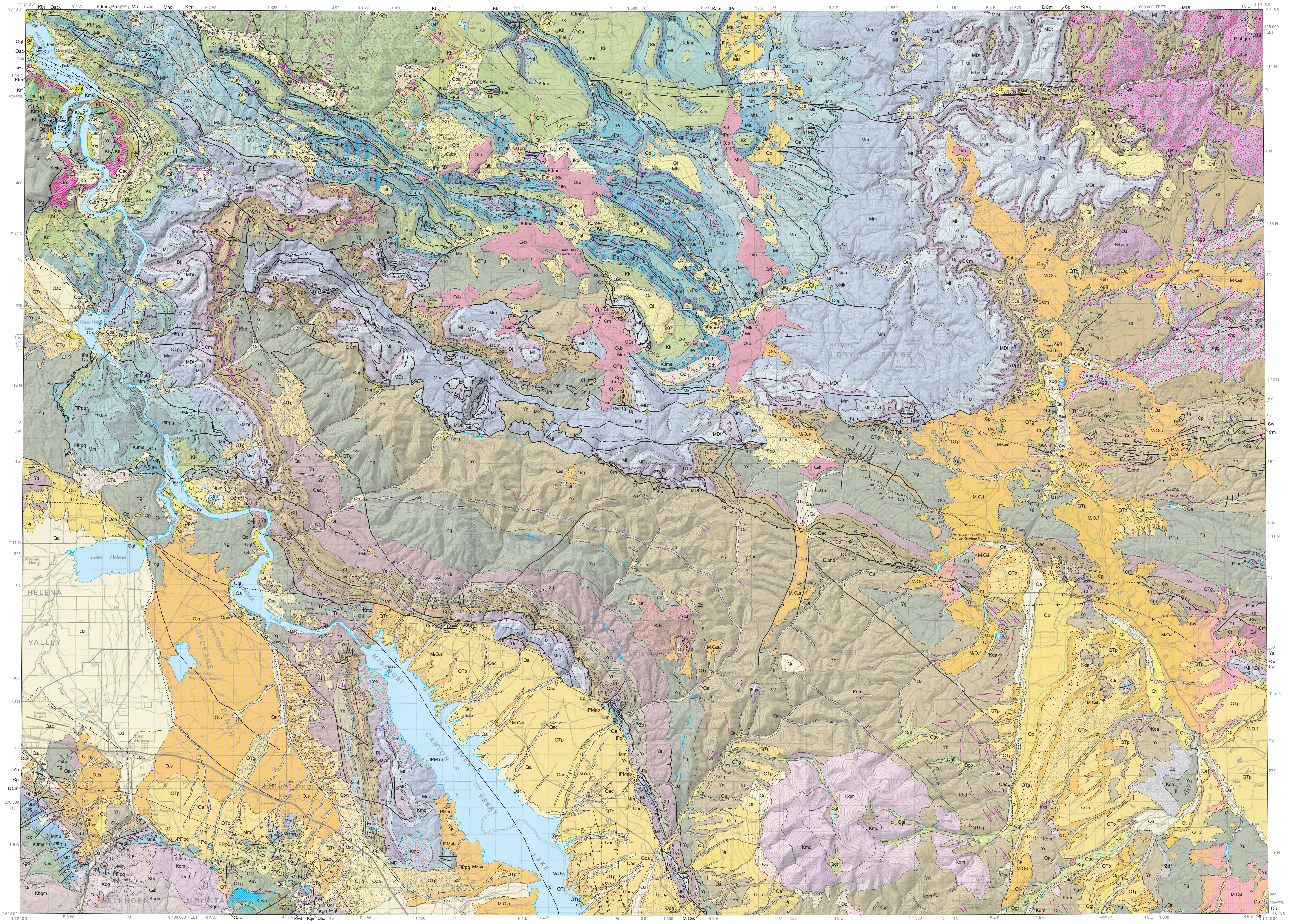
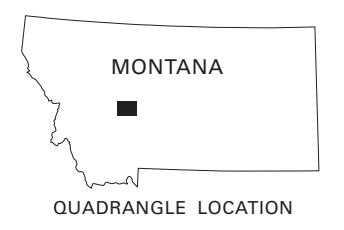

112°00′
47°00′
46°30′
111°00′
R 3 W
R 2 W
R 1 W
R 1 E
R 2 E
R 3 E
R 4 E
R 5 E
R 6 E
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
T 9 N
45′
30′
15′
425 000 FEET
275 000 FEET
1 400 000 FEET
1 600 000 FEET
ADEL MOUNTAINS
Upper Holter Lake
Lake Helena
HELENA
VALLEY
SPOKANE BENCH
MISSOURI
CANYON FERRY LAKE
DRY RANGE
HELENA NATIONAL FOREST
ELKHORN MOUNTAINS
LEWIS AND CLARK CO
BROADWATER CO
East Helena
Helena Airport
Fortuna (U.S.) Inc. Siebein 29-1
Hunt Oil Co. Galt No. 13-1
Getty Oil Co. Federal No. 3-10
American-Petrofina, Manger-Skyline No. 1

Base from U.S. Geological Survey, 1975; photoinspected 1991
Projection and 10,000-meter grid: Universal Transverse Mercator, zone 12
25,000-foot ticks: Montana coordinate system, central zone
1927 North American Datum



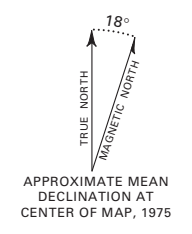
QUADRANGLE LOCATION

SCALE 1:100 000

1 0 1 2 3 4 5 6 7 8 MILES

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

CONTOUR INTERVAL 50 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
ELEVATIONS SHOWN TO THE NEAREST METER


18°
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION AT CENTER OF MAP, 1975

