

MONTANA BUREAU OF MINES AND GEOLOGY: GEOLOGIC MAPPING IN MONTANA

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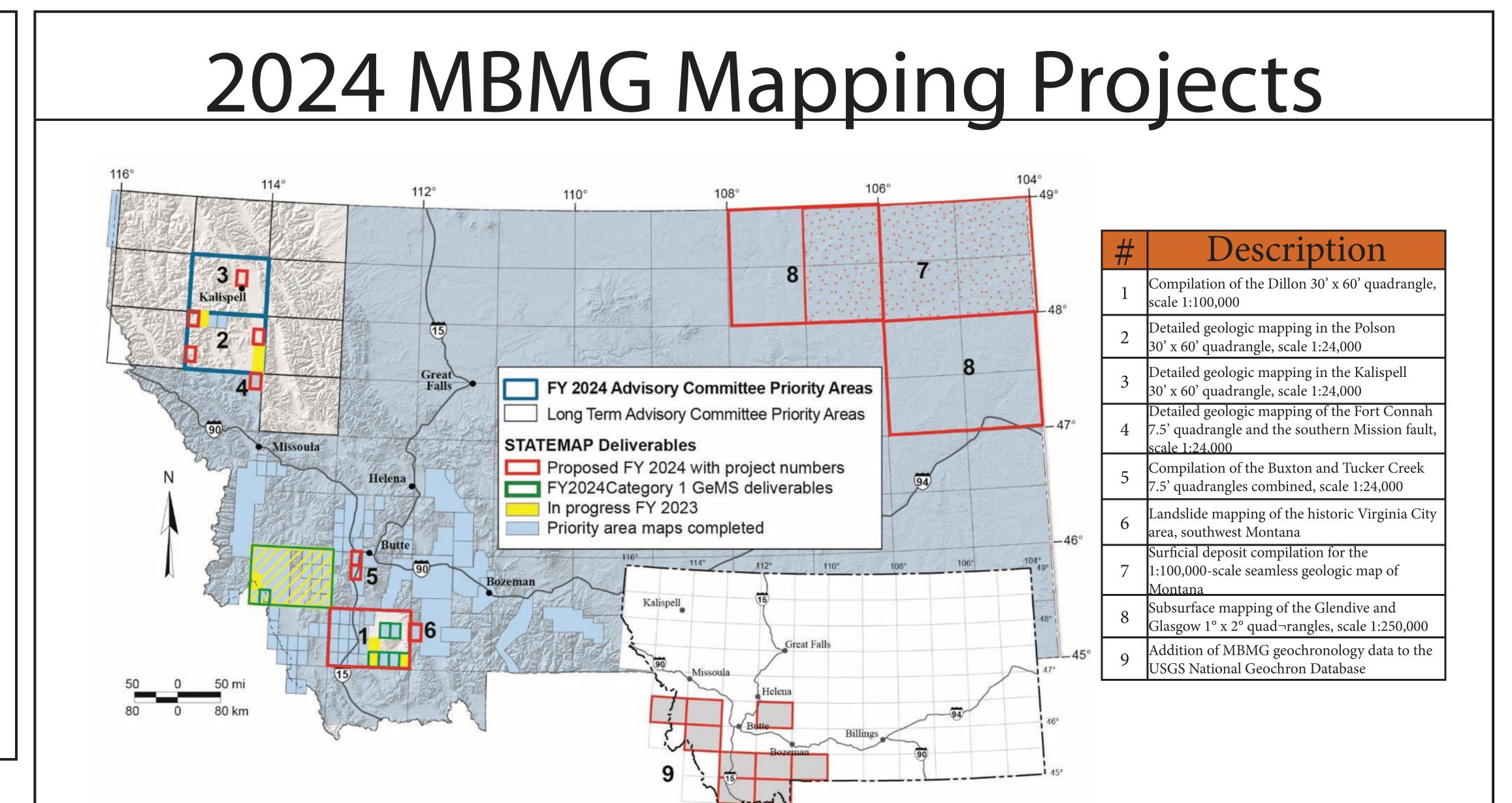


