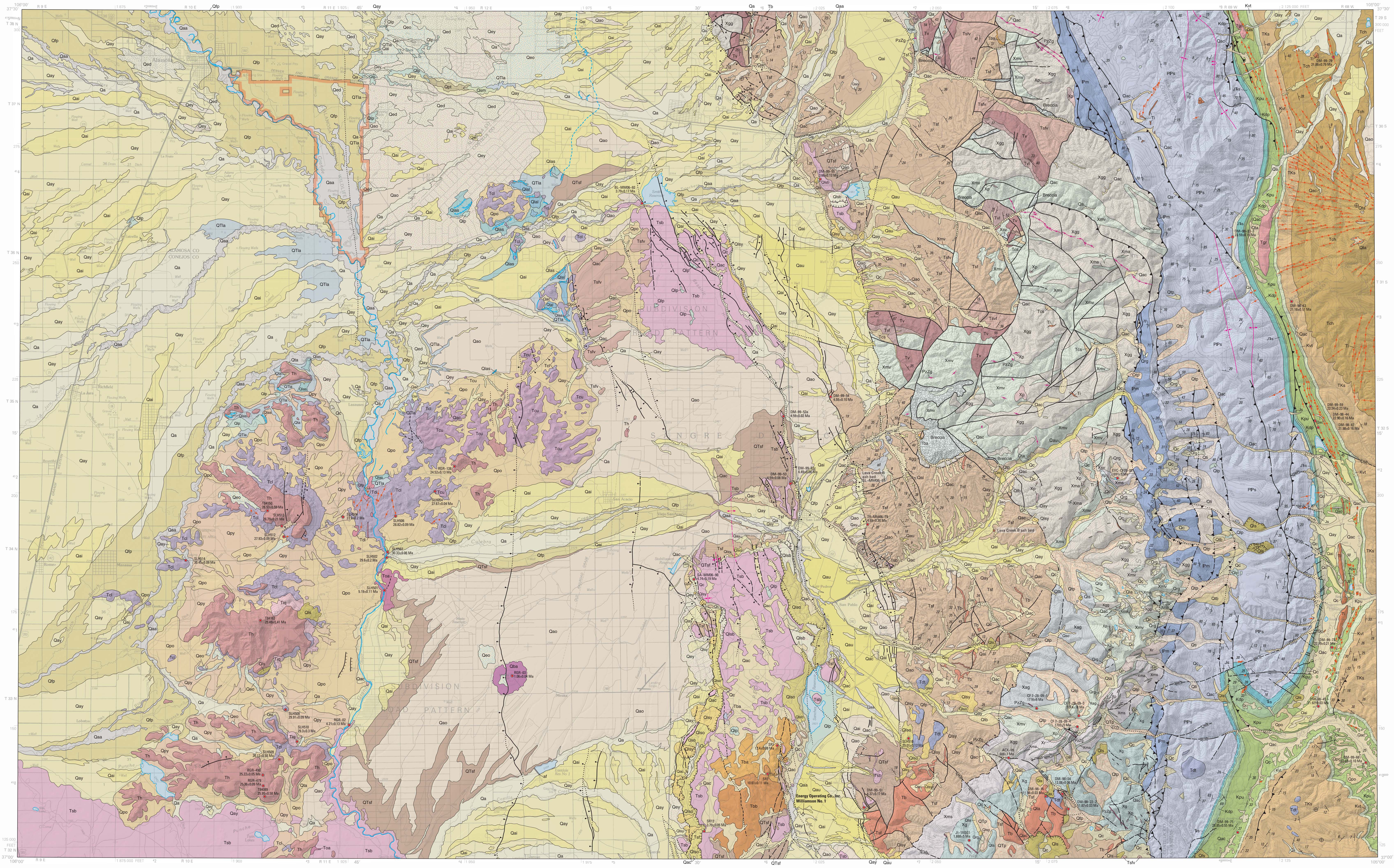
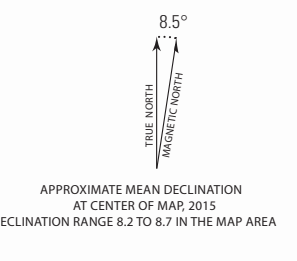
U.S. Department of the Interior
U.S. Geological Survey

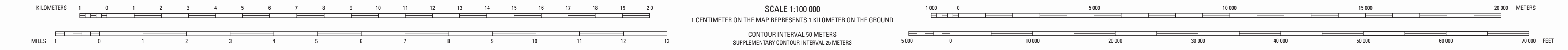
Scientific Investigations Map 3342
Pamphlet accompanies map
Supersedes Open-File Report 2005–1392
Supersedes Open-File Report 2008–1124


106°00′
37°30′
R 9 E
R 10 E
R 11 E
R 12 E
45′
30′
15′
R 69 W
R 68 W
105°00′
T 38 N
T 37 N
T 36 N
T 35 N
T 34 N
T 33 N
T 32 N
T 29 S
T 30 S
T 31 S
T 32 S
37°00′
Alamosa
Estrella
La Jara
Richfield
Sanford
Romeo
Manassa
Bountiful
Lobatos
Lasauses
San Acacio
Viejo San Acacio
San Luis
San Pedro
San Pablo
Chama
Mesita
Jaroso
Garcia
Punche
Twin Lakes
ALAMOSA CO
CONEJOS CO
ALAMOSA CO
COSTILLA CO
Rio Grande
ALAMOSA NATIONAL WILDLIFE REFUGE
Culebra
Costilla
Trinchera Creek
Smith Reservoir
Sanchez Reservoir
Eastdale Res No 1
Mesita Reservoir
SUBDIVISION ROAD PATTERN
SANGRE DE CRISTO
Breccia
Lava Creek B ash bed
SL-MM06-91
BL-MM06-92 3.79±0.17 Ma
SA-MM06-90 4.74±0.19 Ma
RGR-138 24.52±0.13 Ma
SLH504 27.2±0.2 Ma
SLH506 28.82±0.09 Ma
SLH054 27.67±0.04 Ma
T84150 26.53±0.59 Ma
SLH513 26.79±0.21 Ma
SLH512 27.93±0.09 Ma
SLH514 30.45±0.09 Ma
SLH507 30.33±0.06 Ma
SLH502 29.6±0.2 Ma
SLH501 5.19±0.11 Ma
T84163 25.49±0.41 Ma
RGR-03 1.06±0.04 Ma
SLH508 29.91±0.09 Ma
SLH510 29.3±0.3 Ma
RGR-02 4.21±0.13 Ma
SLH509 26.12±0.58 Ma
RGR-490 25.22±0.05 Ma
RGR-479 25.36±0.09 Ma
T84089 25.95±0.58 Ma
DM-99-55 3.66±0.12 Ma
DM-99-54 4.55±0.10 Ma
DM-99-53a 4.59±0.02 Ma
DM-99-83c 4.49±0.08 Ma
DM-99-53 4.59±0.08 Ma
TR-MM06-79 4.69±0.30 Ma
DM-99-79 21.86±0.79 Ma
DM-98-33-3 23.59±0.15 Ma
DM-98-43 21.18±0.11 Ma
DM-99-59 22.24±0.23 Ma
DM-98-44 22.90±0.16 Ma
DM-98-47 21.98±0.16 Ma
EVC-CF05-08 1691±5 Ma
CF7-28-09-1 1716±6 Ma
CF7-28-09-3 1714±18 Ma
CF7-28-09-4 1703±5 Ma
ACX-99 1,688±7 Ma
DM-99-73 22.19±0.21 Ma
DM-98-45 21.92±0.03 Ma
DM-99-68 22.65±0.10 Ma
SR1 13.4±0.08 Ma
SR7 10.61±0.11 Ma
SR12 3.79±0.05 Ma
SLH510 29.01±0.12 Ma
DM-99-51 4.37±0.17 Ma
DM-98-16 11.98±0.03 Ma
DM-98-14 12.08±0.06 Ma
DM-98-22-2 11.87±0.03 Ma
JI-1XGG1 1,688±5 Ma
DM-99-71 25.85±0.55 Ma
Energy Operating Co., Inc. Williamson No. 1

