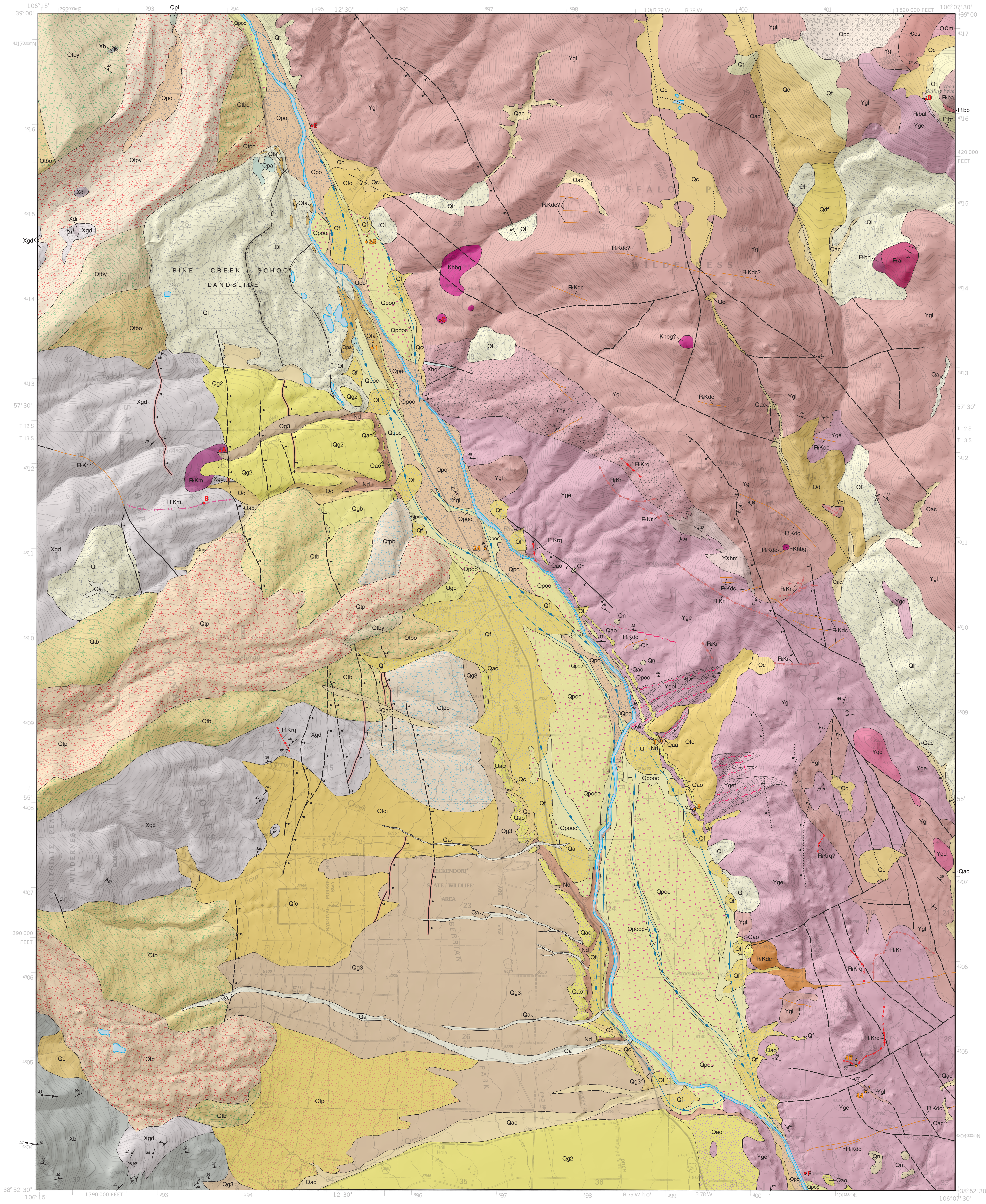
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3267
Pamphlet accompanies Map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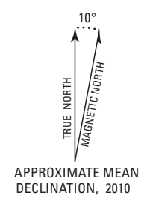
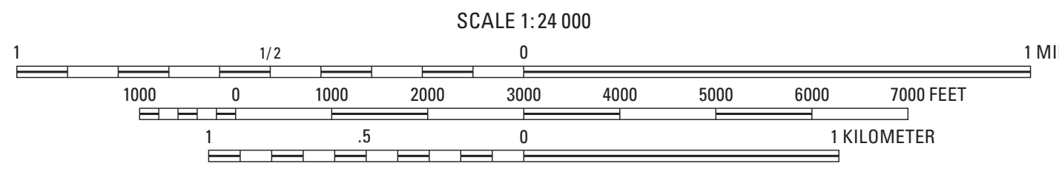
PINE CREEK SCHOOL LANDSLIDE
BUFFALO PEAKS
WILDERNESS
SAN ISABEL NATIONAL FOREST
COLLEGIATE PEAKS WILDERNESS
PIKE NATIONAL FOREST
HECKENDORF STATE WILDLIFE AREA
BERRIAN PARK
West Buffalo Peak
Four Mile Creek
Three Elk Creek
Elephant Rock
Americus
Langhoff Gulch
Fourmile Creek
Drill Hole
Athletic Field

