Montana Bureau of Mines and Geology
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Preliminary Geologic Map of the Philipsburg
30' x 60' Quadrangle, Western Montana

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2003

To view a full scale version of this map, click here.

For the text files with the map information, click here.

Digital data link

Note — This map was originally published at a scale of 1:100,000 but the page sizes have been modified to fit average printer capabilities (8½ x 14; legal size paper). There is an eighth inch overlap on these pages. A full sized colored print of this map can be ordered from the MBMG Publication Sales Office, 1300 West Park Street, Butte, MT, 59701-8997.

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Strike and dip of bedding where stratigraphic “up” direction was confirmed using primary sedimentary structures

MAP SYMBOLS

Contact

Fault: unknown series of movement, dotted where concealed

Normal fault: dotted where concealed; bar and ball on downthrown side

Reverse or thrust fault: teeth on upthrown block

Low angle normal fault (detachment fault) hatches on hanging wall, dashed where approximately located; dotted where concealed

Anticline: showing trace of axial plane and plunge direction where known

Syncline: showing trace of axial plane and plunge direction where known

Overturned anticline: showing trace of axial plane and direction of dip bedding

Small scale fold axis

Strike and dip of bedding

Strike and dip of overturned bedding

Strike and dip of bedding where stratigraphic “up” direction was confirmed using primary sedimentary structures

Strike and dip of overturned bedding where stratigraphic “up” direction was confirmed using primary sedimentary structures
Horizontal bedding
Foliation
Mylonitic foliation, with plunge and bearing of mineral lineation
Cleavage
Gabbric or dioritic sills and dikes
Granitic or granodioritic sills and dikes
Areas of significant tectonic breccia
Areas of mylonitic fabric along the east side of the Anaconda core complex

Holocene
Pleistocene
Cretaceous
Jurassic
Mississippian
Proterozoic
Devonian
Cambrian
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Triassic
Permian
Pennsylvanian
Silurian
Ordovician

Qmd
Ybo
Qal
Qc
Qaf
Qgt
Ds
Ym
Yms
KJs
?
?
?
?
Qgk
Qgtk
QTaf
Qta
Qao
Qafo
Qrg
Qls
Qdf
Tv
Trt
Ttb
Tri
Tlc
Tcg
Tac
Kgdp
Kgdf
Kqdf
Tgd
Tbmg
Tsc
Ts
Tcl
Kqd
TKps
TKgb
TKgd
TKg
Kcg
Kcgp
KJsp
Ygr
Ymi
Yms3
Yss
Ysh
Ysn
Yc
Yra
Ysnq
Yssp
Ymsp
Ymsq
Yboq
Ybq
Ybg
Ymiq
Ycg
Yraq
Ygg
Figure 1. Major tectonic features, structural domains, and mountain ranges of the Philipsburg 30' x 60' quadrangle.

Datum = mean sea level
Surficial deposits not shown

SOURCES OF PREVIOUS GEOLOGIC MAPPING

1. Allen, 1961
2. Bakken, 1984
3. Buckley, 1990
5. Desmarais, 1983
6. Earl, 1972
7. Elliott and others, 1984
8. Emmons and Callena, 1913
9. Heise, 1983
10. Hughes, 1970
11. Langton, 1935
12. LeTour, 1974
13. Leuk, 1979
14. Lewis, 1968a
15. Lidike and Wallace, 1992
16. Loen and others, 1989
17. Lofholm, 1985
18. Mahoney, 1956
19. McGill, 1961
20. Mutch, 1961
22. Pederson, 1976
23. Poulter, 1966
24. Presley, 1971
25. Prinz, 1967
26. Stuart, 1966
27. Wallace, 1987
28. Wallace and others, 1986
29. Wallace and others, 1989
30. Wallace and others, 1992
MAP UNIT DESCRIPTIONS

**Qmd MINE WASTE (HOLOCENE)**

Piles of poorly sorted cobbles, boulders, and sand resulting from placer mining operations. Greenish-gray, micaceous, tabular and lensoidal, hummocky casts. Thickness 1.5-7.5 m (5-25 ft).

