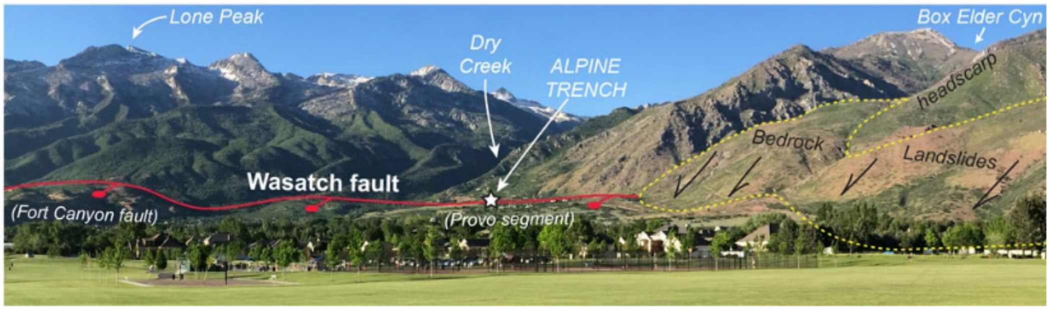
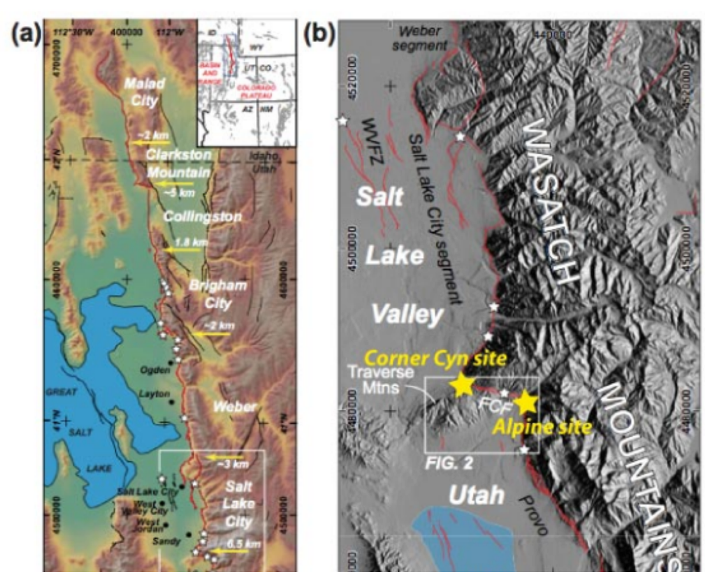
New Methods for Dating and Sequencing Ancient Earthquakes Along the Wasatch Fault Zone

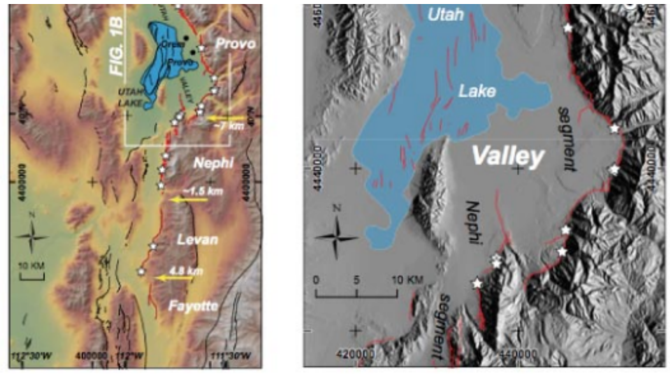


View to the northeast from central Alpine, Utah of the northern Provo segment of the Wasatch fault zone. The Alpine trench (white star) is located less than 1 km south of the northern end of the Provo segment near the mouth of Dry Creek.