Base from U.S. Geological Survey Harvard Lakes, Colo., 1:24,000
North American Datum of 1927 (NAD 27)
Projection and 10,000-foot ticks: Colorado coordinate system, central zone (Lambert conformal conic)
Universal Transverse Mercator, zone 13


10°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2010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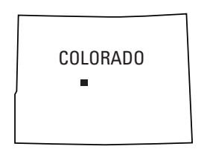
CONTOUR INTERVAL OF 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



MAP LOCATION

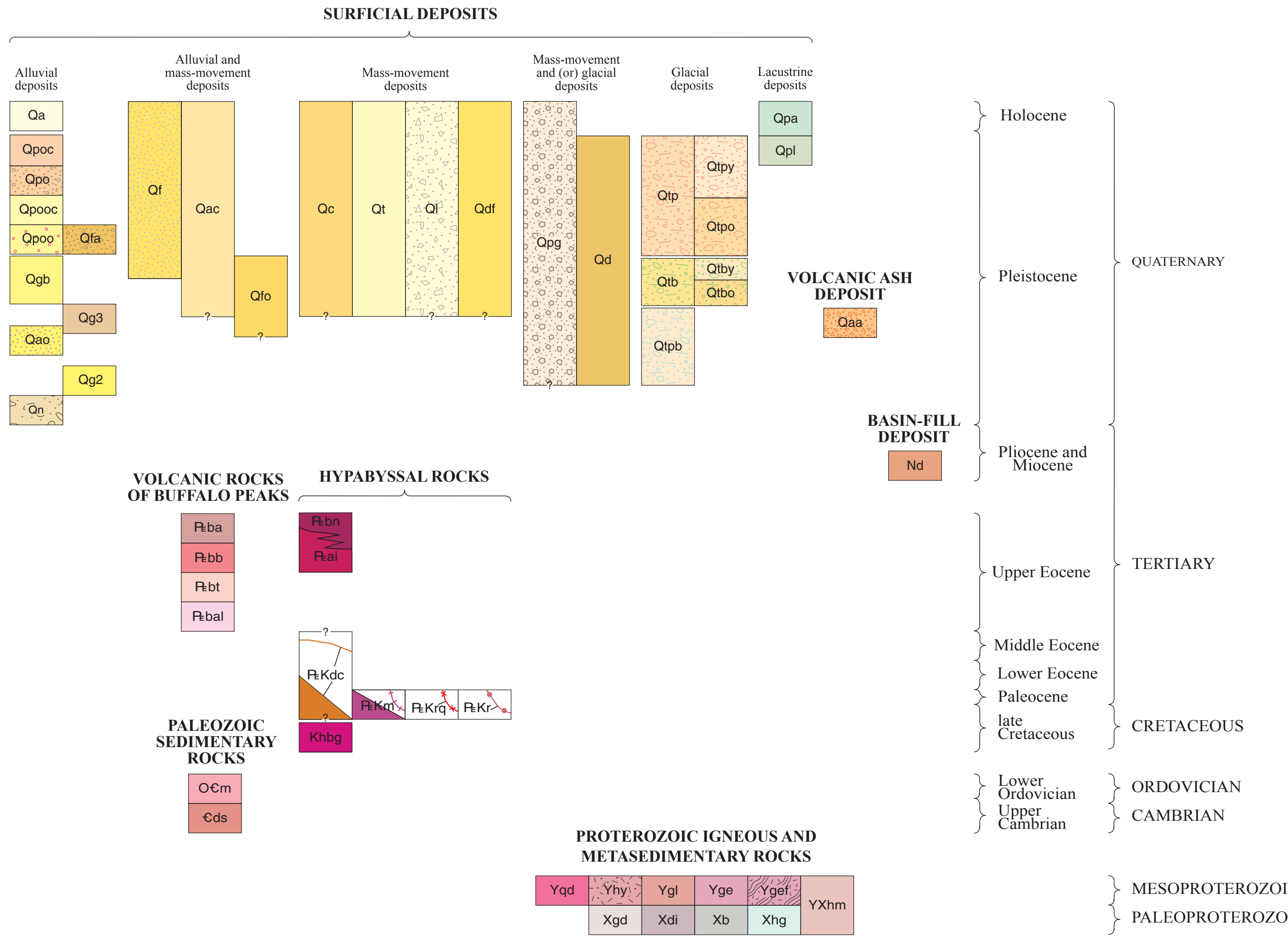
Fieldwork done by K.S. Kellogg and Keenan Lee during the summers of 2009—2011. Kellogg was assisted in the field by Mike Zawaski during part of the 2010 and 2011 field season.