**Qta TALUS DEPOSITS (HOLOCENE AND PLEISTOCENE)**

Accumulations of angular boulders below cliffs. Thickness 1.5-15.0 m (5-25 ft).

**Kgd GRANODIORITIC ROCKS (LATE CRETACEOUS)**

Hornblende-biotite quartz diorite, diorite, and granodiorite. Very coarse-grained channel deposits. In some areas, older alluvium (Qao) is not divided from Qaf.

**Qdf DEBRIS FLOW DEPOSITS (PLEISTOCENE)**

Poorly sorted, sub-angular bouldery deposits of huge boulders, cobbles, sand, silt and clay deposits by catastrophic debris flows.

**Qgt GLACIAL TILL (PLEISTOCENE)**

Unsorted, mostly unstratified, clay, silt, sand, and gravel with subrounded boulders as much as 3 m (10 ft) in diameter. Till is often characterized by large, subdued, exotic boulders that have been transported some distance, and by hummocky topography. Poor drainage, with swamplike areas and numerous springs, and subangular clasts distinguish it from kame deposits (Qqk).

**Qgk GLACIAL KAME DEPOSITS (PLEISTOCENE)**

Moderately to well-sorted, sub-rounded to well-rounded, well-stratified sand, pebbles, and gravels. The sediments are composed primarily of material to glacially transported gravel and matrix material to glacially deposited gravel. Eurospheric surfaces are common in the upper part of the deposits.

**Qpf SEDIMENTARY ROCKS OF THE SHEDHORN, PHOSPHORIA, PARK CITY AND QUADRANT FORMATIONS, UNDIVIDED (PERMIAN AND PENNSYLVANIAN)**

The Shedhorn Formation is a package of white to cream-colored, siltstone and sandstone with minor shale and conglomerate. The Phosphoria Formation is characterized by thin, interbedded layers of limestone and dolomite. The Park City Formation is composed of carbonates and siltstones. The Quadrant Formation includes sandstones, mudstones, and conglomerates.

**Qksp PHYLITE AND QUARTZITE OF THE METAMORPHOSED KOOTENAI AND ELLIS FORMATIONS**

Phyllite, quartzite, and minor marble that are the metamorphic equivalent of the Kootenai and Ellis Formations.

**Qss SHEPARD AND SNOWSLIP FORMATIONS, UNDIVIDED (MESOPROTEROZOIC)**

Total thickness as much as 1,067 m (3,500 ft). Metamorphic equivalent of these formations.
REFERENCES


Langton, C.M., 1935, Geology of the northeastern part of the Idaho Batholith and adjacent region in Montana: Journal of Geology, v. 43, p. 35-60, map scale 1:422,000.


Ysh SHEPARD FORMATION (MESOPROTEROZOIC)
Dark green siltite and light green argillite in microlaminae and deposition.

Ts SEDIMENTARY ROCKS, UNDIVIDED (TERTIARY)
Includes both coarse- and fine-grained rocks.

Taf ALLUVIAL FAN DEPOSITS (EARLY PLEISTOCENE AND LATE TERTIARY)
Poorly to well-sorted, rounded to sub-angular boulders, cobbles, sand, silt, and clay. Surfaces of these deposits have a distinct fan shape and now stand more than 15 m (50 ft) above modern deposits.

Pipq QUARTZITE OF THE METAMORPHOSED SEDIMENTARY ROCKS (PERMIAN AND PENNSYLVANIAN)
Mostly quartzite, but also includes minor phylite and marble. Metamorphic equivalent of the Upper Member of the Shoshone, Shoshone, Park City, and Quadrant Formations.

