Montana Bureau of Mines and Geology

PRELIMINARY GEOLOGIC MAP OF PARADISE VALLEY

SOUTH-CENTRAL MONTANA

by

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Montana Bureau of Mines and Geology
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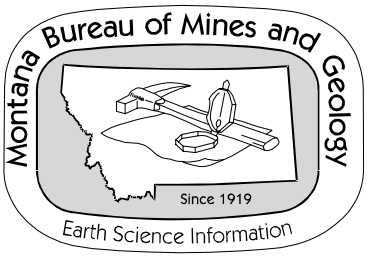

This report has been reviewed for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

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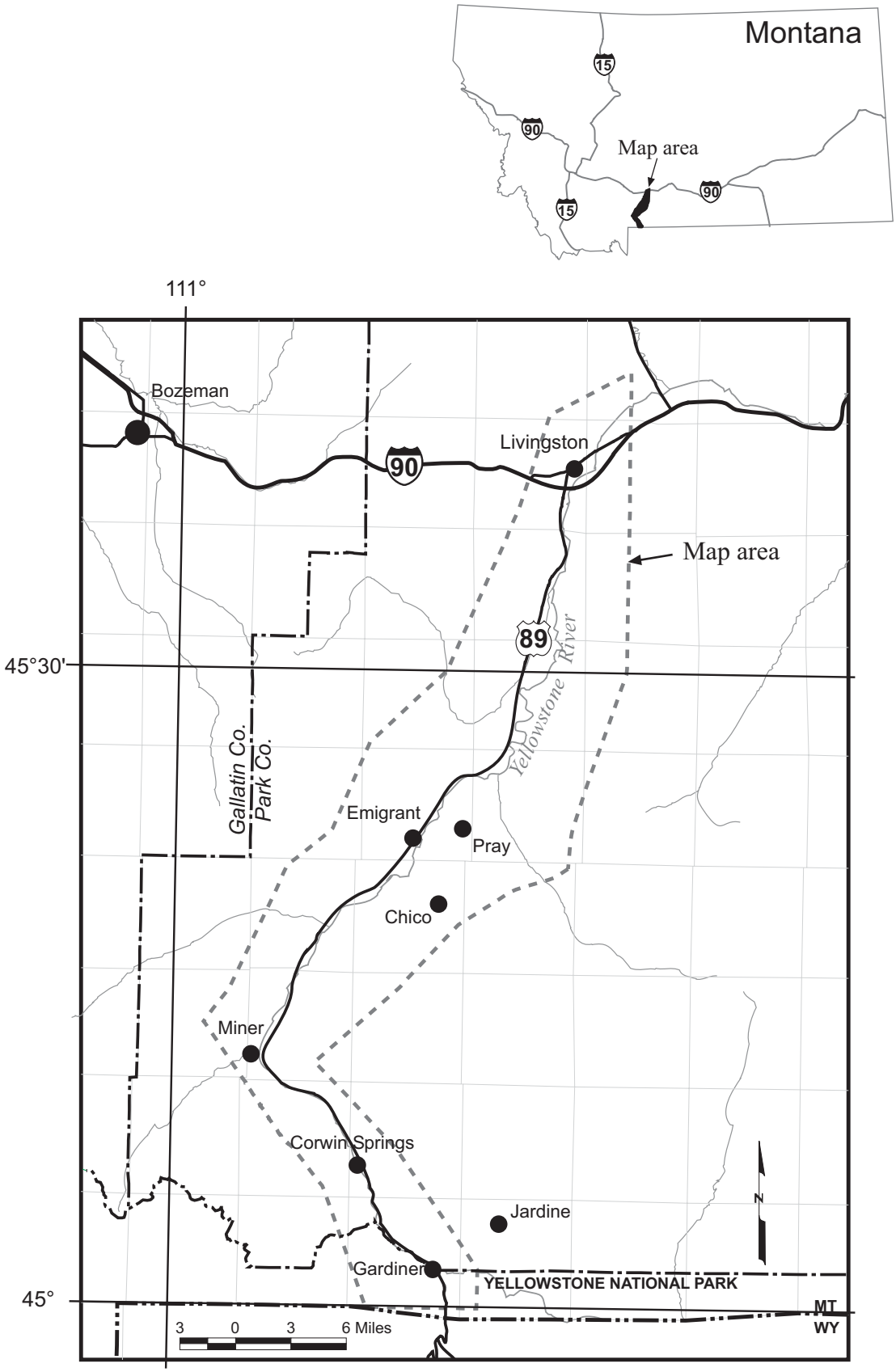
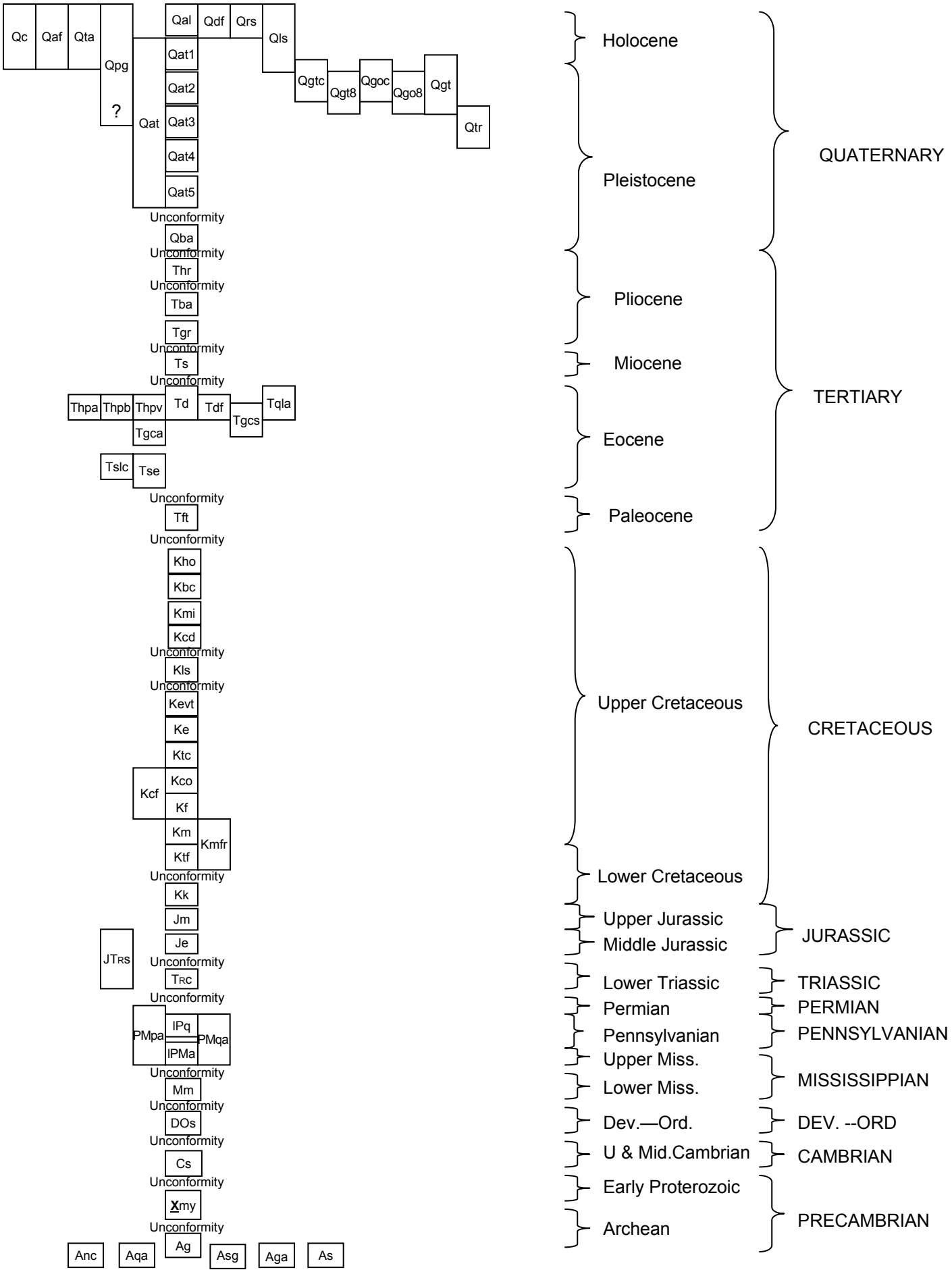


