GEOLOGIC MAP OF THE IRIS POINT 7.5' QUADRANGLE, WESTERN MONTANA

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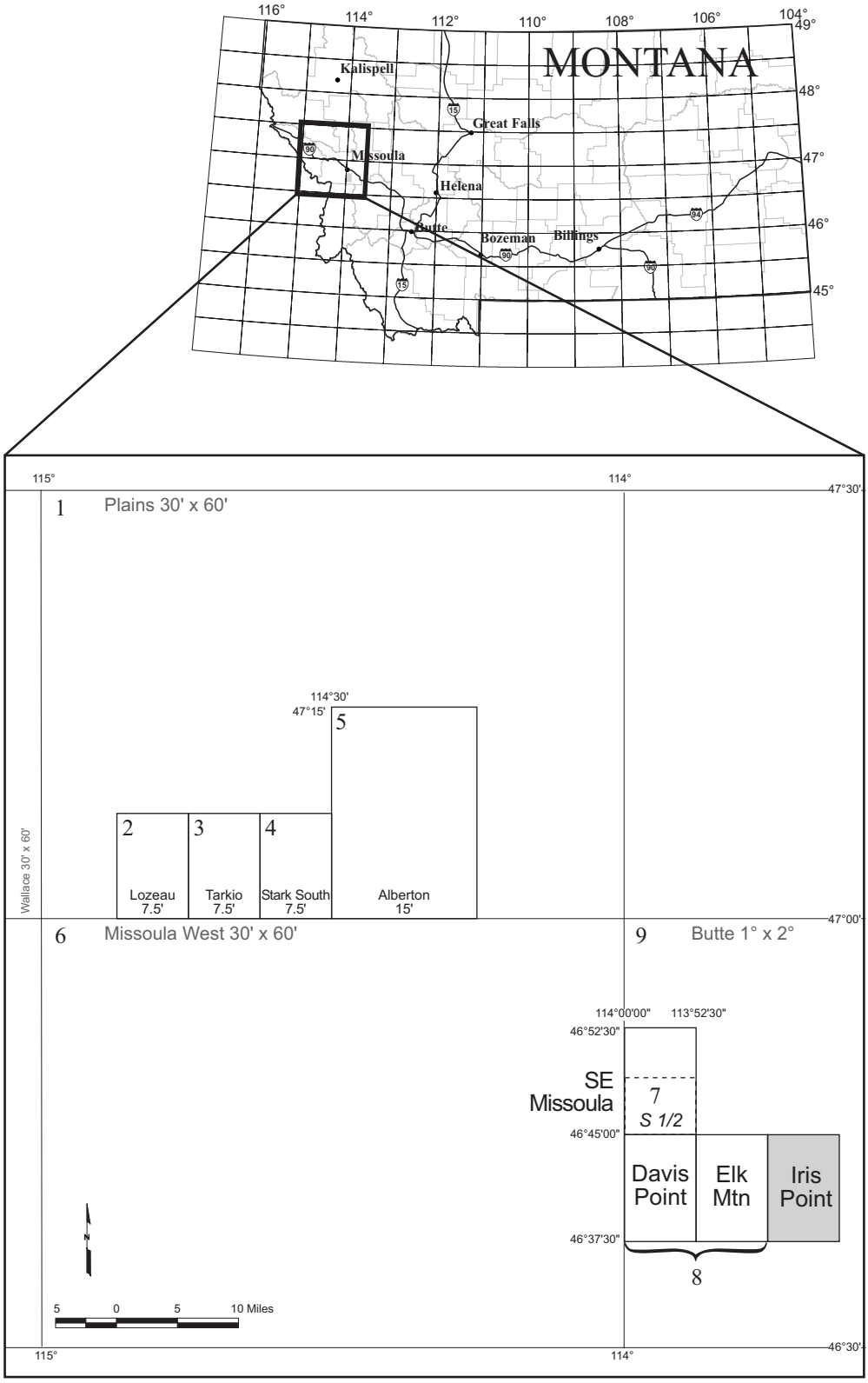
Introduction

