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Socorro Canyon fault zone, southern section (Class A) No. 2108b

Last Review Date: 2015-10-17

Compiled in cooperation with the New Mexico Bureau of Geology & Mineral Resources

citation for this record: **Machette, M.N., and Chamberlin, R.M., compilers, 2015, Fault number 2108b, Socorro Canyon fault zone, southern section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 12/14/2020 02:21 PM.**

Synopsis	**General:** The Socorro Canyon fault zone is comprised of two sections that bound the Socorro and Lemitar Mountains, west of Socorro. The fault zone dips east, has a normal sense of displacement, and parallels and influences the alluvial margin of the Rio Grande Valley in the Socorro Basin. The northern section of the fault zone forms the eastern margin of the Socorro and northern Lemitar Mountains. In the intervening area between these two uplifted, backtilted ranges, the fault zone juxtaposes Pliocene and Miocene basin-fill sediment along the western margin of the topographically defined Socorro Basin.

	South of Socorro Canyon, the southern section of the fault zone strikes south and southeast across the piedmont, widening southward. The fault zone is mapped at 1:24,000 scale, and a one detailed study has been made of the fault's movement history. At least one strand of the fault appears to be of latest Pleistocene to Holocene age based on the presence of a small (single-event) fault scarp on young alluvial deposits adjacent to Socorro Canyon. **Sections:** This fault has 2 sections. Although Chamberlin referred to segments of the fault, no definitive work has been done to substantiate such a scheme. The fault is herein divided into two sections on the basis of apparent recency of movement and surficial expression of faulting.
Name comments	**General:** Machette and McGimsey (1983 #1024) named this prominent fault zone after scarps exposed near Socorro Canyon, a major yet ephemeral east-trending stream canyon that enters the Rio Grande just south of Socorro, New Mexico. It was previously named the Socorro fault by Kelley (1954 #1222). The Socorro Canyon fault zone extends from San Lorenzo Canyon (on the north) southward to a point just east of U.S. Interstate Highway 25 about 2 km north of the highway exit to San Antonio, New Mexico. The north end of the Socorro Canyon fault is linked to the south end of the Loma Pelada fault [2113] by the south-southeast facing Vivarosa relay ramp (Chamberlin and others, 2001 #7474). **Section:** The southern section forms mainly continuous fault scarps that extend along the southern part of the Socorro Mountains and across the piedmont slope that flanks the eastern margin of the Chupadera Mountains. As discussed herein, the southern section includes the MCA fault of Chamberlin and Eggleston (1996 #1224). The northern end of the section is at Sedillo Springs, whereas the southern end is at a point just east of Interstate Highway 25 about 2 km north of the exit to San Antonio, New Mexico. **Fault ID:** Fault number 13 of Machette (1982 #1401) and fault number 12 of Machette and McGimsey (1983 #1024).
County(s) and State(s)	SOCORRO COUNTY, NEW MEXICO
Physiographic province(s)	BASIN AND RANGE
Reliability of location	Good Compiled at 1:100,000 scale.

	Comments: Trace from unpublished 1:24,000-scale mapping by Machette used to compile fault map of Machette and McGimsey (1983 #1024), and from Chamberlin's recent 1:24,000-scale mapping of the Socorro (Chamberlin, 1999 #7310) and Luis Lopez 7.5-minute quadrangles (Chamberlin and others, 2002 #1224). Traces compiled on1:100,00 scale topographic base map.
Geologic setting	The Socorro Canyon fault zone defines the eastern uplifted margin of the Socorro and northern Lemitar Mountains, which lie west of the Rio Grande valley. North of Socorro Canyon, east-dipping normal faults bound the Socorro and Lemitar Mountains, which were strongly uplifted and west-titled in late Oligocene to late Miocene time. These mountains are cored by Precambrian and Paleozoic rocks, but the Socorro Mountains are cut by the north wall of the Socorro Caldera, an Oligocene eruptive center that was the source of the 32-Ma Hells Mesa Tuff (Chamberlin and others, 2004 #7309). About 3 km north of Socorro Canyon, the fault splays southward into a distributed but subparallel intrabasin scarps on a variety of ages of piedmont-slope surfaces. Southward bifurcation of the Socorro Canyon fault zone is generally coincident with a transverse tilt-block domain boundary known as the Socorro accommodation zone (SAZ; previously called the Socorro transverse shear zone; Chapin and others, 1978 #1240). The SAZ is coincident with an older crustal flaw that controlled emplacement of the ENE-trending Socorro-Magdalena caldera complex. The pattern of distributed Quaternary faulting may be the surficial expression of "hotter" (more plastic) middle crust associated with the geophysically defined Socorro magma body along the southern section of the Socorro Canyon fault zone. There is about 208 m of cumulative down-to-the-east displacement of a basalt that flowed across the fault zone in Socorro Canyon about 4.0 Ma (Chamberlin and Harrison, 1996 #1225). Total Pliocene through Pleistocene displacement is probably not more than 300 m. Field relations around the 7.8-Ma rhyolitic lava dome (perlite deposit) near Socorro Canyon indicates that the fault zone did not exist prior to about 6 Ma. Larger offsets of Miocene and Oligocene strata (in the Socorro and Lemitar Mountains) predate the Socorro Canyon fault zone.
Length (km)	This section is 26 km of a total fault length of 49 km.
Average strike	N19°W (for section) versus N14°W (for whole fault)
Sense of movement	Normal

