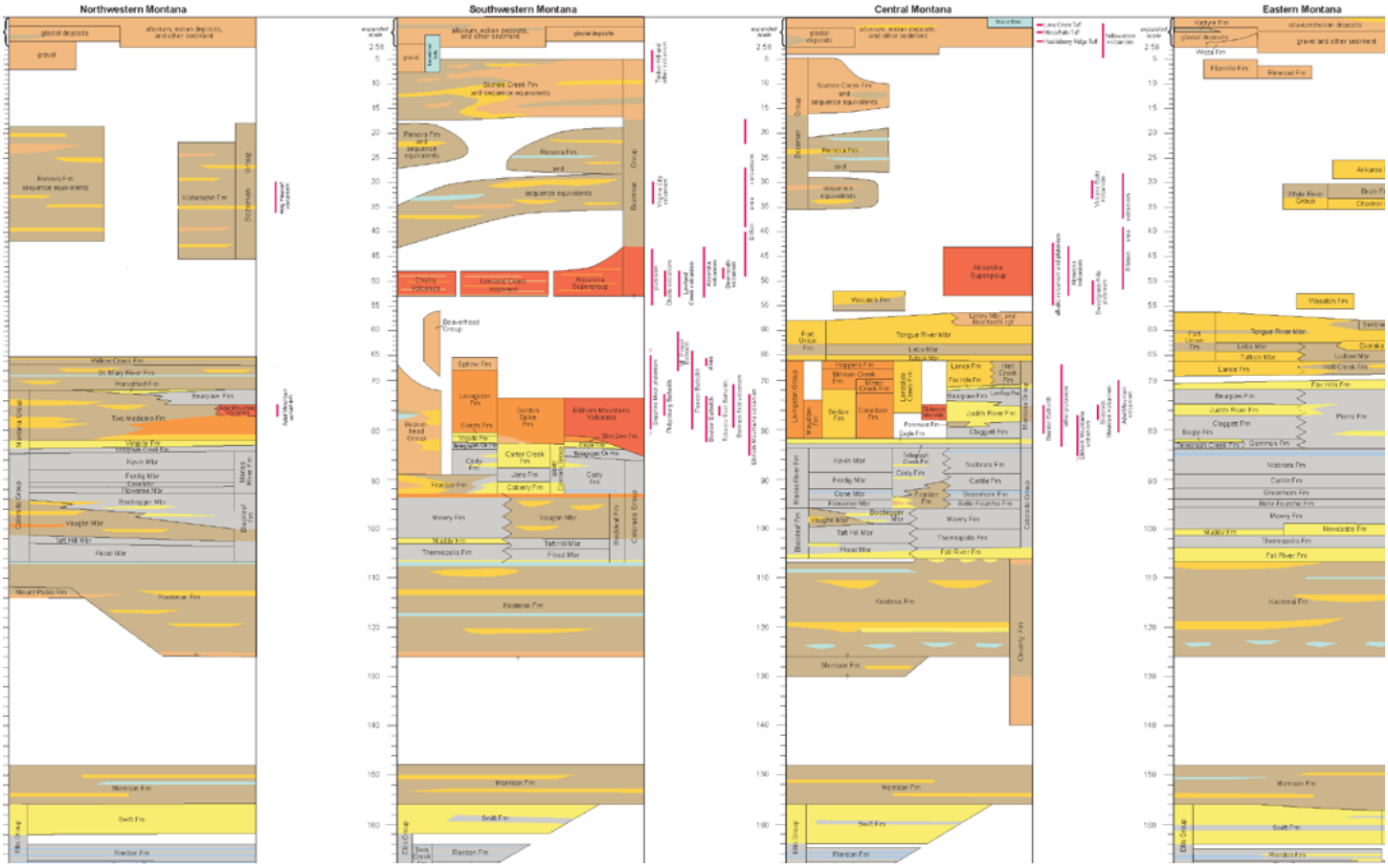
STRATIGRAPHIC CORRELATION CHART OF MONTANA

Pamphlet to Accompany Chart

Susan M. Vuke and Catherine McDonald

Montana Bureau of Mines and Geology



MBMG
Montana Bureau of Mines and Geology

STRATIGRAPHIC CORRELATION CHART OF MONTANA

Pamphlet to Accompany Chart

Susan M. Vuke and Catherine McDonald

Montana Bureau of Mines and Geology

Montana Bureau of Mines and Geology Open-File Report 777

https://doi.org/10.59691/GNQT2608

January 2026

INTRODUCTION

This report provides an update to the 2007 stratigraphic correlation chart that accompanies the printed version of the Geologic Map of Montana (Vuke and others, 2007). The updated chart reflects current knowledge of the age and correlation of map units shown on most geologic maps published by the Montana Bureau of Mines and Geology (MBMG) and other entities working in Montana. It accompanies a 2025 release of the updated 1:500,000-scale digital Geologic Map of Montana (MBMG, 2025). In addition to the 2007 correlation chart, an earlier stratigraphic nomenclature chart (Balster, 1980) is available from the MBMG. This earlier chart includes formation names that appear on some older geologic maps but are no longer in use and thus omitted in this work.