The Montana Bureau of Mines and Geology (MBMG), in conjunction with the STATEMAP advisory committee, selected the Iris Point 7.5' quadrangle in western Montana (fig. 1) for detailed (1:24,000-scale) mapping because: (1) it extends large-scale mapping eastward from recent adjacent work (Lonn, 2007, 2008); (2) the area lies within the Lewis and Clark shear zone that has been a focus of recent MBMG studies (Lewis, 1998b; Lonn and McFaddan, 1999; Lonn and Smith, 2005, 2006; Lonn, 2007, 2008; Lonn and others, 2007); and (3) MBMG's strategy is to map selected structurally complex 7.5' quadrangles that will lead to completion of the Missoula East 1:100,000-scale quadrangle in 2010.

The Iris Point quadrangle lies within the Lewis and Clark Line (Billingsley and Locke, 1941), a wide, poorly understood, west-northwest-striking zone of faults and folds that transects the more northerly structural grain of western Montana (fig. 2). Although Billingsley and Locke's (1941) original definition of the line was based on geography controlled by Cenozoic strike-slip and normal faults rather than compressional features, most subsequent workers have concluded that Cretaceous compressive structures are an important component of the Lewis and Clark Line. The west-northwest-oriented compressional features have been attributed to: 1) sinistral transpression (Smith, 1965; Lorenz, 1984; Hyndman and others, 1988; Reid and others, 1993; Sears and Clements, 2000; Lonn and others, 2007), 2) dextral transpression (Wallace and others, 1990), 3) rotation of originally north-trending folds through left-lateral (Burmester and Lewis, 2003) or right-lateral (Hobbs and others, 1965) shear, or 4) northeast-directed compression that did not involve lateral movement (White, 1993; Yin and others, 1993; Yin and Oertel, 1995). Subsequent Cenozoic extension and/or right-lateral shear (Hobbs and others, 1965; Reynolds 1979; Harrison and others, 1974; Bennett and Venkatakrishnan, 1982; Sheriff and others, 1984; Winston, 1986a; Doughty and Sheriff, 1992; Yin and others, 1993; Yin and Oertel, 1995; Lonn and McFaddan, 1999; Lonn and others, 2007) superimposed high angle normal and/or dextral faults that roughly parallel and obscure the compressional features. This series of tectonic events has created an extremely complex structural geometry along the Lewis and Clark Line.

The Lewis and Clark Line forms the southern boundary of the Late Cretaceous Libby thrust belt, the northern boundary of the Late Cretaceous Sapphire allochthon and Georgetown thrust, and the northern borders of the Eocene Bitterroot and Anaconda metamorphic core complexes and associated detachment faults(fig. 2). Although the Lewis and Clark Line appears to postdate the compressional features of the Libby thrust belt and Purcell anticlinorium (Lonn and others, 2007), its relationships to the Sapphire allochthon and the core complexes are still unknown.



References:
1. Lonn & others, 2007
2. Lonn & Smith, 2005
3. Lonn & Smith, 2005
4. Lonn & Smith, 2006
5 Wells, 1974
6. Lewis, 1998b
7. Lonn, 2007
8. Lonn, 2008
9. Lewis, 1998a; Wallace, 1987

Figure 1. Location of the map area in relation to previous work.

