

# BEDROCK GEOLOGY OF LUKE MOUNTAIN AND GARRISON QUADRANGLES POWELL COUNTY, MONTANA

by

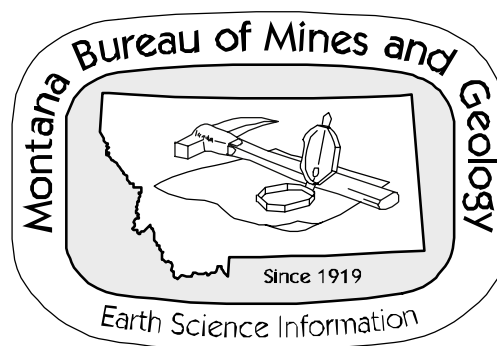
James W. Sears, Benjamin Webb, and Michael Taylor

The University of Montana

MONTANA BUREAU OF MINES AND GEOLOGY

OPEN FILE REPORT 403

2000



This report has had preliminary reviews for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

Partial support has been provided by the EDMAP component of the National Cooperative Geologic Mapping Program of the U. S. Geological Survey under Contract Number 98-HQ-AG-2091.

# BEDROCK GEOLOGY OF GARRISON QUADRANGLE POWELL COUNTY, MONTANA

by

James W. Sears, Benjamin Webb, and Michael Taylor

The University of Montana

MONTANA BUREAU OF MINES AND GEOLOGY

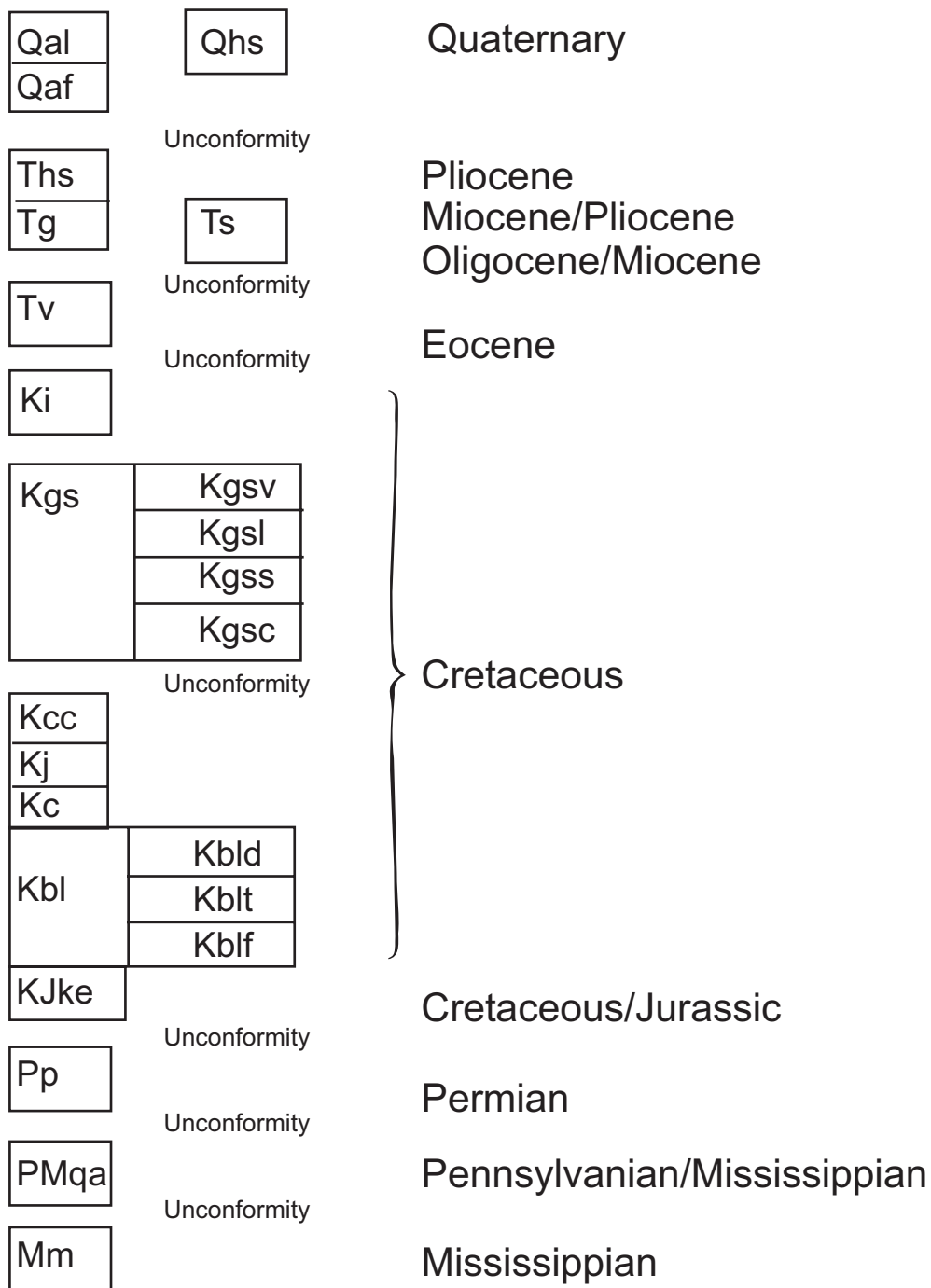
OPEN FILE REPORT 403, Part A

2000

This report has had preliminary reviews for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

Partial support has been provided by the EDMAP component of the National Cooperative Geologic Mapping Program of the U. S. Geological Survey under Contract Number 98-HQ-AG-2091.

# Correlation of Map Units on Garrison Quadrangle



BEDROCK GEOLOGY OF GARRISON QUADRANGLE, POWELL COUNTY,  
MONTANA

DESCRIPTION OF MAP UNITS

QUATERNARY

Qaf Alluvial fan deposits. Broad, fan-shaped gravel, sand, and clay deposits at the confluence of Rock Creek with the Clark Fork River.

