Documenting Recent Rupture Traces and Opportunistic Paleoseismic Exposures from the Northern Provo Segment to the Southern Salt Lake City Segment of the Wasatch Fault.

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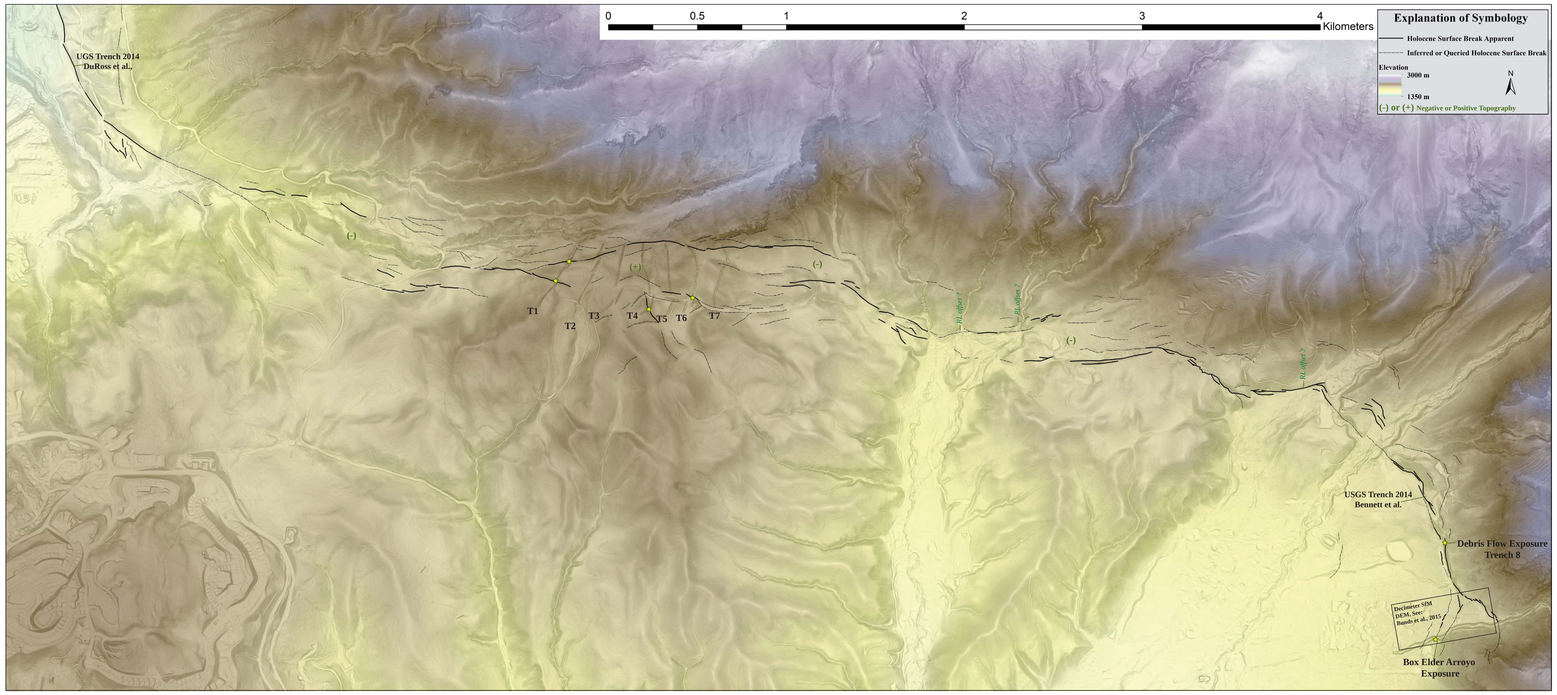
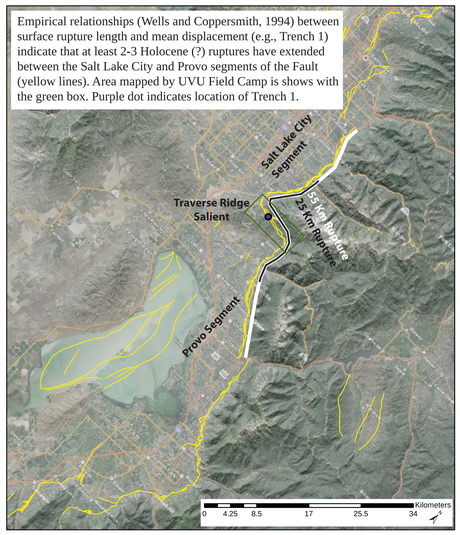
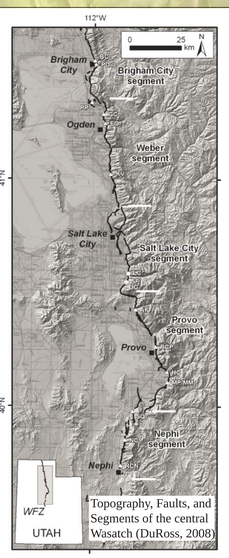
Preliminary Mapping of Holocene Surface Breaks of the Wasatch Fault along Traverse Ridge from field Work and 2 m LiDAR-derived Digital Terrain Products