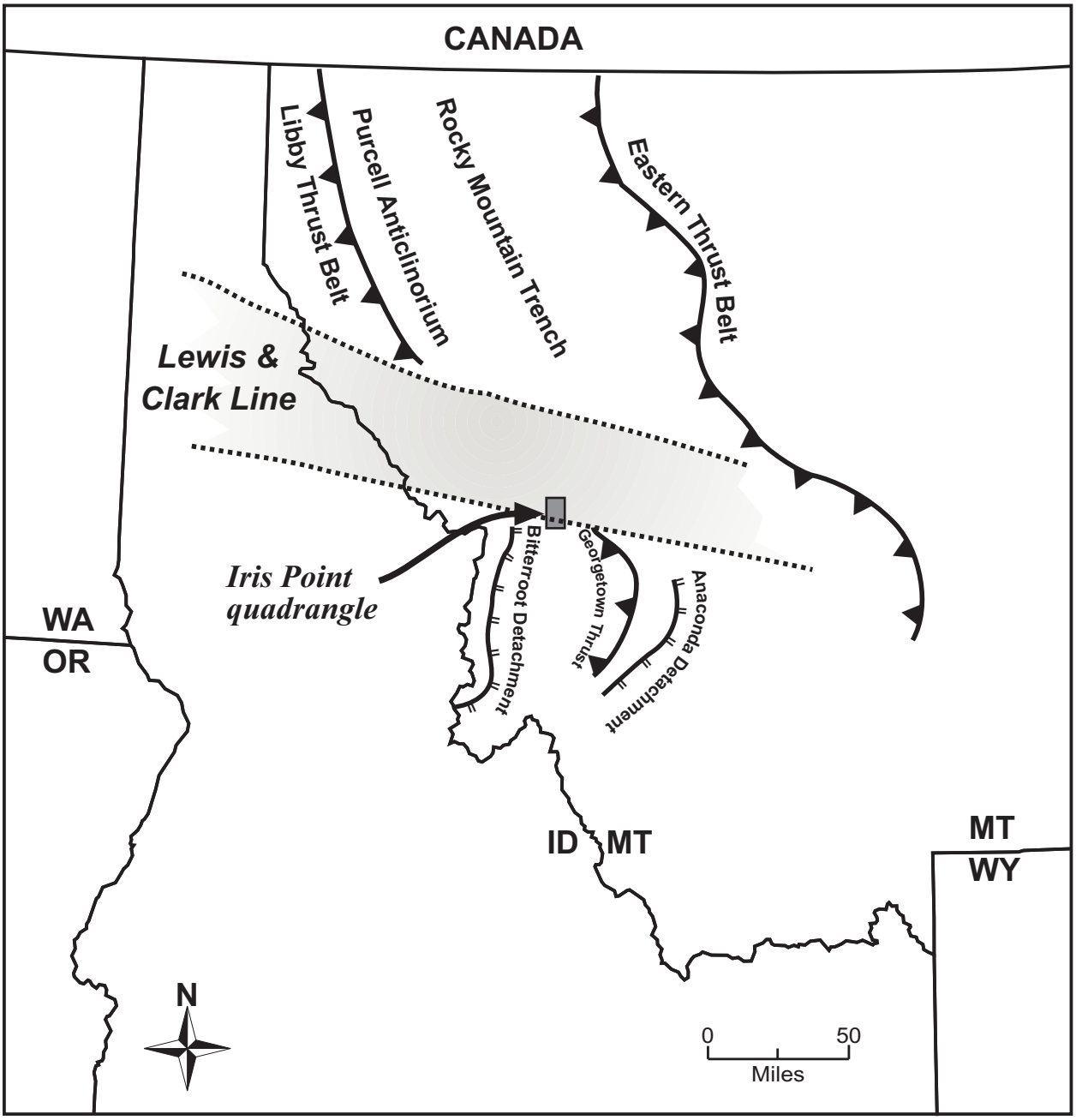


Figure 2. Location of Iris Point 7.5' quadrangle with respect to major structural features of western Montana.

Stratigraphy

The correlation chart and the description of map units (p.5) provide a detailed description of stratigraphy in the map area. Most of the area is underlain by low-grade metasedimentary rocks of the middle Proterozoic Belt Supergroup. The map area includes the Belt section from the middle Wallace Formation through the Pilcher Formation with a total estimated thickness of more than 4,900 meters (16,000 feet). Cambrian sedimentary units disconformably overlie the Belt rocks in the northern part of the map area. Thin Quaternary deposits are present in the stream valleys.

Structure

At least two generations of faults and two fold orientations are observed in the Iris Point quadrangle. The northern half of the map area contains a system of south-dipping, east-west-trending imbricate reverse faults developed in the footwall of the North Woodchuck thrust fault. This Cretaceous fault system defines a segment of the Lewis and Clark Line and extends west to the edge of the Bitterroot Valley near Missoula (Lonn, 2007, 2008; Nelson and Dobell, 1961). It plunges gently east, and the lower structural levels exposed suggest that these faults flatten and sole in the Wallace Formation (Lonn, 2007). Some east-west-oriented folds formed prior to and synchronous with these faults (see cross section A-A').

