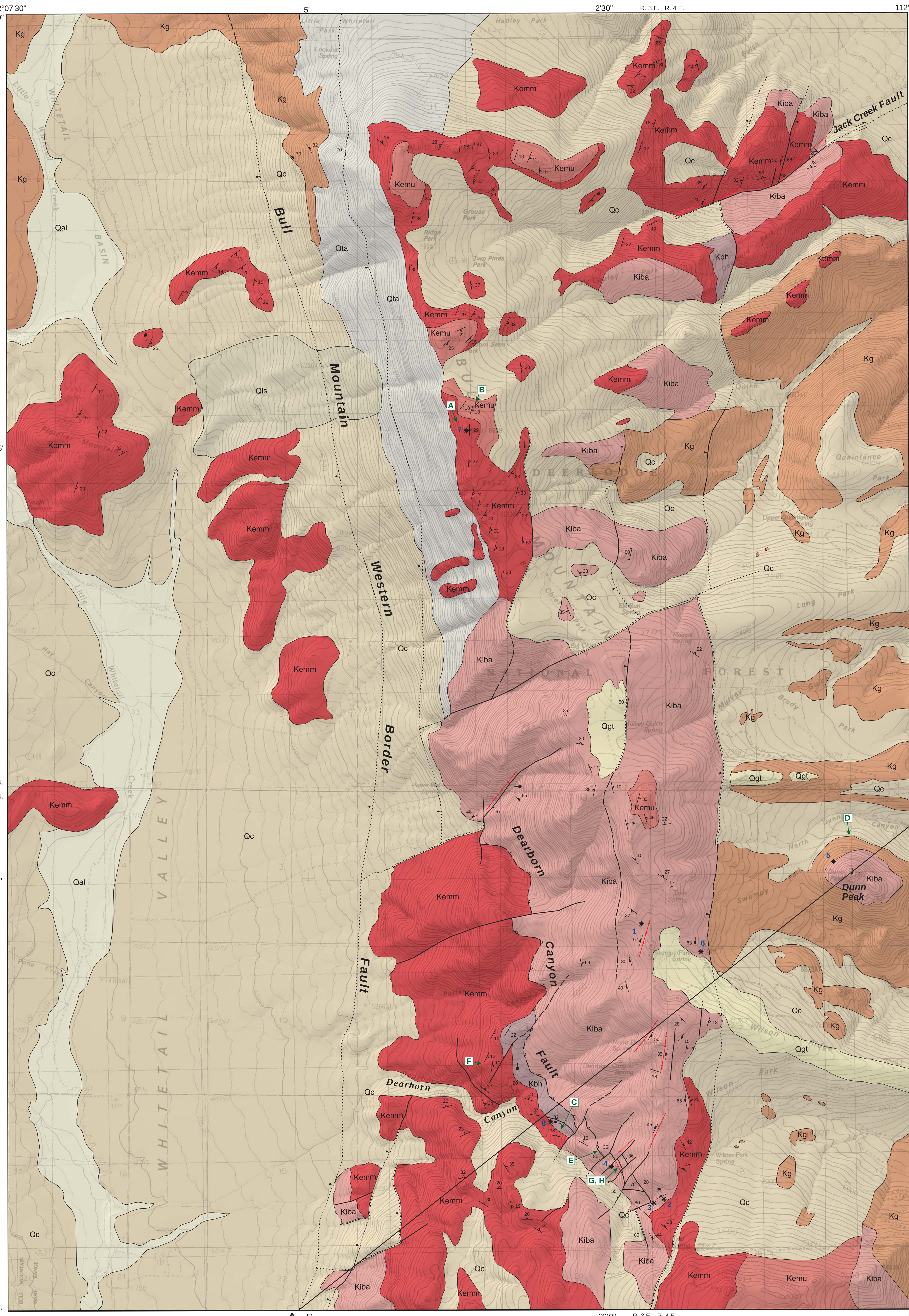
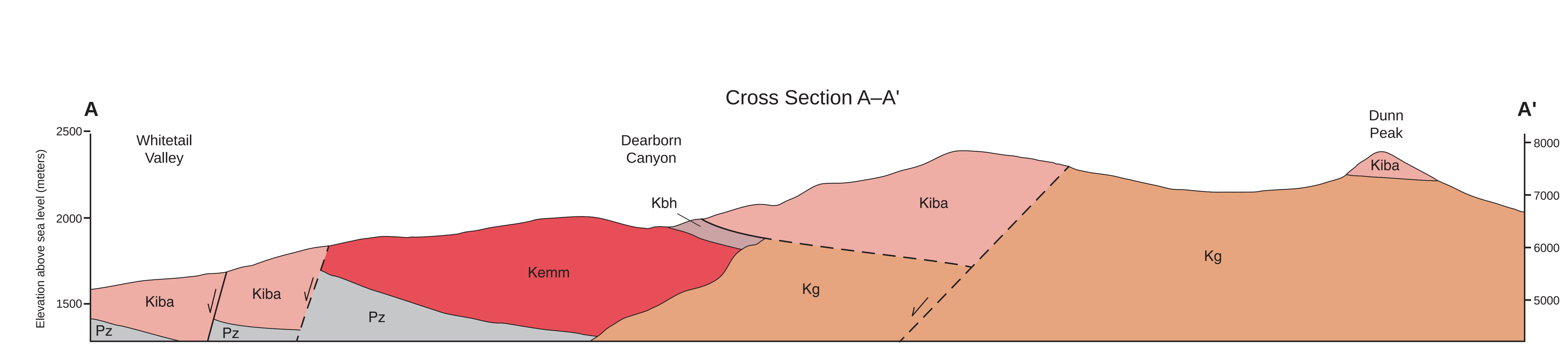