Base from U.S. Geological Survey Alamosa, Colorado 100,000-scale map, 1983
Universal Transverse Mercator projection and 10,000-meter grid, zone 13
25,000-foot grid ticks based on Colorado coordinate system, south zone
1927 North American Datum.
To place on the North American Datum of 1983 (NAD 83) move the projection lines 2 meters north and 49 meters east
Alamosa National Wildlife Refuge boundary from U.S. Fish and Wildlife Service cadastral geodatabase, accessed July 24, 2015 at http://www.fws.gov/GIS/data/CadastralDB/index.htm

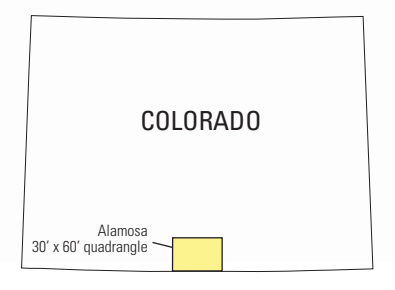

8.5°
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION AT CENTER OF MAP, 2015
DECLINATION RANGE 8.2 TO 8.7 IN THE MAP AREA


KILOMETERS
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
MILES
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
1 000
0
5 000
10 000
15 000
20 000
METERS
5 000
0
10 000
20 000
30 000
40 000
50 000
60 000
70 000
FEET

SCALE 1:100 000
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

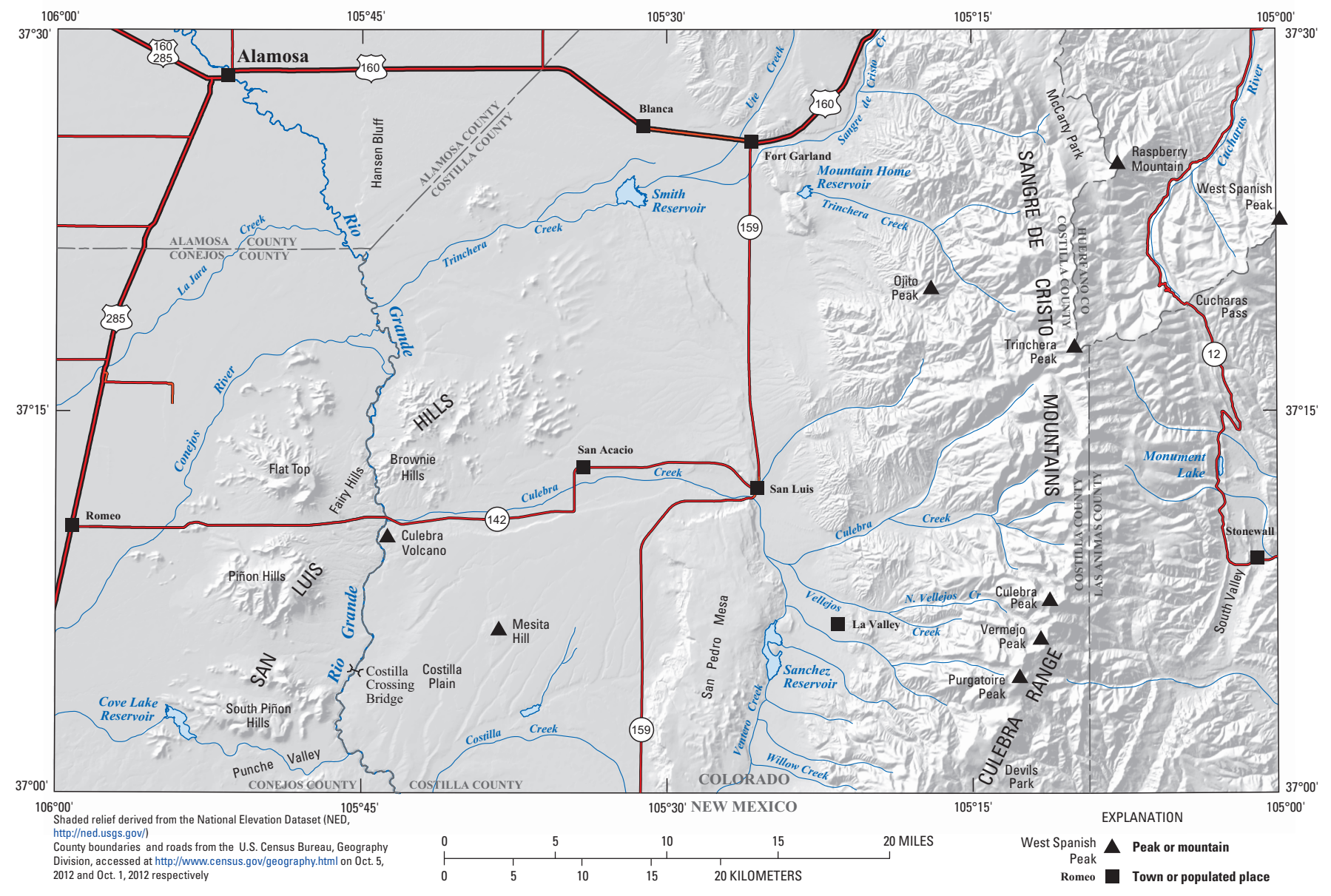
CONTOUR INTERVAL 50 METERS
SUPPLEMENTARY CONTOUR INTERVAL 25 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929


