U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3382
Sheet 1 of 2
Pamphlet accompanies map

View north of ash bed (white layer ~30 centimeters [cm] thick), about 1 meter (m) below the top of an exposed section of Dry Union Formation, just below the Qg2 outwash gravel deposit, on which the person is standing. Note the few clasts of unit Qg2 in colluvial mantle in the lower left of the photo. The ash bed in the photo is correlated with dated ash exposed at location B, about 0.9 kilometers (km) southwest of photo. The ash bed at location B has a U-Pb zircon age of 10.233±0.032 Ma (table 2). Figure 9 in text.

The Upper Arkansas River Valley

EXPLANATION
Qu Surficial deposits (Quaternary)
Nd Dry Union Formation and Santa Fe Group (Pliocene and Miocene)
₽s Predominantly sedimentary deposits (Oligocene and Eocene)
₽v Volcanic rocks (Oligocene and Eocene)
₽t Ignimbrites of San Juan and Thirtynine Mile volcanic fields (early Oligocene to middle Eocene)
₽Kg Felsic, mostly porphyritic intrusive rocks (Oligocene to Late Cretaceous)
₽lg Leucogranite suite of Mount Antero (early Oligocene)
₽ma Monzogranite of Mount Aetna (late Eocene)
₽mp Rocks of Mount Princeton batholith (late Eocene)
₽cs South Park Formation (Paleocene and Upper Cretaceous)
Mzu Upper Cretaceous to Triassic sedimentary rocks
Pzu Paleozoic sedimentary rocks
Yg Mesoproterozoic granite and granodiorite
YXg Intrusive rocks of either Mesoproterozoic or Paleoproterozoic age—Mostly granitic rock
Xg Intrusive rocks of Paleoproterozoic age
Xm Metasedimentary rocks (Paleoproterozoic)
Xvs Metavolcanic and metasedimentary rocks of the Gunnison-Salida metamorphic belt Paleoproterozoic)
Contact
Normal fault—Bar and ball on downthrown side
Reverse fault—Rectangles on upthrown block (hanging wall)
Fault—Type undetermined. Dashed where location is concealed
Mount Aetna cauldron ring-dike
COLORADO
DENVER
Map area
MAP LOCATION

Regional structure map of the mapped area. Figure 1-4 in text.

View to the north of Buffalo Peaks, which are composed mostly of andesite flows, andesite breccias, lahars, and welded tuff deposited on Mesoproterozoic granite. The peak on the left is West Buffalo Peak (4,062 meters [m]; 13,326 feet [ft]) and the peak on the right is East Buffalo Peak (4,054 m; 13,330 ft). Figure 10 in text.

Bighorn sheep on a large outcrop of Langhoff Gulch Granite, about 5 km north of the town of Granite, Colo. Photograph by K.S. Kellogg, July 2013.

Table 2. Isotopic ages for rocks in the upper Arkansas Valley region.

[No., line number; --, for symbol on map, indicates location uncertain or unit was sampled outside of the map area; --, for sample number, indicates no number given;σ, sigma, standard deviation; rasp., raspberry; rhy, rhyolite; p'phy, porphyry.]

