Base map produced by the United States Geological Survey
Wilson Park 1:24,000 scale quadrangle map
Control by: USGS and NOS/NOAA
Compiled from aerial photographs taken 1980
Field checked: 1981. Map edited 1985
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM Grid Declination: 0°46' West
1994 Magnetic North Declination: 16°30' East
Vertical Datum: National Geodetic Vertical Datum of 1929
Horizontal Datum: 1927 North American Datum

SCALE 1:24,000
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Maps may be obtained from:
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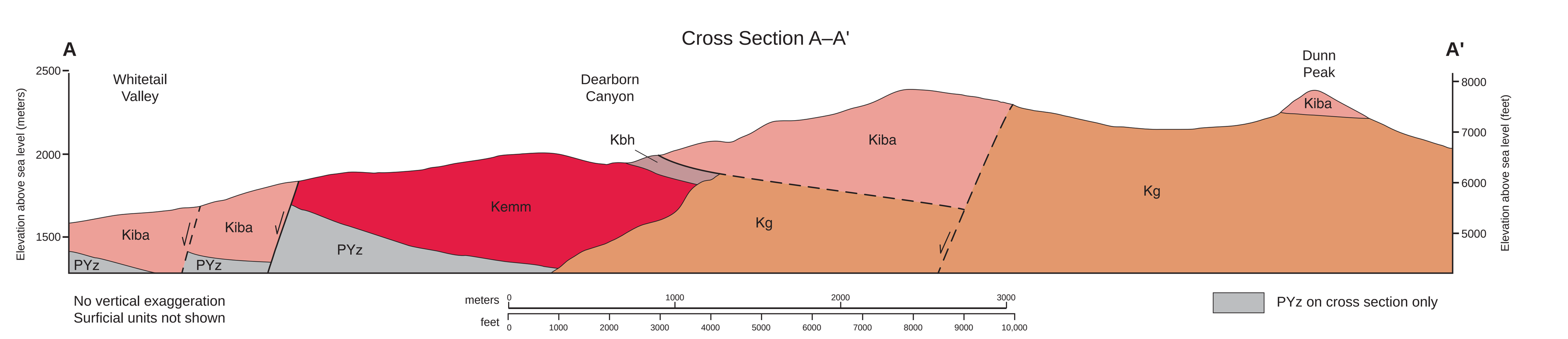

No vertical exaggeration
Surficial units not shown
SCALE: 1:24,000
PYz on cross section only

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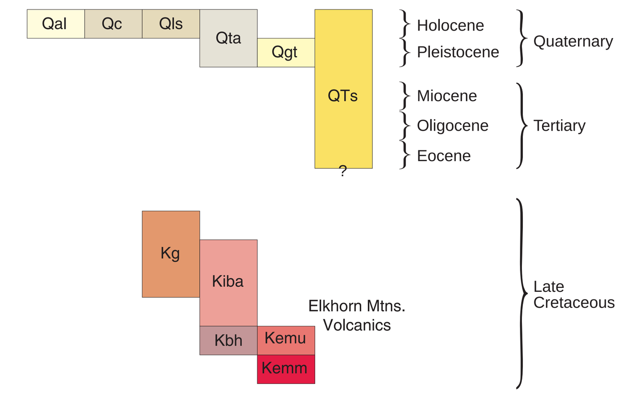
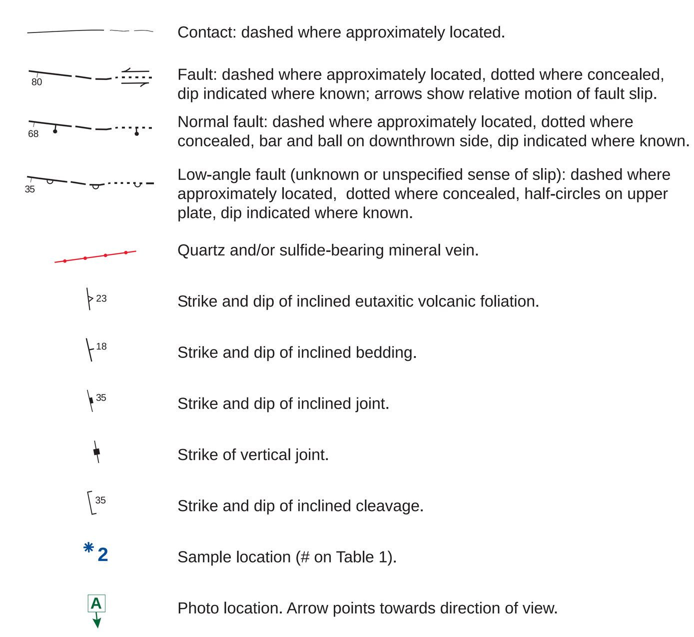
GIS production: Yiwen Li and Paul Thale, MBMG. Map layout: Susan Smith, MBMG. Editing: Susan Barth, MBMG.

