GEOLOGIC MAP OF THE RADERSBURG-TOSTON BASIN, MONTANA

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GEOLOGY OF THE RADERSBURG-TOSTON BASIN

The Radersburg-Toston Basin lies between the Townsend Basin to the north and the Three Forks Basin to the south (figure 1). The thickness of Cenozoic deposits in the basin is not known, but was interpreted to be as much as a few thousand feet (Kinoshita and others, 1965). The basin lies within the Intermountain Seismic Belt (Stickney and Bartholomew, 1987).

Tertiary deposits

The oldest exposed Tertiary sediment and rock in the map area is Eocene upper Climbing Arrow Formation (Tca). It is overlain by the lower Dunbar Creek Formation (Tdc) as designated by Robinson (1963) immediately to the south in the Three Forks area. Numerous small vertebrate fossils were found throughout the length of the western part of the map area during field work for this report. A total of forty-three fossils from both formations were identified. The fossils are Chadronian (late Eocene) with three that could also be Orellan (early Oligocene) (A. Tabrum, written communication, 2007). A collection of fossils at one locality in the upper Climbing Arrow Formation is medial Chadronian, and two fossils at one locality in the Dunbar Creek Formation are probably late Chadronian (A. Tabrum, written communication, 2007). The part of the Climbing Arrow Formation exposed in the Radersburg-Toston Valley is the informal Price Farm unit mapped to the south (Vuke, 2006).

The Rattlesnake Creek bed (Tcarc) mapped in the upper Climbing Arrow Formation is composed of white or light gray lapilli tuff, or tuff-, pumice- or clay-clast conglomerate and associated tuffaceous sandstone. Its light gray to white color contrasts with darker colors typical of the Climbing Arrow Formation making it a mappable marker bed.

Although both the upper Climbing Arrow Formation and the lower Dunbar Creek Formation contain Chadronian fossils in the Radersburg-Toston Basin, they are lithologically distinct and have a sharp bounding contacts. Finer sediment in the Climbing Arrow Formation is dark-colored or reddish brown, bentonitic, silty mudstone. It has a “popcorn” texture when dry with desiccation cracks as much as one inch wide, and it is very sticky and slippery when wet. Finer sediment in the Dunbar Creek Formation is argillaceous, tuffaceous, light-colored silt that is powdery when dry and sticky when wet, and argillaceous, locally calcareous siltstone.

Coarse-grained clasts also distinguish the two formations. Clasts in the upper Climbing Arrow Formation gravel or conglomerate lenses are much more mature and more extensive than coarse-grained lenses in the lower Dunbar Creek Formation. Clasts in the lower Climbing Arrow Formation are dominantly dark igneous rocks and Proterozoic Belt Supergroup metaquartzite, with subordinate quartz and chert. They are dominantly subrounded, but range from rounded to subangular. Pebbles or cobbles are the dominant clast size, and limestone clasts were not found. By contrast, clasts in the Dunbar Creek Formation lenses of coarse sediment are immature. They are dominantly angular to subangular and very poorly sorted by size, and boulder-size clasts are common. Clasts in the Dunbar Creek Formation are generally moderately well to well sorted by composition (generally one to three lithologies in a coarse-grained lens) and include locally derived clasts of Proterozoic Spokane Formation, Cambrian Flathead Quartzite, Paleozoic limestone, Mesozoic sandstone, and Elkhorn Mountains Volcanics. The degree of clast rounding