Qhs Calcareous travertine deposits forming waterfall in Warm Springs Creek.

Qal Alluvial gravel, sand, and clay deposits in stream valleys.

Unconformity

TERTIARY

Ths Thick, white to light-grey, banded, calcareous travertine deposits on high bench between Warm Springs Creek and Brock Creek.

Tpg Rounded gravel deposits capping high-level erosional surface between Warm Springs Creek and Brock Creek. Possible Sixmile Creek Formation equivalent.

Ts Unconsolidated sediments, undivided, in southwest corner of map. Includes possible Sixmile Creek and Renova Formation equivalents.

Unconformity

Tv Volcanic rocks, undivided. Probable Lowland Creek Volcanics equivalent.

Angular Unconformity

CRETACEOUS

Ki Pyroxene-biotite andesitic and dioritic sills and dikes. Large euhedral pyroxene crystals common.  $^{40}\text{Ar}/^{39}\text{Ar}$  biotite date of 76 Ma from sample 1 km west of quadrangle from Interstate 90W road cut, near Mile Post 169 (Sears and others, 1997). Crosscuts Golden Spike Formation and older units.

Kgs Golden Spike Formation. Interlayered, laterally discontinuous, nonvolcanic

and volcanic rocks, 2.0 to 2.5 km thick, differentiated by Gwinn and Mutch (1965) into the following informal mapped units:

Kgsv Volcaniclastic sandstone and conglomerate (informal unit).

Kgsl Andesitic lava flows (informal unit).

Kgss Nonvolcanic sandstone, shale, and conglomerate (informal unit).

Kgsd Mixed volcanic and nonvolcanic diamictite ("chaos beds"). A debris flow deposit composed of blocks of Cretaceous sandstone and volcanic rock and rounded cobbles of Paleozoic and Proterozoic rocks in volcanic mud matrix (informal unit).

Kgsc Nonvolcanic fluvial conglomerate composed of rounded pebbles and cobbles of Paleozoic and Proterozoic lithologies (informal unit).

#### Angular Unconformity

Kcc Carter Creek Formation (Gwinn, 1965). Interlayered grey shale, yellow-brown weathering, friable, cross-bedded, "salt-and-pepper" sandstone and minor conglomerate; contains *Cardium pauperulum* (Wallace and others, 1990). Thickness 1.8 km in Brock Creek, thinning southeastward to 500 m beneath sub-Golden Spike unconformity.

Kj Jens Formation. Grey shale with thin, tabular, grey sandstone beds and minor porcellanite; locally cleaved; contains *Inoceramus sp.* (Gwinn, 1965). Thickness 200 m.

Kc Coberly Formation. Grey sandstone and shale with burrows. Contains two distinctive, well-cemented, yellow-weathering beds of oyster-rich (*Ostrea soleniscus*; Gwinn, 1965) and gastropod-rich sandstone, indicated on map as dashed line. Thickness 250 m.

Kbl Blackleaf Formation.

Kbld Dunkleberg Member. Interlayered light grey, laminated, siliceous mudstone, porcellanite, grey and green shale, white, cross-bedded salt-and-pepper sandstone, and black chert-quartzite pebble conglomerate. Disharmonically folded on small scale. Thickness 450 m.

Kblt Taft Hill Member. Interlayered brown, cross-bedded, salt-and-pepper sandstone, conglomerate, and grey to green shale.

Thickness 250 m.

Kblf Flood Member. Black shale, with brown sandstone beds and thin, grey, shelly limestone at base. Thickness 200 m.

## CRETACEOUS AND JURASSIC

KJke Kootenai Formation and Ellis Group, undivided. Brown, well-cemented, salt-and-pepper sandstone, black-chert pebble conglomerate, red shale, and light grey and yellow, micritic limestone. Thickness 400 m.

Unconformity

## PERMIAN

Pp Phosphoria Formation. Dark grey and brown, well-indurated sandstone, shale, bedded chert, and oolitic phosphatic rock. Thickness 75 m.

Unconformity

## PENNSYLVANIAN AND MISSISSIPPIAN

PMqa Quadrant Formation and Amsden Formation, undivided. Grey and tan silicified quartzite and dolomitic siltstone (Quadrant Formation), and red dolomitic siltstone and shale (Amsden Formation). Thickness 125 m.

Unconformity

Mississippian

Mm Madison Group. Light grey, thick bedded, biosparite limestone, and thin-bedded micrite with nodular chert; cliff-forming. Thickness 800 m, upper 500 m exposed in Warm Springs Canyon.

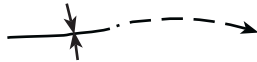
Ds Sedimentary rocks, undivided (cross sections only).

Cs Sedimentary rocks, undivided (cross sections only).

## GEOLOGIC MAP SYMBOLS



Contact; dashed where approximately located, dotted where concealed.



Synclinal fold showing trace of axial plane; dashed where approximately located, dotted where concealed. Arrow indicates direction of plunge where known.



Anticlinal fold showing trace of axial plane; dashed where approximately located, dotted where concealed. Arrow indicates direction of plunge where known.



Strike and dip of bedding; degree of dip indicated.