The updated correlation chart is organized into four geographic areas across Montana. Colors represent general lithologies with emphasis on sedimentary surface units. The updated chart also includes information on the geologic history of Precambrian crystalline metamorphic rocks not provided on the 2007 chart.

The references used for this update are listed below and are in addition to those cited for the 2007 chart. Most older references refer to stratigraphic units on the 2025 release of the digital Geologic Map of Montana that were not included on the 2007 map. The timescale is based on the 2022 Geological Society of America timescale (Walker and Geissman, 2022). Other time-scale references are provided at the end of the list.

REFERENCES FOR UPDATES TO 2007 STRATIGRAPHIC CORRELATION CHART OF MONTANA

UPDATED DIGITAL GEOLOGIC MAP OF MONTANA (1:500,000-SCALE)

Montana Bureau of Mines and Geology, 2025, Geologic Map of Montana—A digital database: Montana Bureau of Mines and Geology Digital Map 1, scale 1:500,000, https://doi.org/10.59691/TQRS9419 [Accessed November 12, 2025].

CENOZOIC SEDIMENTARY ROCK

Glacial deposits

Smith, L.N., Hill, C.L., and Reiten, J., 2020, Quaternary and late Tertiary of Montana: Climate, glaciation, stratigraphy, and vertebrate fossils, *in* Metesh, J.J., and Vuke, S.M., eds., Geology of Montana—Geologic History: Montana Bureau of Mines and Geology Special Publication 122, v. 1, 64 p., available at https://mbmg.mtech.edu/pubs/GeologyofMontana/ [Accessed January 2026].

Kintyre, Flaxville, Wiota Formations

Jensen, F.S., and Varnes, H.D., 1964, Geology of the Fort Peck area, Garfield, McCone, and Valley Counties, Montana: U.S. Geological Survey Professional Paper 414-F, 48 p., https://doi.org/10.3133/pp414F

Kishenehn Formation

Calede, J.J., Constenius, K.N., Famoso, N.S., and Kehl, W.A., 2024, Discovery of Oligocene-aged mammals in Glacier National Park (Kishenehn Formation), Montana: Geodiversitas, v. 46, no. 9, p. 367–386, available at https://npshistory.com/publications/glac/g-v46n9-2024.pdf [Accessed January 2026]

CRETACEOUS SEDIMENTARY ROCK

Beaverhead Formation

Garber, K.L., Finzel, E.S., and Pearson, D.M., 2020, Provenance of synorogenic foreland basin strata in southwestern Montana requires revision of existing models for Laramide tectonism: North American Cordillera: Tectonics, v. 39, 26 p., e2019TC005944, https://doi.org/10.1029/2019TC005944

Upper Cretaceous and Albian rocks

Singer, B.S., Jicha, B.R., Sawyer, D.A., Walaszczyk, I., Landman, N., Sageman, B.B., and McKinney, K.C., 2023, *in* Hart, M.B., Batenburg, S.J., Huber, B.T., Price, J.D., Thibault, N., Wagreich, M., and Walaszczyk, I., eds., Cretaceous Project 200, v. 1: The Cretaceous World: Geological Society of London Special Publications 544, https://doi.org/10.1144/SP544-2023-76

Hell Creek Formation

Fastovsky, D.E., and Bercovici, A., 2016, The Hell Creek Formation and its contribution to the Cretaceous–Paleogene extinction: A short primer: Cretaceous Research, v. 57, p. 368–390, doi: https://doi.org/10.1016/j.cretres.2015.07.007

Fowler, Denver, 2020, The Hell Creek Formation, Montana: A stratigraphic review and revision based on a sequence stratigraphic approach: Geosciences, v. 10, no. 435, 59 p., https://doi.org/10.3390/geosciences10110435

Sprain, C.J., Renne, P.R., Wilson, G.P., and Clemens, W.A., 2015, High-resolution chronostratigraphy of the terrestrial Cretaceous–Paleogene transition and recovery interval in the Hell Creek region, Montana: Geological Society of America Bulletin, v. 127, p. 393–409, https://doi.org/10.1130/B31076.1

Fox Hills Formation

Fowler, Denver, 2020, The Hell Creek Formation, Montana: A stratigraphic review and revision based on a sequence stratigraphic approach: Geosciences, v. 10, no. 435, 59 p., https://doi.org/10.3390/geosciences10110435

St. Mary River Formation

Hunter, J.P., Heinrich, R.E., and Weishampel, D.B., 2010, Mammals from the St. Mary River Formation (Upper Cretaceous), Montana: Journal of Vertebrate Paleontology, v. 30, no. 3, p. 885–898, available at https://www.jstor.org/stable/40666203 [Accessed January 2026].

