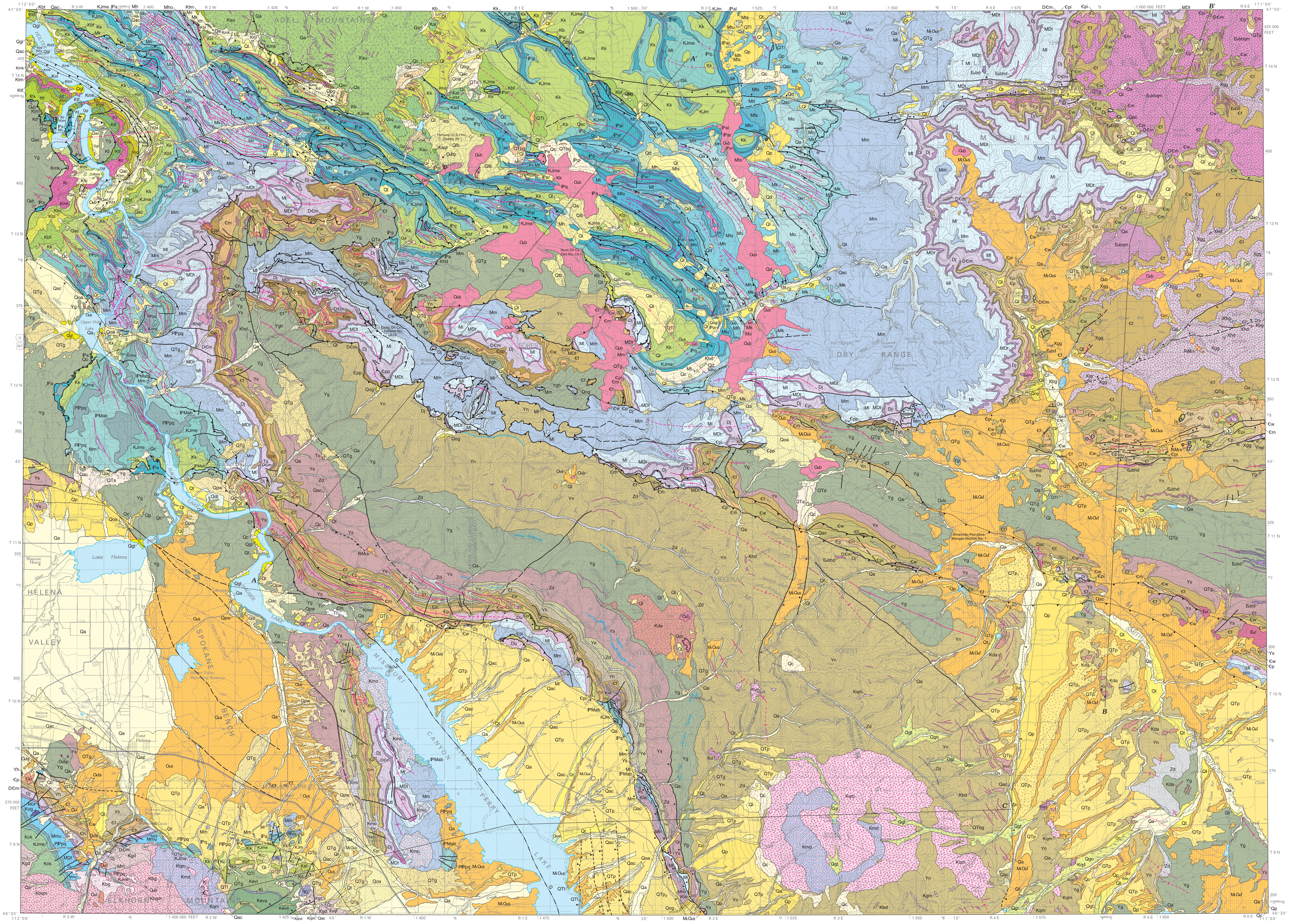
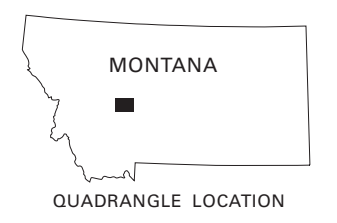
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2860
SHEET 1 OF 3
Pamphlet accompanies map