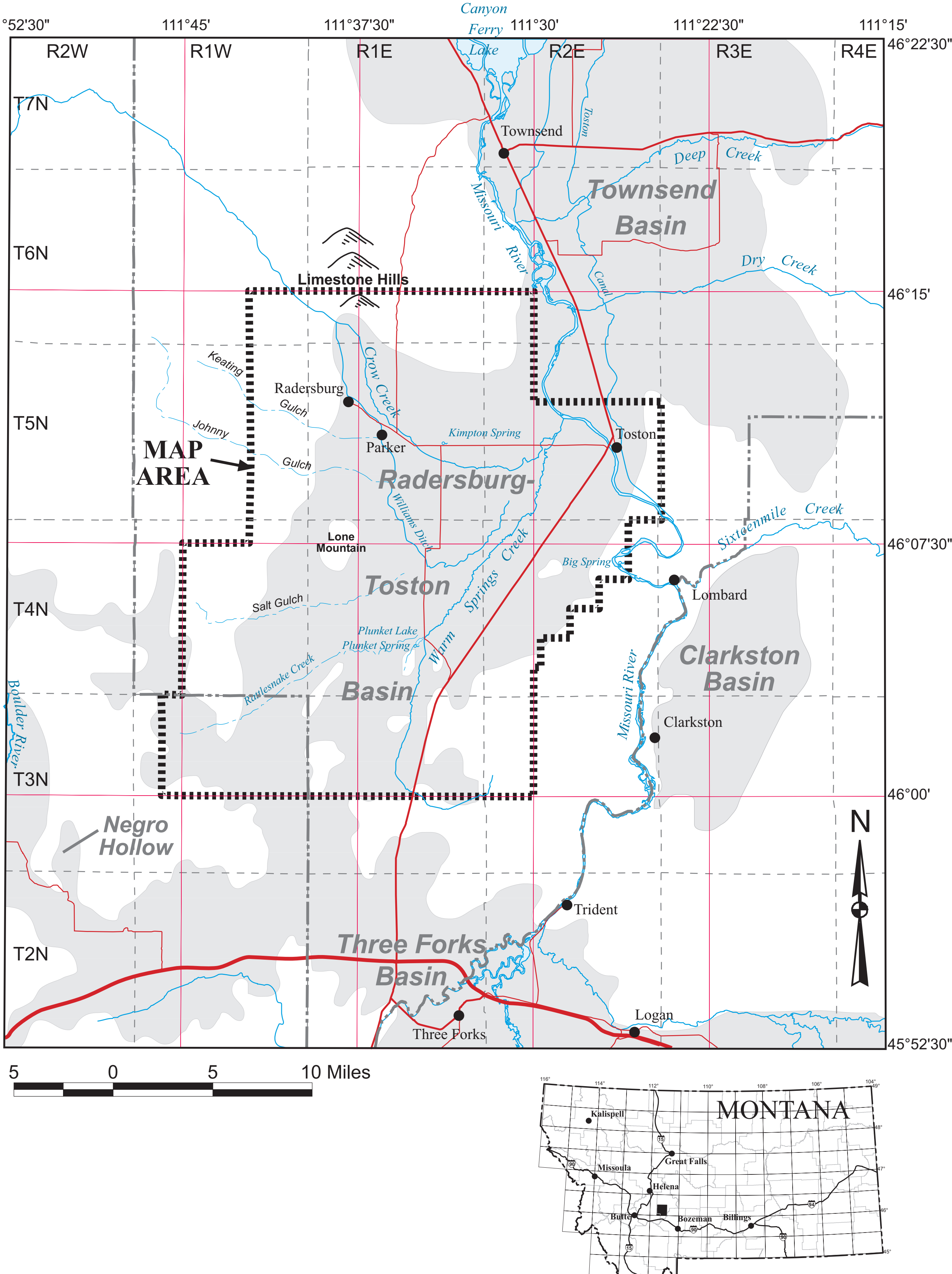


Figure 1. Location of map area showing adjacent basins.

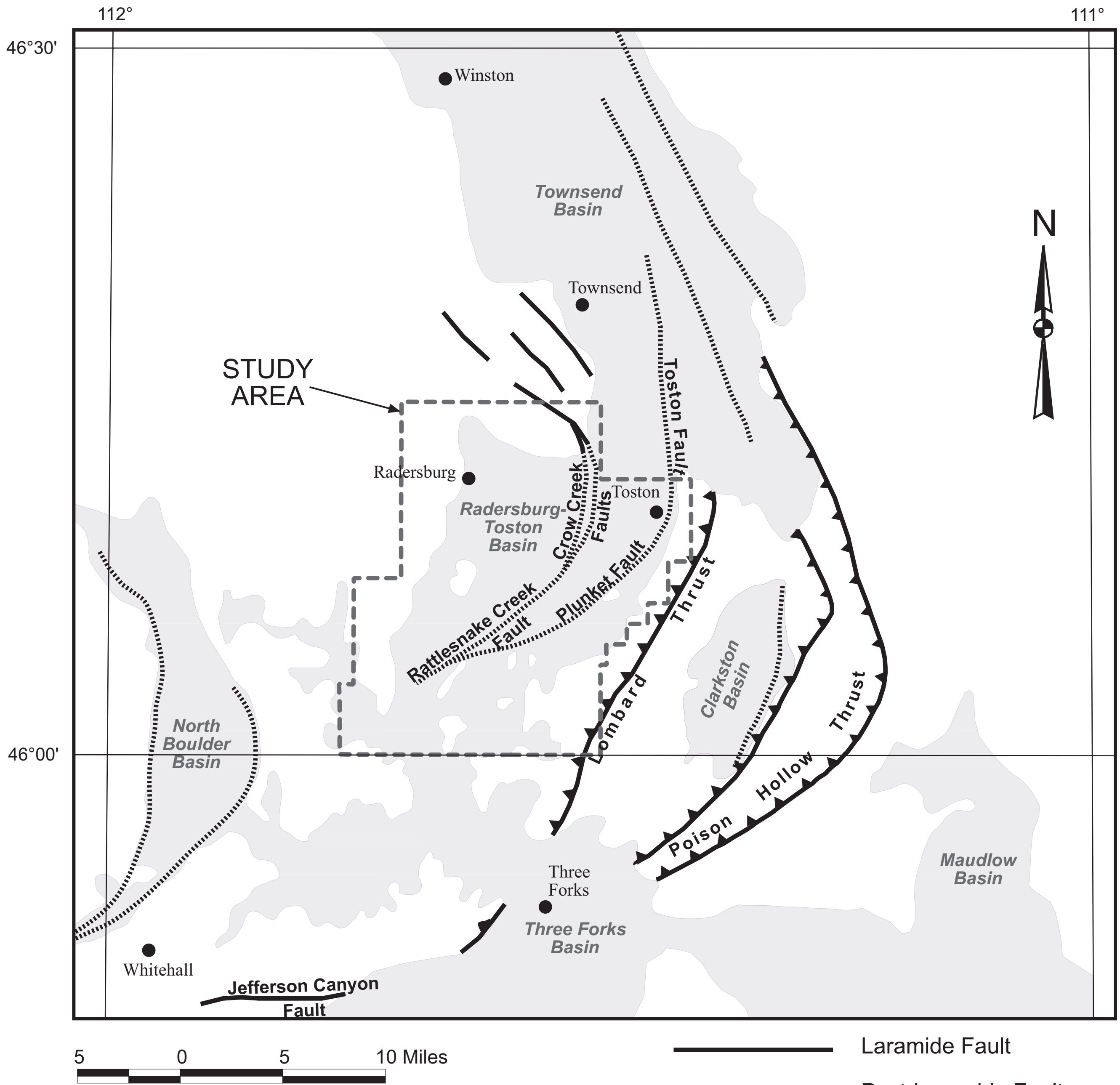


Figure 2. Faults mapped in the Radersburg-Toston Basin relative to other selected post-Laramide faults and Laramide thrust faults in the area. Most of the post-Laramide thrust faults shown have had Quaternary movement (Stickney and others, 2000; Wong and others, 1999).

and lack of limestone and sandstone clasts in the upper Climbing Arrow Formation contrasts with the angularity and very local derivation of the clasts in the Dunbar Creek Formation, suggesting more distal sources for the Climbing Arrow Formation and a change in depositional environment at the onset of Dunbar Creek Formation deposition. Climbing Arrow Formation clasts were not found reworked in the Dunbar Creek Formation.

