Geologic Map of the Upper Clark Fork Valley between Garrison and Bearmouth

Southwestern Montana

Mapped and Compiled
by
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Montana Bureau of Mines and Geology

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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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Geologic Summary

This map covers a narrow strip along the Clark Fork River Valley from Garrison to several miles west of Bearmouth, Montana (Figures 1, 2, and 3) and is a continuation of special focus mapping that began at the Continental Divide east of Butte (Berg and Hargrave, 2004). Mapping will be continued along the Clark Fork Valley west to Missoula. The map for the area from Bearmouth to Missoula is scheduled to be released in July 2006. Sources of geologic information are shown in Figure 4.

This stretch of the Clark Fork Valley is narrow as compared to the broad Deer Lodge Valley and is only 1.5 miles wide at its widest point near Jens west of Gold Creek. This valley was eroded along the Lewis and Clark Line, a major fault zone that extends west-northwest from the vicinity of Garrison into northern Idaho. Evidence of this fault zone is shown by the abundance of faults in the sedimentary rocks exposed on both sides of the valley, particularly west of Drummond. Rocks exposed along this valley range in age from Proterozoic metamorphic rocks of the Belt Supergroup exposed west of Bearmouth to the Tertiary clay-rich sedimentary beds that are well exposed on the north side of the valley a few miles east of Drummond. Limestone of the Madison Group forms spectacular cliffs along the Clark Fork Valley west of Drummond and was quarried at two sites along Rattler Gulch, also west of Drummond. Another prominent formation exposed along the Clark Fork Valley is the Amsden Formation that overlies the Madison Group and is recognized by its brick-red color. The Quadrant Formation, overlying the Amsden Formation, forms distinctive outcrops of very hard, tan to white quartzite. The Kootenai Formation, consisting of sandstone, limestone, and maroon, green, and gray shale beds, is well exposed on the north side of the Clark Fork Valley west of Drummond. Tan, clay-rich Cabbage Patch beds of Tertiary age are exposed east of Drummond on the north side of the valley. Older sandstone and shale beds of Cretaceous age are exposed farther to the east on the north side of the valley. Dark weathering basalt flows and light-gray rhyolitic volcanic rocks are exposed along both sides of the valley.

Speculation

The Clark Fork River in the area between Bearmouth and Garrison may have flowed from west to east in the past, probably during the Tertiary. Pink to maroon, well-rounded quartzite cobbles are found in gravel (QTgr) with a greater concentration of quartzite to the west near Bearmouth and decreased concentration to the east at Jens. These cobbles resemble the quartzite in the Belt Supergroup that is exposed only along the Clark Fork downstream about one mile west of Bearmouth. For this reason, it is suggested that these cobbles were transported by an ancestral river flowing to the east, probably during the Tertiary.

Distinctive, light-gray, granitic pebbles and cobbles occur in the gravels along the Clark Fork River upstream from Drummond. Similar granite cobbles and boulders are abundant in glacial till and outwash deposits on the west side of the Deer Lodge Valley. They were eroded from granitic plutons in the Flint Creek Range by glaciers. During melting of these glaciers in

the Flint Creek Range, there must have been high water flow along the Clark Fork River with enough energy to move these rocks downstream to the Drummond area.

Acknowledgments

The cooperation of land owners along the Clark Fork River Valley who, without exception, granted access to their land, is sincerely appreciated. Phyllis Hargrave assisted with illustrations; Ken Sandau and Susan Smith prepared the map. Their assistance and that of reviewers contributed to a better map.

