

**SEQUENCE OF MAP UNITS**

Quaternary	Qa	Quaternary
Pleistocene	Qp	Quaternary
Cretaceous	Ks, Kc, Kp	Cretaceous
Late and Middle Proterozoic	Cu, Cg, Cq, Ck, Cn, Cw, Cv, Cy, Cz, Ca, Cb, Cc, Cd, Ce, Cf, Cg, Ch, Ci, Cj, Ck, Cl, Cm, Cn, Co, Cp, Cq, Cr, Cs, Ct, Cu, Cv, Cw, Cx, Cy, Cz	Late and Middle Proterozoic
Middle Proterozoic	Yp, Yq, Yr, Ys, Yt, Yu, Yv, Yw, Yx, Yy, Yz	Middle Proterozoic

**DESCRIPTION OF MAP UNITS**

**Qa** Alluvial deposits (Holocene)—Clay, sand, silt, and clay in flood plains and low terraces along present drainage.

**Qp** Landslide deposits (Holocene)—Angular blocks of bedrock in finer grained matrix, most at places with glacial debris.

**Qc** Glacial and fluvio-glacial deposits (Pleistocene)—Includes till (ground and end moraine), outwash, and other fluvio-glacial deposits. Also includes lake sediments where they were not mapped separately.

**Ql** Lake sediments (Pleistocene)—Bull laminated clay and silt containing a few lenses of gravel. Unit commonly is found within Qp and is shown only where mapped separately.

**Tu** Dikes (Tertiary?)—Quartz latite porphyry and diorite.

**Ks, Kc, Kp** Feldic plutons (Cretaceous)—Biotite or hornblende-biotite granite or granodiorite. Larger blocks and plutons shown on map, but unit also occurs in scattered dikes.

**Cu, Cg, Cq, Ck, Cn, Cw, Cv, Cy, Cz** Syenitic (Cretaceous)—Gray to buff, coarse-grained plutons and dikes. Composed largely of orthoclase and andesine (Gibson, 1948) with small amounts of pyroxene and hornblende. Forms part of a pyroxenite complex at Vermilion Mountain.

**Cy** Pyroxenite (Cretaceous)—Found only in intrusive complex at Bairy Creek-Vermilion Mountain. A core of biotite is surrounded by coarse-grained biotite pyroxenite that in turn is ringed by magnetite pyroxenite (Boettcher, 1967).

**Cc** Cambrian sedimentary rocks, undivided—Used on cross sections where thickness of individual Cambrian formations is uncertain.

**Dolomite and limestone (Cambrian)**—Unnamed gray to tan dolomite and minor limestone containing shaly intervals (Aasland, 1977). Referred to as the dolomite of Fishtrap Creek by Bush (Bush and others, 1985), who identified small outcrops of Ordovician strata above the Cambrian strata near Fishtrap Lake.

**Wolsey Shale and Flathead Quartzite (Middle Cambrian)**—Wolsey Shale is an olive-blastic shale that contains trilobites and brachiopods of early Middle Cambrian age (Horn and Becker, 1968). The shale sharply overlies the Flathead Quartzite, which is a buff quartzite that grades down into massive quartzite at base; sparse trace fossils near base.

**Mafic sills (Late and Middle Proterozoic)**—Diorite to gabbro that commonly show alteration of the mafic minerals. Sills range in thickness from 3 to about 200 ft. Only larger or more persistent sills shown. Used above the Flathead Formation.

**Libby Formation (Middle Proterozoic)**—Upper part is greenish-gray silty argillite underlain by hummocky crossbedded coarse siltite and fine-grained quartzite; lower part is greenish-gray stromatolite and oolitic siltite underlain by black laminated argillite (Kiddler, 1986). Lower part contains chert in chips and thin beds. Upper and lower parts mapped together (Yl) in most of the map area.

**Upper part of Libby Formation**—Shown separately only on Flagstaff Mountain west of Libby.

**McNamara Formation (Middle Proterozoic)**—In the southern part of the map area (south of Highway 2) consists of alternating beds of laminated red argillite and green argillite. Displays small-scale cut-and-fill structures, mud chips, chert chips, thin chert beds, ripple marks, and thin crossbedded coarse-grained siltite lenses. Northern part of the area has only the green-bed facies.

**Bonner Quartzite (Middle Proterozoic)**—Red to pink, micaceous, argillite, crossbedded, fine- to medium-grained quartzite containing red argillite interbeds. Beds of red argillite and red planar laminated siltite increase in abundance to north.