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

Final digital database by Theodore R. Brandt
Supplementary local digital data by Kenzie J. Turner
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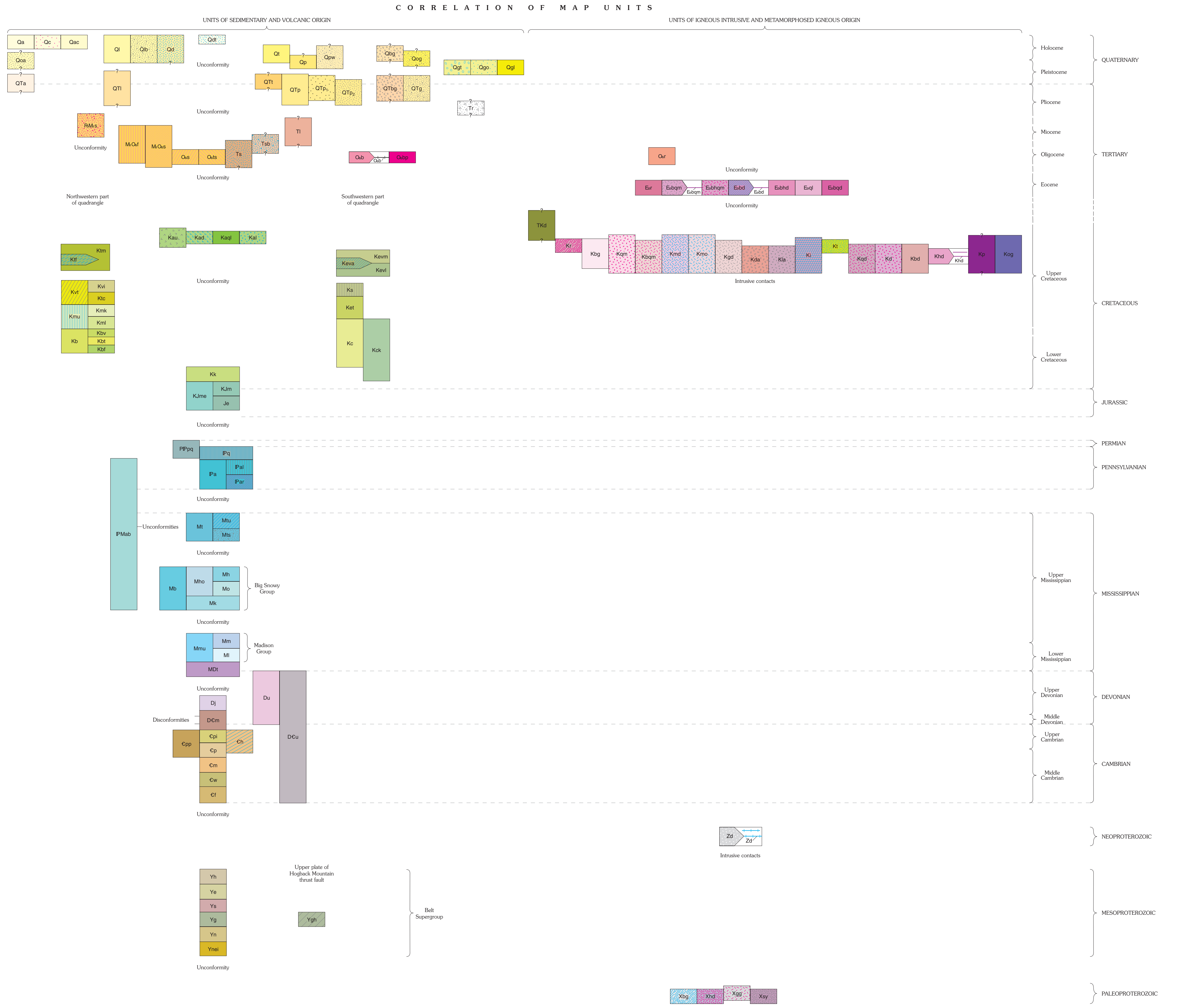
CORRELATION OF MAP UNITS