Location of the Paradise Valley map area.

CORRELATION OF MAP UNITS



DESCRIPTIONS OF MAP UNITS

Qal **Alluvium of modern channels and flood plains (Holocene)** – Younger alluvium generally confined to the present flood plain developed along active rivers and streams.

Qc **Colluvium (Holocene and Pleistocene)** -- Locally derived slope-wash deposits mainly of sand, silt, and clay. Typically a thin veneer concealing bedrock, but locally as thick as 30 ft. Commonly grades into Qal. Locally contains cobbles derived from alluvial terrace gravel and glacial deposits.

Qaf **Alluvial fan deposits (Holocene and Pleistocene)** -- Gravel, sand, silt, and clay deposited in fans being formed by modern streams along major valley margins. Display characteristic fan-shaped map pattern and convex upward profile. Typically grade upstream into Qal. Near the north end of the map area, in the Suce Creek and Deep Creek drainages, Qaf includes glacial outwash fans that merge with other alluvial fan deposits and are incised by the modern stream channels. Thickness ranges from very thin at toe to as much as 50 ft.

Qls **Landslide deposits (Holocene and Pleistocene)** -- Unconsolidated mixture of soil and blocks of bedrock transported down steep slopes by mass wasting. Characteristic hummocky surface with concentric swales and ridges near down-slope limits. Common along steep slopes beneath resistant rocks but can occur wherever slope and moisture content produce unstable conditions.

Qdf **Debris flow deposits (Holocene)** -- Unconsolidated mixture of soil and blocks of bedrock, and vegetation transported in highly fluid, water-saturated debris flows. Have a tongue-like outcrop pattern with a very rough upper surface.

Qrs **Rockslide deposits (Holocene)** -- Mass of bedrock that has been transported down slope along a surface of weakness. Typically broken up by numerous fractures and small faults within the mass. Mapped in the Gardiner area where the rockslide is composed of basalt (Qba).

Qta **Talus deposit (Holocene and Pleistocene?) --** Angular and subangular cobbles and boulders at base of steep valley walls or cliffs.

Qpg **Pediment gravel deposits (Holocene and Pleistocene?)** -- Angular and subangular coarse gravel derived from local bedrock; gravel deposits beneath smooth pediment surfaces sloping away from mountainous areas. About 10 to 30 ft thick.

Qgtc **Glacial till, Chico advance (Pleistocene)** -- Dominantly unsorted and unstratified sediment ranging from clay fragments to boulders of glacial moraines associated with the Pinedale Chico advance (Horberg, 1940) of the piedmont glacier out of the Yellowstone Park region and other associated glacial and glaciofluvial deposits. Land surface overlying these deposits is typically hummocky and covered with glacial erratic boulders. May locally include subordinate alluvium, colluvium, talus, and landslide deposits.

Qgt8 **Glacial till, Eightmile advance (Pleistocene)** -- Dominantly unsorted and unstratified sediment ranging from clay fragments to boulders of glacial moraines associated with the Eightmile advance (Pierce, 1979) of the piedmont glacier out

of the Yellowstone Park region. Land surface overlying these deposits is typically hummocky and covered with glacial erratic boulders. May locally include subordinate alluvium, colluvium, talus, and landslide deposits.

Qgoc **Glacial outwash, Chico advance (Pleistocene)** -- Dominantly poorly sorted and stratified gravels of glaciofluvial deposits associated with the Pinedale Chico advance of the piedmont glacier out of the Yellowstone Park region. May locally include subordinate alluvium, glacial till, colluvium, talus, and landslide deposits.

Qgo8 **Glacial outwash, Eightmile advance (Pleistocene)** -- Dominantly poorly sorted and stratified gravels of glaciofluvial deposits associated with the Eight Mile advance of the piedmont glacier out of the Yellowstone. May locally include subordinate alluvium, glacial till, colluvium, talus, and landslide deposits.

Qgt **Glacial deposits, undivided (Holocene and Pleistocene)** -- Dominantly unsorted and unstratified till of Holocene and Pleistocene glacial moraines and other associated glacial and glaciofluvial deposits. May locally include subordinate alluvium, colluvium, talus, and landslide deposits.

Qtr **Travertine deposit (Pleistocene)** -- Deposits of travertine on the east side of the Yellowstone Valley above Gardiner; quarried for many years for decorative stone. Two distinct U-Th ages have been reported for this travertine deposit: 19.57 + - 0.12 ka and 22.64 +- 0.17 ka (Pierce and others, 1991).

Qat **Alluvial gravel undivided (Holocene and Pleistocene?)** -- Gravel, sand, silt, and clay underlying terraces about 20 to 600 ft above present altitude of modern streams and rivers. Equivalent to Qat1 through Qat5.

Qat1 **Alluvial gravel, terrace level 1 (Holocene and Pleistocene) --** Gravel

underlying terraces about 10 to 20 ft above altitude of Qal (present altitude of rivers). Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, volcanic rocks, and quartzite, with lesser amounts of limestone and sandstone. About 10 to 40 ft thick.

Qat2 **Alluvial gravel, terrace level 2 (Pleistocene)**—Gravel underlying terraces about 20 to 40 ft above Qal. Mostly cobbles and pebbles with minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, volcanic rocks, and quartzite, with lesser amounts of limestone and sandstone. About 10 to 40 ft thick.

