Geologic Map of the Upper Clark Fork Valley Between Bearmouth and Missoula, Southwestern Montana

Mapped and Compiled
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This map has been reviewed for conformity with technical and editorial standards of the Montana Bureau of Mines and Geology.

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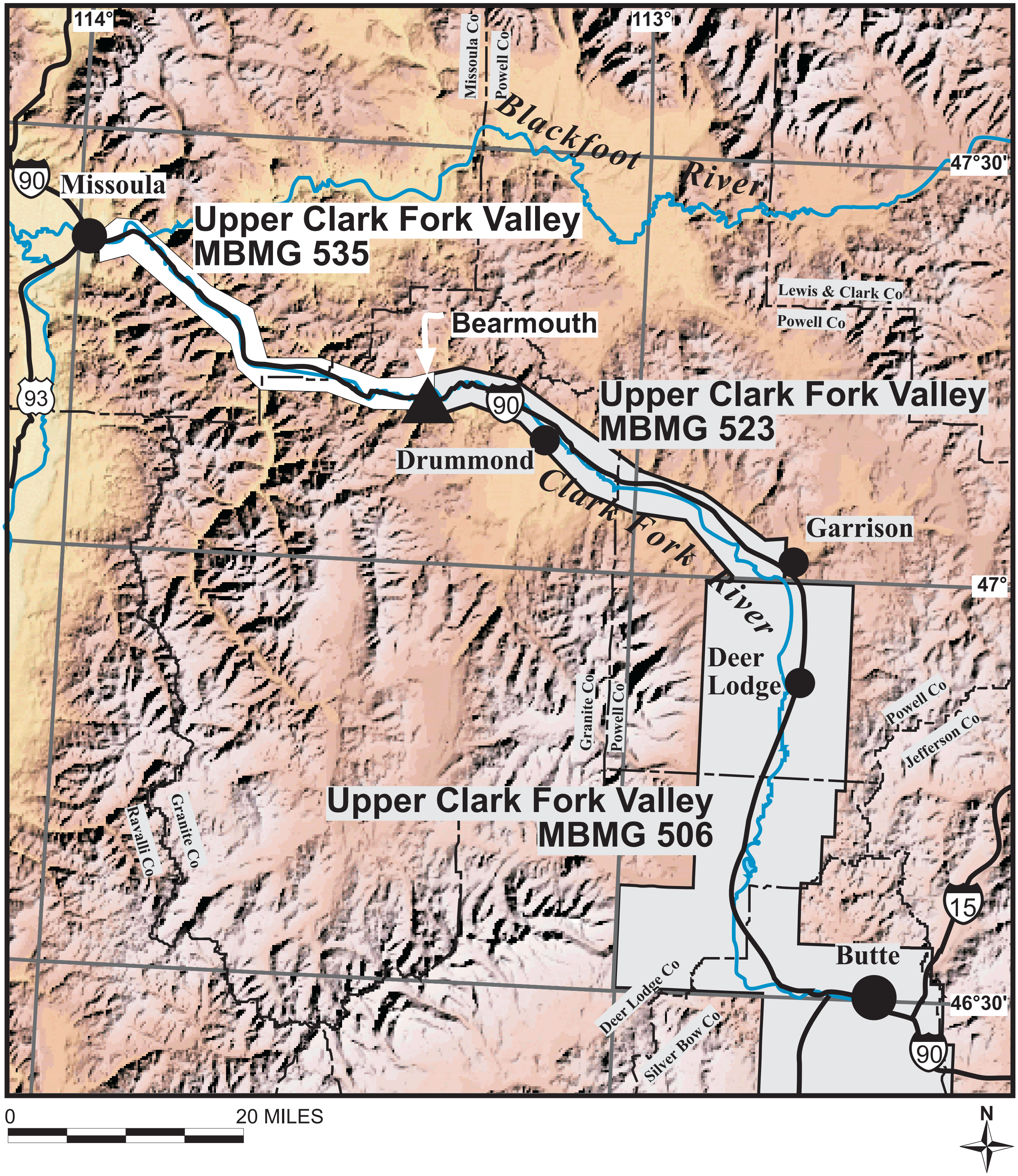


Figure 1. Location of current mapping, the last of three maps for the Upper Clark Fork River Valley. The first map (Berg and Hargrave, 2004) covers the area from Butte to Garrison; the second map (Berg, 2005) covers the area from Garrison to Bearmouth; and this map covers the area from Bearmouth to Missoula.

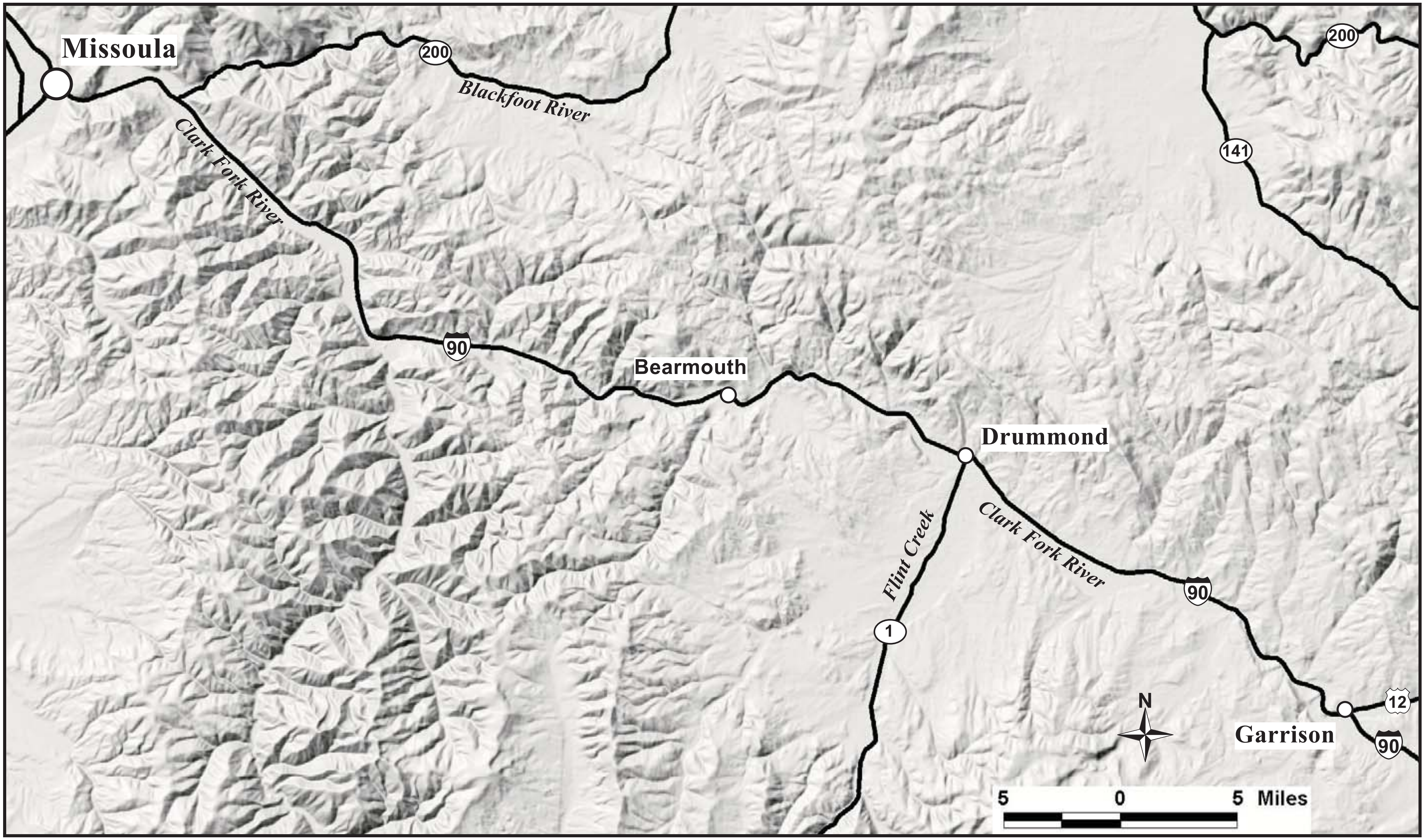


Figure 2. Shaded-relief map showing topography along the Clark Fork River in the area mapped.

