Jump to Navigation

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Wasatch fault zone, Nephi section (Class A) No. 2351h

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Compiled in cooperation with the Utah Geological Survey

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Synopsis	**General:** The Wasatch fault zone is one of the longest and most tectonically active normal faults in North America. The fault zone shows abundant evidence of recurrent Holocene surface faulting and has been the subject of detailed studies for over three decades. Half of the estimated 50 to 120 post-Bonneville surface-faulting earthquakes in the Wasatch Front region have been on the Wasatch fault zone. Earthquake-timing, recurrence-interval, and displacement-rate estimates for the Brigham City, Weber, Salt Lake City, Provo, Nephi, and Levan sections of the Wasatch fault

	zone reflect the consensus values of the Utah Quaternary Fault Parameters Working Group (Lund, 2005 #6733). Lund (2005 #6733) did not evaluate the Clarkston Mountain, Collinston, and Fayette sections due to a lack of fault-trench data. The preferred values reported in Lund (2005 #6733) approximate mean values based on available paleoseismic-trenching data, and the minimum and maximum values approximate two-sigma (5th and 95th percentile) confidence limits. The confidence limits incorporate both epistemic (data limitation) and aleatory (process variability) uncertainty (Lund, 2005 #6733). **Sections:** This fault has 10 sections. The nearly 350-km-long Wasatch fault zone has traditionally been divided into seismogenic segments that are thought to rupture at least somewhat independently. The established model is used to define the sections described in this report. The southern eight sections are entirely in Utah. To the north, the Clarkston Mountain section straddles the state line between Idaho and Utah and the northernmost (Malad City) section is entirely in Idaho. The chronology of surface-faulting earthquakes on the Wasatch fault is one of the best dated chronologies in the world and includes 16 earthquakes since 5.6 ka, with an average repeat time of 350 yr. Four of the central five sections [2351e-h] ruptured in the last hundreds to about a thousand years ago, whereas the next section to the north, Brigham City [2351d], has not ruptured in the past 2,125 yr. Vertical displacement rates of 1–2 mm/yr are typical for the central sections during Holocene time. In contrast, middle and late Quaternary (<150–250 ka) rates on these sections are about an order of magnitude lower. This substantial change in the displacement rate may indicate a causal relation between increased Holocene rates of deformation and isostatic rebound/crustal relaxation following deep lake cycles such as Bonneville.
Name comments	**General:** **Section:** All section names follow those proposed by Machette and others (1991 #189; 1992 #607).
County(s) and State(s)	JUAB COUNTY, UTAH UTAH COUNTY, UTAH
Physiographic province(s)	BASIN AND RANGE
Reliability of	Good

location	Compiled at 1:50,000 scale. *Comments:* Fault traces from 1:50,000-scale mapping of Machette (1992 #4529) and Harty and others (1997 #4619).
Geologic setting	Generally north-trending, range-bounding normal fault along the western side of the Malad Range (Clarkston Mountain), Wellsville Mountains, Wasatch Range, and San Pitch Mountains. The Wasatch fault zone marks the eastern boundary of the Basin and Range in northern Utah. Alluvial-fan deposits and lacustrine deposits of Pleistocene Lake Bonneville dominate the surficial geology along the fault zone.
Length (km)	This section is 43 km of a total fault length of 357 km.
Average strike	N4°E (for section) versus N10°W (for whole fault)
Sense of movement	Normal
Dip	72° W *Comments:* Measured at the Red Canyon trench in alluvial fan, mudflow, and fluvial deposits (Jackson, 1991 #4621).
Paleoseismology studies	Hanson and others (1981 #4987) excavated three trenches at North Creek (site 2351-4), about 6 km northeast of the town of Mona (results also summarized in Schwartz and others, 1983 #558; Schwartz and Coppersmith, 1984 #347; Machette and others, 1992 #607). Colluvial-wedge stratigraphy exposed in the trenches indicated two surface-faulting events; an older, third event was inferred from a tectonic strath terrace incised in an uplifted part of the North Creek alluvial fan. Charcoal obtained from deposits exposed in the trenches, although not from stratigraphically definitive positions, yielded radiocarbon age estimates that provide a maximum limiting age for the most recent event; scarp morphology suggests the age of this event may be considerably younger than the limiting radiocarbon age estimate. An organic-rich soil that formed on scarp-derived colluvium deposited after the penultimate event yielded a radiocarbon age estimate that provides a minimum limiting age for this event. Radiocarbon dating of a buried, offset burn layer in the North Creek alluvial-fan deposits provides a maximum limiting age for the antepenultimate event.