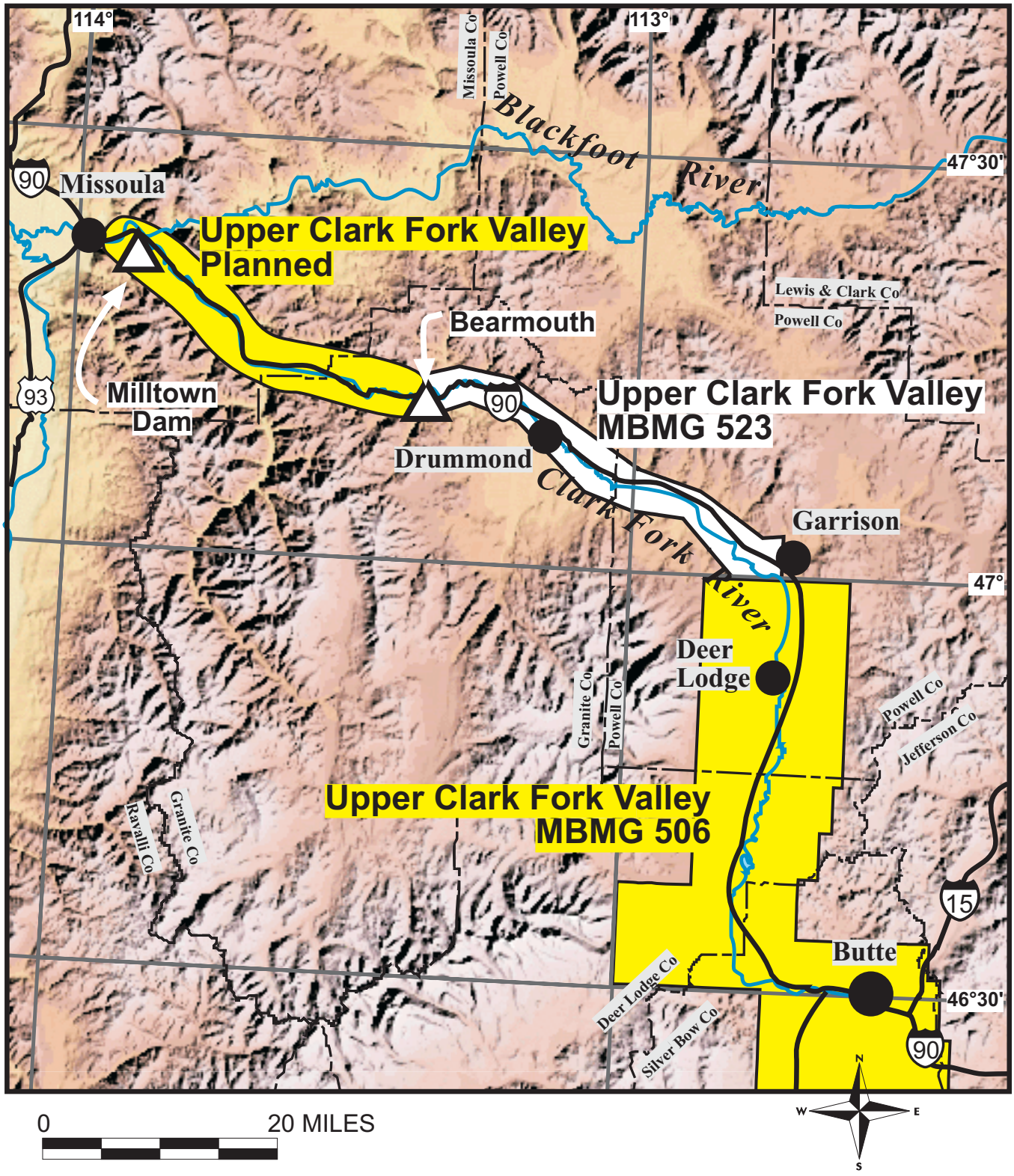


Figure 1. Location of the current map, the second of three maps planned for the Upper Clark Fork River Valley. MBMG Open File 506 covers the area from Butte to Garrison; the current map, MBMG Open File 523, covers the area from Garrison to Bearmouth; and the final map will cover the area from Bearmouth to Missoula.

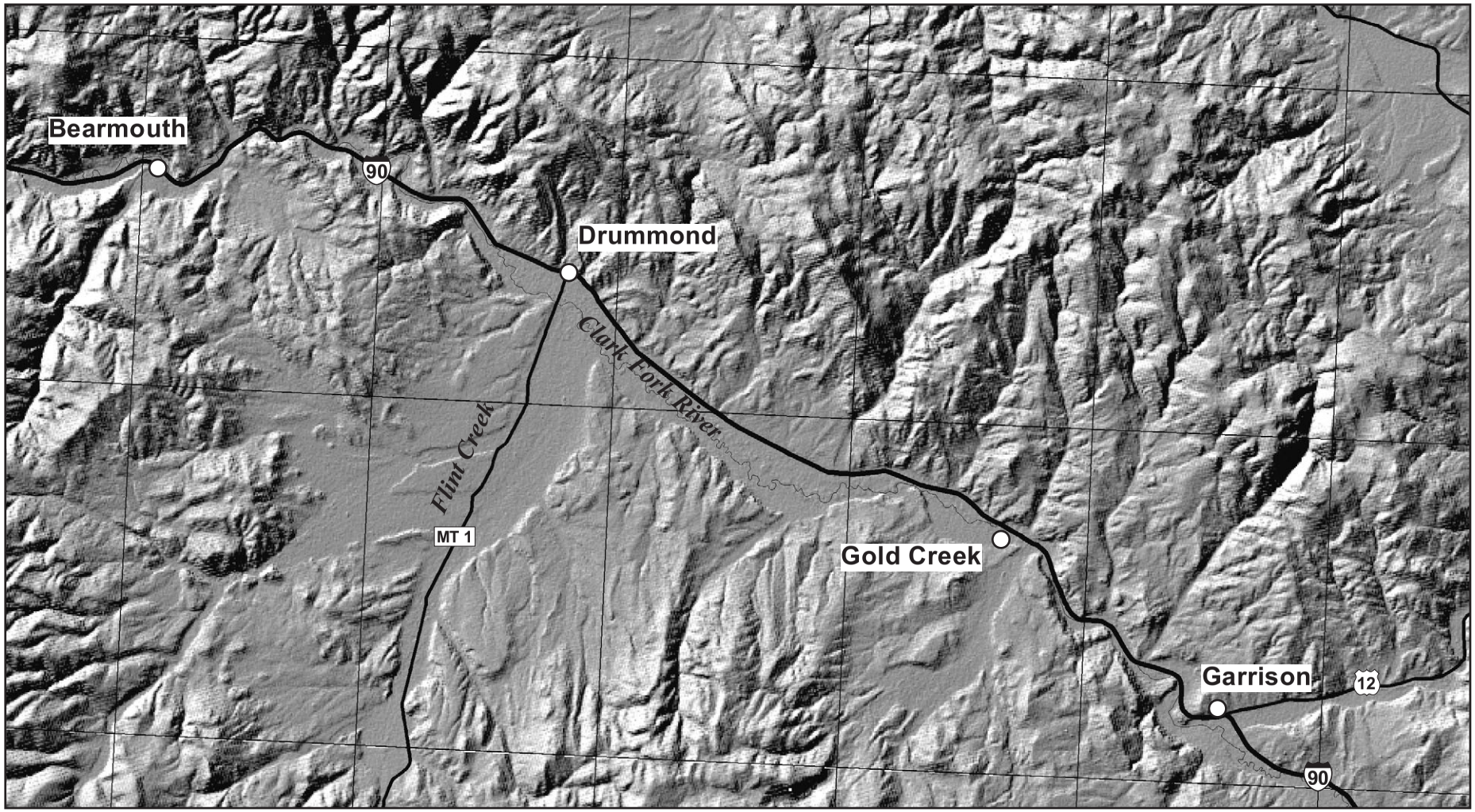


Figure 2. Shaded relief map showing topography along the Clark Fork River in the area mapped.

