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Wasatch fault zone, Provo section (Class A) No. 2351g

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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)	SALT LAKE COUNTY, UTAH UTAH COUNTY, UTAH
Physiographic province(s)	BASIN AND RANGE
Reliability of	Good

location	Compiled at 1:50,000 scale. *Comments:* From 1:50,000 scale mapping of Machette (1992 #607).
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 59 km of a total fault length of 357 km.
Average strike	N14°W (for section) versus N10°W (for whole fault)
Sense of movement	Normal
Dip	77° W. *Comments:* Measurements are from the main fault in the trench at Rock Canyon in alluvium and debris-flow deposits (Lund and Black, 1998 #4624), south trench at Mapleton in lacustrine deposits (Lund and others, 1991 #4625), and Hobble Creek trench HC-1 (site 2351-3)in Provo level fan-delta deposits.
Paleoseismology studies	Near Springville, Swan and others (1980 #88) profiled scarps where the main fault trace crosses a large alluvial-fan complex near the mouth of Hobble Creek Canyon, and excavated three trenches about 2 km northwest of Hobble Creek at Deadmans Hollow (site 2351-3). Collectively, the study area showed evidence for six or seven post-Provo (14.3 ka) surface-faulting events. The trenches revealed colluvial stratigraphy indicating three young events, and three or four older events are inferred from tectonic strath terraces preserved along Hobble Creek upstream from the fault zone. Machette and Lund excavated three trenches in 1986 just south of the mouth of American Fork Canyon (site 2351-12; results described in Machette, 1988 #5033, 1992 #4529; Machette and others, 1987 #5034, 1992 #607). The trenches crossed several traces of the fault, and collectively revealed stratigraphic and structural evidence for four surface-faulting events since 8 ka.

Radiocarbon and thermoluminescence age estimates on charcoal and bulk-soil samples from colluvial-wedge deposits and buried A horizon soils constrain the timing of the events.

In 1986, M.N. Machette and W.E. Mulvey mapped a natural stream-cut exposure of the fault northeast of Provo at Rock Canyon (site 2351-13). They observed evidence for the most recent surface-faulting event; radiocarbon age estimates on bulk-soil samples from a colluvial-wedge deposit and a paleosol buried by post-event deposits constrain fault timing (Machette and others, 1992 #607; Machette, 1992 #4529). In 1988, a trench excavated across the fault scarp about 50 m south of the stream-cut exposure (site 2351-19; Lund and others, 1990 #5032; Lund and Black, 1998 #4624) also revealed evidence for the most recent event, and re-examination of the cut identified a second fault trace. Radiocarbon age estimates from bulk-soil samples of three buried paleosols exposed in the trench provided additional constraints on the timing of the most recent event. Also, additional samples (collected in 1988 and 1995) of a paleosol that was buried by scarp-derived colluvial-wedge material, and exposed at the stream cut, yielded a radiocarbon age estimate that provides a maximum limiting age for the most recent event.

In 1987, Lund and others (1991 #4625) excavated a total of five trenches at two closely spaced sites southeast of the town of Mapleton. The Mapleton North (2351-14) and Mapleton South (2351-15) sites are 4 and 5.5 km, respectively, south of the Hobble Creek site. The north trench site revealed stratigraphic and structural evidence for the most recent surface-faulting event; radiocarbon age estimates from charcoal contained in pre- and post-event deposits constrain the timing of this event. Trench exposures at the south site revealed evidence for two surface-faulting events. A lack of datable material precluded determining the timing of the most recent event. Timing of the penultimate event was estimated from radiocarbon and thermoluminescence age estimates obtained from a buried soil that was displaced by faulting shortly before the time of burial. In 2003, Olig and others (2004 #6876) reoccupied the Mapleton North trench site to extend the earthquake chronology beyond the three most recent earthquakes (site 2351-31). The Mapleton megatrench exposed evidence for older surface-faulting events; however, only preliminary results of that study are available.