**Siltite facies of Bonner Quartzite**—Predominates near Libby, Montana.

**Mount Shields Formation (Middle Proterozoic)**—The Mount Shields Formation consists of an informal member in the map area. Member 6, at the top of the formation, is thinly interbedded black and white argillite. Member 5, is characterized by limestone that has a conspicuous bow-tie structure; the limestone is interbedded with green dolomitic silty argillite. Member 4 is similar to the green beds of member 5. Member 3 consists of beds of red interbedded argillite and siltite that alternate with beds of green interbedded argillite and siltite; salt casts are common. Member 2 is a planar-laminated purple or green coarse-grained siltite that has carbonate lenses and streaks; at its top is a zone of red stromatolites. Member 1, at the base of the formation, is a massive micaceous quartzite and siltite that has red argillite films on bedding surfaces.

**Upper part—members 6 and 5. Mapped locally**

**Yp** Shepard Formation (Middle Proterozoic)—Dominant lithology is siltite, pale-green argillite, pale-green argillite. Also contains green dolomitic argillite and siltite. Beds of black and white argillite, and interbedded argillite and siltite, and white quartzite are sparse. Stromatolite at places.

**Yq** Purcell Lava (Middle Proterozoic)—Fine-grained to porphyritic basalt.

**Yr** Snowplow Formation (Middle Proterozoic)—Two facies of the Snowplow are exposed in the area. One facies (Yr1) is similar to the Snowplow in its type section (Chilcote, 1963). It is purple-red interbedded argillite and siltite interbedded with green argillite and siltite. The other facies (Yr2) is a zone of black and green interbedded argillite and siltite occurs slightly above the middle of the unit. The red and green facies occur in the northernmost exposures of Snowplow and in the southern third of the map area. It grades through loss of red beds to the green facies (Yr3) in the remainder of the map area.

**Ys** Green facies—Dominantly green interbedded argillite and siltite. On Government Mountain, more than one zone of black and green interbedded argillite and siltite occurs in the map area.

**Yt** Shepard, Snowplow, and Wallace Formations, undivided (Middle Proterozoic)—Unit mapped only in Cabinet Mountains Wilderness Area.

**Yv** Wallace Formation (Middle Proterozoic)—Used where subdivisions of the Wallace are uncertain or were not mapped separately. Most commonly a combination of the lower and middle members.

**Yw** Upper member—Very thickly interbedded black and green to dark green and light green argillite. Grades into green facies of the Snowplow Formation.

**Yx** Middle member—Wavy interbedded black laminated argillite and white coarse siltite or very fine grained quartzite. Top and base commonly calcareous and dolomitic. Calcite is in vertical wavy ribbons (molar tooth structure), vertical and horizontal pods; dolomite is in cement.

**Yy** Lower member—Blocky green calcareous and dolomitic argillite and argillite siltite. Molar tooth structure and calcite pods present in some exposures. Dense, orange-weathering dolomite beds sparsely present in north where lower member intertongues with the lower part of the Helena Formation. Inch-thick to foot-thick white quartzite beds scattered through the member.

**Yz** Helena and Wallace Formations (Middle Proterozoic)—Intertongued main body of the Helena Formation and middle member of the Wallace Formation.

**Y1** Main body of the Helena Formation (Middle Proterozoic)—Gray limestone and dolomite, commonly in massive beds a few feet thick. Upper unit is dense orange-weathering gray dolomite; middle unit is gray dolomitic siltite displaying molar tooth structure plus horizontal and vertical pods of calcite; base of cycle is a thin white quartzite or layer of wavy bedded black argillite and white quartzite.

**Y2** Lower member—Dense orange-weathering dolomite commonly displaying molar tooth and pod structures. Interbedded with layers of thinly interbedded brown-weathering, very fine grained quartzite and apple-green argillite.

**Y3** Empire Formation (Middle Proterozoic)—Thinly interbedded dark-green argillite and green argillite or argillite and siltite. Beds of pink planar-laminated siltite are particularly common in center of unit. Displays mud cracks, ripple marks, fluid-escape structures, mud-chip breccias, and small ball-and-pillow structures. At places has dolomite cement and scattered siderite specks.

**Y4** St. Regis Formation (Middle Proterozoic)—Alternating beds of a few feet of thick, purple interbedded argillite and siltite and green interbedded argillite and siltite. Commonly displays mud chips, mud cracks, ripple marks, and fluid-escape structures.

**Y5** Spokane Formation (Middle Proterozoic)—Interbedded beds of purple argillite and green argillite or argillite and siltite. Beds of pink planar-laminated siltite are particularly common in center of unit. Displays mud cracks, ripple marks, fluid-escape structures, mud-chip breccias, and small ball-and-pillow structures. At places has dolomite cement and scattered siderite specks.

