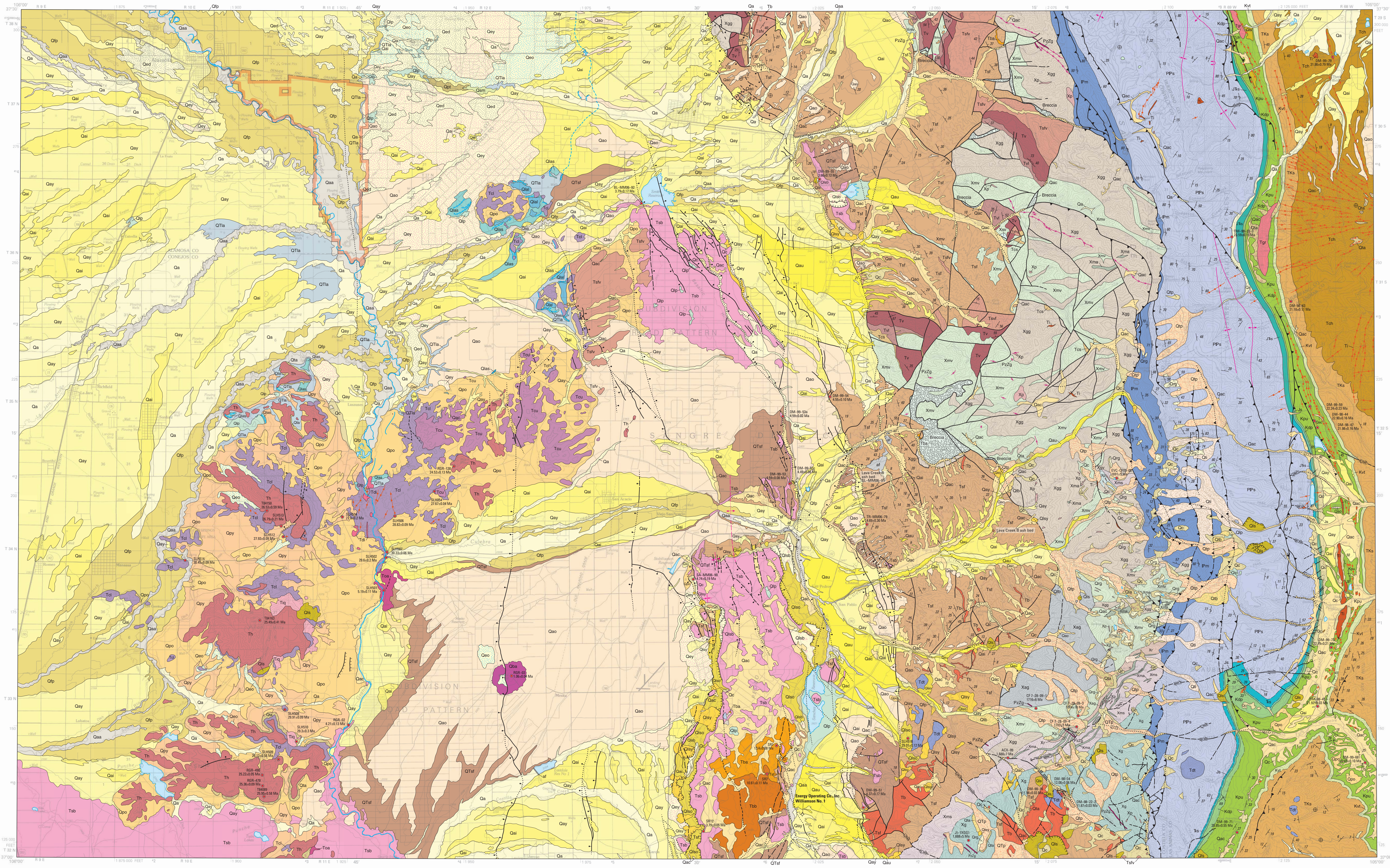
USGS
science for a changing world

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



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

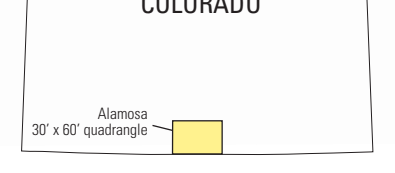
APPROXIMATE MEAN DECLINATION
AT CENTER OF MAP, 2015
DECLINATION RANGE 8.2 TO 8.7 IN THE MAP AREA