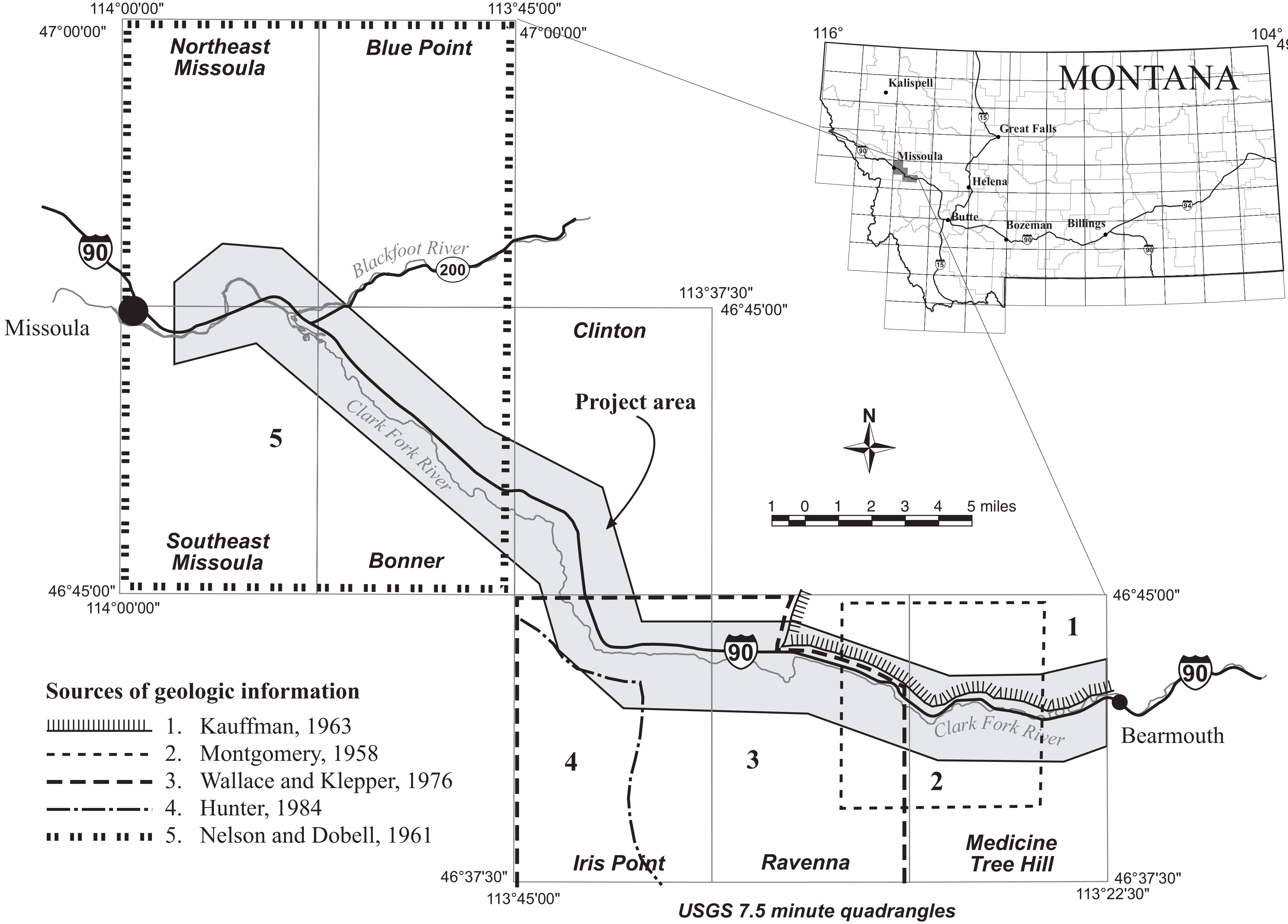


Figure 3. Location of map area and sources of geologic information for the area between Bearmouth and Missoula, Montana. Maps by Wallace (1987), Wallace and others (1986), and Lewis (1998) were also used. Complete citations are given in the reference section of this text.

Geologic Summary

This geologic map covers a narrow strip along the Clark Fork River Valley from several miles west of Bearmouth, Montana to Hellgate Canyon just east of Missoula, Montana (Figure 1) and is a continuation of geologic mapping that began at the Continental Divide east of Butte (Berg and Hargrave, 2004; Berg, 2005). It includes parts of the Southeast Missoula, Northeast Missoula, Blue Point, Bonner, Clinton, Iris Point, Ravenna, and Medicine Tree Hill 7.5´ quadrangles (Figures 2 and 3). Geologic field work concentrated on surficial deposits in the Clark Fork River Valley; bedrock geology on both sides of the valley was largely compiled from available sources.

Almost all of the exposed bedrock on both sides of the Clark Fork River belongs to the Proterozoic-age Belt Supergroup that consists largely of siltite, argillite, and quartzite. Gabbro that intruded these metasedimentary formations is also considered to be of Proterozoic age and is most abundant down river from Clinton. Cambrian to Cretaceous sedimentary rock formations are exposed north of the Clark Fork River in the eastern part of this mapped area where they are in fault contact with formations of the Belt Supergroup. Igneous rock types include basalt, dacite porphyry, quartz latite, and granodiorite. These igneous rocks are inferred to be of Tertiary age.

The Lewis and Clark line, a major shear zone that extends from eastern Idaho to Helena, Montana, is a major control on the development of the Clark Fork River Valley down river from Garrison. Movement along faults in this zone began in the Middle Proterozoic and continued into the Holocene (Wallace and others, 1986). Although evidence of faulting along this zone is present in the deformed rocks on both sides of the Clark Fork River, the actual trace of the fault is obscured by young sediments along the course of the river. Thrust faults of Laramide age, along which there has been north and northeastward transport, are an important structural feature on both sides of the Clark Fork Valley.

Glacial Lake Missoula deposits

With the exception of one small area near the mouth of Dry Gulch in the NW¼NE¼ sec. 21, T. 11 N., R. 11 W., the only remnants of Glacial Lake Missoula sediments (Qgl) are in the East Missoula area where they form a hill and also cover a large area south of the Clark Fork River (see detailed inset map). It is most likely that these lake sediments were deposited during the last filling of this glacial lake. If they were deposited during an earlier filling it is unlikely that they would have withstood emptying of the lake.

Large boulders, interpreted to be dropstones are concentrated in the East Missoula area (see inset map for the East Missoula area). The following observations relate to these boulders.

