Influence of sediment dynamics and alluvial fan formation on paleoseismic studies in southern California, North America

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2019 SCEC Annual Meeting Poster #129

Abstract -

Paleoseismic data provide a record of past surface-rupturing earthquakes, but the fidelity of the record depends on the completeness of trench stratigraphy and the precision of geochronology.

For example:

* A period of erosion might scour fault terminations from multiple earthquakes to a single stratigraphic level

At southern SAFS: many paleoseismic sites are located on alluvial fans with widely different stratigraphic completeness (*Fig. 1*)

* Distinct tectonic behaviors across different fault strands are often proposed for widely variable apparent recurrence intervals (RIs) from trenches
* Instead of sedimentary history (*Fig. 1*).

Hypothesis -

Apparent RIs depend on local depositional history and stratigraphic completeness (*Fig. 1*).

It is therefore possible that the variation in the apparent RIs are affected by depositional history in some paleoseismic sites, rather than the variations in tectonic activities.

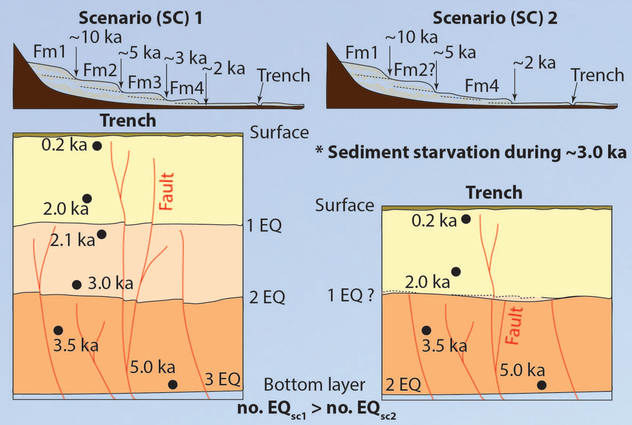
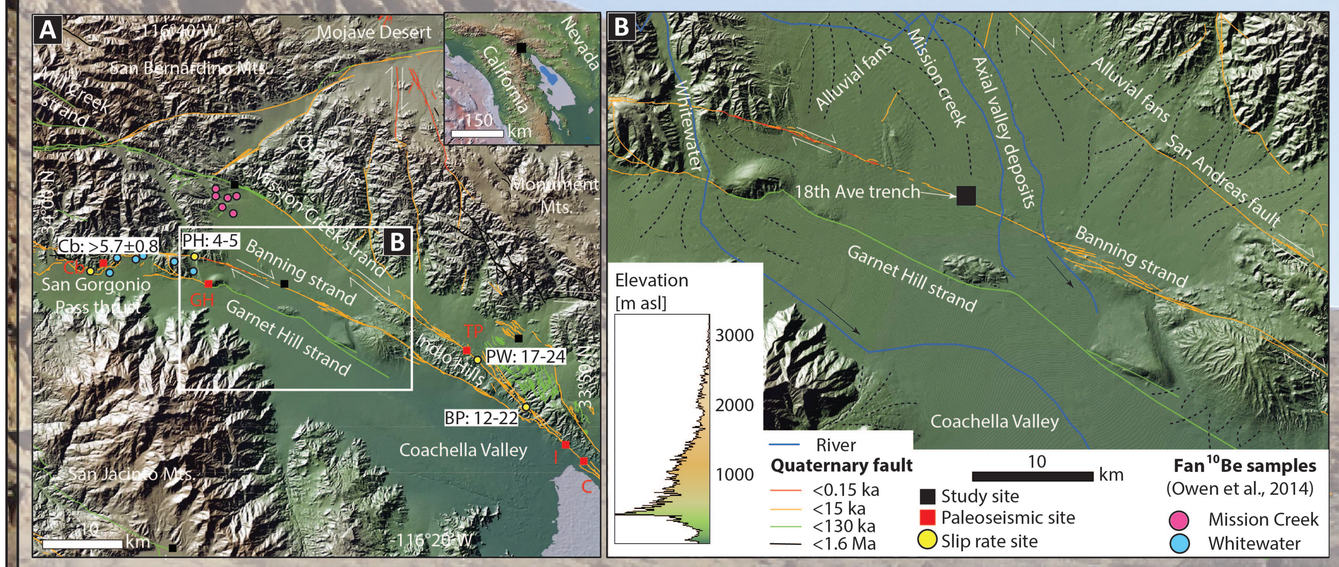


Fig. 1: Schematic diagram showing two different scenarios (SC) of stratigraphic preservation of earthquake events. Scenario 1: systematic sedimentation and alluvial fan formation and preservation of primary stratigraphy. Scenario 2: lack of sedimentation and stratigraphic preservation between ~3–2 ka and number of past earthquakes (EQ) could be underestimated for the Event horizon 1. Black circles represent hypothetical samples.