No.	Symbol on map	Sample number	Rock type		USGS 7½' quadrangle	Age±2σ	Reference
1	A	RGB12102	Dry Union Formation, ash layer	Nd	Salida West	9.30±0.04(s)[2]	Morgan and Cosca, 2017
3	B	PP15147B	Dry Union Formation, ash layer	Nda?	Salida East	15.6±0.3[2]	Morgan and Cosca, 2017
4	C	--	Dry Union Formation, ash layer	Nda	Maysville	13.5±0.2[2,8]	Hubbard and others, 2001
5	C	--	Dry Union Formation, ash layer	Nda	Maysville	14.4±1.4[2,8]	Hubbard and others, 2001
6	--	--	Late felsite dike (Rasp. Gulch rhy)	₽ar	Mount Antero	22±1 (w)[3]	Limbach, 1975
7	D	GR11–711	Basaltic andesite porphyry flow	₽bf	Granite	24.12±0.12 (h)[2]	Shroba and others, 2014
8	E	GR11–756	Quartz porphyry stock	₽rc	Granite	24.3±0.6 (s?)[2]	Shroba and others, 2014
9	--	--	High-silica rhyolite dike	₽rp	--	26.1±1.0[3]	Limback, 1975[5]
10	--	--	Leucogranite of Mount Antero	₽ag	Mount Antero?	29.97±0.13 (b,m)[2,8]	McIntosh and Chapin, 2004
11	--	--	Rhyolite of Bald Mtn, upper flow	₽nr	Buena Vista East	29.25±0.12 (p)[2,8]	McIntosh and Chapin, 2004
12	--	--	Rhyolite of Ruby Mtn	₽nr	Buena Vista East	29.25±0.21 (s)[2,8]	McIntosh and Chapin, 2004
13	--	--	Rhyolite of Ruby Mtn	₽nr	Buena Vista East	30.47±0.08 (s)[2,8]	McIntosh and Chapin, 2004
14	--	--	Rhyolite of Ruby Mtn lower flow	₽nr	Buena Vista East	30.74±0.08 (s)[2,8]	McIntosh and Chapin, 2004
15	--	--	California bt-granite leucogranite	₽cg	Mount Antero	30.7±1.1[3]	Coolbaugh, 1985[6]
16	--	MP–27	Granite of North Fork	₽nf	--	31.37±0.18[1]	Zimmerer and McIntosh, 2012
17	--	--	Rhyodacite flow and tuff	₽rd	Poncha Pass	33.2±1.3 (b)[3]	Van Alstine, 1974
18	--	--	Bonanza Tuff	₽bt	--	33.31±0.08 (s)[2,8]	McIntosh and Chapin, 2004
19	--	--	Bonanza Tuff	₽bt	--	33.42±0.20 (s)[2,8]	McIntosh and Chapin, 2004
20	--	--	Bonanza Tuff	₽bt	--	33.12±0.03 (s)[2]	Lipman and others, 2015
21	--	--	Badger Creek Tuff	₽bc	--	34.83±0.22[1]	Zimmerer and McIntosh, 2012
22	--	--	Mount Aetna ring dike	₽ma	--	34.57±0.18[2,8]	McIntosh and Chapin, 2004
23	--	--	Monzogranite of Mount Aetna	₽ma	--	34.51±0.90[2,8]	McIntosh and Chapin, 2004
24	--	MP–21	Monzogranite of Mount Aetna	₽ma	--	34.36±0.59[1]	Zimmerer and McIntosh, 2012
25	--	NM–2117	Basaltic lava, Tenderfoot Hill	₽ab	Salida East	34.31±0.16[2,8]	Kellogg and others, 2017
26	--	NM–2118	basaltic lava, Tenderfoot Hill	₽ab	Salida East	34.34±0.14[2,8]	Kellogg and others, 2017
27	--	NM–2116	basaltic lava, Tenderfoot Hill	₽ab	Salida East	35.74±1.17[2,8]	Kellogg and others, 2017
28	--	--	Late white porphyry	₽lw	Climax	34.9±3.8[7]	Bookstrom, 1989
29	--	--	Late white porphyry	₽lw	--	38.5[3]	Pearson and others, 1962
30	--	--	Andesite of Triad Ridge	₽cn	Buena Vista East	36.61±0.10[2,8]	McIntosh and Chapin, 2004
31	F	MOS–4	Little Union Quartz Latite	₽lu	Leadville South	36.3±0.2[1]	Kellogg and others, 2017
32	--	NM–2120	Capping andesite, Buffalo Peaks	₽a	Marmot Peak	38.28±0.56[2,8]	Kellogg and others, 2017
33	--	1303	Tuff of Buffalo Peaks	₽tu	Marmot Peak	38.68±0.32 (h)[2,8]	McIntosh and Chapin, 2004
34	G	HL09–170–1	lower tuff of Buffalo Peaks	₽tl	Harvard Lakes	37.9±0.3 (h)[2]	Kellogg and others, 2013
35	--	--	Upper tuff of Triad Ridge	₽tr	Buena Vista East	36.69±0.32 (s)[2,8]	McIntosh and Chapin, 2004
36	--	--	Lower tuff of Triad Ridge	₽tr	Buena Vista East	37.96±0.22 (b,h)[2,8]	McIntosh and Chapin, 2004
37	--	--	Tuff of Triad Ridge	₽tr	Buena Vista East	37.66±0.11[2,8]	Wallace and Keller, 2003
38	--	--	Tuff of Triad Ridge	₽tr	Buena Vista East	38.45±0.30[2,8]	Wallace and Keller, 2003
39	--	--	Wall Mountain Tuff	₽wm	--	37.17±0.09[2,8]	McIntosh and Chapin, 2004
40	--	--	Wall Mountain Tuff	₽wm	--	37.25±0.10[4]	Zimmerer and McIntosh, 2012
41	--	--	Mount Princeton batholith	₽mp	--	34.75±0.21[2,8]	McIntosh and Chapin, 2004