Qat3 **Alluvial gravel, terrace level 3 (Pleistocene)** -- Gravel underlying terraces about 50 to 90 ft above present altitude of rivers. Mostly cobbles and pebbles and minor amounts of sand and silt. Clasts are mainly granitic igneous rocks, granitic gneiss, schist, volcanic rocks, and quartzite, with lesser amounts of limestone and sandstone. About 10 to 30 ft thick.

Qat4 **Alluvial gravel, terrace level 4 (Pleistocene)** -- Gravel underlying terraces about 200 to 300 ft above present altitude of rivers. These terraces locally exhibit a relatively steep gradient toward the Yellowstone River Valley and may actually include several levels of terraces that are difficult to distinguish. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, volcanic rocks, and quartzite. Thickness as much as 20 ft.

Qat5 **Alluvial gravel, terrace level 5 (Pleistocene)** -- Gravel underlying terraces about 400 to 600 ft above present altitude of rivers. Occurs mainly as small

discontinuous erosional remnants. Cobble- and pebble-size clasts are mainly granite, granitic gneiss, schist, volcanic rocks, and quartzite. Calcite cement locally present, especially at base. Thickness ranges from a very thin remnant to about 20 ft.

Qba **Basalt (Pleistocene)** -- Basalt flows in the Gardiner area. Mainly non-porphyritic, except for rare olivine phenocrysts, only slightly vesicular. Flowed in a paleovalley of the Yellowstone River (Fraser and others, 1969). Much of the exposure of basalt occurs in a highly faulted slump block north of Gardiner.

Thr **Huckleberry Ridge Tuff of Yellowstone Group (Pliocene)** -- Welded rhyolite ash-flow tuff, light-brown to pale-purple-gray. Age from $^{40}Ar/^{39}Ar$ date of 2 Ma (Christiansen, 2001, p. G22).

Tba **Basalt (Pliocene)** -- Basalt exposed on Hepburn's Mesa and west of Emigrant. Basalt is dark gray and generally contains scattered plagioclase and olivine phenocrysts and is apparently zoned because it locally also contains augite phenocrysts (Bush, 1967). Bush (1967) described two basalt units separated by gravel. There is actually only one basalt unit but it is faulted on the southeast side of Hepburn's Mesa. The basalt and underlying gravel, repeated by faulting, was mistaken for an upper flow and intervening gravel bed. A K-Ar date on the upper flow yields a date of 8.4 Ma (Bush, 1967). However, Locke and others (1995) suggest that the basalt on Hepburn's Mesa is correlative with basalt west of Emigrant that has a 2.2 Ma date. The proximity, continuity, and stratigraphic relationship with the underlying gravel in both the Emigrant area and Hepburn's Mesa indicate these basalts are correlative, in spite of the

indicated radiometric age difference.

Tgr **Gravel (Pliocene ?) --** Unconsolidated gravel underlying basalt at Hepburn's Mesa and west of Emigrant. Mostly well-rounded, cobble-size clasts composed mainly of andesitic volcanic rocks, and lesser amounts of metamorphic and igneous rocks.

Ts **Sediment or sedimentary rocks, undivided (Miocene)** -- Middle Miocene age (Barstovian) Hepburn's Mesa Formation of Barnosky and Labar (1989), exposed at Hepburn's Mesa and a few miles north along east side of the Yellowstone River. Rocks are very light gray, pale pinkish-gray, and pale green tuffaceous claystone, siltstone, and sandstone.

Td **Dacite and dacite porphyry (Eocene)** -- Pink to light-gray, fine-grained dacite, and feldspar-hornblende dacite porphyry. Small hornblende phenocrysts much more abundant than feldspar phenocrysts. Stock, laccoliths, sills, and dikes; may include some andesitic and rhyolitic rocks.

Tdf **Dacite flows (Eocene)** -- Reddish to gray, altered, hornblende porphyry with sparse feldspar laths. Some flow breccia. Shown in area west of the Yellowstone River.

Tqla **Quartz latite and andesite (Eocene) --** Medium-gray to pinkish-gray porphyritic intrusive rocks, varying in composition from quartz latite to andesite.

Thpb **Andesite breccia of Hyalite Peak Volcanics (Eocene)** – Poorly to well-stratified. This unit is thought to be correlative with the Sepulcher Formation of the Washburn Group as mapped by the U.S. Geological Survey near the northern boundary of Yellowstone National Park (1972), after Chadwick, 1982.

Thpa **Andesite flows of Hyalite Peak Volcanics (Eocene)** -- Commonly autobrecciated; includes some epiclastic lenses (Chadwick, 1982).

Thpv **Vent facies of Hyalite Peak Volcanics (Eocene) –** Dark-gray and reddish-gray breccias and vesicular vent breccias interbedded with autobrecciated lava lenses and sheets, intruded by numerous andesite dikes and sills (Chadwick, 1982).