The Radersburg map unit (Tra) is dominantly a matrix-supported, coarse gravel deposit that has a linear map pattern interpreted as fault-controlled, and extends from near the mouth of Crow Creek to just south of Lone Mountain. Larger clasts are of similar composition to those of the upper Climbing Arrow Formation, but are dominantly subangular and are dominantly cobble and small boulder size, with clast size to the south. The age of the Radersburg map unit is unknown, although it is younger than the lower Dunbar Creek Formation which it overlies, and it was deposited prior to faulting that down-dropped the unit. It has different lithologies and clast composition than the Miocene Sixmile Creek Formation designated by Robinson (1967) on the east side of the southern Townsend Valley to the northeast. The Radersburg map unit was mapped as older glacial outwash deposits by Freeman and others (1958), but the lack of limestone clasts suggests a pre-Pleistocene age because limestone must have been exposed in the Devils Fence area a few miles to the west during the Pleistocene. Other deposits interpreted as older glacial outwash deposits in the area (Freeman and others, 1958; present report) contain abundant limestone. Scattered younger, platy, dark igneous clasts as much as 2 ft wide overlie the Radersburg map unit but could not be mapped separately.

Pliocene and/or Pleistocene deposits

Many pediment surfaces and bedding-plane surfaces on Elkhorn Mountains Volcanics and Eocene deposits are covered with locally cemented gravel deposits (QTgr) that are less than 20 ft thick, with subrounded clasts of variable compositions, all found in the adjacent highlands. Younger deposits of fine-grained sediment (QTs) that contain matrix-supported angular locally-derived clasts are located in the southern part of the map area. Deposits of dominantly coarse clasts on the southern margin of bedrock east of Limestone Hills and on the north side of Lone Mountain are mapped as older alluvium and colluvium (QTac).

Quaternary deposits

Quaternary deposits range from those dominated by boulders (Qbgr) and cobbles (Qcgr) to those dominated by argillaceous silt (Qs, Qac). Deposits dominated by boulders include those near the mouth of the Crow Creek, and deposits along Johnny Gulch and Keating Gulch. Farther east in the Crow Creek Valley, clast size is dominantly cobbles.

Fine sediment (Qs) with surfaces that dip toward the east, northeast, or northwest is probably dominantly eolian, derived from tuffaceous silt of Dunbar Creek Formation. Much of the outwash gravel in the Crow Creek Valley (Qbgr, Qcgr) is covered by fine sediment (Qac) that displays abundant small channel scars and may reflect sheetwash and colluvial reworking of Qs that once blanketed the older gravel deposits. Other Quaternary deposits include terrace deposits of the Missouri River (Qat), limited younger gravel deposits in the southwestern part of the map (Qgr), colluvium (Qc), paludal deposits (Qpa), alluvial fan deposits (Qaf), and alluvium along streams and the Missouri River (Qal).

Faults

Several faults were mapped that offset Tertiary and Quaternary deposits. The faults were inferred primarily from map pattern.

The Rattlesnake Creek Fault was recognized by the offset of the Rattlesnake Creek marker bed, the abrupt limit of down-dropped Dunbar Creek Formation (Tdc), and the apparent offset of gravel deposits (QTgr). Its northeast strike is supported by the linearity and orientation of part of Rattlesnake Creek where it follows the interpreted fault.

The Parker Fault was recognized by the linear to sinuous contact of the dominantly northeast-dipping Dunbar Creek Formation, with the younger Radersburg map unit (Tra). Tufa veins fill fractures very close to the fault plane of the Parker Fault west of Radersburg.

The Salt Gulch Fault was mapped based on the abrupt termination of the Dunbar Creek Formation at the northeast end, and the abrupt termination of the Rattlesnake Creek bed at the southwest end. It may offset QTgr, although that is unclear. Northeast-striking, sparry calcite veins are present in the Climbing Arrow Formation between the Salt Gulch and Rattlesnake Creek faults. A small fault is exposed on the southeast side of Lone Mountain within the Dunbar Creek Formation.

The Radersburg Fault was mapped based on the abrupt linear western contact of Tertiary deposits with Cretatceous igneous and sedimentary rock. The fault parallels previously mapped faults in the Cretaceous units immediately west of the Radersburg Fault (Klepper and others, 1971).

The Radersburg, Parker, and Lone Mountain faults bound the Radersburg and Lone Mountain grabens in the western part of the map area. The maximum age of the grabens depends on the age of basalt and the overlying Radersburg map unit within the grabens, neither of which is known, but basalt to the north in the Big Belt Mountains has been dated as 30.09$\pm$0.13 to 32.84$\pm$0.23 Ma (Oligocene) (Reynolds and Brandt, 2005). The monzonitic Lone Mountain Stock on the east side of Lone Mountain, sharply cuts gently dipping rocks of the Elkhorn Mountains Volcanics (Kem) (Klepper and others, 1971). The stock is younger than intrusive rock (Ki) in the western part of the map area that is related to the Elkhorn Mountains Volcanics (Freeman and others, 1958). Klepper and others (1971) show the Lone Mountain Stock as "younger Tertiary intrusive rocks" (figure 4, p. 34), but indicate a lead-alpha age on zircons of 76 Ma (p. 25). Depending on its age, the stock may have intruded along a pre-existing fault that was reactivated during graben development, or it may have intruded within the graben during its development. The Lone Mountain Graben cuts the northeast- and east-dipping Climbing Arrow and Dunbar Creek Formations that onlapped Cretaceous igneous and sedimentary rocks, but no clasts of these formations were found along the margins of the grabens.

Gold was discovered in placer gravel southwest of Radersburg in 1866 and traced to lodes in pyrite veins primarily in intrusive rock (Gilbert, 1932a; Klepper and others, 1971). The veins are oriented N10ºW (Gilbert, 1932a) or "nearly north" (Klepper and others, 1971). These orientations are generally similar to those of the Radersburg, Lone Mountain, and Parker Faults, and previously mapped faults north of Radersburg (Klepper and others, 1971). This suggests that the general north-south structural grain on the west side of the Radersburg-Toston Basin may have influenced both mineralization, and episodes of faulting at least into the Paleogene and probably into the Neogene.