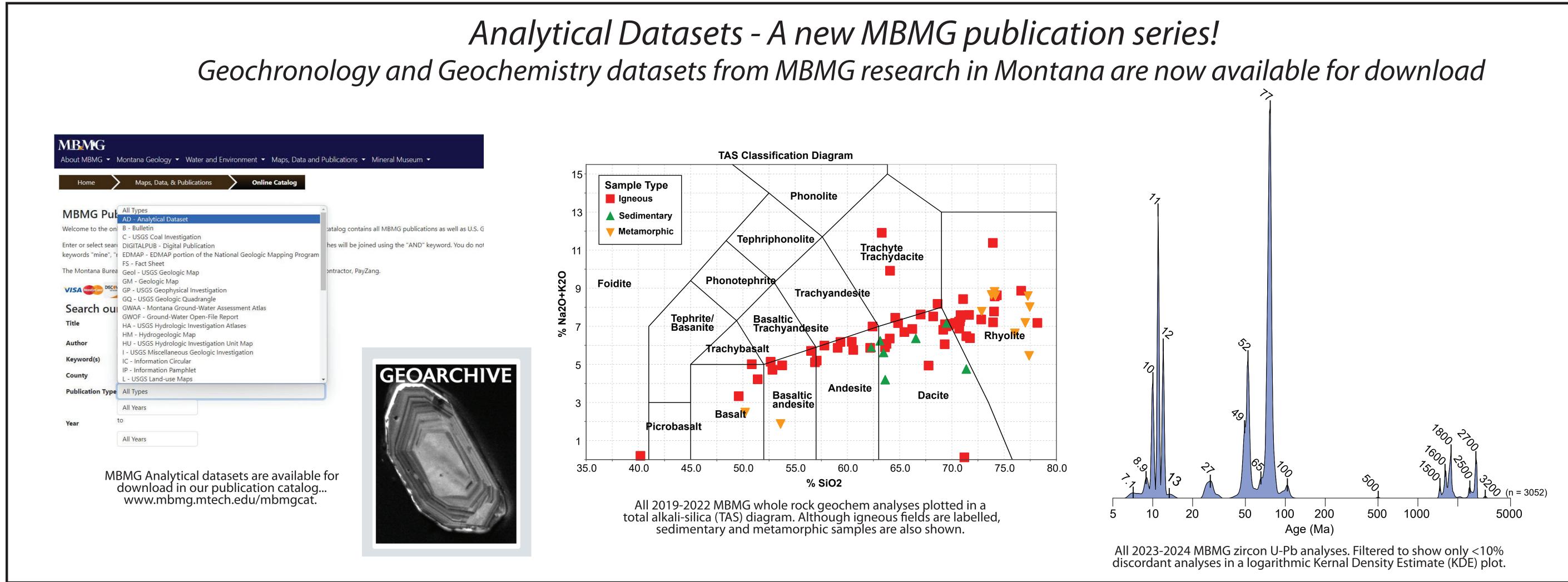
This poster highlights current geologic mapping projects at the Montana Bureau of Mines and Geology (MBMG). Our mapping program is primarily funded by state and federal taxpayer dollars as part of the STATEMAP component of the USGS National Cooperative Geologic Mapping Program. MBMG's mapping team comprises 12 permanent, emeritus, and contract field geologists, GIS specialists, cartographers, and laboratory assistants. The primary goal of MBMG's mapping program is to complete geologic mapping of all 30' x 60' quadrangles in the state and achieve seamless geologic coverage at 1:100,000-scale. The 2023 field season focused on new mapping of seven 7.5' quadrangles (1:24,000-scale). These maps contribute towards completing the Dillon and Wisdom 30' x 60' quadrangles, the final 1:100,000-scale STATE-MAP projects in southwestern Montana. Mapping in the Polson 30' x 60' quadrangle resumed in 2023, with the support of the Confederated Salish and Kootenai Tribes. This project has important implications for seismic hazards associated with the active Mission Fault. In addition to these projects, the Economic Geology program recently began mapping four 7.5' quadrangles in the Radersburg and Mineral Point mining districts, as part of the USGS Earth Mapping Resources Initiative.