LIST OF MAP UNITS

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)
PMis	Sedimentary rocks, undivided (Pliocene and Miocene)
MiOgf	Fort Logan Formation (Miocene and Oligocene)
MiOgs	Sedimentary rocks, undivided (Miocene and Oligocene)
Ogs	Sedimentary rocks, undivided (Oligocene)
Ogts	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?)
Ogb	Basalt (Oligocene)
Ogbp	Basalt in plug or volcanic neck (Oligocene)
Ogr	Rhyolite flows and shallow intrusive bodies (Oligocene)
Eor	Rhyolite (Eocene)
Eobqm	Biotite quartz monzonite (Eocene)
Eobhqm	Biotite hornblende quartz monzonite (Eocene)
Eobd	Biotite dacite (Eocene)
Eobhd	Biotite hornblende dacite (Eocene)
Eoql	Quartz latite (Eocene)
Eobqd	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)
PℙPpq	Phosphoria (Permian) and Quadrant (Pennsylvanian) Formations, undivided
ℙq	Quadrant Formation (Pennsylvanian)
ℙa	Amsden Formation (Pennsylvanian)
ℙal	Limestone succession at top
ℙar	Red-bed succession at base
ℙMab	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
D€u	Upper and Middle Devonian and Upper and Middle Cambrian rocks, undivided
Dj	Jefferson Formation (Upper Devonian)
D€m	Maywood Formation (Upper and Middle Devonian) and local Upper Cambrian beds
€pp	Pilgrim Formation (Upper Cambrian) and Park Shale (Upper and Middle Cambrian), undivided
€pi	Pilgrim Formation (Upper Cambrian)
€p	Park Shale (Upper and Middle Cambrian)
€h	Hasmark Formation (Upper and Middle Cambrian)
€m	Meagher Limestone (Middle Cambrian)
€w	Wolsey Formation (Middle Cambrian)
€f	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

R **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

G **Fault**—Located by gravity survey

Anticline—Showing trace of axial surface. Dashed where approximately located; dotted where concealed

Overturned anticline—Showing trace of axial surface and direction of dip of limbs. Dashed where approximately located; dotted where concealed

Inverted anticline—Beds in both limbs are overfolded and dip toward trace of axial surface shown

Syncline—Showing trace of axial surface. Dashed where approximately located; dotted where concealed

Overturned syncline—Showing trace of axial surface and direction of dip of limbs. Dashed where approximately located; dotted where concealed

Inverted syncline—Beds in both limbs are overturned and dip away from trace of axial surface shown. Dashed where approximately located; dotted where concealed

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

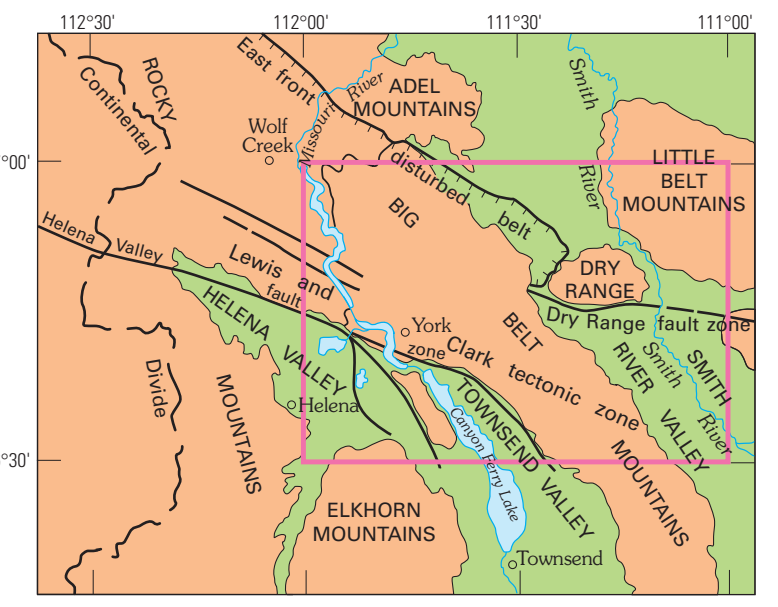


Figure 1. Generalized physiographic map of west-central Montana, showing location of the Canyon Ferry Dam quadrangle (magenta outline) in relation to regional tectonic features. Mountains and uplands are shown in tan, and valleys and benchlands in green.