Pphq SEDIMENTARY ROCKS OF THE SNOWCREST RANGE GROUP, AMSDEN FORMATION, AND MADISON GROUP UNDIVIDED (PENNSYLVANIAN AND MISSISSIPPIAN)
The Snowcrest Range Group (Lidke and Wallace, 1992) and equivalent Amsden Formation (Enns and Calkins, 1951). These rocks include the very thick dolomite/limestone section above the Madison Group. Some beds are the same as the Madison Group, but others are distinctly different. These deposits are found in the Wyomissing Basin and are overlain by the Madison Group. This unit is often tectonically thinned.

Sixsie SIXMILE CREEK FORMATION (PICOUCINO AND MICOCENIAN)
Mostly conglomerate with some sandstone and siltstone. Commonly caps the remnant Tertiary surfaces.

Tcl CLAY AND SILT (MICOCENIAN AND OLOCCINO)
White to light-gray clay and silt deposited in fluvial and lacustrine environments, and probably correlate with the Koino Formation. The underlying beds are tuff breccias.

Taco ANACONDA FORMATION (PICOUCINO, PICOUCINO, AND TERTIARY)
Unstratified deposits of angular, poorly sorted boulders and cobbles of unmetamorphosed sedimentary rocks deposited in debris flow and mass wasting environments, interbedded with and grading to overlying stratified and tuffaceous rocks. The upper part is tuffaceous, with interbeds of volcanic ash, tuff, and tuff breccias.

Tcqb QUARTZITE OF THE METAMORPHOSED ANACONDA FORMATION (PICOUCINO)
Mostly quartzite, but also includes minor phylite and marble. Metamorphic equivalent of the Snowcrest Range Group, Amsden Formation, and Madison Group. This unit is often tectonically thinned. See geologic discussion for more detail.

Tcjem CONGLOMERATE (PICOUCINO)
Grey, fine- to medium-grained quartzite in beds 0.15-1.5 m (0.5-5 ft) thick. The unit is often tectonically thinned. The overlying Mount Shields Formation contains no pebbles. Slight metamorphism is common. The unit is tentatively correlated with the Red Lion Formation of the Ravalli Group.

Tlq Polychrome GNEISS AND SCHIST OF THE METAMORPHOSED GREY SNAKE RANGE (MESOPROTEROZOIC)
Includes marble, quartzite, gneiss, schist, and phyllite that are the metamorphic equivalents of the Piegan Group.

Tlpe PELITIC GNEISS AND SCHIST OF THE METAMORPHOSED GREY SNAKE RANGE (MESOPROTEROZOIC)
Includes marble, quartzite, gneiss, schist, and phyllite that are the metamorphic equivalents of the Piegan Group.

Tlq BIOTITE QUARTZITE OF THE METAMORPHOSED BELT SUPERGROUP (PICOUCINO)
Includes quartz monzonite, gneiss, and granite. Metamorphic equivalent of the Maywood Formation. This unit is often tectonically thinned. See geologic discussion for more detail.

Tlra QUARTZITE OF THE METAMORPHOSED RAVALLI GROUP (MESOPROTEROZOIC)
Highly recrystallized quartzite, phylite, schist, and calsilicate gneiss equivalents of the Snowflake Formation.

Yc PIEGAN GROUP (MESOPROTEROZOIC)
Includes the Wallace and Helena Formations. The upper part is characterized by tuff-breccia and metasedimentary rocks. The section is well exposed in the northern part of the region, and the overlying Piegan Group. Unit includes a thin zone of locally tectonically thinned. See geologic discussion for more detail.

Yra RAVALLI GROUP (MESOPROTEROZOIC)
Mostly flat-lying, medium- to fine-grained quartzite separated by thin layers of dolomite. Not significantly metamorphosed. Best exposed along the eastern margin of the Anaconda Complex. The overlying Piegan Group. Unit includes a thin zone of locally tectonically thinned. See geologic discussion for more detail.

Ylg PELITIC GNEISS AND SCHIST OF THE METAMORPHOSED GREY SNAKE RANGE (MESOPROTEROZOIC)
Includes marble, quartzite, gneiss, schist, and phyllite that are the metamorphic equivalents of the Piegan Group.