CORRELATION DIAGRAM



MAP SYMBOLS



INTRODUCTION

The Wilson Park 7.5' quadrangle is located 16 km (10 mi) north of Whitehall in southwestern Montana (fig. 1). Two-thirds of the quadrangle lies within the northern Beaverhead–Deerlodge National Forest. Land use in the National Forest is a checkerboard of public and private ownership, and cattle graze the high-altitude parks of Bull Mountain. Bull Mountain and the Whitetail Valley form a stark topographic contrast throughout the map region (fig. 2A). An elevation difference of ~1,000 m (~3,280 ft) over a map distance of ~3 km (~2 mi) (30% grade) is common.

PREVIOUS MAPPING

Weeks (1974) mapped the Wilson Park 7.5' quadrangle at a scale of 1:48,000 and Prostka (1966) mapped the Dry Mountain 7.5′ quadrangle at a scale of 1:24,000 (fig. 1). Several EDMAP projects produced 1:24,000-scale maps of adjacent quadrangles, including Tacoma Park (Mahoney and others, 2008); Dunn Creek 7.5' (MacLaurin and others, 2012); and parts of the Black Butte and Doherty Mountain 7.5' quadrangles (Dixon and Wolfgram, 1998).

GEOLOGIC SUMMARY

Late Cretaceous welded ignimbrites (fig. 2A) and thin beds of water-lain tuff (fig. 2B) are the oldest rocks exposed in the Wilson Park quadrangle. These volcanic rocks belong to the middle and upper members of the Elkhorn Mountains Volcanics (EMV) (Klepper and others, 1957; Weeks, 1974). Welded ignimbrite caps Bull Mountain (fig. 2A) and correlates with ignimbrite on the Ratio Mountain 7.5′ quadrangle to the west (compare sample 7 to “RM” in table 1 and fig. 3A).

A high-K andesitic vent complex (Kiba) intruded and erupted through the EMV. The vent is exposed over 27 km^2 on Bull Mountain. Hornblende lavas (fig. 2C) from the complex are shoshonite (fig. 3A, table 1, sample 8), and feeder dikes and sills are gabbro, diorite, and syeno-diorite (SiO_2 = 47.9–59.7 wt. %) (fig. 3B). Coarsely porphyritic rocks of the shoshonite magma series (fig. 3A) are hybrids that likely formed during assimilation of gabbro by high-temperature syenite magma (e.g., Prostka, 1973).

The largest gold producer in Montana, the Golden Sunlight Mine (Oyer and others, 2014), is located south of the quadrangle and northeast of Whitehall (fig. 1). Late Cretaceous hydrothermal mineralization occurred during emplacement of a rhyolite porphyry intrusion. Gold is concentrated as electrum in pyrite (Porter and Ripley, 1985). Ore occurs in an 80 m.y. old (U-Pb on zircon) rhyolite breccia cut by 76.9 ± 0.5 Ma ($^{40}Ar/^{39}Ar$ on biotite) lamprophyre dikes (DeWitt and others, 1996). The lamprophyre dikes are emplaced along structures that contain earlier gold mineralization. These relationships indicate that mineralization began with porphyry intrusion and continued during emplacement of the lamprophyre bodies.

On Bull Mountain, Kiba cut and brecciated siliceous rocks of the EMV. Kiba intrusions contain sulfide minerals and formed in shear zones. These geologic relationships are similar to the ore setting at the Golden Sunlight Mine and suggest that mineralized zones may extend for several tens of kilometers north of the mine along Bull Mountain.