Final digital database by Theodore R. Brandt
Supplementary local digital data by Kenzie J. Turner
Digital cartography and layout design by Alessandro J. Donatich
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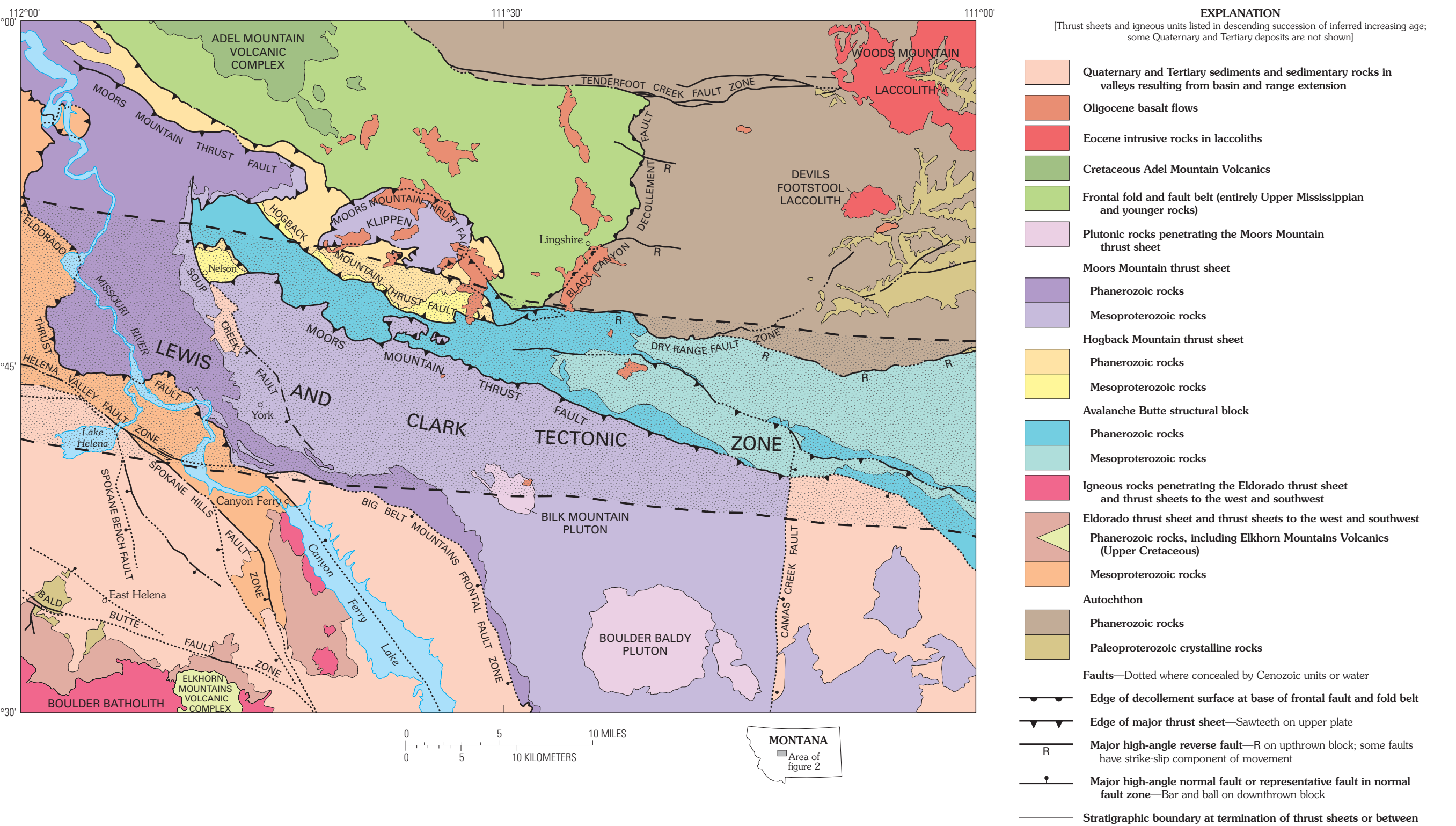

112°00′
111°30′
111°00′
47°00′
46°45′
46°30′
ADEL MOUNTAIN VOLCANIC COMPLEX
WOODS MOUNTAIN LACCOLITH
TENDERFOOT CREEK FAULT ZONE
DEVILS FOOTSTOOL LACCOLITH
MOORS MOUNTAIN THRUST FAULT
MOORS MOUNTAIN KLIPPEN
HOGBACK MOUNTAIN THRUST FAULT
BLACK CANYON DECOLLEMENT FAULT
Lingshire
Nelson
SOUP CREEK FAULT
DRY RANGE FAULT ZONE
ELDORADO THRUST
MISSOURI RIVER FAULT
HELENA VALLEY FAULT ZONE
LEWIS AND CLARK TECTONIC ZONE
York
Lake Helena
Canyon Ferry
SPOKANE BENCH FAULT
SPOKANE HILLS FAULT ZONE
BIG BELT MOUNTAINS FRONTAL FAULT ZONE
Canyon Ferry Lake
BILK MOUNTAIN PLUTON
BOULDER BALDY PLUTON
CAMAS CREEK FAULT
East Helena
BALD BUTTE FAULT ZONE
ELKHORN MOUNTAINS VOLCANIC COMPLEX
BOULDER BATHOLITH
R
0 5 10 MILES
0 5 10 KILOMETERS
MONTANA
Area of figure 2
EXPLANATION
[Thrust sheets and igneous units listed in descending succession of inferred increasing age; some Quaternary and Tertiary deposits are not shown]
Quaternary and Tertiary sediments and sedimentary rocks in valleys resulting from basin and range extension
Oligocene basalt flows
Eocene intrusive rocks in laccoliths
Cretaceous Adel Mountain Volcanics
Frontal fold and fault belt (entirely Upper Mississippian and younger rocks)
Plutonic rocks penetrating the Moors Mountain thrust sheet
Moors Mountain thrust sheet
Phanerozoic rocks
Mesoproterozoic rocks
Hogback Mountain thrust sheet
Phanerozoic rocks
Mesoproterozoic rocks
Avalanche Butte structural block
Phanerozoic rocks
Mesoproterozoic rocks
Igneous rocks penetrating the Eldorado thrust sheet and thrust sheets to the west and southwest
Eldorado thrust sheet and thrust sheets to the west and southwest
Phanerozoic rocks, including Elkhorn Mountains Volcanics (Upper Cretaceous)
Mesoproterozoic rocks
Autochthon
Phanerozoic rocks
Paleoproterozoic crystalline rocks
Faults—Dotted where concealed by Cenozoic units or water
Edge of decollement surface at base of frontal fault and fold belt
Edge of major thrust sheet—Sawteeth on upper plate
Major high-angle reverse fault—R on upthrown block; some faults have strike-slip component of movement
Major high-angle normal fault or representative fault in normal fault zone—Bar and ball on downthrown block
Stratigraphic boundary at termination of thrust sheets or between Phanerozoic and pre-Phanerozoic rocks within a thrust sheet
Inferred approximate boundaries of the Lewis and Clark tectonic zone

Figure 2. Tectonic map of the Canyon Ferry Dam 30′ × 60′ quadrangle, west-central Montana, showing thrust sheets, tectonic elements, and the distribution of Early and Middle Proterozoic rocks, Phanerozoic rocks, Eocene laccoliths, Oligocene basalt flows, and selected Cenozoic rocks and sediments in valleys resulting from basin and range extension.