Dip	75–90° E *Comments:* Fault dips 75–90° E in near surface as measured from trench log of Behr and Harrison (1998 #4469). May dip at shallower angle in the subsurface. Many of the fault traces have antithetic west-dipping faults that form small grabens.
Paleoseismology studies	A single trench was excavated across a 3- to 4-m-high scarp at the mouth of Socorro Canyon about 40 m north of U.S. Highway 60 in the early 1980s, but the trench was not adequately mapped or sampled to decipher the fault's movement history. In the winter of 1997–98, Bruce Harrison (New Mexico Tech, Socorro, New Mexico) refreshed the main trench and excavated a second trench across the aforementioned small scarp. These two trenches are collectively referred to as site 2108-1. Preliminary interpretations of the times of faulting and amounts of displacement were presented on a 1998 Rocky Mountain Cell Friends of the Pleistocene field trip (Araybe and others, 1998, #4467; Behr and Harrison, 1998 #4469). By using the concentration and distribution of cosmogenically produced chlorine, Fred Phillips and Bruce Harrison and their students at New Mexico Tech were able to estimate the age of the faulted terrace surface (Bull Lake in unpublished field notes used for Machette, 1983 #1024), and the times of two subsequent faulting events. According to Aryarbe and others (1998, #4467), the estimated age of the older of two faulted terraces at the Socorro Canyon site (2108-1) is 136 ka (no error limits were stated). Using time definitions for this database (see Glossary), the higher older terrace is latest middle Pleistocene (130–750 ka). Two bodies of tectonic colluvium were mapped in the trench by Behr and Harrison (1998 #4469). The lower (older) colluvium was deposited as a result of a major faulting event at about 119 ka, thus implying a period of about 17 k.y. (an incomplete recurrence interval) between stabilization of the terrace and the first faulting event. The upper (younger) colluvium was deposited as a result of a second faulting event at about 46 ka, thus implying a period of about 53 k.y. (a complete recurrence interval) between the first and second faulting events. As mentioned above, there is a second lower, younger terrace at the Socorro Canyon site. Machette and McGimsey (1983 #1024) measured scarp heights of 0.7–0.8 m, and considered this scarp to be slightly younger than the Drum Mountains scarps in Utah (i.e., early Holocene). Clark (1998, #4468) re-profiled this scarp (height of 0.58 m) and used a diffusion model to estimate the time of its formation.

	Her results indicated a time of formation of about 1.4–1.6 ka, considerably younger that than estimated by Machette and McGimsey (1983 #1024). Nevertheless, both studies indicate that the youngest movement on the southern section of the Socorro Canyon fault zone is Holocene. Using a time span of 1.5 to 7 ka (Clark's mean estimate versus the inferred age of the Drum Mountains comparison scarps), one can obtain a second recurrence interval for the faulting. It ranges from about 39 k.y. (7 ka and 46 ka faulting events) to 44.5 k.y. (1.5 ka and 46 ka faulting events).
Geomorphic expression	South of Socorro Canyon, the fault zone forms a southward-widening distributed zone of subparallel scarps (7 km wide) on a variety of ages of piedmont-slope surfaces. There are several discontinuous east- to southeast-trending scarps that strike away from the main trace of the fault zone at the section boundary; these scarps may be following preexisting faults associated with the Socorro caldera in the subsurface. Not all the scarps are present on the same-age landforms, suggesting that some strands of the fault may be more or less active than others. On the south bank of Socorro Canyon the fault forms scarps that appear to represent the most recent and penultimate faulting events on the main (active) strand of the fault zone. The morphology of these scarps, and others to the south, have been analyzed by Machette and McGimsey (1983 #1024). They suggested that most of the scarps along the fault zone are the result of multiple faulting events. For example, scarps on uppermost Pleistocene terrace and piedmont slope surfaces are 0.7–1.0 m high (single event), those on upper Pleistocene surfaces are commonly 2–3 m high (possibly two events), and those on early Pleistocene surfaces are as much as 25 m high (many events).
Age of faulted surficial deposits	The fault zone cuts a 3.8-Ma basalt flow at the mouth of Socorro Canyon, and a wide variety of Quaternary surficial deposits, the youngest of which are generally of late Pleistocene age (Chamberlin, 1999 #7310). The most spectacular scarps are formed on the old, high-level Las Canas surface of McGrath and Hawley (1987 #1239). This surface is offset 21–24 m by the main trace of the fault zone south of Socorro Canyon (Chamberlin and Harrison, 1996 #1225); this surface is now considered to be 800±100 ka based on a tentative correlation with the lower La Mesas surface in Las Cruces area, which Mack and others (1993 #1020) dated as older than 0.73 Ma and younger than 0.9 Ma. None of the older deposits along the fault have been dated. However, faulted deposits mapped as Bull Lake (glacial) equivalents in Socorro Canyon have been dated by Araybe and others (1998,