Two to four kilometers (one to two miles) southwest of the North Woodchuck fault and parallel to it is the south-dipping Eightmile Creek fault with younger strata in its hanging wall. The sub-parallel North Woodchuck and Eightmile Creek faults bound a sliver of older Wallace and Snowslip Formations between two blocks of younger Missoula Group strata. This structural geometry is common in western Montana (Lewis, 1998c; Lonn and others, 2007), and is thought to form either: 1) by extensional reactivation of a pre-existing thrust (Lewis, 1998c; Lonn and others, 2007), or 2) contemporaneously with the thrust through extrusion or extraction of a wedge of older rocks between two coeval faults with opposing senses of motion (Lonn and others, 2007). A third alternative proposed by Lidke and others (1988) is that the Eightmile Creek fault is an out-of-sequence, younger-over-older thrust.

A segment of the Davis Creek-Ranch Creek fault zone (Lonn, 2007, 2008) cuts northwest across the southwest corner of the map. This fault zone has a geometry like that of the North Woodchuck-Eightmile Creek system: a fault-bounded sliver of older rocks is caught between younger rocks on each side. However, the Davis-Ranch Creek system cuts the North Woodchuck system to the west and is thought to be slightly younger (Lonn, 2008).

Younger north-trending faults and associated north-trending folds deform the east-west faults. North-striking overturned strata adjacent to these younger faults suggest that the north-south faults are also reverse faults. In the southeastern corner of the map area, the North Woodchuck-Eightmile Creek structure curves southward as a result of deformation by the younger north-striking faults and folds.

Description of Map Units

Descriptions use the sediment-type terminology of Winston (1986b) for describing bed thickness and sedimentary structures.

Qal — ALLUVIUM OF MODERN CHANNELS AND FLOODPLAINS (HOLOCENE)
Well- to moderately sorted gravel, sand, and minor silt along active stream channels and on modern floodplains. Unit includes minor colluvium at the bases of hill slopes. Thickness is probably less than 15 meters (50 feet).

Qao — OLDER ALLUVIUM (HOLOCENE AND PLEISTOCENE)
Well-sorted, well-rounded gravel deposits found along Rock Creek and the Clark Fork River at levels above the surface of the modern alluvium (Qal). Includes both the terrace deposits and older alluvium of Berg (2006).

Qls — LANDSLIDE DEPOSITS (PLEISTOCENE?)
Unsorted mixtures of mud and angular boulders of locally derived bedrock transported by mass movement down slopes; characterized by hummocky topography.

QTgr — OLDER GRAVEL (PLEISTOCENE OR LATE TERTIARY)
Well-sorted, well-rounded boulder-cobble gravel deposited by the ancestral Clark Fork River on a high terrace (Berg, 2006). Clasts are composed almost entirely of Belt Supergroup quartzite.

TKgd — GRANODIORITE AND GABBRO, UNDIVIDED (TERTIARY OR CRETACEOUS)
Dark-weathering, fine-grained, equigranular biotite or hornblende granodiorite containing 32-37% plagioclase, 20-27% quartz, 18-20% biotite and hornblende, and 12-15% potassium feldspar (Jerome, 1968). Contains some gabbroic phases that were not mapped separately. The gabbro consists of 40% altered plagioclase, 30% altered pyroxene, 14% myrmekitic and micrographic intergrowths, 5% quartz, 5% chlorite, and 4% ilmenite (Jerome, 1968). The two rock types are difficult to distinguish in the field, and commonly occur together in the same intrusive body. Occur mostly along fault zones of late Cretaceous to early Tertiary age.

Ꞓh — HASMARK FORMATION (UPPER CAMBRIAN)
Light-gray to white, massive to mottled dolomite. Thickness about 300 meters (1,000 feet) (Thomas, 1987) but only about 90 meters (300 feet) is exposed in the study area.