1. Large boulders are not found up river from the confluence of the Blackfoot River with the Clark Fork River.

2. Most boulders are limited to a specific area in East Missoula. Their concentration can be most easily recognized by examining the banks of the Clark Fork River where these boulders are easily distinguishable from the much smaller boulders found all along the Clark Fork River.
3. Boulders are also found in the SW¼SE¼ sec. 12, T.13 N., R. 19 W. in the pass between the Rattlesnake Creek drainage and the Clark Fork River Valley. Here there are at least ten boulders; most are quartzite with the exception of one boulder that is dolomite veined by quartz.
4. Fifty boulders were examined in Bandmann Flats between the Clark Fork River and Interstate 90. The following is a summary.
    - 60 percent quartzite, white to very light green with generally rounded edges and nearly equidimensional.
    - 14 percent phyllonite, always angular and typically larger than boulders of other lithologies. The largest boulder seen is 12 ft long and phyllonite.
    - 12 percent argillite, argillite grades into phyllonite in degree of deformation.
    - 8 percent gabbro, smaller than other boulders, angular, and always lichen covered.
    - 6 percent siltite, green, finely layered and angular shape that is fracture controlled.
    - 2 percent (one boulder) massive white quartz probably from a quartz vein.
5. All of the boulders along the Clark Fork River in Hellgate Canyon are smaller than those in East Missoula, but still larger than those generally found along the Clark Fork River.
6. All of the boulders, with the exception of one dolomite boulder in the pass between the Rattlesnake Creek drainage and the Clark Fork River, are rock types exposed within 5 miles up river of East Missoula. The large phyllonite boulders resemble deformed beds of the Mount Shields Formation along the Blackfoot thrust fault exposed in a road cut along Montana Highway 200 just east of Bonner.

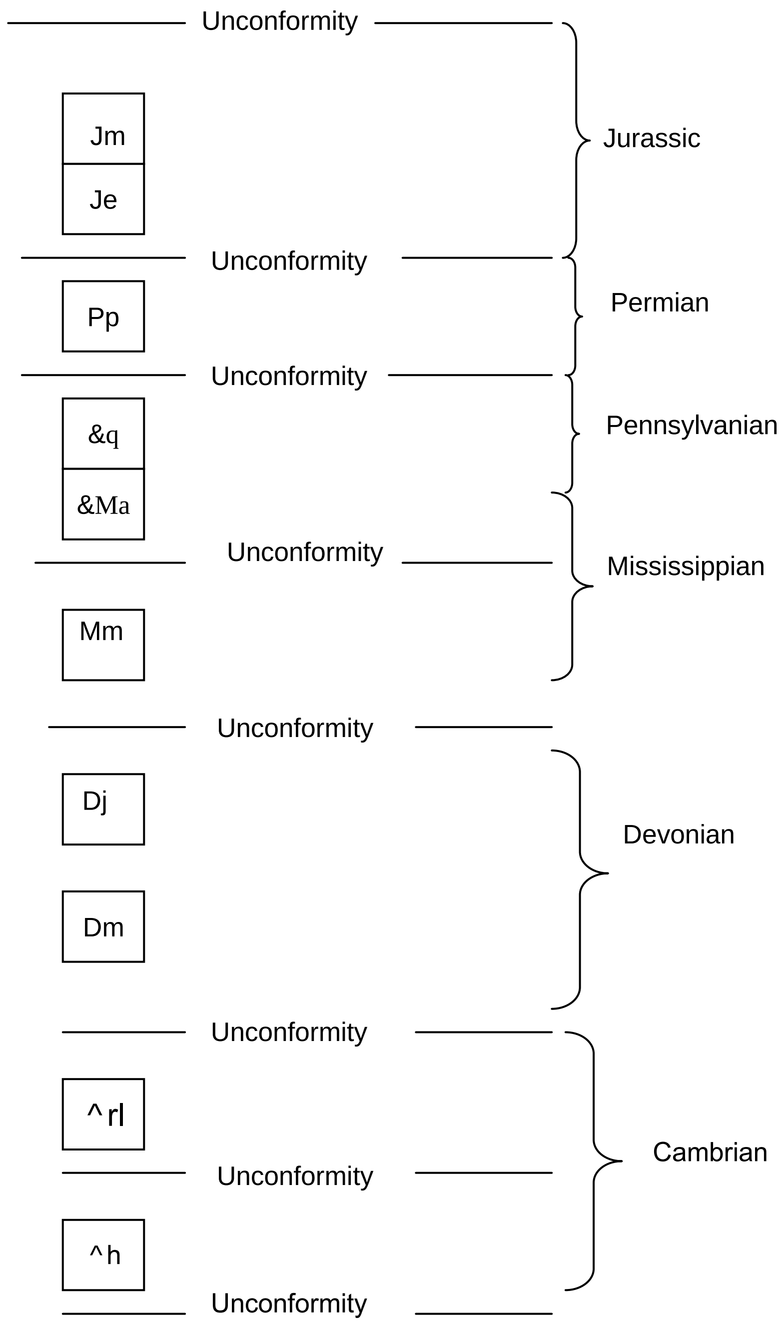
Speculation on origin and distribution of boulders

Because most of these boulders are much larger than the boulders found elsewhere along the Clark Fork River, it is concluded that they were deposited when Glacial Lake Missoula partly filled the Clark Fork River Valley. Their concentration in only part of the East Missoula area requires explanation. The farthest up river that they were found is below the confluence of the Blackfoot River and the Clark Fork River. This distribution suggests that their concentration is somehow related to the constriction of the Clark Fork Valley in Hellgate Canyon, just down river from East Missoula. The boulders in the pass between the Rattlesnake Creek drainage and the Clark Fork River can be explained by ice rafting where the ice floes in which boulders were trapped grounded at this pass while Glacial Lake Missoula was draining. It is most likely that these boulders, as well as those in the East Missoula area, were not deposited during one draining of Glacial Lake Missoula, but accumulated during repeated drainings of this lake. The best explanation for their concentration in East Missoula is that ice floes were dammed up in this area and melted, slowly releasing these boulders. Their concentration close to the middle of the present Clark Fork River Valley awaits explanation.

Acknowledgments

The cooperation of land owners along the Clark Fork Valley who, without exception, granted access to their land, is sincerely appreciated. Ken Sandau and Susan Smith prepared the map and illustrations. Their assistance and that of the reviewers is also appreciated.