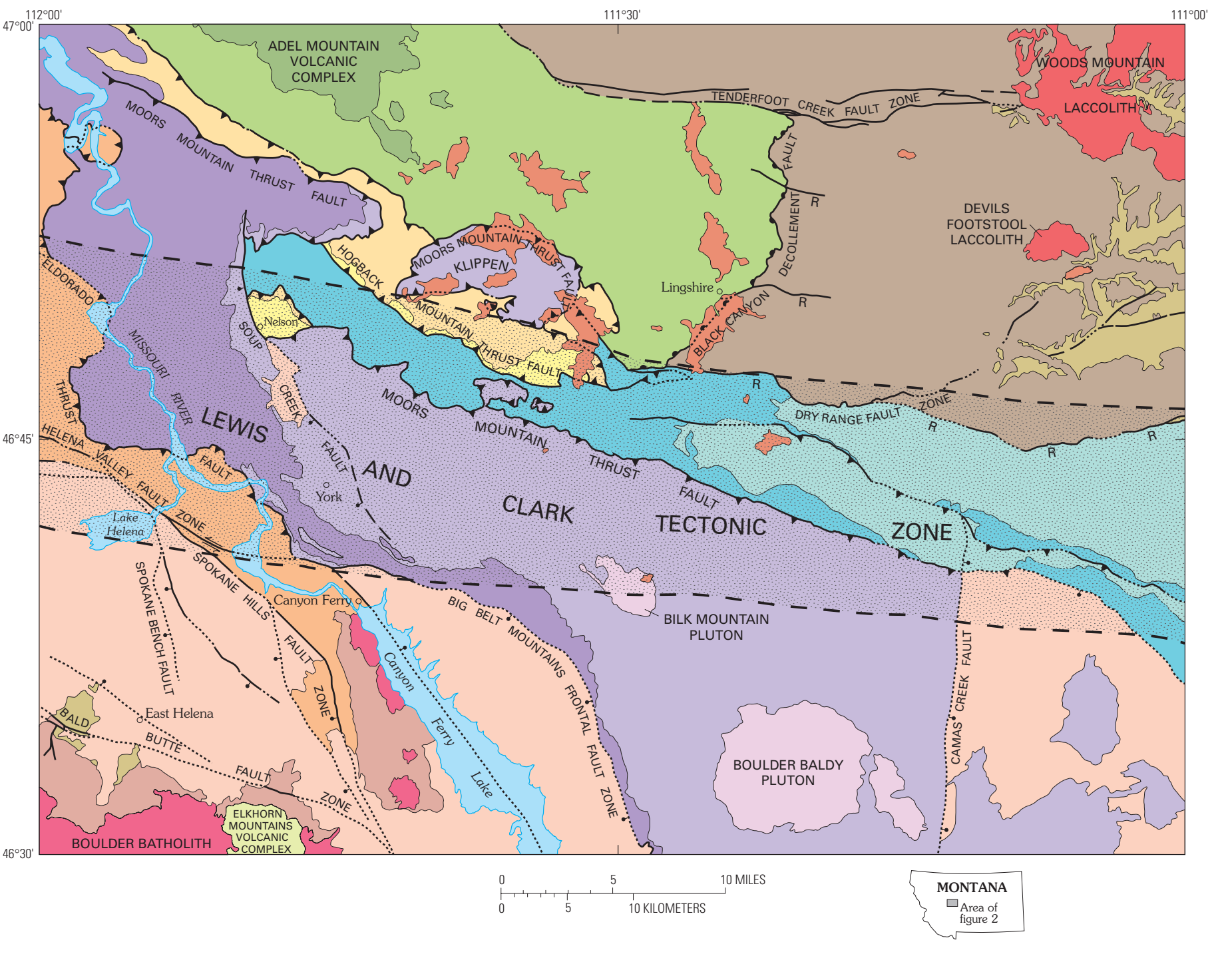


Figure 2. Tectonic map of the Canyon Ferry Dam 30' × 60' quadrangle, west-central Montana, showing thrust sheets, tectonic elements, and the distribution of Early and Middle Proterozoic rocks, Phanerozoic rocks, Eocene laccoliths, Oligocene basalt flows, and selected Cenozoic rocks and sediments in valleys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