Base map produced by the United States Geological Survey
Wilson Park 1:24,000 scale quadrangle map
Control by: USGS and NOS/NOAA
Compiled from aerial photographs taken 1980
Field checked: 1981. Map edited 1985
Projection: Lambert Conformal Conic
Grid:1000 meter Universal Transverse Mercator Zone 12
UTM 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

N

SCALE 1:24,000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

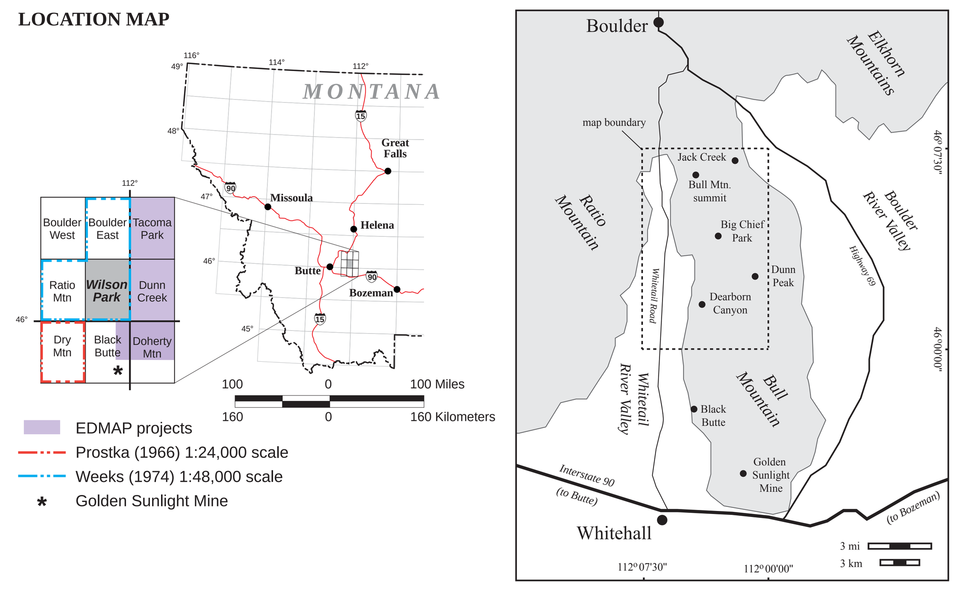
Maps may be obtained from:
Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-8997
Phone: (406) 496-4174 Fax: (406) 496-4451
http://www.mbmg.mtech.edu



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 G14AC00221.

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

LOCATION MAP



MAP SYMBOLS

- Contact: dashed where approximately located.
- Fault: dashed where approximately located, dotted where concealed, dip indicated where known; arrows show relative motion of fault slip.
- Normal fault: dashed where approximately located, dotted where concealed, bar and ball on downthrown side, dip indicated where known.
- Low-angle fault (unknown or unspecified sense of slip): dashed where approximately located; dotted where concealed, half-circles on upper plate, dip indicated where known.
- Quartz and/or sulfide-bearing mineral vein.
- Strike and dip of inclined eutaxitic volcanic foliation.
- Strike and dip of inclined bedding.
- Strike and dip of inclined joint.
- Strike and dip of vertical joint.
- Strike and dip of inclined cleavage.
- Sample location.
- Photo location. Arrow points towards perspective of view.