Correlation of map units in the Upper Clark Fork Valley between Bearmouth and Missoula



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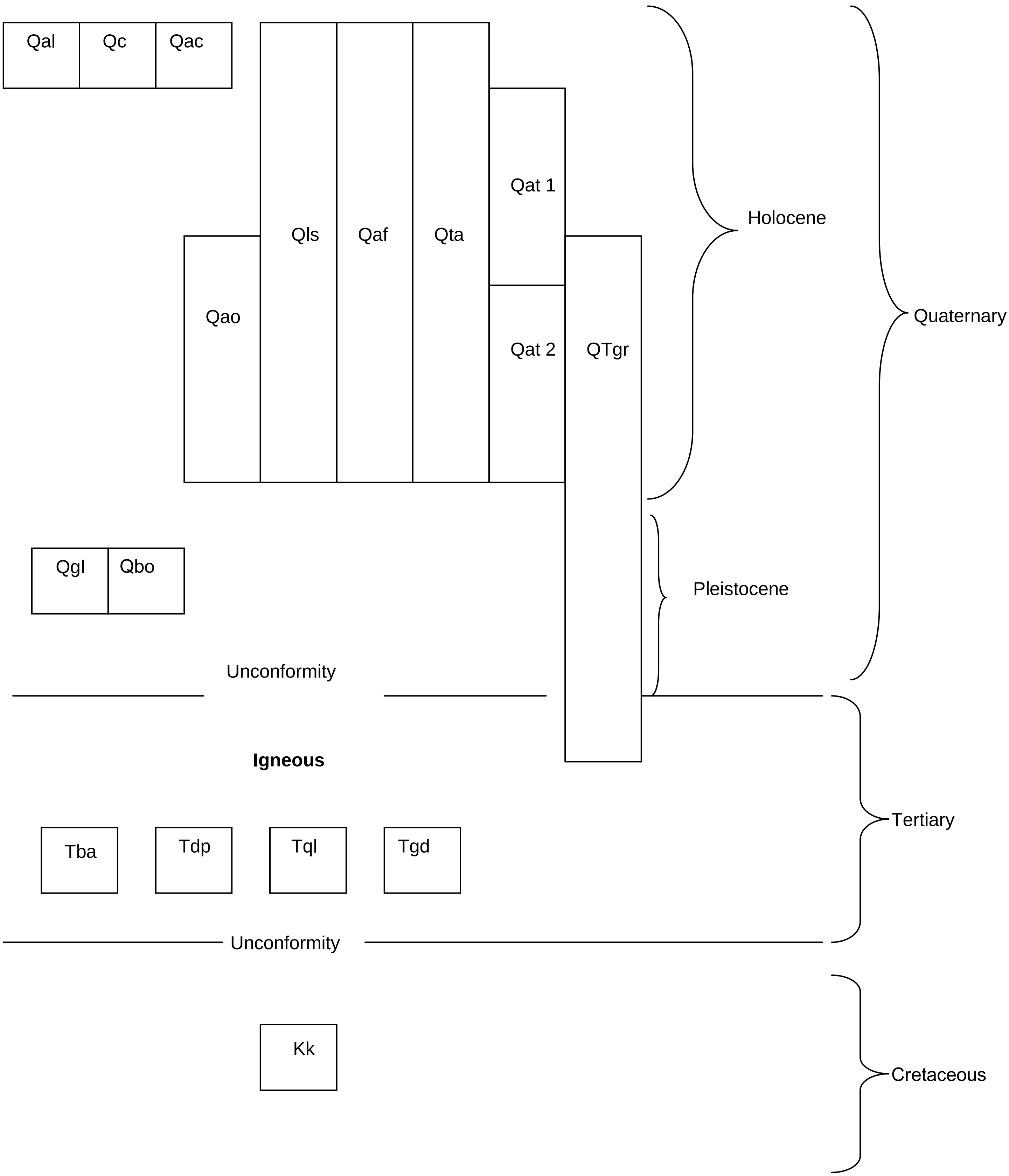
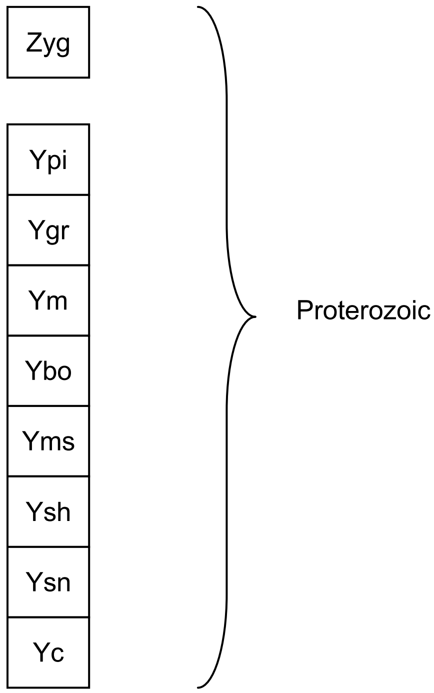


Correlation of map units in the Upper Clark Fork Valley between Bearmouth and Missoula



Description of Map Units along the Clark Fork River Valley from Bearmouth to Missoula

Note: Map unit thicknesses and distances are given in feet. To convert feet to meters multiply feet by 0.30. To convert meters to feet, multiply meters by 3.28.

Note: The distinction between different Quaternary deposits is, in some instances somewhat arbitrary and based on topographic form. For instance, Qac (alluvium and colluvium) that was deposited by sheetwash and soil creep is locally indistinguishable from Qaf (alluvial fan deposits) deposited by fluvial processes.

QUATERNARY

Qal **Alluvium of modern channels and flood plains –** Gravel, sand, silt, and clay along the Clark Fork and Blackfoot Rivers. Quartzite derived from the Belt Supergroup is the dominant rock type in alluvium along both of these rivers. Gravel along the Clark Fork River near Beavertail Hill (NE¼NE¼SW¼ sec. 11, T. 11 N., R. 16 W.) is estimated to consist of 53 percent quartzite, 24 percent various igneous rocks, 21 percent sedimentary rocks, and 9 percent distinctive light-gray biotite granite. This estimate is for material > 1 inch in diameter and represents the number of individual pebbles and cobbles. Downstream near the mouth of Schwartz Creek (SW¼NE¼ sec. 34, T. 12 N., R. 17 W.), light-gray biotite granite accounts for approximately one percent of the pebbles and cobbles. This distinctive granite is found in the alluvium upstream from the area covered in the present map and is inferred to have been derived from granitic plutons in the Flint Creek Range.

Qac **Alluvium and colluvium undivided –** Unconsolidated deposit that contains some rounded boulders, cobbles, and pebbles characteristic of alluvium, but also significant unsorted angular clasts characteristic of colluvium.

Qc **Colluvium –** Unconsolidated deposit of unsorted material that ranges from angular boulders to clay and in several instances found at the base of slopes between exposed bedrock uphill and alluvial deposits. Thickness of colluvium ranges from a thin blanket of less than 10 ft to a somewhat hummocky area in the S½ sec. 6, T. 11 N., R.16 W. where, on the basis of a water well log, the colluvium is about 134 ft thick.

Qls **Landslide deposit –** With the exception of shallow landslides in colluvium derived from the McNamara Formation on the north side of the Clark Fork Valley (NW¼ sec. 19, T. 11 N., R. 14 W.), all landslides shown on this map appear to be inactive. Two landslides are developed on the Mount Shields Formation in the vicinity of East Missoula, one small landslide in the McNamara Formation just south of Clinton, and another small landslide in the Kootenai Formation on the north side of the Clark Fork Valley near the center of sec. 17, T. 11 N., R. 14 W.

Qta **Talus deposit –** Talus deposits of sufficient extent to show at the scale of this map are developed below outcrops of the Bonner Quartzite on the northeast side of the Clark Fork River Valley. Most quartzite blocks are less than 1 ft in maximum dimension, but some are larger than 2 ft across.

Qaf **Alluvial fan deposit –** Poorly sorted deposits of locally derived detritus formed at the mouths of almost all of the small tributaries to the Clark Fork River.

Qat 1 **Alluvium of youngest alluvial terrace –** These terrace deposits are best developed along the Clark Fork Valley between Clinton and Hellgate Canyon west of East Missoula. They are generally 10 - 20 ft above the Qal and consist of gravel similar to that described for the Qal.

