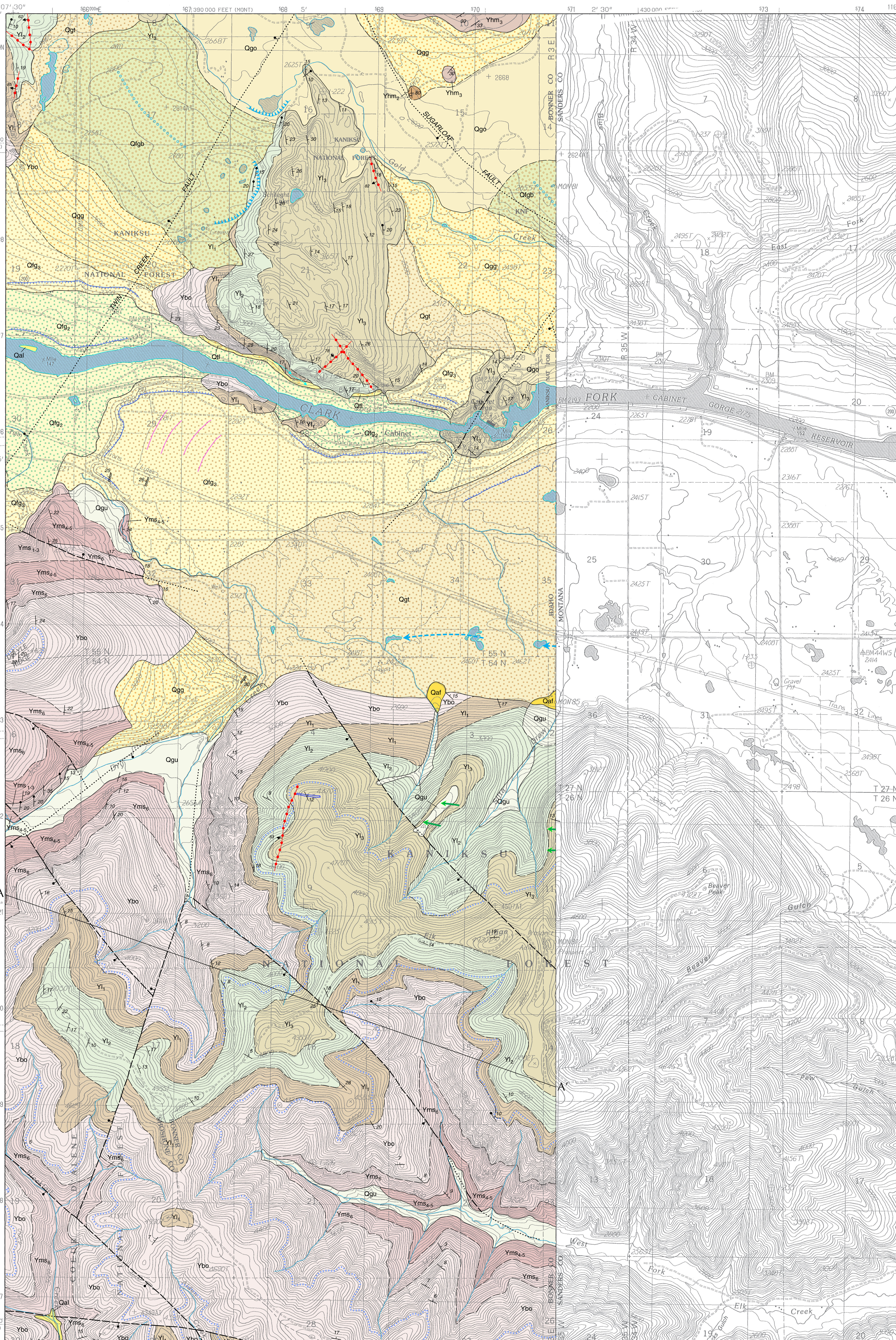
Geologic Map of the Cabinet Quadrangle, Bonner and Shoshone Counties, Idaho

Compiled and Mapped by
Mark D. McFadden, Roy M. Breckenridge, Russell F. Burmester, and Reed S. Lewis

2006

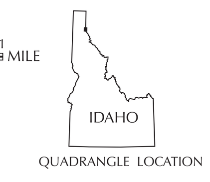


Base map scanned from USGS film-positive base, 1989.
Topography by photogrammetric methods from aerial photographs taken 1986. Field checked 1987. Map edited 1989.
Transverse Mercator projection. 1927 North American Datum.
10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.