D. Paco Van Sistine prepared the digital compilation of the geologic map and the GIS database

Digital topographic base prepared by Theodore R. Brandt

Edit and cartographic layout by L.J. Binder
Denver Publishing Service Center

CORRELATION OF MAP UNITS


SURFICIAL DEPOSITS
Alluvial deposits
Alluvial and mass-movement deposits
Mass-movement deposits
Mass-movement and (or) glacial deposits
Glacial deposits
Lacustrine deposits
Qa
Qpoc
Qpo
Qpooc
Qpoo
Qfa
Qgb
Qg3
Qao
Qg2
Qn
Qf
Qac
Qfo
Qc
Qt
Ql
Qdf
Qpg
Qd
Qtp
Qtpy
Qtpo
Qtb
Qtby
Qtbo
Qtpb
Qpa
Qpl
VOLCANIC ASH DEPOSIT
Qaa
BASIN-FILL DEPOSIT
Nd
VOLCANIC ROCKS OF BUFFALO PEAKS
₱ba
₱bb
₱bt
₱bal
HYPABYSSAL ROCKS
₱bn
₱ai
₱Kdc
₱Km
₱Krq
₱Kr
Khbg
PALEOZOIC SEDIMENTARY ROCKS
O€m
€ds
PROTEROZOIC IGNEOUS AND METASEDIMENTARY ROCKS
Yqd
Yhy
Ygl
Yge
Ygef
YXhm
Xgd
Xdi
Xb
Xhg
Holocene
Pleistocene
Pliocene and Miocene
Upper Eocene
Middle Eocene
Lower Eocene
Paleocene
late Cretaceous
Lower Ordovician
Upper Cambrian
QUATERNARY
TERTIARY
CRETACEOUS
ORDOVICIAN
CAMBRIAN
MESOPROTEROZOIC
PALEOPROTEROZOIC

LIST OF MAP UNITS

[Due to the addition of a shaded relief base, colors on the List of Map Units and the Correlation of Map Units may not exactly match unit colors on the map]

SURFICIAL DEPOSITS

	Alluvial deposits
Qa	**Stream-channel and overbank alluvium (Holocene)**
Qpoc	**Channel deposit in younger Pinedale-age outwash deposit (late Pleistocene)**
Qpo	**Younger Pinedale-age flood deposit (late Pleistocene)**
Qpooc	**Channel deposits in older Pinedale-age outwash deposit (late Pleistocene)**
Qfa	**High-level flood gravel of older Pinedale glaciation (late Pleistocene)**
Qpoo	**Older Pinedale-age flood deposit (late Pleistocene)**
Qgb	**Piedmont-slope deposit of Bull Lake glaciation (late and middle? Pleistocene)**
Qg3	**Old piedmont-slope deposit (middle Pleistocene)**
Qao	**Old alluvial gravel of Arkansas River (middle Pleistocene)**
Qg2	**Very old piedmont-slope deposit (middle to early Pleistocene)**
Qn	**Nussbaum(?) alluvium of Scott (1975) (early Pleistocene)**
	Alluvial and mass-movement deposits
Qf	**Fan deposit (Holocene to middle Pleistocene)**
Qac	**Alluvium and colluvium, undivided (Holocene to middle? Pleistocene)**
Qfo	**Old fan deposit (late to middle? Pleistocene)**
	Mass-movement deposits
Qc	**Colluvium (Holocene to middle? Pleistocene)**
Qt	**Talus deposit (Holocene to middle Pleistocene)**
Ql	**Landslide deposit (Holocene to middle? Pleistocene)**
Qdf	**Debris-flow deposit (Holocene to middle? Pleistocene)**
	Mass-movement and (or) glacial deposits
Qpg	**Periglacial deposit (Holocene to early? Pleistocene)**
Qd	**Diamicton (late to early Pleistocene)**
	Glacial deposits
Qtp	**Till of Pinedale glaciation, undivided (late Pleistocene)**
Qtpy	**Younger till of Pinedale glaciation (late Pleistocene)**
Qtpo	**Older till of Pinedale glaciation (late Pleistocene)**
Qtb	**Till of Bull Lake glaciation, undivided (late and middle Pleistocene)**
Qtby	**Younger till of Bull Lake glaciation (late or and middle(?) Pleistocene)**
Qtbo	**Older till of Bull Lake glaciation (late or middle Pleistocene)**
Qtpb	**Till of pre-Bull Lake glaciation (middle or early Pleistocene)**
	Lacustrine deposits
Qpa	**Pond alluvium (Holocene and late Pleistocene)**
Qpl	**Lacustrine deposit (late Pleistocene)**