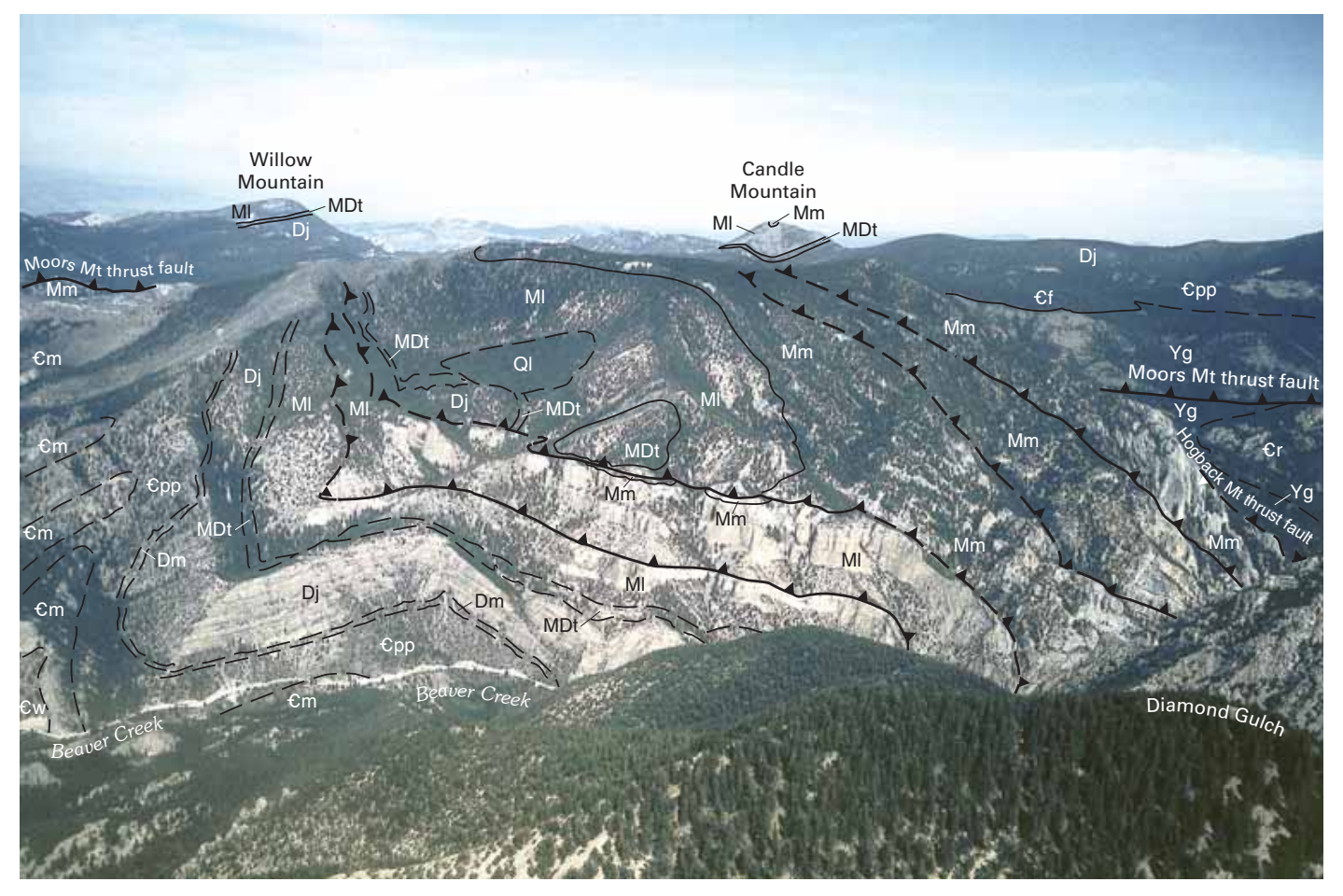

Willow Mountain
Candle Mountain
Ml
Dj
MDt
Mm
Moors Mt thrust fault
Ꞓm
Ꞓpp
Ꞓf
Ꞓr
Ql
Mm
Dm
Yg
Hogback Mt thrust fault
Ꞓw
Beaver Creek
Diamond Gulch

Figure 3. Disharmonic, stacked recumbent and asymmetric folds in the Avalanche Butte thrust plate, exposed on north side of Beaver Creek, secs. 28–31, T. 13 N., R. 1 W. Cliff of the Upper Devonian Jefferson Formation (Dj) (near canyon bottom, left) and repeated units of the overlying Lower Mississippian Lodgepole Limestone (Ml) are overlain by recumbently folded rocks of the Lower Mississippian and Upper Devonian Three Forks Formation (MDt) and the Lodgepole Limestone. Rocks of the recumbently folded Hogback Mountain thrust plate are at center, right edge; bare patches in upper right edge are eroded across siltite and argillite beds of the Mesoproterozoic Greyson Formation (Yg) on upper plate of the Moors Mountain thrust fault, which overrides and truncates both the Hogback Mountain and Avalanche Butte thrust plates below. View is north-northwest from Hogback Mountain toward Willow Mountain (upper left) and Candle Mountain (upper center). Unit labels as on map explanation. In this view, unit Ꞓr consists of recumbently folded Upper and Middle Cambrian rocks, undivided.

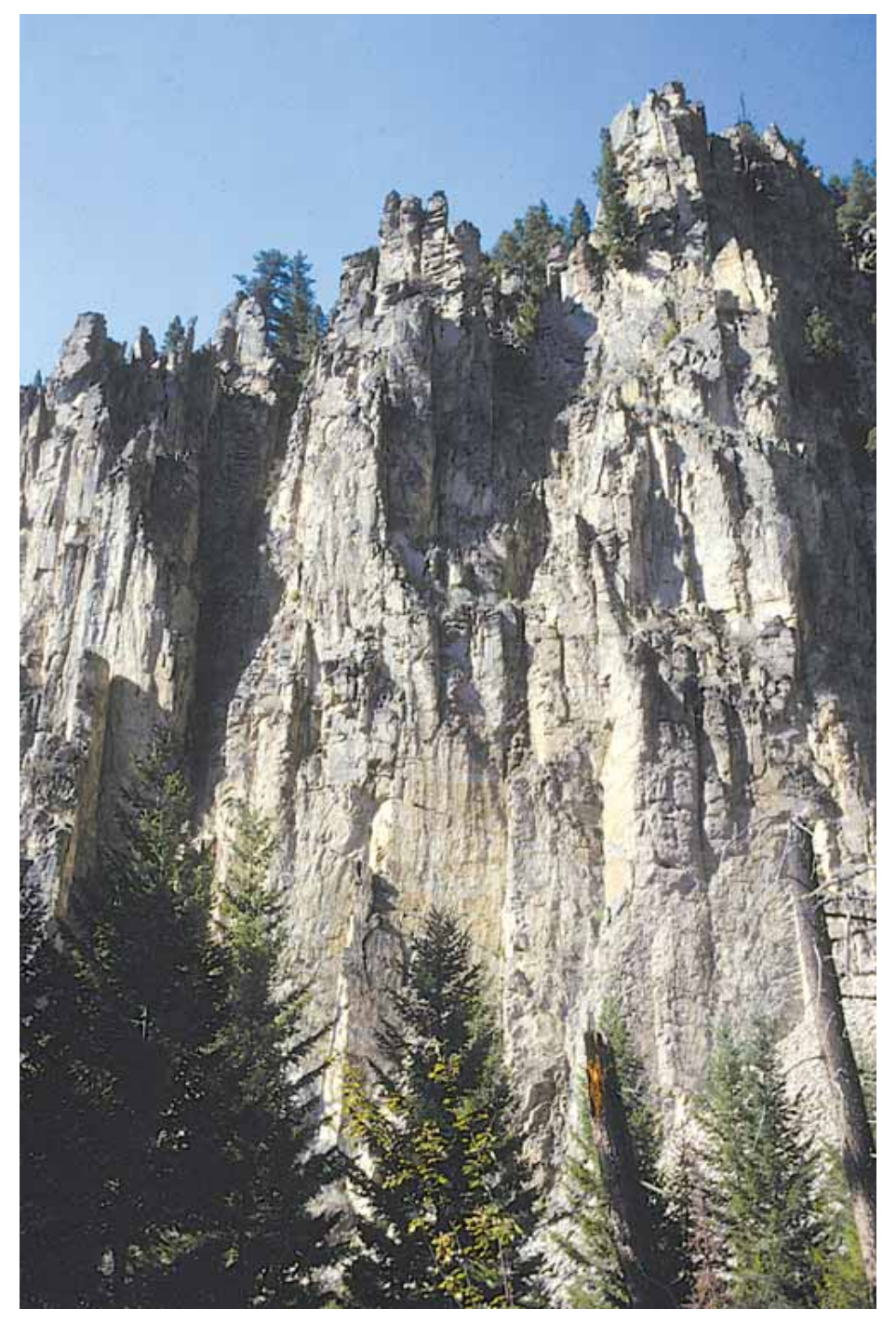


Figure 8. Spires on north wall of canyon of Tenderfoot Creek are eroded in lower part of the Eocene biotite hornblende quartz monzonite of the Woods Mountain laccolith. Canyon walls are as high as 160 m. View is in east center, sec. 21, T. 14 N., R. 5 E.