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

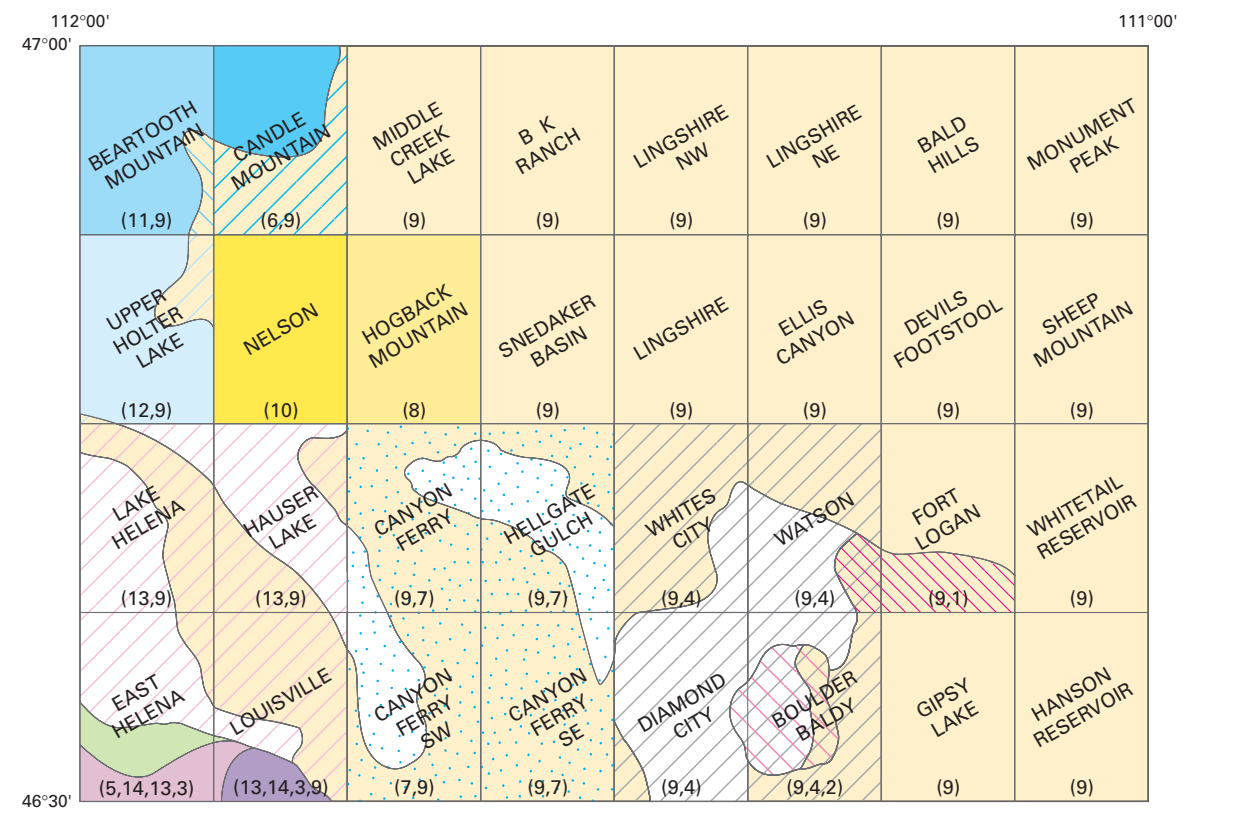
Eldorado thrust sheet and thrust sheets to the west and southwest
- **Phanerozoic rocks, including Elkhorn Mountains Volcanics (Upper Cretaceous)**
- **Mesoproterozoic rocks**

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
- R **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

