U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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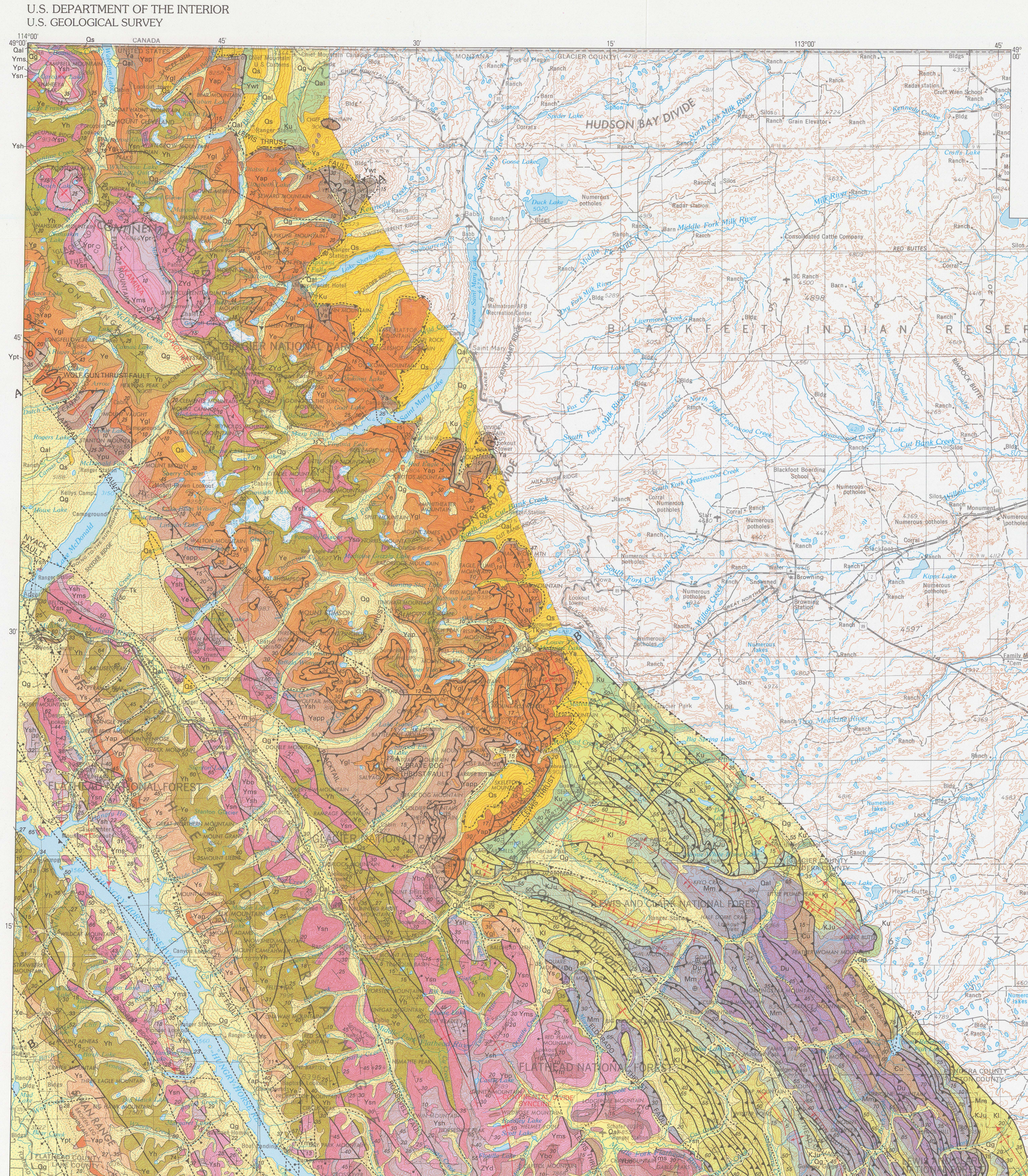
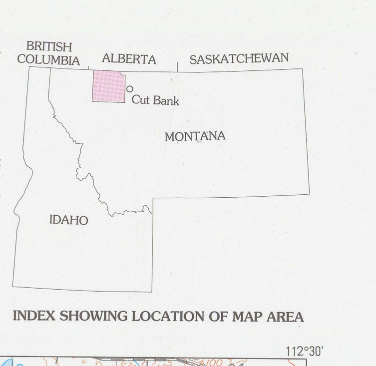
I–2593





INDEX SHOWING LOCATION OF MAP AREA

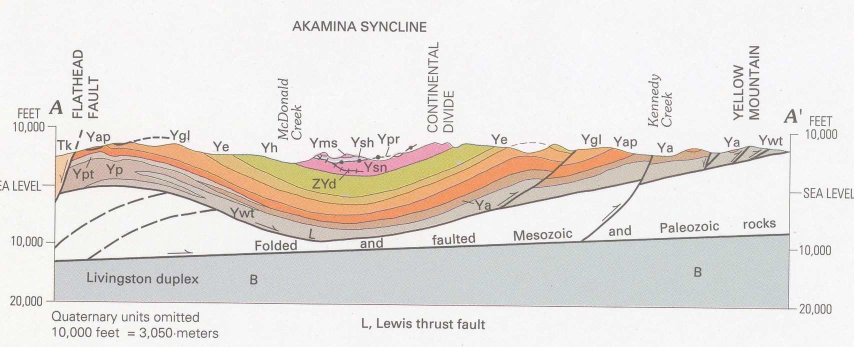
Base from U.S. Geological Survey, 1960; limited revision, 1968
Transverse Mercator projection