The Toston Fault, a down-to-the-west normal fault that extends beyond the map area to the north, was recently identified north and east of Toston in the eastern part of the map area, based on geomorphic, stratigraphic, structural, and geophysical evidence (Gorton and Olig, 1999; Wong and others, 1999). The Plunket Fault is inferred from a linear aeromagnetic pattern (Kinoshita and others, 1965), and from the northern limit of pre-Cenozoic rock exposures.

A linear band of Proterozoic rock and Tertiary sediment protrudes through the cobble gravel and overlying deposits near Crow Creek. Reynolds and Brandt (2006) interpreted a concealed fault along parts of both sides of the band. There may be two parallel, mostly concealed faults, the Crow Creek faults, one on either side of the band, that form a narrow horst.

The Rattlesnake Creek and the Crow Creek faults probably join to form an arcuate fault that parallels Laramide thrust faults in the Helena Salient (figure 2), and that includes an exposed Laramide fault in the area east of the Limestone Hills in the northern part of the map area. A parallel arcuate pattern is formed by the Toston and Plunket faults. The two arcuate fault patterns may represent separation on a Laramide thrust fault decollemont during post-Laramide Tertiary extension that created the Toston Graben between the separated hanging wall (eastern Crow Creek Fault) and footwall (Toston Fault) of the thrust. The Toston Graben is now partly occupied by the Missouri River. The western Crow Creek Fault, a down-to-the-west normal fault, apparently broke in a position slightly to the west of the eastern Crow Creek Fault, leaving the leading edge of the hanging wall of the original thrust as a horst.

Development of the Toston Graben may have started during initiation of Basin and Range extension during the middle Miocene, but younger movement has also occurred and is probably ongoing. Gravel that may be Pliocene or Pleistocene (QTgr) appears to be down-dropped by both the Rattlesnake Creek and the Plunket faults. The Crow Creek faults appear to truncate Pleistocene cobble gravel (Qcgr). The Toston Fault has been recurrently active during the last 500,000 years and is regarded as a potentially significant seismic source (Wong and others, 1999). Slip rate on the Toston Fault is estimated as 0.1 to 0.5 mm/year (Anderson and LaForge, 2003). This area experienced the magnitude 6¾ Clarkston Earthquake in June 1925 (Pardee, 1926; Qamar and Hawley, 1979). That earthquake has been attributed to either the Clarkston Valley Fault along the east margin of the Clarkston Valley (Qamar and Hawley, 1979; Wong and others, 1999) (figure 2), or to the Toston Fault (Wong and others, 1999).

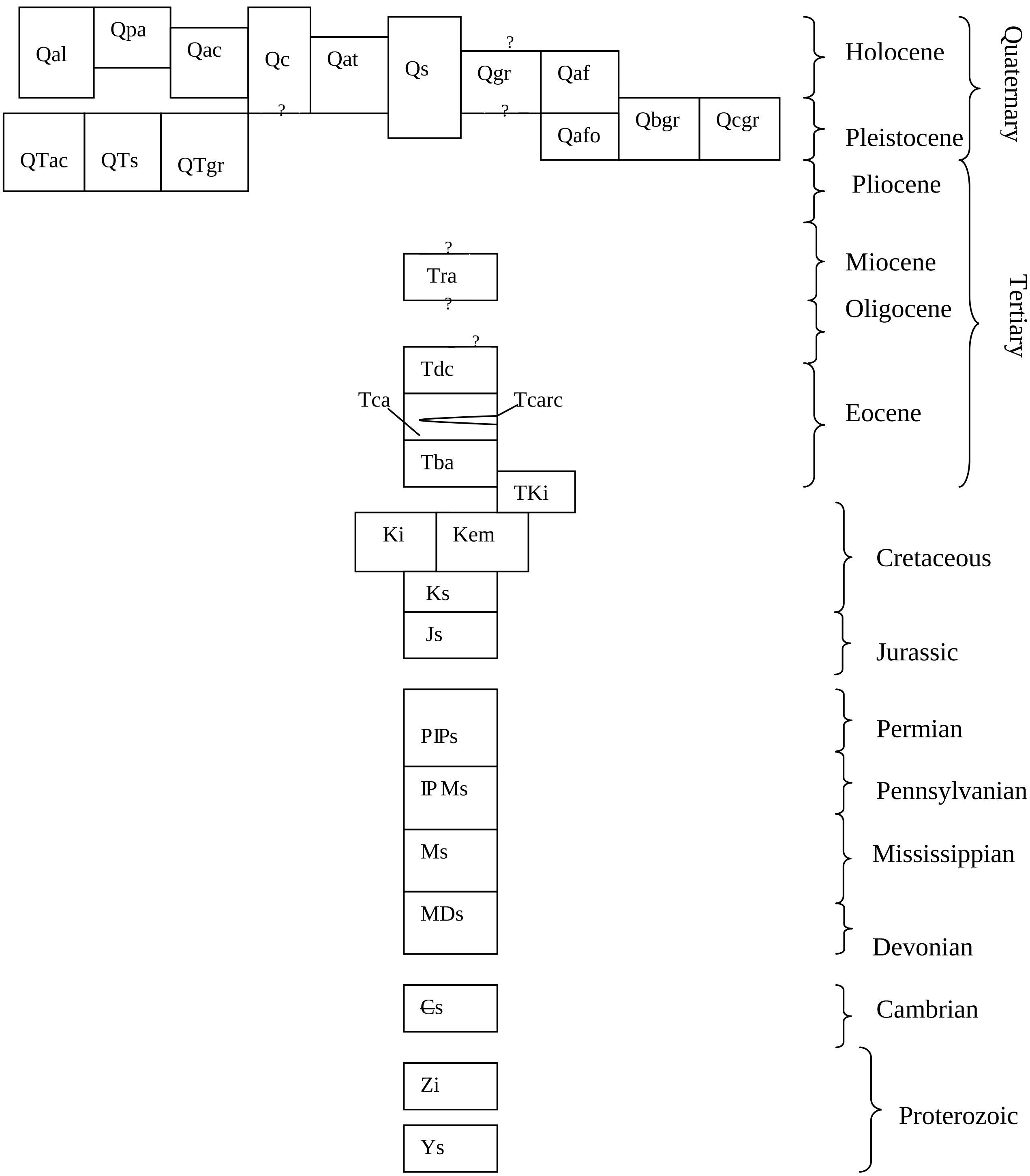
The Radersburg-Toston Basin is bounded on the north by the southern part of the Lewis and Clark Zone of northwest-striking faults that extends from the map area westward into Idaho, represented in the map area by northwest-striking faults in the southern Limestone Hills and the area of bedrock to the east. The Lewis and Clark Zone represents the northernmost accommodation zone of the Basin and Range Province (Stickney and Lageson, 2004).