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 to the west.

#	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
	intrusive						extrusive		
XRF (wt. %)									
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

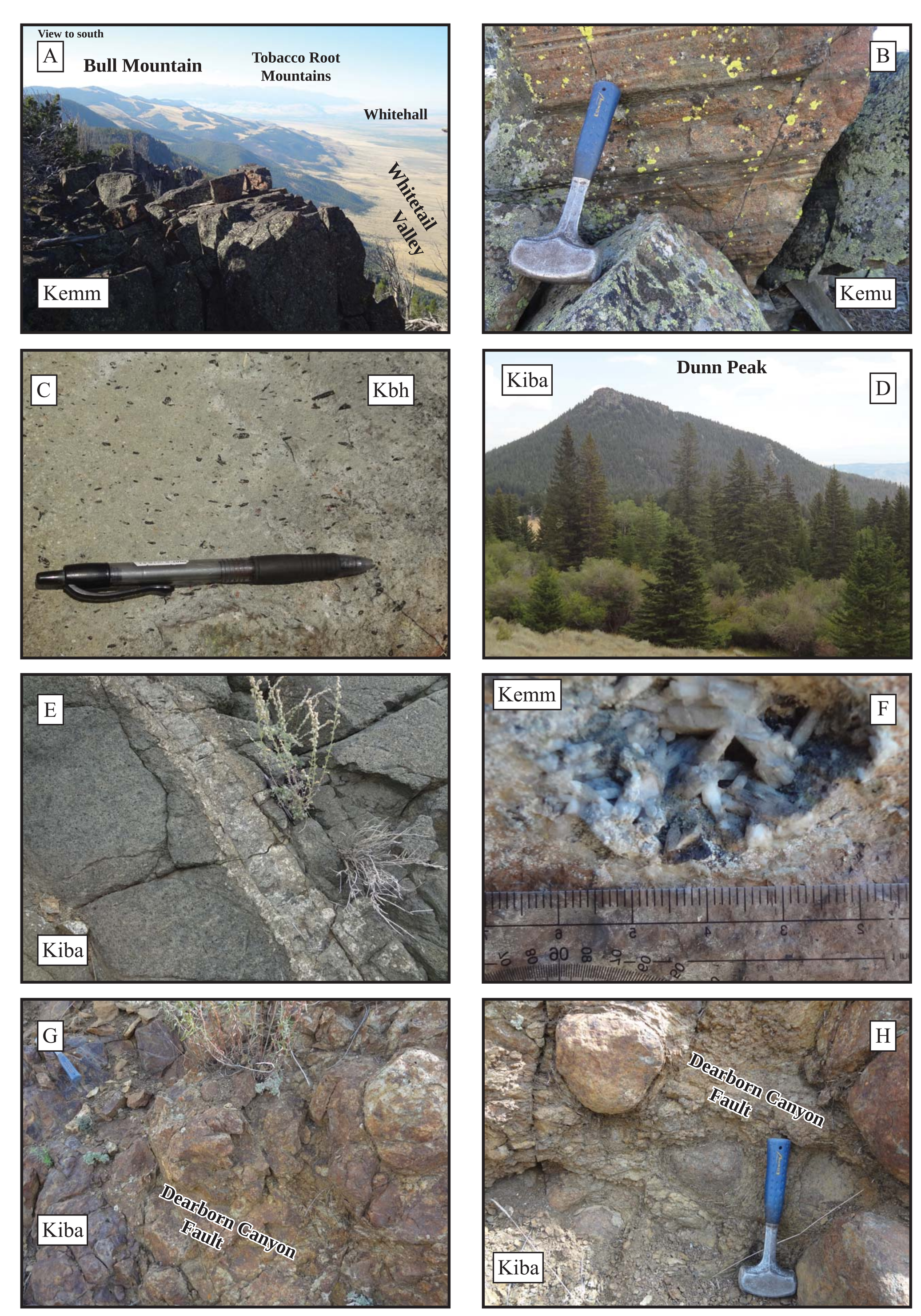
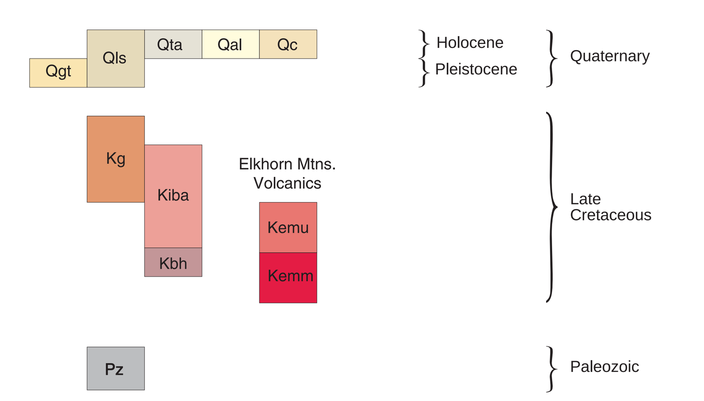