42	--	--	Mount Princeton batholith	₽mp	--	36.6±0.4[5]	McCalpin and Shannon, 2005
43	--	--	Mount Princeton batholith	₽mp	--	35.80±0.10[1]	Mills and Coleman, 2013
44	--	--	Mount Princeton batholith	₽mp	--	35.37±0.10[1]	Mills and Coleman, 2013
45	H	MOS–20	Johnson Gulch Porphyry	₽gj	Mount Sherman	39.5±0.6[1]	Kellogg and others, 2017
46	I	GR11–725	White felsite porphyry	₽wf	Granite	42.25±0.13[2]	Shroba and others, 2014
47	--	TL	Twin Lakes Granodiorite p'phy	₽tl	Mount Elbert	42.7±1.2 (b)[3]	Obradovich and others, 1969
48	--	R8–28–84–8a	Twin Lakes Granodiorite p'phy	₽tl	Mount Elbert	64.6±1.4 (h)[2,8]	Fridrich and others, 1998
49	--	NM–2124	Granite porphyry of Tumble Hill	₽gt	Jones Hill	60.64±0.17[2,8]	Kellogg and others, 2017
50	--	NM–2125	Granite porphyry of Tumble Hill	₽gt	Jones Hill	60.57±0.16[2,8]	Kellogg and others, 2017
51	--	NM–2126	Granite porphyry of Tumble Hill	₽gt	Jones Hill	60.58±0.15[2,8]	Kellogg and others, 2017
52	J	MOS–5	correlated with Pando Porphyry	₽Kw	Mount Sherman	64.1±0.9[1]	Kellogg and others, 2017
53	--	--	correlated with Pando Porphyry	₽Kw	--	71.8[3]	Cunningham and others, 1994
54	--	--	Granite porphyry of Black Mtn.	₽gp	Jones Hill	60.97±0.15[2]	Widmann and others, 2011
55	K	HL09–44	Monzodiorite dike	₽Km	Harvard Lakes	65.3±0.5 (b)[2]	Kellogg and others, 2013
56	L	HL09–89	Hornblende syenodiorite	₽Km	Harvard Lakes	65.4±0.5 (b)[2]	Kellogg and others, 2013
57	M	HL09–136	Hornblende-biotite diorite plug	₽Km	Harvard Lakes	68.1±0.9 (b)[2]	Kellogg and others, 2013
58	N	USGS(D)G–A–82	Rhyolite dike	₽Kw	Granite	65.3±2.4[3]	Marvin and others, 1989
59	--	--	Whitehorn Granodiorite	Kwg	Salida East?	69.4±2.1 (h)[3]	McDowell, 1971
60	--	--	Whitehorn Granodiorite	Kwg	Salida East?	70.0±2.1 (b)[3]	Wrucke, 1974
61	--	--	Whitehorn Granodiorite	Kwg	Salida East?	70.4±2.1 (b)[3]	McDowell, 1971
62	--	9–13–84–1	Browns Pass Granite	Ybp	Mount Yale	1,439±11[1]	Moscati and others, 2012
63	--	CO–38	Browns Pass Granite	Ybp	Mount Yale?	1,420±35 (w)[3]	Wetherill and Bickford, 1965
64	O	8–3–83–1	Granodiorite of Mount Harvard	Ygdh	Mount Harvard	1,414±20[1]	Moscati and others, 2012
65	P	9–8–83–1	Granodiorite of Mount Elbert	Ygdm	Mount Elbert	1,415±15[1]	Moscati and others, 2017
66	Q	WRP–03–6B	Granite of Granite	Ygrg	Granite	1,429±9[1]	Moscati and others, 2017
67	R	GR10–511	Granite of Granite	Ygrg	Granite	1,434±6[1]	Moscati and others, 2017
68	S	8–31–84–3	Langhoff Gulch Granite	Ygl	Mount Sherman	1,435±26[1]	Moscati and others, 2017
69	T	9–1–84–10	St. Kevin Granite	Ygs	Mount Massive	1,425±12[1]	Moscati and others, 2017
70	U	HL09–53	Langhoff Gulch Granite	Ygl	Harvard Lakes	1,441±54[1]	Moscati and others, 2017
71	V	MP09–191	Langhoff Gulch Granite	Ygl	Marmot Peak	1,438±11[1]	Moscati and others, 2017
72	W	WRP03–7	Elephant Rock Granite	Yge	Buena Vista East	1,434±8[1]	Moscati and others, 2017
73	X	HL09–121	Elephant Rock Granite	Yge	Harvard Lakes	1,436±8[1]	Moscati and others, 2017
74	--	RB8–10–83–1	Granodiorite	--	Winfield	1,436±11[1]	Moscati and others, 2017
75	Y	R8–17–83–2A	Granite of Mount Yale	Xgy	Mount Yale	1,695±11[1]	Moscati and others, 2017
76	Z	8–11–84–3	Denny Creek Granodiorite	Xdk	Mount Elbert	1,691±5[1]	Moscati and others, 2017
77	--	R8–20–84–1	Denny Creek Granodiorite	Xdk	Mount Harvard	1,710±10[1]	Moscati and others, 2017
78	AA	Bickford	Henry Mountain? Granite	Xgd	Cameron Mountain	1,672±5[1]	Bickford and others, 1989
79	BB	CM11–736	Henry Mountain? Granite	Xgd	Cameron Mountain	1,709±6[1]	Moscati and others, 2017
80	CC	WRP03–8	Metadacite of Salida	Xvs	Salida East	1,732±4[1]	Kellogg and others, 2017
81	DD	Z–3	Metadacite of Salida	Xvs	Salida East	1,728±6[1]	Bickford and others, 1989