	Jackson (1991 #4621) excavated one trench at Red Canyon near the southern end of the Nephi section (site 2351-23), about 3.5 km north of the town of Nephi. The trench revealed colluvial-wedge stratigraphy indicating three surface-faulting events since about 4.5 ka. Thermoluminescence and radiocarbon age estimates from soil buried by the youngest colluvial wedge provide a maximum limiting age for the most recent event. Samples collected from colluvial-wedge material associated with the penultimate event yielded radiocarbon age estimates that constrain the upper age of this event. A maximum age for the antepenultimate event is thought to be close to the oldest radiocarbon age estimate for the colluvium, about 4–4.5 ka. DuRoss (2004 #6743) completed a regional geomorphic analysis of fault scarps at 20 sites along the length of the Nephi section, which included the profiling and nonlinear diffusion modeling of fault scarps on alluvial fans of four different ages. A preferred rupture scenario integrates the timing and geometry of the surface ruptures with fault trench data, results of mechanical modeling (Chang, 1998 #6742), and historical Basin and Range surface-faulting data. The scenario involves at least six ruptures on the Nephi section since the latest Pleistocene (~12 ka), including two complete ruptures of the section, and four partial ruptures along either the Nephi or Santaquin fault strands.
Geomorphic expression	The Nephi section is divided into two fault strands separated by a connecting fault in bedrock: (1) the 25-km-long southern (Nephi) strand and (2) the 17-km-long northern (Santaquin) strand (DuRoss, 2004 #6743). The northern half of the Santaquin strand overlaps the southern part of the Provo section at the Payson salient. The Benjamin fault forms the west side of the salient and displacement dies out as the fault extends northward into Utah Valley (Harty and others, 1997 #4619). Sediments of the Provo phase of the Bonneville lake cycle are displaced up to 2 m along this fault (Machette, 1992 #4529). The southern section boundary is at a 5-km gap in Quaternary surface faulting (Hylland and Machette, 2004 #6745) in the vicinity of a large alluvial fan (Levan Ridge) that extends westward from the San Pitch Mountains. Gravity data suggest the fault continues through and beneath Levan Ridge, but has been inactive for perhaps tens of thousands of years (Zoback, 1983 #213; Machette and others, 1992 #607). Faults associated with young scarps north of the town of Nephi are probably continuous with near surface faults in the town identified from seismic-reflection data (Crone and

	Harding, 1984 #4545). A number of small faults in Quaternary deposits have been identified on the western flank of the Gunnison Plateau east of Nephi (Biek, 1991 #4614). Fault scarps vertically displace unconsolidated Quaternary alluvial-fan and lacustrine deposits up to 27 m on the Nephi strand (Mattson and Bruhn, 2001 #6746) and up to 16 m on the Santaquin strand (DuRoss, 2004 #6743). Displacement due to the most recent event is 1.2–2.2 m along the Nephi strand and 0.9–1.1 m along the Santaquin strand (DuRoss, 2004 #6743). Vertical displacement per event is estimated at 1.4–2.5 m for the last three surface-faulting earthquakes, based on trench studies on the Nephi strand. DuRoss (2004 #6743) indicates 1.4–2.2 m of displacement per event since the latest Pleistocene (~12 ka), based on regional fault-scarp analyses along both strands
Age of faulted surficial deposits	Holocene alluvial fan, debris-flow and stream deposits; late Pleistocene alluvial fan deposits, and middle (?) Pleistocene alluvial fan deposits (Harty and others, 1997 #4619).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* In a review of available paleoseismic data for the southern (Nephi) strand, including the evaluation of earthquake timing by McCalpin and Nishenko (1996 #4436), Lund (2005 #6733) reported the following paleoearthquake chronology, which incorporates both the geologic and laboratory uncertainty: Z <1±0.4 ka, but possibly as young as 0.4±0.1 ka Y ~3.9±0.5 ka X >3.9±0.5 ka, <5.3±0.7 ka Scarp morphology and continuity suggest very recent displacement (~300 500 years ago), although a combination of 14C and TL dates suggest an age of about 1.2 ka for the most recent event (event Z). Schwartz and Coppersmith (1984 #347) determined that the penultimate event (event Y) occurred before about 4 ka, whereas Jackson (1991 #4621) constrained the event between about 3 and 3.5 ka. Event X may have occurred between 4 and 4.5 ka (Jackson, 1991 #4621). Thus, actual middle to late Holocene recurrence intervals may vary from less than 1 to more than 3 k.y. Three middle to late Holocene events post date a late Pleistocene (?) fan at the southern end of the section (at Red Canyon), suggesting a possible hiatus in faulting activity during