Tgcs **Andesite sills of Golmeyer Creek Volcanics (Eocene) --** Gray hornblende-augite andesite porphyry (Chadwick, 1982).

Tgca **Andesite flows and breccia of Golmeyer Creek Volcanics (Eocene) --** Pyroxene and horneblende-pyroxene andesite flows, dark gray to pinkish- or reddish-gray (Chadwick, 1982).

Tse **Sepulcher Formation (Eocene)** -- Dominantly light-colored andesitic volcanic rocks.

Tslc **Lost Creek Tuff Member of Sepulcher Formation (Eocene)** -- Light-colored rhyodacite ash-flow tuff.

Tft **Tullock Member, Fort Union Formation (Paleocene)** --Yellowish-gray, fine- to medium-grained, ledge-forming sandstone, cross-bedded in part. Interbedded with gray to greenish-gray claystone, siltstone, and minor carbonaceous shale. Supports growths of pine trees. About 400 to 600 ft thick.

Livingston Group (Upper Cretaceous

Kho **Hoppers Formation (Upper Cretaceous)** -- Andesitic sandstone with

interbedded claystone and siltstone; massive cross-bedded yellowish-gray sandstone member at the base.

Kbc **Billman Creek Formation (Upper Cretaceous)** -- Olive-gray, brownish-gray, and grayish-red claystone with interbedded sandstone, siltstone, and conglomerate; contains fresh-water mollusks and dinosaur bones.

Kmi **Miner Creek Formation (Upper Cretaceous) --** Andesitic siltstone and sandstone with beds of tuff and bentonite in lower part; contains fossil spores, plants, wood, and dinosaur bones.

Kcd **Cokedale Formation (Upper Cretaceous)** -- Andesitic siltstone and sandstone with claystone, tuff, bentonite, and coal; lower part carbonaceous with some thin coal beds; sandstone locally conglomeratic; contains fossil spores, plants, wood, dinosaur bones, and fresh-water mollusks.

Kls **Landslide Creek Formation (Upper Cretaceous)** -- Gray, greenish-gray, brown-weathering, fine-grained to conglomeratic sandstone and interbedded claystone and mudstone. Conglomeratic beds in the lower 450 ft are mainly chert and quartzite; above that they are andesitic. Interbedded mudstones and claystones are variegated and highly bentonitic. Dinosaur bones and fossil plants are common. Total thickness about 2000 ft (after Fraser and others, 1969).

Kevt **Everts Formation (Upper Cretaceous) --** Interbedded light-colored, fine- to medium-grained, lenticular sandstone and medium- to light-gray mudstone, locally greenish-, yellowish-, or brownish-gray. About 1250 ft thick.

Ke **Eagle Sandstone (Upper Cretaceous)** -- Lower quarter of the formation is light brownish gray to very pale gray, very fine to fine grained, cross-bedded sandstone, burrowed to bioturbated in part. The upper part is interbedded lenticular sandstone and shale and contains coal beds that have been mined in the area southwest of Corwin Springs. Total thickness is about 750 ft.

Ktc **Telegraph Creek Formation (Upper Cretaceous)** -- Shale and sandy shale, brownish-gray to medium-dark-gray, with thin interbedded sandstone. Dusky-red concretions common near base. Sandstone beds thicker and more abundant upward, grading into Eagle Sandstone. Contact with Eagle is placed at the base of the first cliff-forming sandstone. Maximum thickness about 150 ft.

Kcf **Cody Shale and Frontier Formation, undivided (Upper Cretaceous)** -- Cody Shale: Gray shale and mudstone interbedded with grayish-green and olive-gray sandstone and siltstone and minor brown-weathering nodular limestone and yellowish-gray bentonite. Entire formation is locally fossiliferous and contains fish scales, starfish, ammonites and other mollusks. Frontier Formation: Light-brownish-gray, fine-grained, thick-bedded to massive sandstone. Interbedded with dark-gray, fissile shale.

Kmfr **Mowry Shale through Fall River Sandstone, undivided (Upper and Lower Cretaceous) --** Mowry Shale: Interbedded, siliceous, very fine- to fine-grained

sandstone, siltstone, and shale. Contains several prominent bentonite beds. Sandstones and siltstones mostly light-gray to medium-gray, with a silvery sheen. Fish scales on bedding planes of sandstones and siltstones are characteristic of this formation. Thermopolis Shale: Dominantly dark-gray fissile shale, bentonitic shale, and several beds of bentonite. Has hematitic concretionary zone near base. Fall River Sandstone: Brownish-gray, thin-bedded, argillaceous, fine-grained, quartz sandstone. Generally poorly exposed in map area, mostly covered by glacial deposits. Total thickness is approximately 1300 ft.