Ground Water

The two main aquifers in the Radersburg-Toston Basin are the Mississippian Madison Group limestone beneath the Cenozoic deposits, and the Cenozoic valley-fill deposits recharged by surface water and water from the Madison Group (Wyatt, 1984). Plunket Spring that feeds Plunket Lake on the south side of the basin, and Big Spring along the Missouri River south of Toston (figure 1), the two largest springs in the basin, indicate a large-volume, low temperature geothermal resource (Sonderegger, 1984) that suggests a deep source in the Madison Group for those springs (Wyatt, 1984). A smaller spring in the map area, Kimpton Spring, located three miles southeast of Radersburg (figure 1), is also a warm spring (Lorenz and McMurtrey, 1956). Tufa veins in the Dunbar Creek Formation west of Radersburg and tufa deposits west of the map area in Johnny Gulch (Klepper and others, 1971) indicate a history of late Eocene or younger thermal activity in the area.

Along the inferred juncture of the Rattlesnake Creek and Crow Creek faults, Lorenz and McMurtrey (1956) noted artesian flow at the surface in a well drilled to 75 ft, and other confined groundwater in nearby wells. The water may be structurally confined by low-angle faults.

RADERSBURG-TOSTON BASIN
CORRELATION DIAGRAM



RADERSBURG-TOSTON BASIN

EXPLANATION OF MAP UNITS

Qal **Alluvium (Holocene)**—Gravel, sand, silt, and clay in modern stream valleys and the Missouri River valley. Clasts generally cobble size and smaller, but with some boulders along the Missouri River. Many streams that drain toward the Missouri River are absorbed into the valley deposits or diverted by irrigation ditches so alluvium does not extend to the Missouri River Valley.

Qpa **Paludal deposit (Holocene)**—Argillaceous silt, sand, and organic matter deposited in a swamp environment.

Qac **Alluvium and colluvium (Holocene)**—Argillaceous silt and sand with lenses of coarser sediment generally pebble size or smaller. Thickness ranges to about 20 ft based on Montana Bureau of Mines and Geology Groundwater Information Center well data (http://mbmggwic.mtech.edu).

Qc **Colluvium (Holocene and Pleistocene?)**—Angular clasts, boulder size and smaller derived from adjacent pre-Cenozoic rock.

Qat **Alluvial terrace deposit (Holocene and Pleistocene)**—Gravel, sand, silt, and clay on benches above the Missouri River. Clasts generally rounded to subrounded, cobble size and smaller. Hachured line symbol shows meander scars with subdued fluvial scarps primarily mapped from aerial photographs.

Qs **Sediment (Holocene and Pleistocene)**—Argillaceous silt and fine-grained sand. Includes sparse pebble gravel deposits in drainages.

Qaf **Alluvial fan deposit (Holocene and Pleistocene)**—Gravel, sand, silt, and clay in small deposits with fan-shaped morphology. Moderately well sorted to poorly sorted with larger clasts both matrix- and clast-supported, and locally derived. Coarse clast size, dominantly pebbles with subordinate cobbles.

Qgr **Gravel (Holocene or Pleistocene)**—Deposits of small areal extent in southwestern part of map area. Clasts are subrounded, dominantly pebble and small cobble size, and dominantly composed of dark igneous rocks, quartzite, and Proterozoic Belt metaquartzite. Thickness less than 10 ft.

Qafo **Older alluvial fan deposit (Pleistocene)—**Gravel, sand, silt, and clay along break in slope at Missouri River Valley margin. Moderately well sorted to poorly sorted and locally derived. Coarse clast size, dominantly cobbles with subordinate boulders.

Qbgr **Boulder gravel (Pleistocene)—**Gravel in the Crow Creek drainage with abundant subrounded and subangular boulders and cobbles, dominantly of Elkhorn Mountains Volcanics and subordinately of pre-Cenozoic sedimentary rock. Gravel along Johnny Gulch and Keating Gulch with abundant subrounded and subangular boulders that range to as much as 5 ft in diameter. Clast composition Elkhorn Mountains Volcanics and pre-Cenozoic sedimentary rock. Thickness along Johnny Gulch and Keating Gulch as much as 250 ft. Thickness south of Crow Creek more than 200 ft, but probably much thinner or only a veneer north of Crow Creek (Klepper and others, 1971).

Qcgr **Cobble gravel (Pleistocene)—**Gravel in the Crow Creek drainage with abundant rounded and subrounded cobbles, dominantly of Elkhorn Mountains Volcanics and subordinately of pre-Cenozoic sedimentary rock and subordinate boulders.

QTac **Gravel (Holocene, Pleistocene and Pliocene?)—**Locally derived alluvial and colluvial deposits that cover lower slopes on the north side of Lone Mountain and bedrock east of the southern Limestone Hills.