UTM Grid and 1989 Magnetic North Declination at Center of Map

SCALE 1:24,000

Contour interval 40 feet



QUADRANGLE LOCATION

Field work conducted 2004.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program.

Digital cartography by Jesse S. Bird and Loudon R. Stanford at the Idaho Geological Survey's Digital Mapping Lab.

Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run but not to the fading caused by long-term exposure to light.

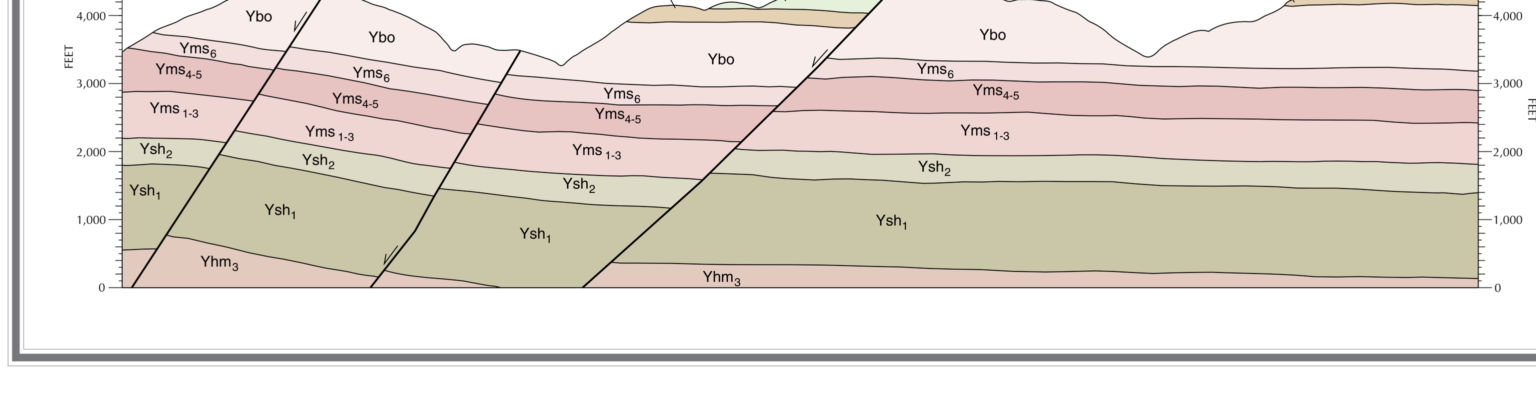
Map version 3-13-2006.

PDF map (Acrobat Reader) may be viewed at www.idahogeology.org.

INTRODUCTION

Geology depicted on this 1:24,000-scale Cabinet 7 1/2' quadrangle is based partly on previous 15' mapping by Harrison and Jobin (1963). The area was remapped at a larger scale primarily to show glacial and flood-related deposits that record Pleistocene glacial and flood events. In addition, we remapped the bedrock during five weeks of fieldwork in 2004 to apply some different unit definitions and contact placements for consistency with more current mapping. See Harrison and Jobin (1963) for the history of naming units in the area; departures from their naming scheme are explained below within descriptions of affected units. Overall, the bedrock areas of the map differ little from Harrison and Jobin (1963); visual differences are attributable to slight changes in placement of contacts, including faults, and the more detailed topography of the 1:24,000 base map.

Bedrock in the Cabinet quadrangle is low metamorphic grade metasedimentary rocks of the upper part of the Belt-Purcell Supergroup, Precambrian in age. Sediments in the Clark Fork drainage date from Pleistocene glaciation and multiple catastrophic floods from glacial Lake Missoula. The terminus of a late Wisconsin ice tongue advancing east up the Clark Fork was positioned from the town of Clark Fork to as much as 30 kilometers up valley. Glacial deposits show that one of the latest advances was located near the Idaho-Montana state line.