General strike and dip direction of bedding; estimated in field or from aerial photographs



Fault; dashed where approximately located, dotted where concealed. Ball and bar on down-thrown side



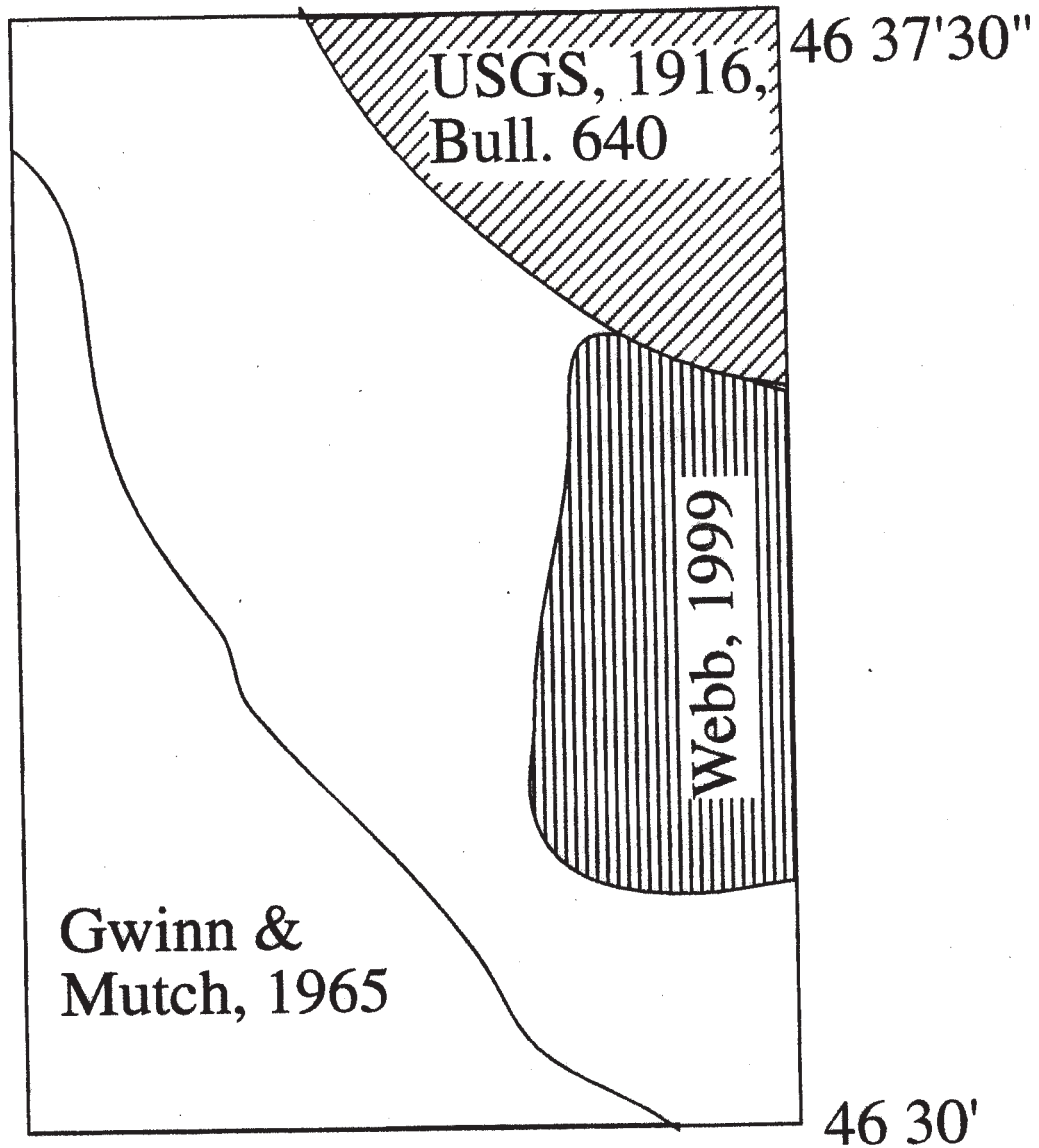
Oyster marker bed in Coberly Formation (Kc)



Schematic folds in Dunkleberg Member; on cross sections only

112 52'30"

112 45'



Index map of sources of previous geologic mapping in Garrison Quadrangle.



## References Cited

- Gwinn, V. E., 1965, Cretaceous rocks of the Clark Fork Valley, central western Montana, *in* Fields, R.W., and Shepard, W., eds., *Geology of the Flint Creek Range, Montana: Billings Geological Society 16th Annual Field Conference Guidebook*, p. 34-57.
- Gwinn, V. E. , and Mutch, T. A. , 1965, Intertongued Upper Cretaceous volcanic and nonvolcanic rocks, central-western Montana: *Geological Society of America Bulletin*, v. 76, p. 1125-1144.
- Kauffman, M. E., 1963, *Geology of the Garnet-Bearmouth area, western Montana: Montana Bureau of Mines and Geology Memoir 39*, 40 p.
- Lewis, R. S. 1996, *Geologic map of the Butte 1° x 2° quadrangle, Montana: Montana Bureau of Mines and Geology Open File Report 363*, 16 p., scale 1:250,000 (digital data).
- Pardee, J. T., 1916, *The Garrison and Philipsburg phosphate fields, Montana: U. S. Geological Survey Bulletin 640*, p. 195-228, map scale 1:125,000.
- Sears, J. W. , Hendrix, M. S. , Webb, B. , and Archibald, D. A. , 1998 (abs.), Constraints on deformation of the northern Rocky Mountain fold-thrust belt in Montana from <sup>40</sup>Ar/<sup>39</sup>Ar geochronology of andesite sills: *American Association of Petroleum Geologists, in Bridges to Discovery (1 CDROM): American Association of Petroleum Geologists Annual Convention, May 17-20, 1998, Salt Lake City, Utah, saltlake/551\_600/abs.587.pdf*.
- Wallace, C. A. , Lidke, D. J. , and Schmidt, R. G. , 1990, Faults of the Lewis and Clark line and fragmentation of the Late Cretaceous foreland basin in west-central Montana: *Geological Society of America Bulletin* v. 102, p. 1021-1037.
- Webb, Benjamin, 1999, *Detailed mapping of the Garrison and Luke Mountain quadrangles, Powell County, Montana: Missoula, The University of Montana, M.S. thesis,, 33 p., map scale 1:24,000.*