This past year, five new 1:24,000-scale geologic maps were published by MBMG; two of which were EDMAP products authored by Montana State University students. We also published a 1:55,000-scale geologic map related to a seismic hazards study of the Bitterroot Fault. Seven datasets of geochemical, geochronological, and assay data from across the state were published as part of our new Analytical Dataset publication series. This new publication series will facilitate access to growing analytical datasets generated by MBMG annually. The first-ever Montana Geologic Map puzzle was also released this year.

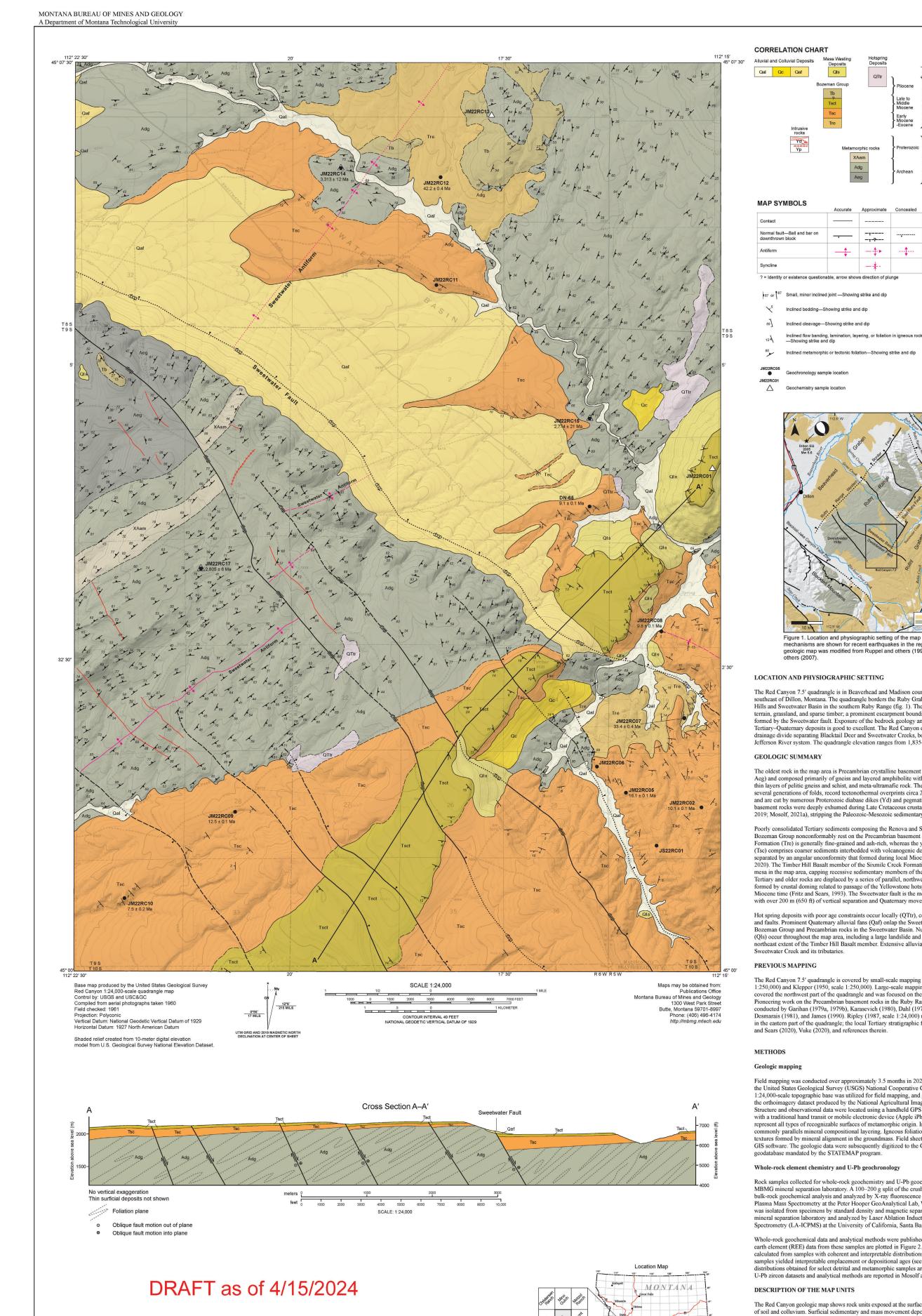
In the upcoming field season, MBMG geologists will wrap up mapping in the Dillon 30' x 60' quadrangle, and continue our shift to mapping the ten remaining 30' x 60' quadrangles in the northwestern part of the state.