by Jason Thomas, with the 2013 and 2014 UVU Geology Field Camp Classes; compiled and modified by Nathan Toké



Empirical relationships (Wells and Coppersmith, 1994) between surface rupture length and mean displacement (e.g., Trench 1) indicate that at least 2-3 Holocene (?) ruptures have extended between the Salt Lake City and Provo segments of the Fault (yellow lines). Area mapped by UVU Field Camp is shows with the green box. Purple dot indicates location of Trench 1.

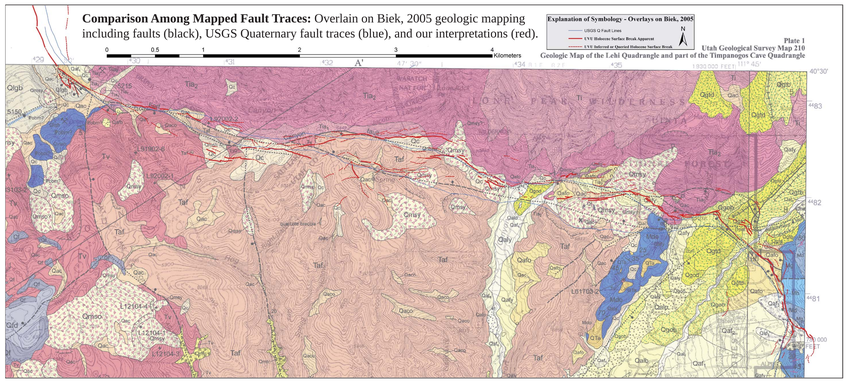




Topography, Faults, and Segments of the central Wasatch (DuRoss, 2008)

Mapping Summary: Between the Provo and Salt Lake City segments the Wasatch fault is expressed as an 8-12 Km long network of discontinuous surface breaks. At both ends of the segment boundary the trend of the fault rotates by ~90 degrees, over a distance of ~2 km, from roughly N-S to E-W. The most prominent surface breaks (*Holocene surface break apparent*) range from 15 to 470 m in length with a mean length of ~120 m. The one sigma distribution of surface breaks includes lengths of 40 to 200 m. The width of faulting throughout the mapping area is consistently greater than 100 m with much of area presenting good evidence for Holocene ruptures extending across a fault-perpendicular zone of 500-750 m in width. Scarps within the segment boundary display relatively modest relief as compared to other portions of the Wasatch Fault. There is some evidence for a component of right lateral slip along the portions of the fault zone which trend east to west. Evidence includes 1) several apparent right-lateral offsets of stream channels, 2) negative topography between large right steps in the main surface trace of the fault, and 3) positive topography between large left steps in the main surface trace of the fault. In addition to mapping recent surface breaks and geomorphic surfaces (not shown here), the UVU geology field camps from 2013-2014 have identified and documented several opportunistic paleoseismic exposures across the segment boundary. Here we present preliminary logging from six of these exposures. We are still seeking funding for geochronology.

