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Northern Sangre de Cristo fault, Zapata section (Class A) No. 2321b

Last Review Date: 2012-01-13

Compiled in cooperation with the Colorado Geological Survey

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Synopsis	**General:** The Northern Sangre de Cristo fault is a major down-to-west normal fault within the Rio Grande rift in Colorado. This high-angle normal fault dips to the west and forms the structural boundary between the Sangre de Cristo Range/Culebra Range on the east and the San Luis basin. The San Luis basin is the largest of the major north-trending extensional basins of the northern Rio Grande rift. The fault extends from Poncha Pass to near the Colorado-New Mexico state line. **Sections:** This fault has 4 sections. The Northern Sangre de

	Cristo fault is divided into sections based on mountain-front and fault-scarp morphology for the purpose of this compilation. The entire fault shows evidence that suggests multiple late Quaternary surface displacements, including Holocene movement. The following sections from north to south are: the Crestone section, the Zapata section, the Blanca section, and the San Luis section; these three segments are herein called sections. A fourth section (San Luis) extends generally southward from the south side of the Blanca Peak Massif to Jarosa Creek near the Colorado-New Mexico state line.
Name comments	**General:** The Sangre de Cristo fault zone borders the eastern side of San Luis basin from near Poncha Pass, Colorado, to near Taos, New Mexico. This fault zone has been subdivided into two discrete faults for this compilation: the Northern Sangre de Cristo fault, which bounds the west side of the Sangre de Cristo Mountains in Colorado and the Southern Sangre de Cristo fault, which is in New Mexico. Ruleman and Machette (2007 #7165), Ruleman and others (2008 #7286), and Crone and others (2006 #7753) suggest the geomorphology of the Northern Sangre de Cristo fault and the adjacent range front indicate differing amounts of offset and different faulting histories north of Blanca Peak massif in contrast to the San Luis section defined here, which they prefer to call the Central Sangre de Cristo fault zone. **Section:** The Zapata section was named during this compilation by Widmann and others (1998 #3441). It corresponds to segment 'B' of the Northern Sangre de Cristo fault of McCalpin (1982 #791). The Zapata section is marked by several discontinuous scarps. **Fault ID:** Fault number Q69d of Widman and others (1998 #3441); fault 116 in Kirkham and Rogers (1981 #792); fault 131 in Witkind (1976 #2792); fault 3 of Colman (1985 #1953).
County(s) and State(s)	ALAMOSA COUNTY, COLORADO SAGUACHE COUNTY, COLORADO
Physiographic province(s)	SOUTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:125,000 scale. *Comments:* All or parts of this section were mapped by McCalpin (1982 #791; scale 1:50,000), Colman and others (1985 #1954;

	scale 1:125,000), Witkind (1976 #2792; scale 1:500,000), and Kirkham and Rogers (1981 #792; scale 1:500,000). The trace used for this compilation is from Colman and others (1985 #1954).
Geologic setting	The Northern Sangre de Cristo fault is a major down-to-west normal fault within the Rio Grande rift. It forms the eastern boundary of the east-tilted half-graben of San Luis basin. The deepest part of San Luis basin lies adjacent to the Northern Sangre de Cristo fault (Gaca and Karig, 1965 #2690). Estimates of the maximum thickness of synorogenic basin fill in that part of San Luis basin have widely ranged. Gaca and Karig (1965 #2690) suggested a maximum thickness of about 9.7 km; Huntley (1976 #2698; 1976 #2699) reported it at about 5 km; Stoughton (1977 #2750) at 6,000 m; and Kluth and Schaftenaar (1994 #1183) at 6.4 km. Estimates of the amount of vertical displacement on the Northern Sangre de Cristo fault also vary widely. Kluth and Schaftenaar (1994 #1183) suggested the Northern Sangre de Cristo fault has approximately 9.2 km of vertical separation; geophysical data suggest that total Neogene throw on the Northern Sangre de Cristo fault is at least 4 km (Brister and Gries, 1994 #1178).
Length (km)	This section is 28 km of a total fault length of 164 km.
Average strike	N35°E (for section) versus N19°W,N35°E (for whole fault)
Sense of movement	Normal
Dip	60° W *Comments:* The dip of the Zapata section is poorly understood. Tweto (1979 #2767), Burroughs (1981 #2661), and Brister and Gries (1994 #1178) described the fault as high angle, an interpretation supported by the trench exposures mapped by McCalpin (1981 #2723, 1982 #791). Using seismic reflection and gravity data, Kluth and Schaftenaar (1994 1183) concluded the fault dip is about 60° W, the value used herein.
Paleoseismology studies	One trench near Uracca Creek was excavated across this section by McCalpin (1981 #2723, 1982 #791) and four additional trenches were excavated near the Visitor's Center in 2002 and 2003 (McCalpin, 2006 #7285). The trench nearest the Visitor Center failed to expose a tectonic fault but possibly exposed an