Learn more at https://www.mbmg.mtech.edu and view our 1:100,000-scale seamless database at https://gis-data-hub-mbmg.hub.arcgis.com/apps/53bf38cf17fd45dbbcf93b6cafaa3365/explore





Geologic Map of the Red Canyon 7.5' Quadrangle, Beaverhead and Madison Counties, Montana Jesse G. Mosolf and James Sears; 2024



Colluvium (Quaternary: Holocene)—Unconsolidated slope deposit that contains angular, poorly sorted pebbles, cobbles, and boulders. Includes talus. Thickness is generally less than 10 m (33 ft).

Cal Alluvial-fan deposit (Quaternary: Holocene)—Unconsolidated, poorly sorted cobbles, gravel, sand, and slit forming extensive, fan-shaped deposits shed from the Sweetwater fault escarpment. Thickness as much as 30 m (100 ft).

Cal Landslide deposit (Quaternary: Holocene)—Unconsolidated, poorly to well-sorted, weakly stratified grave sand, silt, and clay. Clasts are subangular to rounded cobbles and smaller. Thickness is generally less than 6 m (20 ft).

Cal Landslide deposit (Quaternary: Holocene)—Unconsolidated slope deposit that contains angular, poorly sorted pebbles, cobbles, and boulders. Includes talus. Thickness is generally less than 10 m (33 ft).

Cal Landslide deposit (Quaternary: Holocene)—Unstratified, poorly sorted rock fragments deposited by slumps, slides, rock falls, and debris flows. Typically characterized by hummocky topography, subdued landslide scarps, and rock talus. Variable thickness, generally less than 30 m (100 ft).

Cat Travertine (Holocene and Tertiary?)—Deposits of white-to-gray, massive travertine that generally lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with lacks.

subdued landslide scarps, and rock talus. Variable thickness, generally less than 30 m (100 ft).

Travertine (Holocene and Tertiary?)—Deposits of white-to-gray, massive travertine that generally lacks internal structure but is porous locally. Mainly occurs as isolated patches but is intercalated with Tertiary sediments locally. Thickness unknown.

Bozeman Group

The Bozeman Group is mapped as two formations in the quadrangle: the Eocene-Oligocene Renova Formation (Tre) and the Miocene Sixmile Creek Formation (Tsc and Tsct). The Renova Formation comprises shale and siltstone of lacustrine origin. The Sixmile Creek Formation is a complex sequence of coarse volcano-fluvial sedimentary deposits, including the informal Timber Hill Basalt, Big Hole River, Anderson Ranch, and Sweetwater members (Thomas and Sears, 2020 and references therein). The Sweetwater member marks the chronostratigraphic base of the Sixmile Creek Formation and consists mainly of conglomeratic deposits derived from the erosion of local basement uplifts and Eocene volcanogenic deposits. A thick sequence of roundstone conglomerate and interbedded tephra composing the Big Hole River and Anderson Ranch members rests on the Sweetwater member and older map units. The Big Hole River, Anderson Ranch, and Sweetwater members were previously defined by lithostratigraphy that proved challenging to map and were lumped as an undivided unit (Tsc). The Timber Hill Basalt member (Tsct) locally caps the Tertiary sequence in the quadrangle and is the northeasterm- most remnant of a lava flow that can be traced for approximately 50 km (31 mi) along an ancestral paleovalley extending from Lima to the upper Ruby Valley (Sears, 1995). The basalt forms a prominent mesa in the quadrangle, inverting the topography of the paleovalley it armored. Seattered outcroppings of basalt in the north part of the quadrangle (Tb) are possibly equivalent to the Timber Hill Basalt member, or a Pliocene basalt northeast of the map area (approximately 4 Ma; Marvin and others, 1995; Perkin