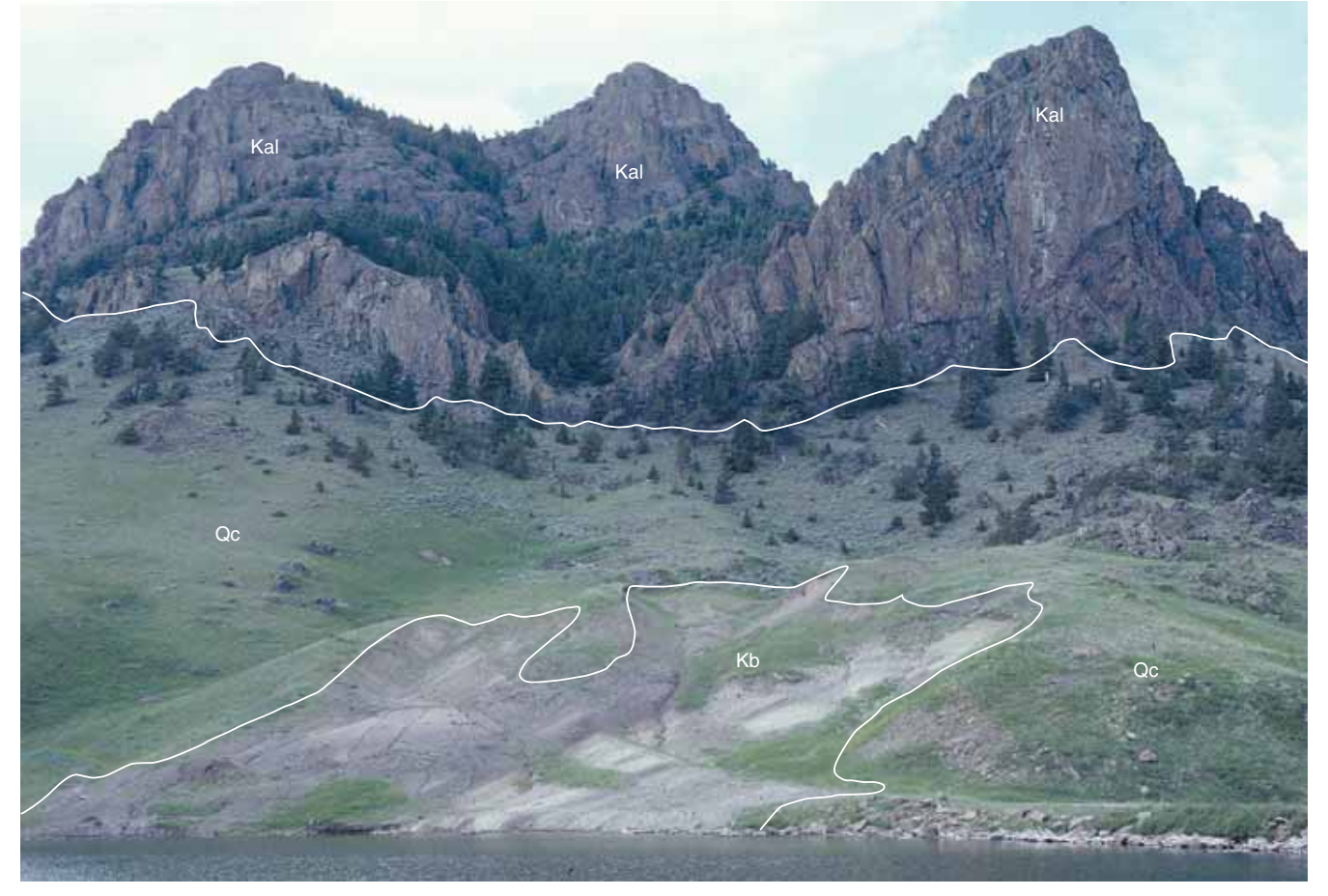

Kal
Kal
Kal
Qc
Kb
Qc

Figure 4. Latite (Kal) of the Upper Cretaceous Adel Mountain Volcanics is intruded into beds of the Upper and Lower Cretaceous Blackleaf Formation (Kb), which were tilted by thrust faulting before intrusion of the latite. White beds are bentonite beds in the Blackleaf Formation. Peaks eroded in the latite form south flank of mountain, known locally as "Almost-a-Dog Mountain," on north side of Middle Creek Lake (foreground). View is north in secs. 24 and 25, T. 14 N., R. 1 W. Unit labels as on map explanation.