Two Medicine Formation

Foreman, B.Z., Rogers, R.R., Deino, A.L., Wirth, K.R., and Thole, J.T., 2008, Geochemical characterization of bentonite beds in the Two Medicine Formation (Campanian, Montana), including a new $^{40}Ar/^{39}Ar$ age: Cretaceous Research, v. 29, p. 373–385, https://doi.org/10.1016/j.cretres.2007.07.001

Jackson, F.D., and Varricchio, D.J., 2010, Fossil eggs and eggshell from the lowermost Two Medicine Formation of western Montana, Sevenmile Hill locality: Journal of Vertebrate Paleontology, v. 30, no. 4, p. 1142–1156, https://doi.org/10.1080/02724634.2010.483537

Penkalski, Paul, 2014, A new ankylosaurid from the Late Cretaceous Two Medicine Formation of Montana, USA: Acta Palaeontologica Polonica, v. 59, no. 3, p. 617–634, https://doi.org/10.4202/app.2012.0125

Roberts, E.M., and Hendrix, M.S., 2000, Taphonomy of a petrified forest in the Two Medicine Formation (Campanian), northwest Montana: Implications for palinspastic restoration of the Boulder Batholith and Elkhorn Mountains Volcanics: Palaios, v. 15, no. 5, p. 476–482, https://doi.org/10.2307/3515516

Bearpaw and Pierre Formations

Fowler, Denver, 2020, The Hell Creek Formation, Montana: A stratigraphic review and revision based on a sequence stratigraphic approach: Geosciences, v. 10, no. 435, 59 p., https://doi.org/10.3390/geosciences10110435

Penkalski, Paul, 2014, A new ankylosaurid from the Late Cretaceous Two Medicine Formation of Montana, USA: Acta Palaeontologica Polonica, v. 59, no. 3, p. 617–634, https://doi.org/10.4202/app.2012.0125

Sageman, B.B., Singer, B.S., Meyers, S.R., Siewert, S.E., Walaszczyk, I., Condon, D.J., Jicha, B.R., Obradovich, J.D., and Sawyer, D.A., 2014, Integrating $^{40}Ar/^{39}Ar$, U-Pb, and astronomical clocks in the Cretaceous Niobrara Formation, Western Interior Basin, USA: Geological Society of America Bulletin, v. 126, no. 7/8, p. 956–973, https//:doi.org/10.1130/B30929.1

Judith River and Claggett Formations

Penkalski, Paul, 2014, A new ankylosaurid from the Late Cretaceous Two Medicine Formation of Montana, USA: Acta Palaeontologica Polonica, v. 59, no. 3, p. 617–634, https://doi.org/10.4202/app.2012.0125

Ramezani, J., Beveridge, T.L., Rogers, R.R., Eberth, D.A., and Roberts, E.M., 2022, Calibrating the zenith of dinosaur diversity: High-resolution Campanian chronostratigraphy of the Western Interior Basin based on CA-ID-TIMS U-Pb zircon geochronology: Scientific Reports, v. 12, 16026, https://doi.org/10.1038/s41598-022-19896-w

Rogers, R.R., Eberth, D.A., and Ramezani, J., 2024, The "Judith River–Belly River problem" revisited (Montana–Alberta–Saskatchewan): New perspectives on the correlation of Campanian dinosaur-bearing strata based on a revised stratigraphic model updated with CA-ID-TIMS U-Pb geochronology: Geological Society of America, v. 3/4, p. 136, no. 1221–1237, https://doi.org/10.1130/B36999.1

Rogers, R.R., Kidwell, S.M., Deino, A.L., Mitchell, J.P., Nelson, K., and Thole, J.T., 2016, Age, correlation, and lithostratigraphic revision of the Upper Cretaceous (Campanian) Judith River Formation in its type area (north-central Montana), with a comparison of low- and high-accommodation alluvial records: Journal of Geology, v. 124, p. 99–135, https://doi.org/10.1086/684289

Eagle and Telegraph Creek Formations

Davis, B.M., Cifelli, R.L., and Cohen, J.E., 2016, First fossil mammals from the Upper Cretaceous Eagle Formation (Santonian, northern Montana, USA), and mammal diversity during the Aquilan North American Land Mammal Age: Palaeontologia Polonica, v. 67, p. 101–126, available at https://palaeontologia.pan.pl/PP67/Davis.pdf [Accessed January 2026].

Staub, James R., 2017, Sandstone composition variation in regressive to transgressive cycles in the Telegraph Creek and Eagle Formations in south-central Montana: American Association of Petroleum Geologists Search and Discovery Article #51415, available at https://www.searchanddiscovery.com/pdfz/documents/2017/51415staub/ndx_staub.pdf.html [Accessed January 2026].