STRUCTURAL SUMMARY

1. Low-angle faulting (Late Cretaceous–Miocene?)
The Dearborn Canyon Fault (DCF) occurs near the contact between Kiba and Kemm in the southeast corner of the map area. The fault zone dips ~20°–30° east and contains sheared, spheroidal Kiba set in a cataclasite matrix (figs. 2G, 2H). It is unclear if the DCF represents a thrust fault, a listric normal fault, or both. Palinspastic restoration of Late Cretaceous volcanic strata to the west rotates the DCF to horizontal.

The DCF may be a thrust fault that rotated eastward during Basin and Range block uplift. The geometry of the DCF is similar to that of the Corridor Fault at the Golden Sunlight Mine. The Corridor Fault cuts the breccia pipe at the mine, and although the fault dips shallowly to the east, it originally acted as an east-directed thrust fault (Oyer and others, 2014). Diorite sills intruded Cambrian–Mississippian strata at 77 Ma (^{40}Ar-^{39}Ar on biotite) ~15 km east of the Golden Sunlight Mine and were then folded during thin-skinned shortening (Harlan and others, 2008). Andesitic intrusions (Kiba) in the DCF are not folded, but are sheared, and may have intruded a ramp in the fold-thrust belt.

2. Normal faulting (Eocene?)
Normal faults are exposed south and north of Big Chief Park at ~2,440 m (~8,000 ft) elevation. The faults are recognized by crude dip-slip lineations on north-striking fault surfaces. These faults may be transtensional pull-apart structures that formed within broad zones of northeast-striking, high-angle faults. For example, in Jack Creek, in the northeast map corner, north-striking normal faults formed as pull-apart structures during right-lateral slip on the northeast-striking, high-angle Jack Creek Fault. The age of faulting is constrained by fission track data that suggest block uplift between 50 and 55 Ma near the Golden Sunlight Mine (DeWitt and others, 1996). These structures appear to pre-date similarly oriented Basin and Range normal faults (discussed below), although a component of Quaternary movement cannot be ruled out.

3. Basin and Range block faulting (Miocene–Holocene?)
The Bull Mountain Western Border Fault (see map) controls modern topography and is continuous for nearly 30 km (20 mi). The fault formed during Neogene Basin and Range extension in southwestern Montana (e.g., Reynolds, 1979), and it dropped the Whitetail Valley down to the west relative to Bull Mountain (fig. 2A). Quaternary displacement on the fault is about 320 m (1,050 ft) (Stickney and others, 2000). If the fault formed prior to the Quaternary, which is likely for Basin and Range faults in southwestern Montana, then cumulative slip may be much greater.

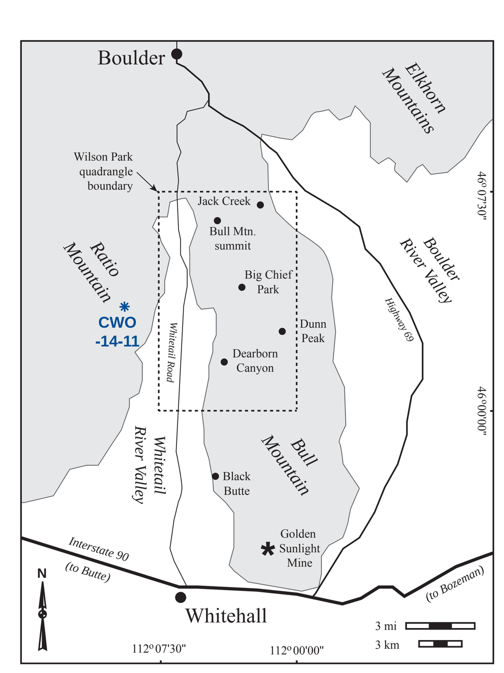


Figure 1. Location map of the Wilson Park 7.5' quadrangle. Also shown is the location of a tuff sample from the Ratio Mountain 7.5' quadrangle (CWO-14-11; table 1).

DESCRIPTION OF MAP UNITS

Sediments

Qal **Alluvium (Holocene)**—Well-sorted gravel, sand, silt, and clay along modern streams and floodplains. The unit is less than 3 m (10 ft) thick.

Qc **Colluvium (Holocene)**—Broad areas of debris found on hillsides and the upland basins or parks of Bull Mountain. Consists of a mantle of stony soils and unconsolidated deposits of boulder debris, resulting from slope wash, mudflows, creep, and related mass-wasting processes (Weeks, 1974). May include cliff debris, alluvial fan, and glacial deposits.