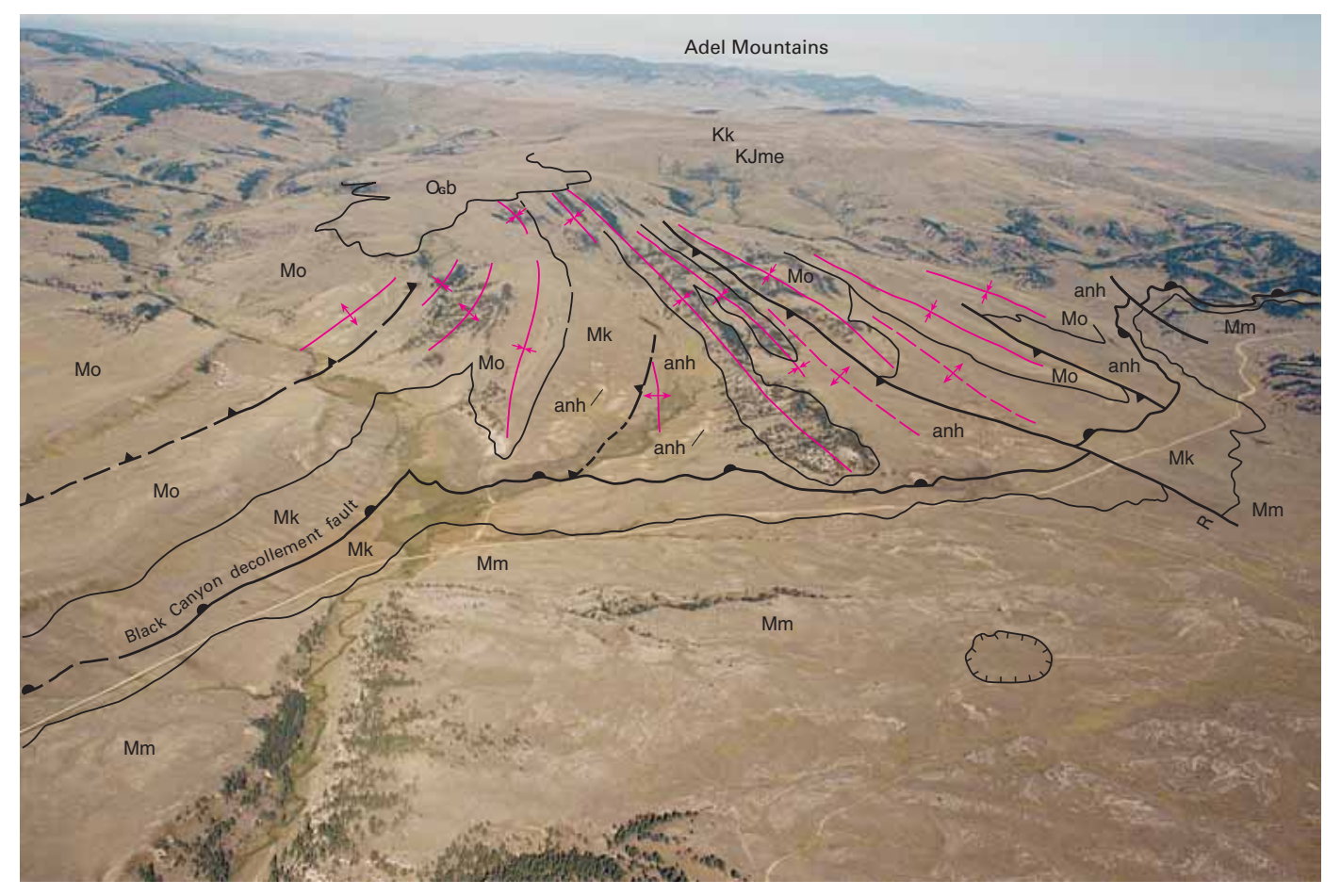

Adel Mountains
Kk
KJme
Ob
Mo
Mk
anh
Mm
Black Canyon decollement fault
R

Figure 5. The Black Canyon decollement fault separates tightly folded rocks at the southeast edge of the Montana disturbed belt above from gently west dipping rocks of the continental autochthon below. Detachment zone is along an anhydrite unit (fig. 6) in the Upper Mississippian Kibbey Formation (Mk); anh denotes outcrop areas of anhydrite or anhydrite residuum with breccia. The underlying Upper and Lower Mississippian Mission Canyon Limestone (Mm) is in undeformed stratigraphic succession downward to Paleoproterozoic crystalline rock (southeast of area shown). View is northwest across northwestern part of T. 13 N., R. 3 E. Freeman Creek is on left and State road 360 crosses the area near center of photograph. Adel Mountains are in background. Unit labels as on map explanation. Circle with hachures is karst area in the Mission Canyon Limestone.

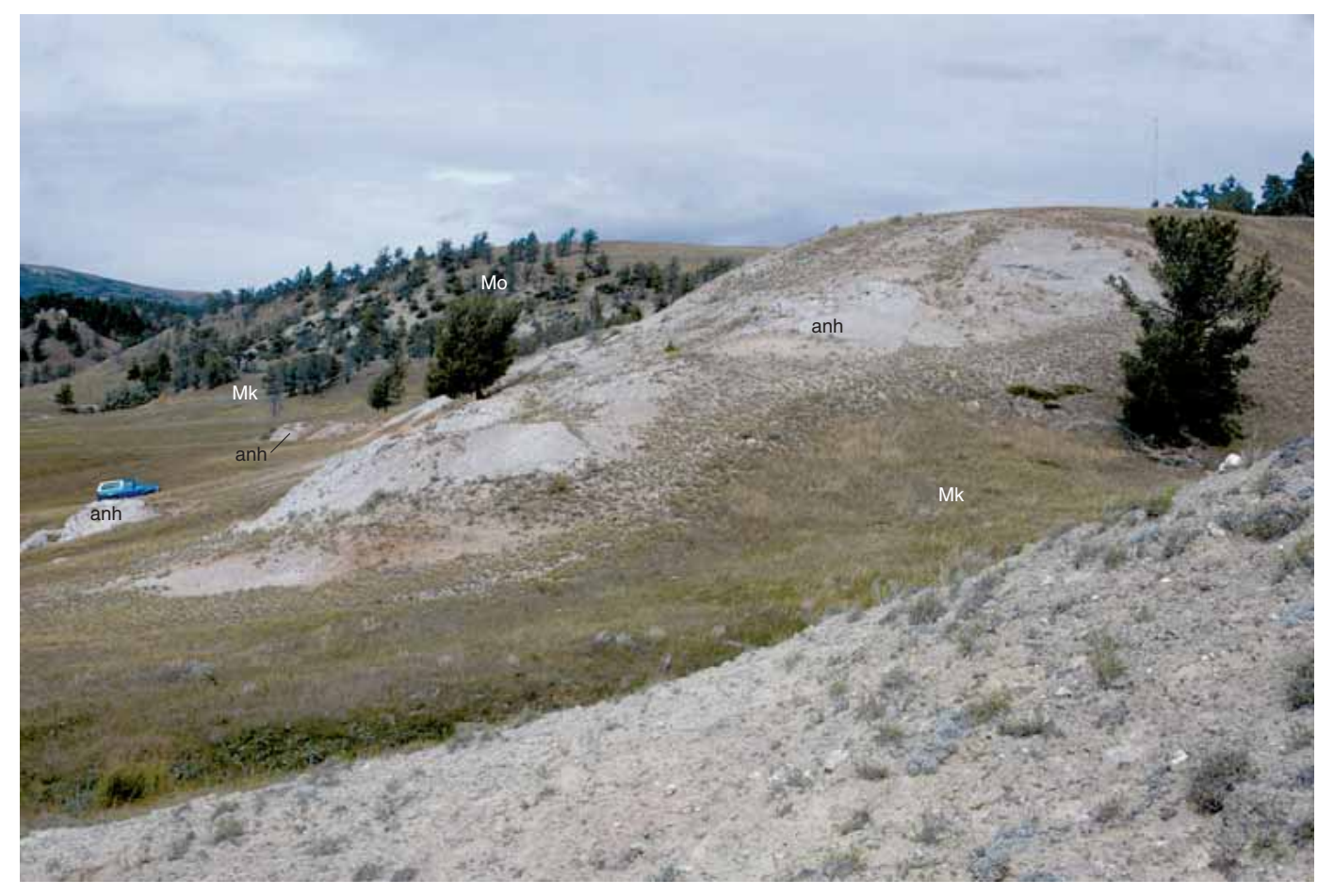

Mo
anh
Mk
anh
anh
Mk

Figure 6. Outcrops of contorted anhydrite (anh) (white) with infolded and faulted pale-red siltstone of the Upper Mississippian Kibbey Formation (Mk). Anhydrite beds serve as detachment intervals that structurally separate tightly folded units of the Upper Mississippian Big Snowy Group and younger strata above from the little-deformed lower part of the Kibbey Formation and underlying Upper and Lower Mississippian Mission Canyon Limestone (fig. 5). Tree-covered slope in left rear is supported by the Upper Mississippian Otter Formation (Mo). View is northwest in north center sec. 16, T. 13 N., R. 3 E. Vehicle at left edge for scale.