Ybq BIOTITE QUARTZITE OF THE METAMORPHOSED BELT SUPERGROUP (PICOUCINO)
Mylonitic foliation is present within and adjacent to the Anaconda detachment fault. Quartz monzonite and granodiorite.


GRANITIC ROCKS (EARLY TERTIARY AND LATE CRETACEOUS)
- Non-foliated biotite-muscovite monzogranite, leucomonzogranite, and granodiorite.

GRANODIORITIC ROCKS (EARLY TERTIARY AND LATE CRETACEOUS)
- Non-foliated biotite granodiorite, hornblende-biotite granodiorite, tonalite, and quartz diorite.

GABBROIC ROCKS (EARLY TERTIARY AND LATE CRETACEOUS)
- Gabbro, microgabbro, diorite, and lamprophyre.

PYROXENITE AND SYENITE (EARLY TERTIARY OR LATE CRETACEOUS)
- Pyroxenite and syenite found near the western boundary of the map area.

MISSOULA GROUP, UNDIVIDED (MIDDLE PROTEROZOIC)
- Includes, in descending order, the Garnet Range, McNamara, Bonner, Mount Shields, Shepard, and Snowslip Formations. Total thickness as much as 3,261 m (10,700 ft).

QUARTZITE AND PHYLLITE OF THE METAMORPHIZED MISSOULA GROUP (MIDDLE PROTEROZOIC)
- Quartzite, phyllite, schist, calcsilicate rocks, and gneiss that are metamorphic equivalents of the Missoula Group. The Bonner, McNamara, and Garnet Range Formations have been eroded off. In addition, this unit is often tectonically thinned, and varies from 62 to 677 m (200 to 2,200 ft) in thickness. See the geologic discussion for more detail.

GEOLOGIC SUMMARY

Introduction
- Montana Bureau of Mines and Geology's new Geologic Map of the Philipsburg 30' x 60' Quadrangle represents a revised version of the Preliminary Geologic Map of the Philipsburg Quadrangle (Lonn and others, 2003) based on new field work by Lonn and Lewis from 2003 to 2008. This new field work addressed structural and stratigraphic problems revealed by, but not resolved on, the previous map.

Structural Geology
- The Philipsburg quadrangle can be divided into two major structural domains separated by the north-northeast-striking Georgetown-Philipsburg thrust system (fig. 1). The eastern structural domain, comprising the Flint Creek and northeastern Anaconda Ranges, is characterized by upper greenschist to upper amphibolite facies metamorphism, tight folds, closely spaced faults, and a complex structural history. The western domain, previously termed the Sapphire tectonic block (Hyndman and others, 1975) or Skalkaho slab (Dougherty and Sherriff, 1992), is an allochthon composed mostly of low-grade metasedimentary rocks deformed into upright, open folds and cut by numerous reverse and normal faults. Both domains are extensively intruded by late Cretaceous to early Tertiary granitic and dioritic plutons.

Eastern Structural Domain
- Structural geology is extremely complex within the eastern domain. Mayor east-directed thrust faults, represented by the Georgetown-Philipsburg thrust system, presumably buried the rocks of the eastern domain to mid-crustal depths in late Cretaceous time. An increase in metamorphic grade from west to east probably reflects greater uplift in the east. The southeastern-most part of the Anaconda Range contains relict kyanite and kyanite pseudomorphs (Kalakay and others, 2003; Grice, 2006) indicative of high-pressure metamorphism, overprinted by a high-temperature, lower pressure metamorphic event at about 80-75 Ma (Grice and others, 2004, 2005; Grice, 2006; Haney, 2008).