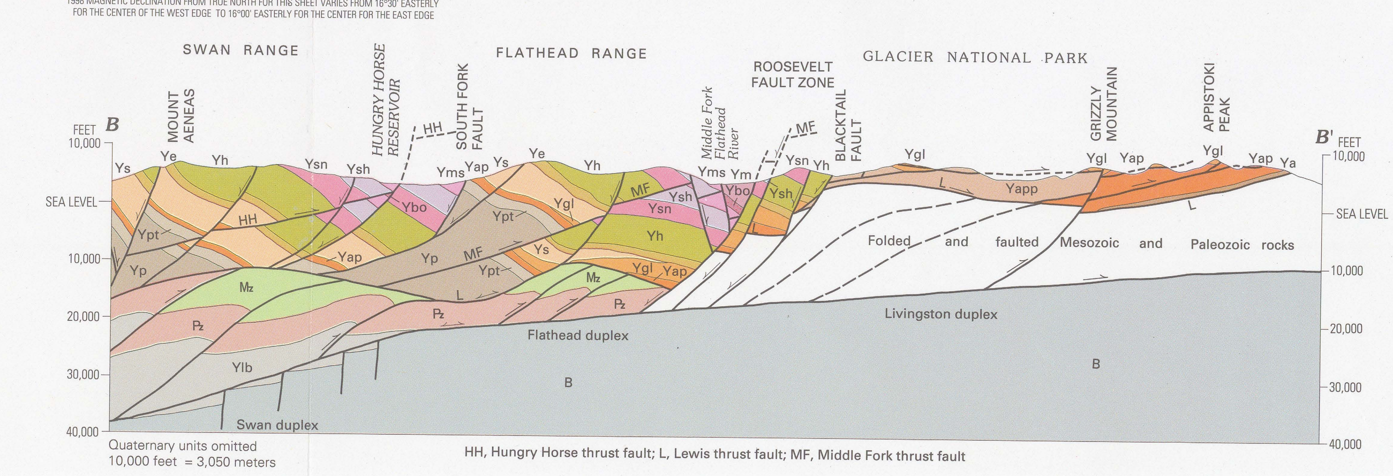
SCALE 1:250 000
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

1998 MAGNETIC DECLINATION FROM TRUE NORTH FOR THIS SHEET VARIES FROM 16°30' EASTERLY FOR THE CENTER OF THE WEST EDGE TO 16°00' EASTERLY FOR THE CENTER FOR THE EAST EDGE

Geology in Swan Range and part of Flathead Range by J.E. Harrison, assisted by J.P. Harrison, 1987-1991
Edited by Alessandro J. Donatich
Color design by Denny Welp
Graphics design by Patricia L. Wilber
Cartography by Joseph A. Romero
Manuscript approved for publication October 15, 1996





HH, Hungry Horse thrust fault; L, Lewis thrust fault; MF, Middle Fork thrust fault

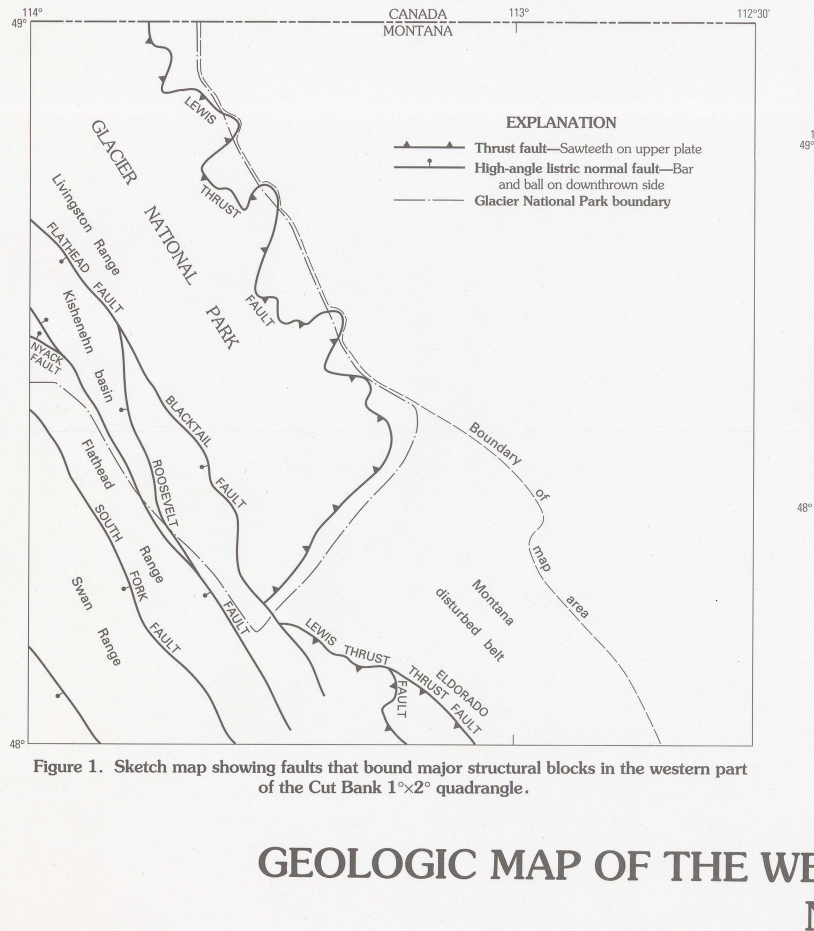
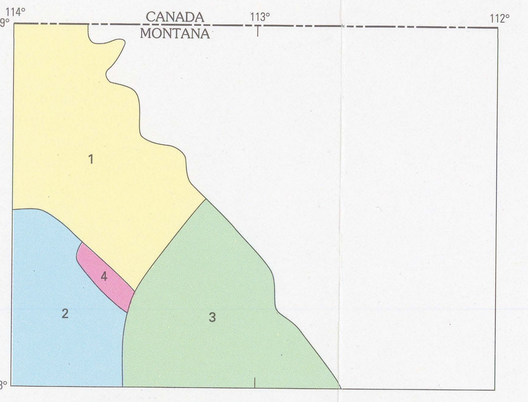


Figure 1. Sketch map showing faults that bound major structural blocks in the western part of the Cut Bank 1°×2° quadrangle.