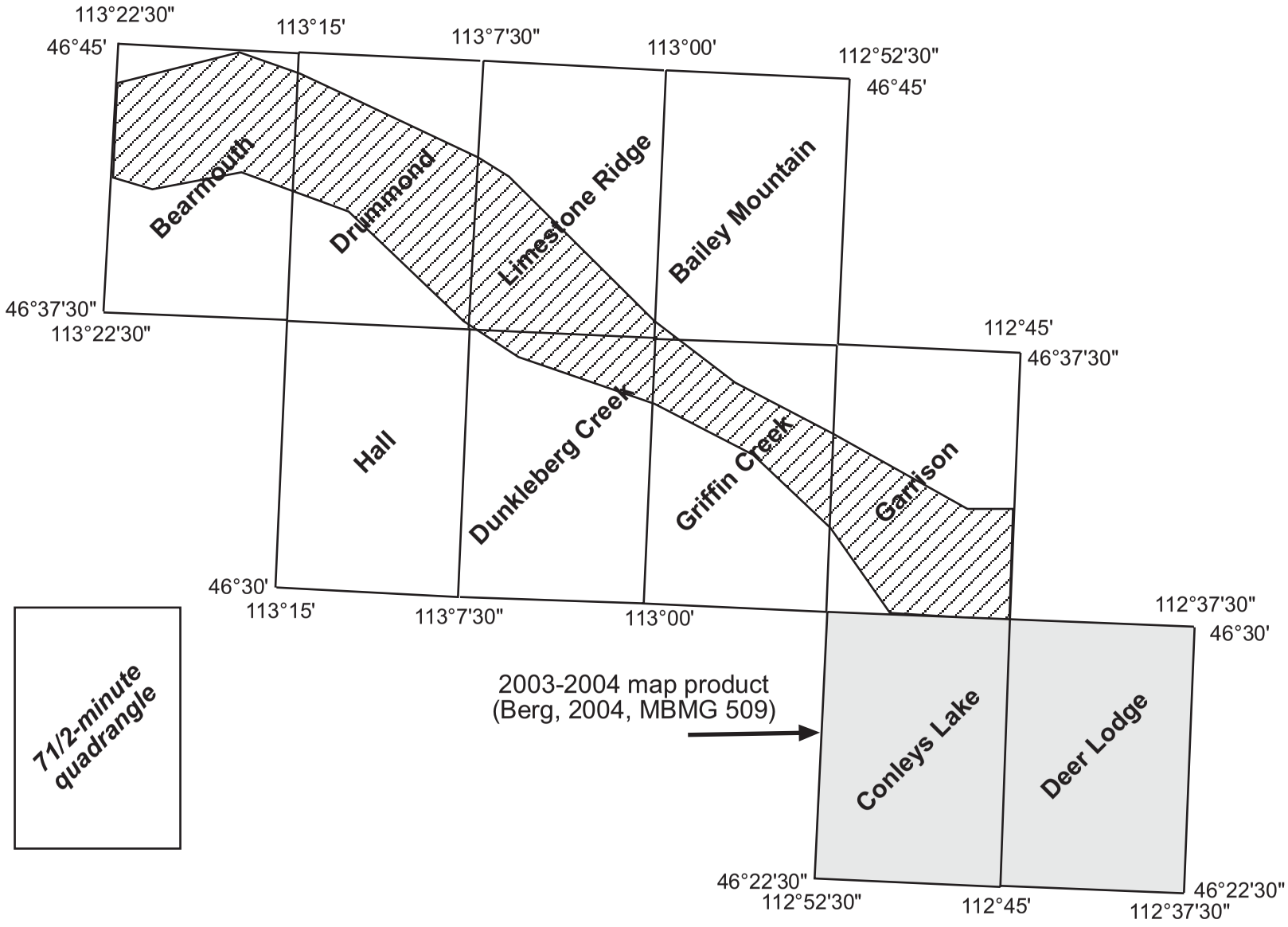


Figure 3. Area of accompanying geologic map.