In the Flint Creek and Anaconda ranges, the Mesoproterozoic through metasedimentary sequence appears to be tectonically attenuated by an array of bedding-parallel fabrics and structures that include concordant mylonitic shear zones that cut out stratigraphic section, zones of vertical shortening that flatten the units through pure shear and plastic flow, and brittle bedding-parallel faults that place younger units over older units (Lonn and McDonald, 2003; Lonn and Lewis, 2009). Parallel solid-state fabrics are present in the oldest (> 75 Ma) late Cretaceous plutons (units Kgdf, Kqdf) intruding the metasediments (Hawley, 1974; Desmarais, 1983; Grice and others, 2005, 2006). The strain fabrics apparently formed during the 73-80 Ma high temperature metamorphic event (Grice and others, 2004, 2005, Grice, 2006), and they have been deformed with the beds into tight, NNE-trending, west-verging, asymmetric to overturning folds whose east-dipping axial planes appear to become more gently inclined with increasing structural depth. Undeformed late Cretaceous to early Tertiary plutons intrude the metasediments. Most plutons are sheet-like and roughly concordant to bedding, and their intrusion may have been synchronous with the folding.

The eastern flanks of the Anaconda and Flint Creek Ranges are overprinted by structures and fabrics associated with the Eocene Anaconda metamorphic core complex (O'Neill and others, 2002, 2004). The confusing geology in the southeastern corner of the Philipsburg quadrangle typifies map patterns in this extensional terrane. Here, chaotic, breciated sedimentary rocks of the upper plate are separated from lower plate metamorphic and plutonic rocks by brittle detachment faults and a greenschist-facies mylonitic shear zone. The sinuous and discontinuous Anaconda mylonite, gently folded and broken by faults, extends for more than 100 km (62 miles) along strike. It dips gently east, has a top-to-the-east shear sense, and was active from at least 53 to 47 Ma (Grice and others, 2005; Grice, 2006). Mineral lineations consistently plunge gently ESE (102°-108°), bearings almost identical to those associated with the coeval (Foster and others, 2007) Bitterroot metamorphic core complex 100 km (62 miles) to the west and outside the quadrangle.

The Georgetown-Philipsburg Thrust
- The Georgetown-Philipsburg thrust system divides the western and eastern domains. It is a complex imbricate fault system that places Mesoproterozoic Piygan Group of the Belt Supergroup over upper Paleozoic and Mesozoic sediments for a total stratigraphic separation of 7,400 m (24,000 ft). Regional cross sections that restore the slight angular unconformity at the Belt-Cambrian contact suggest about 35 km (22 miles) of horizontal displacement. The Georgetown fault is folded, perhaps by the same folds that deform the rocks of the eastern domain, and the thrust is also overprinted by normal faults that obscure the original thrust geometries along much of its trace. A minimum age of 78 Ma for the fault is inferred from cross-cutting late Cretaceous plutons (Hyndman and others, 1982; Desmarais, 1983; Marvin and others, 1989; Wallace and others, 1992).

Western Structural Domain
- West of the Georgetown-Philipsburg thrust is the Sapphire allochthon, mostly composed of gently folded, low-grade, Mesoproterozoic Belt Supergroup rocks intruded by late Cretaceous to early Tertiary plutons. However, the Sapphire allochthon is clearly not an intact block. It is complexly deformed by faults and shear zones of several types: 1) major
Metamorphic Rocks

Amphibolite facies regional metamorphic rocks are common in the quadrangle, although previous maps identified them only as their sedimentary equivalents. Because the distribution of metamorphic rocks is so important to interpreting the structural geology, we have attempted to show them on the map as metamorphic equivalents of the various units. Metamorphism probably occurred prior to intrusion of most of the major plutons in the Philipsburg quadrangle (Stuart, 1966; Grice, 2006; Haney, 2008).

In addition, areas of mylonitic foliation are shown along the eastern flank of the Anaconda metamorphic core complex. Areas of significant tectonic breccia are also shown.