Kk **Kootenai Formation (Lower Cretaceous)** -- Mostly reddish-brown, olive-gray, and dusky-purple mudstones with interbedded, lenticular, fine- to coarse-grained sandstones. Locally thick, lenticular, fluvial, fine-grained sandstone (Greybull Sandstone) is present at the top in the Livingston area (Roberts, 1972). The basal member, the Pryor Conglomerate, is brown conglomerate and pebbly coarse-grained sandstone, 20 to 60 ft thick. The total thickness is 300 to 500 ft.

Jm **Morrison Formation (Upper Jurassic)** -- Variegated, mainly greenish-gray and pale-reddish-brown mudstone. Very fine to fine-grained, quartzose, calcareous, cross-bedded sandstones are commonly present at about mid-section. Five to 10 ft thick, but locally as much as 30 ft thick. Fossil dinosaur remains locally present. Upper contact placed at the base of the Pryor Conglomerate. The basal contact is placed at the top of fossiliferous, calcareous sandstone and coquina of the underlying Swift Formation. Thickness is about 200 ft.

Je **Ellis Group, undivided (Middle and Upper Jurassic)** -- Individual formations are not mapped separately; includes the Swift, Rierdon, and Piper Formations. Swift: interbedded medium-gray shale, limestone, and calcareous sandstone, fossiliferous. Brownish-gray, fossiliferous, very sandy limestone occurs at the top of the formation, and commonly has brownish-gray coquina at the top. Rierdon: mostly pale-greenish-gray, very fossiliferous shale with minor interbedded, brownish-gray limestone. Typically poorly exposed, forming smooth slopes littered with fossils, including oysters (*Gryphaea and Ostrea),* belemnites (*Pachyteuthis),* and crinoids fragments (*Pentacrinus).* Piper: interbedded medium-gray and pale-reddish-gray, thin-bedded limestone and medium-gray shale. Includes thin interbeds of gypsum. Forms ledge below smooth slopes of the Rierdon shales. Thickness of the Ellis Group is about 500 ft.

TRc **Chugwater Formation (Lower Triassic)** -- Interbedded moderate reddish-brown fine-grained sandstone, siltstone, and mudstone. Maximum thickness is about 100 ft.

JTRs **Sedimentary rocks, undivided (Jurassic and Triassic)** -- Includes the Chugwater Formation and the Ellis Group.

PMpa **Phosphoria through Amsden Formations, Undivided (Permian through Upper Mississippian** -- Formations not mapped separately because of narrow outcrop width. Phosphoria Formation: poorly exposed and includes yellowish-gray shale, light-gray sandstone and quartzite, and light-gray to grayish pink, cherty limestone; thickness is 50 to 75 ft. Quadrant Sandstone: light-brown to

very pale orange sandstone, fine-grained, well-sorted, well-rounded, cross-bedded. Locally contains thin limestone beds, locally cherty near the top, and is locally silicified to form quartzite; about 250 ft thick. Amsden Formation: interbedded grayish-pink to light-red mudstone, limestone, and siltstone. Limestones are commonly cherty. Unconformably overlies karst surface developed on limestone of the Madison Group. Characteristically produces pink stain on underlying cliffs of Madison Group; thickness about 200 ft but locally tectonically thinned to only a few feet along the mountain front. Total thickness about 500 to 600 ft.

IPq **Quadrant Sandstone (Pennsylvanian)** -- Quartzite, well-sorted quartzose sandstone, and dolomite.

IPMa **Amsden Formation (Lower Pennsylvanian and Upper Mississippian)** -- Dolomite, calcareous sandstone, and siltstone in upper part; argillaceous limestone in middle part; massive sandstone and red calcareous siltstone and limestone in lower part; mostly concealed.

IPMqa Quadrant Sandstone and Amsden Formation, undivided (Upper Mississippian and Pennsylvanian)

Mm **Madison Group, undivided (Middle Mississippian)** -- Limestone and dolomitic limestone, light-gray to light-brownish-gray. Thick-bedded to massive in the upper part (Mission Canyon Limestone) and thin-bedded to thick-bedded in the lower part (Lodgepole Limestone). Also contains thin, interbedded gray shales. Fossiliferous and cherty beds are present throughout. Collapse features and

caves are common at the upper karst surface. Thickness of the Madison is 800 to 1,000 ft.