The Wasatch fault zone in Utah follows the western edge of the Wasatch Range for about 350 km (220 mi), posing a significant earthquake hazard to the Wasatch Front urban corridor. Two recent paleoseismic (ancient earthquake) studies of the Wasatch fault zone were conducted to investigate the history of past fault ruptures within Salt Lake and Utah valleys. These studies each investigated geologic evidence of large (ground-rupturing) Wasatch fault earthquakes near a part of the fault previously thought to be a barrier, or boundary, between earthquake ruptures along the fault. That is, the Wasatch fault near Salt Lake City and Sandy (the Salt Lake City segment) has long been considered as a separate source of large earthquakes from the part of the fault near Spanish Fork, Provo, and Orem (the Provo segment). At each paleoseismic site, the scientists determined the age and sequence of past earthquakes, and they developed new methods to evaluate the earthquake data. These data highlight the history of large earthquakes along this densely populated part of the Wasatch Front, and will be used in a future study of whether or not past earthquakes have ruptured through the boundary between the Salt Lake City and Provo segments.

In each of these two investigations, geologists studied exposures of geologic units faulted by large earthquakes in a paleoseismic trench. At the Alpine trench site, the scientists documented six earthquakes on the northernmost part of the Provo segment during the past 6000 years. Soil and sediment from the fault zone were dated to determine the approximate sequence and timing of the six earthquakes. The scientists in this study refined a new method that uses the amount of sediment that collapses off of a fault scarp to estimate the fault offset at that location. Two or more of the paleoearthquakes appear to have ruptured across the boundary between the Provo and Salt Lake City segments, but further studies are needed to confirm.

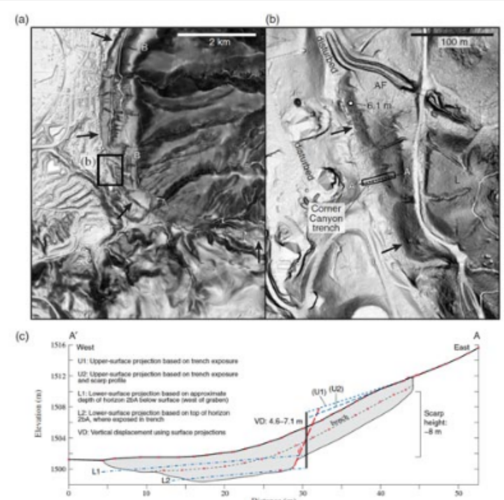




A close-up view of the Salt Lake City and Provo segments of the Wasatch fault zone, indicated by the white rectangle in map (a). The two trench sites (yellow stars) from these studies are located on either side of the boundary between these two fault segments.

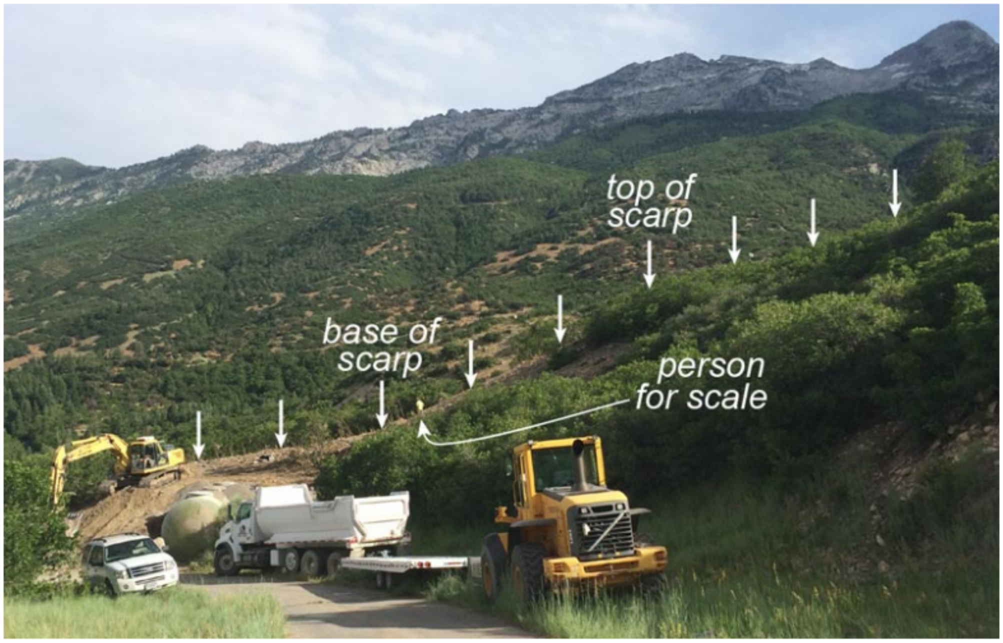
At the Corner Canyon site, the scientists also found geologic evidence of six ground-rupturing earthquakes on the southernmost part of the Salt Lake City segment in the past 4800 years. For this study, the scientists developed a multiple-method approach to evaluate and model the timing of individual earthquakes at the site. Paleoseismologists typically analyze collected data using statistical analysis, which works well in a geological environment where earthquakes occur among a continuous and uninterrupted sedimentary record, such as in lakes or ponds. The approach doesn't work as well when the sedimentary record is sporadic and/or complex, such as along the toe of the steep Wasatch Mountains. The new multi-method approach developed in this study more accurately assesses earthquake timing in areas with a more sporadic sedimentary record.