Qls **Landslide deposit (Holocene)**—Mass-wasting deposits of clay- to boulder-size sediment. Includes rotated or slumped blocks of bedrock and surficial sediment, soils, and mudflow deposits. Thickness undetermined.

Qta **Talus (Quaternary)**—Rock fragments, usually coarse and angular, found at the base of cliffs and steep slopes.

Qgt **Glacial till (Lower Pleistocene)**—Unconsolidated, coarse debris exposed on the crest of Bull Mountain. These deposits are characterized by unsorted, angular to rounded pebbles, cobbles, boulders, and angular blocks of many lithologies in a clay, silt, sand, and gravel matrix (Weeks, 1974). Thickness varies from 20 to 200 m (6 to 60 ft).

QTs **Sediment (Holocene–Eocene?)**—The age of the Whitetail Valley basin-fill is unknown. Valley sediments formed in response to Quaternary block faulting, and uplift of Bull Mountain along the active Bull Mountain Western Border Fault (Stickney and others, 2000). Recent faulting produced an apron of talus and broad alluvial fan deposits that effectively mask older sediments. The Whitetail Valley is the northern extent of the Jefferson Basin, which contains extensive Miocene through Eocene sediments of the Sixmile Creek and Renova Formations, respectively (Kuenzi and Fields, 1971). Thickness undetermined.

Late Cretaceous igneous rocks

Kg **Granitic plutons (Cretaceous)**—Plutonic rocks that crop out west of Bull Mountain resemble the Butte Granite, the principal pluton by volume of the Boulder Batholith. The granite is best exposed in the northwestern map corner where it thermally metamorphosed, and sheared the Elkhorn Mountains Volcanics at Fletcher Mountain (see map). Minerals include normal-zoned plagioclase (45–50%), orthoclase (20–30%), and quartz (5–10%) (Berg and Hargrave, 2004). Lund and others (2002) dated the Butte Granite at ~74.5 Ma using U/Pb geochronology. Plutonic rocks that crop out on the east side of Bull Mountain, in Quinn Creek specifically (see map), also resemble the Butte Granite.

Kiba **High-K andesitic vent complex (Cretaceous)**—Dioritic and gabbroic intrusive rocks, lamprophyre dikes and sills, and high-K basaltic to andesitic lavas and agglomerate. The vent complex formed within the middle member of the Elkhorn Mountains Volcanics (Kemm; discussed below). Angular fragments of Kemm in Kiba marks the intrusive contact. Intrusive rocks (table 1, samples 1–4 and 6) occur at lower elevations and transition to lavas and breccia near the top of Bull Mountain. An exception is a syeno-diorite laccolith (table 1, sample 5; fig. 3B) that has zoned augite phenocrysts >1 cm in length and forms Dunn Peak (fig. 2D). The laccolith is faulted up relative to the extrusive phase of the vent complex (see cross section). Lavas and breccia contain augite, olivine, and hornblende phenocrysts and are best exposed near Big Chief Park. Includes fine-grained dioritic to syeno-dioritic porphyries interpreted as intrusive equivalents to the Elkhorn Mountains Volcanics by Weeks (1974). Lamprophyre dikes (fig. 2E) contain biotite and augite phenocrysts. A metamorphic overprint of epidote, albite, and chlorite occurs throughout the igneous complex. The composite thickness of the high-K andesitic sequence ranges from ~600 to 1,200 m (1,970 to 3,940 ft).

Kbh **Hornblende basalts (Cretaceous)**—Porphyritic lava flows with hornblende phenocrysts commonly 1 cm in length (fig. 2C). A thin coating of epidote occurs on many fracture surfaces. In thin section the hornblende is pale green, pleochroic, and largely converted to actinolite. Maximum thickness is 75 m (246 ft). The unit has a preliminary age of 78.6 ± 0.17 Ma ($^{40}Ar/^{39}Ar$ from hornblende; J.H. Dilles, written commun., 2015).