COLORADO
Alamosa
30′ x 60′ quadrangle

MAP LOCATION

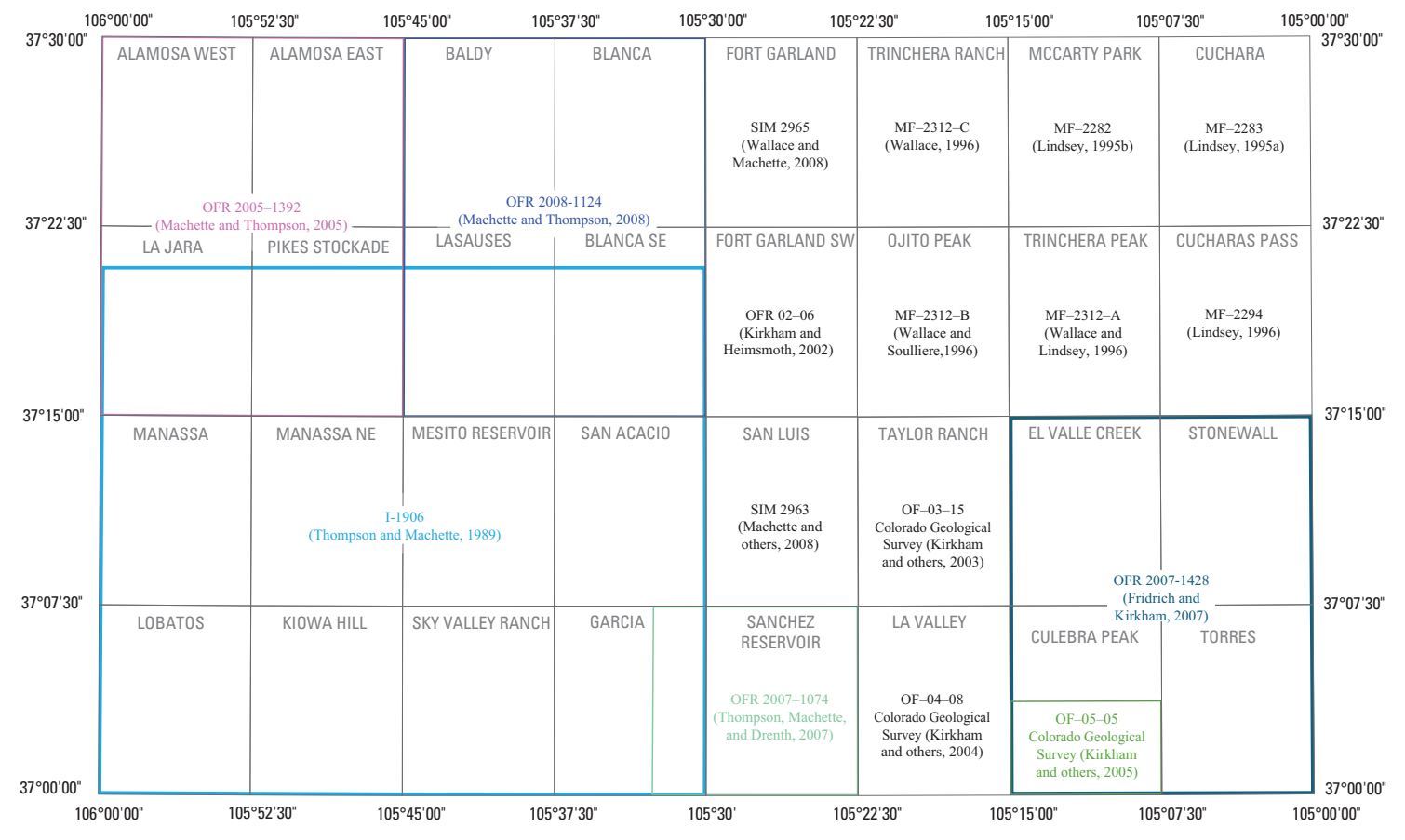
Bedrock mapping represents a regional synthesis of geologic data compiled and published over the past quarter century and necessarily includes both simplification and expansion of previously published data with respect to the adopted stratigraphic nomenclature and aerial depiction of map units and faults. Fault depictions are largely simplified and reflect our interpretation of the most regionally significant and better-exposed structures. Previously mapped inferred faults, particularly those buried beneath younger surficial deposits in the San Luis Valley, typically have large locational uncertainties and are poorly dated. Consequently, depiction of these buried faults on this map compilation is minimized.

Surficial deposits were mapped and compiled by Machette and Shroba (2005–2013). Bedrock deposits were mapped and compiled by Thompson and Fridrich (2005–2013). All authors contributed to the fault compilation. Brandt was responsible for the digital cartography and database development.


106°00′
105°45′
105°30′
105°15′
105°00′
37°30′
37°15′
37°00′
Alamosa
Blanca
Fort Garland
Raspberry Mountain
West Spanish Peak
Cucharas Pass
Ojito Peak
Trinchera Peak
SANGRE DE CRISTO MOUNTAINS
Mountain Home Reservoir
Smith Reservoir
Trinchera Creek
ALAMOSA COUNTY
CONEJOS COUNTY
COSTILLA COUNTY
HUERFANO COUNTY
LAS ANIMAS COUNTY
Hansen Bluff
Rio Grande
La Jara Creek
Conejos River
Flat Top
Fairy Hills
Brownie Hills
HILLS
San Acacio
San Luis
Culebra Creek
Romeo
Culebra Volcano
Piñon Hills
SAN LUIS
Mesita Hill
Costilla Crossing Bridge
Costilla Plain
San Pedro Mesa
La Valley
Vallejos Creek
Culebra Peak
Vermejo Peak
Purgatoire Peak
Sanchez Reservoir
CULEBRA RANGE
Cove Lake Reservoir
South Piñon Hills
Punche Valley
Costilla Creek
Willow Creek
Devils Park
COLORADO
NEW MEXICO
Stonewall
Monument Lake
South Valley
Cuchara River
160
285
159
142
12
0
5
10
15
20 MILES
20 KILOMETERS
EXPLANATION
West Spanish Peak
Peak or mountain
Romeo
Town or populated place

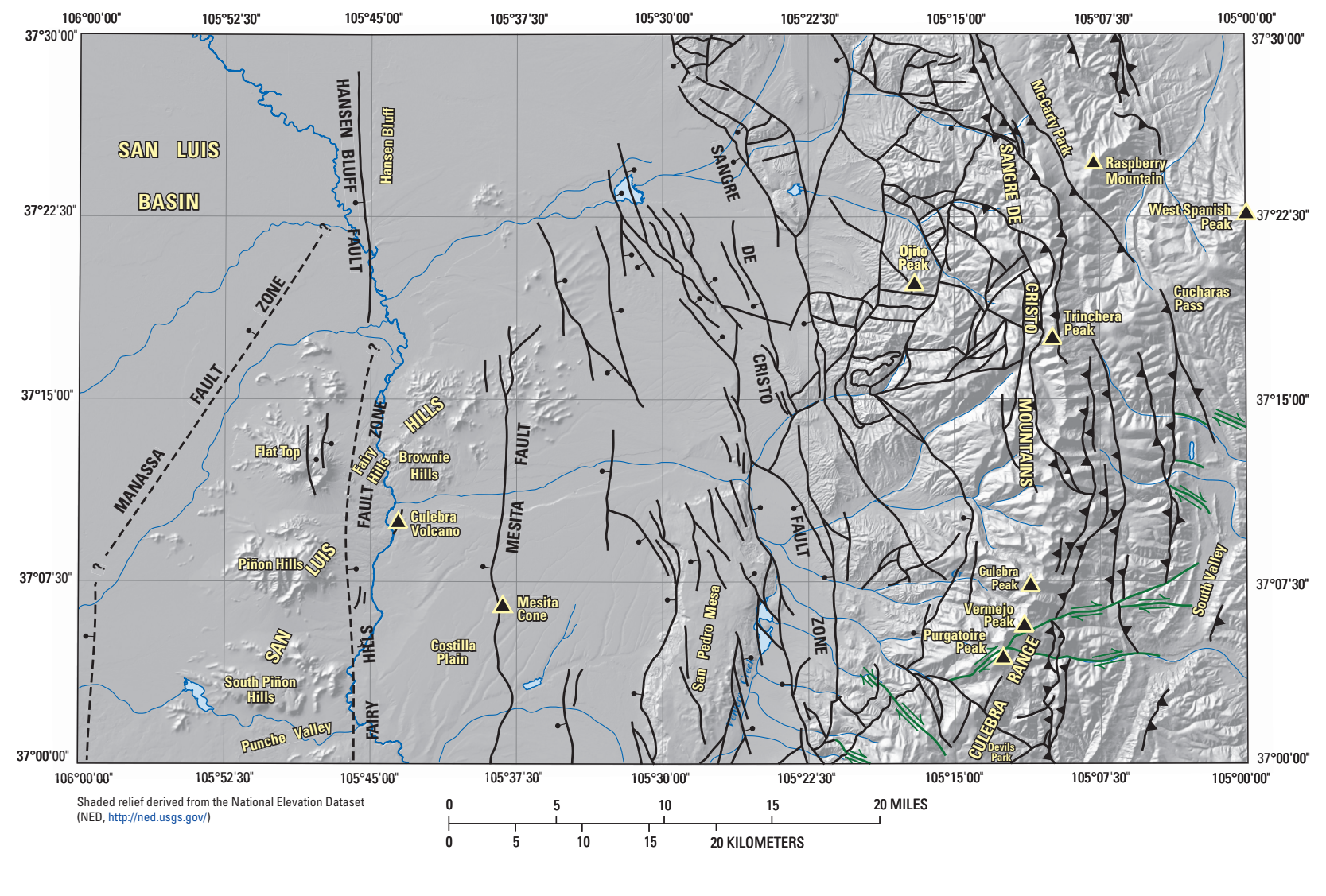
Shaded relief derived from the National Elevation Dataset (NED, http://ned.usgs.gov/)
County boundaries and roads from the U.S. Census Bureau, Geography Division, accessed at http://www.census.gov/geography.html on Oct. 5, 2012 and Oct. 1, 2012 respectively