Figure 1. Photographs of rocks and features discussed in the map text.

CORRELATION DIAGRAM



INTRODUCTION

The Wilson Park 7.5′ quadrangle is located 16 km (10 mi) north of Whitehall in southwestern Montana. 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. 1A). 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. 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. 1A) and thin beds of water-lain tuff (fig. 1B) 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. 1A) and correlates with ignimbrite on the Ratio Mountain 7.5′ quadrangle to the west (compare sample #7 to “RM” in table 1 and on fig. 2A).

A high-K vent complex (Kiba) intruded the EMV on Bull Mountain. The vent is exposed over 27 km^2. Hornblende lavas (fig. 1C) from the complex are shoshonite (fig. 2A, table 1, sample 8), and feeder dikes and sills are gabbro, diorite, and syeno-diorite (SiO_2 = 47.9–59.7 wt. %) (fig. 2B). Coarsely porphyritic rocks of the shoshonite magma series (fig. 2A) are hybrids that likely formed during assimilation of gabbro by high-temperature syenitic 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 (see location map). 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 80 m.y. old (U-Pb) rhyolite breccia cut by 76.9 ± 0.5 Ma ($^{40}Ar/^{39}Ar$), high-K, lamprophyre bodies (DeWitt and others, 1996). The lamprophyre bodies contain high-grade gold where emplaced into shear zones. These relationships indicate that mineralization began with porphyry intrusion and continued during emplacement of the lamprophyre bodies.

Similar geologic relationships suggest that mineralization may extend north into the Wilson Park quadrangle. On Bull Mountain, high-K intrusions cut and brecciate siliceous rocks of the Late Cretaceous EMV. Intrusions emplaced into shear zones contain sulfide minerals, which are currently being analyzed for gold.

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 deformed bodies of Kiba. Kiba dikes intruded the fault (hammer on rock, fig. 1G) and are sheared to spheroidal balls set within a matrix of cataclasite (fig. 1H). 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. If Kiba dikes in the DCF are related to high-K lamprophyres at the Golden Sunlight Mine, then faulting began prior to ~77 Ma.

2. Normal faulting (Eocene?)
Normal faults are exposed south of Big Chief Park at ~2,440 m (~8,000 ft) elevation, and are recognized by crude dip-slip lineations on north-striking fault surfaces. These faults may be 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, although some component of Quaternary movement cannot be ruled out.

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. 1A). Quaternary displacement on the fault is on the order of 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.