Qat 2 **Alluvium of second youngest alluvial terrace –** These deposits are best developed along the Clark Fork Valley between Clinton and Hellgate Canyon west of East Missoula. In this stretch of the Clark Fork Valley remnants of these terrace deposits are preserved on both sides of the Clark Fork River 20 - 40 ft above the Qat1 deposits. Gravel of these deposits is similar to that of the Qal and Qat1 deposits.

Qao **Alluvium, older undivided –** Alluvium along most of the smaller tributaries to the Clark Fork River; elevations are 5 - 30 ft above the Clark Fork River flood plain, or youngest alluvial terrace, second youngest alluvial terrace or alluvial fan. A significant portion of the alluvium along Rock Creek including that just south of the Clark Fork River is interpreted to be older alluvium.

Qgl **Glacial lake deposit –** Varved, Glacial Lake Missoula deposits are well exposed at the following localities in East Missoula: (1) railroad cut (private property) in the NE1¼ sec. 19, T. 13 N., R. 18 W., (2) roadcut along Interstate 90 in the SE¼ sec. 19, T. 13 N., R. 18 W., (3) old clay pit on the south side of hill composed of Glacial Lake Missoula sediments in the NE¼ sec. 24, T. 13 N., R. 19 W., (4) road cut along Highway 200 in the SE¼ sec. 13, T. 13 N., R. 19 W., and (5) in a roadcut in the NW¼SE¼ sec. 13, T. 13 N., R. 19 W. Lenses and beds of gravel of quartzite pebbles and granules within fine-grained glacial lake sediments are well exposed at this last locality. Bricks made from these illitic sediments mined in East Missoula were reported to be of poor quality (Chelini and others, 1965). Farther east there is a small exposure of glacial lake sediments along the frontage road near the mouth of Dry Gulch in the NE¼NE¼ sec 21, T.11 N., R. 15 W. Glacial lake sediments around several badger holes up Dry Gulch indicate that there are remnants of Glacial Lake Missoula sediments in this drainage.

Qbo **Boulders –** Boulders attributed to deposition in Glacial Lake Missoula (dropstones) are abundant in East Missoula (see inset on geologic map) where they range up to 15 ft in length. See discussion of dropstones in the Geologic Summary.

QUATERNARY AND TERTIARY

QTgr **Gravel –** This unit was mapped on the presence of boulders and cobbles on the surface that are remnants of more extensive deposits. It is probable that the finer material were eroded leaving only the coarser material. This gravel consists almost entirely of quartzite derived from units in the Belt Supergroup. Unlike gravel in the Quaternary deposits that contains distinctive light - gray biotite granite pebbles and cobbles, this rock type was not identified in the QTgr.

Three deposits shown as QTgr are interpreted as alluvial fans that are at a higher elevation than the Quaternary alluvial fans. These are at the mouths of Little Bear Gulch in the NE¼ SE¼ sec. 17, T. 11 N., R. 14 W., Deer Creek in the center, sec. 28, T. 18 W., R. 13 W., and Marshall Creek in the N½ sec. 18, T. 13 N., R. 18 W. The other QTgr deposits are remnants of gravel deposited by the Clark Fork River at elevations that range from 3,480 to 3,800 ft. A remnant of a pebble gravel near the drainage divide between the Rattlesnake Creek drainage and the Clark Fork River in the NW½ sec. 13, T. 13 N., R. 19 W. is also QTgr.

TERTIARY

Tba **Basalt -** Includes andesite. Brown to black with scattered plagioclase phenocrysts that have generally weathered to produce tan spots. A potassium-argon date of basalt at Bearmouth east of the area shown on this map gives an age of 44.9 ± 2.5 m.y. (Williams and others, 1976). Another determination on basalt from the Rattler Gulch area gives an age of 46.7 ± 2.5 m.y.

Tdp **Dacite porphyry –** Consists of 20-50 percent plagioclase, 1-5 percent biotite, 1 - 3 percent hornblende and less than 3 percent orthoclase and quartz phenocrysts in a fine-grained groundmass (Reitz, 1980).

Tql **Quartz latite –** Orthoclase phenocrysts 1 - 3 mm in a fine-grained groundmass of quartz, plagioclase, and biotite. Feldspars are chalky because of alteration. Small exposure in the NE¼NW¼ sec. 34, T. 12 N., R. 17 W.

Tgd **Granodiorite -** One specimen consists of 50 percent plagioclase, 20 percent orthoclase, 20 percent quartz, 5 percent biotite, 3 percent hornblende, and 2 percent opaque minerals (Reitz, 1980).

CRETACEOUS

Kk **Kootenai Formation (Lower Cretaceous) –** Kauffman (1963) divided the Kootenai Formation into four mappable units in the Garnet-Bearmouth area and the following descriptions are summarized from his descriptions. The total thickness of the Kootenai Formation in this area is 929 ft. The upper calcareous member consists mainly of coarsely to finely crystalline limestone including the "gastropod limestone"at the top of the formation. Shale, siltstone, and sandstone are minor lithologies in this member. The upper clastic member consists mainly of sandstone, quartzite, and siltstone with lesser shale and limestone. The clastic beds are red, maroon, green, and gray. The lower calcareous member consists of interbedded, very fine-grained, dark - gray to black limestone and purple, maroon, or green shale. The lower clastic member consists of maroon shale and sandstone.

JURASSIC

Jm **Morrison Formation -** Consists of claystone, shale, siltstone, and medium-grained sandstone that are generally some shade of green or yellow. This formation reaches a maximum thickness of 220 ft in this area (Kauffman, 1963).

Je **Ellis Group, undivided** - The Ellis Group, where exposed in this area, consists of, from youngest to oldest, the Swift, Rierdon, and Sawtooth Formations. The Swift Formation is 244 ft thick and is composed mainly of sandstone with lesser limestone and siltstone. The Rierdon Formation has a maximum thickness of 75 ft and consists of limestone of medium grain size, calcarerous shale, and shaly limestone. The Sawtooth Formation is 270 ft thick and consists of a basal fossiliferous calcareous buff-weathering siltstone; a middle very calcareous dark-gray shale or argillaceous limestone that weathers to a creamy-white surface; and an upper unit of interbedded calcareous shale, siltstone, and limestone (Kauffman, 1963).

PERMIAN

Pp **Phosphoria Formation –** The Phosphoria Formation is poorly exposed in this area with only the Shedhorn Quartzite Member typically exposed. Thickness of the Phosphoria Formation is 290 ft (Kauffman, 1963).

PENNSYLVANIAN

&q **Quadrant Formation –** The Quadrant Formation is usually well exposed forming bold outcrops of distinctive tan, vitreous quartzite. Where not exposed, float of this durable quartzite is easily recognizable. Thickness of the Quadrant Formation is 140 ft (Kauffman, 1963).

PENNSYLVANIAN AND MISSISSIPPIAN

&Ma **Amsden Formation –** Distinctive, reddish-brown, calcareous siltstone and shale with an estimated thickness of 310 ft. (Kauffman, 1963).

MISSISSIPPIAN

Mm **Madison Group, undivided –** The maximum thickness of the Madison group in this area is 2,220 ft. The lower formation, the Lodgepole Limestone, consists of well-bedded limestone interbedded with shaly limestone that is in contrast to the massive, gray limestone of the overlying Mission Canyon Formation (Kauffman, 1963).