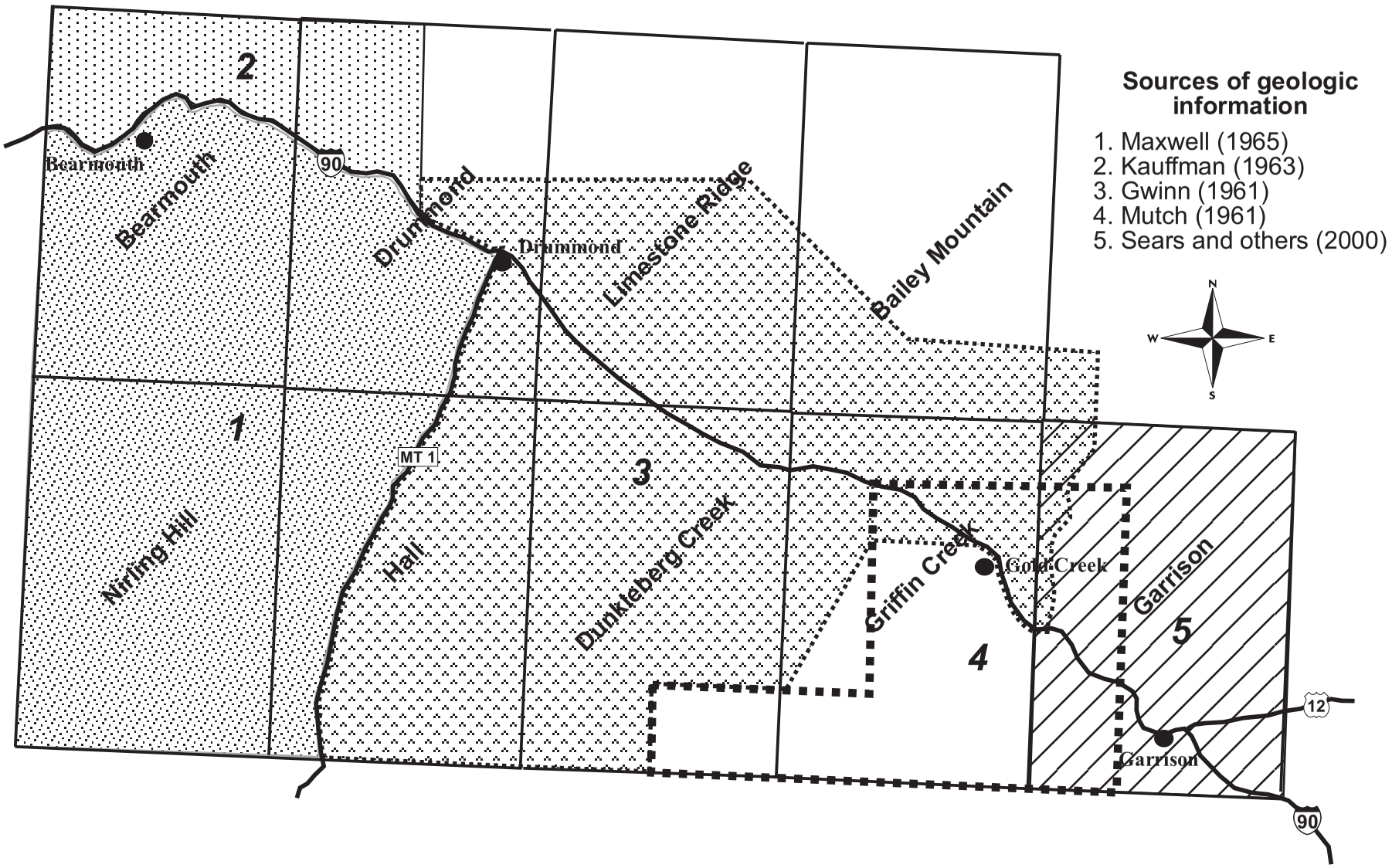
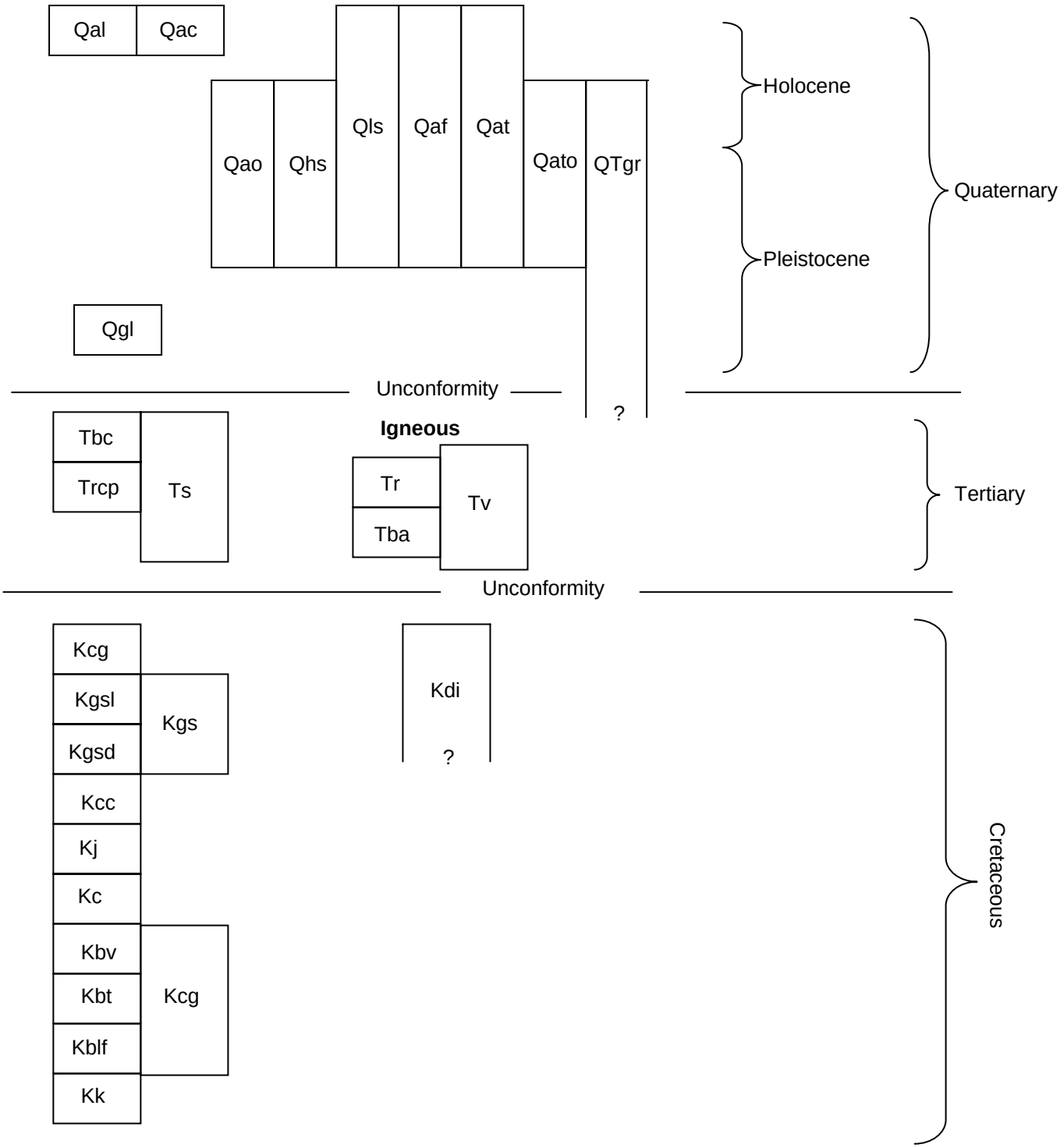