DESCRIPTION OF ROCK UNITS

Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale (Wentworth, 1922). Bedding thickness and lamination type are after McKee and Weir (1963) and Winston (1986). Thicknesses and distances are given in abbreviation of metric units (e.g., dm=decimeter). Multiple lithologies within a rock unit are listed in order of decreasing abundance. Soil series after Weisel and others (1982).

ALLUVIAL AND LACUSTRINE DEPOSITS

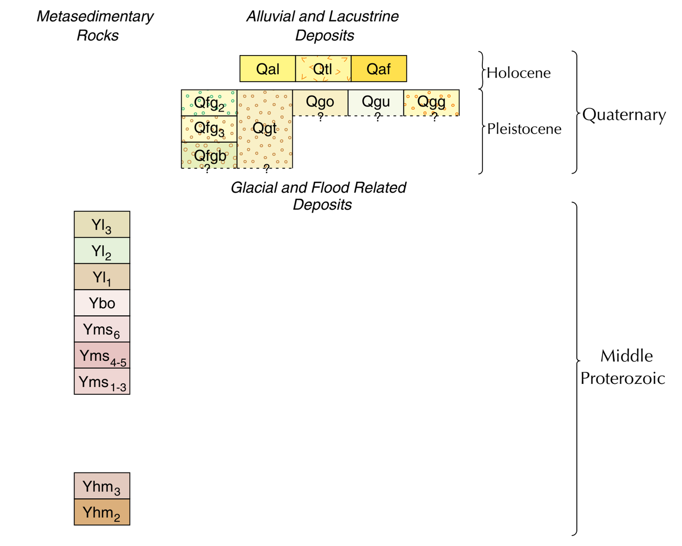
Qtl **Talus (Holocene)**—Blocky and tabular, poorly sorted angular clasts of Belt Supergroup rocks forms talus deposits below cliffs oversteepened by glaciation and flood scour. Locally mined for decorative stone. Mining of these deposits has revealed scour features preserved by the talus aprons. Generally no soil development. Varied thickness usually 3-9 m (10-30 feet).

Qal **Alluvium (Holocene)**—Mixed fine- to coarse-grained sand and gravel deposits in modern stream valleys tributary to the Clark Fork. Some coarse gravel clasts are reworked from older Holocene and Pleistocene alluvial and glacial units. Soils are silt to sandy loams of the Capehorn and Colburn series. Varied thickness usually 1-3 m (3-10 feet).

Qaf **Alluvial fan deposits (Holocene)**—Mixed pebble to cobble gravel deposited as fans at the mouth of local drainages. Mostly subangular to angular platy clasts derived locally from the Belt-Purcell Supergroup. Soils mainly of the Colburn, Pend Oreille, and Bonners series. Thickness 1-10 m (3-33 feet).

Disclaimer: This Digital Web Map is an informal report and may be revised and formally published at a later time. Its content and format may not conform to agency standards.

CORRELATION OF MAP UNITS



GLACIAL AND FLOOD-RELATED DEPOSITS

Qgu **Glacial deposits, undivided (Pleistocene)**—Gravel, sand, and silt deposits of till and associated proglacial outwash and glacial sediments. Unstratified to poorly bedded, unsorted to moderately sorted. Mostly isolated remnants of moraines and terraces, preserved on slopes along valley sides and in smaller tributaries. May include some interbedded lake sediments. Thickness 1-10 m (3-33 feet).

Qfg_2 **Gravels of Missoula Floods, terrace 2 (Pleistocene)**—Moderately sorted pebble to boulder gravel. Locally mantled by silt of the latest phases of glacial Lake Missoula that post-date episodes of catastrophic flooding. Except for the silt mantle the deposit lacks interstitial fines (boxwork texture). Moderately stratified to unstratified depending on the depositional landform. In the Cabinet quadrangle, the surface of this unit exhibits a series of giant current ripples deposited by the latest floods from Glacial Lake Missoula about ,000 years ago. Forms the middle of three terrace levels of flood gravel at about 630-660 meters (2100-2200 feet) in the lower Clark Fork River valley. The lower terrace (*Qfg_1*) is not present in the Cabinet quadrangle. Soils of the Odenson and Wrencoe series.

