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Quaternary Fault and Fold Database of the United States

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Alamogordo fault, Deadman section (Class A) No. 2054c

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

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Synopsis	**General:** The Alamogordo fault is a long range-bounding fault that forms the structural boundary between the Sacramento Mountains (to the east) and the Tularosa Basin (to the west) in the southern Rio Grande rift. Conspicuous, nearly continuous fault scarps extend from near the north end of the Phillips Hills southward to about 22 km northeast of Orogrande, New Mexico. Detailed geolog and geomorphic mapping has been completed along most of the fault north of the McGregor Range. Near Alamogordo, numerous scarp profiles and dating of exposures constrain the timing of 3–5 late Quaternary surface-rupturing earthquakes that resulted in 5–10 m of cumulative slip. In addition, mountain-fro

	morphology and geophysical data are used to identify the Deadman section [2054c], extending south of Alamogordo, as the most active part of the fault. **Sections:** This fault has 4 sections. The northern and southern sections are define herein on the basis of fault location relative to the main escarpment of the Sacramento Mountains as well as continuity and apparent age of scarps. The central two sections are defined based on the frequency of late Quaternary surface ruptures and systematic differences of short- and long-term throw. These differences in throw are measured using fault-scarp height, elevation of stratigraphic markers on the mountain front, the elevation of the crest of the Sacramento Mountains with respect to the base of the mountain front, and estimation of basin-fill depth using geophysical data (Koning, 1999; #5535).
Name comments	**General:** First mapped by Otte (1959 #983) and later by Pray (1961 #984), this fault was initially named the Sacramento fault (Kelly and Thompson, 1964 #7254 but subsequently renamed the Alamogordo fault (Machette, 1987 #847) for its proximity to the town of Alamogordo, New Mexico. The fault is characterized by conspicuous fault scarps that extend from near the north end of the Phillips Hills (about 60 km north of Alamogordo, New Mexico), south through Tularosa and Alamogordo, and into the McGregor Bombing Range. The southernmost scarps end near Otero County Road 506, about 45 km south of Alamogordo. **Section:** The Deadman section constitutes the main, range-bounding fault south of Alamogordo that bounds a prominent mountain-front escarpment. This section w part of the Sacramento Mountains section in earlier characterizations of this fault (Machete and others, 1998 #5535), but further work indicates that the Sacramento Mountains section should be subdivided into the Sabinata section and the Deadm section. The Sabinata and McGregor sections lie to the north and south, respectively, of the Deadman section. The Deadman section largely coincides wit the Deadman segment of Koning (1999 #5535), who also interprets a 12 km-long boundary zone on the north end of the Deadman section at Alamogordo. Most of this boundary zone is subsumed into the Deadman section and the common endpoint of the Deadman and Sabinata sections is placed at the salient in the Alamogordo boundary zone (north side of the mountain-front re-entrant). The south end of the Deadman section lies at Bug Scuffle Canyon. The Deadman section is defined separately from the Sabinata section because of its larger displacement values—indicated by greater scarp heights, higher mountain crest, and deeper depth of basin fill on the hanging wall. **Fault ID:** Previously referred to as fault 7 on figure 1 and table 2 of Machette (1987 #847), the southernmost part of 2054a and the northern part of 2054b (Machette and others, 1998 #2848).
County(s) and State(s)	OTERO COUNTY, NEW MEXICO