Elkhorn Mountains Volcanics (Late Cretaceous)

Kemu **Upper member**—A sequence of dominantly water-lain andesitic tuffs and volcaniclastic sedimentary rocks ranging from conglomerate to mudstone. Contains a few lenticular beds of fresh-water limestone and some andesitic flows (Weeks, 1974). East of Bull Mountain, the unit consists of ~20 m (~65 ft) of water-lain tuff (fig. 2B) capped by 30 m (98 ft) of platy, maroon hornblende-bearing lavas. North of Bull Mountain, the unit consists of isolated beds of banded chert overlain by 50 m (164 ft) of maroon, welded ash-flow tuff. The welded tuff contains lapilli and lithics at its base and flattened pumice (fiamme) near the top. The top of the welded tuff is rheomorphic and preserves three eruptive pulses. West to east transport is indicated by flow structures that separate each pulse. The unit is ~50 to 75 m (~165 to 250 ft) thick.

Kemm **Middle member**—A sequence of moderate to strongly welded dacitic ignimbrites (table 1, samples 7 and RM) and interlayered epiclastic deposits. Includes interlayered well-bedded, ash-fall crystal tuffs (Weeks, 1974). The unit crops out in the vicinity of Dearborn Canyon where it is several hundred meters (~1,000 ft) thick. The base is bedded, blue and gray, andesitic tuff. Bedding cleavage in the andesitic tuff occurs at 10 to 15 cm (~4 to 6 in) spacing. The top ~150 m (~490 ft) of the sequence is a gray–maroon lithic-bearing welded tuff. Lithophysea (fig. 2F) occur in narrow zones near the base of the welded tuff and are on average 5 cm (~2 in) in length. The presence of lithophysea is an indicator of dense welding and divitrification of the tuff. Hexagonal quartz, Fe-oxide minerals, and epidote crystals line the lithophysea. Lithic clasts are sand to pebble size, and most are well rounded. Dark bands in the tuff are fiamme. The uppermost 50 m (164 ft) of welded tuff is fragmental and coarsens upward. Banded pumice and lithic clasts are typically 1 to 3 cm (~0.5 to 1.0 in) long, and occur in a purple breccia matrix. The clasts are 4 to 5 cm (~1.5 to 2.0 in), and as much as 8 cm (~3 in) long towards the top of the exposure. North of Bull Mountain, the welded tuff is rheomorphic; it exhibits isoclinal folding due to post-emplacement flow. The tuff is commonly recrystallized and deformed within a kilometer (~3,280 ft) of Late Cretaceous granite plutons (Kg). The exposed composite thickness ranges from ~300 to 1,000 m (~980 to 3,280 ft).

Cross section

PYz **(Paleozoic–Middle Proterozoic)**—Pre-Cretaceous rocks are not exposed in the Wilson Park quadrangle, but likely occur within 450 m (1,500 ft) below land surface. A bedded section of Devonian–Middle Proterozoic sedimentary rocks crop out at Black Butte (fig. 1) 5.6 km (3.5 mi) south of the quadrangle boundary, and along the east side of the Whitetail Road (McDonald and others, 2012). Black Butte rocks are a piece of the faulted west limb of a north-plunging regional syncline. The fold axis extends south to the Golden Sunlight mine, where Middle Proterozoic Belt rocks host the Late Cretaceous ore body (DeWitt and others, 1996).

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Location and Previous Mapping

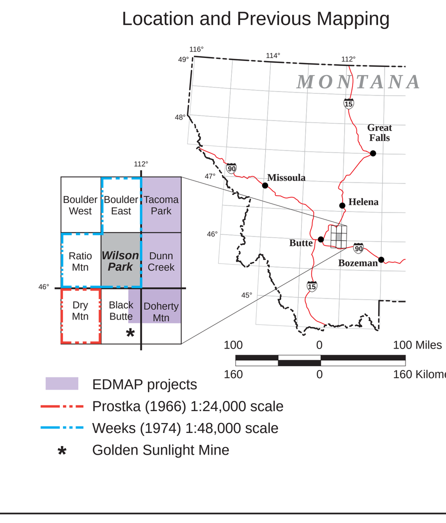

Table 1. Geochemical data for Late Cretaceous igneous rocks. Sample locations shown on the map. Note that sample CWO-14-11 comes from the Ratio Mountain (RM) quadrangle (shown on fig. 1).