# BEDROCK GEOLOGY OF LUKE MOUNTAIN QUADRANGLE POWELL COUNTY, MONTANA

by

James W. Sears, Benjamin Webb, and Michael Taylor

The University of Montana

MONTANA BUREAU OF MINES AND GEOLOGY

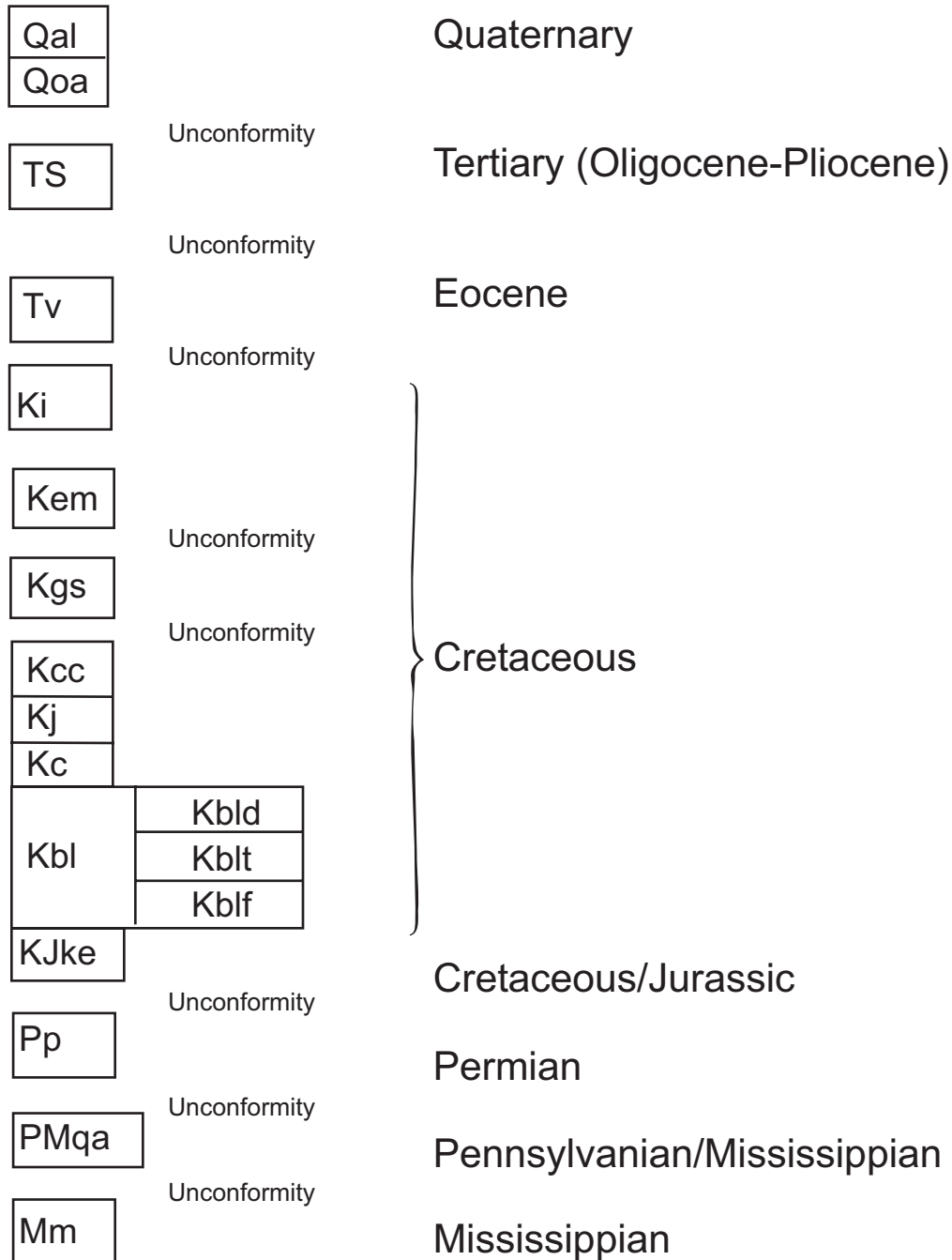
OPEN FILE REPORT 403, Part B

2000

This report has had preliminary reviews for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

Partial support has been provided by the EDMAP component of the National Cooperative Geologic Mapping Program of the U. S. Geological Survey under Contract Number 98-HQ-AG-2091.

# Correlation of Map Units on Luke Mountain Quadrangle



BEDROCK GEOLOGY OF LUKE MOUNTAIN QUADRANGLE, POWELL COUNTY,  
MONTANA

DESCRIPTION OF MAP UNITS

QUATERNARY

Qal Alluvial gravel, sand, and clay deposits in stream valleys.

Qao Older alluvial gravels in Sixmile Creek valley in northeast corner of map.

Unconformity

TERTIARY

Ts Unconsolidated sediments in northeast corner of map; includes possible Sixmile Creek and Renova Formation equivalents.

Unconformity

Tv Volcanic rocks, undivided; probable Lowland Creek Volcanics equivalent.

Angular Unconformity

CRETACEOUS

Ki Pyroxene-biotite andesitic and dioritic sills and dikes; possible laccolithic intrusions up to 500 m thick. Large euhedral pyroxene crystals common. Ar/Ar biotite date of 76 Ma from sample 1 km west of Garrison quadrangle from Interstate 90W road cut at Mile Post 169 (Sears and others, 1997).

Kem Elkhorn Mountains Volcanics. Andesite lava flows and volcanoclastic sandstones and conglomerates. The flows form ridges while the volcanoclastics form swales. Probably equivalent to the volcanic flow (KgsI) and volcanoclastic (KgsV) units of the Golden Spike Formation in the Garrison quadrangle. Greater than 2 km thick (Gwinn and Mutch, 1965).

Unconformity

Kgs Golden Spike Formation. Mixed volcanic and nonvolcanic, laterally

discontinuous units including: (1) diamictite ("chaos beds") debris flow deposit containing blocks of Cretaceous sandstone and volcanic rock and rounded cobbles of Paleozoic and Proterozoic rocks in volcanic mud matrix; (2) sandstone; (3) shale; and (4) fluvial conglomerate with rounded pebbles and cobbles of Paleozoic and Proterozoic lithologies. Thickness 0-100 m.

