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Hubbell Spring fault (Class A) No. 2120

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

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Synopsis	The north-striking Hubbell Spring fault is an intrabasin 18-km-wide zone of normal faults composed of numerous subparallel, anastomosing, predominately west-dipping faults in the central Rio Grande rift. The fault forms the western edge of a prominent intrabasin topographic bench called the Hubbell bench, which is 5–11 km west of the steep escarpment at the foot of the Manzano Mountains. At its northern end, the active trace of the Hubbell Spring fault merges with and offsets the Tijeras-Cañoncito fault system [2033] near the Travertine Hills on Sandia National Laboratory. It extends southward to include several previously unnamed faults [2117]. Fault scarps are 4–30 m high on deposits ranging from late to early Pleistocene age. The Hubbell Spring

	fault has been recurrently active throughout the Quaternary.
Name comments	The Hubbell Spring fault was originally mapped and named the Ojuelos fault by Read and others (1944 #1416). Numerous other investigators have used the names "Ojuelos fault", "Ojuelos-Hubbell Springs fault", and "Hubbell Spring (or Springs) fault" interchangeably for this structure (Reiche, 1949 #1417; Kelley, 1954 #1222; Stark, 1956 #1419; Titus, 1963 #1421; Baltz, 1976 #1431; Kelley, 1977 #1106). The namesake for the fault is Hubbell Spring, a spring that flows from the fault zone near its northern end, so the name "Hubbell Spring fault", as used in more recent publications (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430; Love and others, 1996 #1762) is retained herein. Following mapping of Olig and Zachariasen (2010 #7219) we included in the Hubbell Spring fault, the Palace-Pipeline fault and McCormick Ranch faults of Maldonado and others (2007 #7218), the unnamed faults on the Llano de Manzano of Machette and McGimsey (1983 #1024), and the Contreras Cemetery fault of McCraw and others (2006). **Fault ID:** Fault no. 4 of Machette (1982 #1401), fault no. 3 of Machette and McGimsey (1983 #1024).
County(s) and State(s)	VALENCIA COUNTY, NEW MEXICO BERNALILLO COUNTY, NEW MEXICO
Physiographic province(s)	BASIN AND RANGE
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* We include the numerous subparallel, anastomosing and branching normal faults interpreted from high-resolution aeromagnetic data and geomorphic mapping (Grauch and Hudson, 2007 #7243; Olig and Zachariasen, 2010 #7219) to augment fault traces mapped by Machette and McGimsey (1983 #1024), GRAM, Incorporated and William Lettis and Associates, Incorporated (1995 #1430), Love and others (1996 #1762). The southern extent of the Hubbell Spring fault is extended to include the Palace Pipeline and McCormick Ranch faults of Maldonado and others (2007 #7218), the unnamed faults on the Llano de Manzano of Machette and McGimsey (1983 #1024), and the Contreras Cemetery fault of McCraw and others (2006 #7255),

	which nearly doubles the previous length of the fault.
Geologic setting	The Hubbell Spring fault forms the western edge of the Hubbell bench, which is west of the steep escarpment at the foot of the Manzano Mountains. The Hubbell Spring fault marks the eastern margin of the Rio Grande rift in this part of the Albuquerque-Belen basin. The 3D geophysical model of Grauch and Connell, 2013 #7268) suggests a steep eastern edge of the Belen basin resulting from 2–4 km of overall vertical displacement. The structure of the Rio Grande rift determined by analyzing gravity and magnetic data suggests the largest total offset across the Hubbell Spring fault is 5 km west of the fault scarps at the surface where the depth to the top of the Precambrian is greater than 6 km; however, the location of this offset is not well constrained in the resistivity model (Grauch and Connell, 2013 #7268; Rodriguez and Saywer, 2013 #7267).
Length (km)	74 km.
Average strike	N3°E
Sense of movement	Normal
Dip	48°–85° W *Comments:* Measurements of fault dip are from shallow exposures at the Hubbell Spring and Carrizo Spring trench sites. At Hubbell Spring, the fault is reported to dip 70°–85° W. (S.F. Personius, unpublished data, 1997), and individual faults dip 48°–52° W., 65°–73° W., and 70°–85°W. in the Carrizo Spring trench exposure (Olig and others, 2011 #7184).
Paleoseismology studies	Hubbell Spring trench (site 2120-1). A 60-m-long trench and two soil test pits were excavated across a 8-m-high scarp near the northern end of the Hubbell Spring fault in the fall of 1997 (Personius, 1998 #1415). The trench exposed two west-dipping fault zones and an intervening 16-m-wide horse block broken by numerous small displacement east- and west-dipping faults (Personius and others, 2000 #5249). Well-sorted sands of the lower Pleistocene upper Santa Fe Group are overlain by middle Pleistocene alluvial-fan deposits in the upthrown block; three wedges or sheets of mixed eolian sand and minor colluvium overlie the fan deposits in the downthrown blocks. Three sand wedges and net vertical offset determined by near-field