QTs **Sediment (Pleistocene and Pliocene?)—**Argillaceous silt and sand with floating, angular and subangular pebble- or small cobble-size clasts.

QTgr **Gravel (Pleistocene and/or Pliocene)—**Gravel that overlies northeast-dipping pediment and bedding-plane surfaces on Tertiary deposits and Elkhorn Mountains Volcanics. Clasts subrounded to subangular, as large as small boulder size, but are generally cobble size and smaller. Clasts generally coated with, and locally cemented by, calcium carbonate. Clast composition varies from one location to another, but includes only locally derived rock (Elkhorn Mountains Volcanics, intrusive rock, and local pre-Cenozoic sedimentary rock). Moderately well sorted to well sorted by composition. Thickness generally 20 ft or less.

Tra **Radersburg map unit (Tertiary)—**Gravel or conglomerate composed of dominantly subangular and subordinately subrounded clasts that range to boulder size. Boulders dominate the coarser clasts to the north, and cobbles dominate to the south. Clasts are typically stained by iron oxide and in many places coated with calcium carbonate. Clasts are dark igneous rocks, Proterozoic Belt Supergroup rocks, chert, quartzite, and quartz, but no limestone. Dominantly matrix-supported with matrix of granules, sand, silt, and clay. Extensively exposed along abandoned system of placer flumes north of Radersburg. Exposed thickness as much as 300 ft.

Tdc **Dunbar Creek Formation (Tertiary, late Eocene and possibly early Oligocene)—**Yellowish-gray ("tan"), grayish-orange pink ("light salmon"), light brown and subordinate white or light gray ash, tuffaceous and argillaceous siltstone, and fine-grained sandstone, with widely interspersed lenses of breccia and/or conglomerate in a sandstone or sandstone/granule matrix. Lenses range from thin stringers to 50 ft thick and miles long. Breccia/conglomerate clasts vary in composition from one location to another, but include only locally derived rock (Elkhorn Mountains Volcanics, local intrusive rock, and local pre-Cenozoic sedimentary rock). Clasts of breccia/conglomerate very poorly sorted by size, as large as medium boulder size, and generally moderately to well sorted by composition. Clasts range from angular to subrounded. Associated soil is red where clasts are dominantly or exclusively Proterozoic Spokane Formation. Coarse lenses may have clasts of boulder-size slabs of resistant bedded units such as the Flathead Formation and are probably debris-flow deposits. Breccia/conglomerate locally iron-cemented (both reduced and oxidized), but generally cemented with calcium carbonate or uncemented. Uncemented, in-place gravel from the Dunbar Creek Formation is easily confused with colluvium or other transported gravel deposits.

Tuffaceous beds, thinly bedded to massive, with local zones that have floating sand or granules of glassy quartz and/or rock fragments, and local relatively resistant pods or beds of calcareous siltstone or marl typically with root casts. Siltstone beds may be relatively resistant and weather to small angular chips. Locally calcium-carbonate-filled root and rootlet casts or specks of calcium carbonate abundant. Age determined by vertebrate fossils. Exposed thickness as much as 200 ft.

Tca **Climbing Arrow Formation, upper (Tertiary, late Eocene)—**Dark brown, dark gray, grayish-olive green, moderate red, pale red, and moderate reddish-brown, silty, bentonitic mudstone interspersed with numerous lenses and extensive sheets of partly cemented rounded to subrounded pebble and/or cobble conglomerate/gravel and subordinate lenses of sandstone. Clasts of conglomerate/gravel are dominantly dark igneous rocks, Belt Supergroup rocks, chert, quartzite and quartz, with only rare limestone clasts. Gravel is both clast- and matrix-supported. Conglomerate/gravel and sandstone often iron-oxide stained. Dry bentonitic mudstone displays "popcorn" weathered surfaces broken by desiccation cracks as much as 1 inch wide. Mudstone is barren of vegetation over large areas except for abundant growth of lichen *Xanthoparmelia chlorochroa* (identified by B. McCune, Oregon State University); extremely sticky and slippery when wet. Upper Climbing

Arrow Formation above Rattlesnake Creek bed is shown with stippled pattern. Age determined by vertebrate fossils. Exposed thickness as much as 250 ft.

Tcarc **Rattlesnake Creek bed (Tertiary, late Eocene)** (bed in upper Climbing Arrow Formation)—White or light gray lapilli tuff, or tuff-, pumice- or clay-clast conglomerate in a white or light gray tuffaceous sandy matrix with floating dark gray lithic clasts, and occasional pebble to cobble size, dusky red scoria clasts. Conglomerate clasts generally granule to pebble size, with subordinate small cobbles. Dark gray lithic clasts of matrix range from clay to granule size, but are generally sand size. Conglomerate associated with trough crossbedded, tuffaceous, light gray sandstone to granule conglomerate that may include granule or sand size, white or light gray pumice or clay clasts as in conglomerate described above. Carbonaceous shale and white or pinkish montmorillonite beds may be interbedded with the white or light gray conglomerate. Locally Rattlesnake Creek bed includes dark gray, brown or reddish-brown bentonitic mudstone that separates two white or light-gray conglomerate units. Thickness 0-15 ft.

Tba **Basalt**

TKi **Intrusive rock**

Ki **Intrusive rock**

Kem **Elkhorn Mountains Volcanics**

Ks **Cretaceous sedimentary rock:** Slim Sam, Eagle, Telegraph Creek, Cody, Frontier, Mowry, Muddy, Thermopolis, and Kootenai formations.

Js **Jurassic sedimentary rock:** Morrison and Swift formations.

PIPs **Permian and Pennsylvanian sedimentary rock:** Phosphoria and Quadrant formations.

IPMs **Pennsylvanian and Mississippian sedimentary rock:** Amsden Formation

Ms **Mississippian sedimentary rock:** Big Snowy Group, and Mission Canyon and Lodgepole formations.

MDs **Mississippian and Devonian sedimentary rock:** Three Forks, Jefferson, and Maywood formations.