#### Angular Unconformity

Kcc Carter Creek Formation (Gwinn, 1965). Interlayered grey shale, yellow-brown weathering, friable, cross-bedded, "salt-and-pepper" sandstone and minor conglomerate; contains *Cardium pauperulum* (Gwinn, 1965; Wallace and others, 1990). Thickness 300 m on Beck Hill, thinning southeast to 150 m beneath sub-Golden Spike unconformity.

Kj Jens Formation. Grey shale with thin, tabular, grey sandstone beds and minor porcellanite; locally cleaved; contains *Inoceramus sp.* (Gwinn, 1965). Thickness 200 m.

Kc Coberly Formation. Grey sandstone and shale with burrows. Two distinctive, well-cemented, yellow-weathering beds of oyster-rich (*Ostrea soleniscus*, Gwinn, 1965) and gastropod-rich sandstone, indicated by dashed line on map. Thickness 250 m.

#### Kbl Blackleaf Formation

Kbld Dunkleberg Member. Interlayered light-grey, laminated, siliceous mudstone, porcellanite, grey and green shale; white, cross-bedded salt-and-pepper sandstone; and black chert-quartzite pebble conglomerate. Disharmonically folded on small scale. Thickness 450 m.

Kblt Taft Hill Member. Interlayered brown, cross-bedded, salt-and-pepper sandstone, conglomerate, and grey to green shale. Thickness 250 m.

Kblf Flood Member. Black shale with brown sandstone beds and thin, grey, shelly limestone at base. Thickness 200 m.

#### CRETACEOUS AND JURASSIC

KJke Kootenai Formation and Ellis Group, undivided. Brown, well-cemented salt-and-pepper sandstone, black-chert pebble conglomerate, red shale, and light-grey and yellow, micritic limestone. Thickness 400 m.

Unconformity  
PERMIAN

Pp            Phosphoria Formation. Dark grey and brown, well-indurated sandstone, shale, bedded chert, and oolitic phosphatic rock. Thickness 75 m.

Unconformity

PENNSYLVANIAN AND MISSISSIPPIAN

PMqa        Quadrant Formation and Amsden Formation, undivided. Grey and tan, silicified quartzite and dolomitic siltstone (Quadrant Formation), and red dolomitic siltstone and shale (Amsden Formation). Thickness 125 m.

Unconformity

MISSISSIPPIAN

Mm            Madison Group. Light grey, thick-bedded, biosparite limestone and thin-bedded micrite with nodular chert; cliff-forming. Thickness 800 m; upper 500 m exposed in Warm Springs Canyon.

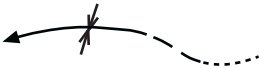
Ds            Sedimentary rocks, undivided (cross sections only).

Cs            Sedimentary rocks, undivided (cross sections, only).

## GEOLOGIC MAP SYMBOLS



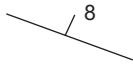
Contact; dashed where approximately located, dotted where concealed.



Synclinal fold showing trace of axial plane; dashed where approximately located, dotted where concealed. Arrow indicates direction of plunge where known.



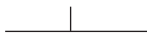
Anticlinal fold showing trace of axial plane; dashed where approximately located, dotted where of plunge concealed. Arrow indicates direction where known.



Strike and dip of bedding; degree of dip indicated.



Strike and dip of overturned bedding; degree of dip indicated.



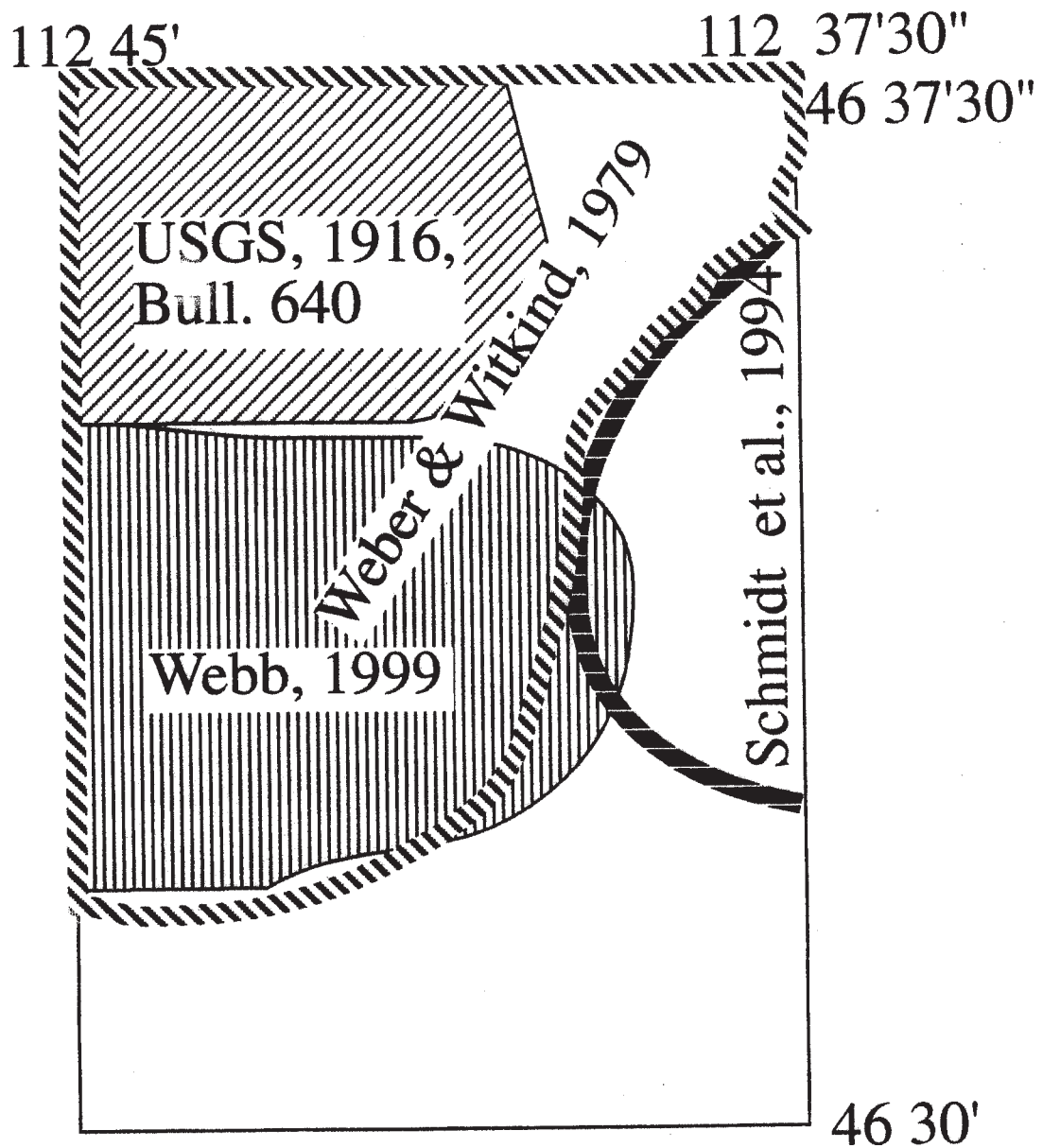
General strike and dip direction of bedding; estimated in field or from aerial photographs.