DOs **Sedimentary rocks, undivided (Upper Devonian and Ordovician)** -- Three Forks Formation (Devonian): Mainly yellowish-weathering, argillaceous limestone and medium-gray shale, very poorly exposed. Jefferson Formation (Devonian): Dolomitic limestone, light-brownish-gray, fetid, poorly exposed, typically occurs as float. Big Horn Dolomite (Ordovician): Cliff-forming dolomite and dolomitic limestone, very light gray to very pale orange, lower part massive, thin- to thick-bedded in upper part. Has characteristic pock-marked surface due to differential weathering. Total thickness of DOs unit is about 600 ft.

Ꞓs **Cambrian sedimentary rocks, undivided (Middle and Upper Cambrian)** -- Light-reddish sandstone and quartzite, greenish-gray shale and sandy shale, gray, thin-bedded limestone, and greenish-gray, flat-pebble limestone conglomerate. Includes the Flathead, Wolsey, Meagher, Park, and Pilgrim Formations in ascending order. Thickness is 600 to 800 ft.

Xmy **Mylonite (Early Proterozoic)** -- Madison Mylonite Zone along the southeast flank of Paradise Valley (Erslev, 1982). Dark-gray, fine-grained, biotite-rich mylonite. Derived from older metasedimentary rocks. Some rocks are retrograde chloritic schist and mylonite, and serpentinite.

Ag **Granite gneiss (Archean)** -- Includes stocks and irregular-shaped bodies of granite gneiss in the Gardiner area, coarse-grained, gray to pinkish-gray. Probably intruded into metasedimentary rocks in the area.

Asg **Schist and gneiss (Archean)** -- Metasedimentary rocks, including dark-gray biotite schist and fine- to medium-grained quartzo-feldspathic gneiss. Minor quartzite beds. Highly deformed and are progressively more deformed as they grade into mylonitized rocks along Madison Mylonite zone (Xmy).

Aga **Amphibolite and gneiss (Archean)** -- Includes trondhjemitic gneiss-amphibolite paragneiss, and heterogeneous gneiss sequences; trondhjemitic gneiss, tonalitic gneiss, amphibolite; minor schist, quartzite, and iron formation (after Van Gosen and others, 1993).

Anc **Nappe core complex (Archean)** -- Includes Barney Creek amphibolite, George Lake marble, and Jewel quartzite. Lithologies present include amphibolite, marble, dolomitic marble, quartzite, and minor amounts of schist and iron formation (after Van Gosen and others, 1993).

Aqa **Quartzite and amphibolite (Archean)** -- Interlayered quartzite and orthoamphibolite; minor schist (after Van Gosen and others, 1993).

As **Biotite schist (Archean)** -- Includes minor quartzite, iron formation, and amphibolite (after Van Gosen and others, 1993).

MAP SYMBOLS

Strike and dip of bedding or flow layering in volcanic rocks.

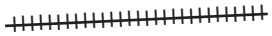
Strike and dip of foliation or schistosity in metamorphic rocks.

Contact - Dashed where approximately located; dotted where concealed.

Fault - Sense of movement unknown. Dashed where approximately located; dotted where concealed.

Normal fault - Dashed where approximately located; dotted where concealed. Ball and bar on downthrown side.

Thrust fault or reverse fault - Dashed where approximately located; dotted where concealed. Sawteeth on upper plate (upthrown side).

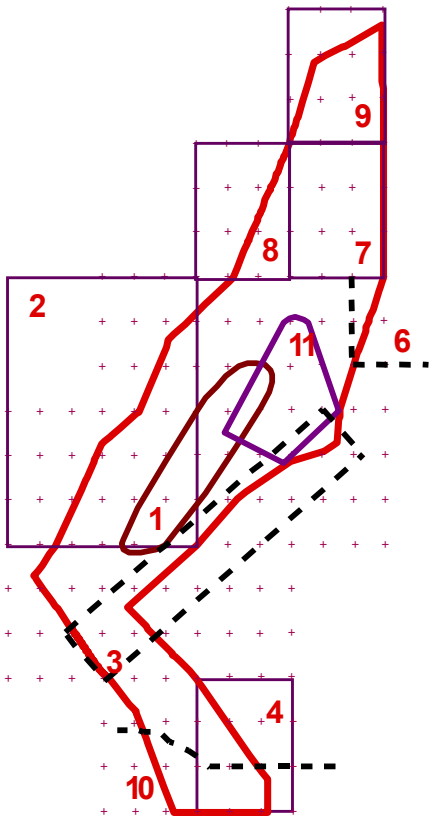


Tertiary intermediate and felsic dikes

Glacial melt-water channels

Sources of Geologic Mapping

See numbered references on next page



Sources of Geologic Mapping in Quadrangle

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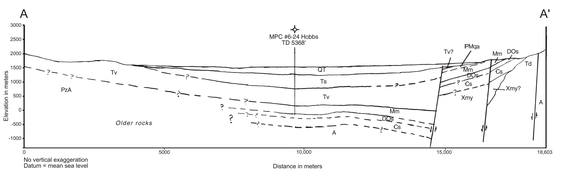
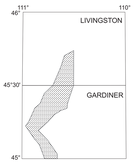
Cross Section A–A'