Ꞓsh — SILVER HILL FORMATION (UPPER OR MIDDLE CAMBRIAN)
Lower green to black shale member, and upper dark gray limestone member that contains wavy, irregular stringers of brown silty limestone. Thickness about 60 meters (200 feet).

Є Yq QUARTZITE, UNDIVIDED FLATHEAD AND PILCHER FORMATIONS (MIDDLE CAMBRIAN AND MIDDLE PROTEROZOIC)
Includes the Cambrian Flathead and Middle Proterozoic Pilcher Formations; the disconformable contact between these formations is difficult to locate in the field. The Pilcher consists of medium- to coarse-grained, vitreous to feldspathic quartzite with distinctive alternating purple and light gray, trough cross-laminae. Flathead sandstone is medium- to coarse-grained, white to red, massive to crossbedded, vitreous quartzite. Thickness 185 meters (600 feet).

Ygr GARNET RANGE FORMATION (MIDDLE PROTEROZOIC)
Rusty-brown to yellow weathering, greenish gray, micaceous, hummocky cross-stratified, fine-grained quartzite with olive green to black argillite interbeds. Distinguished by rusty yellow weathered surfaces and abundant detrital mica. Only a thin, fault-bounded sliver is exposed in the study area, but Nelson and Dobell (1961) reported a thickness of 554 meters (1,800 feet) on the nearby Bonner 15' quadrangle to the northwest.

Ym MCNAMARA FORMATION (MIDDLE PROTEROZOIC)
Dense, interbedded green and red siltite and argillite in microlaminae and couplets. Mudcracks and chips are common. Contains diagnostic thin chert beds and chert rip-up clasts. Dominated by mudcracked even couplet and mudcracked lenticular couplet sediment types. At least 460 meters (1,500 feet) thick; the upper contact is not exposed. Immediately to the northwest on the Bonner quadrangle, Nelson and Dobell (1961) estimated the complete section to be 1,230 meters (4,000 feet) thick.

Ybo BONNER FORMATION (MIDDLE PROTEROZOIC)
Pink, medium- to coarse-grained feldspathic, crossbedded quartzite. Contains some granule-size grains, and locally includes micaceous, maroon argillite interbeds. Mostly composed of the crossbedded sand sediment type. Thickness 492 meters (1,600 feet).

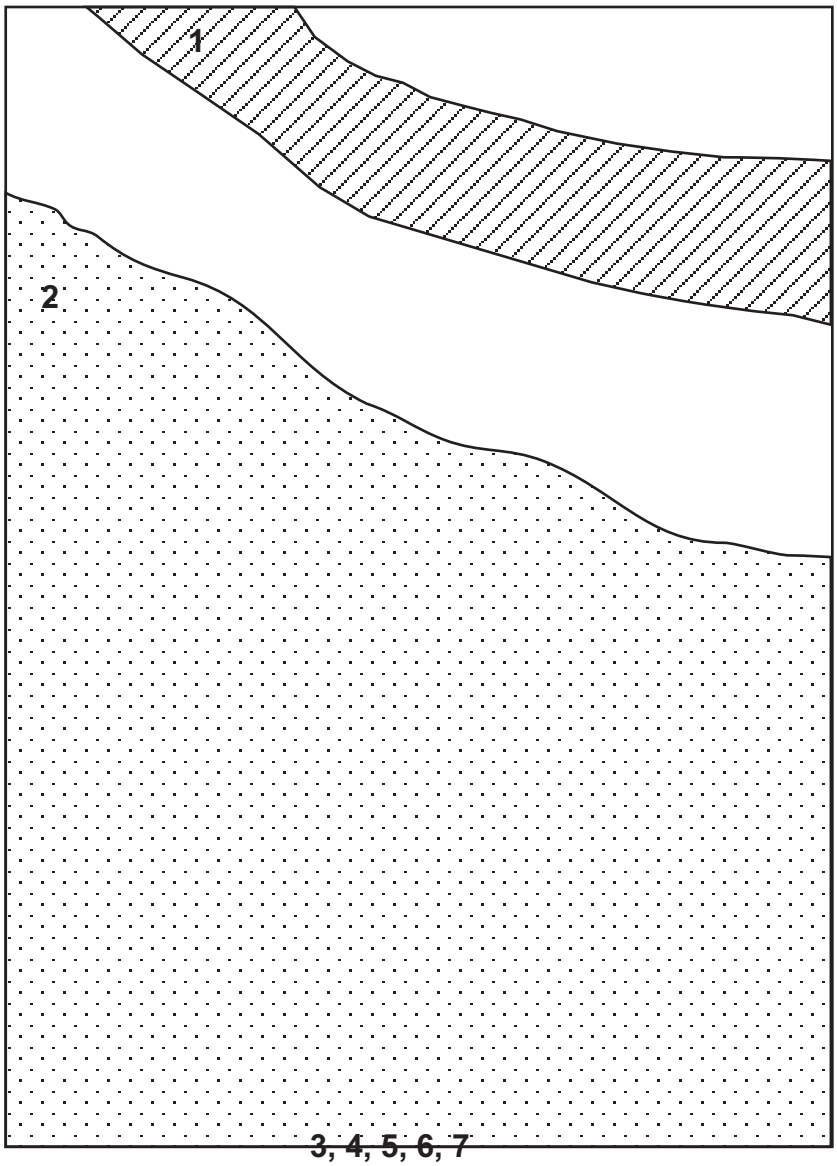
Yms3 MOUNT SHIELDS FORMATION, MEMBER 3, INFORMAL (MIDDLE PROTEROZOIC)
Red quartzite to argillite couples and couplets with abundant mudcracks, mudchips, and diagnostic, well-formed, cubic salt casts. Includes green interbeds, and some red microlaminae. Thickness 615 to 770 meters (2,000 to 2,500 feet).