Figure 1. Shaded relief location index for Alamosa 30′ × 60′ quadrangle


106°00′00″
105°52′30″
105°45′00″
105°37′30″
105°30′00″
105°22′30″
105°15′00″
105°07′30″
105°00′00″
37°30′00″
37°22′30″
37°15′00″
37°07′30″
37°00′00″

ALAMOSA WEST	ALAMOSA EAST	BALDY	BLANCA	FORT GARLAND	TRINCHERA RANCH	MCCARTY PARK	CUCHARA
OFR 2005–1392 (Machette and Thompson, 2005)		OFR 2008–1124 (Machette and Thompson, 2008)		SIM 2965 (Wallace and Machette, 2008)	MF–2312–C (Wallace, 1996)	MF–2282 (Lindsey, 1995b)	MF–2283 (Lindsey, 1995a)
LA JARA	PIKES STOCKADE	LASAUSES	BLANCA SE	FORT GARLAND SW	OJITO PEAK	TRINCHERA PEAK	CUCHARAS PASS
				OFR 02–06 (Kirkham and Heimsmoth, 2002)	MF–2312–B (Wallace and Soulliere, 1996)	MF–2312–A (Wallace and Lindsey, 1996)	MF–2294 (Lindsey, 1996)
MANASSA	MANASSA NE	MESITO RESERVOIR	SAN ACACIO	SAN LUIS	TAYLOR RANCH	EL VALLE CREEK	STONEWALL
	I–1906 (Thompson and Machette, 1989)			SIM 2963 (Machette and others, 2008)	OF–03–15 Colorado Geological Survey (Kirkham and others, 2003)	OFR 2007–1428 (Fridrich and Kirkham, 2007)	
LOBATOS	KIOWA HILL	SKY VALLEY RANCH	GARCIA	SANCHEZ RESERVOIR	LA VALLEY	CULEBRA PEAK	TORRES
				OFR 2007–1074 (Thompson, Machette, and Drenth, 2007)	OF–04–08 Colorado Geological Survey (Kirkham and others, 2004)	OF–05–05 Colorado Geological Survey (Kirkham and others, 2005)	

Figure 2. Index to geologic map data sources used in map compilation. For U.S. Geological Survey publications, the publication number, author(s), and year of publication are shown. For non-USGS publications, the State agency, author, and publication year are shown.


106°00′00″
105°52′30″
105°45′00″
105°37′30″
105°30′00″
105°22′30″
105°15′00″
105°07′30″
105°00′00″
37°30′00″
37°22′30″
37°15′00″
37°07′30″
37°00′00″
SAN LUIS BASIN
HANSEN BLUFF FAULT
Hansen Bluff
MANASSA FAULT ZONE
FAIRY HILLS FAULT ZONE
Flat Top
Fairy Hills
Brownie Hills
Culebra Volcano
Piñon Hills
SAN LUIS
South Piñon Hills
Punche Valley
MESITA FAULT
Mesita Cone
Costilla Plain
San Pedro Mesa
SANGRE DE CRISTO FAULT ZONE
Ojito Peak
Trinchera Peak
Raspberry Mountain
West Spanish Peak
Cucharas Pass
McCarty Park
SANGRE DE CRISTO MOUNTAINS
Culebra Peak
Vermejo Peak
Purgatoire Peak
CULEBRA RANGE
South Valley
0
5
10
15
20 MILES
20 KILOMETERS

Shaded relief derived from the National Elevation Dataset (NED, http://ned.usgs.gov/)

Figure 3. Simplified fault map for Alamosa 30′ × 60′ quadrangle showing major faults of the San Luis Basin and Sangre de Cristo Mountains. Older thrust faults of the Sangre de Cristo Mountains are shown in black with thrust attribution. Post-thrust faults of indeterminate age are depicted in green with sense of oblique-slip displacement indicated by green arrows. Cenozoic extension-related faulting of the basin includes numerous dip-slip faults reflecting down-to-east or down-to-west displacement basinward of the numerous range-bounding faults of the Sangre de Cristo fault zone (solid black lines with bar and ball on downthrown side of fault). Dashed faults indicate faults or fault zones of Oligocene to Miocene age and are inferred based on geologic constraints exposed in adjacent bedrock or geophysical constraints. The location of the Manassa fault zone is derived from Drenth and others (2011). The Fairy Hills fault zone coincides with a zone of extensive hydrothermal alteration and mineralization exposed on the east side of South Piñon Hills, Piñon Hills, and the Flat Top mesas west of the fault zone. The Fairy Hills are deeply incised remnants of altered Miocene and Oligocene volcanic deposits exposed along the Rio Grande near the Colo. Hwy 142 bridge crossing. The down-to-east sense of fault displacement is inferred from offset deposits of preserved Hinsdale lavas of Oligocene age on mesas west of the Rio Grande and in the Brownie Hills east of the Rio Grande, and is supported by geophysical modeling of Drenth and others (2013). Black triangles, mountain peak.

Table 1. *Approximate height, in meters, of the top of selected alluvial units above modern stream level in the Alamosa 30′ × 60′ quadrangle. Unit heights vary depending on proximity to major stream and active Quaternary faults.*

[Unit Qau is composed chiefly of deposits of units Qa and Qay, and locally includes unmapped deposits of unit Qac along and near valley sides and deposits of sheetwash alluvium. Unit Qau is not listed separately; —, no deposits]

Map Unit	Rio Grande	Major tributaries to the Rio Grande in the western half of the quadrangle	Major streams in the piedmont on the west side of the Culebra Range east of San Pedro Mesa	Mountainous reaches of major streams west of the crests of the Sangre de Cristo Mountains and Culebra Range	Major streams near the eastern boundary of the quadrangle
Qa	—	—	1–2	1–10	—
Qay	5–10	1–2	2	5–10	5
Qai	18–22	2–5	5	25–35	25–60
Qao	50–60	5–15	25	60–120	65–80