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

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

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

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

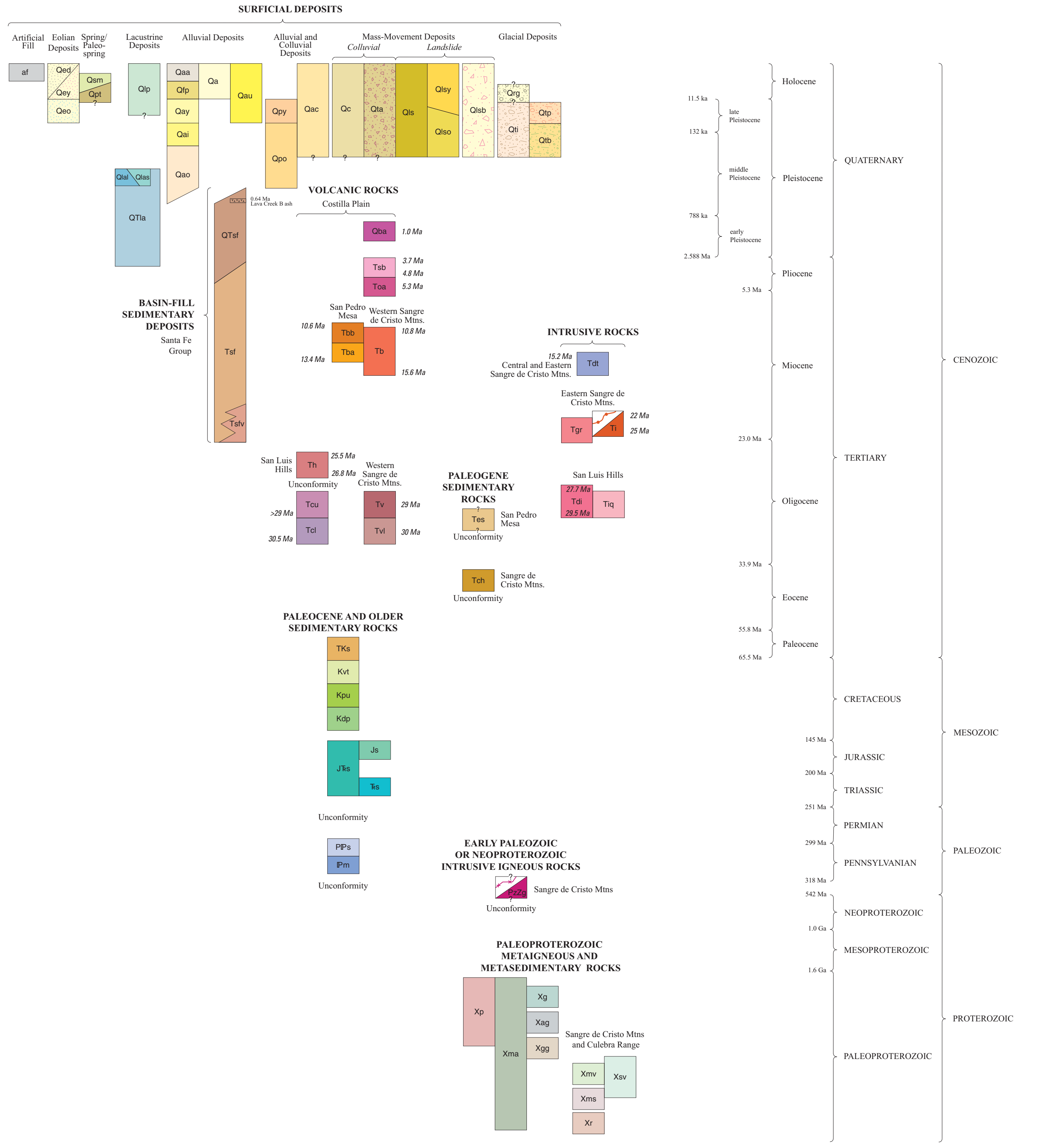


MAP LOCATION

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.

## CORRELATION OF MAP UNITS



SURFICIAL DEPOSITS
Artificial Fill — af
Eolian Deposits — Qed, Qey, Qeo
Spring/Paleo-spring — Qsm, Qpt
Lacustrine Deposits — Qlp, Qlal, Qlas, QTla
Alluvial Deposits — Qaa, Qfp, Qay, Qai, Qao, Qa, Qau
Alluvial and Colluvial Deposits — Qpy, Qpo, Qac
Mass-Movement Deposits — *Colluvial*: Qc, Qta; *Landslide*: Qls, Qlsy, Qlso, Qlsb
Glacial Deposits — Qrg, Qti, Qtp, Qtb

BASIN-FILL SEDIMENTARY DEPOSITS
Santa Fe Group — QTsf, Tsf, Tsfv
0.64 Ma Lava Creek B ash