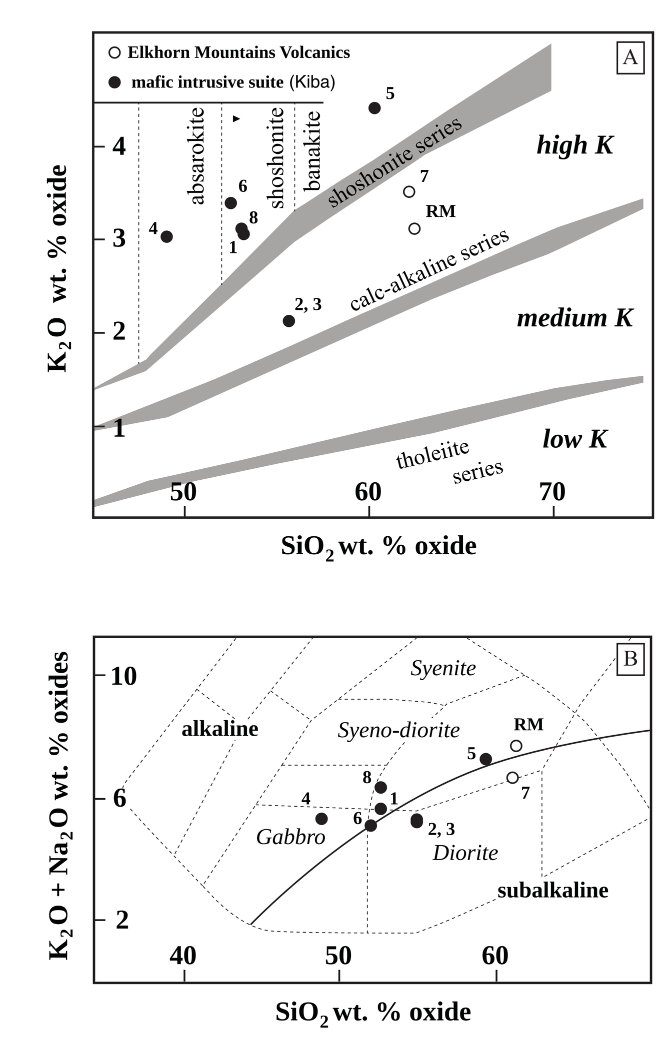


Figure 2. Late Cretaceous igneous rock compositions. Note that all samples are plotted on both diagrams. (A) Subdivision of high-K volcanic rocks after LeBas and others (1986) and Rickwood (1989). (B) Chemical classification of plutonic rocks after Wilson (1989). The curved solid line separates the alkalic and subalkalic fields.

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 and alluvial fan deposits. Thickness undetermined.

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

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.

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).

Late Cretaceous igneous rocks

Kg **Granitic plutons (Cretaceous)**—Plutons that crop out west of Bull Mountain resemble the Butte Granite, the principal pluton by volume of the Boulder Batholith, which is best exposed in the northwestern map corner. Here the granitic pluton thermally metamorphosed the Elkhorn Mountains Volcanics along the intrusive contact between the units. 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. Plutons that crop out along the east side of Bull Mountain also resemble the Butte Granite. MacLaurin and others (2012) described these plutonic rocks as white and black, equigranular granodiorite to diorite with smoky gray quartz, biotite, and hornblende in varying amounts.

Kiba **Intrusive rock, basaltic and andesitic, related to the Elkhorn Mountains Volcanics (Cretaceous)**—High-K vent complex. Most rocks of the complex exhibit intrusive texture, but lavas and flow breccia occur also. Includes fine-grained dioritic to syeno-dioritic porphyries mapped as intrusive equivalents to the Elkhorn Mountains Volcanics by Weeks (1974). These rocks contain augite, olivine, and hornblende phenocrysts. Lamprophyre dikes (fig. 1E) contain biotite. A metamorphic overprint of epidote, albite, and chlorite occurs throughout the igneous complex. Angular fragments of Kemm occur at the intrusive contact. A syeno-diorite laccolith (table 1, sample 5; fig. 2B) forms Dunn Peak (fig. 1D) and contains zoned augite crystals >1 cm long. The composite thickness of the high-K 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 long. In thin section the hornblende is pale green, pleochroic, and largely converted to actinolite. A thin coating of epidote occurs on many fracture surfaces. Maximum thickness is 75 m (246 ft).

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. 1B) capped by 30 m (98 ft) of platy, maroon, and welded 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 ash-flow tuffs, most of which are weakly to strongly welded, and some 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. Miarolitic cavities (fig. 1F) occur in narrow zones near the base of the welded tuff and are on average 5 cm (~2 in) in length. Hexagonal quartz, Fe-oxide minerals, and epidote crystals line the miarolitic cavities. 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. Within a kilometer (~3,280 ft) of Late Cretaceous granite plutons (Kg), the tuff is recrystallized and deformed. The exposed composite thickness ranges from ~300 to 1,000 m (~980 to 3,280 ft).

Cross section

Pz **Paleozoic**—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 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 syncline. The fold axis extends south to the Golden Sunlight mine, where Middle Proterozoic Belt rocks host the ore body (DeWitt and others, 1996).