**Y6** Revett Formation (Middle Proterozoic)—Mostly blocky, medium grained, crossbedded quartzite and siltite. Upper and lower parts quartzite plus interbedded argillite and siltite in middle part. Quartzite is white to buff in southernmost part of map area where siltite and argillite are mostly green. Conspicuous brown-weathering carbonate cement west of Bull River. To east and north, beds become mostly purple to purple gray and amount of quartzite increases. Hosts major stratabound silver-copper deposits west of Bull Lake and in southern part of Cabinet Mountains.

**Y7** Burke Formation (Middle Proterozoic)—The Burke Formation can, in most areas, be divided into three units. An upper member is dominantly purple argillite and siltite interbedded with green argillite and siltite. The middle member is dominantly planar laminated purple to gray-green argillite. The lower member is blocky to fluggy greenish-gray argillite and argillite. Thin subhorizontal magenta beds are abundant in the lower member and lens conspicuous in the middle member. Biotite porphyroblasts are common in the lower member and decrease in abundance upward in the formation. Includes the transition member of the Flathead Formation as mapped on the east flank of the Cabinet Mountains.

**Y8** Pritchard Formation (Middle Proterozoic)—This formation is the basal and thickest formation of the Bull Supergroup. Several informal members or combinations of members have been used on the map.

**Transition member**—This member consists of beds similar to those of the lower member of the Burke Formation, interbedded with black and gray pyritic laminated argillite of the upper member of the Pritchard Formation. Argillite increases in abundance toward the base. This member was included with the Burke Formation on the east flank of the Cabinet Mountains.

**Upper member**—Black and light gray thinly interbedded argillite and siltite argillite, commonly biotitic. Weathers rusty brown due to disseminated quartz of pyrite and pyrrhotite.

**Transition and upper members, undivided**—Used only in southern part of map area.

**Quartzite member**—Mostly dark to light gray fine-grained to very fine grained argillite quartzite. Includes beds of gray siltite and dark gray argillite. Also contains marker beds of interbedded dark-green and light-gray argillite. Biotitic.

**Argillite member in quartzite member**—Mostly dark-gray, massive, silty argillite separating the upper part of the quartzite member from the lower part. Biotitic.

**Lower part**—A more argillite facies of the quartzite member and similar to lower part of the Pritchard as described for the area southwest of Plains, Montana (Creasman, 1984). Precise relations between Y8 and Y9 are not known, and units are arbitrarily separated on cross sections of plate 2.

**Structural features:**

- Contact—Dotted where concealed
- Fault—Dotted where concealed, bar and ball downthrown side, arrows show direction of apparent strike slip
- Thrust fault—Sawtooth on upper plate, bars on downthrown side
- Thrust fault with later normal throw—Dotted where concealed; Sawtooth on upper plate, bars on downthrown side
- Anticline—Showing direction of plunge
- Overturned anticline—Showing direction of dip of limbs
- Syncline—Showing direction of plunge
- Monoclinial fold—Showing direction of plunge

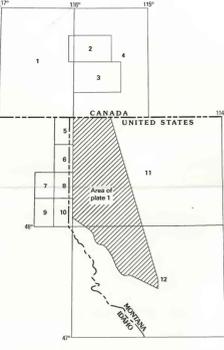
**Strike and dip of beds:**

- Inclined
- Vertical
- Horizontal
- Overturned

**Other symbols:**

- MT-1 Location and number of seismic traverse
- A-A Line of geologic section shown on plate 2

Base from U.S. Geological Survey, 1983.  
Map scale 1:125,000.  
Horizontal datum: North American Datum of 1983.  
Vertical datum: Mean Sea Level.  
Transverse mercator projection.



- SOURCES OF GEOLOGIC DATA**
1. Creasman, E.R., in Creasman, E.R., and Harrison, J.E., 1986 (scale 1:48,000).
  2. Creasman, E.R., U.S. Geological Survey unpublished mapping at 1:250,000.
  3. Van Loenen, R.E., 1984 (scale 1:50,000).
  4. Harrison, J.E., U.S. Geological Survey unpublished mapping at 1:250,000.
  5. ASARCO Staff, unpublished mapping at 1:12,000 to 1:24,000.
  6. Earhart, R.L., 1981 (Plate 1, scale 1:62,500).
  7. Wells, J.D., and Linday, D.A., and Van Loenen, R.E., 1981 (Plate 1, scale 1:62,500).
  8. Griggs, A.B., in Harrison, J.E., Griggs, A.B., and Wells, J.D., 1986 (scale 1:250,000).
  9. Field relations by J.E. Harrison and J.D. Wells of Griggs, A.B., in Harrison, J.E., and Creasman, E.R., and Whipple, A.W., 1988 (scale 1:250,000).
  10. Harrison, J.E., and Griggs, A.B., and Wells, J.D., 1986 (scale 1:250,000).

SCALE 1:125,000  
CONTOUR INTERVAL 100 FEET