Frontier and Blackleaf Formations

Frinzel, E.S., Rosenblume, J.A., Pearson, D.M., and Zippi, P.A., 2023, Timing of the transition from Sevier- to Laramide-style tectonism in southwestern Montana based on the provenance of the Frontier Formation, North American Cordillera: Tectonics, v. 42, no. 8, https://doi.org/10.1029/2023TC007777

Gardner, C.T., Finzel, E.S., Rosenblume, J.A., and Pearson, D.M., 2022, Foreland basin response to middle Cretaceous thrust belt evolution, southwestern Montana, USA: Geosphere, v. 18, no. 6, p. 1783–1803, https://doi.org/10.1130/GES02521.1

Krumenacker, L.J., Varricchio, D.J., Wilson, J.P., Martin, A., and Ferguson, A., 2019, Taphonomy of and new burrows from *Oryctodromeus cubicularis*, a burrowing neornithischian dinosaur, from the mid-Cretaceous (Albian–Cenomanian) of Idaho and Montana, U.S.A.: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 530, p. 300–311, https://doi.org/10.1016/j.palaeo.2019.05.047

Singer, B.S., Jicha, B.R., Sawyer, D., Walaszczyk, I., Buchwaldt, R., and Mutterlose, J., 2020, Geochronology of late Albian–Cenomanian strata in the U.S. Western Interior: Geological Society of America Bulletin, v. 133, no. 7/8, p. 1665–1678, https://doi.org/10.1130/B35794.1

Kootenai Formation

D'Emic, M.D., Foreman, B.Z., Jud, N.A., Britt, B.B., Schmitz, M., and Crowley, J.L., 2019, Chronostratigraphic revision of the Cloverly Formation (Lower Cretaceous, Western Interior, USA): Bulletin of the Peabody Museum of Natural History, v. 60, no. 1, p. 3–40, https://doi.org/10.3374/014.060.0101

Finzel, E.S., and Rosenblume, J.A., 2020, Dating lacustrine carbonate strata with detrital zircon U-Pb geochronology: Geological Society of America Bulletin, v. 49, p. 294–298, https://doi.org/10.1130/G48070.1

Quinn, G.M., Hubbard, S.M., Putnam, P.E., Matthews, W.A., Daniels, B.G., and Guest, B., 2018, A Late Jurassic to Early Cretaceous record of orogenic wedge evolution in the Western Interior Basin, USA and Canada: Geosphere, v. 14, no. 3, p. 187–1208, https://doi.org/10.1130/GES01606.1

Raines, M.K., Hubbard, S.M., Kukulski, R.B., Leier, A.L., and Gehrels, G.E., 2013, Sediment dispersal in an evolving foreland: Detrital zircon geochronology from Upper Jurassic and lowermost Cretaceous strata, Alberta Basin, Canada: Geological Society of America Bulletin, v. 125, no. 5/6, p. 741–755, https://doi.org/10.1130/B30671.1

Rosenblume, J.A., Finzel, E.S., and Pearson, D.M., 2021, Early Cretaceous provenance, sediment dispersal, and foreland basin development in southwestern Montana, North American cordillera: Tectonics, v. 40, e2020TC006561, https://doi.org/10.1029/2020TC006561

JURASSIC SEDIMENTARY ROCK

Morrison Formation and Ellis Group

Fuentes, F., DeCelles, P.G., and Gehrels, 2009, Jurassic onset of foreland basin deposition in northwestern Montana, USA: Implications for along-strike synchroneity of Cordilleran orogenic activity: Geology, v. 37, no. 4, p. 379–382, https://doi.org/10.1130/G25557A.1

Parcell, W.C., and Williams, M.K., 2005, Mixed sediment deposition in a retro-arc foreland basin: Lower Ellis Group (M. Jurassic), Wyoming and Montana, U.S.A.: Sedimentary Geology, v. 177, p. 175–194, https://doi.org/10.1016/j.sedgeo.2005.02.007

Sundance Formation

Parcell, W.C., and Williams, M.K., 2005, Mixed sediment deposition in a retro-arc foreland basin: Lower Ellis Group (M. Jurassic), Wyoming and Montana, U.S.A.: Sedimentary Geology, v. 177, p. 175–194, https://doi.org/10.1016/j.sedgeo.2005.02.007

Syzdek, J.C., Craddock, J.P., and Malone, D.H., 2019, Detrital zircon U-Pb geochronology and provenance of the Sundance Formation, western Powder River Basin, Wyoming: Mountain Geologist, v. 56, no. 3, p. 295–317, https://doi.org/10.31582/rmag.mg.56.3.295

MISSISSIPPIAN AND PENNSYLVANIAN ROCK

Sando, William J., 1992, Western Interior Mississippian lithosomes: A progress report: U.S. Geological Survey Open File Report 92-213, 19 p., available at https://pubs.usgs.gov/of/1992/0213/report.pdf [Accessed January 2026].