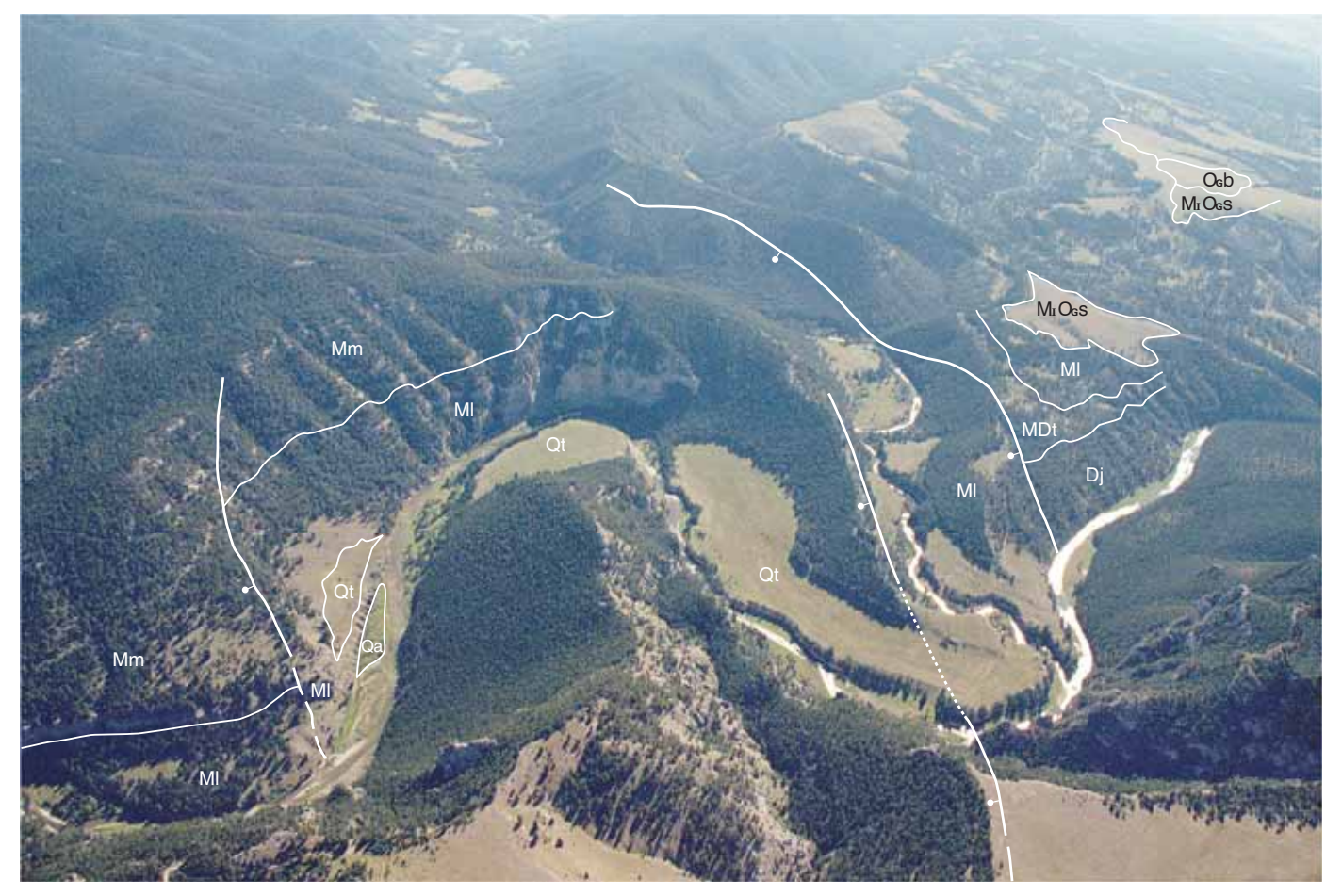
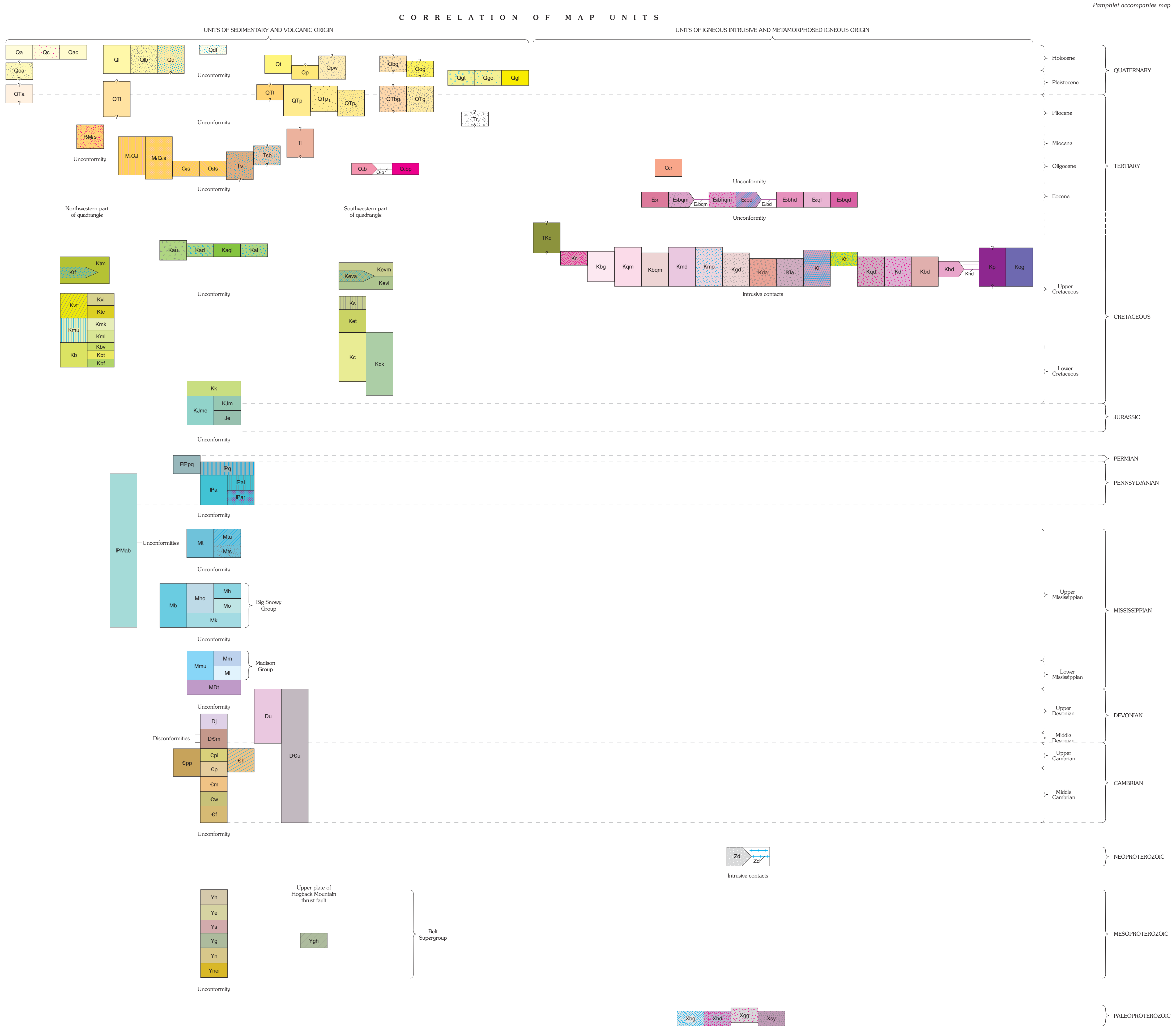