DEVONIAN

Dj **Jefferson Formation –** The total estimated thickness is 1,700 ft with an upper limestone member, a middle dolomitic member, and a lower limestone member (Kauffman, 1963).

Dm **Maywood Formation –** The Maywood Formation is poorly exposed in this area and consists of dolomite, limestone, dolomitic siltstone, and dolomitic sandstone. It is 368 ft thick (Kauffman, 1963).

CAMBRIAN

^rl **Red Lion Formation –** The lower 30 ft of the Red Lion Formation consists of yellowish shale, calcareous siltstone, and dolomite that are overlain by beds of laminated limestone. The total thickness of this formation is 358 ft (Kauffman, 1963).

^h **Hasmark Dolomite -** Consists mainly of crystalline dolomite of medium grain size. Thickness in this area is estimated to be approximately 1,800 ft (Kauffman, 1963).

PROTEROZOIC

ZYg **Gabbro –** Described from this area by various authors as gabbro, diabase, and metagabbro. Typically concordant intrusive bodies. This rock consists mainly of plagioclase and pyroxene with hornblende present locally. Diabasic texture shown where plagioclase laths are surrounded by pyroxene (Nelson and Dobell, 1961).

Ypi **Pilcher Formation –** White to pink quartzite that tends to be quite vitreous, but with individual round quartz grains recognizable. Features found locally include muscovite on bedding planes, crossbedding, maroon argillite clasts, and alternating thin (5 mm thick) laminae of gray and maroon quartzite.

Ygr **Garnet Range Formation –** Generally fine-grained, grayish-green quartzite in which individual quartz grains are not easily recognizable. Abundant mica. Hematite and limonite coat many fractures.

Ym **McNamara Formation –** Fine-grained gray, pink, and maroon quartzite with tan to maroon argillite beds with some argillite occurring as wisps and clasts in the quartzite. Chert nodules, usually lenticular, are abundant and characteristic of this formation.

Ybo **Bonner Formation –** Generally massive beds of pink to tan arkosic quartzite with sparse argillite beds. Produces prominent talus deposits of angular blocks.

Yms **Mount Shields Formation –** Reddish quartzite and subordinate argillite and siltite in the lower and middle parts of this formation with predominately reddish argillite in the upper part. Abundant planar laminations and ripple cross-laminations (Lewis, 1998).

Ysh **Shepard Formation –** This poorly exposed formation consists of green microlaminated argillite at its base overlain by thin lenticular beds of green dolomitic siltite and fine-grained quartzite. The upper part is red, thinly bedded dolomitic quartzite and siltite (Lewis, 1998).

Ysn **Snowslip Formation –** Green and red argillite near the base with increasing siltite and quartzite upward. Some quartzite beds contain coarse, well-rounded quartz grains and less feldspar than is typical for quartzite in the Belt Supergroup. The upper quartzitic part of this formation is difficult to distinguish from the Mount Shields Formation (Lewis, 1998).

Yc **Middle Belt carbonate, informal –** Tan to gray, argillaceous dolomite and limestone, some thinly laminated, with quartzite beds and numerous calcite veinlets.

YZr **Proterozoic rocks undivided –** Includes Precambrian Y units of the Belt Supergroup and Precambrian Z gabbro bodies. Used only on the detailed inset map of the East Missoula area.