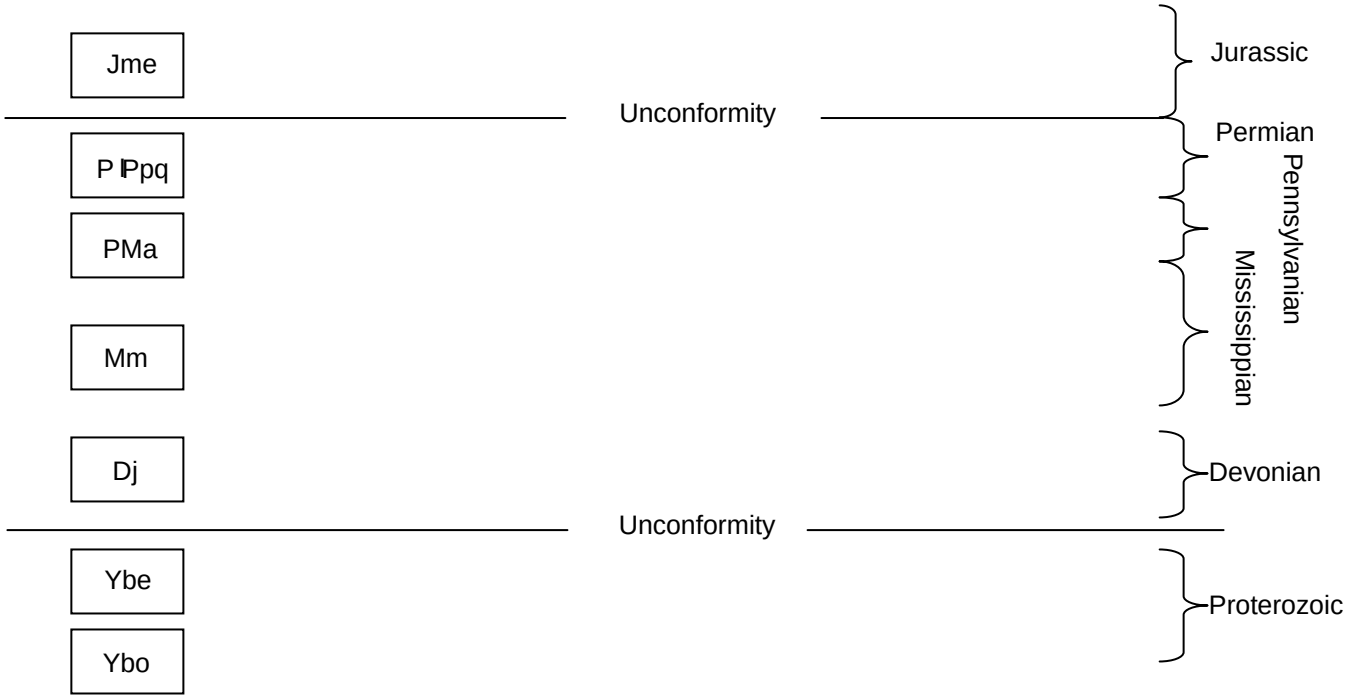
Figure 4. Sources of geologic information for the Garrison to Bearmouth area. See complete citations in reference section of this report.

Correlation of map units in the Upper Clark Fork River Valley area from Garrison to Bearmouth



(Continued next page)

Correlation of map units in the Upper Clark Fork River Valley area from Garrison to Bearmouth



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

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, entirely arbitrary and may be based on topographic form. For instance, Qac (colluvium) that was deposited by sheet wash and soil creep is locally indistinguishable from Qaf (alluvial fans) deposited by fluvial processes.

QUATERNARY

Qal **Alluvium** - Gravel, sand, silt, and clay along the Clark Fork River and many tributaries. Gravel along the Clark Fork west of Drummond consists mainly of pebbles and cobbles of gray quartzite, pink quartzite, rhyolite, with lesser amounts of gray limestone and distinctive light- gray biotite granite. The abundance of light-gray granite pebbles and cobbles is greater east of Drummond. Just west of the confluence of Gold Creek with the Clark Fork, more than 10 percent of the cobbles are light-gray biotite granite. These granite cobbles are well rounded and are equigranular granite that ranges in texture from massive to foliated. One boulder of granite at this locality is 3 ft in maximum dimension.

Qac **Alluvium-colluvium** - Developed at the base of fairly steep slopes along the Clark Fork River Valley where sediment has been deposited by sheetwash and soil creep. Colluvium is poorly sorted and consists of angular rocks. This unit also includes alluvium that consists of rounded pebbles and cobbles from local sources.

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Qls **Landslide deposit** - These deposits occur on the steeper slopes developed on the poorly consolidated Tertiary sedimentary rocks and also on some of the clayey beds in the Kootenai Formation.

Qaf **Alluvial fan deposit** - Poorly sorted deposits of locally derived detritus formed at the mouths of tributaries to the Clark Fork River. Alluvial fan deposits are most prominent on the north side of the Clark Fork River Valley where tributaries to the Clark Fork River are generally larger than on the south side of the valley. These deposits grade laterally into colluvium along the Clark Fork River.

Qat **Alluvium of alluvial terrace** - At least three levels of alluvial terraces are recognizable along the Clark Fork River. Two levels of alluvial terraces can be seen from Interstate 90 about 5.5 miles west of Drummond where the highway crosses the Clark Fork. The upper terrace is at an elevation of approximately 4,000 ft and the lower terrace at an

approximate elevation of 3,920 ft. The alluvium of alluvial terraces in the Clark Fork Valley consists mainly of cobbles of limestone, quartzite, and volcanic rocks. With the exception of the pink to maroon quartzite, undoubtedly from the Belt Supergroup, these cobbles are from the bedrock exposed on both sides of the Clark Fork River. The quartzite is presumably derived from QTgr gravel that contains similar quartzite cobbles

Qao **Older alluvium** - Alluvium along some tributary streams to the Clark Fork River at 5-30 ft above the Clark Fork River flood plain near the confluence of the tributary with the Clark Fork River. Also isolated remnants of alluvial deposits deposited by the Clark Fork River but 10-30 ft above the present flood plain. Includes small areas of Qal along flowing and intermittent streams that are tributaries to the Clark Fork River.

Qato **Alluvium of older alluvial terrace** - Only found in the area just east of Gold Creek. This gravel is 8 ft thick in the NE¼ NE¼ sec. 1, T. 9 N., R. 11 W. where it was mined for gold (Pardee, 1951). It consists of boulders of granite, quartzite, and other metamorphic rocks.

Qhs **Hot spring deposit** - Concentration of travertine float in the NE ¼ NE ¼ SE ¼ sec. 10, T. 11 N., R. 13 W. There is a concentration of float of fine-grained limestone some with finely interlayered calcite and quartz (layers 1 mm or less thick) in the C SW¼ SW¼ sec. 31, T. 11 N., R. 12 W. This rock that contains small snail fossils is interpreted to be a hot spring deposit.