Fault; dashed where approximately located, dotted where concealed. Ball and bar on downthrown side.



Oyster marker bed in Coberly Formation (Kc).



Index map of sources of previous geologic mapping in Luke Mountain Quadrangle.

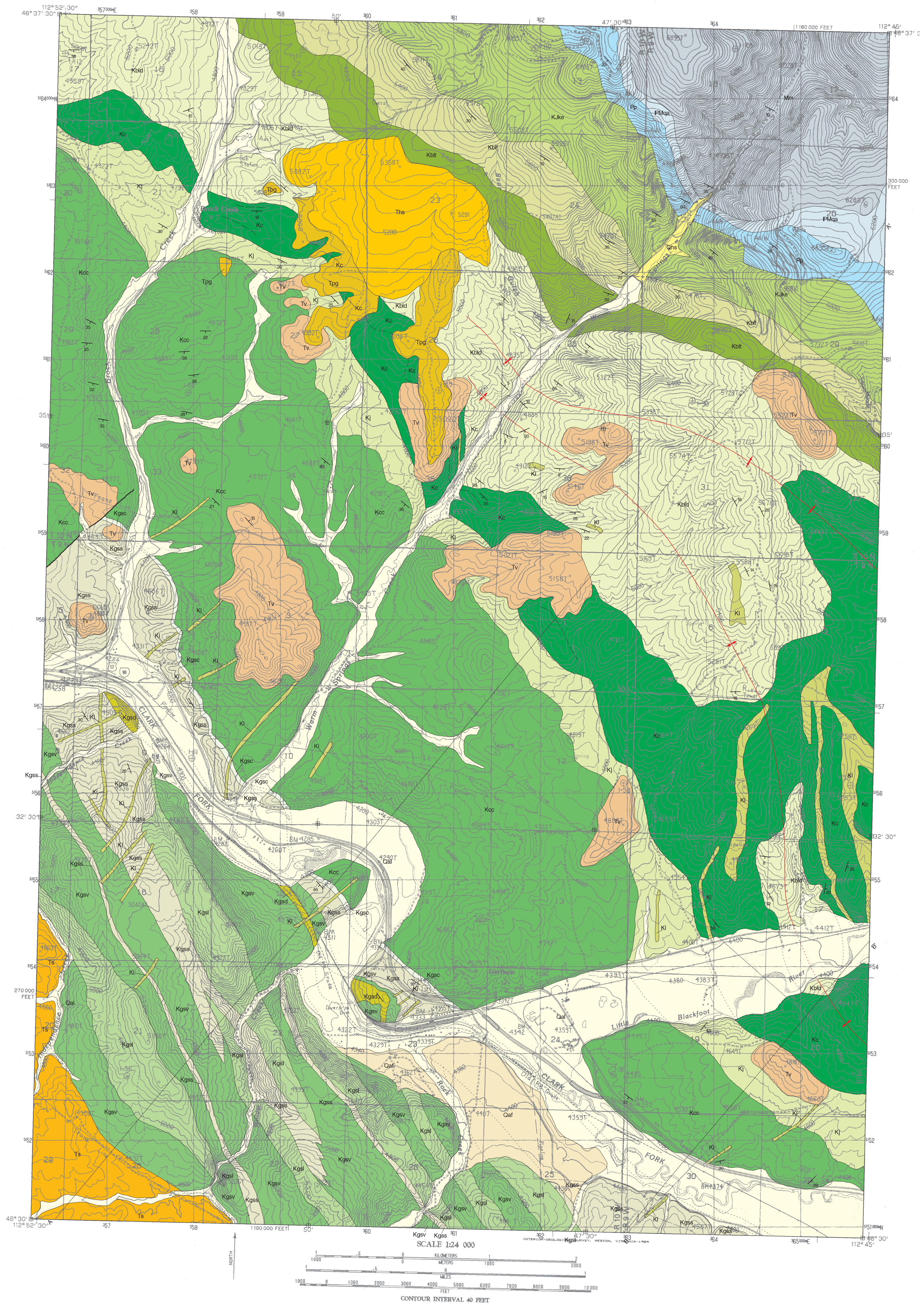


## References Cited

- Gwinn, V. E., 1965, Cretaceous rocks of the Clark Fork Valley, central western Montana, *in* Fields, R.W., and Shepard, W., eds., *Geology of the Flint Creek Range, Montana: Billings Geological Society 16th Annual Field Conference Guidebook*, p. 34-57.
- Gwinn, V. E. , and Mutch, T. A. , 1965, Intertongued Upper Cretaceous volcanic and nonvolcanic rocks, central-western Montana: *Geological Society of America Bulletin*, v. 76, p. 1125-1144.
- Kauffman, M. E., 1963, *Geology of the Garnet-Bearmouth area, western Montana: Montana Bureau of Mines and Geology Memoir 39*, 40 p.
- Lewis, R. S. 1996, *Geologic map of the Butte 1° x 2° quadrangle, Montana: Montana Bureau of Mines and Geology Open File Report 363*, 16 p., map scale 1:250,000 (digital data).
- Pardee, J. T., 1916, *The Garrison and Philipsburg phosphate fields, Montana: U. S. Geological Survey Bulletin 640*, p. 195-228, map scale 1:125,000.
- Schmidt, R. G., Loen, J. S., Wallace, C. A., and Mehnert, H. H., 1994, *Geology of the Elliston region, Powell and Lewis and Clark Counties: U. S. Geological Survey Bulletin 2045*, 25 p., map scale 1:62,500.
- Sears, J. W. , Hendrix, M. S. , Webb, B. , and Archibald, D. A. , 1998 (abs.), Constraints on deformation of the northern Rocky Mountain fold-thrust belt in Montana from <sup>40</sup>Ar/<sup>39</sup>Ar geochronology of andesite sills: *American Association of Petroleum Geologists, in Bridges to Discovery (1 CDROM): American Association of Petroleum Geologists Annual Convention, Salt Lake City, Utah, May 17-29, 1998*, saltlake/551\_600/abs.587.pdf.
- Wallace, C. A. , Lidke, D. J. , and Schmidt, R. G. , 1990, Faults of the Lewis and Clark line and fragmentation of the Late Cretaceous foreland basin in west-central Montana: *Geological Society of America Bulletin* v. 102, p. 1021-1037.
- Wallace, C. A., Schmidt, R. G., Lidke, D. J., Waters, M. R., Elliott, J. E., French, A. B., Whipple, J. W., Zarske S. E., Blaskowski, M. J., Heise, B. A., Yeoman, R. A., O'Neill, J. M., Lopez, D. A., Robinson, G. D., and Klepper, M. R., 1986, *Preliminary map of the Butte 1° x 2° quadrangle, western Montana: U. S. Geological Survey Open File Report 86-292*, scale 1:250,000.

Webb, Benjamin, 1999, Detailed mapping of the Garrison and Luke Mountain quadrangles, Powell County, Montana: Missoula, The University of Montana, M.S. thesis, 33 p., map scale 1:24,000.

Weber, W. M., and Witkind, I. J., 1979, Reconnaissance geologic map of the northern two-thirds of the Avon quadrangle, Lewis and Clark and Powell counties, Montana: U. S. Geological Survey Open File Report 79-437, xx p., scale 1:xxxxx.