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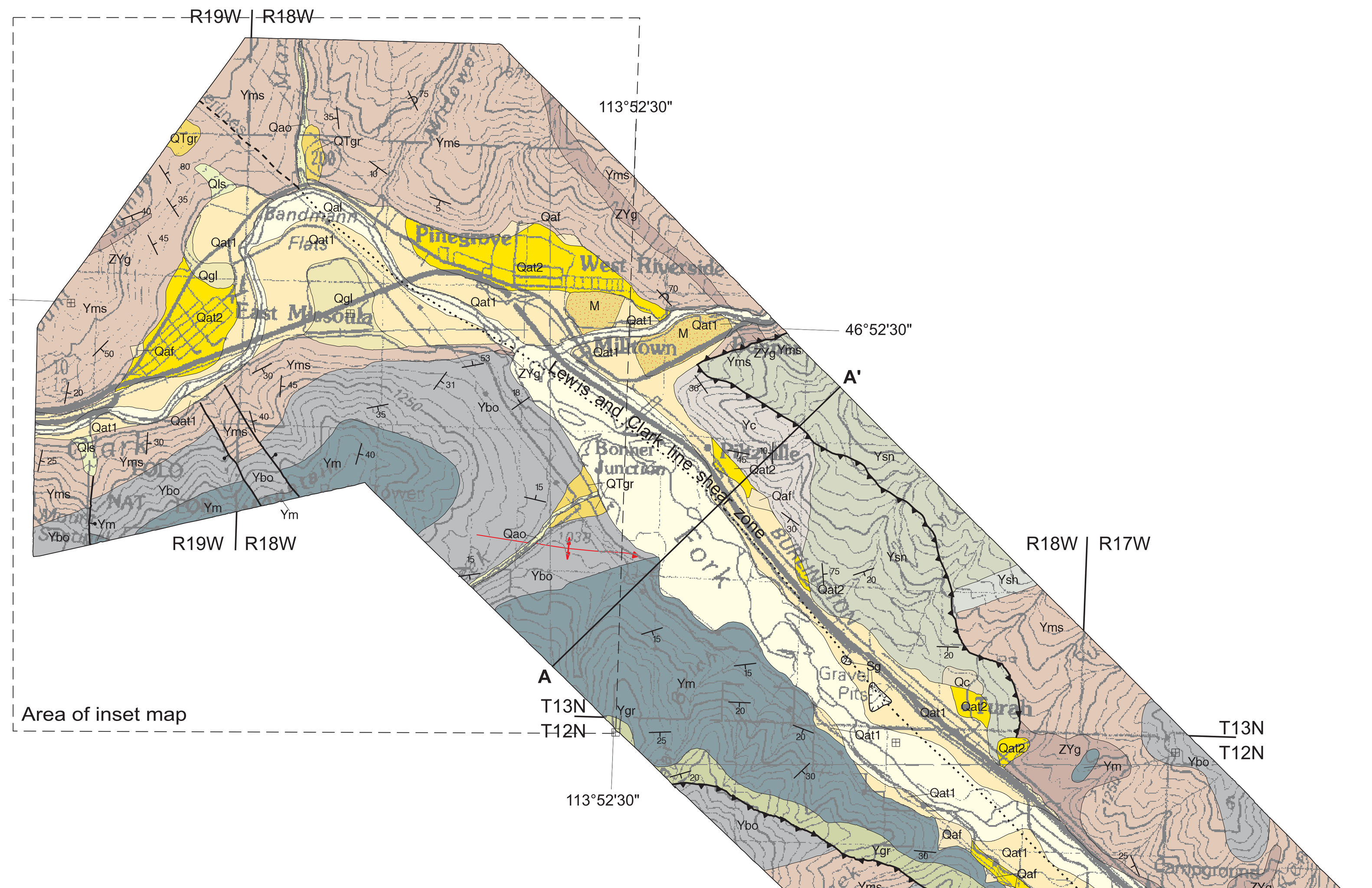
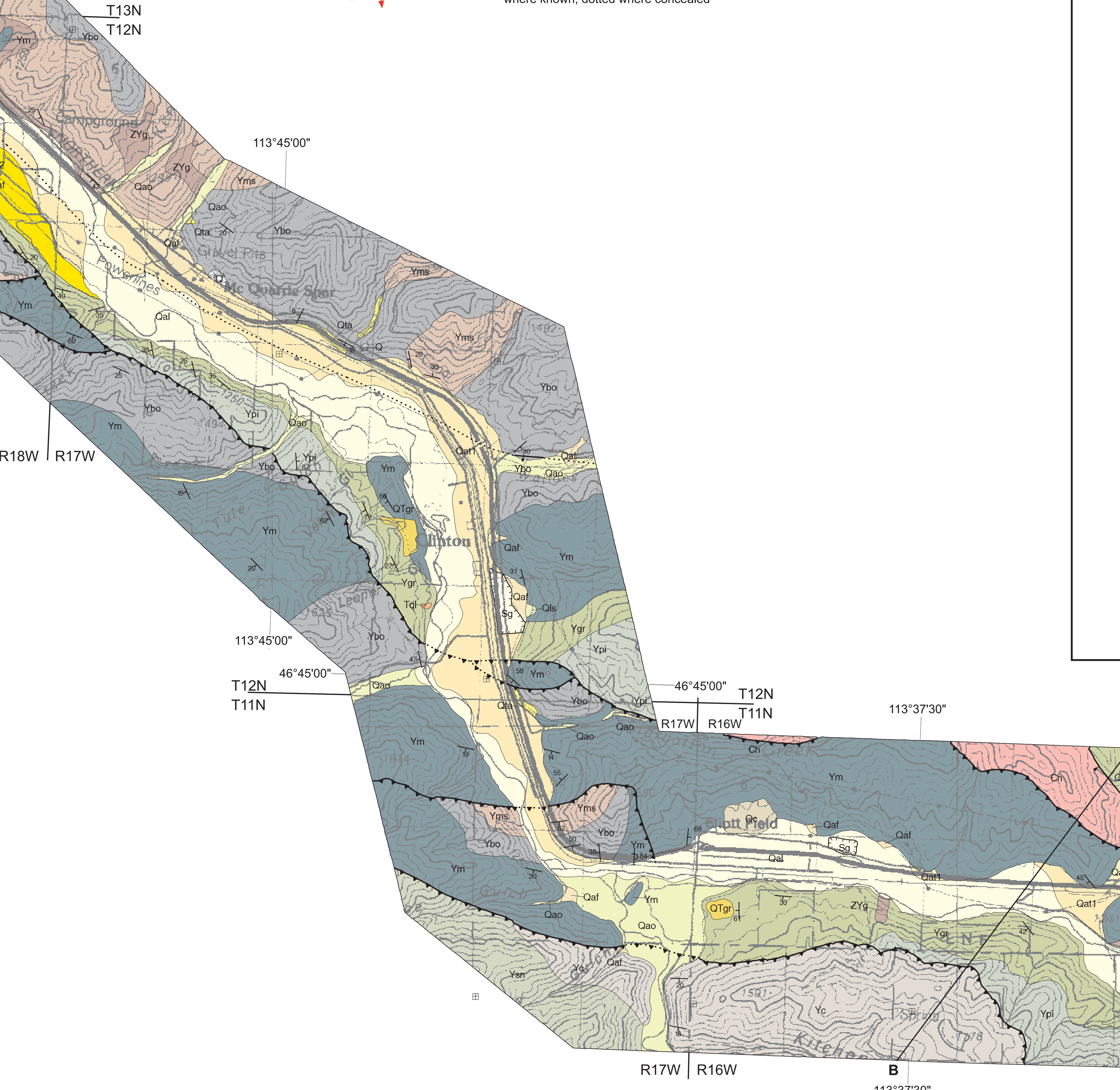
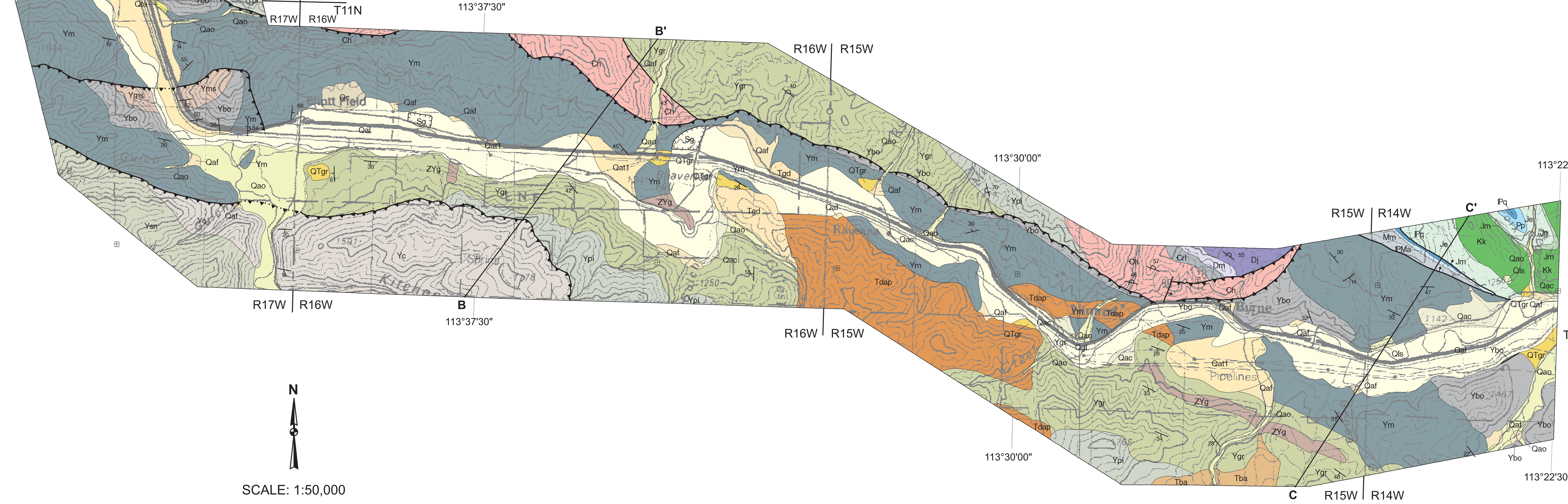




Map Symbols

Contact: dotted where concealed

Fault: dashed where approximately located; dotted where concealed, bar and ball on downthrown side where known

Thrust fault: Teeth on upper plate, dashed where known

Strike and dip of inclined beds

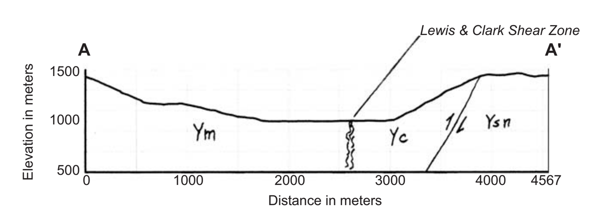
Anticline: showing trace of axial plane and plunge direction where known, dotted where concealed