Qgl **Glacial lake deposit** - Varved Glacial Lake Missoula deposits occur at several localities west of Drummond. These preserved deposits are within approximately 60 ft in elevation of the Clark Fork River and consist of silt- and clay-sized particles. The most spectacular exposure of Glacial Lake Missoula sediments is in sec. 17, T. 11 N., R 13 W. where the course of the Clark Fork River was diverted into a channel cut during construction of Interstate 90. This exposure is just east of mile post 147 at 147.3 miles.

QUATERNARY AND TERTIARY

QTgr **Gravel** - Remnants of gravel on hill slopes above the present Clark Fork River flood plain from the Bearmouth area to the Jens area. This gravel is at least 16 feet thick locally but in some areas appears to be a thin veneer on bedrock. At several localities, scattered cobbles on the surface are an indication of its former presence. This gravel is exposed in a road cut on the frontage road west of Drummond in the NE¼ sec. 21, T. 11 N., R. 13 W., just west of Rattler Gulch where it consists mainly of pink and red quartzite (thought to be from the Belt Supergroup), tan quartzite (Quadrant Formation), basalt, sandstone (Kootenai Formation), rare gray limestone (Madison Group), and rare, light-gray biotite granite cobbles. This gravel is poorly sorted and consists of pebbles, cobbles, and rare boulders in a fine-grained, clayey matrix. It is also well exposed in a cut along the abandoned Chicago, Milwaukee, St. Paul & Pacific Railroad west of Bearmouth on the south side of the Clark Fork River in the SE ¼ SW¼ sec. 16, T. 11 N., R. 13 W. The

estimated abundance of pebbles and cobbles in a clayey matrix at this locality is as follows: pink, red, and maroon quartzite, 30 percent; tan quartzite, 30 percent; pale green quartzite, 23 percent; tan to gray siltite, 7 percent; and tan to gray limestone, 7 percent. All of the pebbles and cobbles are well rounded. The siltite pebbles and cobbles are probably derived from the metasedimentary rocks of the Belt Supergroup. Farther east in the area between Drummond and Jens, this gravel consists of clasts of tan quartzite (Quadrant Formation), sandstone (Kootenai Formation), basalt and andesite, gray limestone (Madison Group), rare pink and red quartzite (Belt Supergroup), and rare, light- gray biotite granite. There is a general decrease in the abundance of pink and red quartzite from the Bearmouth area to the Jens area. There is an anomalously high concentration of light-gray granite cobbles in the gravel where it is exposed in a road cut at the eastern Drummond exit on Interstate 90.

TERTIARY

Tv **Volcanic rocks, undivided -** Generally light-gray to tan, fine-grained felsic volcanic rocks. This map unit includes a variety of different rock types and perhaps rocks of different ages.

Ts **Tertiary sedimentary rocks undivided** - This unit includes clayey beds in several areas west of Drummond that have not been assigned a specific age. It also includes beds that are exposed north of the Clark Fork River about 4 miles east of Drummond that were described by Gwinn (1961) as “Red, montmorillonitic pebbly clay found in discontinuous patches between the Cabbage Patch beds and pre-Tertiary strata .....”

Tbc **Barnes Creek beds, informal -** Description of gravel exposed in a gravel pit southeast of Drummond in the NW¼ NE¼ sec. 17, T. 10 N., R. 12 W. These beds are estimated to consist predominately of pebbles with 20-30 percent sand, and an almost complete lack of cobbles. The estimated composition of the gravel is 60 percent tan quartzite, 15 percent brown quartzite, 15 percent pink quartzite, 5 percent dark-gray, fine-grained sandstone and siltstone, < 3 percent crumbly claystone, < 2 percent volcanic rock, and rare white granite pebbles. Tan claystone underlies 12 ft of gravel. This gravel differs from the gravel shown as QTgr that contains abundant cobbles.

Trcp **Cabbage Patch beds, informal -** Late Oligocene to early Miocene (Arikareean) beds that are correlated with the upper Renova Formation of the Bozeman Group and described in detail by Rasmussen (1977 and 1989). These beds consist predominately of tuffaceous sediments and bentonitic mudstones with lesser siltstones, sandstones, and conglomerates.

Tr **Rhyolite or rhyolitic sediment** - Distinctive rhyolite with small (< 3 mm) black quartz and smaller glassy sanidine phenocrysts in a white to tan to pink, fine-grained groundmass. Some of the sanidine phenocrysts are opalescent when viewed in bright sunlight (moonstone). Tuffaceous beds occur within this sequence of rhyolite flows. A

potassium-argon date on sanidine from this rhyolite west of Bearmouth gives an age of 44.5± 2.0 m.y. (Williams and others, 1976).

Tba **Basalt and andesite** - Brown to black with scattered plagioclase phenocrysts that have weathered to produce small tan spots. A potassium-argon date on this basalt at Bearmouth gives an age of 44.9 ± 2.0 m.y. and another specimen of basalt from the Rattler Gulch area to the east gives an age of 46.7 ±2.5 m.y. (Williams and others, 1976). Three closed depressions on the west side of Rattler Gulch in the SE¼ NE¼ sec. 16, T. 11 N., R. 13 W. have been interpreted by Alt and others (1972) to be maar craters that are related to the basalt exposed here. These authors conclude that these craters developed on a strath terrace that was eroded on a bedrock surface by the Clark Fork River and thus are Pleistocene in age. The establishment of a Pleistocene age for this basalt awaits further investigation.

CRETACEOUS

Kdi **Diorite sills and other bodies that have intruded Cretaceous formations** - Gwinn (1961) described the diorite as containing quartz, orthoclase, and oligoclase.

Kgs **Golden Spike Formation (Upper Cretaceous)** - The non-volcanic sandstone consists mainly of quartz, lithic fragments, biotite, and muscovite, whereas the volcaniclastic beds consist mainly of plagioclase feldspar, volcanic glass, and volcanic rock fragments in a fine-grained matrix (Mackie, 1986). The Golden Spike Formation unconformably overlies the Carter Creek Formation (Gwinn, 1961).