	#4467) as 136 ka, which is essentially equivalent to the commonly accepted 140 ka age for the end of the Bull Lake glaciation in the northern Rocky Mountains.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Machette and McGimsey (1983 #1024) suggested a late Pleistocene age (10–130 ka) for the fault scarps based on their subdued morphology. This is confirmed by the trenching studies at Socorro Canyon, which indicate two events in the late Pleistocene, and another even in the Holocene. Some scarps, such as the 0.6–0.7 m high (possible single-event) scarp on an uppermost Pleistocene terrace of Socorro Canyon, probably formed in the Holocene. Other scarps in the zone could be pre-late Pleistocene, but the general presence of well-preserved scarps argues for late Pleistocene movement over most of the fault zone.
Recurrence interval	39–53 k.y. (<136 ka) *Comments:* Two recurrence intervals have been derived from the paleoseismic studies. The older recurrence interval is 53 k.y., as determined from cosmogenic dating of tectonic colluvium. The younger recurrence interval is 39–44.5 k.y., as determined from cosmogenic dating of the younger tectonic colluvium and scarp morphology data for an adjacent single event scarp on the same trace of the Socorro fault zone. No error limits have been assigned to these data.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Low slip-rate category based on reported small vertical displacements in the past 130 k.y. Chamberlin and Harrison, (1996 #1225) published an estimated long-term vertical displacement rate of 39 ± 9 m Ma (0.04 ± 0.01 mm/yr) across the main strand of the fault zone. Based on a new unpublished cross section (Fig.1, this report) the cumulative rate across the entire Socorro Canyon fault zone north of Socorro Canyon over the last 3.78 Ma is now estimated at 152 ± 8m/Ma , (~0.15 mm/yr). In 2004, the city of Socorro drilled a stratigraphic test well along Evergreen road, approximately 3 km northeast of Socorro Canyon. The Evergreen test well intersected 12 m of Quaternary piedmont gravels (Qvo), above 345 m of ancestral Rio Grande beds (QTsf, Fig.1), and bottomed in 9 m of sticky red

	claystone of the late Miocene Popotosa Formation (Tpp, playa facies, ca. 6.9 Ma). Where exposed below the 3.78 Ma basalt of Socorro Canyon (Tbsc, Fig.1), the ancestral riverbeds (Tslf) contain rounded granitic pebbles and locally derived volcanic clasts. Granite-dominated gravels are present at 265–338 m depth in the Evergreen well, which suggests Tbsc would project to near 1060 m depth in the well. The cross section (Fig 1) indicates approximately 576 ± 30 m of stratigraphic throw across the Socorro Canyon fault zone in the last 3.78 million years, which yields a long-term maximum slip rate of 152 m ± 8 m/Ma, (~0.15 mm/yr) significantly greater than previous estimates. Reilinger and others (1980 #1237), who measured elevation changes along the now abandoned rail line from Socorro to Magdalena, showed an abrupt roughly 20-mm-high uplift zone (block edge) near the mouth of Socorro Canyon. This leveling anomaly probably represents aseismic warping along the fault zone between 1934 and 1978. The resultant modern rate of deformation (possibly as a result of draping rather than brittle failure) across the fault zone is about 0.6 mm/yr, as determined from geodetic data. This amount of uplift (strain accumulation) would be equivalent to forming the youngest 0.6 m high scarp once 100 years, which is clearly much faster than indicated from the purely geologic data. Although active, the Quaternary history of the fault zone is one of relatively slow stress accumulation interrupted by surface faulting events having 0.6 to as much as 3–3.6 m of offset.
Date and Compiler(s)	2015 Michael N. Machette, U.S. Geological Survey, Retired Richard M. Chamberlin, New Mexico Bureau of Geology & Mineral Resources
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