SCEC Annual Report 2012

Project Title:
Development of a new paleoseismic site at Elizabeth Lake, central Mojave section of the San Andreas fault

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Project Summary:
Despite the recent development of several high-quality paleoseismic records for sites on the southern San Andreas fault (Figure 1), the distance between some of these sites remains too great to reliably test models of earthquake behavior and understand possible persistent segmentation of earthquake ruptures. Because the earthquake record from Bidart Fan (Akçiz et al., 2010) and Frazier Mountain are very similar (Figure 2), but quite different from that of Pallett Creek (Scharer et al. 2011), last year we began new paleoseismic investigations at Elizabeth Lake, CA. This location splits a 100 km gap between Pallett Creek and Frazier Mountain that is large enough to hold its own M7 earthquakes, and the site has the stratigraphic potential to provide important constraints on the extent and timing of ruptures along the Mojave section of the southern San Andreas fault over the past 1000 years (Bemis et al., 2012).

Results of 2012 SCEC-funded research at Elizabeth Lake:
The SAF near Elizabeth Lake (EL) is characterized by a long, south-facing geomorphic scarp that traps sediments shed from the north-facing slopes of the San Gabriel mountains (Figures 1 and 3). Our SCEC-funded investigations during 2012 focused on two small transtensional pull-apart basins that pond these sediments. Our excavations revealed excellent cm- to dm-scale stratigraphy, including several organic-rich clayey layers that separate coarser-grained clastic units (Figures 5 and 6). The clastic units likely record the distal deposits of debris flows emanating from the mountains to the south, whereas the clayey deposits represent the periods of time between debris flows characterized by a low-energy, ephemeral marsh environment. All units thin northward towards the main fault zone and onto the base of the long-term geomorphic scarp at the north side of the pull-apart basin. Dating of five charcoal fragments recovered from these strata exposed in trench EL1 provides a preliminary chronology showing that the uppermost 2 m of sediment records ~900 years of deposition. Additional radiocarbon samples collected in 2012 are being analyzed to refine this chronology with our 2012 SCEC allocation.

Preliminary Earthquake Evidence: In EL1, the most recent event is marked by folding of the unit 2 soil horizon and subsequent burial by unit 1. It is unclear if the ground surface was also faulted at this time, due to the massive character of unit 3, but a cut back exposure of the west wall suggests it was not. We are confident that the base of unit 4 is faulted and subsequently capped by unit 3, and thus places the penultimate event within unit 4 (Figure 6). There is no positive evidence in trench EL1 that more than two earthquakes occurred since unit 4 was deposited. Earlier events are indicated by the thinning and onlapping character of units 5 and older, but a deeper trench and additional exposures are required to determine the exact horizons of these events. Preliminary dating of the penultimate event in EL1 would place that earthquake between ca. 1298 and 1953 AD (Figure 5). This range means the penultimate event at Elizabeth Lake could correlate either to the 1812 event (seen at Pallett Creek) or the ~1750 event at Frazier, but not both (Figure 2).

Future Work at Elizabeth Lake:
Evidence from our trench EL1 and from a 1998 investigation by Dr. James Dolan (trench ERT; Dolan 1999; Figure 4) show that the Elizabeth Lake site has high sedimentation rates and dateable layers, required characteristics for paleoseismic investigations on the San Andreas fault. We have obtained

permission from the landowners to continue this work in 2013. Thus, the primary goals for our proposed 2013 fieldwork are:

(1) Lengthening the paleoearthquake record for the past millennium at the promising Elizabeth Lake site. In order to establish a 1000+ year paleoearthquake record for this site, we will develop a deep excavation at EL1 where we already know that we have ~900 yr old deposits that rapidly thicken from 20 cm to 1 m at ~1.5 m depth. The thickening of Units 4-7 suggest the possibility of multiple events, thus it will be important create a deeper exposure in order to examine the relative thickening and tilting of these units as they extend below the base of EL1, and to provide additional exposures to clarify the stratigraphic horizons of each event. Given the transtensional step evident by the geomorphic trace of the fault (Figure 4), we anticipate we will also identify secondary strands of the SAF within the basin flat that will provide important supporting event evidence.