Yms2 MOUNT SHIELDS FORMATION, MEMBER 2, INFORMAL (MIDDLE PROTEROZOIC)
Pink to gray, flat-laminated to crossbedded, fine- to medium-grained quartzite. Contains some tan-weathering dolomitic blebs. Crossbedded intervals are difficult to distinguish from the Bonner Formation. Thickness estimated at 1,015 meters (3,300 feet).

Ysh SHEPARD FORMATION (MIDDLE PROTEROZOIC)
Dolomitic and non-dolomitic, dark green siltite and light green argillite in microlaminae and couplets, and lenticular couplets of white quartzite and green siltite. Poorly exposed, but weathers into thin plates. Dolomitic beds have a characteristic orange brown weathering rind. Ripples and load casts are common, and mudcracks are rare. Thickness approximately 185 meters (600 feet).

Ysn SNOWSLIP FORMATION (MIDDLE PROTEROZOIC)
Interbedded intervals of quartzite to red argillite couples and couplets, and dark green siltite to light green argillite couplets. Desiccation cracks and mud rip-up clasts are common throughout. Contains beds and lenses of well-sorted, well-rounded, quartz-rich, white quartzite. Thickness about 923 meters (3,000 feet).

Yw WALLACE FORMATION (MIDDLE PROTEROZOIC)
The upper 462 meters (1,500 feet) are exposed in the map area. Wallace Formation is characterized by the distinctive “black and tan” lithology of pinch-and-swell couples and couplets composed of tan weathering, dolomitic, hummocky cross-stratified quartzite and siltite capped by black argillite. The quartzite/siltite beds commonly have scoured bases or bases with load casts. Molar-tooth structure and non-polygonal crinkle cracks are common throughout the section.



1. Berg, 2006
2. Lidke & others, 1988
3. Langton, 1935, entire area at 1:400,000
4. Desormier, 1975, entire area at 1:125,000
5. Wallace & Klopper, 1976, entire area at 1:48,000
6. Wallace, 1987, entire area at 1:250,000
7. Lewis, 1998a, entire area at 1:250,000

Figure 3. Index of previous geologic mapping in the Iris Point 7.5' quadrangle.