VOLCANIC ASH DEPOSIT

Qaa	**Lava Creek B ash and fluvial sediments (middle Pleistocene)**

BASIN-FILL DEPOSIT

Nd	**Dry Union Formation (Pliocene and Miocene)**

VOLCANIC ROCKS OF BUFFALO PEAKS (UPPER EOCENE)

₱ba	**Cap andesite**
₱bb	**Basal andesite flow breccia**
₱bt	**Tuff of Buffalo Peaks**
₱bal	**Lower andesite flow**

HYPABYSSAL ROCKS

₱bn	**Basaltic andesite (late Eocene)**
₱ai	**Intrusive andesite (late Eocene)**
₱Kdc	**Rhyodacite and dacite dike (middle Eocene to Late Cretaceous?)**
₱Km	**Hornblende monzonite (early Paleocene or Late Cretaceous)**
₱Krq	**Quartz rhyolite porphyry dike (early Paleocene or Late Cretaceous)**
₱Kr	**Rhyolite and quartz latite dikes of Scott (1975) (early Paleocene or Late Cretaceous)**
Khbg	**Hornblende-biotite gabbro or diorite (Late Cretaceous)**

PALEOZOIC SEDIMENTARY ROCKS

O€m	**Manitou Formation (Lower Ordovician and Upper Cambrian)**
€ds	**Dotsero Formation and Sawatch Quartzite, undivided (Upper Cambrian)**

PROTEROZOIC IGNEOUS AND METASEDIMENTARY ROCKS

Yqd	**Quartz diorite (Mesoproterozoic)**
Yhy	**Intermixed granite of Langhoff Gulch and granite of Elephant Rock (Mesoproterozoic)**
Ygl	**Granite of Langhoff Gulch (Mesoproterozoic)**
Yge	**Granite of Elephant Rock (Mesoproterozoic)**
Ygef	**Augen gneiss facies of granite of Elephant Rock**
YXhm	**Hornblende monzodiorite (Meso- or Paleoproterozoic)**
Xgd	**Foliated granodiorite (Paleoproterozoic?)**
Xdi	**Diorite (Paleoproterozoic)**
Xb	**Biotite gneiss (Paleoproterozoic)**
Xhg	**Hornblende-biotite gneiss (Paleoproterozoic)**

EXPLANATION

Contact—Dashed where approximately located

Normal fault—Bar and ball on downthrown side; dashed where approximately located, short dash where location inferred, dotted where concealed

Normal fault—Identified using lidar. Bar and ball on downthrown side

Fault—Identified using aerial photography (NAIP)

Fault—Dashed where approximately located; dotted where concealed

Ductile deformation fabric in Proterozoic rocks (shear zone)

Channel in younger Pinedale-age flood deposit (Qpo)—Dashed where covered or eroded. Arrow indicates direction of flow