INDEX TO SOURCES OF GEOLOGIC DATA

SOURCES OF GEOLOGIC DATA

1. Whipple (1992); Carrara (1990)
2. Harrison, J.E., U.S. Geological Survey unpublished mapping
3. Mudge and Earhart (1983)
4. Mudge and Earhart (1991)

CONVERSION FACTORS

Multiply	By	To obtain
inches (in.)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

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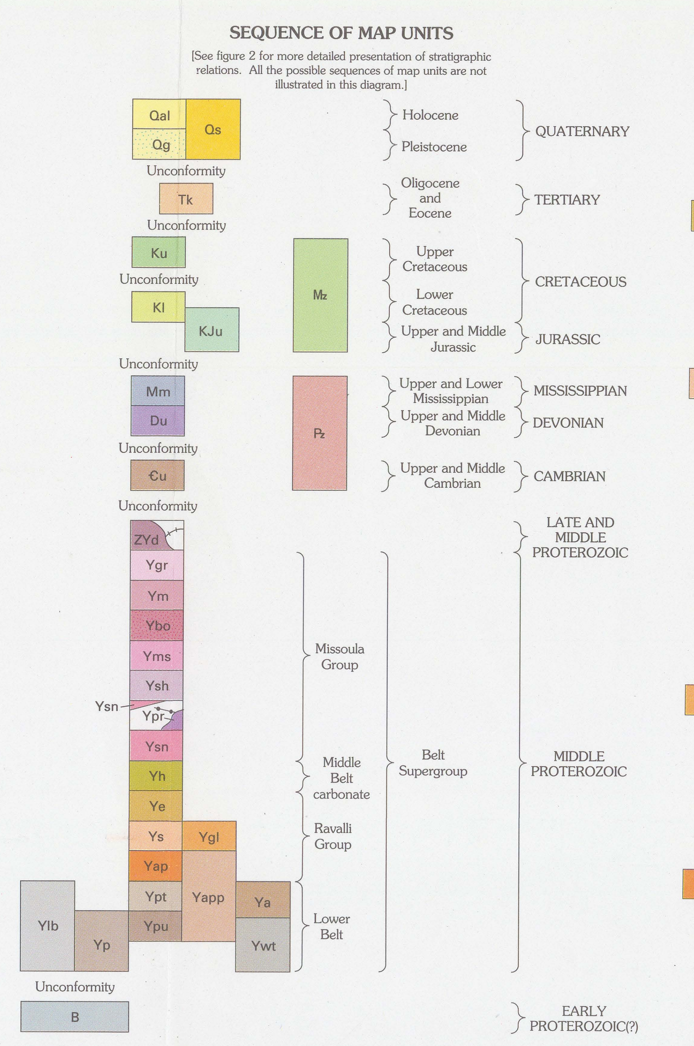
GEOLOGIC MAP OF THE WESTERN PART OF THE CUT BANK 1°×2° QUADRANGLE, NORTHWESTERN MONTANA

Compiled by
Jack E. Harrison, James W. Whipple, and David J. Lidke
1998

For sale by U.S. Geological Survey Information Services
Box 25286, Federal Center, Denver, CO 80225

SEQUENCE OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qal **Alluvial deposits (Holocene)**—Gravel, sand, silt, and clay in flood plains and low terraces along present drainages. Includes alluvial fans

Qs **Landslide deposits (Holocene and Pleistocene)**—Includes large rock slumps, flow, and slides. Generally consists of angular blocks of bedrock in a finer grained matrix; mixed at places with glacial debris. Most abundant on slopes topographically below trace of Lewis thrust fault on east and south sides of Glacier National Park (Carrara, 1990)

Qg **Glacial and fluvioglacial deposits (Pleistocene)**—Includes till (in ground, end, and ablation moraines), outwash, and other fluvioglacial deposits from both continental and mountain glaciers. Includes eskers at a few places in Glacier National Park (Carrara, 1990)

Tk **Kishenehn Formation (Oligocene and Eocene)**—Conglomerate, sandstone, siltstone, marlstone, oil shale, and coal deposited in the Kishenehn basin. About 3,800 ft thick in the valley of the Middle Fork of the Flathead River in central part of map area (Whipple, 1992)

Ku **Upper Cretaceous rocks, undivided**—Mainly dark-gray mudstone of the Marias River Shale as described by Mudge and Earhart (1983). May include the Horsethief Sandstone and St. Mary River Formation at northeast edge of Glacier National Park. At least 1,500 ft thick

Kl **Lower Cretaceous rocks, undivided**—Predominantly gray to olive mudstone and gray sandstone interbedded with some limestone. Includes the Blackleaf, Kootenai, and Mount Pablo Formations as mapped and described by Mudge and Earhart (1983). Thickness about 2,200 ft

KJu **Mount Pablo Formation (Lower Cretaceous), Morrison Formation (Upper Jurassic), and Ellis Group (Upper and Middle Jurassic), undivided**—Includes siltstone, sandstone, and shale accompanied by minor limestone and thin conglomerate at base of some members as mapped and described by Mudge and Earhart (1983). About 1,500 ft thick