a) The Corner Canyon trench site at the beginning of the digging process. The small black and white arrows highlight the top and bottom of the fault scarp, respectively. b) Looking east at the Corner Canyon trench after the excavation was completed. The black line across trench shows the location of the Wasatch fault, where it juxtaposes different color geologic units (tan and brown).



Maps of the Corner Canyon site showing a) an overview of the area and b) a close-up view of the rectangular area shown in map (a) with the trench drawn in as a rectangle and dashed line. c) This topographic profile (cross section) shows how geologists calculate the total ground offset from several prehistoric earthquakes.

Collectively, the results from these two fault-trench studies demonstrate the history of large earthquakes on either side of the boundary between the Salt Lake City and Provo segments. The results also refined and confirmed two new data analyzation methods for complex geologic environments along an active fault zone. These data will help fill in the complex puzzle of what is going on along the Wasatch fault zone and what we might expect to happen during the next large earthquake along the Wasatch Front. The newly developed methods will be used to reanalyze all previous paleoseismic data for this part of the Wasatch fault zone, to evaluate whether past earthquakes have ruptured more than one fault segment at the same time.



A photo from the Alpine site showing the extent of the trench across the Wasatch fault (white arrows), as well as the top and bottom of the scarp caused by vertical offset from past earthquakes.

- written by Lisa Wald, USGS, September 2018

A photo of one exposed wall of the Alpine trench showing the Wasatch fault and the sense of motion on the fault (red lines and arrows). The alluvial fan deposits are shown by the dashed white lines.

For More Information

- How Big and How Frequent Are Earthquakes on the Wasatch Fault?
- Christopher B. DuRoss, Scott E. K. Bennett, Richard W. Briggs, Stephen F. Personius, Ryan D. Gold, Nadine G. Reitman, Adam I. Hiscock, Shannon A. Mahan; 2018, Combining Conflicting Bayesian Models to Develop Paleoseismic Records: An Example from the Wasatch Fault Zone, Utah. Bulletin of the Seismological Society of America. doi: https://doi.org/10.1785/0120170302
- Bennett, S. E. K., DuRoss, C. B., Gold, R. D., Briggs, R. W., Personius, S. F., Reitman, N. G., DeVore, J. R., Hiscock, A. I., Mahan, S. A., Harrison, G. J., Gunnarson, S., Stephenson, W. J., Klein, T., Pettinger, E., and Odum, J. K., 2018, Paleoseismic Results from the Alpine Site, Wasatch Fault Zone: Timing and Displacement Data for Six Holocene Earthquakes at the Salt Lake City-Provo Segment Boundary, Bulletin of the Seismological Society of America. doi: https://doi.org/10.1785/0120160358

The Scientists Behind the Science

Chris DuRoss is a Research Geologist with the USGS in Golden, Colorado. As a paleoseismologist, he studies geologic evidence of large, prehistoric earthquakes in areas of active faulting such as the Wasatch Front. When not working, he can be found (or not) with his family in the remote parts of the West.

Chris DuRoss.

Scott Bennett is a geologist with the USGS who studies the deformation and evolving landscape of continents, collecting data that allows him to reconstruct tectonic movements over a large range of temporal and spatial scales, from earthquakes to orogenies and from faults to plate boundaries. When not conducting research, he enjoys hiking or biking up mountains, hanging out at the beach with his family, and a spirited game of cribbage.

Scott Bennett.