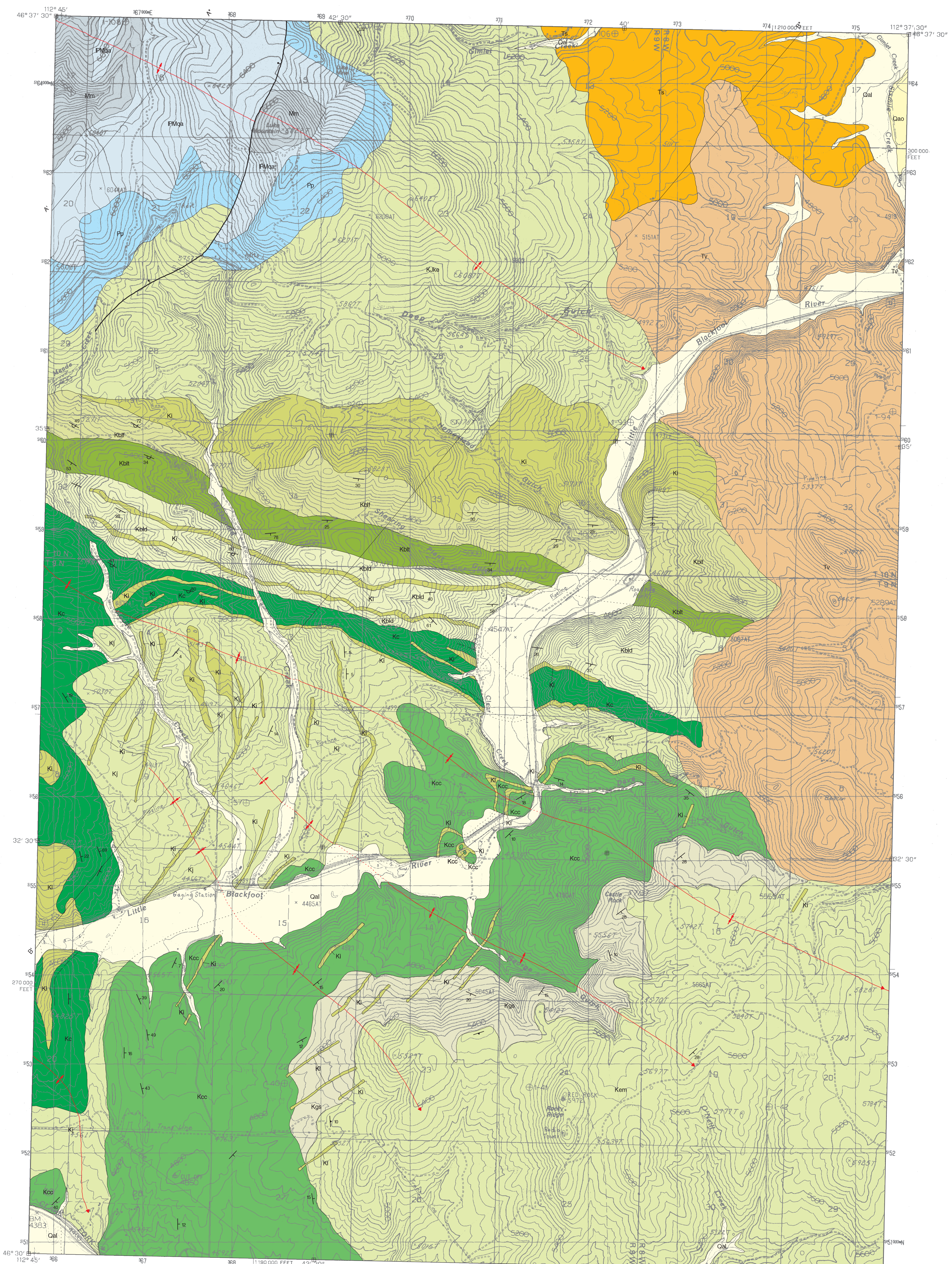


MAP UNITS

Qal	Alluvium of modern channels and flood plains	Kcc	Carter Creek Formation
Qaf	Alluvial fan deposit	Kj	Jens Formation
Ohs	Hot spring deposit	Kc	Coberly Formation
Ohs	Hot springs deposits	Kbld	Dunkleberg Member of Blackleaf Formation
Tpg	Pediment gravel	Kbit	Taft Hill Member of Blackleaf Formation
Ts	Sediment or sedimentary rocks, undivided	Kblf	Flood Member of Blackleaf Formation
Tv	Volcanic rocks, undivided	K,ke	Koolenal Formation and Ellis Group, undivided
Ki	Intrusive rocks, undivided	Pp	Phosphoria Formation
Kgsv	Volcaniclastic sedimentary rocks	PMqa	Quadrant Formation and Amsden Formation, undivided
Kgsl	Lava flows, informal unit of Golden Spike Formation	Mm	Madison Group, undivided
Kgss	Nonvolcanic sandstone, shale, and conglomerate, informal unit of Golden Spike Fm		
Kgsd	Diamictite "chaos beds", informal unit of Golden Spike Formation		
Kgsc	Fluvial conglomerate, informal unit of Golden Spike Formation		

Montana Bureau of Mines and Geology Open File Report  
 MBMG 403, Plate 1 of 3  
**Bedrock Geology of Garrison 7.5' Quadrangle,  
 Powell County, Montana**