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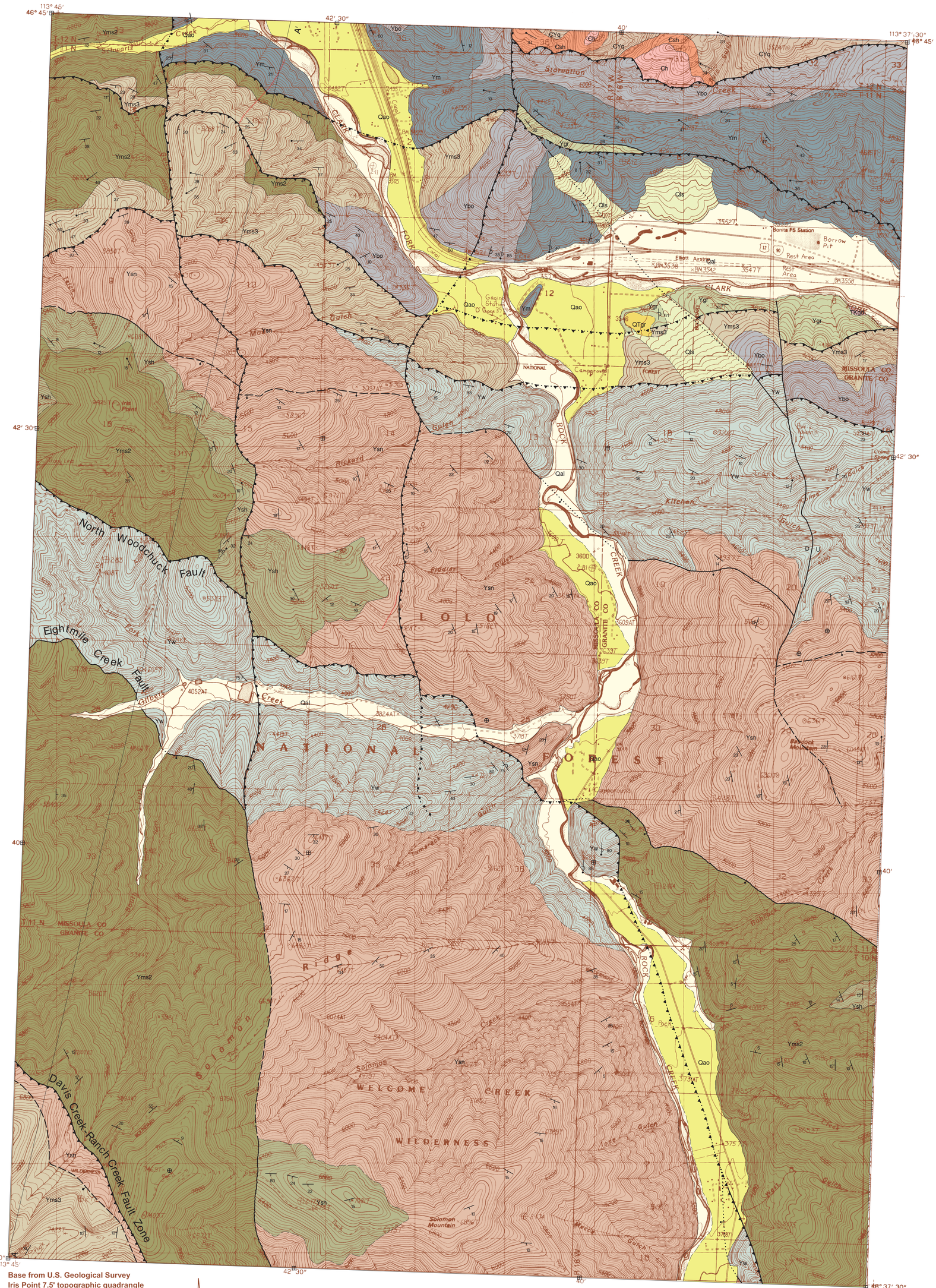


Base from U.S. Geological Survey
Iris Point 7.5' topographic quadrangle
Map date: 1989
Projection: Lambert Conformal Conic
UTM zone 12; 1927 NAD
1989 Magnetic North Declination: 17° East

meters 0 1000 2000 3000
feet 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10,000