Regional Structural Interpretation

The earliest tectonic event that can be documented in the region is the 2e-5e westward tilting and subsequent erosion of the Mesoproterozoic Belt Supergroup before deposition of the middle Cambrian Flathead Formation. Although there are some disconformities present within the Paleozoic and Mesozoic stratigraphic sections, no other major tectonic events can be identified until the start of the Cretaceous Sevier orogeny. During Sevier orogenesis, east-directed thrust systems like the Stony Lake, Ranch Creek, and Georgetown-Philipsburg thickened the crust and buried the football rocks (the eastern domain) to mid-crustal depths beneath the rocks of the western domain. The football rocks then underwent high-pressure metamorphism followed by high-temperature, low-pressure metamorphism that coincided with the bedding parallel fabrics that are associated with the tectonically attenuated stratigraphic section (Kalakay and others, 2003; Grice, 2006). The thinning of the entire >12,200-meter-thick (40,000 ft) metavolcanic section, the faults and shear zones that always omit and never duplicate section, and the dominance of pure shear (coaxial strain) fabrics over simple shear (non-coaxial strain) fabrics suggest to us that the thin stratigraphic section and bedding-parallel fabrics resulted from a period of synorogenic, late Cretaceous extension synchronous with thrusting in other areas of the Sevier hinterland, while numerous studies in the Andes and Himalaya have documented the occurrence of active extension in a convergent setting (Dalmanyon and Molnar, 1981; Burchfiel and Royden, 1985; McNulty and Farber, 2002). The postulated late Cretaceous extension may have been facilitated by thermal heating that resulted from crustal thickening and the emplacement of the earliest plutons; in turn, the extension has generated more plutonism, represented by the voluminous 75-60 Ma intrusions, through decompression melting.

Although some folding undoubtedly occurred during thrusting, the puzzling, west-vergent folds formed during or after most of the thrusting and the proposed extensional structures. The folds may be synchronous with many of the sheet-like, 75-65 Ma intrusions. These folds that verge west—the wrong way—have been difficult to explain. Although they have been attributed to thin-skinned thrust tectonics (Emmons and Callins, 1913; Copey, 1962; Flood, 1974; Wallace and others, 1992), they may represent hot, ductile middle crust (infrastructure) that continued to plastically deform beneath the brittle, cold, upper crust (superstructure) after deformation in the suprastructure had ceased (Gulick and others, 2006).

Convergent tectonism in the region ended in the Paleocene (Harlan and others, 1998) and was immediately followed by crustal extension represented by the Eocene Anaconda metamorphic core complex (O’Neill and others, 2002, 2004). The main Anaconda detachment initiated at about 53 Ma and the mylonitic shear zone was active until at least 47 Ma, and possibly until 30 Ma (Grice and others, 2004; Grice, 2006). The Bitterroot metamorphic core complex just beyond the western border of the Philipsburg quadrangle developed at the same time, and the two are thought to be “nested” core complexes (Foster and others, 2007). Eocene Lowland Creek volcanic rocks (unit Tlc) interfinger with coarse clastic and landslide deposits of the Anaconda beds (unit Ta) that were derived from unroofing of the Anaconda core complex (O’Neill and others, 2004; O’Neill, 2005). Rhyolitic rocks of the Rock Creek volcanic field are probably also of Eocene age.

Most high-angle and listric normal faults appear to be Eocene and younger. Some bound Tertiary valleys like the Upper Willow Creek Valley. Others, like those of the Ranch Creek fault zone and the Georgetown thrust zone, emerge and anastomose with reverse faults, and may have developed in response to normal-sense reactivation of thrust faults (Lewis, 1998b), although some could have formed synchronously with the thrusts through a constructive strain/extrusion process (Reid and others, 1995; Froitzheim and others, 2006) or that the normal faults developed in response to normal-sense reactivation of thrust faults (Lewis, 1998b), although some could have formed synchronously with the thrusts through a constructive strain/extrusion process (Reid and others, 1995; Froitzheim and others, 2006; Lonn and others, 2007). Displacements on some small normal faults could have contributed to the development of the Tertiary normal faults.