Mz **Mesozoic sedimentary rocks, undivided**—Shown only in cross section *B–B'*. Probably at least includes Cretaceous and Jurassic strata mapped by Mudge and Earhart (1983) at southeast end of Glacier National Park where Mesozoic rocks are overridden by the Lewis thrust fault

Mm **Madison Group (Upper and Lower Mississippian)**—Upper part is the Castle Reef Dolomite and lower part is the Allan Mountain Limestone as mapped and described by Mudge and Earhart (1983). About 1,200 ft thick

Du **Three Forks (Upper Devonian), Jefferson (Upper Devonian), and Maywood (Upper and Middle Devonian) Formations, undivided**—Mainly limestone and dolomite in upper part; in lower part mudstone increases downward. Units mapped and described by Mudge and Earhart (1983). About 1,700 ft thick

Ꞓu **Upper and Middle Cambrian rocks, undivided**—Alternating units of carbonate and shale above a basal sandstone. In Montana disturbed belt, includes (in descending order): Devils Glen Dolomite (Upper Cambrian), Switchback Shale (Upper and Middle Cambrian), and Steamboat Limestone, Pentagon Shale, Pagoda Limestone, Dearborn Limestone, Damnation Limestone, Gordon Shale, and Flathead Sandstone (Middle Cambrian) (Mudge and Earhart, 1983). Only lower three or four formations exposed unconformably above Belt rocks in southern part of map area. Maximum exposed thickness about 1,000 ft

Pz **Paleozoic sedimentary rocks, undivided**—Shown only in cross section *B–B'*. Probably includes Mississippian, Devonian, and Cambrian strata as mapped by Mudge and Earhart (1983) south of Glacier National Park

ZYd **Mafic sills and dikes (Late and Middle Proterozoic)**—Dioritic to gabbroic rocks that commonly show alteration of mafic minerals to calcite, epidote, clinozosite, and hematite or limonite. Sills range in thickness from a few tens to a few hundreds of feet. Thicker sills tend to have contact-metamorphic zones around them. Sills commonly persist for many miles and in most places maintain approximately the same stratigraphic position. Locally, they cut across the section at a low angle or, rarely, cut steeply across section to form dikes. Intruded in map area probably at about 1,000 Ma, or 800 Ma, or both (Harrison, 1972)

Ygr **Garnet Range Formation (Middle Proterozoic)**—Gray to olive, micaceous siltite to quartzarenite interlaminated or interbedded with gray-green, micaceous, argillitic siltite. Occurs only in small exposures at south edge of map area beneath Cambrian unconformity. Maximum thickness of remnant about 500 ft

Ym **McNamara Formation (Middle Proterozoic)**—Predominantly grayish-green, interbedded and interlaminated argillite and siltite that contain thin chert laminae and chips. Oolites, stromatolites, quartzarenite, and stratabound cooper minerals present at places. Relatively thin red-bed sequences locally interbedded in the green strata. Small-scale sedimentary features include ripple marks, shrinkage cracks, scours, and crossbeds. Rests sharply on Bonner Quartzite. About 4,000 ft thick

Ybo **Bonner Quartzite (Middle Proterozoic)**—Red to pink, micaceous, arkosic, crossbedded, fine- to medium-grained quartzite containing red argillite interclasts. Tabular and trough crossbeds and climbing ripple marks common. Interbeds of red, laminated argillite and pink, planar-laminated siltite scattered throughout unit. Rests in sharp contact on Mount Shields Formation. Thickness ranges from about 800 to 1,200 ft

Yms **Mount Shields Formation (Middle Proterozoic)**—Consists of a series of informal members similar to those seen to the west in the Kalispell 1°×2° quadrangle (Harrison and others, 1992) where six informal members are described; sequence in the Cut Bank quadrangle is similar, but member **5** is missing. Type section (Childers, 1963), about 2,550 ft thick, is between the Blacktail and Roosevelt faults in southeast corner of Glacier National Park on Mount Shields. Childers did not use the informal members subsequently found to be widespread in the formation. Maximum thickness in map area about 2,900 ft.

Uppermost unit in map area (member **6**) is a thinly laminated, black argillite and white or green siltite that commonly displays small-scale slump folds and shrinkage cracks. Thickness about 200 ft. Conformably below is member **4**, which consists of blocky, green, dolomitic, silty argillite that shows parallel-laminated graded couplets. Foot-thick carbonate beds are scattered throughout unit, as are rare salt casts. Thickness about 900 ft. Grades downward into member **3**, which is predominantly alternating red and green beds of interlaminated argillite and siltite. Mud chips, mud cracks, ripple marks, and fluid-escape structures are common. Salt casts are abundant, particularly in red beds. Thickness about 500 ft. Grades by interlayering, through a few tens of feet, to member **2** below. Member **2** is pale-red, flat-laminated, coarse-grained siltite to fine-grained quartzarenite that is blocky, feldspathic, and dolomitic. Dolomite is in cement or in streaks and pods parallel to bedding. Minor layers of red or green argillite. Red or buff stromatolites and oolites in a zone of one or more beds at top. Thickness about 700 ft. Grades downward into member **1**. Member **1** is red to maroon, feldspathic quartzarenite interbedded with red siltite. Siltite increases in abundance to east and north. Red argillite beds and partings common between coarser grained beds. Cross stratification, mud chips, and heavy-mineral streaks common. Rare stromatolites. Thickness about 600 ft in southern part of map area