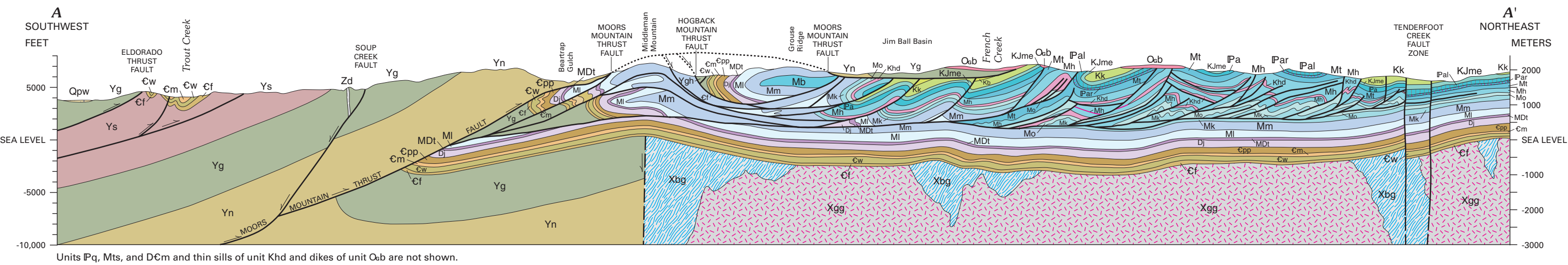
Inferred approximate boundaries of the Lewis and Clark tectonic zone



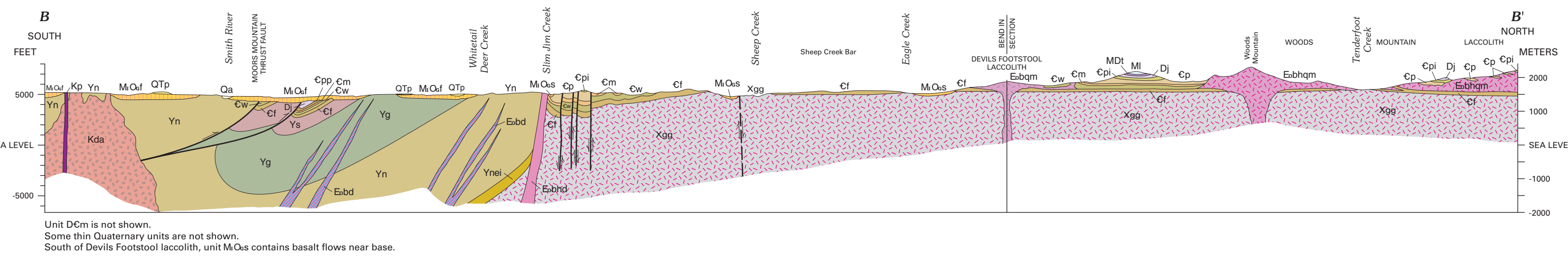
INDEX TO MAJOR SOURCES OF GEOLOGIC MAPPING AND 7.5-MINUTE QUADRANGLES
[Reference numbers listed in order of principal map contribution in the quadrangle shown]