Qfg_3 **Gravels of Missoula Floods, terrace 3 (Pleistocene)**—Moderately sorted pebble to boulder gravel. Locally mantled by silt of the latest phases of glacial Lake Missoula that post-date episodes of catastrophic flooding. Except for the silt mantle the deposit lacks interstitial fines (boxwork texture). Moderately to stratified to unstratified depending on the depositional landform. In the Cabinet quadrangle, the surface of this unit exhibits giant current ripples deposited by the latest floods from Glacial Lake Missoula about 12,000 years ago. Forms the highest of three terrace levels of flood gravel at about 670-690 meters (2260-2290 feet) in the lower Clark Fork River valley. Soils of the Odenson and Wrencoe series.

Qfgb **Glacial flood bar deposits (Pleistocene)**—Crudely sorted and bedded cobble to boulder gravel forms large-scale expansion bars in the lee of bedrock knobs in the Clark Fork Valley. Exhibits large scale cross beds indicating high flow regime in deeper water of larger Missoula flood events. Mostly preserved on the north side of the Clark Fork valley with crests at elevations as high as 840 m (2800 feet). Soils of the Cabinet and Klootch series.

Qgt **Till deposits (Pleistocene)**—Dense clayey pebble and cobble till with local boulders deposited by the Clark Fork tongue of the Purcell Trench Lobe. Compact basal till includes ground moraine and some proglacial deposits formed by calving and meltwater discharge into Glacial Lake Missoula. Soils of the Pend Oreille and Vay-Ardtoo series. Thickness varies; may exceed 50 m (160 feet).

Qgo **Outwash gravel (Pleistocene)**—Unsorted to moderately sorted, sandy pebble to boulder gravel. Rounded to subrounded intrusive clasts and subrounded to subangular Belt-Purcell Supergroup clasts. Coarsely stratified to moderately stratified and locally interbedded with ice contact and some glaciolacustrine sediments. Soils of the Bonner series. Thickness 30 m (100 feet) or more.

Qgg **Gravels of glacial origin (Pleistocene)**—Poorly rounded unsorted gravels; includes proglacial outwash and englacial drift deposits. Probably deposited by a post-Missoula floods advance of the Clark Fork ice tongue up the Clark Fork valley into a late Glacial Lake Missoula. Forms large deposit at the mouth of Dry Creek exhibiting Gilbert-type cross-bedding that dips up the Clark Fork valley. Soils of the Pend Oreille series and Vay-Ardtoo association. Thickness 15 m (50 feet).

BELT-PURCELL SUPERGROUP

Libby Formation (Middle Proterozoic)—Laminated to microlaminated dark gray to black argillite and white to light gray to pale green siltite, tan-weathering dolomitic siltite, oolite and stromatolites. Highly resistant, chert-like material superficially resembling argillite commonly occurs as silicified mud-cracked tops of siltite and argillite couplets and mud chips. We followed Harrison and Jobin's (1963) subdivisions of the Libby because the same system was used to the east in Montana (Harrison and others, 1992). Best exposed north of the Clark Fork River; weathered and discontinuously exposed south of the river.

Yl_3 **Libby Formation, member 3 (Middle Proterozoic)**—Microlaminated to laminated, dark gray to black argillite and light gray to white siltite interstratified with laminated pale green argillite and olive siltite, with scattered carbonate layers of low domal stromatolites and thin (<10 cm) oolite beds. Mudcracked tops, mudchips, and small-scale cross-laminated bases common within the green siltite-argillite intervals. Olive siltite commonly dolomitic, weathering to characteristic tan color. Silicification varied, but especially common within pale green argillite and argillite mudchips. Poorly exposed; mostly seen as chips in steeper slopes. Similar to Kidder's (1988) member C except that it includes some carbonate near the base. Top eroded in map area so thickness unknown. Minimum thickness 360 m (1200 feet).

Yl_2 **Libby Formation, member 2 (Middle Proterozoic)**—Laminated to less commonly microlaminated pale green to olive siltite and lighter green argillite. Siltite layers, commonly a few cm thick with much thinner argillite caps, commonly display loaded bases and internal low angle cross-lamination. Deep mudcracks to 5 cm disrupt both siltite and argillite layers; some may be dewatering structures. Thin mudchips of pale green argillite ubiquitous and commonly silicified. Silicification of strata most common within the mm-thick argillite layers, although patchy silicification affects both siltite and argillite throughout unit. Upper part of unit contains multiple layers of low, domal stromatolites and punky, recessively weathering layers of oolite 1-10 cm thick. Upper contact placed above the concentrated stromatolitic and oolitic carbonate beds and below a concentration of microlaminated to laminated white siltite and black argillite at base of *Yl3*. Unit similar to Kidder's (1988) member B but excludes gray argillite at top and base included in B. Thickness about 180 m (600 feet); corresponds to calcareous member of Harrison and Jobin (1963), with reported thickness of 600 feet (180 m).