VOLCANIC ROCKS
Costilla Plain — Qba 1.0 Ma; Tsb 3.7 Ma, 4.8 Ma; Toa 5.3 Ma
San Pedro Mesa — 10.6 Ma Tbb; Tba 13.4 Ma
Western Sangre de Cristo Mtns. — Tb 10.8 Ma, 15.6 Ma
San Luis Hills — Th 25.5 Ma, 26.8 Ma; Unconformity; Tcu >29 Ma; Tcl 30.5 Ma
Western Sangre de Cristo Mtns. — Tv 29 Ma; Tvl 30 Ma

PALEOGENE SEDIMENTARY ROCKS
Tes San Pedro Mesa; Unconformity
Tch Sangre de Cristo Mtns.; Unconformity

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 — Tdi 27.7 Ma, 29.5 Ma; Tiq

PALEOCENE AND OLDER SEDIMENTARY ROCKS
TKs, Kvt, Kpu, Kdp, JŦs, Js, Ŧs
Unconformity
PIPs, 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

Holocene — 11.5 ka — late Pleistocene — 132 ka — middle Pleistocene — 788 ka — early Pleistocene — 2.588 Ma — Pleistocene — QUATERNARY
Pliocene — 5.3 Ma — Miocene — 23.0 Ma — Oligocene — 33.9 Ma — Eocene — 55.8 Ma — Paleocene — 65.5 Ma — TERTIARY — CENOZOIC
CRETACEOUS — 145 Ma — JURASSIC — 200 Ma — TRIASSIC — 251 Ma — MESOZOIC
PERMIAN — 299 Ma — PENNSYLVANIAN — 318 Ma — PALEOZOIC
542 Ma — NEOPROTEROZOIC — 1.0 Ga — MESOPROTEROZOIC — 1.6 Ga — PALEOPROTEROZOIC — PROTEROZOIC

## LIST OF MAP UNITS

[Note: 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** |
| JŦs | **Jurassic and Triassic sedimentary rocks, undivided** |
| Ŧs | **Triassic sedimentary rocks, undivided** |
| PIPs | **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** |

## 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**
  - 3 **Inclined**—Showing strike and dip
  - **Vertical**—Showing strike
  - 80 **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