Physiographic province(s)	BASIN AND RANGE
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location of the northern part of this section (north of Dog Canyon) is based on 1:24,000-scale mapping by Koning and others (2007 #7341) and Romer and Koning (2006 #7342). To the south, this fault was mapped from aerial photographs (scale of approximately 1:24,000) using stereogrammetry software (Stereo Analyst for ARCGIS 10.1, an ERDAS extension, version 11.0.6). Previou aerial photography-based mapping and field studies by Machette (1987 #847) aid this effort.
Geologic setting	The Alamogordo fault is a west-down, range-front normal fault forming the structural boundary between the west side of the Sacramento Mountains and the Tularosa Basin. The eastern Tularosa Basin corresponds to a half-graben tilted eastward towards the Alamogordo fault (Healy and others, 1978 #7329; Orr and Myers, 1986 #7338; Seager and others, 1987 #627; Johnson and others, 1989 #7331; Lozinsky and Bauer, 1991 #7336). The Alamogordo fault juxtaposes Quaternary basin fill against Paleozoic bedrock at the foot of the Sacramento Mountains. Due to variable northward and southward components of dip in the mountain block, the particular Paleozoic lithologic unit exposed at the ranges fro Ordovician through Permian (Pray, 1961 #984). Sufficient throw occurred 25 km south of Alamogordo to expose local Proterozoic rock at the base of the mountai (Pray, 1961 #984). North of La Luz, a broad pediment surface has formed largely in erodible strata of the Abo Formation (Otte, 1959 #983). In the Three Rivers are relatively low hills, including the Phillips Hills, are found on the immediate footwall of the fault. Aside from the Godfrey Hills, relatively low relief and shallow Quaternary deposits characterizes the 18- to 23-km-wide area between th northern Alamogordo fault (i.e., the Three Rivers section) east to the imposing western face of Sierra Blanca. South of Bug Scuffle Canyon, the fault forms smal scarps across the piedmont slope and along low-relief bedrock hills. Depth to basement in the eastern Tularosa Basin is 200–1,200 m based on geophysical and well data (Hood, 1959 #7330; McLean, 1970 #7337; Healy and others, 1978 #73 Orr and Myers, 1986 #7338; Lanka, 1995 #7335; gravity and aeromagnetic data from R. Keller, pers. comm., 1998; Koning, 1999 #5535).
Length (km)	This section is 33 km of a total fault length of 130 km.
Average strike	N15°W (for section) versus N10°W (for whole fault)
Sense of movement	Normal
Dip	71–80° W.

	Comments: Koning (1999 #5535) shows the fault as a high-angle (74–80°) norma dip-slip fault in figure 52a.
Paleoseismology studies	Three exposures along the Deadman section support the interpretation of four surface-rupturing earthquakes in the latest Pleistocene and possibly early Holocen (Koning, 1999 #5535; Koning and Pazzaglia, 2002 #6932). Koning and Pazzaglia (2002 #6932) further suggest that none of these earthquakes are directly observed at the Laborcita Canyon exposure to the north on the Sabinata section, but large displacement during the penultimate earthquake on the Deadman section (within 2000 years prior to 12.6 ka uncorrected radiocarbon years) implies that the Sabinata section also ruptured. Koning (2014 #7339) suggests that the oldest preserved colluvial wedge at the Laborcita Canyon site on the Sabinata section could possibly be associated with one of the large-magnitude earthquakes that occurred within 2000 years prior to 12.6 ka (uncorrected radiocarbon years) on th Deadman section. The surface-rupture history that Koning (1999 #5535) and Koning and Pazzaglia (2002 #6932) interpret for the late Quaternary is as follows (1) an older event at ca. 20–30 ka; 2 & 3) two closely spaced, large-displacement events within 2,000 years prior to 12.6 ka (uncorrected radiocarbon years); (4) a younger, lower-displacement event inferred to offset the lower part of an early Holocene deposit. Estimated maximum displacement for the oldest and youngest events is ~2 m, and the average combined displacement for the middle two events is 4–5 m (Koning and Pazzaglia, 2002 #6932). Site 2054-2 (M-19, Koning, 1991 #5535; Koning and Pazzaglia, 2002 #6932) is located north of Mule Creek. Offset (7.8 m) at the site is attributed to three prehistoric earthquakes. The two earlier ones occurred within 2000 years prior to 12.6 ka (radiocarbon years) and are responsible for the majority of the scarp heigh The latter is inferred to have taken place in the early Holocene, based on interpretations at Site 2054-4. Site 2054-3 (L-13, Koning, 1991 #5535; Koning and Pazzaglia, 2002 #6932) is located on the south side of Lead Canyon. There are two fault scarps north of the drainage. The western one is 4 m high and only found on the oldest alluvial fan surface (late Pleistocene). The eastern one is 8.5 m tall and offsets both the aforementioned late Pleistocene surface and a younger, inset surface inferred to b older than 20 ka based on degree of soil development. The oldest interpretable rupture event(s) observed on the Alamogordo fault formed the 4-m-high scarp. Site 2054-4 (D-36, Koning, 1991 #5535; Koning and Pazzaglia, 2002 #6932) is located on the south side of a landslide complex between Deadman and Escondid canyons. Offset of the lower Qf2 unit is observed here, but the upper 80 cm of the unit is not offset. Unit Qf2 was initially inferred to be early Holocene based on three radiocarbon ages and degree of soil development (Koning, 1999 #5535;