Comparison Among Mapped Fault Traces: Overlain on Biek, 2005 geologic mapping including faults (black), USGS Quaternary fault traces (blue), and our interpretations (red).



Acknowledgments

We thank Draper City and David Dobbins for their assistance with gaining permission to access the site and the city geologist (David Simon) for helpful discussion. Members of the Utah Geological Survey Hazards program provided a helpful trench review of T1 exposures. The 2013 and 2014 GEO 3200 classes and Danny Horns also aided in field discussions that have helped to better this work in progress. The motivation for this research came from discussions with Jim McCalpin and operational expenses were furnished from a grant from the UVU College of Science and Health Scholarly Activities Committee as well as resources related to the 2013 and 2014 summer field geology camp. We also must thank the decision to leave seven consulting trenches open that were dug in 2006. They have been great educational and research tools.

References

Biek, R. F., 2005, Geologic Map of the Lehi Quadrangle and Part of the Timpanogos Cave Quadrangle, Salt Lake and Utah Counties, Utah, M-210 - Utah Geological Survey 7.5' Geological Maps.

Bunds, M., N. Toke, S. Walther, A. Fletcher and M. Arnoff, 2015, Applications of Structure from Motion Software for use in Earthquake Geology Investigations: Examples from the Wasatch, Oquirrh, and San Andreas Faults., Basin and Range Province Seismic Hazards Summit III, January 12-16, Salt Lake City, UT.

DuRoss, C., 2008, Holocene Vertical Displacement on the Central Segments of the Wasatch Fault Zone, Utah, Bulletin of the Seismological Society of America, Vol. 98, No. 6, pp. 2918-2933.

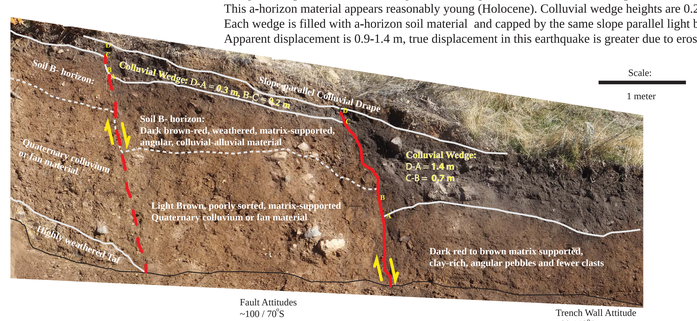
U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 2013, USGS web site: http//earthquake.usgs.gov/hazards/qfaults/.

Utah Automated Geographic Reference Center, 2006, 2 Meter LiDAR Elevation Data, http://gis.utah.gov/data/elevation-terrain-data/2-meter-lidar/.

Wells, D. L. and K.J. Coppersmith, 1994, New empirical relationships among magnitude, rupture length, rupture width, and surface displacement, Bulletin of the Seismological Society of America, Vol. 84, No. 4, pp. 974-1002.

2013 Trench #1 (Westernmost Trench) UVU Field Camp Paleoseismic Logs

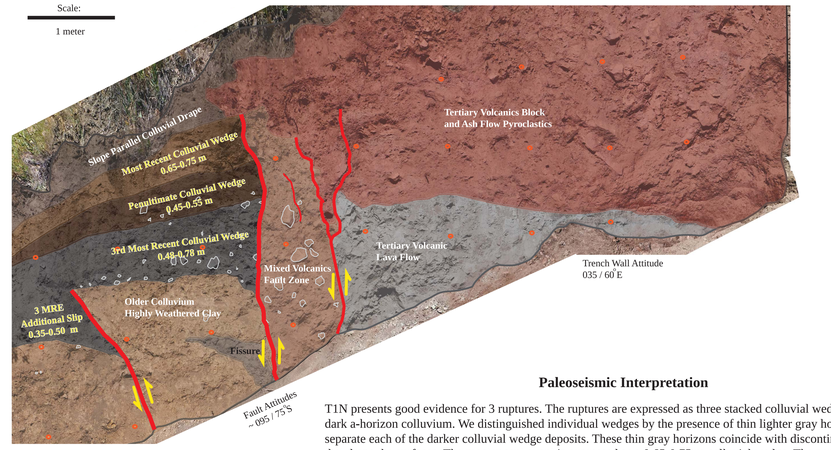
Trench 1 South (east wall)