Landslide scarp—Internal to landslide. Hachures point down scarp

Bedding

16 **Inclined bedding**—Showing strike and dip

40 **Inclined igneous foliation**—Showing strike and dip

60 **Inclined metamorphic foliation**—Showing strike and dip

Vertical metamorphic foliation—Showing strike

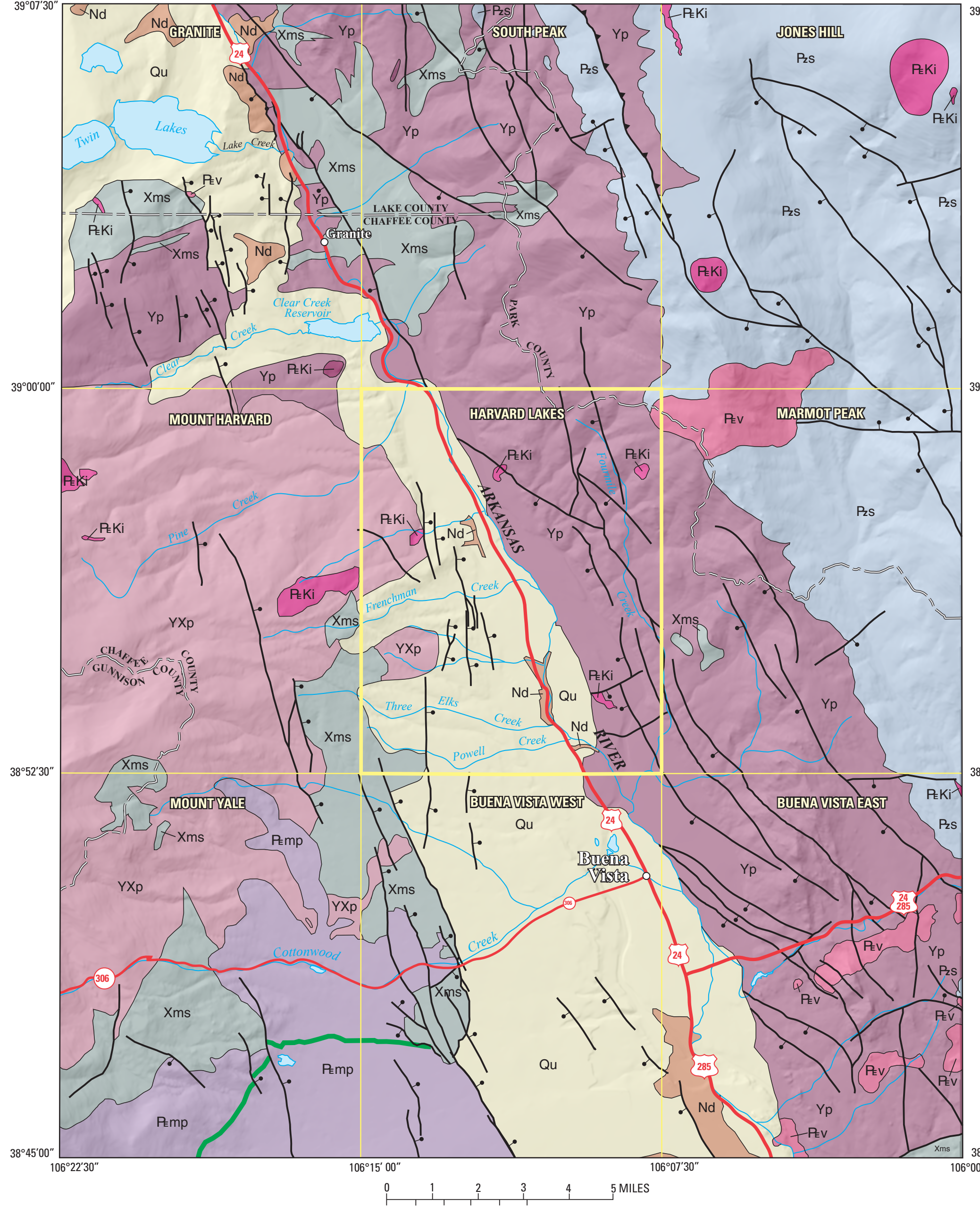
50 **Lineation**—Showing bearing and plunge

●A **Sample location**—For isotopic dates (see table 1)

1 **Figure location**—Location of images in figures 1 through 5 in the accompanying pamphlet. Arrow indicates direction of view

Water body

REGIONAL STRUCTURE MAP


106°22'30"
106°15'00"
106°07'30"
106°00'00"
39°07'30"
39°00'00"
38°52'30"
38°45'00"
GRANITE
SOUTH PEAK
JONES HILL
MOUNT HARVARD
HARVARD LAKES
MARMOT PEAK
MOUNT YALE
BUENA VISTA WEST
BUENA VISTA EAST
Twin Lakes
Lake Creek
Granite
LAKE COUNTY
CHAFFEE COUNTY
PARK COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY
Clear Creek Reservoir
Clear Creek
Pine Creek
Frenchman Creek
Three Elks Creek
Powell Creek
Cottonwood Creek
Fourmile Creek
ARKANSAS RIVER
Buena Vista
24
285
306
Qu
Nd
Xms
Yp
YXp
₱Ki
₱v
₱mp
₱zs
0
1
2
3
4
5 MILES
5 KILOMETERS

Generalized regional structure map of the Harvard Lakes 7.5' quadrangle and the adjacent quadrangles. Mapped part of Harvard Lakes quadrangle shown with a thick yellow outline.