CROSS-SECTION EXPLANATION

QT	Quaternary and Pliocene rocks undivided. Includes all the Quaternary sedimentary map units and Tba and Tgr of Pliocene age.
Ts	Same unit as map unit Ts (Miocene).
Td	Dacite.
Tv	Eocene volcanic rocks undivided: Includes andesite flows and breccias of the Hyalite Peak Volcanics.
PMqa	Quadrant and Amsden Formations undivided.
Mm	Madison Group.
DOs	Devonian and Ordovician sedimentary rocks undivided.
Cs	Cambrian sedimentary rocks undivided.
Xmy	Madison mylonite.
A	Archean metamorphic rocks undivided.
PzA	Paleozoic and Archean rocks undivided.



Base from U.S. Geological Survey
Livingston 30' x 60' topographic quadrangle
Map date: 1992
Projection: UTM zone 12; 1927 NAD
and
Gardiner 30' x 60' topographic quadrangle
Map date: 1997
Projection: UTM zone 12; 1927 NAD

Partial support has been provided by the STATEMAP component of the National Cooperative Geologic Mapping Program of the U.S.Geological Survey under Contract Number G2HQAG0038.

GIS production: Ken Sandau and Paul Thale, MBMG. Map layout: Susan Smith, MBMG.

MAP UNITS

Qal	Alluvium of modern channels and flood plains
Qc	Colluvium
Qaf	Alluvial fan deposit
Qls	Landslide deposit
Qdf	Debris flow deposit
Qrs	Rock slide
Qts	Tufa deposit
Qpg	Pediment gravel deposits
Qpe8	Eight Mile outwash
Qpe2	Chico outwash
Qg8	Glacial till, Eight Mile Creek age
Qgc	Glacial till, Chico age
Qgl	Glacial till
Qal	Alluvium of alluvial terrace deposit
Qa0	Alluvium of youngest alluvial terrace level
Qa01	Alluvium of second youngest alluvial terrace level
Qa02	Alluvium of third youngest alluvial terrace level
Qa04	Alluvium of fourth youngest alluvial terrace level
Qa05	Alluvium of fifth youngest alluvial terrace level, oldest
Qta	Travertine deposit
Qtw	Basalt
Thr	Huckleberry Ridge Tuff, undivided
Tba	Basalt
Tgr	Gravel
Ts	Sediment or sedimentary rocks, undivided
Tgks	Andesite sills of Gutmeyer Creek volcanics
Td	Dacite
Tdf	Dacite flows
Tgck	Gutmeyer Creek andesite
Thpa	Hyalite Peak andesite
Thph	Hyalite Peak breccia
Thpv	Hyalite Peak vent facies
Tqfa	Quartz latite and andesite
Tse	Sepulcher Formation
Tsst	Lost Creek Tuff Member of Sepulcher Formation
Tb	Tuffaceous Member of Fort Union Formation
Kho	Hoppers Formation
Kbc	Billman Creek Formation
Kmc	Miner Creek Formation
Kcd	Cokedale Formation
Kld	Landslide Creek formation
Kvd	Everts Formation
Ke	Eagle Formation
Kte	Telegraph Creek Formation
Kco	Cody Shale
Kf	Frontier Formation
Kcf	Cody Shale and Frontier Formation
Kmv	Mowry Shale
Kmb	Mowry Formation through Fall River Formation, undivided
Kf	Thermopolis Formation and Fall River Formation, undivided
Kk	Kootenai Formation
Jm	Morrison Formation
Je	Ellis Group, undivided
JRs	Sedimentary rocks, undivided
Jc	Chugwater Formation
PMsu	Phosphoria and Quadrant Formations and Amsden Group
Pq	Quadrant Formation
PMsp	Quadrant Sandstone and Amsden Formation
PMs	Amsden Formation
Mm	Madison Group, undivided
DOs	Sedimentary rocks, undivided
Cs	Sedimentary rocks, undivided
Xmy	Mylonite
Ag	Granite gneiss
Aga	Amphibolite and gneiss
Agp	Neppe core complex
Aga	Quantzite and amphibolite
Ab	Biotite schist
Agg	Schist and gneiss

Montana Bureau of Mines and Geology
Open File Report 480

Preliminary Geologic Map of Paradise Valley South-central Montana

David A. Lopez and Jon C. Reiten

2003

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