Skipp, B., and Janecke, S.U., 2004, Geologic map of the Montana part of the Dubois 30′ x 60′ quadrangle, southwest Montana: Montana Bureau of Mines and Geology Open-File Report 490, 12 p., 1 sheet, scale 1:100,000, available at https://www.mbmg.mtech.edu/mbmgcat/public/listcitation.asp?pub_id=11361 [Accessed January 2026].

DEVONIAN SEDIMENTARY ROCK

Hofmann, Michael H., 2020, The Devonian sedimentary record of Montana, *in* Metesh, J.J., and Vuke, S.M., eds., Geology of Montana—Geologic History: Montana Bureau of Mines and Geology Special Publication 122, v. 1, 51 p., available at https://mbmg.mtech.edu/pubs/GeologyofMontana/ [Accessed January 2026].

Hu, M., Myrow, P.M., Fike, D.A., di Pasquo, M., Zaton, M., Fischer, W.W., and Coates, M., 2024, Depositional history of Devonian to lower Carboniferous (Tournaisian) strata, northern Wyoming and southern Montana, USA: Geological Society of America Bulletin, v. 136, no. 7/8, p. 3311–3334, https://doi.org/10.1130/B36728.1

DiPasquo, M., Grader, G.W., Warren, A., Rice, B., Isaacson, P., and Doughty, P.T., 2017, Palynologic delineation of the Devonian–Carboniferous boundary, west-central Montana, USA: Palynology, v. 41, no. S1, p. 189–220, https://doi.org/10.1080/01916122.2017.1366180

ORDOVICIAN–CAMBRIAN SEDIMENTARY ROCK

Snowy Range Formation

Lindsey, D.A., 1980, Reconnaissance geologic map of the Big Snowies Wilderness and contiguous RARE II study areas, Fergus, Golden Valley, and Wheatland Counties, Montana: U.S. Geological Survey Miscellaneous Field Studies Map, MF-1243-A, 1 sheet, scale 1:100,000, https://doi.org/10.3133/mf1243A

Myrow, P.M., Taylor, J.F., Runkel, A.C., and Ripperdan, R.L., 2012, Mixed siliciclastic–carbonate upward-deepening cycles of the Upper Cambrian inner detrital belt of Laurentia: Journal of Sedimentary Research, v. 82, p. 216–231, https://doi.org/10.2110/jsr.2012.20

Weaver, Patricia G., 1992, Lithostratigraphy and conodont biostratigraphy of the Grove Creek Dolomite Member of the Snowy Range Formation (Cambrian–Ordovician), Big Snowy Mountains, Montana: Missoula, University of Montana, M.S. thesis, 77 p., available at https://scholarworks.umt.edu/etd/7452/ [Accessed January 2026].

Emerson Formation

Knechtel, Maxwell M., 1956, Emerson Formation of the Cambrian and probable Early Ordovician age in Little Rocky Mountains, Montana: American Association of Petroleum Geologist Bulletin, v. 40, p. 1994–1995, https://doi.org/10.1306/5CEAE54D-16BB-11D7-8645000102C1865D

Lochman-Balk, C., and Wilson, J.E., 1967, Stratigraphy of Upper Cambrian–Lower Ordovician subsurface sequence in Williston basin: American Association of Petroleum Geologists Bulletin, v. 51, no. 6, p. 883–917, https://doi.org/10.1306/5D25C0FB-16C1-11D7-8645000102C1865D

Cambrian section

Schwimmer, David R., 1975, Quantitative taxonomy and biostratigraphy of Middle Cambrian trilobites from Montana and Wyoming: Mathematical Geology, v. 7, no. 2, p. 149–166, https://doi.org/10.1007/BF02080490

CAMBRIAN IGNEOUS ROCK

Beaverhead Granite

Link, P.K., Todt, M.K., Pearson, D.M., and Thomas, R.C., 2017, 500–490 Ma detrital zircons in Upper Cambrian Worm Creek and correlative sandstones, Idaho, Montana, and Wyoming: Magmatism and tectonism within the passive margin: Lithosphere 2017, v. 9, no. 6, p. 910–926, https://doi.org/10.1130/L671.1

Lund, K., Aleinikoff, J.N., Evans, K.V., duBray, E.A., Dewitt, E.H., and Unruh, D.M., 2010, SHRIMP U-Pb dating of recurrent Cryogenian and Late Cambrian–Early Ordovician alkalic magmatism in central Idaho: Implications for Rodinian rift tectonics: Geological Society of America Bulletin, v. 122, p. 430–453, https://doi.org/10.1130/B26565.1

MESOPROTEROZOIC BELT SUPERGROUP

Missoula Group and equivalent strata

Burmester, R.F., Lonn, J.D., Lewis, R.S., and McFaddan, M.D., 2016, Stratigraphy of the Lemhi subbasin of the Belt Supergroup, *in* MacLean, J.S., and Sears, J.W., eds., Belt Basin: Window to Mesoproterozoic Earth: Geological Society of America Special Paper 522, Chapter 5, p. 121–138, https://doi.org/10.1130/2016.2522(05)