Ysh **Shepard Formation (Middle Proterozoic)**—Consists of a variety of rock types, most of which are carbonate bearing or carbonate rich. The most characteristic lithology is green to gray, dolomitic argillite and siltite in even-parallel to wavy laminae that show graded couplets. This rock weathers into distinctive orange-brown platy slabs. Common interbeds a few to a few tens of feet thick include gray dolomitic limestone, stromatolites and oolites, laminated green argillite, gray argillitic siltite, and white quartzarenite. All rock types may contain pyrite cubes, small-scale wiggly calcite segregations (molar tooth structure), horizontal carbonate pods, ripple marks, or mud cracks. Base of unit is marked at places by shallow channels of quartzarenite, or in northwestern part of map area by an unconformity that separates the Shepard from the underlying Purcell Lava. Shepard thickness ranges from about 700 ft in Glacier National Park to about 2,700 ft in the Swan Range in southwestern part of map area (fig. 2)

Ypr **Purcell Lava (Middle Proterozoic)**—Exposed only in northeastern part of map area. Black to greenish-black basalt of continental alkaline basalt affinity (McGimsey, 1985). Multiple flow units, commonly 5–10 ft thick, that intertongue with the upper part of the Snowslip Formation or separate the Snowslip and Shepard Formations. Can be divided into three parts in most areas. Upper part is multiple basalt flow units, fine grained in their lower parts and amygdaloidal and vesicular in their upper parts; ropy flow structures cap many flow units. Middle part is flow units that have indistinct contacts and fine-grained porphyritic zones. Lower part is flow units that are porphyritic, contain long (1–2 in.) tabular plagioclase crystals in a fine-grained and highly altered groundmass, and are locally pillowed. Maximum thickness about 200 ft

Ysn **Snowslip Formation (Middle Proterozoic)**—Type section of the Snowslip Formation (Childers, 1963) is on the south spur of Mount Shields in the southern part of Glacier National Park. Detailed study of the Snowslip by Whipple and Johnson (1988) in the park has led to recognition of six informal members that can be correlated over at least the 1,000 mi^2 of the park. The Snowslip generally consists of two alternating intervals that are each one hundred to several hundred feet thick. One interval consists of thinly laminated, red to purple argillite and siltite interbedded with thinly laminated green argillite and siltite. The other interval consists of couplets of greenish-gray siltite and olive argillite. Within both intervals are beds of stromatolites, arenite, and carbonate as layers or cement; certain characteristics of these carbonate and arenite interbeds help to distinguish the various members of the Snowslip (Whipple and Johnson, 1988). Small-scale sedimentary structures include mud cracks, ripple marks, mud-chip breccias, fluid-escape structures, cross lamination (particularly in the arenite beds), and flat-pebble conglomerate. Sharply overlies Helena Formation. The Snowslip and its members generally thin to the north and thicken to the west across depositional strike. Ranges in thickness from about 1,200 ft in the north to about 4,000 ft in the Swan Range to the south (fig 2)

Yh **Helena Formation (Middle Proterozoic)**—The most carbonate-rich formation in the Belt Supergroup. Contains abundant beds of dolomite, stromatolitic or oolitic limestone, and molar-tooth limestone and dolomite, and lesser amounts of quartzarenite and black argillite. In Glacier National Park contains an interval of stromatolitic limestone about 100 ft thick (the conophyton zone of Rezak, 1957) that separates the upper and middle parts of the Helena. Commonly displays sedimentary cycles, 6–50 ft thick, that in eastern exposures have a clastic bed at the base, stromatolitic and oolitic beds in the middle, and dolomite at the top (Eby, 1977). Abundance of stromatolites and oolites decreases rapidly to the west and south where cycles are still well defined but change to a clastic bed at the base, a middle unit of silty dolomite containing pods and ribbons of calcite, and an upper unit of dense, conchoidal-fracturing dolomite. Rests on laminated green argillite beds of the Empire Formation. Formation changes thickness rapidly across the various structural blocks in the map area (fig. 2), ranging from about 1,200 ft in southeastern Glacier National Park to about 7,000 ft in the Swan Range

Ye **Empire Formation (Middle Proterozoic)**—Thinly laminated, dark-green and light-green dolomitic argillite and silty argillite or siltite. Laminae mostly wavy and discontinuous although some are even parallel. Fluid-escape structures are characteristic, and horizontal pods of white or pink calcite are particularly abundant in upper part. Ripple marks, syneresis cracks, and mud chips common in places. Lower part contains white dolomitic quartzarenite beds as thick as 10 ft. Pyrite cubes common in more carbonate-rich strata, and a few exposures display stratabound copper minerals. A few purple interlaminated argillite and siltite beds commonly occur near base and at places near middle of unit. Thickness about 500 ft

Ys **Spokane Formation (Middle Proterozoic)**—Three lithologic units are found in most areas. The upper member has beds a few feet to a few tens of feet thick of laminated, green argillite and siltite that alternate with much thicker beds of purple, laminated argillite and siltite. Dolomitic cement is common as are ripple marks, mud chips, desiccation cracks, fluid-escape structures, ball-and-pillow structures, and flute casts. Beds a few inches to a few feet thick of white, rounded grains forming medium-grained, crossbedded quartzite that displays mud chips and balls on cross strata are abundant in northern part of map area but decrease rapidly in both number and thickness in southern and western parts. The middle member is predominantly pink to purple-gray, very fine grained, feldspathic quartzite or coarse siltite that has planar lamination or long tabular cross lamination. Interbeds of purple argillite are common. The lower member is similar to the upper member but has more purple argillitic beds, is more dolomitic, and has scattered iron-carbonate specks and cement. The Spokane changes facies eastward and northward where abundance of distinctive white, rounded-grain quartzite has been used arbitrarily to define the laterally equivalent Grinnell Formation. Maximum thickness of the Spokane is about 4,500 ft in the Swan Range, but the unit thins to about 1,700 ft in northern exposures (fig. 2)