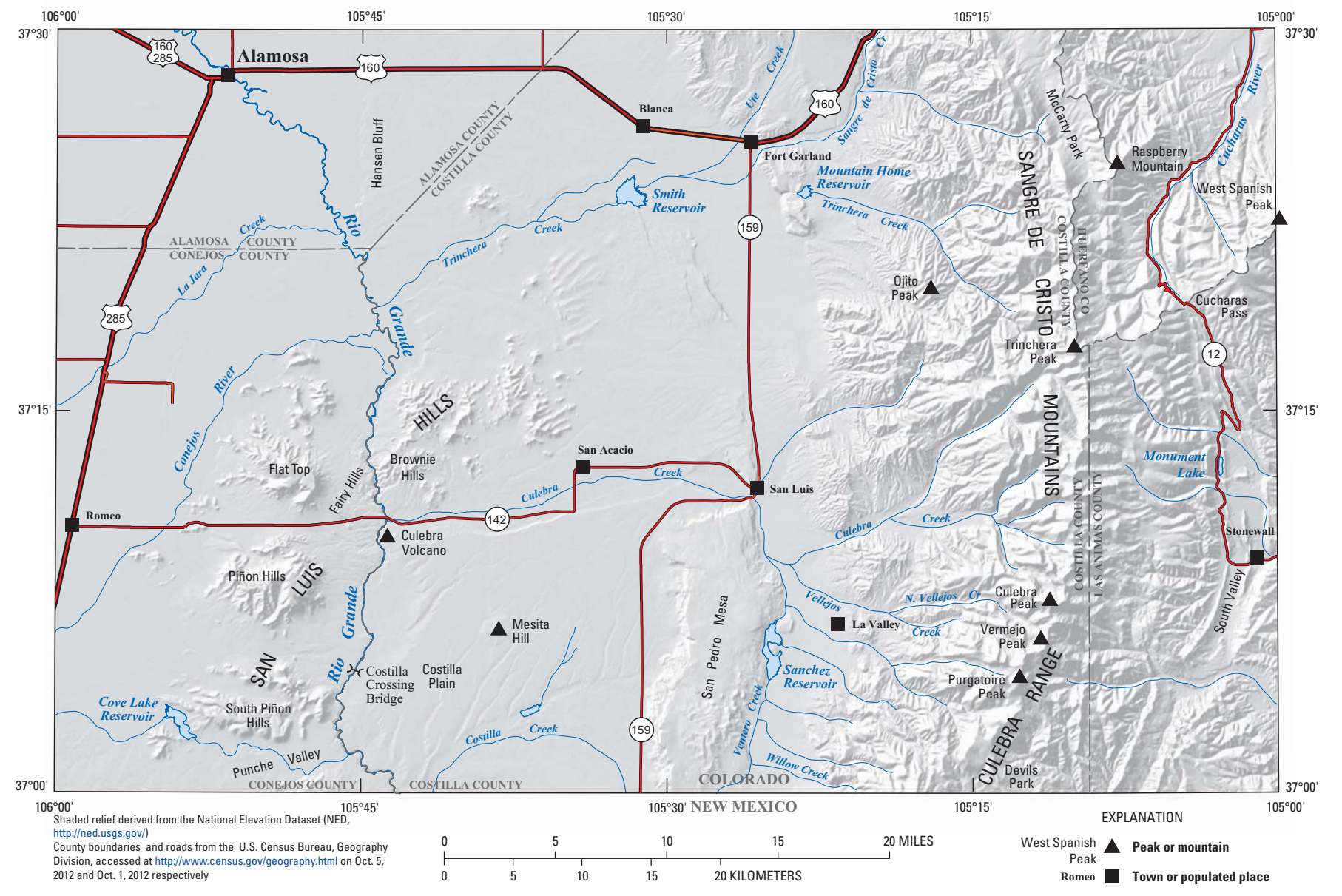
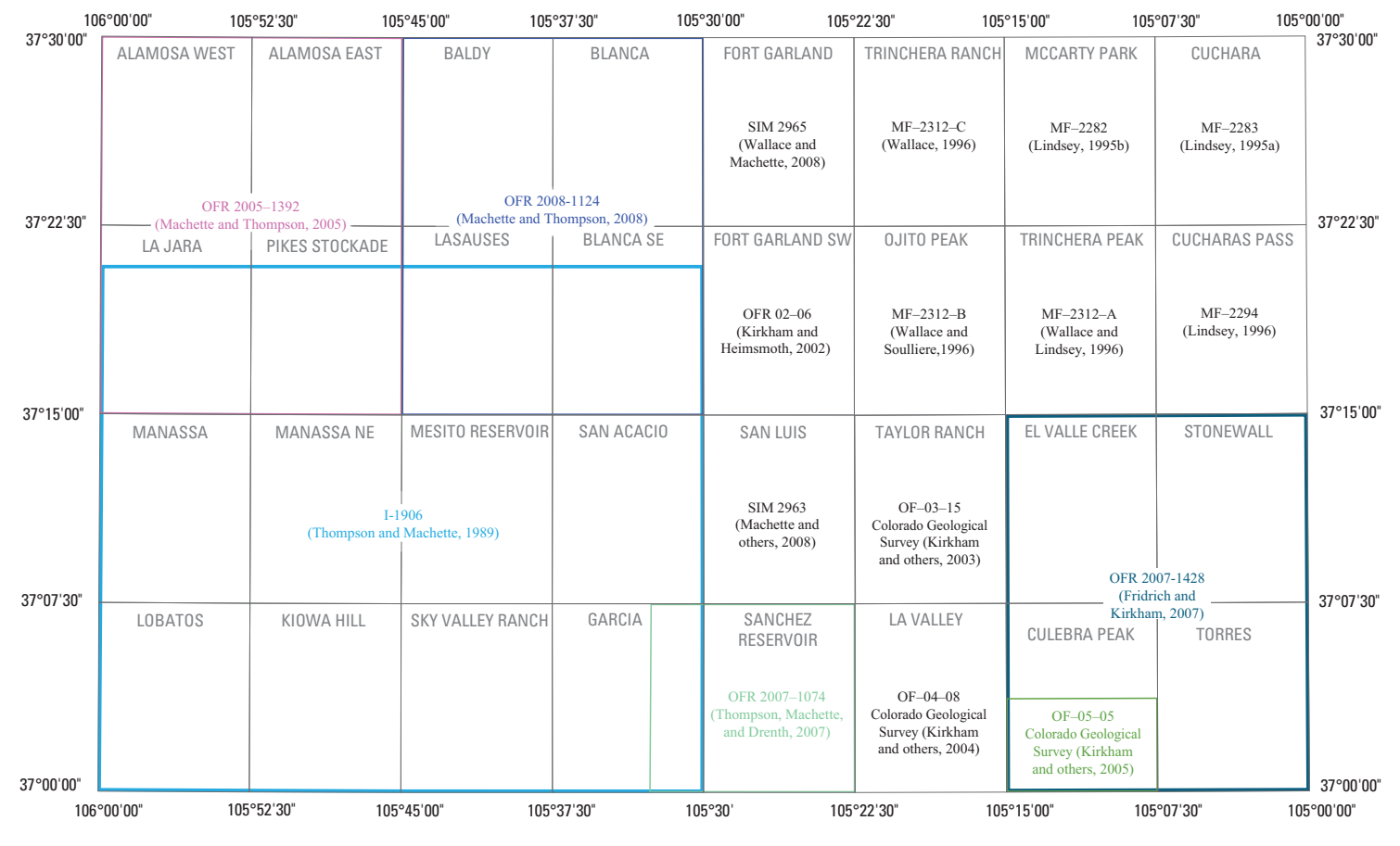