MAP UNITS

Qal	Alluvium of modern channels and flood plains
Qac	Alluvium and colluvium, undivided
Qc	Colluvium
Qls	Landslide deposit
Qta	Talus deposit
Qaf	Alluvial fan deposit
Qat1	Alluvium of youngest alluvial terrace
Qat2	Alluvium of second youngest alluvial terrace
Qao	Alluvium, older, undivided
Qgl	Glacial lake deposit
QTgr	Gravel
Tba	Basalt
Tdap	Dacite porphyry
Tql	Quartz latite
Tgd	Granodiorite
Kk	Kootenai Formation
Jm	Morrison Formation
Je	Ellis Group, undivided
Pp	Phosphoria Formation
IPq	Quadrant Formation
IPMa	Amsden Formation
Mm	Madison Group, undivided
Dj	Jefferson Formation
Dm	Maywood Formation
Ꞓrl	Red Lion Formation
Ꞓh	Hasmark Dolomite
Ꞓs	Sedimentary rocks, undivided
ZYg	Gabbro
Ypi	Pilcher Formation
Ygr	Garnet Range Formation
Ym	McNamara Formation
Ybo	Bonner Formation
Yms	Mount Shields Formation
Ysh	Shepard Formation
Ysn	Snowslip Formation
Yc	Middle Belt carbonate, informal
Q	Quarry
Sg	Sand and gravel pit
M	Modified

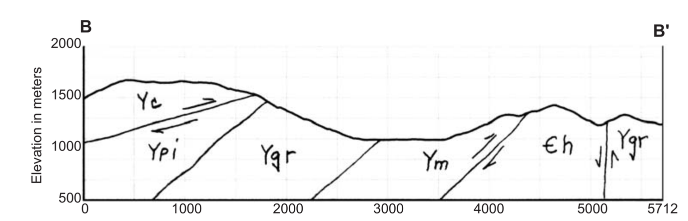
For a more detailed description of the map units and symbols, please refer to the text accompanying this map.

A-A' cross section



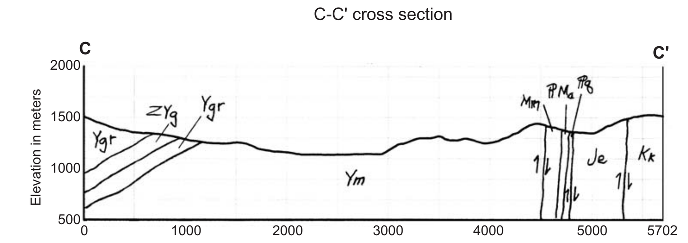
Datum: mean sea level
No vertical exaggeration
Quaternary deposits not shown

B-B' cross section



Datum: mean sea level
No vertical exaggeration
Quaternary deposits not shown

C-C' cross section

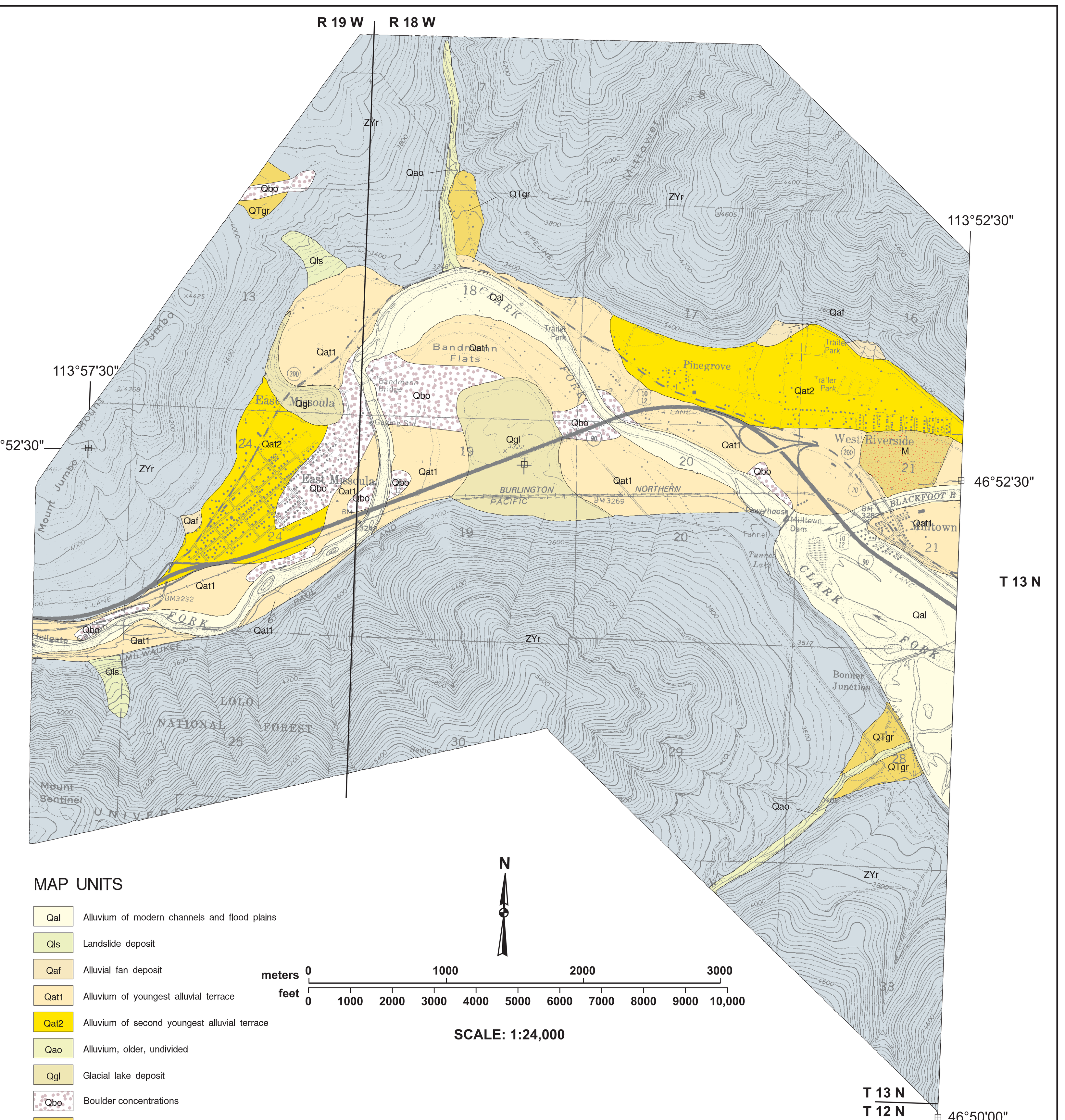


Datum: mean sea level
No vertical exaggeration
Quaternary deposits not shown

SCALE: 1:50,000

0 1 2 4 6 8 Miles

0 1,250 2,500 5,000 7,500 10,000 Meters



MAP UNITS

Qal	Alluvium of modern channels and flood plains
Qls	Landslide deposit
Qaf	Alluvial fan deposit
Qat1	Alluvium of youngest alluvial terrace
Qat2	Alluvium of second youngest alluvial terrace
Qao	Alluvium, older, undivided
Qgl	Glacial lake deposit
Qbo	Boulder concentrations
QTgr	Gravel
ZYr	Proterozoic rocks, undivided
M	Modified

N

meters 0 1000 2000 3000

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

SCALE: 1:24,000

Inset Map of Northwest Map Area Showing Concentrations of Boulders in East Missoula Area

MBMG Open File 535

Geologic Map of the Upper Clark Fork Valley between Bearmouth and Missoula, Southwestern Montana

Richard B. Berg

2006

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