts

Thrust fault in axial region of overturned anticline—Long-dashed where approximately located

Thrust fault in axial region of overturned syncline—Long-dashed where approximately located

Anticline—Showing approximate trace of axial surface and direction of plunge; dotted where concealed

Overturned anticline—Showing approximate trace of axial surface and direction of plunge; dotted where concealed. Tick mark shown locally indicates dip direction of beds in hinge region

Syncline—Showing approximate trace of axial surface and direction of plunge; dotted where concealed

Overturned syncline—Showing approximate location of trace of axial surface and direction of plunge; dotted where concealed. Tick mark shown locally indicates dip direction of beds in hinge region

14 Minor anticline—Showing direction and amount of plunge of axis

65 Minor syncline—Showing direction and amount of plunge of axis

20 Small folds or crenulations—Showing direction and amount of plunge of axis

Strike and dip of bedding—Queried where uncertain

Horizontal

18 Inclined

Vertical

70 Overturned

Strike and dip of cleavage—Includes fracture cleavage and schistosity

30 Inclined

Vertical

45 Inclined cleavage coincident with bedding

42 Strike and dip of foliation

Strike and dip of joints

42 Inclined

Vertical

Fault—In cross section; barbs show directions of relative movement in plane of section; T, movement towards observer; A, movement away from observer

Bedding foreline—In cross section

Both contacts and faults projected as dashed lines above topographic surface, in cross section

[1] Intrusive rocks are classified according to the IUGS system (Streckeisen, 1973)