Timber Hill and Sweetwater Creek. The interior of the flow is flaggy-to-massive and mostly aphanitic with <1 percent fresh olivine phenocrysts. Columnar joints are common. Basalt is black to dark gray on a fresh surface and weathers to brown. Reported K-Ar whole rock ages span 6.3 ± 0.2 Ma to 5.9 ± 0.2 Ma (Fritz and others, 2007). Geochemical data are enriched in light rare earth elements, indicative of fractionation, mixing or assimilation by parental melts (fig. 2). Thickness is approximately 12 m (40 ft).

Tso

Sixmile Creek Formation, undivided (late to middle Miocene)—Weakly consolidated sequence of conglomerate, sandstone, mudstone, and tephra up to 500 m (1,500 ft) thick. Published radiometric age dates for the Sixmile Creek Formation span 16–3.7 Ma, consistent with vertebrate fossil ages (Monroe, 1976; Fritz and Sears, 1993). U-Pb zircon ages obtained in this study span 16.1–7.5 Ma (Table 1).

Big Hole River member, informal (Miocene)—Well-sorted, well-rounded fluvial conglomerate that forms crude and possibly channelized bedforms. Conglomerate clasts are typically spherical, pebble to cobble sized, and predominantly composed of quartzite but also include gneiss, basalt, rhyolite, and limestone. Clast lithologies include vitroous pink quartz-arenite, fine-grained white quartz-arenite, black quartz-arenite, black chert laced with quartz veins, and brown cherty litharenite. Subordinate sandstone beds are cross-bedded and form tabular, stepped cliffs. The Big Hole River member rarely crops out and typically forms gravel-draped hillslopes.

Anderson Ranch member, informal (Miocene)—Distinct white, friable beds of tephra up to 30 m (100 ft) thick that are interlayered with roundstone conglomerate, sandstone, and mudstone. Best exposed in low cliffs located in the drainage bottom east of Timber Hill (section 24, T.9 S., R. 6 W.). The tephra beds are generally lenticular, trough cross-bedded and composed of a mix of ash and pumice, silicic sand and gravel, and tabular to irregular fragments of tuffaceous rip-u

(Monroe, 1976).

Sweetwater Creek member, informal (earliest middle Miocene)—Interbedded conglomerate and feldspathic sandstone intervals lithologically distinct from the Big Hole River member.

Conglomerates are channelized and trough cross-bedded deposits of clast-supported, angular to subangular pebbles and cobbles in a coarse, sandy matrix. Clasts are mainly derived from local Precambrian basement and Eocene volcanic rocks. Brown interbeds of immature, medium-to-coarse sandstone are up to 1 m (3 ft) thick, massive to cross-bedded, and contain ash, pumice, and small lithic fragments (<4 mm) locally.

Tre

Renova Formation, undivided (Eocene to Oligocene)—Slope forming sequence of light-colored smectitic fissile shale, siltstone, and limestone with subordinate amounts of sandstone, conglomerate, and tuff that are generally well stratified. Contains fossil fish, insect, leaf, and vertebrate fossils of Arikareean age (Becker, 1961; Dorr and Wheeler, 1964; Monroe, 1976, Ripley, 1987). Typically forms low rounded hills with outcrops limited to gullies and steep bluffs; best exposed in section 19, T. 9 S., R. 5 E., east of Timber Hill. A siltstone sample at this location (JM22RC07) yielded a max depositional U-Pb zircon age of 33.4 ± 0.4 Ma and is likely equivalent to the late Oligocene—early Miocene Passamari member of the Renova Formation in the upper Ruby Valley (Monroe, 1976). A poorly exposed sandstone in the north part of map area (sample JM22RC12; section 26, T. 8 S., R. 6 W) tentatively correlated to the Renova Formation yielded a max depositional age of 42.2 ± 0.4 Ma. As thick as 60 m (200 ft).