	old landslide. McCalpin (1981 #2723; 1982 #791) and Colman and others (1985 #1954) profiled several scarps on the Zapata section. Site 2321-3. The Uracca Creek trench was excavated across a Holocene scarp near Uracca Creek that is about 1.2 km west of the range front. The fault exposed in this trench moved about 2.0 m during a single event between 8.0 and 5.64 ka (McCalpin, 1981 #2723, 1982 #791), which is similar in time and perhaps contemporaneous with the last fault event at the Major Creek site (site 2321-1) on the Crestone section. Site 2321-4. Four trenches excavated were across the subparallel fault scarps near Morris Gulch near the Visitor's Center for the Great Sand Dunes National Park and National Preserve (McCalpin, 2006 #7285). The three down to the west faults have a total vertical displacement of about 8 m. Exposures of the faults near Morris Gulch show evidence for two post-Pinedale (post-15 ka to 35 ka) surface-faulting earthquakes. A total of seven radiocarbon samples obtained from the three trenches and two optically-stimulated luminescence (OSL) samples from trench D: however, ages from the samples proved to be unreliable. Trench B was located about 150 m south of the water tank across a 4-m-high scarp on Pinedale–equivalent deposits. The trench was deepened following the initial mapping. Two events are evident based on the two colluvial wedges in the exposed section; the earliest surface fault occurred soon after deposition of the Pinedale alluvial fan and the most recent is thought to correlate to the 4000–5000 cal yr BP event in other trenches. Trench C was located about 10 m south of the active channel of Morris Gulch and exposed one colluvial wedge suggesting surface-faulting event that predates 3,370–4,040 cal yr BP, based on two radiocarbon ages, by several hundred to a few thousand (?) years. Trench D was located about 100 m southwest of the stables and exposed evidence of two surface-faulting events with total displacement of about 3.3 m. A single radiocarbon sample yielded an anomalously young age and two optically stimulated luminescence (OSL) samples that yielded age estimates in reversed stratigraphic order. The average cumulative displacement per event across all three scarps might be 3.15–4.85 m if back rotation is negligible (McCalpin, 2007 #7288).
Geomorphic expression	The northern part of the section is characterized by fairly prominent, discontinuous scarps, but they are less numerous south

	of North Zapata Creek (McCalpin, 1982 #791; Colman and others, 1985 #1954). In the northern part, the scarps are generally at or near the range front, but the most prominent scarp in the southern part lies about 1.2 km west of the range front (McCalpin, 1982 #791). McCalpin (1982 #791) and Colman and others (1985 #1954) profiled several scarps on this section; mapping of fault scarps of various heights on deposits such as Pinedale (3- to 8-m-high fault scarps), Bull Lake (5-to 13-m-high fault scarps), and pre-Bull Lake (up to 85 m high) shows repeated activity along the fault during the late Quaternary
Age of faulted surficial deposits	McCalpin (1981 #2723, 1982 #791) reported that Pinedale and Holocene deposits are faulted along the Zapata section.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Holocene surface rupture is demonstrated by McCalpin (1982 #791) and McCalpin (2006 #7285) at two sites along this part of the fault. The available geochronologic data indicate the most recent event occurred about 4.8–5.3 ka, at least based on interpretation of data from trench D (site 2321-4). Simultaneous rupture on the two nearby scarps at the site is supported by their overall stratigraphy. This age is similar to the age of surface rupture deduced by McCalpin (1982 #791) at the Uracca Creek trench (site 2321-3), which had a closely limiting maximum age of about 5.5 ka.
Recurrence interval	10–20 k.y. *Comments:* McCalpin (1982 #791) estimated that the long-term (post-Bull Lake) recurrence on the Zapata section of the northern Sangre de Cristo fault zone was on the order of 10–20 k.y.; McCalpin (1981 #2723) suggested the post-Pinedale recurrence interval for this section is about 8.0 k.y. More recent studies do not improve the resolution of recurrence intervals as there are no age constraints on penultimate event other than it being Pinedale age, but McCalpin (2006 #7285) suggests return times of 5–20 k.y. for the purpose of estimating seismic hazard.
Slip-rate category	Less than 0.2 mm/yr