**Figure 1**. Shaded relief location index for Alamosa 30' × 60' quadrangle



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

**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.

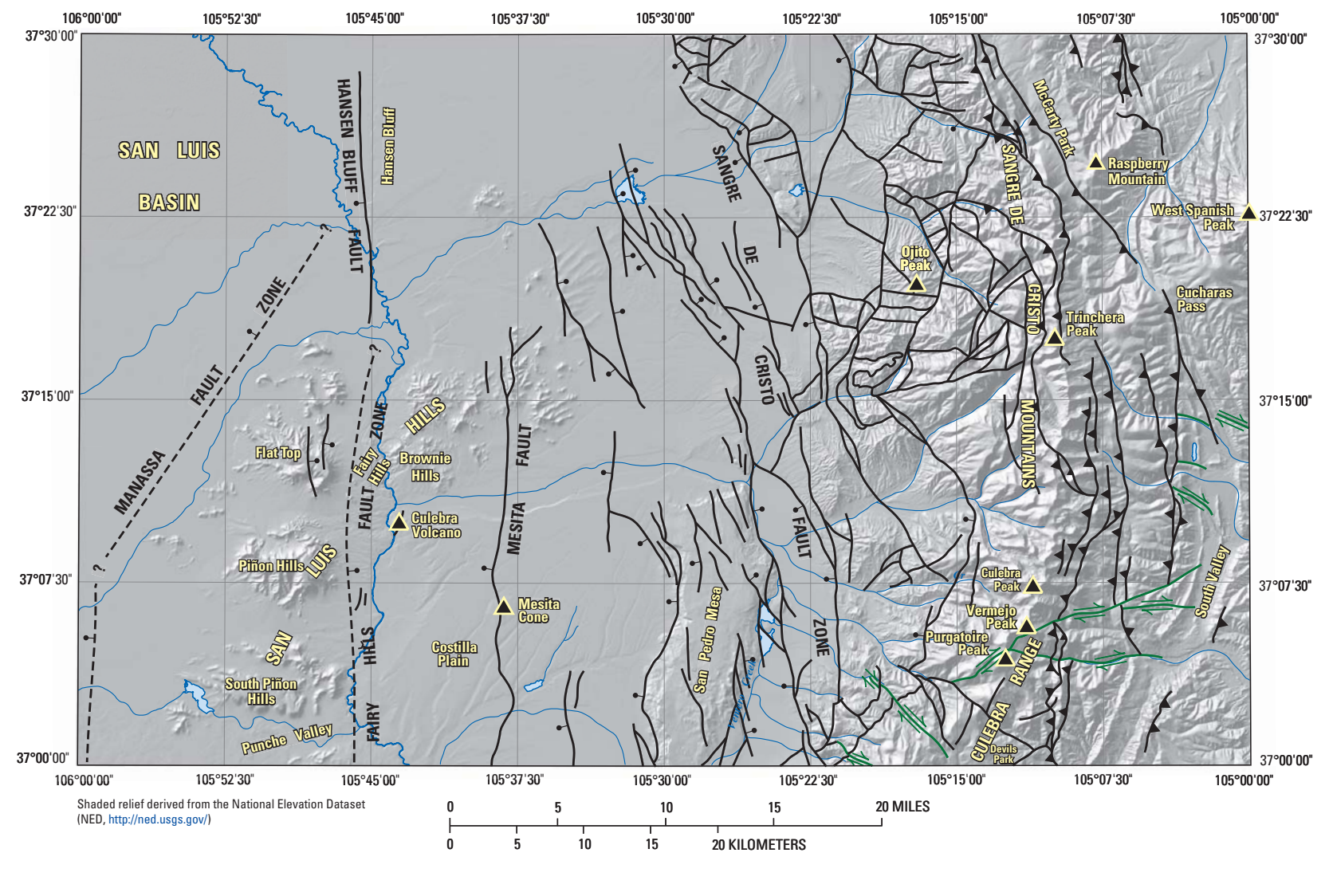


**Figure 3.** Simplified fault map for Alamosa 30' × 60' quadrangle showing major faults of the San Luis Basin and Sangre de Cristo Mountains. Older thrust faults of the Sangre de Cristo Mountains are shown in black with thrust attribution. Post-thrust faults of indeterminate age are depicted in green 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.