The Precambrian metamorphic basement rocks in the Ruby Range can be divided into three northeast-trending belts comprising the Christensen Ranch Metasedimentary Suite, the Dillon Gneiss, and the Elk Gulch Suite; only the latter two units are exposed in the quadrangle where gneiss and amphibolite enriched in incompatible elements are the dominate lithologies observed (fig. 2). The Elk Gulch Suite and Dillon Gneiss are intensely deformed and commonly contain northeast-striking isoclinal folds. Geochronology data suggest that basement protoliths had formed by 3.30–2.77 Ga with tectonothermal overprints of the Beaverhead/Tendoy and Big Sky orogenies occurring at approximately 2.45 Ga and 1.78 Ga, respectively (fig. 3; this study; Harms and Baldwin, 2020; Jones, 2008; Cramer, 2015).

The Elk Gulch Suite is the structurally deepest metamorphic assemblage in the Ruby Range and is inferred to be the oldest. The petrologically diverse assemblage is composed of gneiss, migmatite, and amphibolite. The Dillon Gneiss is a massive-to-foliated grantic gneiss that is enriched in incompatible elements (fig. 2) and contains abundant intercalations of amphibolite. The Elk Gulch Suite and Dillon Gneiss are difficult to differentiate in the field; the former tends to be more mafe and richer in plagioclase (Garnhan, 1979b). Amphibolite occurs throughout both metamorphic assemblages but is only mapped in areas with intercalations thick and abundant enough to be shown at 1:24,000 scale.

Northwest-striking diabase dikes generally crosscut the metamorphic fabric in the crystalline basement rocks and commonly parallel northwest-striking fractures and faults. Wooden and others (1978) classified the diabase in the Ruby Range as low potassium tholeitie with a whole-rock Rb-57 age of 1.46 Ga A single northeast-striking pegmatite dike of unknown age was identified in the quadrangle; Giletti (1966) reported radiometric ages of approximately 1.6 Ga for pegmatites in the adjacent Christensen Ranch quadrangle, and Mosolf (2021b) peported U-Pb zi

Amphibolite (Archean or Early Proterozoic)—Black and white, massive- to well-foliated, sheet-like bodies primarily composed of fine- to coarse-grained homblende, plagioclase, and quartz. Amphibolite typically occurs as two compositional varieties: gneiss containing 40-50 percent homblende in alternating homblende-rich and quartz-plagioclase rich layers; or homblendite with accessory plagioclase and quartz. The presence of garnet varies locally from approximately 0–25 percent. Amphibolite is intercalated with the other basement assemblages, ranging in size from centimeter-scale lenses to extensive sheets that are tens of meters thick.

