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Wasatch fault zone, Levan section (Class A) No. 2351i

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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)	SANPETE COUNTY, UTAH JUAB COUNTY, UTAH
Physiographic province(s)	BASIN AND RANGE
Reliability of	Poor

location	Compiled at 1:266,000 scale. *Comments:* Mapping from Machette and others (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 30 km of a total fault length of 357 km.
Average strike	N17°E (for section) versus N10°W (for whole fault)
Sense of movement	Normal
Dip	68° W. *Comments:* Measured at the Skinner Peaks trench in sandstone bedrock in fault contact with Holocene mudflow and fluvial deposits. In contrast to the planar fault geometry at the southern end of the Nephi section (Zoback, 1992 #611), this section of the fault appears to have a listric subsurface geometry and/or to terminate at a shallow detachment fault (Standlee, 1982 #4638; Smith and Bruhn, 1984 #4561).
Paleoseismology studies	Paleoseismic data for the Levan segment come from a faulted alluvial fan at Pigeon Creek, a natural stream-channel exposure at Deep Creek, and a trench excavated near Skinner Peaks. At Pigeon Creek (site 2351-5), 2 km east of the town of Levan, radiocarbon ages on charcoal from faulted late Holocene alluvial-fan deposits provide a maximum limiting age for the most recent surface-faulting event (Crone, 1983 #554; Schwartz and Coppersmith, 1984 #347). At Deep Creek (site 2351-7), about 5 km south of Levan, faults forming a 30-m-wide graben are exposed in the north bank of the stream channel. Schwartz and Coppersmith (1984 #347), Machette (unpublished mapping, 1984-86), and Jackson (1991 #4621) concluded that the main scarp resulted from a single faulting event. During reconnaissance mapping between Levan and Gunnison, Schwartz and Coppersmith (1984 #347) obtained a radiocarbon age on charcoal from an unspecified position in the footwall exposure that

	provides a broad maximum limiting age for the surface-faulting event. Jackson (1991 #4621) logged the Deep Creek exposure and obtained a thermoluminescence (TL) age estimate of 1000±100 yr B.P. for a buried A horizon that formed on the ground surface prior to faulting; this age estimate was corroborated by an approximate mean residence time (AMRT) radiocarbon age estimate on the same paleosol (Hylland and Machette, 2004 #6745). Jackson (1991 #4621) and Hylland and Machette (2004 #6745) consider this age estimate to closely approximate the time of faulting. The Skinner Peaks trench site (site 2351-24) is about 15 km south of Levan and 200 m east of State Route 28. Jackson (1991 #4621) interpreted the stratigraphic relations exposed in the trench as providing evidence for two surface-faulting events. A combination of TL and calendar-calibrated radiocarbon age estimates on samples from a burn horizon in the footwall block provide maximum limiting ages for the most recent surface-faulting event. Similarly derived age estimates on samples (including disseminated charcoal) from a buried incipient A horizon in the hanging-wall block provide a minimum limiting age for the penultimate event.
Geomorphic expression	A 5 km long gap in Quaternary fault scarps marks the boundary between the Levan and Nephi sections (Hylland and Machette, 2004 #6745). Quaternary fault scarps at the northern end of the Levan segment consist of old, degraded scarps on middle (?) Pleistocene surfaces, and show no evidence for latest Pleistocene or Holocene faulting. Holocene fault scarps extend southward from Hartleys Canyon to the southern end of the segment. Net vertical tectonic displacement from the most recent event was 1.8 to 2.0 m, based on measurements made at a natural exposure of the fault at Deep Creek and a trench exposure near Skinner Peaks. At the southern end of the segment, Quaternary fault scarps step left (east) 3.5 km to the Fayette segment.
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	latest Quaternary (<15 ka)

deformation	*Comments:* Lund (2005 #6733) indicates the following paleoearthquake chronology, based on available paleoseismic data, including natural and trenched fault exposures and preliminary fault mapping and scarp analyses (Hylland and Machette, 2004 #6745), with uncertainty ranges incorporating both geologic and laboratory error: Z <1000±150 cal yr B.P. Y early Holocene/latest Pleistocene (partial section rupture ?) Stratigraphic relations at Deep Creek indicate that 1 ka is a close maximum limiting age for event Z; TL and 14C dates from the Skinner Peaks and Pigeon Creek sites provide a maximum age of about 1.5–1.7 ka. Event Y is based on the possibility of two Holocene surface-faulting earthquakes on at least the southern end of the Levan section (south of Chriss Creek), inferred from stratigraphic relations exposed in the Skinner Peaks trench (Jackson, 1991 #4621) and preliminary scarp profile data (Hylland and Machette, 2004 #6745). At the trench site, event Y is inferred from greater stratigraphic thicknesses on the downthrown side of the fault, and predates TL and 14C ages of 3 to 4 ka. At Deep Creek, Jackson (1991 #4621) suggested Schwartz and Coppersmith's (1984 #347) radiocarbon age of 7300±1000 yr B.P. provides a broad minimum limiting age for any unexposed event Y.
Recurrence interval	>3 and <12 k.y. *Comments:* Based on the possibility of two Holocene earthquakes near the southern end of the section (Lund, 2005 #6733).
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Because of limited data, Lund (2005 #6733) reports a range in paleoseismic vertical displacement rate of 0.1–0.6 mm/yr rather than preferred, minimum, and maximum consensus values. This range considers the possibility of two Holocene earthquakes on the southern end of the section. However, the timing and lateral extent of the earlier event are poorly constrained. The maximum late Quaternary geologic vertical displacement rate may be approximately 0.05 mm/yr, based on 5 m of net vertical displacement of a middle to late Pleistocene alluvial-fan surface estimated to be at least 100,000 years old and possibly much older (M.D. Hylland, Utah Geological Survey, written communication, 2004).
Date and	2004

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