#	1	2	3	4	5	6	7	8	RM
Sample ID	KCS-14-67	KCS-14-77	KCS-14-80	KCS-14-83	KCS-14-73	KCS-14-26	KCS-14-38	KCS-14-20	CWO-14-11
Map unit	Kiba	Kiba	Kiba	Kiba	Kiba	Kiba	Kemm	Kbh	*Kemm
XRF (wt. %)	intrusive						extrusive		
SiO_2	51.12	55.24	55.56	47.84	59.68	51.84	60.58	51.15	61.71
TiO_2	0.83	0.92	0.92	0.77	0.82	0.74	0.65	0.78	0.70
Al_2O_3	14.31	15.96	16.19	13.39	14.80	13.52	19.04	15.50	18.95
**FeO_{Total}	8.93	8.81	8.77	9.85	6.34	8.60	3.49	8.58	3.97
MnO	0.15	0.17	0.17	0.16	0.11	0.18	0.06	0.17	0.09
MgO	6.58	4.87	4.82	9.97	4.00	9.22	1.08	5.32	1.25
CaO	8.36	7.76	7.75	9.79	5.49	9.11	5.72	8.03	4.21
Na_2O	2.46	3.07	3.17	2.25	2.86	1.69	3.08	3.15	4.54
K_2O	2.98	2.11	2.11	2.96	4.35	3.37	3.42	2.94	3.08
P_2O_5	0.44	0.32	0.33	0.43	0.29	0.45	0.16	0.50	0.17
LOI	2.66	0.10	0.00	1.53	0.15	0.51	1.63	2.18	0.81
a.t.	96.17	99.23	99.77	97.41	98.74	98.71	97.29	96.12	98.67
Trace elements (ppm) (XRF)									
Ni	40	17	16	158	40	195	3	15	3
Cr	129	66	66	485	110	559	5	51	9
Sc	31	25	24	29	18	27	9	25	11
V	244	207	207	222	159	201	61	220	69
Ba	712	773	778	483	718	663	1258	735	1155
Rb	56	49	49	65	155	83	91	60	77
Sr	1101	1010	1042	1061	667	798	844	1471	769
Zr	86	137	137	82	252	94	269	99	290
Y	18	24	24	18	23	18	22	20	24
Nb	9	11	11	9	17	7	11	10	12
Ga	16	19	19	16	18	15	19	17	19
Cu	92	22	26	100	61	103	7	34	5
Zn	82	82	85	95	66	81	47	119	58
Pb	6	9	8	4	17	9	17	9	19
La	22	32	31	23	51	21	38	32	38
Ce	48	66	63	42	88	40	65	53	70
Th	4	7	6	4	22	4	9	6	10
Nd	25	31	28	24	36	20	28	25	29
U	1	3	3	3	5	1	2	3	2

* Sample was collected west of the map region in the Ratio Mountain 7.5' quadrangle **All Fe expressed as Fe^{2+}
Analysis performed by X-Ray Fluorescence (XRF) at Washington State University LOI = loss on ignition; a.t. = analytical total