Yl_1 **Libby Formation, member 1 (Middle Proterozoic)**—Laminated to microlaminated light gray to white to green siltite and dark gray to black argillite and minor dolomitic gray siltite and stromatolites. Lamination mostly wavy and uneven. Graded gray siltite and black argillite couplets locally disrupted by ptygmatic silt-filled cracks. Elsewhere, lamination thinner with more distinct siltite and argillite lamina. Commonly rusty weathering. Includes scattered and discontinuous gray siltite layers to 5 cm thick, with olive-colored cm-scale siltite beds more abundant in upper part and low domal stromatolites at the top. Upper contact is placed above the stromatolitic zone that is above the highest occurrence of the microlaminated white siltite and black argillite. Distinct white and black striped appearance, ptygmatic siltite dikelets, and parallel laminated intervals that contain thin zones of contorted and folded microlaminations and laminations distinguish this black argillite unit from others. Unit is best exposed in roadside cliffs along Highway 200, as well as on the steep canyon walls on the upper West Fork of the Elk Creek drainage. Similar to Kidder's (1988) member A but includes about 10 m (30 feet; Harrison and Jobin, 1963) of carbonate-bearing (stromatolitic) layers included in Kidder's member B. Thickness about 80 m (250 feet); corresponds to laminated argillite and siltite member of Harrison and Jobin (1963), who reported a thickness of 230 feet (70 m).

Ybo **Bonner Formation (Middle Proterozoic)**—Pink, red, and green fine- to medium-grained feldspathic quartzite, siltite, and argillite that typically form resistant, cliffy outcrops in the map area. Characterized by 10-30 cm, tabular beds of flat-laminated pink quartzite with microlaminated to laminated red argillite caps. Internal lamination of quartzite beds commonly defined by discontinuous wisps of red argillite or mm thin red argillite mudchips. Some parting surfaces nearly covered with detrital muscovite flakes up to 4 mm across. Plagioclase feldspar is more abundant (20 percent) than potassium feldspar (5 percent). Base is gradual transition from the underlying dark green and gray laminated siltite and argillite of *Yms_6* with increasing abundance of 10-30 cm tabular light to medium green quartzite beds. These have thin, discontinuous lenses or lags of well-rounded medium quartz grains, less feldspar than overlying red quartzite, and typically mm-thick, cracked light green argillite caps. Some green siltite with mm-thick black laminated caps also present. Well-rounded medium quartz grains also in wispy lenses of white sand lags typically less than one cm thick at bases of some red quartzite beds higher in the section. Interstratified with the red quartzite are intervals of laminated pink quartzite and red argillite and wavy laminated green siltite and green argillite in zones 10-30 cm thick. These zones decrease upwards from constituting about half to about one quarter of the strata. At the top of *Ybo* are minor very thin beds of green quartzite, overlain by several beds of white quartzite 5-10 cm thick with well-rounded medium grains. Upper white quartzite is less feldspathic than lower pink quartzite. Upper contact placed at lowest appearance of dark gray argillite and gray to white siltite of overlying *Yl_1*. Zircons from a thin tuff at this contact about 40 km NE yielded an age of 1.401 Ga (U-Pb; Evans and others, 2000). Three or more distinct marker horizons that may be other tuffs are present within the Bonner Formation in the Derr Point quadrangle to the west, and are likely in this quadrangle too. The markers consist of 3-20 cm thick couplets to couples of dark purple to nearly black, flat-laminated siltite and thinner light green argillite. The marker horizons are distinctly smooth and fracture conchoidally; the lowest two occur approximately 200 feet (60 m) from the base of the unit where predominately green quartzite passes upward into predominately red quartzite; the next marker is approximately 200-300 feet (60-90 m) higher in the section within predominately red quartzite. Bonner resembles Mount Shields members 1 and 2 except has more and coarser detrital muscovite, coarser grained quartzite and less common rippled and mud cracked surfaces. Distinguished from the Mount Shields Formation members 1-3 by medium sand grains in basal lags and rare higher beds, coarser and generally more abundant muscovite on some parting surfaces, wispy occurrence of argillite and thin mudchips in dm quartzite beds, lack of salt casts and greater abundance of mm rusty spots in many quartzites. Best exposed in cliffs east of Dry Creek and north of West Fork Elk Creek. Thickness approximately 270 m (900 feet) (650-700 feet; Harrison and Jobin, 1963). Equivalent to Bonner Quartzite in the Missoula area (Nelson and Dobell, 1961). Name changed from Harrison and Jobin's (1963) Striped Peak 4 to allow underlying strata to be assigned to the Mount Shields Formation.