	Comments: Widmann and others (1998 #3441) placed this section of the fault within the <0.2 mm/yr slip-rate category.
Date and Compiler(s)	2012 Robert M. Kirkham, Colorado Geological Survey Kathleen M. Haller, U.S. Geological Survey
References	#1178 Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 39-58. #7819 Bruce, R.M., and Johnson, B.R., 1991, Reconnaissance geologic map of parts of the Zapata Ranch and Mosca Pass quadrangles, Alamosa and Huerfano Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2168, scale 1:24,000. #2661 Burroughs, R.L., 1981, A summary of the geology of the San Luis Basin, Colorado-New Mexico, with emphasis on the geothermal potential for the Monte Vista graben: Colorado Geological Survey Special Publication 17, 30 p. #1953 Colman, S.M., 1985, Map showing tectonic features of late Cenozoic origin in Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations I-1566, 1 sheet, scale 1:1,000,000. #1954 Colman, S.M., McCalpin, J.P., Ostenaa, D.A., and Kirkham, R.M., 1985, Map showing upper Cenozoic rocks and deposits and Quaternary faults, Rio Grande Rift, south-central Colorado: U.S. Geological Survey Miscellaneous Geologic Investigations I-1594, 2 sheets. #2690 Gaca, J.R., and Karig, D.E., 1965, Gravity survey in the San Luis Valley area, Colorado: U.S. Geological Survey Open-File Report. #2698 Huntley, D., 1976, Groundwater recharge to the aquifers of the northern San Luis Valley, Colorado: Golden, Colorado School of Mines, Ph.D. dissertation T-1864, 298 p. #2699 Huntley, D., 1976, Ground water recharge to aquifers of

northern San Luis Valley, Colorado—A remote sensing investigation: Colorado School of Mines Remote Sensing Report v. 76-3, 247 p.

#7790 Ingersoll, R.V., 2001, Structural and stratigraphic evolution of the Rio Grande Rift, northern New Mexico and southern Colorado: International Geology Review, v. 43, p. 687–891, doi:10.1080/00206810109465053.

#2703 Jack Benjamin & Associates and Geomatrix Consultants, 1996, Probabilistic seismic hazard assessment for the U.S. Army chemical disposal facility, Pueblo Depot Activity, Colorado: Technical report to Science Applications International Corporation, Maryland, under Contract JBA 148-130-PU-002.

#7813 Johnson, B.R., and Bruce, R.M., 1991, Reconnaissance geologic map of parts of the Twin Peaks and Blanca Peak quadrangles, Alamosa, Costilla, and Huerfano Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2169, scale 1:24,000.

#7818 Johnson, B.R., Bruce, R.M., and Lindsey, D.A., 1989, Reconnaissance geologic map of the Medano Pass quadrangle and part of the Liberty quadrangle, Alamosa, Huerfano, and Saguache Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-2089, scale 1:24,000.

#792 Kirkham, R.M., and Rogers, W.P., 1981, Earthquake potential in Colorado: Colorado Geological Survey Bulletin 43, 171 p., 3 pls.

#1183 Kluth, C.F., and Schaftenaar, C.H., 1994, Depth and geometry of the northern Rio Grande rift in the San Luis Basin, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande rift—Structure, stratigraphy, and tectonic setting: Geological Society of America Special Paper 291, p. 27-37.

#2723 McCalpin, J., 1981, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Golden, Colorado School of Mines, unpublished Ph.D. dissertation, 287 p.

#7288 McCalpin, J., 2007, Stop A3—Paleoseismology of range-

front fault scarps at Great Sand Dunes, *in* Machette, M.N., Coates, M-M., and Johnson, M.L., eds., 2007 Rocky Mountain Section Friends of the Pleistocene Field Trip—Quaternary geology of the San Luis basin of Colorado and New Mexico, September 7–9, 2007: U.S. Geological Survey Open-File Report 2007-1193, p. 19–23.

#791 McCalpin, J.P., 1982, Quaternary geology and neotectonics of the west flank of the northern Sangre de Cristo Mountains, south-central Colorado: Colorado School of Mines Quarterly, v. 77, no. 3, p. 1-97.

#7285 McCalpin, J.P., 2006, Active faults and seismic hazards to infrastructure at Great Sand Dunes National Monument and Preserve: Final report to Great Sand Dunes National Monument and Preserve, Mosca, Colo., February 10, 2006, 49 p.

#7252 Ruleman, C., and Machette, M., 2007, An overview of the Sangre de Cristo fault system and new insights to interactions between Quaternary faults in the northern Rio Grande rift, in Machette, M.N., Coates, M.M., and Johnson, M.L., eds., 2007 Rocky Mountain Section Friends of the Pleistocene field trip—Quaternary geology of the San Luis Basin of Colorado and New Mexico, September 7–9, 2007: U.S. Geological Survey Open-File Report 2007-1193, p. 187–197.

#2750 Stoughton, D., 1977, Interpretation of seismic reflection data from the San Luis Valley, south-central Colorado: Golden, Colorado School of Mines, M.S. thesis T-1960, 100 p.

#2767 Tweto, O., 1979, The Rio Grande Rift system in Colorado, *in* Rio Grande Rift—Tectonics and magmatism: American Geophysical Union, p. 33-56.

#3441 Widmann, B.L., Kirkham, R.M., and Rogers, W.P., 1998, Preliminary Quaternary fault and fold map and database of Colorado: Colorado Geological Survey Open-File Report 98-8, 331 p., 1 pl., scale 1:500,000.

#2792 Witkind, I.J., 1976, Preliminary map showing known and suspected active faults in Colorado: U.S. Geological Survey Open-File Report 76-154.

Questions or comments?