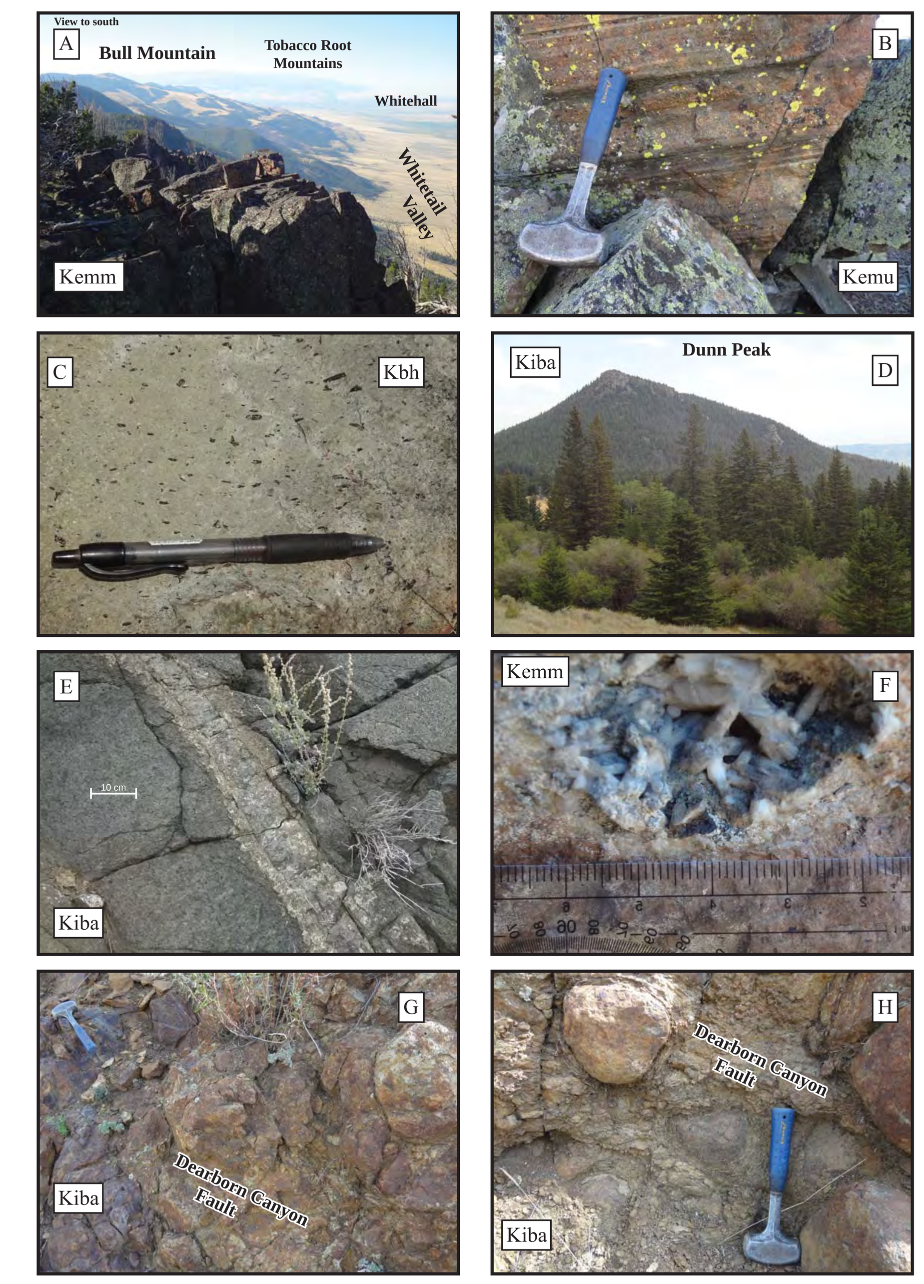

Figure 2. Photographs of rocks and features discussed in the text.

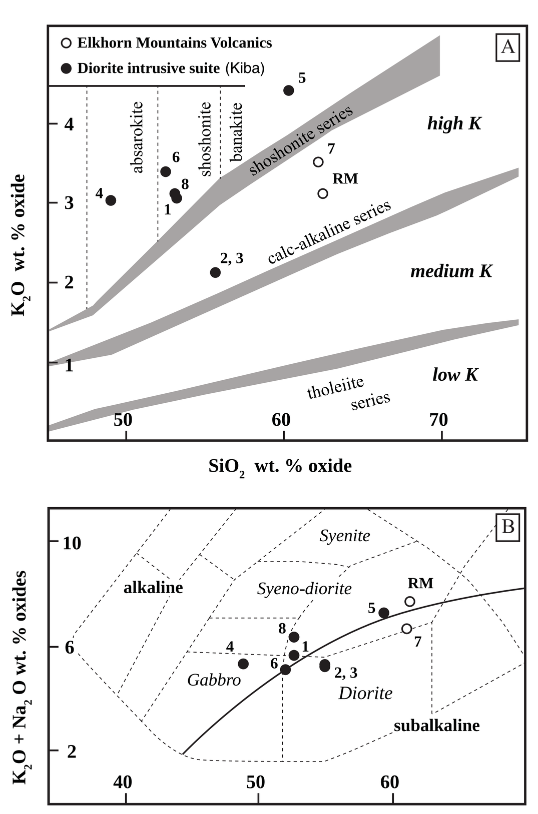

Figure 3. Late Cretaceous igneous rock compositions. Note that all samples are plotted on both diagrams. (A) Subdivision of high-K volcanic rocks after LeBas and others (1986) and Rickwood (1989). (B) Chemical classification of plutonic rocks after Wilson (1989). The curved solid line separates the alkalic and subalkalic fields.

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Geologic Map 66

Geologic Map of the Wilson Park 7.5' Quadrangle, Southwestern Montana

Kaleb C. Scarberry

2016