EXPLANATION

Qu	**Quaternary deposits**
Nd	**Dry Union Formation (Pliocene and Miocene)**
₱v	**Volcanic rocks (Oligocene and Eocene)**
₱ki	**Intrusive rocks (Oligocene to late Cretaceous)**
	Mount Aetna ring dike (late Eocene)
₱mp	**Mount Princeton batholith (late Eocene)**
₱zs	**Paleozoic sedimentary rocks**
Yp	**Intrusive rocks (Mesoproterozoic)**
XYp	**Intrusive rocks (Meso- and Paleoproterozoic)**
Xms	**Metasedimentary rocks and granitic gneiss (Paleoproterozoic)**

Contact

Fault—Type unknown

Normal fault—Bar and ball on downthrown side

Thrust fault—Teeth in hanging wall

24 **U.S. Route highway**

306 **State Route highway**

County boundary

GRANITE **7.5' Quadrangle name**

Water body

Table 1. *New isotopic dates determined for Harvard Lakes quadrangle.*

[bt, biotite; hb, hornblende; zr, zircon]

Letter on map	Sample number	Rock name	Map unit	Location Easting	Location Northing	Mineral analyzed	Technique*	Age
A	HL09–89	hb monzonite stock	₱Km	393854	4312108	bt	$^{40}Ar/^{39}Ar$	65.4±0.5 Ma
B	HL09–44	hb monzonite dike	₱Km	393692	4311539	bt	$^{40}Ar/^{39}Ar$	65.3±0.5 Ma
C	HL09–136	hb-bt gabbro or diorite	Khbg	396465	4313611	bt	$^{40}Ar/^{39}Ar$	68.1±0.9 Ma
D	HL09–170	tuff of Buffalo Peaks	₱bt	402229	4316142	hb	$^{40}Ar/^{39}Ar$	37.9±0.3 Ma
E	HL09–53	granite of Langhoff Gulch	Ygl	394929	4315994	zr	$^{207}Pb/^{206}Pb$	1,446±50 Ma
F	HL09–121	granite of Elephant Rock	Yge	400600	4305320	zr	$^{207}Pb/^{206}Pb$	1,438±7 Ma

*$^{40}Ar/^{39}Ar$ analysis carried out at U.S. Geological Survey, Denver, Colo.; $^{207}Pb/^{206}Pb$ analysis carried out at joint U.S. Geological Survey–Stanford SHRIMP facility at Menlo Park, Calif.

	106°22'30" – 106°15'00"	106°15'00" – 106°07'30"	106°07'30" – 106°00'00"
39°07'30" – 39°00'00"	GRANITE	SOUTH PEAK	JONES HILL Colorado Geological Survey OF 07–5 (Widmann and others, 2011)
39°00'00" – 38°52'30"	MOUNT HARVARD I Map–952 (Brock and Barker, 1972) I Map–2565 (Fridrich and others, 1998)	HARVARD LAKES SIM–3267 (Kellogg and others, 2013)	MARMOT PEAK Colorado Geological Survey OF 12–1 (Houck and others, 2012)
38°52'30" – 38°45'00"	MOUNT YALE I Map–2565 (Fridrich and others, 1998)	BUENA VISTA WEST Colorado Geological Survey OF 05–8 (McCalpin and Shannon, 2005)	BUENA VISTA EAST Colorado Geological Survey OF 04–4 (Keller and others, 2004)

Index map showing map area in yellow, and adjacent 7.5-minute quadrangles. For U.S. Geological Survey and Colorado Geological Survey publications, the publication number, author(s), and year of publication are shown.

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Geologic Map of the Harvard Lakes 7.5' Quadrangle, Park and Chaffee Counties, Colorado

By

Karl S. Kellogg,[1] Keenan Lee,[2] Wayne R. Premo,[1] and Michael A. Cosca[1]

2013

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