Paleoseismic Interpretation

T1S presents good evidence for 1 rupture and is expressed as two colluvial wedges filled with the same soil colluvium. This a-horizon material appears reasonably young (Holocene). Colluvial wedge heights are 0.2-0.3 m and 0.7-1.1 m. Each wedge is filled with a-horizon soil material and capped by the same slope parallel light brown colluvial debris. Apparent displacement is 0.9-1.4 m, true displacement in this earthquake is greater due to erosion of the up-thrown block.

Trench 1 North (west wall)



Paleoseismic Interpretation

T1N presents good evidence for 3 ruptures. The ruptures are expressed as three stacked colluvial wedges filled with dark a-horizon colluvium. We distinguished individual wedges by the presence of thin lighter gray horizons that separate each of the darker colluvial wedge deposits. These thin gray horizons coincide with discontinuous clasts lines that drape the surfaces. The most recent event is expressed as a 0.65-0.75 m colluvial wedge. The penultimate event's wedge height is 0.45-0.55 m and the 3rd most recent event created two fault scarps with a combined colluvial wedge height of 0.83-1.28 m. The MRE is draped by an unfaulted slope parallel light brown to gray colluvium. Note that the apparent fault dips appear vertical or overhanging because the trench wall is cut obliquely to steeply dipping normal faults and the trench wall is sloping for trench safety. Measurements are resolved into fault coordinates.

Box Elder Arroyo Fault Exposure (South Wall)

Paleoseismic Interpretation

At the mouth of Box Elder Canyon a fan is entrenched. Here, the fault begins to bend from N-S to an E-W trend. This coincides with a relatively wide zone of surface faulting (0.5 km). At least four recent rupture traces are identified from our interpretations of LiDAR data, field mapping, and structure from motion (Bunds et al., 2015). The image here depicts the south wall of the arroyo where the westernmost trace crosses the channel. The fault is expressed as a wide fissure/colluvial wedge filled with soil and debris. Debris flow packages appear to be offset vertically 1-2 m. Roots extend from the surface to near the base of the arroyo wall.

Debris Flow Channel Fault Exposure (Trench 8 North Wall)

Paleoseismic Interpretation

In September 2013, Alpine UT experienced several debris flows which incised through the Wasatch fault scarp in at least three places along this reach of the fault trace. One of these natural entrenchments reveals evidence for a single event along this trace. This exposure is complicated by repeated incision and filling by debris flows. Our interpretation is that the purple and green packages were offset by a Holocene earthquake. Only part of the colluvial wedge remains as evidence of this event. Offset here is between 0.5-0.8 m. Consistent with offsets observed elsewhere near the segment boundary.

Trench #6 2014 UVU Field Camp - Southeast Wall

Preliminary Interpretation

Trench 6 presents discontinuous and deformed paleosols and deeply weathered tertiary fan stratigraphy. Discontinuities within the buried paleo a-horizons imply normal displacement, down to the south, which is consistent with the geomorphic expression of the fault trace. This exposure was cleaned and photographed within one morning. Only one hour was available to investigate the stratigraphy (done by two field camp students and reviewed by N.A. Toke). The investigator interpretations at this site differed significantly. The one we present here infers three fault traces cutting the stratigraphy. A primary fault trace on the northern half of the exposure abuts a thick package of organic-rich soil material. We infer a second, synthetic fault trace 3-4 m to the south of the main trace. We also query an antithetic fault which appears to displace a paleo a-horizon upwards on the southern half of the exposure. That deformation could also be due to soft sediment flow during the trench's wintertime track-hoe excavation.

Trench #4 2014 UVU Field Camp East Wall

Preliminary Interpretation

The southern end of Trench 4 reveals good evidence of faulting on a secondary trace of the segment boundary fault. We initially assumed this scarp was due to landsliding, but the presence of fault gouge implies a deeper history.