	projections of the alluvial-fan surface exposed in the trench and auger cores yield about 4.7 m of throw across the fault zone suggesting average vertical offsets of about 1.6 m; the average could be larger as the far-field vertical displacement is 8 m. Vertical displacement per event is reported as 1–2 m at one trench site (Personius and Mahan, 2003 #6908), but total vertical displacement would be larger if other fault splays also ruptured during these events, as suggested by overlap of event ages with those at the Carrizo Spring site (Olig and others, 2011 #7184). Eleven samples yielded thermoluminescence (TL) and infrared stimulated luminescence (IRSL) ages that are generally consistent and in correct stratigraphic order (Personius and Mahan, 2003 #6908). Carrizo Spring trench (site 2120-2). The trench was over 60-m-long and up to 4.5-m deep; this study also included surficial mapping of previously unrecognized faults and drilling (Olig, 2004 #7223; Olig and others, 2011 #7184). Eleven samples submitted for luminescence analyses constrain the timing of 4–5 surface-rupturing earthquakes at the site. Similar to the findings from the Hubbell Spring site, Olig and others (2011 #7184) interpret large per-event displacements that are similar in age to those at the Hubbell Spring site. Olig and others (2011 #7184) conclude that displacement occurred in the same earthquakes at the two sites.
Geomorphic expression	The Hubbell Spring fault is well expressed as fault scarps and aligned springs along the western margin of the Hubbell bench. Individual scarps in unconsolidated deposits on the Llano de Manzano surface range from 0 to 31 m high, and cumulative vertical surface displacement is about 27.6–54.4 m and 41.4–83.1 m across two transects that crosses the entire fault zone (Olig and Zachariasen, 2010 #7219).
Age of faulted surficial deposits	The Hubbell Spring fault offsets alluvial deposits of early, middle (Love and others, 1996 #1762), and late Pleistocene (Machette and McGimsey, 1983 #1024; GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430) age along much of its length.
Historic earthquake	
Most recent prehistoric	latest Quaternary (<15 ka)

deformation	*Comments:* At both trench sites, the most recent surface rupture occurred after 15 ka. The timing of the most recent earthquake at the Hubbell Spring site is 11.9±0.3 ka (Personius and Mahan, 2003 #6908), and the most recent earthquake at the Carrizon Spring site occurred between 6 and 15 k.y. ago (Olig and others, 2011 #7184). These conclusions support those of earlier studies including fault scarp morphology (Machette, 1982 #1401; Machette and McGimsey, 1983 #1024) and surficial geologic mapping (GRAM Incorporated and William Lettis & Associates Incorporated, 1995 #1430).
Recurrence interval	12–70 k.y. *Comments:* Based on luminescence dating, Personius and Mahan (2003 #6908) conclude that the best age estimate for the last three surface-rupturing events at the Hubbell Spring site is 55.6±1.3, 28.6±0.8, and 11.9±0.3 ka, which results in recurrence intervals of 27 and 17 k.y. between events and an elapsed time of 12 k.y. since the most recent surface-rupturing paleoearthquake. Olig and others (2011 #7184) identify four or possibly five paleoearthquakes since deposition of piedmont deposits on the Llano de Manzano surface ceased about 83.6±6.0 ka. Individual recurrence-interval estimates of 14–27 k.y., further characterized by an average recurrence of 19 (+5/−4) k.y.
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Vertical displacement is highly variable from event to event and it is important to note that data reported for individual trench sites will underestimate total slip. Olig and others (2011 #7184) report cumulative vertical surface displacement of about 28–54 m and 41–83 m across a northern and southern transect, respectively. They assign an age of 80–130 ka to the faulted surface and report a long-term cumulative average vertical-displacement rate of 0.2–0.7 mm/yr for the northern transect and 0.3–1.0 mm/yr for the southern transect. Olig and others (2011 #7184) estimate variable single-event displacements of 3.7, 0.4, 1.7, 4.7, and 2.8 m at their trench site and conclude that vertical-displacement rates for individual seismic cycles vary by an order of magnitude, ranging from 0.044 mm/yr to 0.46 mm/yr. The variation is not due to temporal clustering of earthquakes but instead is primarily due to large variations in slip per event. The reported preferred average vertical-displacement rates of Personius and Mahan (2003 #6908) rate since 56 ka is 0.05

	mm/yr, and interval vertical-displacement rates between the last three events are 0.06 and 0.09 mm/yr represents a minimum because the exposure did not extend across the entire fault zone.
Date and Compiler(s)	2015 Kathleen M. Haller, U.S. Geological Survey Stephen F. Personius, U.S. Geological Survey
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