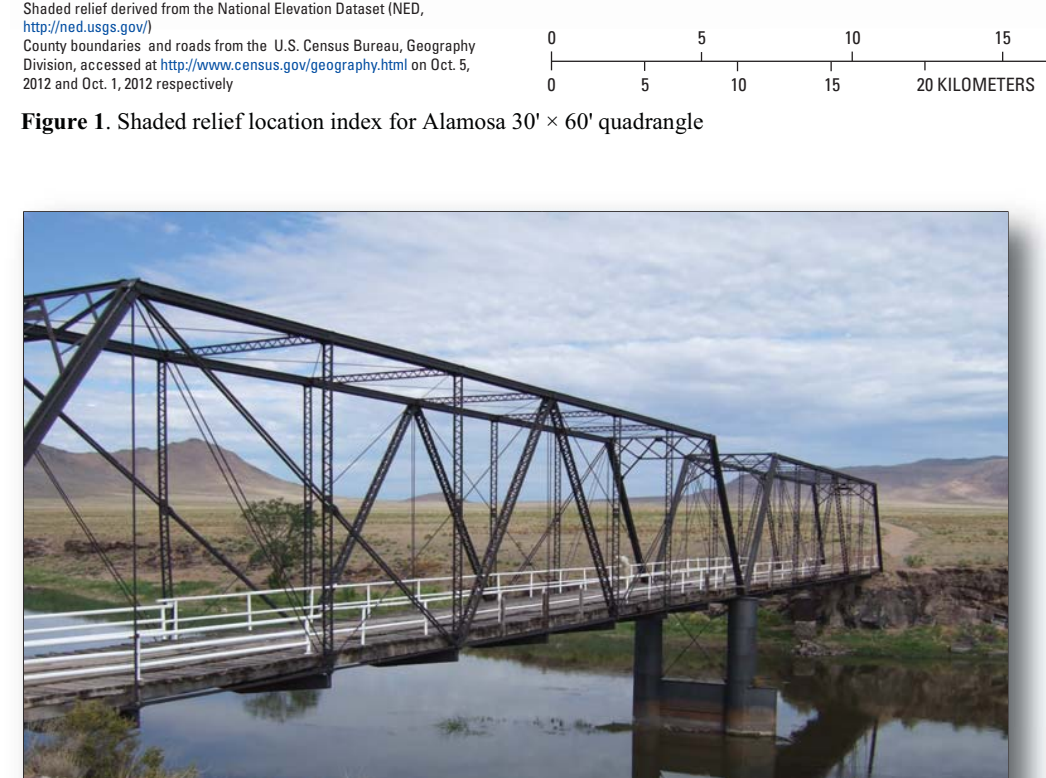


**Figure 4.** Photograph of the Costilla Crossing Bridge over the Rio Grande. The bridge is a single lane, two-span Thatcher through-truss bridge constructed in 1892. It was posted to the National Register of Historic Places in 1985. The bridge is 11.5 km south of the Colorado Hwy 142 bridge over the 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.