(2) Refine the exact event horizon for the penultimate earthquake (e.g., was this 1812, or c. 1750, or an intermediate-aged event?). To refine the event horizon for the penultimate earthquake and ensure that we capture the full record of the past several earthquakes, we will re-excavate and extend the 1998 ERT excavation to expose the young stratigraphy there associated with active alluvial fan deposition. Expansion of EL1 will provide additional exposures of the uppermost section deposited during the past few hundred years. We will also collect samples for pollen analysis from both trenches for inclusion in a collaborative study (Scharer) to use invasive plants and ecological changes to improve event dating in the youngest part of the section, where radiocarbon dating has limitations.

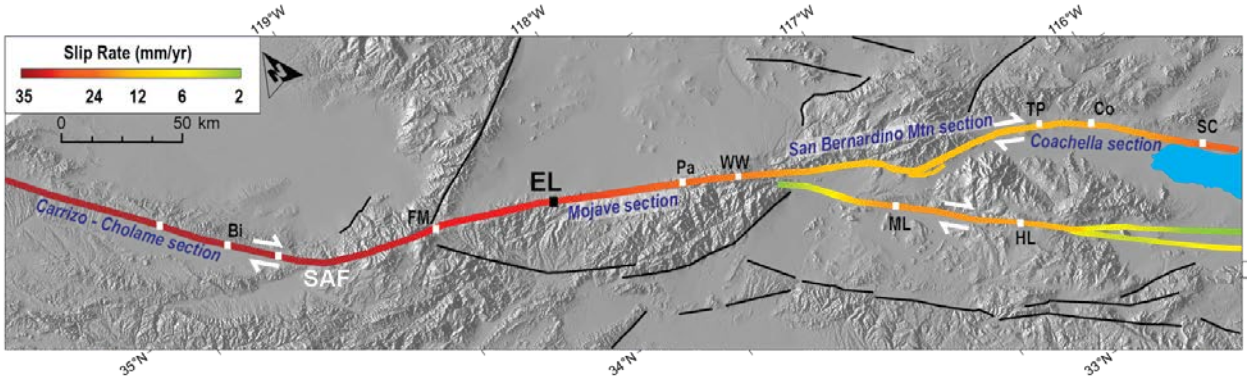


Figure 1. Map of the southern San Andreas/San Jacinto fault systems. The Elizabeth Lake site is shown as "EL", approximately halfway between Frazier Mountain (FM) and Pallett Creek (Pa). Other labeled paleoseismic sites: Bi = Bidart Fan, Co = Coachella, HL = Hog Lake, ML = Mystic Lake, SC = Salt Creek, TP = Thousand Palms, WW = Wrightwood.

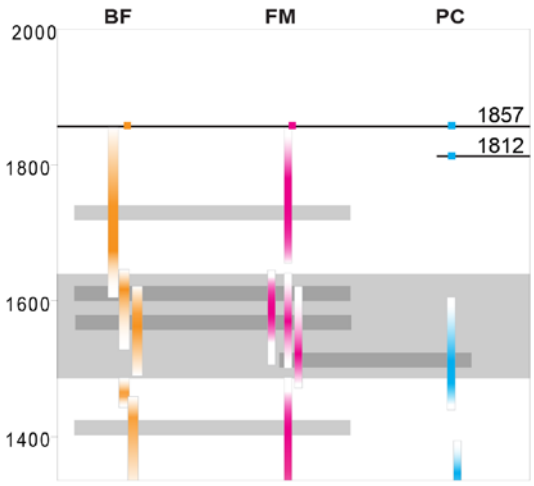


Figure 2. Correlation diagram for the three paleoseismic sites on the northern half of the southern SAF with complete paleoearthquake catalogs for the past ~600 yrs. Colored vertical bars represent the probability distribution functions (pdfs) for earthquake ages at each site, with greater color saturation corresponding with the peaks of the pdfs. Narrow grey bars illustrate potential event correlations between sites, and the broad gray bar show a time period during which, 2/3 of the ruptures do not span Frazier Mountain (FM) to Pallett Creek (PC) no matter how one chooses to correlate events. Moreover, there is no evidence for the ~1750 event at PC, and the penultimate event at FM not likely to be 1812. Data from Scharer et al. (2011), and Akciz et al. (2010).