Ꞓs **Cambrian sedimentary rock:** Red Lion, Pilgrim, Park, Meagher, Wolsey, and Flathead formations.

Zi **Intrusive rock**

Ys **Proterozoic sedimentary or metasedimentary rock:** Spokane and Greyson formations.

MAP SYMBOLS

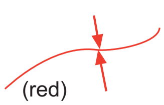
Contact between geologic units

Rattlesnake Creek bed horizon—Projected location of Rattlesnake Creek bed where not mapped.

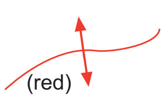
Fault—Dashed where inferred, dotted where inferred fault is concealed. Ball and bar on downthrown side.

Fault, thrust—Dashed where inferred; dotted where concealed; teeth on upper plate.

Strike and dip of bedding—Number indicates angle of dip in degrees. Shown for Tertiary deposits and selected older deposits.



Syncline—Showing axial plane trace.



Anticline—Showing axial plane trace.

Meander scar with subdued scarp—Barbs on downcut side.

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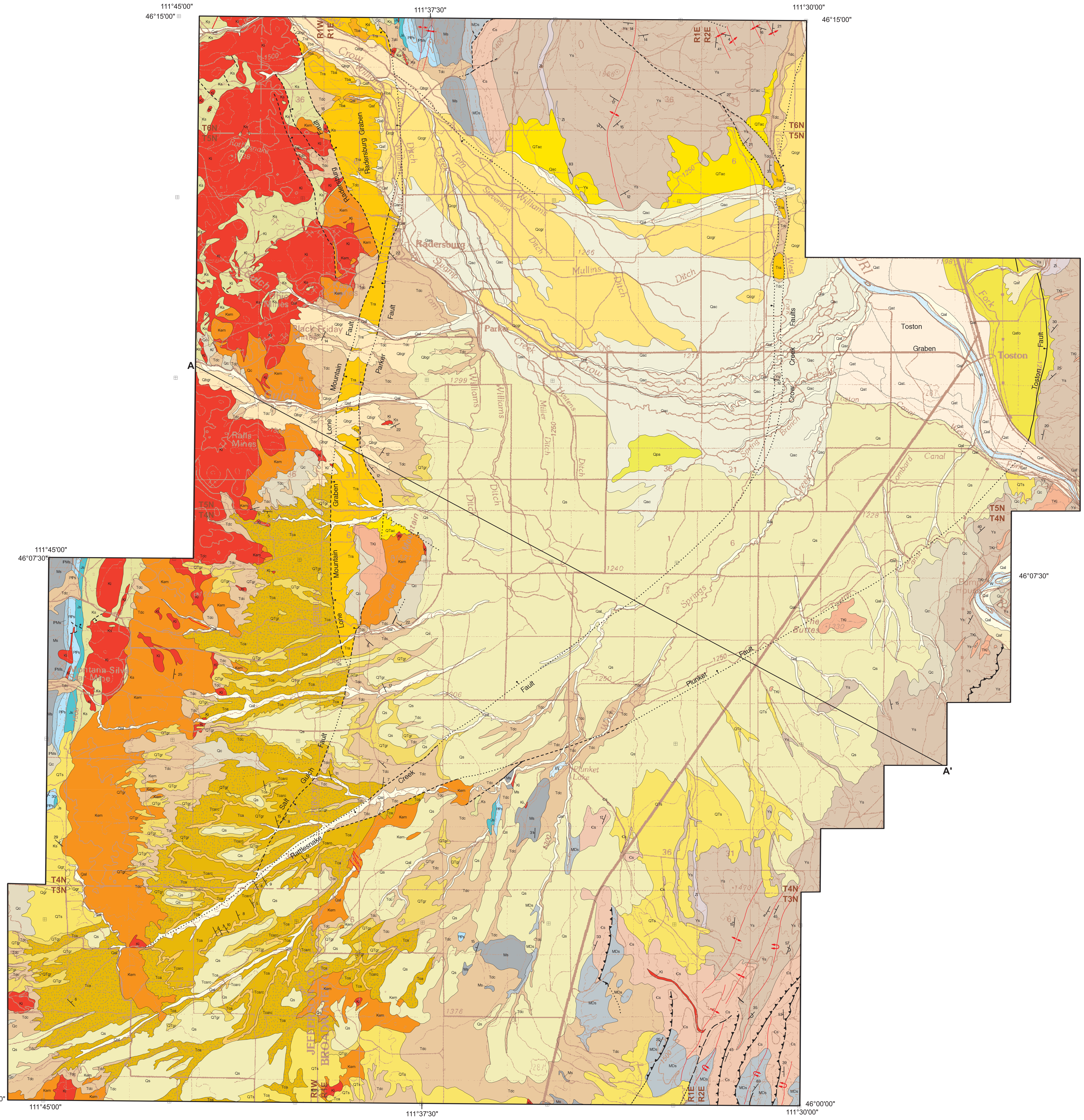


Base enlarged from U.S. Geological Survey:
Townsend 30'x60' topographic quadrangle
Map date: 1976
Projection: UTM zone 12; 1927 NAD
Montana coordinate system, south zone