	Koning and Pazzaglia, 2002 #6932), although later mapping along the Deadman section extended its interpreted age range to the middle Holocene (Romero and Koning, 2006 #7342).
Geomorphic expression	Fault scarps on the Deadman section are generally on late Pleistocene deposits; their heights range from about 2 to 13 m and average 6–7 m (Koning and Pazzaglia, 2002 #6932). Surface offsets range 1–10 m and average about 5 m (Koning and Pazzaglia, 2002, #6932). The last event on the Deadman section is inferred to have created steep bevels observed on the midslopes or footslopes of some fault scarps south of Alamogordo (1–2 m vertical height, <1 m surface offset), and also interpreted to have created a small scarp (0.75 m surface offset) o one possible early Holocene surface (Koning, 1999, #5535). Given the less than 2 m displacement estimate of the most recent rupture, the prior 1–2 rupture events cumulatively formed scarps averaging about 4–6 (?) m in height (Koning, 1999 #5535; Koning and Pazzaglia, 2002 #6932). The scarps are relatively continuous and have steep maximum slope angles, suggesting that the most recent movemen is relatively young. Scarp-morphology studies by Machette (1987 #847) and Koning (1999 #5535) suggest that the youngest scarps are latest Quaternary in ag (i.e., <15 ka). Otte (1959 #983) discussed evidence for abundant Pleistocene displacement along the fault, including the presence of "piedmont scarps" as muc as 7 m in height and isolated gravel that is uplifted 30–60 m above modern drainage.
Age of faulted surficial deposits	Detailed mapping by Koning (1999 #5535) and Romero and Koning (2006 #7342 demonstrates that unequivocal Holocene-age alluvial fan surfaces are not faulted, whereas the Alamogordo fault has produced large fault scarps along late Pleistocene-age alluvial fan surfaces. No surface rupture associated with these events three historic earthquakes that could be associated with the Deadman section of the Alamogordo fault (Koning, 1999 #5535), based on their calculated locations. Their duration magnitudes and dates are: 1) 2.6 MD, Feb 27, 1972; 2) 2.3 MD, April 29, 1987, 3) 2.6 MD, March 23, 1968.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Radiocarbon dating of samples in a faulted exposure at Mule Canyon indicate that two earlier surface ruptures have occurred within 2000 years prior to 12.6 ka (uncorrected radiocarbon age). The most recent rupture is not as well constrained, but is inferred to have possibly occurred in the early Holocene based on offset of the basal part of Qf2 between Deadman and Escondido canyons (Koning, 1999 #5535; Koning and Pazzaglia, 2002 #6932)

Recurrence interval	Highly variable recurrence intervals are suggested by Koning (1999 #5535), Koning and Pazzaglia (2002 #6932), and Koning (2014 #7339). They present evidence for four surface-rupturing earthquakes on the Deadman section between 7–30 ka, which is preceded by a long period (30–130 ka?) of possible quiescence similar to other faults in the Rio Grande rift (Koning, 1999 #5535; Koning and Pazzaglia, 2002 #6932 and references cited therein). Within the past 30,000 years the recurrence intervals between these earthquakes are as short as less than 2000 years or greater than 6000 years (Koning, 1999 #5535). Long recurrence intervals and lower rates of tectonic activity are inferred for 30 to about 250 ka. Consequently, Koning (1999 #5535, 2014 #7339) and Koning and Pazzaglia (200 #6932) interpret a temporal clustering for the Alamogordo fault between 15 and 8 ka, with lower recurrence intervals in the late Pleistocene prior to 20–30 ka. This complicates meaningful estimates for recurrence intervals (Koning, 1999 #5535).
Slip-rate category	Less than 0.2 mm/yr *Comments:* Koning and Pazzaglia (2002 #6932) conclude that this section of the fault has ruptured four times in the latest Pleistocene and early Holocene, and tha there was lesser tectonic activity between 30–130 ka. They present average vertical-displacement rates of 0.04–0.05 mm/yr to 0.17–0.23 mm/yr. The minimu rate assumes tectonic quiescence over the late Pleistocene (30–130 ka), prior to latest Pleistocene temporal clustering, and uses a time value of 130,000 years. Th maximum rate assumes the displacement rates interpreted over the past 30,000 years characterize the late Quaternary. Because temporal clustering is likely (Koning, 1999 #5535, 2014 #7339; Koning and Pazzaglia, 2002 #6932), the lowe displacement values (~0.05 mm/yr) are more reasonable. Salyards (1991 #1061) suggested a similar vertical displacement rate of 0.11 mm/yr using data presented by Machette (1987 #847). The majority of vertical-displacement rates fall within the assigned category.
Date and Compiler(s)	2016 Daniel J. Koning, New Mexico Bureau of Geology & Mineral Resources Kathleen M. Haller, U.S. Geological Survey Michael N. Machette, U.S. Geological Survey, Retired Keith I. Kelson, William Lettis & Associates, Inc.
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