By James W. Sears, Benjamin Webb, and Michael Taylor  
 The University of Montana  
 2000

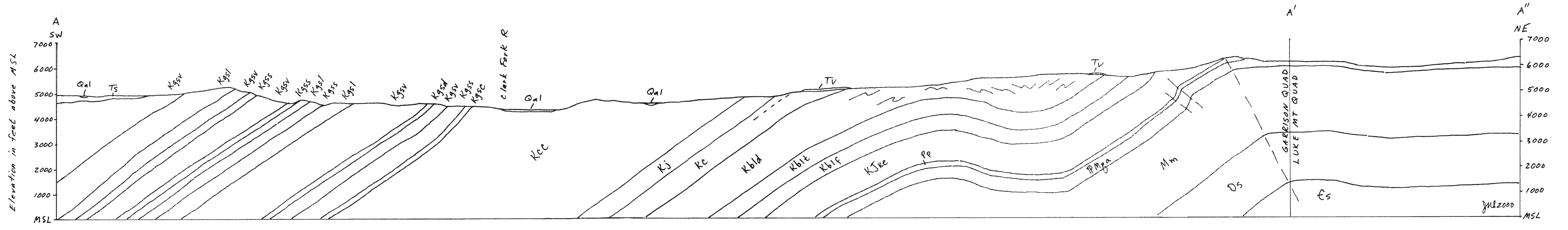


MAP UNITS

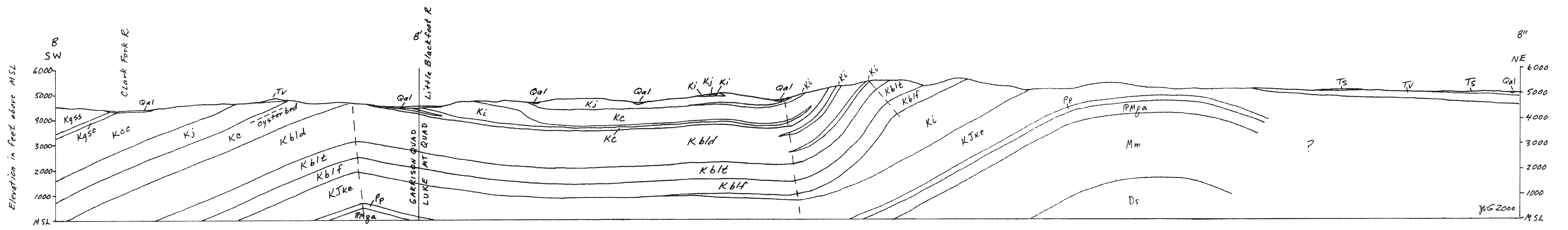
Qal	Alluvium
Qao	Alluvium older, undivided
Ts	Sediment, undivided
Tv	Volcanic rocks, undivided
Ki	Intrusive rocks (sills and dikes), undivided
Kem	Elkhorn Mountains Volcanics
Kgs	Golden Spike Formation
Kcc	Carter Formation
Kj	Jens Formation
Kc	Coberly Formation
Kbld	Dunkleberg Member of Blackleaf Formation
Kbtl	Taft Hill Member of Blackleaf Formation
Kbl	Flood Member of Blackleaf Formation
K,ke	Kootenai Formation and Ellis Group, undivided
Pp	Phosphoria Formation
PMqa	Quadrant Formation and Amsden Formation, undivided
Mm	Madison Group, undivided

Montana Bureau of Mines and Geology Open File Report  
 MBMG 403, Plate 2 of 3  
**Bedrock Geology of Luke Mountain 7.5' Quadrangle,  
 Powell County, Montana**

By James W. Sears, Benjamin Webb, and Michael Taylor  
 The University of Montana  
 2000



Cross Section A-A'', Garrison 7.5' Quadrangle



Cross Section B-B'', Luke Mountain 7.5' Quadrangle

James W. Sears  
2000