Mount Shields Formation (Middle Proterozoic)—Red, green, and gray quartzite, red and green siltite, red, green, and gray to black argillite and minor carbonate. Previously assigned to the Striped Peak Formation (Harrison and Jobin, 1963) but reassigned here because strata are more like strata mapped to the east as Mount Shields Formation (Harrison and others, 1992) than strata on Striped Peak southwest of Wallace, Idaho (Lewis and others, 1999).

Yms_6 **Mount Shields Formation, member 6 (Middle Proterozoic)**—Rusty weathering, unevenly laminated to planar microlaminated, white to dark greenish gray siltite and dark greenish gray to black argillite, and rare gray to greenish-gray siltite and quartzite in tabular beds up to 20 cm thick. Small and very thin dark gray argillite chips occur sparsely within some 10 cm dark gray argillite layers. Rare cm-wide, long, straight cracks and parallel cracks are present, and fine-grained muscovite is common on bedding plane partings. Includes intervals of soft sediment deformation and truncated laminations throughout the unit; scour channels up to 30 cm wide and 20-40 cm deep commonly exhibit loaded lower margins, and are infilled with lenses of horizontally microlaminated to laminated and cross-laminated siltite and argillite. Some load structures exhibit possible channel erosion at their margins. Upper contact placed at lowest appearance of thin (cm) layers of medium-grained feldspathic quartzite. Unit typically provides poor root support for trees and forms open grassy slopes in map area, although may form prominent cliff outcrops in areas of steep topography, such as those eroded by glacial ice. Best exposed on the east side of Dry Creek and canyons of Blacktail and West Fork Elk creeks. Thickness approximately 170 m (500-600 feet). Mapped as Striped Peak 3 by Harrison and Jobin (1963) who estimated thickness as 300 feet (90 m). Unit equivalent to the Mount Shields Formation member 6 to the northeast in the Kalispell quadrangle (Harrison and others, 1992).

Yms_{4-5} **Mount Shields Formation, members 4 and 5 (Middle Proterozoic)**—Tan-weathering, bluish-gray and bluish-green dolomitic siltite and white stromatolitic dolomite. Lower part carbonate-poor green, and lesser red, siltite and argillite with salt casts common on green argillite parting surfaces. Grades upward from *Yms_{1-3}* with increasing carbonate content. Includes common cm-thick, rarely carbonate-rich silitite with tan weathering rinds. Upper part mostly gray to tan-weathering, locally resistant bluish-gray and white dm-scale beds of stromatolitic dolomite characterized by distinctive "boxwork" weathering pattern formed by etching out of resistant, mm-thick vertical and horizontal siliceous sheets along joints and cryptalgal laminations. Algal mats typically flat, but intergrown with rare low domal stromatolites 5-10 cm high and 10-30 cm across. Thin layers of "boxwork" carbonate also occur near the base and scattered throughout the unit, and rare 5-20 cm oolite layers occur below middle but are more common and locally silicified toward the top. Contains common 1-2 m intervals of cm-parting dolomitic siltite and argillite that is generally poorly exposed. Salt casts in carbonate bearing and brown weathering siltite and argillite most common above middle of unit. Lower part weathers recessively, forming topographic benches and poor outcrop; commonly represented by float of platy, tan-weathering, cm-thick light green siltite. "Boxwork" commonly forms lag boulders in areas of subdued topography where outcrop is sparse. Upper contact placed above highest "boxwork" carbonate at lowest occurrence of rusty weathering, resistant, laminated dark siltite and argillite of overlying *Yms_6*. Thickness approximately 200 m (600-700 feet) (400 feet when mapped as Striped Peak 2 by Harrison and Jobin, 1963). Difference in thickness may be partly real and partly from different criteria in picking base of carbonate beds in areas of poor exposures. Best exposed along lower Dry Creek Road.