Hirtz, J.A.M., Constenius, K.N., Horton, B.K., Valencia, V.A., and Pratt, B.R., 2024, Continental-scale drainage reorganization during Mesoproterozoic orogenesis: Evidence from the Belt Basin of western North America: Geosphere, v. 20, no. 4, p. 1133–1161, https://doi.org/10.1130/GES02732.1

Lonn, J.D., Burmester, R.F., Lewis, R.S., McFaddan, M.D., and Mosolf, J.G., in review, Links and missing links between the Mesoproterozoic Missoula Group and the Lemhi subbasin strata of the Belt Supergroup, western Montana and east-central Idaho, *in* Link, P.K., ed., Mesoproterozoic tectonics, deposition, and geochronology of the Belt Supergroup and overlying strata: Geological Society of America Special Paper in honor of Dr. Don Winston, Montana field geologist.

Newland Formation

Zieg, J., Bouley, L., Dietrich, J., Nacey, K., and Mahoney, J. 2024, Timing of Middle Proterozoic mineralization and magmatism in the Helena Embayment of the Belt Basin: Geological Society of America Abstracts with Programs, v. 56, no. 4, https://doi.org/10.1130/abs/2024CD-399440

PALEOPROTEROZOIC METAMORPHIC ROCK

Foster, D.A., Mueller, P.A., Vogl, J.J., Gifford, J., and Mogk, D.W., 2014, The Little Belt arc of the Great Falls orogen: Geological Society of America Abstracts with Programs, v. 46, no. 5, p. 20,

available at https://gsa.confex.com/gsa/2014RM/webprogram/Paper238710.html [Accessed January 2026].

Harms, T.A., and Baldwin, J.A., 2020, Paleoproterozoic geology of Montana, *in* Metesh, J.J., and Vuke, S.M., eds., Geology of Montana—Geologic History: Montana Bureau of Mines and Geology Special Publication 122, v. 1, 37 p., available at https://mbmg.mtech.edu/pubs/GeologyofMontana/ [Accessed January 2026].

Harms, T.A., and Baldwin, J.A., 2023, Paleoproterozoic geology of SW Montana: Implications for the paleogeography of the Wyoming craton and for the consolidation of Laurentia, *in* Whitmeyer, S.J., Williams, M.L., Kellett, D.A., and Tikoff, B., Laurentia: Turning points in the evolution of a continent: Geological Society of America Memoir 220, p. 65–79, https://doi.org/10.1130/2022.1220(05)

Mueller, P.A., Heatherington, A.L., Kelly, D.M., Wooden, J.L., and Mogk, D.W., 2002, Paleoproterozoic crust within the Great Falls tectonic zone: Implications for the assembly of southern Laurentia: Geology, v. 30, no. 2, p. 127–130, https://doi.org/10.1130/0091-7613(2002)030<0127:PCWTGF>2.0.CO;2

ARCHEAN METAMORPHIC ROCK

Mogk, D.A., Frost, C.D., Mueller, P.A., Frost, B.R., and Henry, D.J., 2022, Crustal genesis and evolution of the Archean Wyoming Province: Continental growth through vertical magmatic and horizontal tectonic processes, *in* Whitmeyer, S.J., Williams, M.L., Kellett, D.A., and Tikoff, B., eds., Laurentia: Turning points in the evolution of a continent: Geological Society of America Memoir 220, p. 1–24, https://doi.org/10.1130/2022.1220(01)

Mogk, D.W., Mueller, P.A., and Henry, D.J., 2020, The Archean geology of Montana, *in* Metesh, J.J., and Vuke, S.M., eds., Geology of Montana—Geologic History: Montana Bureau of Mines and Geology Special Publication 122, v. 1, 45 p., available at https://mbmg.mtech.edu/pubs/GeologyofMontana/ [Accessed January 2026].

VOLCANIC ROCK

Lava Creek Tuff

Wilson, C.J.N., Stelten, M.E., and Lowenstern, J.B., 2018, Contrasting perspectives on the Lava Creek Tuff eruption, Yellowstone, from new U-Pb and $^{40}Ar/^{30}Ar$ age determinations: Bulletin of Volcanology, v. 80, no. 53, https://doi.org/10.1007/s00445-018-1229-x

Mesa Falls Tuff

Stelten, M.E., Champion, D.E., and Kuntz, M.A., 2018, The timing and origin of pre- and post-caldera volcanism associated with the Mesa Falls Tuff, Yellowstone Plateau volcanic field: Journal of Volcanology and Geothermal Research, v. 350, no. 15, p. 47–60, https://doi.org/10.1016/j.jvolgeores.2017.12.002

Absaroka Supergroup

Dudás, F.Ö, Chatterjee, N., and Krol, M., 2024, Eocene andesitic adakite from Lone Mountain, southwestern Montana: Journal of Geology, v. 131, no. 1, https://doi.org/10.1086/726207