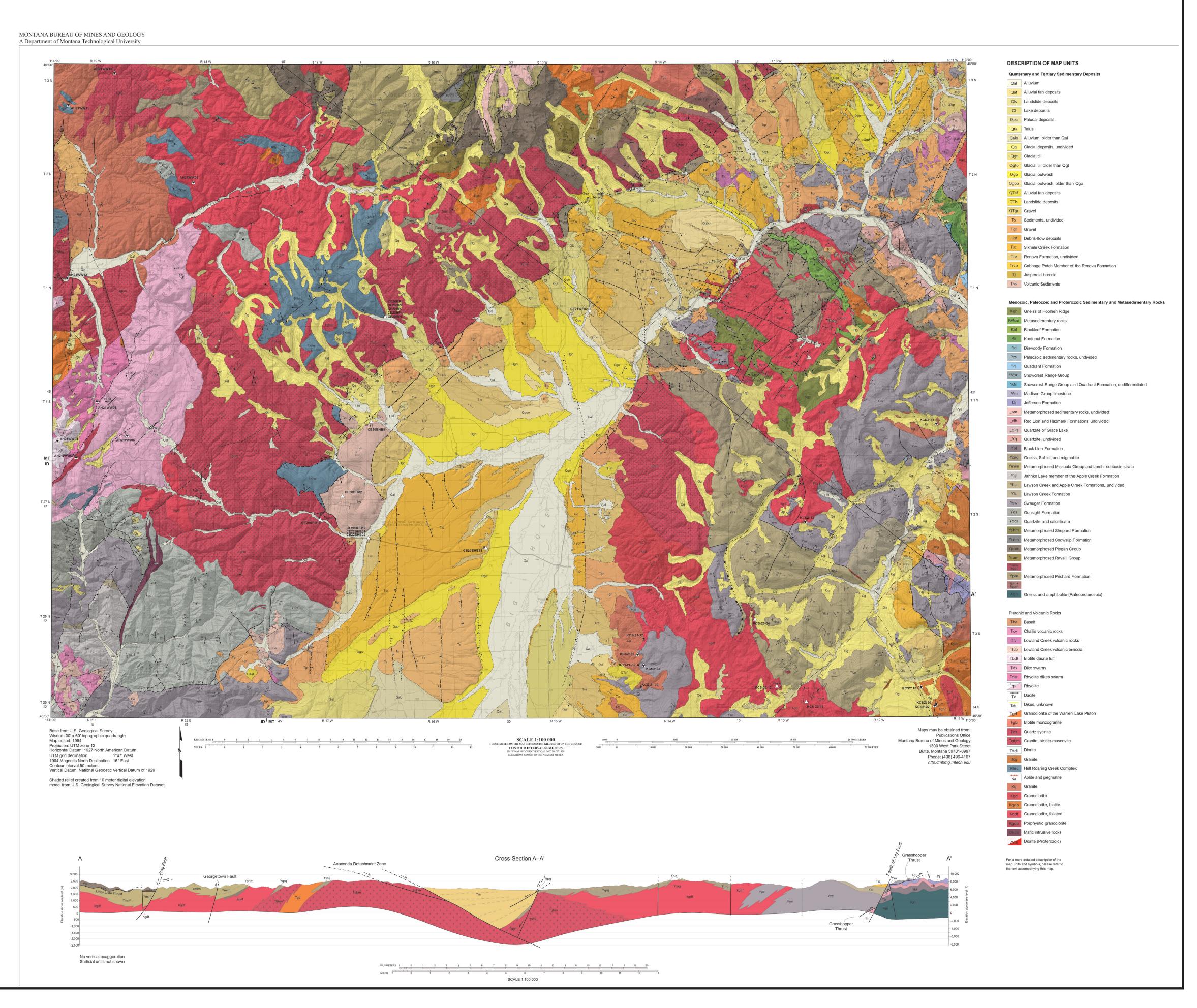
Adg

Dillon Gneiss (Archean)—Gray to reddish-brown, massive- to well-foliated, medium- to coarse-grained, locally garnetiferous gneiss of granitic composition that typically forms large, rounded outcrops. Potassium feldspar is the most abundant mineral, intergrown with oligoclase and quartz in nearly equal proportions. Subordinate mineral constituents include biotite, muscovite, garnet, and fibrous sillimanite. Massive-to-weakly foliated gneiss often grades into a strongly banded gneiss with a greater abundance of darker minerals, including biotite, garnet, and occasional homblende. The Dillon Gneiss includes subordinate layers and pods of amphibolite, narrow ribbons of infolded marble, thin layers of pelitic gneisses and schists, and meta-ultramafic rock. Originally named the "Dillon Granite Gneiss" (Heinrich, 1960) and subsequently referred to as "Quartzofeldspathic Gneiss" by James (1990). Stotter (2019) suggested the assemblage be renamed the "Dillon Gneiss", adopted in this map. U-Pb zircon data constrain a minimum emplacement age between approximately 3.3–2.7 Ga (fig. 3).

Aeg

Elk Gulch Suite (Archean)—Diverse assemblage of biotite gneiss, homblende gneiss, augen gneiss, migmatite, and amphibolite. The most abundant rock type is a banded migmatic gneiss composed of conspicuous dark layers of biotite and homblende that alternate with layers consisting primarily of quartz and

Geologic Map of the Wisdom 30' x 60' Quadrangle, Southwest Montana Colleen G. Elliott and Jeffrey D. Lonn; 2024



Quaternary slip rates and most recent surface rupture on the Bitterroot fault, western Montana Yann Gavillot, Jeffrey Lonn, Mike Stickney and Alan Hidy 2023