EXPLANATION

- **Contact**—Dashed where approximately located; dashed with queries where inferred; dotted where concealed
- **Fault, type unspecified**—Dashed where approximately located; dotted where concealed
- **Normal fault**—Dashed where approximately located, dashed with queries where inferred, dotted where concealed; bar-and-ball symbol on apparent downthrown side
- **Thrust fault**—Dashed where approximately located; dotted where concealed; sawteeth on higher plate
- **Strike-slip fault**—Right-lateral or left-lateral offset as indicated; dashed where approximately located, dotted where concealed; arrows show relative motion
- **Fault scarp**—Hachures point downscarp
- **Landslide scarp**—Hachures are on or near base of scarp; dashed where approximately located. Hachures point down scarp
- **Anticline**—Dashed where approximately located, dotted where concealed
- **Overturned anticline**—Beds on one limb are overturned; arrows show dip direction of limbs
- **Syncline**
- **Shoreline**—Of present-day water bodies
- **Paleoshoreline of ancient Lake Alamosa**—Dashed where inferred. Middle Pleistocene to Pliocene
- **Crest of barrier bars and spits of ancient Lake Alamosa**—Middle Pleistocene to Pliocene
- **Dike, unit PzZg**—Composed of non-foliated pyroxene gabbro that cuts foliated Paleoproterozoic rocks but not Middle Pennsylvanian sedimentary rocks
- **Dike, unit Ti**—Lamprophyre, alkali basalt, and much lesser intermediate and silicic dikes, primarily associated with the Spanish Peaks intrusive complex. ^{40}Ar/^{39}Ar yielded apparent ages ranging rom 25 to 22 Ma (Penn and Lindsey, 1966; Miggins, 2002)
- **Breccia**—Sheared to granulated rocks mostly of Paleoproterozoic age in broad breccia zones typically along and adjacent to major high- to low-angle faults. Characterized locally by abundant secondary iron oxide, chlorite, epidote and (or) silica, sericite, and calcite. Age unknown; north of Ojito Peak may be related to Laramide faulting with minor to major reactivation of some faults during the late Tertiary (Wallace, 1996; Wallace and Soulliere, 1996). South of Ojito Peak breccia is interpreted as a detachment sheet that presumably slid westward during early rifting (Kirkham and others, 2003) prior to about 19 Ma (Wallace and Soulliere, 1996)
- **Strike and dip of bedding**—Measurements in areas of Quaternary surficial deposits were made on outcrops that are too small to show at map scale
  - ⊕ **Horizontal**
  - **Inclined**—Showing strike and dip
  - **Vertical**—Showing strike
  - **Overturned**—Showing strike and dip
- Energy Operating Co., Inc. Williamson No. 1 — **Well**—Plugged and abandoned oil and gas well, with name of operator
- Lava Creek B ash bed SL–MM06–91 — **Location of Lava Creek B ash bed**—Reported by Machette and others (2008) near the eroded top of unit QTsf. Ash has a ^{40}Ar/^{39}Ar mean age of 639±2 ka (Lanphere and others, 2002)
- DM–98–33–3 23.59±0.15 Ma — **Geochemical analysis sample location**—With sample number and age. See table 2 for values

Figure 4. Photograph of the Costilla Crossing Bridge over the Rio Grande. The bridge is a single lane, two-span Thatcher through-truss bridge constructed in 1892. It was posted to the National Register of Historic Places in 1985. The bridge is 11.5 km south of the Colorado Hwy 142 bridge over the Rio Grande and accommodates local traffic in the southern San Luis Valley. Oligocene intrusive rocks (Tiq) of South Piñon Hills (left) and mesa-capping basaltic lava flows (Th) overlying andesite lava flows (Tcl) of Piñon Hills (right) are visible in background. The bridge rests on a single Servilleta Basalt (Tsb) lava flow likely erupted from vent(s) to the south. The bridge was restored in 2006. Photo by Ren A. Thompson, 2005.

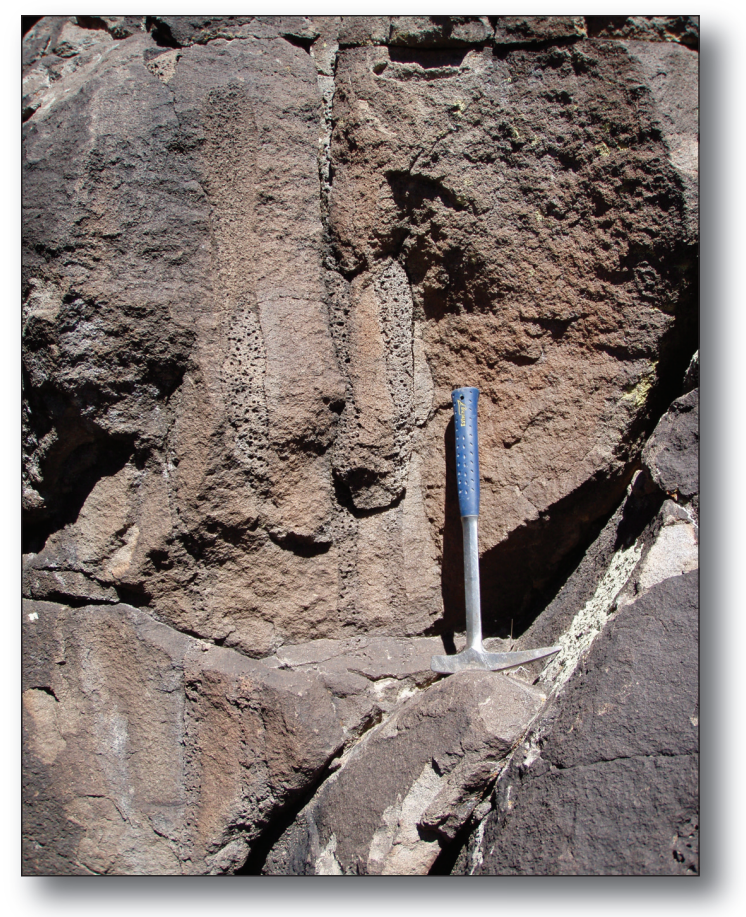


Figure 5. Photograph of vertical vesicle pipes in an olivine tholeiite lava flow, characteristic of Servilleta Basalt (Tsb) in the southern part of the map area, San Pedro Mesa, and scattered outcrops along the western range front of the Sangre de Cristo Range. Photo by Ren A. Thompson, 2005.