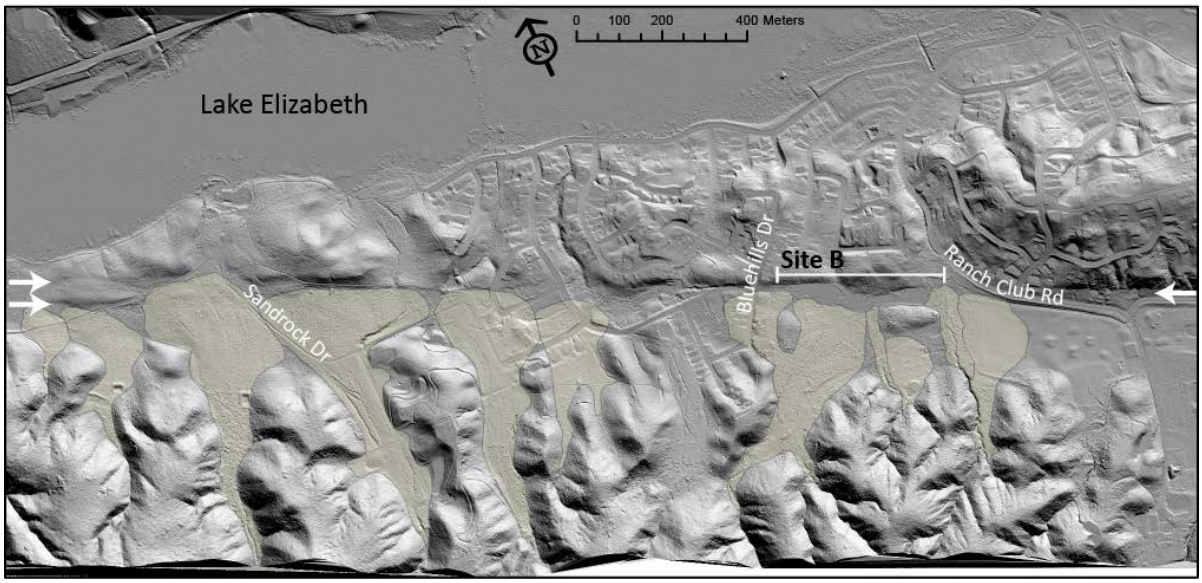


Figure 3. Elizabeth Lake study area (Site B) on a bare earth, shaded-relief LiDAR base (derived from the B4 dataset (www.earthsciences.osu.edu/b4)). White arrows delineate the trace of the SAF and transparent yellow polygons illustrate the alluvial fans that emanate from the south and pond up against the Holocene fault scarp.