Ygl **Grinnell Formation (Middle Proterozoic)**—Term used in Glacier National Park for the quartzarenite-rich lithofacies equivalent to the Spokane Formation. White, rounded-grain, crossbedded quartzarenite containing red argillite chips and pellets forms about 60 percent of the formation and almost 100 percent of the upper part. Amount of quartzarenite decreases rapidly westward and southward (fig. 2). Red to purple laminated siltite, silty argillite, and argillite form interbeds that make up most of the remainder of the unit. Argillitic beds generally have even-parallel lamination, and couplets of argillite and siltite display ripple marks, mud cracks, and fluid-escape structures. Grades by interlayering into the Appekunny Formation. Thickness ranges from about 1,700 to 2,600 ft

Yap **Appekunny Formation (Middle Proterozoic)**—Predominantly bright-green to olive argillite interbedded and interlaminated with laminated olive siltite and gray pyritic quartzarenite that weathers brown. Lower part contains maroon argillite and siltite. Can be divided into five informal members in Glacier National Park (Whipple, 1992). Various members display mud cracks, mud-chip breccia, load structures, fluid-escape structures, and a few scour-and-fill structures. Rests unconformably on Altyn Formation in Glacier National Park but apparently intertongues with Prichard Formation transition member to southwest where unit mapped as Appekunny along west side of Flathead Range has beds characteristic of both Appekunny and Prichard. Maximum thickness about 2,000 ft

Yapp **Appekunny and Prichard Formations, undivided (Middle Proterozoic)**—Shown only in southwestern part of Glacier National Park where map data is insufficient at most places to subdivide the unit. Consists of a few hundred feet of the upper part of the Appekunny (Yap) underlain by about 1,000 ft of the Prichard's transition member (Ypt) and about 4,000 ft of the Prichard's upper laminated argillite member (Ypu) whose base is not exposed

Yp **Prichard Formation, undivided (Middle Proterozoic)**—Shown only in cross sections to indicate inferred rocks of the Prichard that are not exposed but are known from the Kalispell 1°×2° quadrangle to the west (Harrison and others, 1992)

Ypt **Transition member**—Generally consists of three units: a basal unit of medium-gray blocky-weathering siltite and minor quartzite, a middle unit of interlaminated light- and dark-gray siltite and argillite, and an upper unit similar to the middle but containing interbeds of light-olive-gray siltite and quartzite similar to those in the overlying Appekunny Formation. These three units are present nearly everywhere, but their relative proportions vary from place to place. Laminae are wavy to lenticular; scour-and-fill structures, fluid-escape structures, and syneresis cracks are common. Iron sulfide weathers to give rusty aspect to many outcrops. Randomly oriented biotite porphyroblasts common, particularly near top, in all but easternmost exposures. Calcareous siltite and argillite beds, some in the middle but most in the upper unit, make up a small part of the member. Contains some stromatolitic beds in Glacier National Park. Probably intertongues with Altyn Formation to east (fig. 2). Basal contact is sharp. Thickness about 2,000 ft

Ypu **Upper laminated argillite member**—Medium-gray argillite that contains planar laminae and thin planar beds of light- and dark-gray silty argillite. Alternating light and dark layers, 0.05–0.3 in. thick, give lined or banded appearance. Dark-gray silty argillite contains discontinuous laminae of carbonaceous matter and iron sulfide (mostly pyrrhotite, but locally pyrite). Iron sulfide weathers to give rusty appearance to outcrops. Randomly oriented biotite porphyroblasts except in Glacier National Park. In the park, upper part contains thin lenticular beds and pods of calcareous and dolomitic silty argillite. Maximum thickness of about 3,500 ft exposed near head of McDonald Lake in Glacier National Park. Base not exposed

Ya **Altyn Formation (Middle Proterozoic)**—Occurs only on east side of Glacier National Park. Predominantly interbedded white to light-gray to black dolomite, dolomitic arenite, and cross-laminated arenite. Stromatolites common. Probably intertongues with Prichard transition member to west. Thickness about 1,200 ft

Ywt **Waterton Formation (Middle Proterozoic)**—Present only in northeastern Glacier National Park where formation is truncated by Lewis thrust fault. Predominantly gray to tan dolomite and dark-gray to bluish-gray limestone. Minor dolomitic siltite and arenite. Chert nodules or layers and stromatolites common. Maximum thickness exposed above Lewis thrust is about 800 ft

Ylb **Lower Belt rocks, undivided (Middle Proterozoic)**—Shown only in cross section *B–B'* to indicate inferred rocks of the lower Belt that are not exposed. May include Prichard, Altyn, or Waterton Formations

B **Basement rocks (Early Proterozoic?)**—Shown only in cross sections to indicate inferred crystalline rocks of uncertain character and pre-Belt age

Contact—Dotted where concealed

Faults—Dotted where concealed

Thrust fault—Sawteeth on upper plate

High-angle, normal or tear fault—Bar and ball on downthrown side

Reverse fault—Hachures on upthrown side

1 2
Fault in cross section—Single-barbed arrows indicate movement direction of the fault's hanging wall relative to its footwall in plane of cross section; double-barbed arrows indicate two distinct periods of movement—first (1), eastward-directed thrust movement and later (2), westward-directed normal fault movement

Folds—Showing trace of axial plane, direction of dip of limbs, and direction of plunge. Approximately located

Anticline

Overturned anticline

Syncline

Overturned syncline

Monoclinal fold, looking down plunge

Bedding and fault formlines—Shown in cross sections only

Strike and dip of beds

30 **Inclined**

Vertical

Horizontal

25 **Overturned**

NOTES ON BEDROCK GEOLOGY

The principal purpose of this presentation of the western part of the Cut Bank 1°×2° quadrangle is to help complete 1:250,000-scale geologic maps of Belt terrane—a project begun by the U.S. Geological Survey in 1970. This map has been compiled largely from recent studies at scales of 1:100,000 or 1:250,000, but includes some new reconnaissance mapping in previously unmapped parts of the Swan and Flathead Ranges (see "Index to sources of geologic data").