The U.S. Bureau of Reclamation (USBR) excavated two trenches

	in 1987 in alluvial-fan deposits at the mouth of Water Canyon (site 2351-16), about 8 km south of the town of Spanish Fork (Ostenaa, 1990 #221). The trenches revealed evidence for at least three Holocene surface-faulting events. Radiocarbon age estimates from charcoal in surface-burn horizons buried by scarp-derived colluvium provide maximum limiting ages for the two most recent events. Radiocarbon age estimates from detrital charcoal in alluvium and colluvium bracket the ages of the older events. Just prior to the study at Water Canyon, the USBR excavated two trenches across the Woodland Hills fault, a splay of the Provo section of the Wasatch fault. This site (2351-17) is about 2 km southwest of the Water Canyon site. The trenches revealed evidence for three or four surface-faulting events since about 130 ka, based on correlations of faulted alluvial-fan soils with similar soils in the area (Machette and others, 1992 #607; Machette, 1992 #4529). Radiocarbon age estimates on bulk-soil samples from an A horizon soil buried by scarp-derived colluvium provide an approximation for the timing of the most recent event.
Geomorphic expression	Based on fault geometry and apparent recency of movement as indicated by scarp morphology, Machette and others (1986 #180) tentatively subdivided the Provo section (as originally proposed by Schwartz and Coppersmith, 1984 #347) into three subsections (from north to south, the American Fork, Provo "restricted sense," and Spanish Fork). However, based on the timing of the last two events deciphered from trench studies, the entire length of the Wasatch fault zone in Utah Valley appears to be a single section (Machette and others, 1991 #189; Lund and others, 1991 #4625; Machette and others, 1992 #607; Lund and Black, 1998 #4624). Lund and Black (1998 #4624) measured 3.3 m of displacement from the most recent event at Rock Canyon in correlative geologic units across the fault zone, which is one of the most accurate available for the Wasatch fault zone. The Woodland Hills splay of the Spanish Fork subsection has evidence for three or four events, totaling 3 m of displacement (Machette and others, 1992 #607). Movement on the splay apparently occurs during only some of the events on the main fault, although the most recent event on the splay occurred about 1.0 ka and may be correlative with the most recent event on the main fault. Movement on a couple of short subsidiary faults at the northern end of Utah Valley appears to have occurred during, and may be related to, the recession of Lake Bonneville.

Age of faulted surficial deposits	Holocene alluvial fan, debris-flow and stream deposits; late Pleistocene glacial, lacustrine, and alluvial fan deposits, and middle (?) Pleistocene alluvial fan deposits (Machette and others, 1992 #607).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* In a review of available paleoseismic data, including the evaluation of earthquake timing by McCalpin and Nishenko (1996 #6770), Lund (2005 #6733) reported the following paleoearthquake chronology, which incorporates both the geologic and laboratory uncertainty: Z 600±350 cal yr B.P. Y 2850±650 cal yr B.P. X 5300±300 cal yr B.P. The most recent surface-faulting earthquake at the Rock Canyon site occurred just prior to 650 yr ago (Lund and Black, 1998 #4624), which corresponds well with the timing of the most recent surface-faulting earthquakes at the American Fork (500 yr ago; Machette, 1992 #4529) and Mapleton (600 yr ago; Lund and others, 1991 #4625) sites to the north and south, respectively. The penultimate event occurred about 2.6–3.0 ka; based on results from the American Fork site, two prior events also occurred about 5.3 ka and 5.5–8.0 ka. A conflicting chronology of faulting from a site near the southern boundary of the section (at Water Canyon, where two events have occurred in the last 1.0 ka) may be explained by spatial overlap of the Nephi and Provo sections, whereby events from both sections are recorded at the site (Ostenaa, 1990 #221; Machette, 1992 #607).
Recurrence interval	2400 yr (preferred); minimum 1200, maximum 3200 yr (<5.3 ka) *Comments:* Consensus recurrence-interval range reported in Lund (2005 #6733), based on the two interevent times between the three most recent paleoearthquakes (X–Z). Six or seven post Provo events are inferred to have occurred at the Hobble Creek site (east of Spanish Fork) site, yielding an average recurrence interval of 1.7–2.6 k.y.
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Lund (2005 #6733) indicates a Holocene geologic vertical displacement rate of 1.2 mm/yr (preferred), and a consensus minimum-maximum range of 0.6–3.0 mm/yr. The

	displacement-rate estimates are based on displacement measurements across shorelines and surficial deposits related to the Bonneville lake cycle at Hobble Creek (Swan and others, 1980 #88; Machette and others, 1992 #607), American Fork Canyon (Machette, 1988 #5033), Spanish Fork Canyon, and east of Provo between Slate and Slide Canyons (Machette, 1992 #4529). A geologic vertical displacement rate of 2.2–2.7 mm/yr resulting from an anomalously large amount of displacement in sediments of the Bonneville and Provo cycles of Lake Bonneville, as documented by both Swan and others (1980 #88) and Machette and others (1992 #607) at Hobble Creek, remains unexplained.
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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