Ob
MOs
MOs
Ml
MDt
Dj
Mm
Ml
Qt
Qt
Ql
Qa
Mm
Ml
Ml

Figure 7. Incised meanders of Smith River, lower part of photograph, wind through outcrops of the Upper and Lower Mississippian Mission Canyon Limestone (Mm) and Lower Mississippian Lodgepole Limestone (Ml) across the west plunge of the Little Belt Mountains. Faults define a segment of the Tenderfoot Creek fault zone. River flows from south (right) to north (lower left). Tenderfoot Creek, incised normal to river, enters Smith River at lower right. These entrenched meanders are about 48 km directly east of entrenchment of Missouri River across north end of Big Belt Mountains (cover photograph on map jacket). View is east-southeast across secs. 24 and 25, T. 14 N., R. 3 E., and secs. 28–33, T. 14 N., R. 4 E. Unit labels as on map explanation.

CORRELATION OF MAP UNITS


UNITS OF SEDIMENTARY AND VOLCANIC ORIGIN
UNITS OF IGNEOUS INTRUSIVE AND METAMORPHOSED IGNEOUS ORIGIN
Qa
Qc
Qac
Qoa
QTa
Ql
Qlb
Qd
QTl
Qdt
Qt
Qp
Qpw
QTt
QTp
QTp1
QTp2
Qbg
Qog
QTbg
QTg
Qgt
Qgo
Qgl
Tr
PMs
MOf
MOs
Os
Ots
Ts
Tsb
Tl
Ob
Obp
Or
Er
Ebqm
Ebhqm
Ebd
Ebhd
Eql
Ebqd
Unconformity
Northwestern part of quadrangle
Southwestern part of quadrangle
Kau
Kad
Kaql
Kal
Ktm
Ktf
Kvt
Kvi
Ktc
Kmu
Kmk
Kml
Kb
Kbv
Kbt
Kbf
Kevm
Keva
Kevl
Ks
Ket
Kc
Kck
TKd
Kr
Kbg
Kqm
Kbqm
Kmd
Kmo
Kgd
Kda
Kla
Ki
Kt
Kqd
Kd
Kbd
Khd
Kp
Kog
Intrusive contacts
Kk
KJme
KJm
Je
PIPpq
IPq
IPa
IPal
IPar
IPMab
Unconformities
Mt
Mtu
Mts
Mb
Mho
Mh
Mo
Mk
Big Snowy Group
Mmu
Mm
Ml
MDt
Madison Group
Dj
DꞒm
Disconformities
Du
DꞒu
Ꞓpp
Ꞓpi
Ꞓp
Ꞓh
Ꞓm
Ꞓw
Ꞓf
Zd
Upper plate of Hogback Mountain thrust fault
Yh
Ye
Ys
Yg
Yn
Ynei
Ygh
Belt Supergroup
Xbg
Xhd
Xgg
Xsy
Holocene
Pleistocene
QUATERNARY
Pliocene
Miocene
Oligocene
Eocene
TERTIARY
Upper Cretaceous
Lower Cretaceous
CRETACEOUS
JURASSIC
PERMIAN
PENNSYLVANIAN
Upper Mississippian
Lower Mississippian
MISSISSIPPIAN
Upper Devonian
Middle Devonian
DEVONIAN
Upper Cambrian
Middle Cambrian
CAMBRIAN
NEOPROTEROZOIC
MESOPROTEROZOIC
PALEOPROTEROZOIC