Descriptions of rock units are generally brief and have been condensed from more extensive descriptions presented by Whipple (1992) for Glacier National Park and by Mudge and Earhart (1983, 1991) for areas south of the park. Many of the rock units and their facies changes are also described and discussed in text accompanying the Kalispell 1°×2° quadrangle (Harrison and others, 1992), which is just west of the Cut Bank quadrangle.

Stratigraphic units in the Belt Supergroup that are unique to northeastern Belt terrane and crop out in the map area are (in descending stratigraphic order): the Grinnel, Appekunny, Altyn, and Waterton Formations. These and other stratigraphically higher easternmost facies of Belt rocks show stratigraphic and sedimentary features that are rare in the main Belt basin and include obvious unconformities, rapid facies changes, and large thickness changes over relatively short distances. Although tectonic shortening on Late Cretaceous and early Tertiary thrust faults accounts for a small part of the apparent facies and thickness changes, most of the lithologic changes occur within a single structural block and are the result of shallow-water sedimentation on a continental shelf.

MAJOR STRUCTURAL FEATURES

The western part of the Cut Bank 1°×2° quadrangle contains a mosaic of structural domains bounded by Late Cretaceous and early Tertiary thrust faults and Tertiary listric normal faults (fig. 1). The two most complex domains are the Montana disturbed belt and the upper plate of the Lewis thrust fault in Glacier National Park. A map scale of 1:250,000 can display only gross generalities of the intricate folds and faults in parts of these blocks. Southwest of the Blacktail fault are a series of west-facing major listric normal faults (Roosevelt, South Fork, and unnamed fault on west side of Swan Range) that bound blocks that contain three repetitions of much of the Belt stratigraphic section (map and fig. 2). Some of these faults combine with east-dipping normal faults to form a graben (the Kishenehn basin) filled by Tertiary sedimentary rocks. Some segments of thrust faults were reactivated to serve as Tertiary normal-fault surfaces, and where these segments are known or inferred a double-barbed movement symbol is shown in cross section *B–B'* to indicate eastward thrust movement overprinted by later westward normal fault movement.

MONTANA DISTURBED BELT

Fold and thrust structures in the Montana disturbed belt have been generalized from geologic maps at 1:125,000 scale by Mudge and Earhart (1983, 1991). A series of cross sections in those reports, interpreted from surface geology and various oil company bore holes, shows the intensely deformed and displaced Cambrian through Cretaceous rocks in thrust plates above Early Proterozoic crystalline basement. The interpretation shows shingled and folded strata in our map area above a basal surface of detachment at the basement-Cambrian unconformity. The basal thrust rises gently eastward and eventually breaks out above flat-lying Cretaceous and older strata several miles east of the map area. Fritts and Klipping (1987) presented a similar interpretation but added, on the basis of seismic data, a duplex (the Livingstone duplex) contained within the rocks between the basal surface of detachment (floor thrust) and the overlying Lewis thrust fault (roof thrust) at the south end of Glacier National Park.

LEWIS ALLOCHTHON AND LEWIS THRUST FAULT

The Lewis thrust fault skirts the eastern edge of Glacier National Park and places Middle Proterozoic Belt Supergroup rocks over Phanerozoic rocks of the Montana disturbed belt. The Lewis allochthon, defined as the structural block in Glacier National Park between the Flathead and Blacktail normal faults on the west and the trace of the Lewis thrust fault on the east, is internally thrust faulted and folded. Detailed interpretations of the complexities and kinematics of the structures, particularly in the southeastern part of the park, have been published by Davis and Jardine (1984), Hudec and Davis (1989), and Yin and others (1989). In general, these interpretations suggest a series of duplexes (cross section *B–B'*). The intensity of shearing within the Lewis allochthon may result from deformation in a relatively thin, flat-lying, and less-metamorphosed Belt section deposited near the eastern erosional edge of the old Belt basin. The style contrasts sharply with the widely spaced, listric, splayed thrusts without apparent duplexes in the thick, metamorphosed, and previously folded Belt strata to the west (Harrison and others, 1992).

The Lewis thrust is cut and dropped down about 16,000 ft to the west by the Flathead fault in the north and the Blacktail fault and the Roosevelt fault zone (cross section *B–B'*) in the south. Farther west the Lewis thrust is folded above two duplexes, the Flathead and Swan, identified on seismic lines by Fritts and Klipping (1987). There, the basal décollement serves as the floor thrust and the Lewis as the roof thrust. Our cross section *B–B'* incorporates that interpretation and shows these duplexes with the approximate widths and depths calculated by Fritts and Klipping.

BLACKTAIL-ROOSEVELT FAULT ZONE

Highly faulted Belt strata in the zone between the Blacktail fault and the Middle Fork of the Flathead River within the area labeled Roosevelt fault zone on cross section *B–B'* are interpreted as having been caught up in a series of listric normal Tertiary faults that tail into the basal décollement and show thousands of feet of down-to-the-west displacement (cross section *B–B'*). Conjugate faults in and adjacent to the Flathead River form a graben immediately west of the Roosevelt fault zone between the Livingstone and Flathead duplexes as a result of extension in the Lewis thrust plate. The inferred Middle Fork thrust fault is dropped into the graben then lifted above topography east of the westernmost fault in the Roosevelt fault zone (cross section *B–B'*); thus the trace of the Middle Fork thrust fault is not exposed.