UTM grid declination 0°27' West
1976 Magnetic North Declination 17.5° East

SCALE: 1:50,000

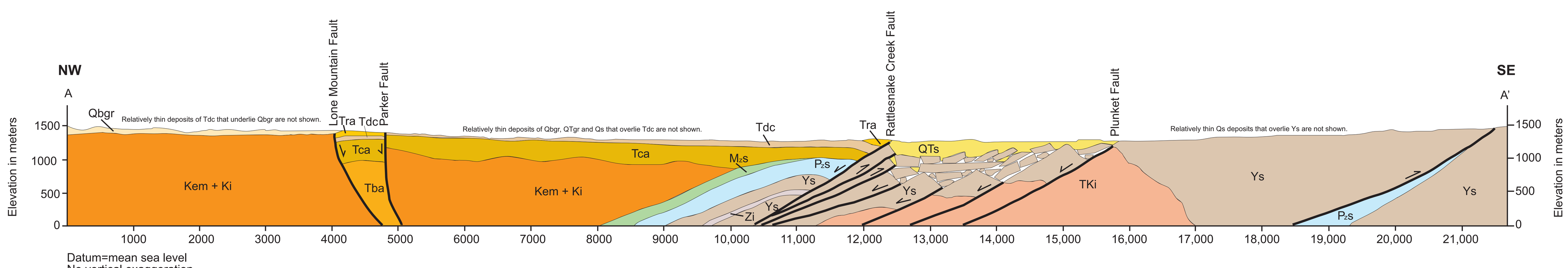
0 1 2 4 6 8 Miles

0 1,250 2,500 5,000 7,500 10,000 Meters

Contour interval 50m

N

INTERPRETIVE CROSS SECTION A-A'



Datum=mean sea level
No vertical exaggeration

Cross section based on surface mapping with reference to Kinoshita and others (1965).

CROSS SECTION EXPLANATION

Qbgr	Boulder gravel
Qs	Fine-grained sediment
QTs	Quaternary or Quaternary and Tertiary sediment and rock
QTgr	Gravel
Tba	Basalt
Tra	Radersburg map unit
Tdc	Dunbar Creek Formation
Tca	Climbing Arrow Formation
TKi	Intrusive rock
Kem	Elkhorn Mountains Volcanics
Ki	Intrusive rock related to Kem
Mzs	Mesozoic sedimentary rock
Pzs	Paleozoic sedimentary rock
Zi	Intrusive rock
Ys	Belt Supergroup metasedimentary rock

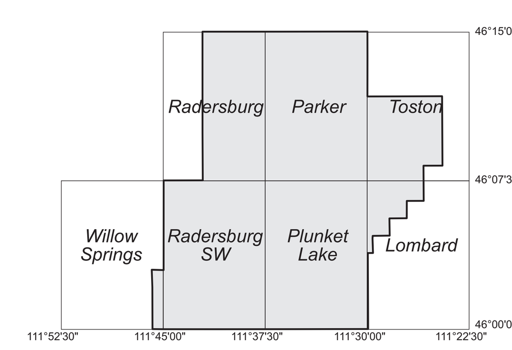
Fault, showing relative movement

MAP UNITS

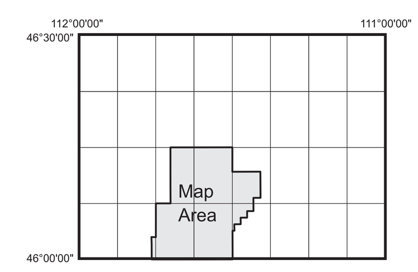
Qal	Alluvium (Holocene)
Qpa	Paludal deposit (Holocene)
Qac	Alluvium and colluvium (Holocene)
Qc	Colluvium (Holocene and Pleistocene)
Qat	Alluvial terrace deposit (Holocene and Pleistocene)
Qs	**Sediment, fine-grained (Holocene and Pleistocene)**
Qaf	Alluvial fan deposit (Holocene and Pleistocene)
Qgr	Gravel (Holocene and Pleistocene)
Qafo	Older alluvial fan deposit (Pleistocene)
Qbgr	Boulder gravel (Pleistocene)
Qcgr	Cobble gravel (Pleistocene)
QTac	Gravel (Holocene, Pleistocene and Pliocene?)
QTs	Sediment (Pleistocene and Pliocene?)
QTgr	Gravel (Pleistocene and/or Pliocene?)
Tra	Radersburg map unit (Tertiary)
Tdc	Dunbar Creek Formation (Tertiary, late Eocene and possibly early Oligocene)
Tca	**Climbing Arrow Formation (Tertiary, late Eocene) above Tcarc**
Tcarc	**Rattlesnake Creek bed of the Climbing Arrow Formation**
Tca	**Climbing Arrow Formation (Tertiary, late Eocene) below Tcarc**
Tba	Basalt
TKi	Intrusive rocks, undivided
Ki	Intrusive rocks, undivided
Kem	Elkhorn Mountains Volcanics
Ks	Cretaceous sedimentary rocks, undivided
Js	Jurassic sedimentary rocks, undivided
PIPs	Permian and Pennsylvanian sedimentary rocks, undivided
IPMs	Pennsylvanian and Mississippian sedimentary rocks, undivided
Ms	Mississippian sedimentary rocks, undivided
MDs	Mississippian and Devonian sedimentary rocks, undivided
Cs	Cambrian sedimentary rocks, undivided
Zi	Intrusive rock
Ys	Proterozoic sedimentary or metasedimentary rock
W	Water

For a more detailed description of the map units and symbols, please refer to the text accompanying this map.

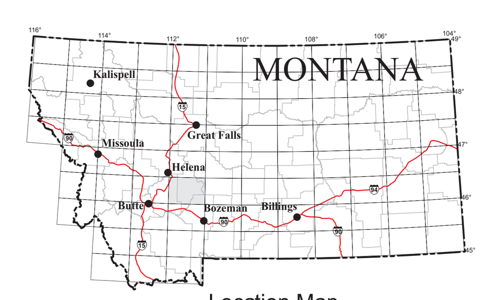
NOTE: The streams on the topographic map do not always match the geologic lines because the geology was mapped on 1:24,000 scale (7.5') quadrangles and reduced to 1:50,000 scale. The base is a 1:100,000 scale (30' x 60') quadrangle enlarged to 1:50,000 scale.



1:24,000 scale (7.5') quadrangles



TOWNSEND 30' x 60' quadrangle



Location Map

Maps may be obtained from: Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4167
Fax: (406) 496-4451
http://www.mbmg.mtech.edu

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

MBMG Open File 561

Geologic Map of Radersburg-Toston Basin, Montana

Susan M. Vuke

2007