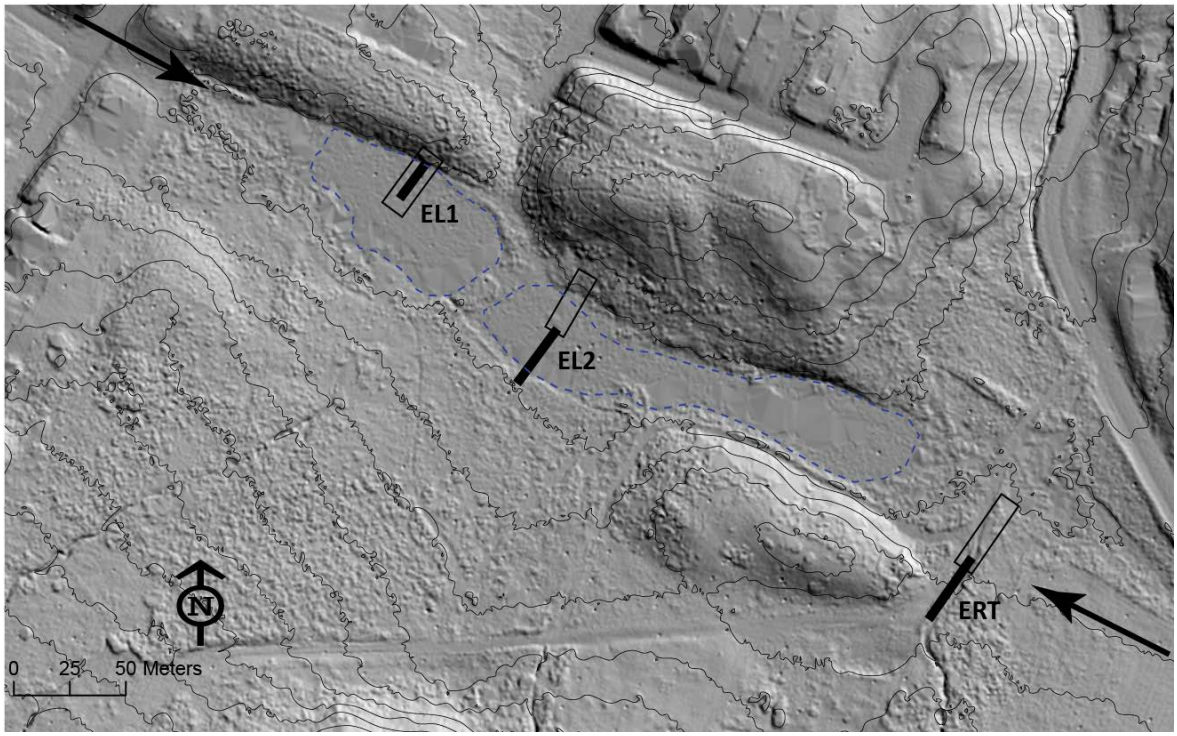
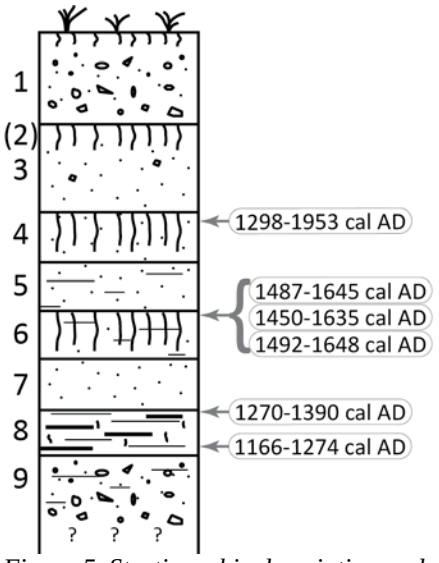


Figure 4. Locations of existing trenches (thick black lines) at Elizabeth Lake site. Trenches EL1 and EL2 were excavated by Bemis and Scharer in 2012, and ERT was excavated by Dolan in 1998; several other exploratory trenches excavated in 1998 near EL1 and EL2 are not shown for clarity. Open rectangles depict proposed new excavations. Large black arrows depict the trace of the SAF and highlight the transtensional step at this site.



1. Debris flow - massive, poorly sorted, gravelly sand. Weak clayey soil on surface.

2. Buried soil - (not a lithostratigraphic unit) clayey silt, pervasive soil structure. Sharp contact with overlying Unit 1. Merges with modern soil on top of Unit 3

3. Sandy colluvium - moderately sorted silt to medium sand with rare pebbles, although varies through trench with coarse and finer grained zones.

4. Clayey colluvium - clay with disseminated weathered feldspar grains. Well-developed soil structure.

5. Upper sand - moderately sorted fine to v.c. sand. Common burrows.

6. Organic-rich silty clay - clayey silt to silty clay with pervasive soil structure.

7. Lower sand - moderately sorted, med. sand with pods of med. to v.c. sand and v.f. to fine sand.

8. Bedded silty clay - 1-2 cm thick, discontinuous beds of organic-rich silty clay and orange-tan silty clay. Local weak soil structure.

9. Clayey gravel - massive, poorly sorted gravelly sand with significant clay fraction. Base not exposed

Figure 5. Stratigraphic description and radiocarbon ages from EL1. Radiocarbon ages calibrated with OxCal 4.1 and represent 2-sigma errors. The 1450-1635 cal AD age from Unit 6 is a lab duplicate of the 1487-1645 cal AD sample.