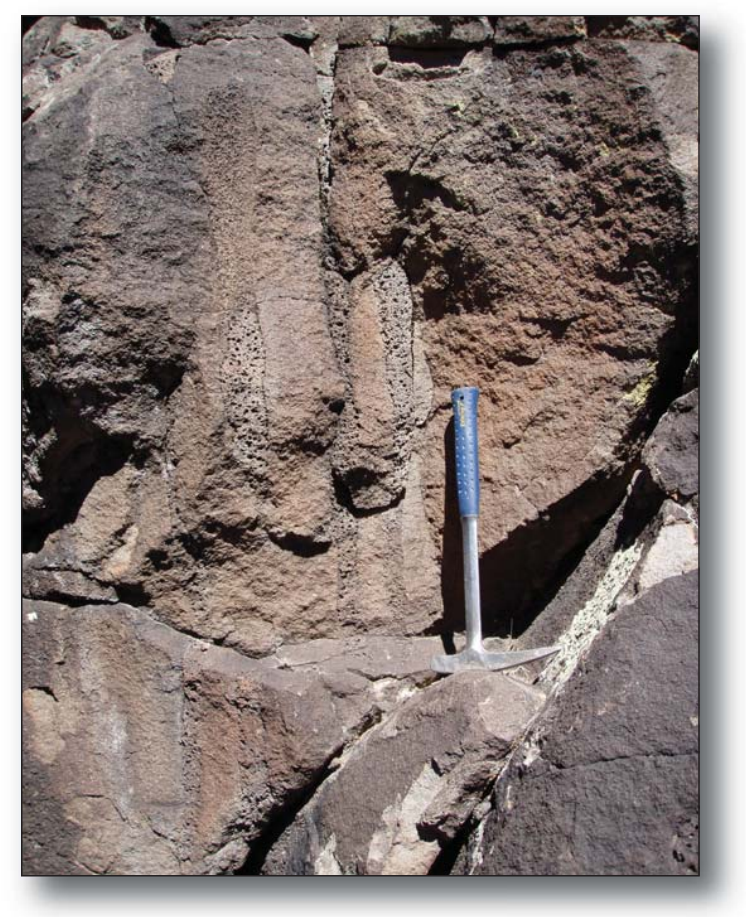


**Figure 5.** Photograph of vertical vesicle pipes in an olivine tholeiite lava flow, characteristic of Servilleta Basalt (Tsb) in the southern part of the map area, San Pedro Mesa, and scattered outcrops along the western range front of the Sangre de Cristo Range. Photo by Ren A. Thompson, 2005.

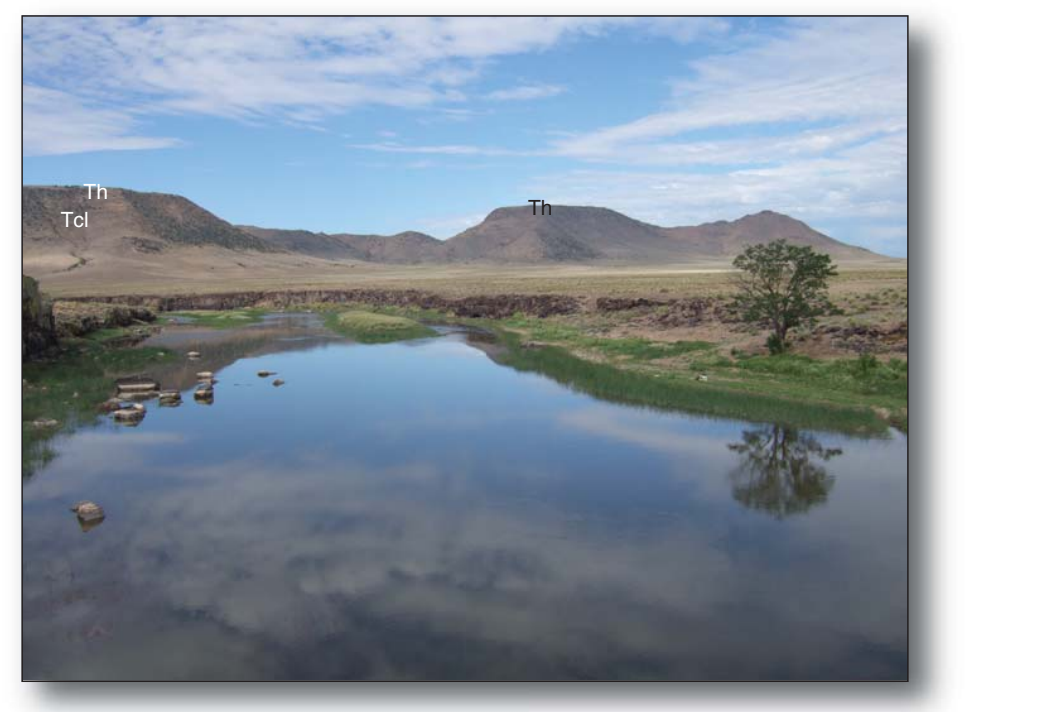


**Figure 6.** Photograph of view northwest from Costilla Crossing Bridge toward Piñon Hills. Flat Top mesas are capped by Oligocene basaltic lava flows of the Hinsdale Formation (Th) that are dominantly underlain by Oligocene andesite and dacite volcanic deposits of the lower Conejos Formation (Tcl).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