SCALE: 1:24,000
Contour Interval 40 feet

MAP UNITS

- Qal — Alluvium of modern channels and flood plains
- Qao — Alluvium, older, undivided
- Qls — Landslide deposits
- QTgr — Gravel
- TKgd — Granodiorite and Gabbro
- Ch — Hasmark Formation
- Csh — Silver Hill Formation
- CYq — Quartzite
- Ygr — Garnet Range Formation
- Ym — McNamara Formation
- Ybo — Bonner Formation
- Yms3 — Mount Shields Formation, member 3, informal
- Yms2 — Mount Shields Formation, member 2, informal
- Ysh — Shepard Formation
- Ysn — Snowslip Formation
- Yw — Wallace Formation

AGE CORRELATION OF MAP UNITS

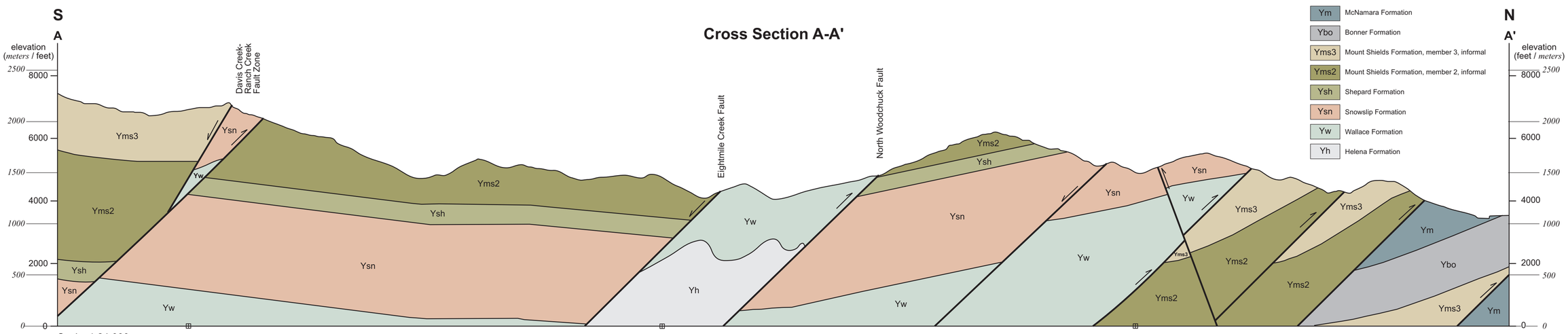
- Quaternary: Qal, Qao, Qls
- Tertiary: QTgr
- Cretaceous: TKgd
- Cambrian: ^h, ^sh, ^Yq
- Proterozoic: Ygr, Ym, Ybo, Yms3, Yms2, Ysh, Ysn, Yw

MAP SYMBOLS

- Contact: dashed where approximately located
- Thrust fault: teeth on upthrown block; dashed where approximately located; dotted where concealed.
- Reverse fault: boxes on upthrown block; dashed where approximately located; dotted where concealed.
- Normal fault: dotted where concealed; bar and ball on downthrown side
- Fault: sense of relative displacement denoted by U & D; dashed where approximately located; dotted where concealed
- Fault: unknown sense of movement; dashed where approximately located; dotted where concealed
- Dike
- 32 — Strike and dip of bedding
- 75 — Strike and dip of overturned bedding
- 65 — Strike and dip of bedding where sedimentary structures were used to confirm stratigraphic tops
- Horizontal bedding
- Vertical bedding

For a more detailed description of the map units and symbols, please refer to the text accompanying this map.

Cross Section A-A'



Scale 1:24,000
Surficial deposits not shown
Vertical scale = horizontal scale

CROSS-SECTION MAP UNITS

- Ym — McNamara Formation
- Ybo — Bonner Formation
- Yms3 — Mount Shields Formation, member 3, informal
- Yms2 — Mount Shields Formation, member 2, informal
- Ysh — Shepard Formation
- Ysn — Snowslip Formation
- Yw — Wallace Formation
- Yh — Helena Formation

Maps may be obtained from: Publications Office
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MBMG Open File 579

Geologic Map of the Iris Point 7.5' Quadrangle, Western Montana

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