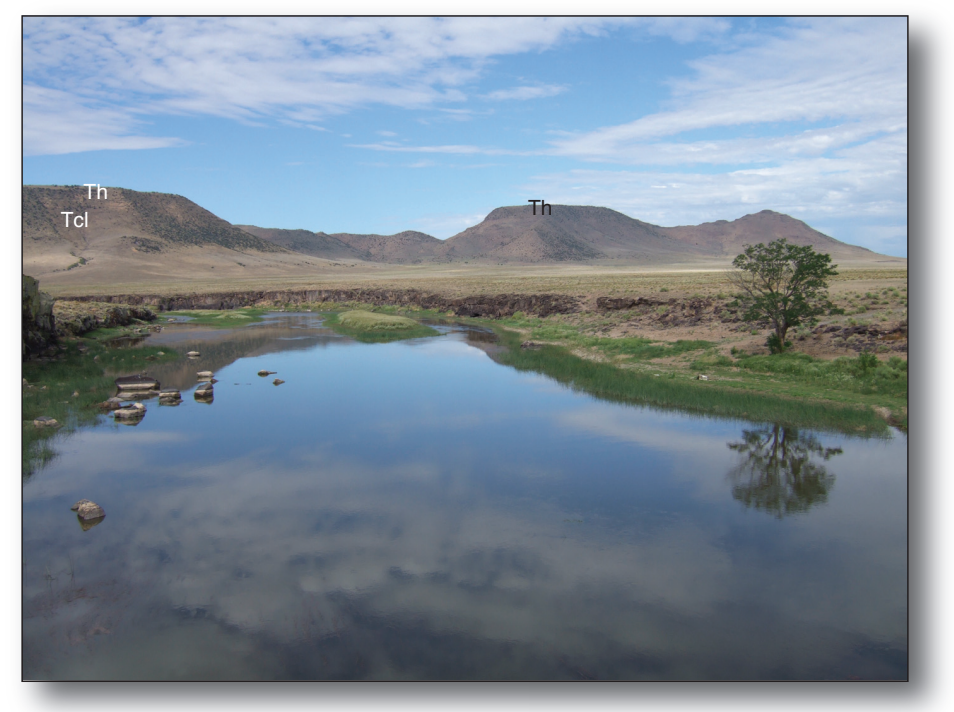
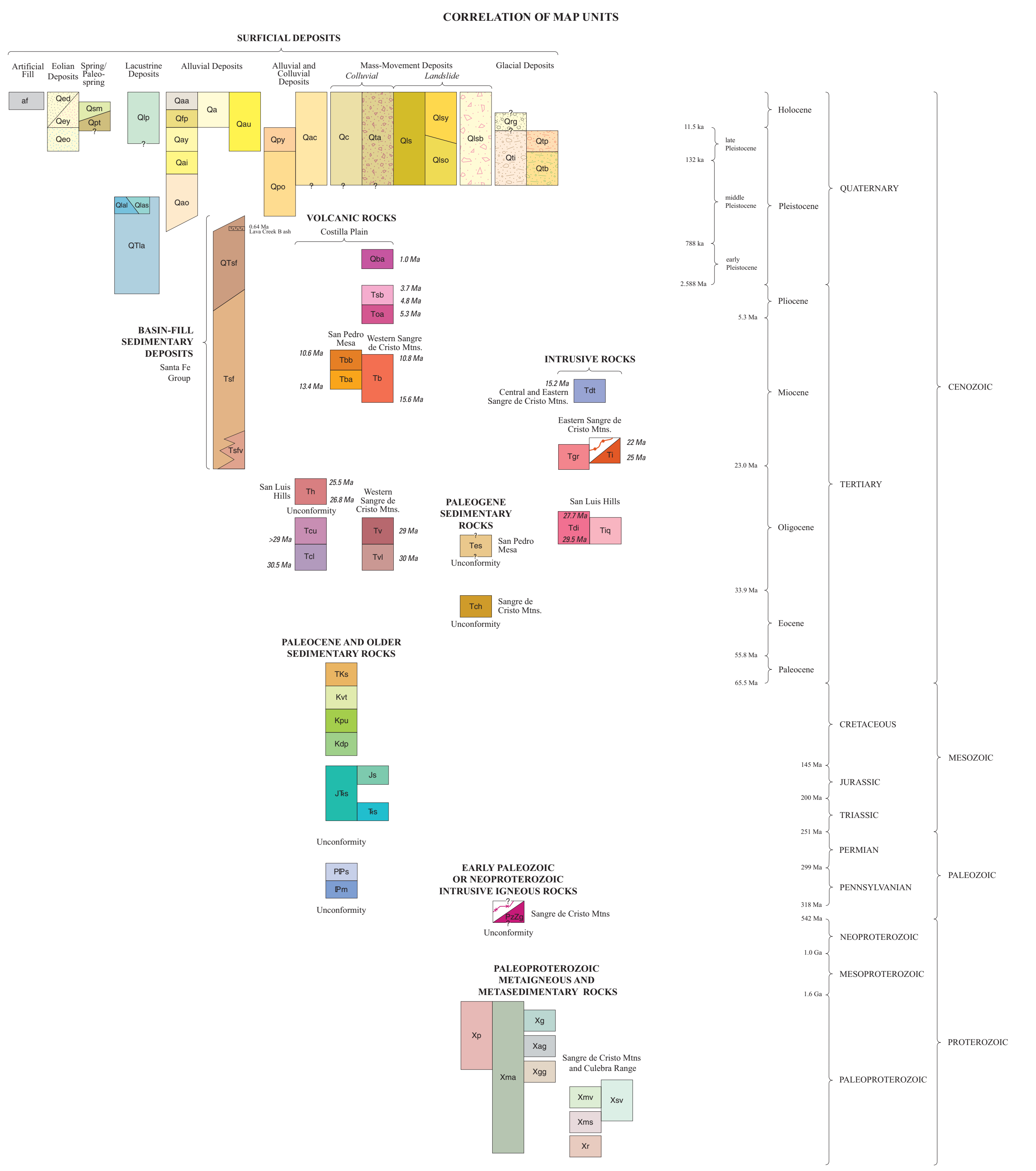


Figure 6. Photograph of view northwest from Costilla Crossing Bridge toward Piñon Hills. Flat Top mesas are capped by Oligocene basaltic lava flows of the Hinsdale Formation (Th) that are dominantly underlain by Oligocene andesite and dacite volcanic deposits of the lower Conejos Formation (Tcl). Photo by Ren A. Thompson, 2005.

CORRELATION OF MAP UNITS


SURFICIAL DEPOSITS
Artificial Fill
Eolian Deposits
Spring/Paleo-spring
Lacustrine Deposits
Alluvial Deposits
Alluvial and Colluvial Deposits
Mass-Movement Deposits
Colluvial
Landslide
Glacial Deposits
af
Qed
Qey
Qeo
Qsm
Qpt
Qlp
Qaa
Qfp
Qay
Qai
Qao
Qa
Qau
Qpy
Qpo
Qac
Qc
Qta
Qls
Qlsy
Qlso
Qlsb
Qrg
Qti
Qtp
Qtb
Qlal
Qlas
QTla
0.64 Ma Lava Creek B ash
BASIN-FILL SEDIMENTARY DEPOSITS
Santa Fe Group
QTsf
Tsf
Tsfv
VOLCANIC ROCKS
Costilla Plain
Qba
1.0 Ma
Tsb
3.7 Ma
4.8 Ma
Toa
5.3 Ma
San Pedro Mesa
Western Sangre de Cristo Mtns.
10.6 Ma
Tbb
Tba
13.4 Ma
Tb
10.8 Ma
15.6 Ma
INTRUSIVE ROCKS
15.2 Ma
Central and Eastern Sangre de Cristo Mtns.
Tdt
Eastern Sangre de Cristo Mtns.
Tgr
Ti
22 Ma
25 Ma
San Luis Hills
Th
25.5 Ma
26.8 Ma
Unconformity
Western Sangre de Cristo Mtns.
Tcu
Tcl
>29 Ma
30.5 Ma
Tv
Tvl
29 Ma
30 Ma
PALEOGENE SEDIMENTARY ROCKS
Tes
San Pedro Mesa
Unconformity
Tch
Sangre de Cristo Mtns.
Unconformity
San Luis Hills
27.7 Ma
Tdi
29.5 Ma
Tiq
PALEOCENE AND OLDER SEDIMENTARY ROCKS
TKs
Kvt
Kpu
Kdp
Js
J̄Ꞧs
Ꞧs
Unconformity
PPs
IPm
Unconformity
EARLY PALEOZOIC OR NEOPROTEROZOIC INTRUSIVE IGNEOUS ROCKS
PzZg
Sangre de Cristo Mtns
Unconformity
PALEOPROTEROZOIC METAIGNEOUS AND METASEDIMENTARY ROCKS
Xp
Xma
Xg
Xag
Xgg
Sangre de Cristo Mtns and Culebra Range
Xmv
Xsv
Xms
Xr
11.5 ka
132 ka
788 ka
2.588 Ma
5.3 Ma
23.0 Ma
33.9 Ma
55.8 Ma
65.5 Ma
145 Ma
200 Ma
251 Ma
299 Ma
318 Ma
542 Ma
1.0 Ga
1.6 Ga
Holocene
late Pleistocene
middle Pleistocene
early Pleistocene
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Paleocene
QUATERNARY
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
NEOPROTEROZOIC
MESOPROTEROZOIC
PALEOPROTEROZOIC
CENOZOIC
MESOZOIC
PALEOZOIC
PROTEROZOIC