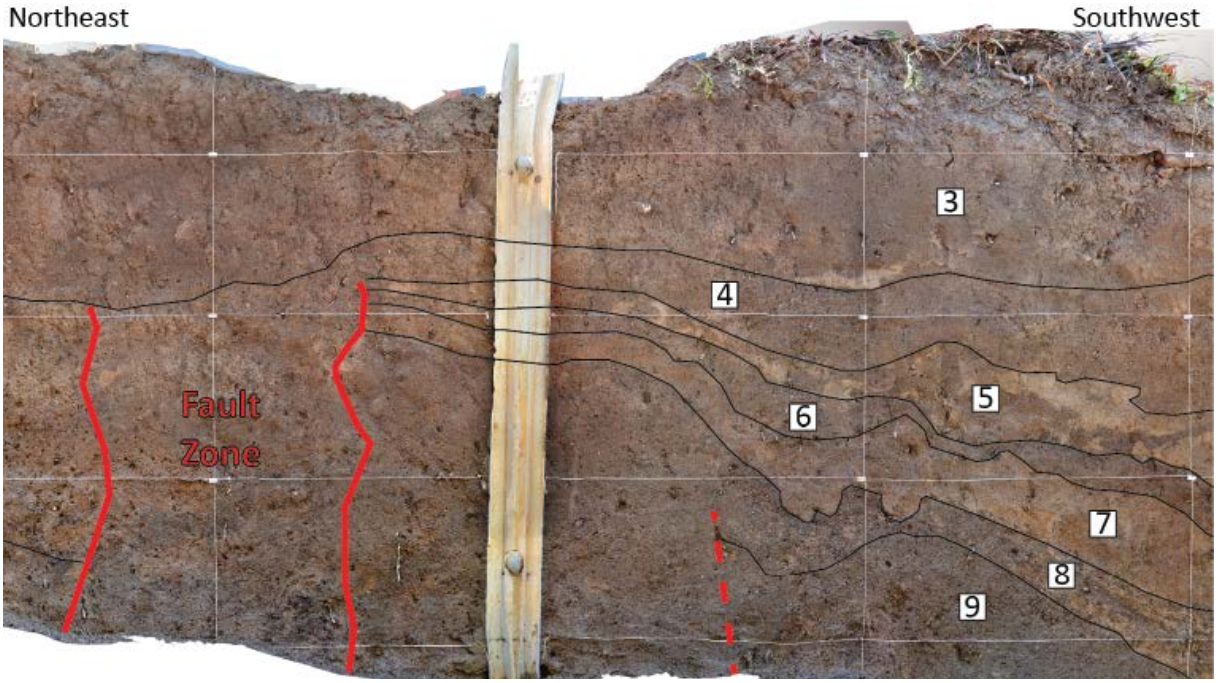


Figure 6. Example of the trench log from the southeast wall of EL1 illustrating the general stratigraphy and the older portion of the exposed stratigraphy. The geometry and thickness of units approaching the fault zone suggests that these units record progressive growth of the small pop-up adjacent to the fault likely through multiple earthquake events. Unit numbers correlate with descriptions in Figure 5.

References

Akçiz, S.O., Ludwig, L.G., Arrowsmith, J.R., and Zielke, O., 2010, Century-long average time intervals between earthquake ruptures of the San Andreas fault in the Carrizo Plain, California: Geology, v. 38, no. 9, p. 787 - 790, doi: 10.1130/G30995.1.

Bemis, S.P., Scharer, K.M., Walker, L., and Taylor, P., 2012, New observations from the Elizabeth Lake paleoseismic site: Current results and future directions: SCEC Annual Meeting, P-145.

Dolan, J. F., 1999, Paleoseismologic reconnaissance of the San Andreas fault, Elizabeth Lake, California: Progress report on SCEC-supported research conducted during 1998: SCEC Report, January 15, 1999.

Scharer, K.M., Biasi, G.P., and Weldon, R.J., 2011, A re-evaluation of the Pallett Creek earthquake chronology based on new AMS radiocarbon dates, San Andreas fault, California: Journal of Geophysical Research,, doi: 10.1029/2010JB008099.

Scharer, K., Weldon, R., Strieg, A., 2012, Earthquakes through the Big Bend: Comparison of earthquake ages from Frazier Mountain, Bidart Fan, and Pallett Creek, CA, Annual SCEC Meeting, P-126.

Scharer, K.M., Weldon, R.J., Gibson, B.C., and Streig, A.R., 2011, Earthquake ages and displacements, Frazier Mountain paleoseismic site, SCEC Annual Meeting, Poster A-141.