Kgsl **Lava flow unit, informal, of the Golden Spike Formation (Upper Cretaceous)** - Lava flows are best exposed along Rock Creek south of Garrison where they range in attitude from horizontal to a 45-degree dip. Plagioclase phenocrysts (most from 3 mm to 1 cm) range from sparse to abundant and, at some localities, define flow foliation. Smaller pyroxene phenocrysts are less abundant. Flow breccias mark the tops of some flows.

Kgsd **Volcanic and nonvolcanic diamictite member ("chaos beds"), informal, of the Golden Spike Formation (Upper Cretaceous)** - Excellent exposure in the road cut on the frontage road about 1 mile west of Garrison. Sears and others (2000), Part A describe the diamictite as "A debris flow deposit composed of blocks of Cretaceous sandstone and volcanic rock and rounded cobbles of Paleozoic and Proterozoic rocks in a volcanic mud matrix."

Kcc **Carter Creek Formation (Upper Cretaceous)** - This formation consists predominately of sandstone, siltstone, and silty mudstone with some dark marine shale in the lower 2,000 ft. It is estimated that the Carter Creek Formation reaches a thickness of 5,700 to 6,000 ft in the vicinity of Carten Creek and disconformably overlies the Jens Formation (Gwinn, 1961). Although formally mistakenly named the Carter Creek Formation, it is named for Carten Creek, a tributary that enters the Clark Fork River from the north and alongside

which the type section is located (Waddell, 1997).

Kj **Jens Formation (Upper Cretaceous)** - Consists of dark shale, siltstone, minor thin-bedded, silty, siliceous mudstone. West of Gough Creek, volcanic-rich beds occur, and this formation reaches a thickness of 1,510 ft (Gwinn, 1961).

Kc **Coberly Formation (Upper Cretaceous)** - Consists of fossiliferous gray limestone and tan salt-and-pepper sandstone, and is 570 to 650 ft thick (Gwinn, 1961).

Kbv **Vaughn Member of the Blackleaf Formation (Upper? and Lower Cretaceous)** - The Vaughn Member is equivalent to the Dunkleberg Member of the Blackleaf Formation as described by Gwinn (1961). This member is 1,700 ft thick and consists of mudstone, siltstone, sandstone, and several thick beds of conglomerate with abundant volcanic detritus.

Kbt **Taft Hill Member of the Blackleaf Formation (Lower Cretaceous)** - Tan, gray, and brown sandstone, siltstone, mudstone, and minor shale. Approximately 900-1,000 ft thick (Gwinn, 1961).

Kblf **Flood Member of the Blackleaf Formation (Lower Cretaceous)** - Sandstone, siltstone, some thin limestone beds, and dark-gray to black fissile shale with a total thickness of 232 ft (Kauffman, 1963).

Kcg **Colorado Group, undivided** - Very dark-gray fissile shale is exposed along the frontage road approximately 6 miles west of Drummond where it is in fault contact with the Kootenai Formation.

Kk **Kootenai Formation (Lower Cretaceous)** - Kauffman (1963) has 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, 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

Jme **Morrison Formation and Ellis Group undivided** - The Morrison Formation consists of claystone, shale, siltstone, and medium-grained sandstone that are generally green or

yellow. The Morrison Formation reaches a maximum thickness of 220 ft in this area. The Ellis Group, as exposed in this area, consists of, from youngest to oldest, the Swift, Rierdon, and Sawtooth Formations. The Swift Formation has a maximum thickness in this area of 244 ft 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, calcareous shale, and shaly limestone (Kauffman, 1963).

PERMIAN AND PENNSYLVANIAN

P IPpq Phosphoria Formation and Quadrant Formation, undivided - 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. The Quadrant Formation is usually well exposed, forming bold outcrops of tan, vitreous quartzite. Where not exposed, float of this durable quartzite is distinctive. Thickness of the Quadrant Formation is 140 ft (Kauffman, 1963).

PENNSYLVANIAN AND MISSISSIPPIAN

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

MISSISSIPPIAN

Mm Madison Group - Maximum thickness of the Madison Group in this area is 2,200 ft. The lower formation, the Lodgepole Limestone, consists of well-bedded limestone interbedded with shaly limestone that is in contrast to the overlying, massive, gray limestone of the Mission Canyon Formation (Kauffman, 1963).

DEVONIAN

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

PROTEROZOIC

Ybe Belt Supergroup, undivided - Maroon argillite and quartzite poorly exposed, but presumably of the Missoula Group.

Ybo Bonner Formation - Tan to maroon to pink, hard quartzite with rounded quartz grains and abundant hematite between detrital grains.

Map Symbols

Contact - Dotted where concealed

Fault - Dashed where approximately located; bar and ball on downthrown side, where known

Thrust fault - Teeth on upper plate; dashed where approximately located; dotted where concealed