LIST OF MAP UNITS

[Note: 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. More detailed descriptions of these units are available in the accompanying pamphlet]

SURFICIAL DEPOSITS

Artificial-Fill Deposits

af	**Artifical fill (latest Holocene)**

Eolian Deposits

Qed	**Eolian dune sand (Holocene)**
Qey	**Younger eolian sheet and dune sand (Holocene)**
Qeo	**Older eolian sheet and dune sand (late Pleistocene)**

Spring/Paleospring Deposits

Qsm	**Spring-mound deposits (Holocene)**
Qpt	**Peat deposits (early Holocene and latest Pleistocene?)**

Lacustrine Deposits

Qlp	**Lake and pond deposits (Holocene and latest Pleistocene?)**
Qlal	**Lagoonal deposits of Lake Alamosa (middle Pleistocene)**
Qlas	**Shoreline deposits of Lake Alamosa (middle Pleistocene)**
QTla	**Alamosa Formation of Siebenthal (1910) (middle Pleistocene to Pliocene)**

Alluvial Deposits

Qaa	**Channel alluvium (late Holocene)**
Qa	**Channel and flood-plain alluvium, undivided (Holocene)**
Qau	**Young alluvium, undivided (Holocene and late Pleistocene)**
Qfp	**Flood-plain alluvium (Holocene)**
Qay	**Younger alluvium (late Pleistocene)**
Qai	**Intermediate alluvium (late and middle Pleistocene)**
Qao	**Older alluvium (middle Pleistocene)**

Alluvial and Colluvial Deposits

Qpy	**Younger piedmont-slope deposits (late Pleistocene)**
Qpo	**Alluvium and colluvium, undivided (Holocene to middle? Pleistocene)**
Qac	**Older piedmont-slope deposits (late and middle Pleistocene)**

Mass-Movement Deposits

Colluvial Deposits

Qc	**Colluvium (Holocene to middle? Pleistocene)**
Qta	**Talus deposits (Holocene to middle? Pleistocene)**

Landslide Deposits

Qls	**Landslide deposits, undivided (Holocene to middle Pleistocene)**
Qlsy	**Younger landslide deposits (Holocene and late Pleistocene)**
Qlso	**Older landslide deposits (late and middle Pleistocene)**
Qlsb	**Landslide blocks (Holocene to middle Pleistocene)**

Glacial Deposits

Qrg	**Rock-glacier deposits (Holocene? and latest Pleistocene?)**
	Till (late and middle Pleistocene)
Qti	**Till of Pinedale age and till of Bull Lake age, undivided (late and middle Pleistocene)**
Qtp	**Till of Pinedale age (late Pleistocene)**
Qtb	**Till of Bull Lake age (late and middle Pleistocene)**

BASIN-FILL SEDIMENTARY DEPOSITS

QTsf	**Santa Fe Group, upper part (middle Pleistocene to Pliocene)**
Tsf	**Santa Fe Group, lower part (Pliocene to Oligocene)**
Tsfv	**Santa Fe Group, volcaniclastic deposits (Miocene and Oligocene)**

VOLCANIC ROCKS

Qba	**Basaltic andesite of Mesita cone (early Pleistocene)**
Tsb	**Servilleta Basalt (Pliocene)**
Toa	**Olivine andesite (Pliocene)**
Tbb	**Basaltic andesite of San Pedro Mesa (Miocene)**
Tb	**Basaltic andesite and trachyandesite, undivided (Miocene)**
Tba	**Andesite and dacite of San Pedro Mesa (Miocene)**
Th	**Hinsdale Formation (Oligocene)**
	Conejos Formation (Oligocene)
Tcu	**Upper part**
Tcl	**Lower part**
Tv	**Volcanic rocks, undivided (Oligocene)**
Tvl	**Volcanic lahar and breccia deposits (Oligocene)**

INTRUSIVE ROCKS

Tdt	**Dacite porphyry and tuff (Miocene)**
Ti	**Intrusive rocks, undivided (Miocene and Oligocene)**
Tgr	**Rhyolite porphyry and dacite (Miocene and Oligocene)**
Tdi	**Dacite porphyry (Oligocene)**
Tiq	**Quartz monzonite (Oligocene)**

PALEOGENE SEDIMENTARY ROCKS

Tcs	**Conglomerate and sandstone (Oligocene?)**
Tch	**Cuchara Formation (Eocene)**

PALEOCENE AND OLDER SEDIMENTARY ROCKS

TKs	**Poison Canyon and Raton Formations, undivided (Paleocene and Upper Cretaceous)**
Kvt	**Vermejo Formation and Trinidad Sandstone, undivided (Upper Cretaceous)**
Kpu	**Pierre Shale, Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale, undivided (Upper Cretaceous)**
Kdp	**Dakota Sandstone and Purgatoire Formation, undivided (Lower Cretaceous)**
Js	**Jurassic sedimentary rocks, undivided**
J̄Ꞧs	**Jurassic and Triassic sedimentary rocks, undivided**
Ꞧs	**Triassic sedimentary rocks, undivided**
PPs	**Sangre de Cristo Formation (Lower Permian to Middle Pennsylvanian)**
IPm	**Madera Formation (Middle Pennsylvanian) and Sandia Formation (Middle and Lower Pennsylvanian), undivided**

EARLY PALEOZOIC OR NEOPROTEROZOIC INTRUSIVE IGNEOUS ROCKS

PzZg	**Gabbro dikes and intrusive bodies (early Paleozoic? or Neoproterozoic?)**

PALEOPROTEROZOIC METAIGNEOUS AND METASEDIMENTARY ROCKS

Xp	**Pegmatite**
Xma	**Amphibolite**
Xg	**Gneissic monzogranite of State Line Peak area**
Xag	**Augen gneiss of Carneros Creek area**
Xgg	**Granitic orthogneiss and monzogranite of Trinchera Peak area**
Xsv	**Interbedded metasedimentary and metavolcanic rocks, undivided**
Xmv	**Metavolcanic rocks**
Xms	**Metasedimentary rocks**
Xr	**Alkali granite gneiss**