Yms_{1-3} **Mount Shields Formation, members 1, 2, and 3 (Middle Proterozoic)**—Pale purplish-red, fine-grained, flat-laminated quartzite, and green and red argillite and siltite; minor carbonate and stromatolites. Only upper part exposed in map area; consists of couplets of light green siltite and argillite, 10 cm apple-green siltite, green and red siltite and argillite couples and couplets, and abundant salt casts, mudcracks, and mudchips. Distinguished from Bonner Formation in having sedimentary structures, such as mud cracks and ripples, more abundant and better preserved on bedding surfaces. Limited mineralogical data indicate that potassium feldspar is more abundant (20 percent) than in *Ybo*. Previously mapped as Striped Peak 1 (Harrison and Jobin, 1963). Equivalent to lowest three members of the Mount Shields Formation mapped to the northeast in the Kalispell quadrangle (Harrison and others, 1992).

Argillite of Howe Mountain (Middle Proterozoic)—Gray and green siltite and dark green and gray argillite, subordinate pale green fine-grained quartzite, and minor carbonate. Gray argillite weathers lighter while accompanying siltite weathers dark rusty red. Green intervals weather yellowish. Corresponds to upper Wallace member 1 to the south (Lewis and others, 2002). Name changed to avoid confusion with upper Wallace that includes Shepard Formation interval elsewhere in Idaho. Corresponds to Snowslip Formation to the north (Burmester, 1986) and east (Harrison and others, 1992). Subdivided into three units where exposure adequate. Only the highest unit exposed in the area; it corresponds closely to the top of the argillite, siltite, and limestone member (Wallace 3) of Harrison and Jobin (1963). Age of the top of unit is approximately that of the Purcell lavas, which occur close to the Snowslip-Shepard contact to the northeast and east (Harrison and others, 1992). Rhyolite in the Purcell lava about 100 km NNE is 1.443 Ga (Evans and others, 2000). Thickness about 760 m (2500 feet). Unit only exposed in northeast corner of the map.

Yhm_3 **Argillite of Howe Mountain, member 3 (Middle Proterozoic)**—Dark green siltite and light green to black argillite as uneven microlaminae and wavy or uneven couplets, and subordinate intervals of unevenly laminated light gray siltite and black argillite. Exposed only near northern map boundary. Includes cm- and dm-scale green siltite beds and mudchips. Neither top nor bottom exposed.

Yhm_2 **Argillite of Howe Mountain, member 2 (Middle Proterozoic)**—Single exposure of microlaminated black argillite and gray siltite exposed northeast of Gold Creek. Outcrop highly shattered as a result of movement on the Sugarloaf fault. Neither top nor bottom exposed.

STRUCTURE

Structures in the area include folds, faults and tilted fault blocks. Overall, Belt strata homoclinally dip to the east-southeast. Dips are gentle everywhere except along the Sugarloaf fault. The major structures are described below.

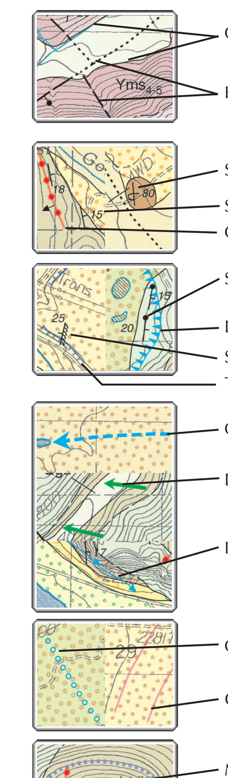
NORTHWEST-STRIKING FAULTS

The southeast continuation of the Sugarloaf fault from the Scotchman Peak quadrangle to the north drops the upper Belt strata exposed over most of the Cabinet quadrangle down against the upper part of the argillite of Howe Mountain. We interpret the shattered microlaminated black argillite and gray siltite northeast of Gold Creek as argillite of Howe Mountain in the footwall along the trace of the fault. This places the fault southwest of where mapped by Harrison and Jobin (1963). Unnamed faults south of the Clark Fork River show similar down to the southwest motion but with considerably less offset.