Challis volcanic rock

Sandford, R.F., and Snee, L.W., 2005, Geology and stratigraphy of the Challis Volcanic Group and related rocks, Little Wood River area, south-central Idaho, with a section on geochronology: U.S. Geological Survey Bulletin 2064-II, 22 p., map scale 1:100,000, https://doi.org/10.3133/b2064II

Lowland Creek volcanic rock

Dudás, F.Ö., Ispolatov, V.O., Harlan, S.S., and Snee, L.W., 2010, $^{40}Ar/^{39}Ar$ geochronology and geochemical reconnaissance of the Eocene Lowland Creek volcanic field, west-central Montana: Journal of Geology, v. 118, no. 3, https://doi.org/10.1086/651523

Hog Heaven volcanic rock

Coppage, Ethan, 2022, Geology and geochronology of the East Dome Complex within the Hog Heaven volcanic field, Flathead County, Montana: Butte, Montana Technological University M.S. thesis, available at https://digitalcommons.mtech.edu/grad_rsch/278 [Accessed January 2026].

Adel Mountain volcanic rock

Harlan, S.S., Snee, L.W., Reynolds, M.W., Mehnert, H.H., Schmidt, R.G., Sheriff, S.D., and Irving, A.J., 2005, $^{40}Ar/^{39}Ar$ and K-Ar geochronology and tectonic significance of the Upper Cretaceous Adel Mountain Volcanics and spatially associated Tertiary igneous rocks, northwestern Montana: U.S. Geological Survey Professional Paper 1696, 29 p., https://doi.org/10.3133/pp1696

Garnet Range volcanic rock

Mosolf, J.G., and McDonald, C., 2015, Geologic field guide to the Tertiary volcanic rocks in the Elliston 30′ x 60′ quadrangle, west-central Montana, *in* Mosolf, J.G., and McDonald, C., eds., Geology of the Elliston area, Montana, and other papers:, Tobacco Root Geological Society 40th annual field conference, Northwest Geology 44, p. 213–231, available at https://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=31772 [Accessed January 2026].

McDonald, C., Mosolf, J.G., Vuke, S.M., and Lonn, J.D., 2020, Geologic map of the Elliston 30′ x 60′ quadrangle, west-central Montana: Montana Bureau of Mines and Geology Geologic Map 77, 34 p., 1 sheet, scale 1:100,000, available at https://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32276 [Accessed January 2026].

Bearmouth volcanic rock

Sears, J.W., MacDonald, K. [sic], and Lonn, J., 2010, Lewis and Clark Line, Montana: Tectonic evolution of a crustal-scale flower structure in the Rocky Mountains: Geological Society of America Field Guide 18, 20 p., https://doi.org/10.1130/2010.0018(01)

Elkhorn Mountains volcanic rock

Lund, K., and Aleinikoff, J.N., 2022, Temporal relations between the Boulder Batholith and Elkhorn Mountains Volcanics, western Montana: "The nature of batholiths" revised, *in* Scarberry, K.C., Gammons, C.H., and Barth, S., eds., Proceedings of the Montana Mining and Mineral Symposium 2021, Montana Bureau of Mines and Geology Special Paper 123, p. 89–97, https://doi.org/10.59691/YXKU1170

Scarberry, K., 2024, Structural and magmatic development of Late Cretaceous magmas and mineral deposits in the Elkhorn 7.5′ quadrangle: Results from Earth-MRI (Mapping Resources Initiative) geologic mapping in southwestern Montana: Geological Society of America Abstracts with Programs, v. 56, no. 4, https://doi.org/10.1130/abs/2024CD-399518

Boulder Batholith

Dilles, J., Kirkland, C.L., Dröllner, M., Way, R.A.M., Acito, S., Olierook, H.K.H., Clevenger, J., Miggins, D.P., Scarberry, K., and Olsen, N., 2024, Zircon age and geochemistry of granites related to porphyry and polymetallic mineral deposits of the eastern Elkhorn Mountains and Boulder Batholith, Montana: Geological Society of America Abstracts with Programs, v., 56, no. 4, available at https://gsa.confex.com/gsa/2024CD/meetingapp.cgi/Paper/399546 [Accessed January 2026].

duBray, E.A., Aleinikoff, J.N., and Lund, K., 2012, Synthesis of petrographic, geochemical, and isotopic data for the Boulder Batholith, southwest Montana: U.S. Geological Survey Professional Paper 1793, 45 p., https://doi.org/10.3133/pp1793

Lund, K., McAleer, R.J., Aleinikoff, J.N., and Cosca, M.A., 2021, Two-event genesis of Butte lode veins: Geologic and geochronologic evidence from ore veins, dikes, and host plutons, *in* Scarberry, K.C., and Barth, S., eds., Proceedings of the Montana Mining and Mineral Symposium 2019: Montana Bureau of Mines and Geology Special Paper 121, p. 71–73, available at https://mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=32264 [Accessed January 2026].