REFERENCES

Berg, R.B., and Hargrave, P.A., 2004, Geologic map of the Upper Clark Fork Valley: Montana Bureau of Mines and Geology Open-File Report 506, scale 1:50,000.

DeWitt, E., Foord, E.E., Zartman, R.E., Pearson, R.C., and Foster, F., 1996, Chronology of Late Cretaceous igneous and hydrothermal events at the Golden Sunlight gold-silver breccia pipe, southwestern Montana: U.S. Geological Survey Bulletin 2155, 48 p.

Dixon, R.M., and Wolfgram, D., 1998, Bedrock geology of the Elkhorn Mountains Volcanics in the southern Bull Mountain area, Jefferson County, Montana, Montana Bureau of Mines and Geology Open File 374, scale 1:24,000.

Klepper, M.R., Weeks, R.A, and Ruppel, E.T., 1957, Geology of the southern Elkhorn Mountains, Jefferson and Broadwater Counties, Montana: U.S. Geological Survey Professional Paper 292, 82 p.

LeBas, M.J., LeMaitre, R.W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali silica diagram: Journal of Petrology, v. 27, p. 745–750.

Lund, Karen, Aleinikoff , J.N., Kunk, M.J., Unruh, D.M., Zeihen, G.D., Hodges, W.C., du Bray, E.A., and O’Neill, J.M., 2002, SHRIMP U-Pb and $^{40}Ar/^{39}Ar$ age constraints for relating plutonism and mineralization in the Boulder Batholith region, Montana: Economic Geology, v. 97, p. 241–267.

MacLaurin, C., Mahoney, J.B., Guy, A., Forgette, M., Kjos, A., Witkop, C., Kohel, C., Balgord, E., Barber, B., and Ihinger, P.D., 2012, Geologic map of the Dunn Creek 7.5′ quadrangle, west-central Montana, Montana Bureau of Mines and Geology EDMAP 9, scale 1:24,000.

Mahoney, J.B., Nawikas, J., Kjos, A., Stolz, J., MacLaurin, C., and Kohel, C., 2008, Geologic map of Tacoma Park 7.5′ quadrangle west-central Montana, Montana Bureau of Mines and Geology Open File 564, scale 1:24,000.

McDonald, C., Elliott, C.G., Vuke, S.M., Lonn, J.D., and Berg, R.B., 2012, Geologic map of the Butte South 30′ x 60′ quadrangle, southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 622, scale 1:100,000.

Oyer, N., Childs, J., and Mahoney, J.B., 2014, Regional setting and deposit geology of the Golden Sunlight Mine: An example of responsible resource extraction, *in* Shaw, C.A., and Tikoff, B., eds., Exploring the Northern Rocky Mountains: Geological Society of America Field Guide 37, p. 115–144.

Porter, E.W., and Ripley, E., 1985, Petrologic and stable isotope study of the gold-bearing breccia pipe at the Golden Sunlight deposit, Montana: Economic Geology, v. 80, p. 1689–1706.

Prostka, H.J., 1966, Igneous Geology of the Dry Mountain Quadrangle, Jefferson County, Montana, U.S. Geological Survey Bulletin 1221-F, scale 1:24,000.

Prostka, H.J., 1973, Hybrid origin of the absarokite-shoshonite-banakite series, Absaroka volcanic field, Wyoming: Geological Society of America Bulletin, v. 84, p. 697–702.

Reynolds, M.W., 1979, Character and extent of Basin-Range faulting, western Montana and east-central Idaho, *in* Newman, G.W., and Goode, H.D., eds., Rocky Mountain Association of Geologists and Utah Geological Association Basin and Range Symposium, p. 185–193.

Rickwood, P.C., 1989, Boundary lines within petrologic diagrams which use oxides of major and minor elements, Lithos, v. 22, p. 247–263.

Stickney, M.C., Haller, K.M., and Machette, M.N., 2000, Quaternary faults and seismicity in western Montana, Montana Bureau of Mines and Geology Special Publication 114, 1 sheet, scale 1:750,000.

Wilson, M., 1989, Igneous petrogenesis, Unwin Hyman, London.

Weeks, R.A., 1974, Geologic map of the Bull Mountain area, Jefferson County, Montana: U.S. Geological Survey Open-File Report 74-354, scale 1:48,000.

Montana Bureau of Mines and Geology

MBMG Open-File Report 668

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

Kaleb C. Scarberry

2015