NORTHEAST-STRIKING FAULTS

The Twin Creek fault is buried by surficial deposits but is a significant down-to the-west normal fault that repeats much of the Bonner and Libby formations. The other northeast-striking faults have considerably less offset. All are down to the northwest and probably normal faults

SYMBOLS



Contact: line showing the boundary between one map unit and another; dashed where approximate. The location accuracy of contact is 80 feet or more on the ground.
High-angle fault: ball and bar indicates downthrown side of a normal fault; dashed where approximately located; dotted where concealed.
Strike and dip of overturned bedding.
Strike and dip of bedding.
Quartz vein: Arrow indicates dip.
Strike and dip of bedding, ball indicates bedding known to be upright.
Dry falls and cataracts of Missoula Floods.
Strike and dip of foreset beds in glacial deposits.
Terrace scarp.
Current direction indicators in Glacial Lake Missoula drainage-ways.
Direction of flow through Missoula Flood gap.
Ice flow direction indicators (glacial striae).
Crest of Missoula Flood gravel bar.
Giant current ripples.
Maximum elevation of Glacial Lake Missoula approximately 4260 feet.
Closed depression (sackung or scour feature).

REFERENCES

Burmester, R.F., 1986, Preliminary geologic map of the Leonia area, Idaho and Montana: U.S. Geological Survey Open File report 86-554, 13 p. and 1:48,000 map.
Evans, K.V., J.N. Aleinikoff, J.D. Obradovich, and C.M. Fanning, 2000, SHRIMP U-Pb geochronology of volcanic rocks, Belt Supergroup, western Montana; evidence for rapid deposition of sedimentary strata: Canadian Journal of Earth Sciences, v. 37, no. 9, p. 1287-1300.
Harrison, J.E., and D.A. Jobin, 1963, Geology of the Clark Fork quadrangle: Idaho-Montana: U.S. Geological Survey Bulletin 1141-K, 38 p.
Harrison, J.E., E.R. Cressman, and J.W. Whipple, 1992, Geologic and structural maps of the Kalispell 1° x 2° quadrangle, Montana, and Alberta and British Columbia: U.S. Geological Survey Miscellaneous Investigations Series Map I-2267, scale 1:250,000.
Kidder, D.L., 1988, Stratigraphy, micropaleontology, petrology, carbonate geochemistry, and depositional history of the Proterozoic Libby Formation, northwestern Montana and northeastern Idaho: U.S. Geological Survey Open-File Report 87-636, 133 p.
Lewis, R.S., R.F. Burmester, R.M Breckenridge, M.D. McFaddan, and J.D. Kauffman, 2002, Geologic map of the Coeur d'Alene 30' x 60' quadrangle, Idaho: Idaho Geologic Survey Geologic Map Series GM-33, scale :100,000.
Lewis, R.S., R.F. Burmester, M.D. McFaddan, P.D. Derkey and J.R. Oblad, 1999, Digital geologic map of the Wallace 1:100,000 quadrangle, Idaho, U.S. Geological Survey Open-File Report 99-390. http://wrgis.wr.usgs.gov/open-file/of99-390/OF99-390.PDF
McKee, E.D., and G.W. Weir, 1963, Terminology for stratification and cross-stratification in sedimentary rocks: Geological Society of America Bulletin, v. 64, p. 381-390.
Nelson, W.H., and J.P. Dobell, 1961, Geology of the Bonner quadrangle, Montana: U.S. Geological Survey Bulletin 111-F, p. 189-235.
Weisel, C.J., P.M. Hartwig, S.D. Keirn, and B.J. Turner, 1982, Soil Survey of Bonner

ACKNOWLEDGMENTS

Mapping and compilation were supported by the U.S. Geological Survey STATEMAP program and the U.S. Geological Survey office in Spokane, Washington.

Published and sold by the Idaho Geological Survey
University of Idaho, Moscow, Idaho 83844-3014