Strike and dip of beds or planar feature in lava flow

Horizontal beds

Anticline - Showing trace of axial plane

Syncline - Showing trace of axial plane; dashed where approximately located

Overturned anticline - Showing trace of axial plane

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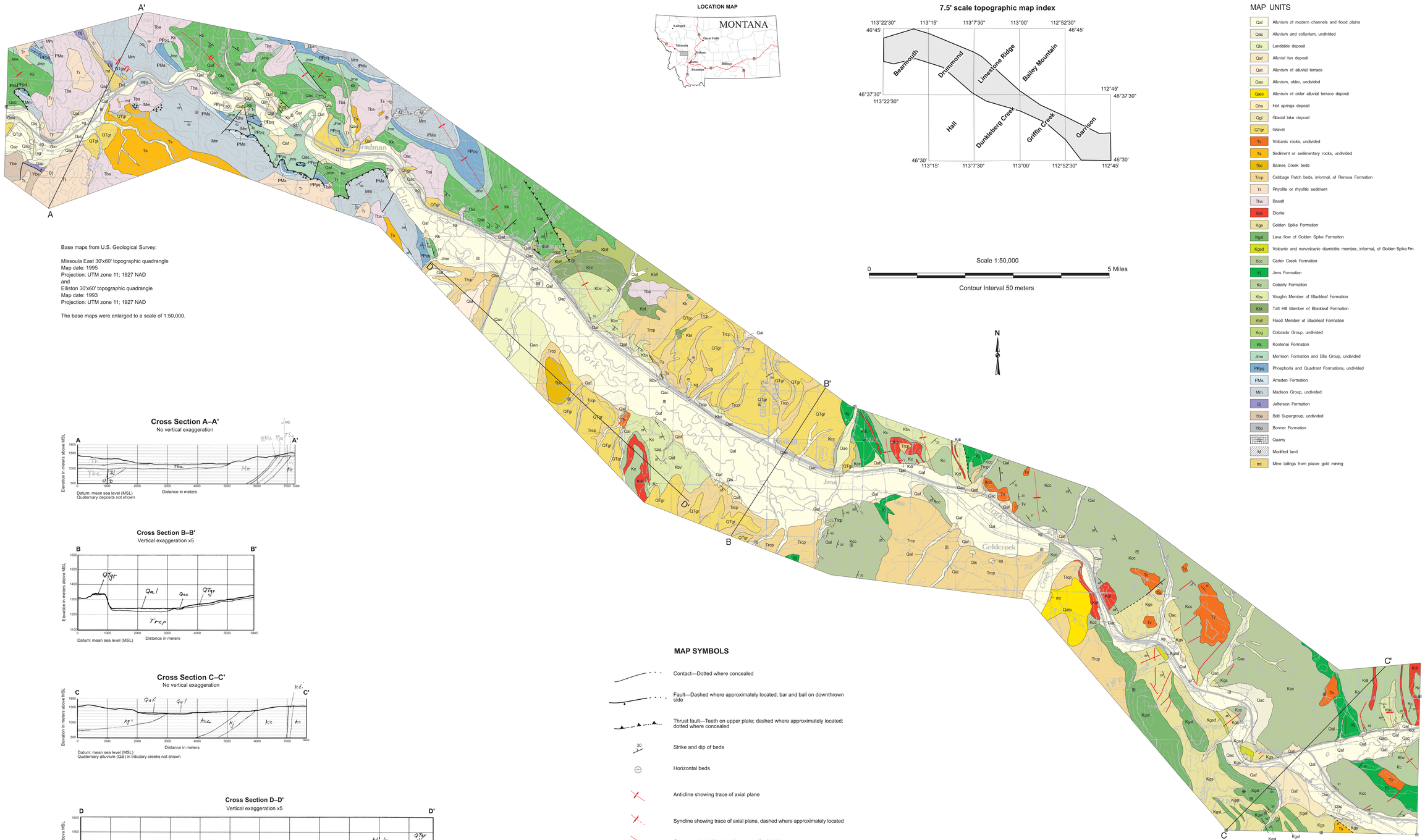


LOCATION MAP

7.5' scale topographic map index

MAP UNITS

- Qal — Alluvium of modern channels and flood plains
- Qac — Alluvium and colluvium, undivided
- Qls — Landslide deposit
- Qaf — Alluvial fan deposit
- Qat — Alluvium of alluvial terrace
- Qao — Alluvium, older, undivided
- Qato — Alluvium of older alluvial terrace deposit
- Qhs — Hot springs deposit
- Qgl — Glacial lake deposit
- QTgr — Gravel
- Tv — Volcanic rocks, undivided
- Ts — Sediment or sedimentary rocks, undivided
- Tbc — Barnes Creek beds
- Trcp — Cabbage Patch beds, informal, of Renova Formation
- Tr — Rhyolite or rhyolitic sediment
- Tba — Basalt
- Kdi — Diorite
- Kgs — Golden Spike Formation
- Kgsl — Lava flow of Golden Spike Formation
- Kgsd — Volcanic and nonvolcanic diamictite member, informal, of Golden Spike Fm.
- Kcc — Carter Creek Formation
- Kj — Jens Formation
- Kc — Coberly Formation
- Kbv — Vaughn Member of Blackleaf Formation
- Kbt — Taft Hill Member of Blackleaf Formation
- Kbf — Flood Member of Blackleaf Formation
- Kcg — Colorado Group, undivided
- Kk — Kootenai Formation
- Jme — Morrison Formation and Ellis Group, undivided
- PPpq — Phosphoria and Quadrant Formations, undivided
- PMa — Amsden Formation
- Mm — Madison Group, undivided
- Dj — Jefferson Formation
- Ybe — Belt Supergroup, undivided
- Ybo — Bonner Formation
- Qs — Quarry
- Qm — Modified land
- mt — Mine tailings from placer gold mining

Cross Section A–A'

No vertical exaggeration

Datum: mean sea level (MSL)
Quaternary deposits not shown

Cross Section B–B'

Vertical exaggeration x5

Datum: mean sea level (MSL)

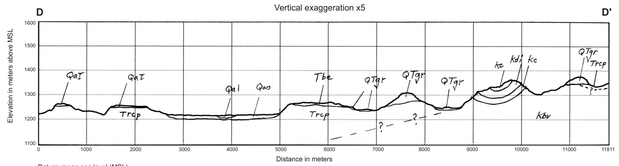
Cross Section C–C'

No vertical exaggeration

Datum: mean sea level (MSL)
Quaternary alluvium (Qal) in tributory creeks not shown

Cross Section D–D'

Vertical exaggeration x5



Datum: mean sea level (MSL)
Quaternary alluvium (Qal) in tributory creeks not shown

MAP SYMBOLS

- Contact—Dotted where concealed
- Fault—Dashed where approximately located; bar and ball on downthrown side
- Thrust fault—Teeth on upper plate; dashed where approximately located; dotted where concealed
- 30 — Strike and dip of beds
- Horizontal beds
- Anticline showing trace of axial plane
- Syncline showing trace of axial plane, dashed where approximately located
- Overturned anticline showing trace of axial plane
- sg — Sand and gravel pit
- Brecciated and silicified limestone of the Madison Group

Maps may be obtained from: Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4167
Fax: (406) 496-4451
http://www.mbmg.mtech.edu

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GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

MBMG Open File 523

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

Mapped and Compiled by
Richard B. Berg

2005