FLATHEAD RANGE AND SWAN RANGE BLOCKS

These relatively uniform east-dipping Belt strata form two faulted major packages or blocks that consist of repetitions of Prichard through Mount Shields strata. Thickness and facies variations across the South Fork normal fault, which repeats the section, are modest. Thrust faults (the Hungry Horse and Middle Fork thrust faults) are inferred in these blocks because of: (1) steepening of some strata as they approach the sole of the inferred thrust plate and (2) local thrust splays that are mappable above the Hungry Horse and Middle Fork thrusts (near southwest corner of map area). Tectonic shortening on these thrusts also helps account for apparent facies changes and sudden eastward thinning as determined from surface exposures of some Belt formations, particularly the Helena. Both the inferred Cretaceous thrust faults and the later Tertiary extension faults are interpreted to sole into the Lewis thrust at depth.

KISHENEHN BASIN

The southern end of a Tertiary graben (Kishenehn basin) is exposed in the west-central part of the map area (fig. 1). The basin extends northward along the North Fork of the Flathead River into Canada. The graben is filled by the Kishenehn Formation of Eocene and Oligocene age (Constenius and Dyni, 1983). Outcrops of the Tertiary rocks are largely covered by Pleistocene glacial debris.

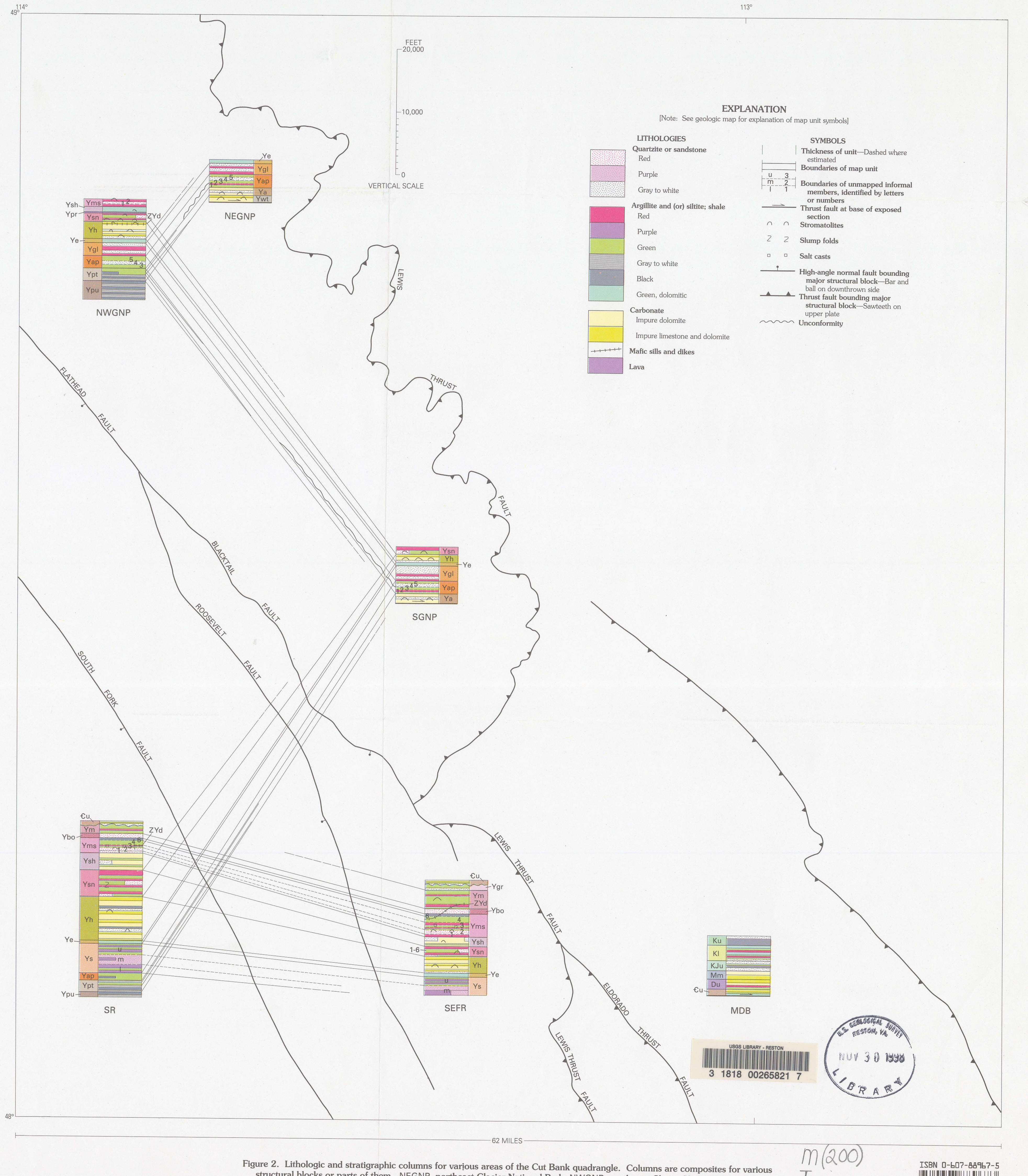


Figure 2. Lithologic and stratigraphic columns for various areas of the Cut Bank quadrangle. Columns are composites for various structural blocks or parts of them. NEGNP, northeast Glacier National Park; NWGNP, northwest Glacier National Park; SGNP, southern Glacier National Park; SR, Swan Range; SEFR, southeast Flathead Range; MDB, Montana disturbed belt.

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