MAJOR SOURCES OF GEOLOGIC MAPPING

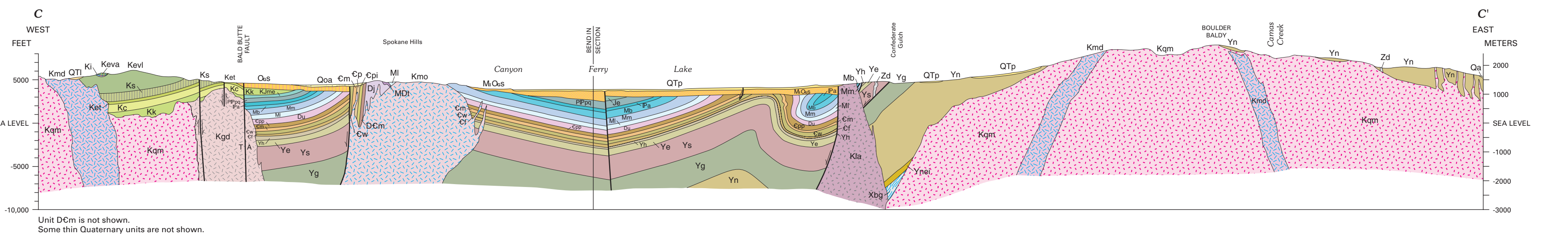
1. Birkholz, D.O., 1967, Geology of the Camas Creek area, Meagher County, Montana: Butte, Mont., Montana College of Mineral Science and Technology M.S. thesis, 68 p.; Plate 1, geologic map, planimetric base, approximate scale 1:31,680. Superposed multicolored ruling indicates area modified using geologic mapping of sources 4 and 9.
2. du Bray, E.A., 1995, Geologic map showing distribution of Cretaceous intrusive rocks in the central Big Belt Mountains, Broadwater and Meagher Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF–2291, scale 1:50,000. Superposed multicolored ruling indicates area modified using geologic mapping of sources 4 and 9.
3. Greenwood, W.R., Ludington, Steve, Miller, W.R., and Hanna, W.F., 1990, Mineral resources of the Elkhorn Wilderness Study Area, Groundwater and Jefferson Counties, Montana: U.S. Geological Survey Bulletin 1805, 37 p.; Plate 1, scale 1:48,000.
4. Gualtieri, J.L., 1975, Preliminary unedited geologic map of the Confederate Gulch area, Broadwater and Meagher Counties, Montana: U.S. Geological Survey Open-File Report 75–211, scale 1:48,000. Superposed solid color indicates area modified using geologic mapping of source 9, and multicolored ruling indicates area modified using geologic mapping of sources 9 and 1.
5. Knopf, Adolf, 1963, Geology of the northern part of the Boulder bathylith and adjacent area, Montana: U.S. Geological Survey Miscellaneous Investigations Map I–381, scale 1:48,000.
6. McCallum, M.E., 1984, U.S. Geological Survey, written communication, unpublished geologic map of the Candle Mountain quadrangle, scale 1:24,000. Ruled where geologic mapping of source 9 was used in entirety.
7. Mertie, J.B., Fischer, R.P., and Hobbs, S.W., 1951, Geology of the Canyon Ferry quadrangle, Montana: U.S. Geological Survey Bulletin 972, 97 p.; Plate 1, scale 1:48,000. Superposed solid color indicates area modified using geologic mapping of source 9.
8. Reynolds, M.W., 2003, Geologic map of the Hogback Mountain quadrangle, Lewis and Clark County, Montana: U.S. Geological Survey Geologic Investigations Series I–2773, scale 1:24,000.
9. Reynolds, M.W., U.S. Geological Survey, unpublished detailed geologic mapping, scale 1:24,000.
10. Reynolds, M.W., and Hays, W.H., 2003, Geologic map of the Nelson quadrangle, Lewis and Clark County, Montana: U.S. Geological Survey Geologic Investigations Series I–2774, scale 1:24,000.
11. Robinson, G.D., and McCallum, M.E., 1991, Preliminary geologic map of the Beartooth Mountain quadrangle, Lewis and Clark County, Montana: U.S. Geological Survey Open-File Report 91–0113, scale 1:24,000. Superposed ruling indicates area modified using geologic mapping of source 9.
12. Robinson, G.D., McCallum, M.E., and Hays, W.H., 1969, Geologic map of the Upper Holter Lake quadrangle, Lewis and Clark County, Montana: U.S. Geological Survey Geologic Quadrangle Map GQ–840, scale 1:24,000. Superposed ruling indicates area modified using geologic mapping of source 9.
13. Schmidt, R.G., 1982, U.S. Geological Survey, written communication, scale 1:48,000. Superposed color indicates area modified using geologic mapping of source 9.
14. Smedes, H.W., 1966, Geology and igneous petrology of the northern Elkhorn Mountains, Jefferson and Broadwater Counties, Montana: U.S. Geological Survey Professional Paper 510, 116 p.; Plate 1, scale 1:48,000.



Units ℙq, Mts, and D€m and thin sills of unit Khd and dikes of unit Ogb are not shown.
Units ℙal and ℙar on map are combined here as ℙa.
Bodies of unit Xbg are shown diagrammatically.
Some thin Quaternary units are not shown.



Unit D€m is not shown.
Some thin Quaternary units are not shown.
South of Devils Footstool laccolith, unit MiOgs contains basalt flows near base.



Unit D€m is not shown.
Some thin Quaternary units are not shown.

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

By

Mitchell W. Reynolds and Theodore R. Brandt

2005

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