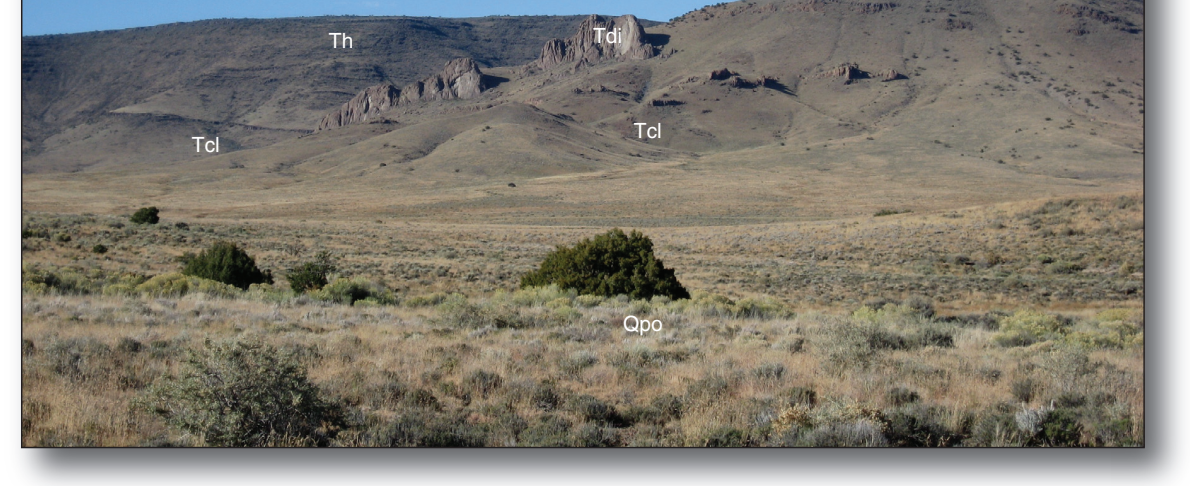

Th
Th
Tdi
Tcl
Tcl
Qpo

Figure 7. Photograph of view northwest toward the southern flanks of Flat Top in the San Luis Hills. Prominent fins of exposed bedrock in near hills are eroded remnants of vertical dacite dikes (Tdi) cutting andesite lava flows and breccia deposits of the lower Conejos Formation (Tcl). Thinly bedded lava flows in far hills are basaltic and basaltic andesite lava flows of the Hinsdale formation (Th) erupted unconformably onto the deeply incised Conejos Formation deposits. Note the northeastern "fanning" dips of the Hinsdale Formation lava flows becoming progressively less tilted upsection, likely related to contemporaneous deposition of lava flows and interbedded deposits in the hanging wall of an active Oligocene down-to-west extensional fault (up valley and out of view in photo). Deposits of undivided alluvium and colluvium are visible in the foreground (Qpo). Photo by Ren A. Thompson, 2006.

Table 2. *Age determinations for select samples in the map area*

Sample no.	Location (UTM-NAD83) Easting	Northing	Age (Ma) ±2 sigma error	Age Type—Material Analysed	Lab/Analyst[1]
ACX–99	475847	4101500	1,688±7	U-Pb age—zircon	USGS/W. Premo
BL–MM06–92	452059	4137915	3.79±0.17	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
CF 7–28–09–1	477696	4104732	1,716±6	U-Pb age—zircon	USGS/W. Premo
CF 7–28–09–3	480450	4104225	1,714±18	U-Pb age—zircon	USGS/W. Premo
CF 7–28–09–4	480351	4103512	1,703±5	U-Pb age—zircon	USGS/W. Premo
DM–98–14	479347	4099121	12.08±0.06	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–16	478260	4098970	11.98±0.03	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–22–2	479740	4098134	11.87±0.03	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–22–7	479740	4098134	11.90±0.21	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–33–3	490677	4135515	23.59±0.15	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–43	494512	4131269	21.18±0.11	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–44	496009	4123441	22.90±0.16	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–45	496124	4104767	21.92±0.03	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–98–47	496205	4123009	21.98±0.16	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–99–51	466369	4098304	4.37±0.17	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–53	461654	4119515	4.59±0.08	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–53a	461235	4123928	4.59±0.02	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–53c	461730	4119548	4.49±0.08	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–54	464325	4125195	4.55±0.10	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–55	463717	4139427	3.66±0.12	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
DM–99–59	495714	4124396	22.24±0.23	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–99–68	499210	4101068	22.65±0.10	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–99–71	490807	4096544	25.85±0.55	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–99–73	497039	4108618	22.19±0.21	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
DM–99–79	497324	4147258	21.86±0.79	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
EVC–CF05–8	483062	4119768	1,691±5	U-Pb age—zircon	USGS/W. Premo
JI–1XGG1	473237	4096115	1,688±5	U-Pb age—zircon	USGS/W. Premo
RGR–02	432719	4103875	4.21±0.13	^{40}Ar/^{39}Ar—whole rock, plateau age	USGS/M. Cosca
RGR–03	443405	4107035	1.06±0.04	^{40}Ar/^{39}Ar—whole rock, plateau age	USGS/M. Cosca
RGR–104	428382	4116917	26.97±0.14	^{40}Ar/^{39}Ar—whole rock, isochron age	USGS/M. Cosca
RGR–138	439704	4120766	24.52±0.13	^{40}Ar/^{39}Ar—whole rock, plateau age	USGS/M. Cosca
RGR–474	427077	4099928	25.36±0.09	^{40}Ar/^{39}Ar—whole rock, inegrated age	USGS/M. Cosca
RGR–490	427058	4100633	25.22±0.05	^{40}Ar/^{39}Ar—whole rock, inegrated age	USGS/M. Cosca
SA–MM06–90	455323	4113291	4.74±0.19	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SLH501	435081	4112675	5.19±0.11	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SLH502	435240	4114819	29.6±0.2	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH503	438414	4119137	28.88±0.05	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/D. Miggins
SLH504	432392	4117495	27.67±0.04	^{40}Ar/^{39}Ar—sanidine, plateau age	USGS/D. Miggins
SLH504	432392	4117495	27.2±0.2	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH504	432392	4117495	28.5±0.4	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/M. Cosca
SLH506	435825	4117529	28.82±0.09	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/D. Miggins
SLH506	435825	4117529	28.7±0.3	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH507	435296	4115178	30.33±0.06	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SLH508	428607	4104700	29.91±0.09	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/D. Miggins
SLH508	428607	4104700	30.2±0.3	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH509	428130	4101650	26.12±0.58	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SLH510	469308	4102812	29.01±0.12	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/D. Miggins
SLH510	469308	4102811	29.3±0.3	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH512	428515	4116219	27.93±0.09	^{40}Ar/^{39}Ar—sanidine, plateau age	USGS/D. Miggins
SLH512	428515	4116219	28.8±0.2	^{40}Ar/^{39}Ar—biotite, plateau age	USGS/M. Cosca
SLH512	428515	4116219	28.9±0.3	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/M. Cosca
SLH513	428429	4116712	26.79±0.21	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SLH514	422090	4114708	30.45±0.09	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SR1	460713	4102386	13.4±0.08	^{40}Ar/^{39}Ar—hornblende, plateau age	USGS/D. Miggins
SR12	455904	4096802	3.79±0.05	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
SR7	460073	4100532	10.61±0.11	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
T84089	427172	4099225	25.95±0.58	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
T84150	427456	4117928	26.53±0.59	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
T84163	426950	4110752	25.49±0.41	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins
TR–MM06–79	466697	4116823	4.69±0.30	^{40}Ar/^{39}Ar—groundmass concentrate, plateau age	USGS/D. Miggins

[1] U.S. Geological Survey (USGS), M. Cosca, Michael A. Cosca; D. Miggins, Daniel P. Miggins

Abandoned home site near the small agricultural community of San Acacio. Photo by Ren A. Thompson, 2005.

Divisions of Quaternary, Neogene, and Paleogene time used in this report[1]

Period or subperiod	Epoch		Age
Quaternary	Holocene		0-11.5 ka
	Pleistocene	late	11.5–132 ka
		middle	132–788 ka
		early	788 ka–2.588 Ma
Neogene	Pliocene		2.588–5.332 Ma
	Miocene		5.332–23.03 Ma
Paleogene	Oligocene		23.03–33.9 Ma
	Eocene		33.9–55.8 Ma
	Paleocene		55.8–65.5 Ma

[1] Ages of time boundaries are those of the U.S. Geological Survey Geologic Names Committee (2010) except those for the late-middle Pleistocene boundary and middle-early Pleistocene boundary, which are those of Richmond and Fullerton (1986). Ages are expressed in ka for kilo-annum (thousand years) and Ma for mega-annum (million years).

Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)

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

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Geologic Map of the Alamosa 30′ x 60′ Quadrangle, South-Central Colorado

By

Ren A. Thompson, Ralph R. Shroba, Michael N. Machette, Christopher J. Fridrich, Theodore R. Brandt, and Michael A. Cosca

2015

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