[1] Mean $^{207}Pb/^{206}Pb$ zircon age or U-Pb zircon concordia age.
[2] $^{40}Ar/^{39}Ar$ date. Mineral dated: p, plagioclase; s, sanidine; b, biotite; m, muscovide; h, hornblende.
[3] K/Ar ages. Mineral dated: b, biotite; h, hornblende; w, whole rock; no letter, not specified.
[4] Weighted mean of five $^{40}Ar/^{39}Ar$ ages in sanadine.
[5] Average of twenty-one K-Ar and fission-track ages.
[6] Recalculated by Shannon, 1988.
[7] Apatite fission-track age.
[8] Recalculated using revised standards for Fish Canyon Tuff sanidine (Kuiper and others, 2008)

Federal lands information was obtained from the U.S. Geological Survey *The National Map,* May 2017 at https://nationalmap.gov/small_scale/atlasftp.html?openChapters=chpbound#chpbound and the Bureau of Land Management, May 2017 at https://navigator.blm.gov/data. There may be private inholdings within the boundaries of National or State reservations shown on this map.

Seleced boundaries. Generalized selected Federal boundaries in the map area. FCW, Fossil Creek Wilderness; LNFH, Leadville National Fish Hatchery; RGNF, Rio Grande National Forest; SDCW, Sangre de Cristo Wilderness; WRNF, White River National Forest.

Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in)
centimeter (cm)	0.3937	inch (in)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Flow rate	
cubic meter per second (m^3/s)	0.3861	cubic foot per second (ft^3/s)
	Mass	
metric ton (t)	1.102	ton, short [2,000 lb]

U.S. customary units to International System of Units

Multiply	By	To obtain
	Mass	
ounce, avoirdupois (oz)	28.35	gram (g)
ton, short (2,000 lb)	0.9072	metric ton (t)

Altitude, as used in this report, refers to distance above sea level.

Topographic base from U.S. Geological Survey 1:100,000-scale Bailey, 1983; Leadville, 1983; Gunnison, 1984; and Pikes Peak, 1983
Shaded relief base from U.S. Geological Survey National Elevation Dataset (NED), accessed on March 15, 2016 at https://lta.cr.usgs.gov/NED
North American Datum of 1927 (NAD 27)
Universal Transverse Mercator, zone 13
Boundary of Browns Canyon National Monument from the Bureau of Land Management, April 26, 2017

There may be private inholdings within the boundaries of the National and State reservations shown on this map. This map is not a legal document. Public lands are subject to change and leasing, and may have access restrictions; check with appropriate offices. Obtain permission before entering private lands.

APPROXIMATE MEAN DECLINATION, 2016

SCALE 1:50 000

CONTOUR INTERVAL 50 METERS
NORTH AMERICAN VERTICAL DATUM 1929

Geologic Map of the Upper Arkansas River Valley Region, North-Central Colorado

By

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2017

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