	latest Pleistocene to early Holocene time (Jackson, 1991 #4621). The preferred rupture scenario of DuRoss (2004 #6743), based on rupture mapping and scarp morphology, includes two paleoearthquakes that ruptured the entire section around 10–15 ka and 5.5–8.5 ka. Also, partial rupture of the Nephi section may have occurred during the Holocene, with the southern (Nephi) strand rupturing at 2.5–5.5 ka and 0.9–1.9 ka, and the northern (Santaquin) strand at 1.9–3.3 ka and 0.4–0.6 ka (DuRoss, 2004 #6743). DuRoss (2004 #6743) concluded that surface faulting on the Provo section to the north may have triggered the two most recent ruptures on the Santaquin strand. This inference is based on the moderate rupture length (6.5 km) and displacement (1–2 m) associated with the youngest Santaquin-strand earthquakes, the similarity in the timing of those events (mean ages of 2.6 and 0.5 ka, based on scarp diffusion modeling) with the two youngest Provo-section events (~2.8 and ~0.6 ka, based on fault trench data; Lund and Black, 1998 #4624), and the geometry of the Payson salient, which may allow the transfer of slip from the Provo section to the Santaquin strand (DuRoss and Bruhn, 2005 #6744).
Recurrence interval	2500 yr (preferred); minimum 1200, maximum 4800 yr (<5.3 ka) *Comments:* Consensus recurrence-interval range reported in Lund (2005 #6733), based on the two interevent times between the three youngest paleoearthquakes (X-Z).
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Lund (2005 #6733) indicates a Holocene vertical displacement rate of 1.1 mm/yr (preferred), and a consensus minimum-maximum range of 0.5–3.0 mm/yr. The displacement-rate estimate incorporates displacement measurements from fault trench exposures and fault scarps, a geologic vertical displacement rate of 1.3 mm/yr based on 7.0 m of displacement across an alluvial fan dated at 5.3 ka (Hanson and others, 1981 #4987; Schwartz and Coppersmith, 1984 #347), and paleoseismic rate estimates ranging from 0.5–1.2 mm/yr made by Harty and others (1997 #4619). Jackson (1991 #4621) indicates that displacement, and thus the rate of slip, decreases toward the southern end of the segment near Red Canyon. DuRoss and Bruhn (2005 #6744) report a paleoseismic vertical displacement rate of 0.5–0.7 mm/yr since the mid-Holocene (<7 ka) and 0.3–0.4 mm/yr from the mid-Holocene to latest Pleistocene (~12 ka),

	using closed seismic cycles of a preferred rupture scenario. DuRoss and Bruhn (2005 #6744) indicate a long-term paleoseismic vertical displacement rate of 0.2 mm/yr from ~12–53 ka.
Date and Compiler(s)	2004 Bill D. Black, Utah Geological Survey Christopher B. DuRoss, Utah Geological Survey Michael D. Hylland, Utah Geological Survey Greg N. McDonald, Utah Geological Survey Suzanne Hecker, U.S. Geological Survey
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