**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 |

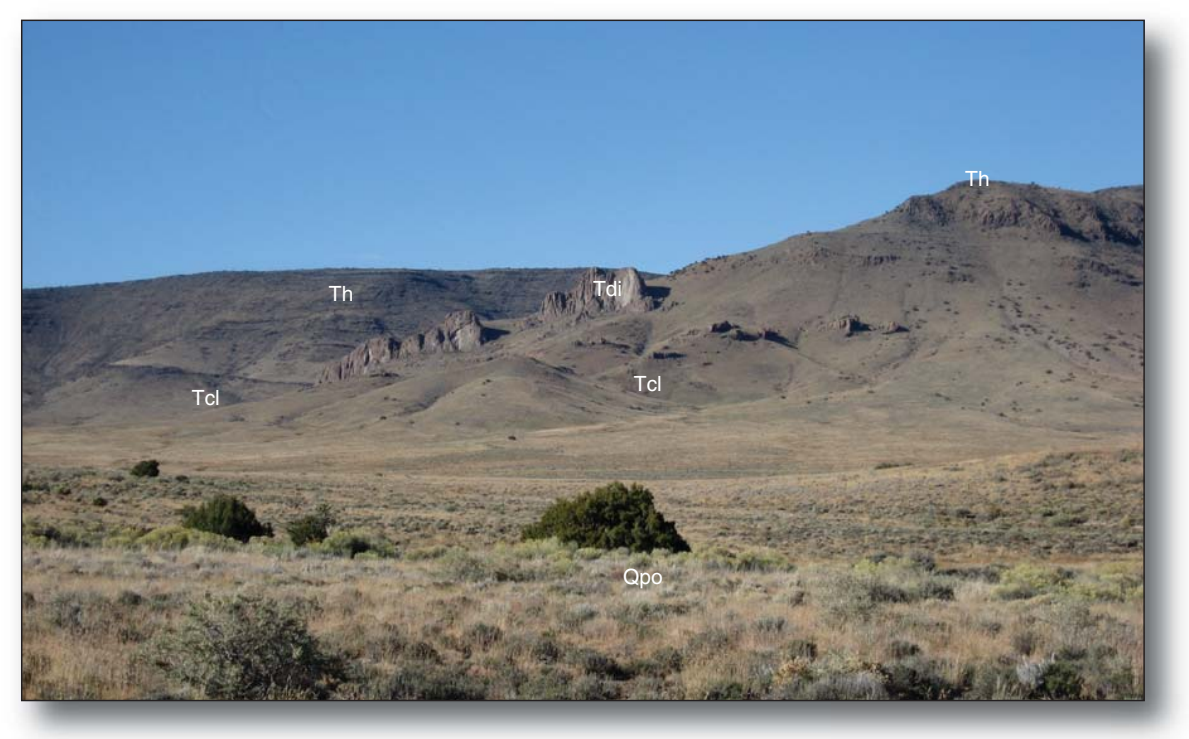


**Figure 7.** Photograph of view northwest toward the southern flanks of Flat Top in the San Luis Hills. Prominent fins of exposed bedrock in near hills are eroded remnants of vertical dacite dikes (Tdi) cutting andesite lava flows and breccia deposits of the lower Conejos Formation (Tcl). Thinly bedded 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 | Location (UTM-NAD83) 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 the 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 (km²) | 0.3861 | square mile (mi²) |

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

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also may contain copyrighted materials as noted in the text. Permission to reproduce copyrighted items must be secured from the copyright owner.

This database, identified as SIM 3342, has been approved for release by the U.S. Geological Survey (USGS). Although this database has been subjected to rigorous review and is substantially complete, the USGS reserves the right to revise the data pursuant to further analysis and review. Furthermore, the database is released on condition that neither the USGS nor the U.S. Government may be held liable for any damages resulting from its authorized or unauthorized use.

# 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**

Publishing support provided by:
Denver Publishing Service Center
Edit and digital layout by L.J. Binder
Manuscript approved for publication August 31, 2014

To learn about the USGS and its information products visit
http://www.usgs.gov/
1-888-ASK-USGS

ISSN 2329-132X (online)
http://dx.doi.org/10.3133/sim3342

For more information concerning this publication, contact:
Center Director, USGS Geosciences and Environmental Change Science Center
Box 25046, Mail Stop 980
Denver, CO 80225
(303) 236-5344

Or visit the Geosciences and Environmental Change Science Center Web site at:
http://gec.cr.usgs.gov/

Digital files available at http://dx.doi.org/10.3133/sim3342 or
http://pubs.er.usgs.gov/publication/sim3342

Suggested citation: Thompson, R.A., Shroba, R.R., Machette, M.N., Fridrich, C.J., Brandt, T.R., and Cosca, M.A., 2015, Geologic map of the Alamosa 30' x 60' quadrangle, south-central Colorado: U.S. Geological Survey Scientific Investigations Map 3342, 23 p., scale 1:100,000, http://dx.doi.org/10.3133/sim3342. (Supersedes Open-File Report 2005–1392, and Open-File Report 2008–1124.)