Lund, K., and Aleinikoff, J.N., 2022, Temporal relations between the Boulder Batholith and Elkhorn Mountains Volcanics, western Montana: "The nature of batholiths" revised, *in* Scarberry, K.C., Gammons, C.H., and Barth, S., eds., Proceedings of the Montana Mining and Mineral Symposium 2021, Montana Bureau of Mines and Geology Special Paper 123, p. 89–97, https://doi.org/10.59691/YXKU1170

Smeets, A.J., Isava, V., Grove, M.J., and Mahoney, B.J., 2020, Thermal history determination of the Boulder Batholith, Montana through $^{40}Ar/^{39}Ar$

thermochronology: Geological Society of America Abstracts with Programs, v. 52, no. 4, https://doi.org./10.1130/abs/2020CD-347034

TIME SCALE REFERENCES

Overall

Walker, J.D., and Geissman, J.W., compilers, 2022, Geologic time scale, v. 6.0: Geological Society of America, https://doi.org/10.1130/2022.CTS006C

Cenozoic North American land mammal ages

Barnosky, A.D., Holmes, M., Kircholtes, R., Lindsey, E., Maguire, K.C., Poust, A.W., Stegner, M.A., Sunseri, J., Swartz, B., Swift, J., and Villavicencio, N.A., 2014, Prelude to the Anthropocene: Two new North American Land Mammal Ages (NALMAs): The Anthropocene Review, v. 1, no. 3, p. 225–242, https://doi.org/10.1177/2053019614547433

Cretaceous North American land vertebrate ages

Fowler, Denver W., 2017, Revised geochronology, correlation, and dinosaur stratigraphic ranges of the Santonian–Maastrichtian (Late Cretaceous) formations of the Western Interior of North America: Plos One, v. 12, no. 11, https://doi.org/10.1371/journal.pone.0188426

Ramezani, J., Beveridge, T.L., Rogers, R., Eberth, D., and Roberts, E., 2022, Calibrating the zenith of dinosaur diversity in the Campanian of the Western Interior Basin by CA-ID-TIMS U–Pb geochronology: Scientific Reports, v. 12, no. 1, https://doi.org/10.1038/s41598-022-19896-w

Permian North American time scale

Henderson, C.M., and Shen, S.Z., 2020, The Permian Period, *in* Gradstein, F., Ogg, J.G., Schmitz, M.D., and Ogg, G.M., eds., Geologic time scale 2020: Elsevier, Amsterdam, Netherlands, v. 2, p. 875–902, https://doi.org/10.1016/B978-0-12-824360-2.00032-2

Pennsylvanian and Mississippian North American time scales

Aretz, M., Herbig, H.G., and Wang, X.D., 2020, The Carboniferous Period, *in* Gradstein, F., Ogg, J.G., Schmitz, M.D., and Ogg, G.M., eds., Geologic time scale 2020: Elsevier, Amsterdam, Netherlands, v. 2, p. 811–874, https://doi.org/10.1016/B978-0-12-824360-2.00032-2

Ordovician North American time scale

Goldman, D., Sadler, P.S., and Leslie, S.A., 2020, The Ordovician Period, *in* Gradstein, F., Ogg, J.G., Schmitz, M.D., and Ogg, G.M., eds., Geologic time scale 2020: Elsevier, Amsterdam, Netherlands, v. 2, p. 631–698, https://doi.org/10.1016/B978-0-12-824360-2.00032-2

Cambrian North American time scale

Peng, S.C., Babcock, L.E., and Ahlberg, P. 2020, The Cambrian Period, *in* Gradstein, F., Ogg, J.G., Schmitz, M.D., and Ogg, G.M., eds., Geologic time scale 2020: Elsevier, Amsterdam, Netherlands, v. 2, p. 565–630, https://doi.org/10.1016/B978-0-12-824360-2.00032-2

OLDER STRATIGRAPHIC NOMENCLATURE CHART REFERENCES

Balster, C.A., 1980, Stratigraphic nomenclature chart for Montana and adjacent areas: Montana Bureau of Mines and Geology Geologic Map 8, 1 sheet, available at https://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=10161 [Accessed January 2026].

Vuke, S.M., Porter, K.W., Lonn, J.D., and Lopez, D.A., 2007, Geologic map of Montana: Montana Bureau of Mines and Geology Geologic Map 62, 73 p., 2 sheets, scale 1:500,000, available at https://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=30079 [Accessed January 2026].

ACKNOWLEDGMENTS

The authors are grateful for MBMG Geologic Cartographer Susan Smith's diligent work on the chart. We thank MBMG reviewers Daniel Brennan, Jesse Mosolf, and Skyler Mavor. We also appreciate the help provided by geologists Jeffrey Lonn, Stuart Parker, David Mogk, Colleen Elliott, Kaleb Scarberry, and Yann Gavillot on aspects of the stratigraphy.