LIST OF MAP UNITS

Symbol	Unit
Qa	Alluvium (Holocene)
Qc	Colluvium (Holocene)
Qac	Alluvium and colluvium, undivided (Holocene)
Ql	Landslide deposit (Holocene and Pleistocene)
Qlb	Landslide deposit of basalt fragments (Holocene and Pleistocene)
Qd	Debris flow deposit (Holocene and Pleistocene?)
Qdt	Dredge tailings (Holocene)
Qt	Terrace gravel (Holocene and Pleistocene)
Qp	Pediment gravel (Holocene? and Pleistocene)
Qpw	Pediment gravel with windblown silt and sand (Holocene? and Pleistocene)
Qbg	Boulder gravel (Holocene or Pleistocene)
Qoa	Old alluvium (Holocene or Pleistocene)
Qog	Old gravel (Holocene or Pleistocene)
Qgt	Glacial till (Pleistocene)
Qgo	Glacial outwash deposit (Pleistocene)
Qgl	Glacial lake Great Falls deposit (Pleistocene)
QTa	Older alluvium (Pleistocene or Pliocene)
QTl	Older landslide deposit (Pleistocene or Pliocene)
QTt	Older terrace gravel (Pleistocene or Pliocene)
QTp	Older pediment gravel, undivided (Pleistocene and Pliocene)
QTp_1	Older pediment gravel, lower level overlying rocks of Miocene and Oligocene age (Pleistocene and Pliocene)
QTp_2	Older pediment gravel, upper level overlying rocks of Miocene age (Pleistocene and Pliocene)
QTbg	Older boulder gravel (Pleistocene or Pliocene)
QTg	Older gravel (Pleistocene and Pliocene)
PMs	Sedimentary rocks, undivided (Pliocene and Miocene)
MOf	Fort Logan Formation (Miocene and Oligocene)
MOs	Sedimentary rocks, undivided (Miocene and Oligocene)
Os	Sedimentary rocks, undivided (Oligocene)
Ots	Tuff and tuffaceous sedimentary rocks (Oligocene)
Ts	Sedimentary rocks (Miocene, Oligocene, and Eocene(?))
Tsb	Sedimentary breccia with pumice- and basalt-fragment tuff bed (Miocene or Oligocene)
Tl	Landslide deposit (Miocene or Oligocene)
Tr	Sedimentary rock rubble (Pliocene?)
Ob	Basalt (Oligocene)
Obp	Basalt in plug or volcanic neck (Oligocene)
Or	Rhyolite flows and shallow intrusive bodies (Oligocene)
Er	Rhyolite (Eocene)
Ebqm	Biotite quartz monzonite (Eocene)
Ebhqm	Biotite hornblende quartz monzonite (Eocene)
Ebd	Biotite dacite (Eocene)
Ebhd	Biotite hornblende dacite (Eocene)
Eql	Quartz latite (Eocene)
Ebqd	Biotite quartz diorite (Eocene)
TKd	Garnet peridotite in diatreme (Tertiary or Upper Cretaceous)
Kau	Adel Mountain Volcanics, undivided (Upper Cretaceous)
Kad	Dacite
Kaql	Quartz latite
Kal	Latite
Kr	Rhyodacite flows or shallow intrusive bodies (Late Cretaceous)
Kbg	Biotite granite (Late Cretaceous)
Kqm	Quartz monzonite (Late Cretaceous)
Kbqm	Butte Quartz Monzonite (Late Cretaceous)
Kmd	Monzodiorite (Late Cretaceous)
Kmo	Monzonite (Late Cretaceous)
Kgd	Biotite granodiorite (Late Cretaceous)
Kda	Dacite (Late Cretaceous)
Kla	Latite (Late Cretaceous)
Ki	Basaltic and andesitic sills, dikes, and irregular-shaped bodies related to the Elkhorn Mountains Volcanics (Late Cretaceous)
Kt	Trachybasalt and syenogabbro (Late Cretaceous)
Kqd	Quartz diorite (Late Cretaceous)
Kd	Diorite (Late Cretaceous)
Kbd	Biotite diorite (Late Cretaceous)
Khd	Hornblende diorite (Late Cretaceous)
Kp	Pyroxenite (Late Cretaceous?)
Kog	Olivine gabbro (Late Cretaceous)
Ktm	Two Medicine Formation, undivided (Upper Cretaceous)
Ktf	Volcanic member
	Elkhorn Mountains Volcanics (Upper Cretaceous)
Keva	Ash-flow tuff member
Kevm	Middle member
Kevl	Lower member
Ks	Slim Sam Formation (Upper Cretaceous)
Ket	Eagle Sandstone and Telegraph Creek Formation, undivided (Upper Cretaceous)
Kvt	Virgelle Sandstone and Telegraph Creek Formation, undivided (Upper Cretaceous)
Kvi	Intrusive igneous rocks, undivided (Late Cretaceous)
Ktc	Telegraph Creek Formation (Upper Cretaceous)
Kmu	Marias River Formation, undivided (Upper Cretaceous)
Kmk	Kevin Member
Kml	Lower part, undivided
Kb	Blackleaf Formation, undivided (Upper and Lower Cretaceous)
Kbv	Vaughn Member (Upper and Lower Cretaceous)
Kbt	Taft Hill Member (Lower Cretaceous)
Kbf	Flood Member (Lower Cretaceous)
Kc	Colorado Group, undivided (Upper and Lower Cretaceous)
Kck	Colorado Group (Upper and Lower Cretaceous) and Kootenai Formation (Lower Cretaceous), undivided
Kk	Kootenai Formation (Lower Cretaceous)
KJme	Morrison Formation (Lower Cretaceous and Upper Jurassic) and Ellis Group (Upper and Middle Jurassic), undivided
KJm	Morrison Formation (Lower Cretaceous and Upper Jurassic)
Je	Ellis Group, undivided (Upper and Middle Jurassic)
PIPpq	Phosphoria (Permian) and Quadrant (Pennsylvanian) Formations, undivided
IPq	Quadrant Formation (Pennsylvanian)
IPa	Amsden Formation (Pennsylvanian)
IPal	Limestone succession at top
IPar	Red-bed succession at base
IPMab	Amsden Formation (Pennsylvanian) and Big Snowy Group (Upper Mississippian), undivided
Mt	Tyler Formation, undivided (Upper Mississippian)
Mtu	Upper part
Mts	Sandstone and conglomeratic sandstone in lower part
Mb	Big Snowy Group, undivided (Upper Mississippian)
Mho	Heath and Otter Formations, undivided
Mh	Heath Formation
Mo	Otter Formation
Mk	Kibbey Formation
Mmu	Madison Group, undivided (Upper and Lower Mississippian)
Mm	Mission Canyon Limestone (Upper and Lower Mississippian)
Ml	Lodgepole Limestone (Lower Mississippian)
MDt	Three Forks Formation (Lower Mississippian and Upper Devonian)
Du	Upper and Middle Devonian rocks, undivided
DꞒu	Upper and Middle Devonian and Upper and Middle Cambrian rocks, undivided
Dj	Jefferson Formation (Upper Devonian)
DꞒm	Maywood Formation (Upper and Middle Devonian) and local Upper Cambrian beds
Ꞓpp	Pilgrim Formation (Upper Cambrian) and Park Shale (Upper and Middle Cambrian), undivided
Ꞓpi	Pilgrim Formation (Upper Cambrian)
Ꞓp	Park Shale (Upper and Middle Cambrian)
Ꞓh	Hasmark Formation (Upper and Middle Cambrian)
Ꞓm	Meagher Limestone (Middle Cambrian)
Ꞓw	Wolsey Formation (Middle Cambrian)
Ꞓf	Flathead Sandstone (Middle Cambrian)
Zd	Diorite (Neoproterozoic)
	Belt Supergroup (Mesoproterozoic)
Yh	Helena Formation
Ye	Empire Formation
Ys	Spokane Formation
Yg	Greyson Formation
Ygh	Greyson Formation, lower plate of Moors Mountain thrust fault and upper plate of Hogback Mountain thrust fault
Yn	Newland Formation
Ynei	Neihart Quartzite
Xgg	Granite gneiss (Paleoproterozoic)
Xbg	Biotite gneiss (Paleoproterozoic)
Xhd	Hornblende diorite (Paleoproterozoic)
Xsy	Syenite (Paleoproterozoic)

Contact—Dashed where approximately located; dotted where concealed. Superimposed or immediately adjacent different generations of landslide deposits (units Ql, Qlb, and QTl) and debris flow deposits (Qd) shown locally by common internal map contacts

Fault—Dashed where approximately located; short dashed where inferred; dotted where concealed

Normal fault—Dashed where approximately located; short dashed where inferred; dotted where concealed. Ball and bar on downthrown side

Reverse fault—Dotted where concealed. R on upthrown side

Thrust fault—Dashed where approximately located; short dashed where inferred; dotted where concealed. Sawteeth on upper plate. In cross sections, arrows show relative direction of displacement

Overturned thrust fault—Base of sawteeth on upper plate of Hogback Mountain thrust fault in SE¼ sec. 20, T. 13 N., R. 1 W. In cross sections, arrows show relative direction of displacement

Strike-slip fault—Arrows show relative direction of displacement. In cross sections, A indicates movement away from observer, T indicates movement toward observer

Detachment fault—Dotted where concealed. Teeth on upper plate. Symbol used for decollement fault at base of disturbed belt

Low-angle fault of gravity origin—At base of major coherent blocks comprised mainly of pre-Tertiary rocks

Fault—Located by gravity survey

Oligocene basalt dike

Eocene and Late Cretaceous dikes and sills—All dikes and sills in northeastern part of quadrangle east of Dry Range and northeast of Smith River are of Eocene age. Dikes and sills west and southwest of that area are of Late Cretaceous age

Neoproterozoic dikes and sills

Collapse structure or sinkhole—Hachures point to down-dropped core

Hunt Oil Co. Galt No. 13-1 ✧ **Oil or gas test hole**—Showing operator and hole number

GEOLOGIC MAP OF THE CANYON FERRY DAM 30' x 60' QUADRANGLE, WEST-CENTRAL MONTANA

By

Mitchell W. Reynolds and Theodore R. Brandt

2005

125 years of science for America 1879–2004

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