Study area - *Fig. 2: DEM showing A) the regional setting and Quaternary faults (after USGS, 2006). Proposed alluvial fan study sites are also highlighted in black squares. Red squares mark the locations of existing paleoseismic sites B) 18th Ave paleoseismic trench site (black square) on the Banning strand of the SAFS.*

Methodology -

Individual feldspar single-grain post-infrared infrared stimulated luminescence (pIR IRSL) dating, field mapping, virtual transport model.

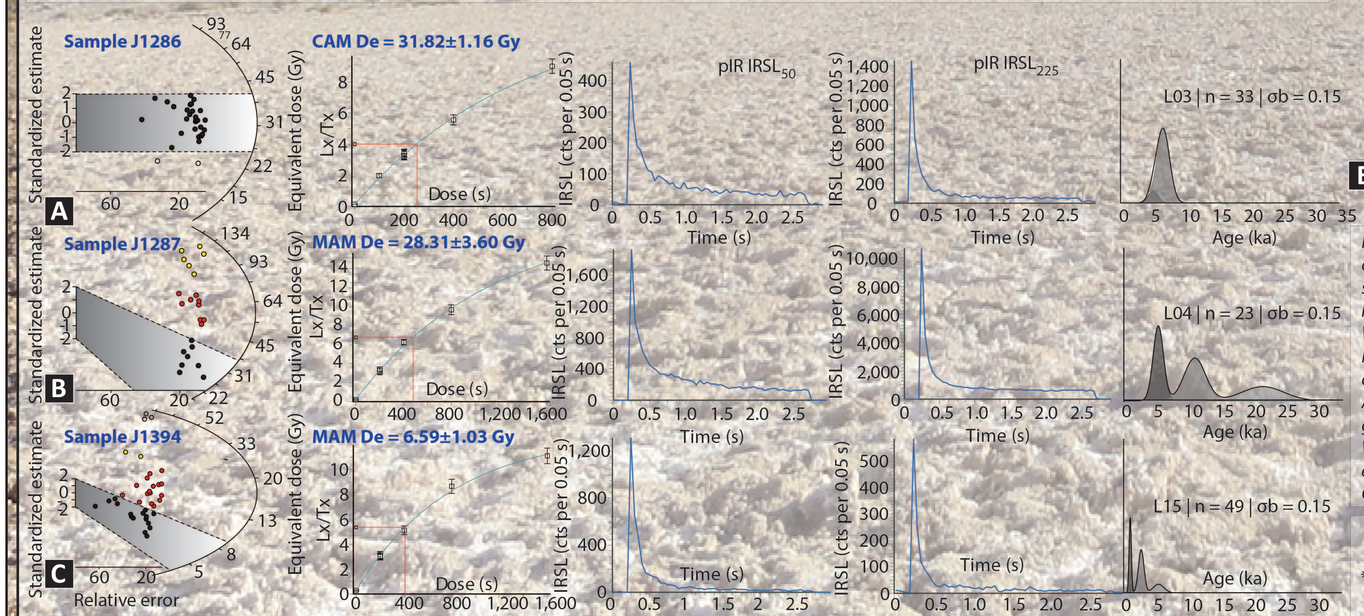


Fig. 3: Examples of radial plots, growth curves, shine down curves at IR50° and IR225 °C, respectively showing equivalent doses (D$_e$) of single-grain feldspars and finite mixture model showing single-grain age subpopulation . A) J1286 is the only one out of the total 17 samples which indicates evidence of complete bleaching. Samples J1287 (B) and J1394 (C) are typical samples showing partial bleaching and multiple subpopulation.

Results -

* An alluvial fan-axial valley deposit *(Fig. 2)*.
* At least 8 event horizons are dated using 17 feldspars pIR IRSL ages *(Fig. 3; Castillo et al. in prep.)*.
* No significant fading at pIR IRSL$_{225}$ *(Fig. 4)*.
* Fifteen of the total 17 pIR IRSL ages show stratigraphic coherence and correspondence with the youngest detrital charcoal ^{14}C ages at 1-sigma *(Fig. 5)*.
* At least 7 single-grain age sub-populations were identified using the finite mixture model *(Fig. 5)*.
* Connection with the alluvial fan incisional ages.

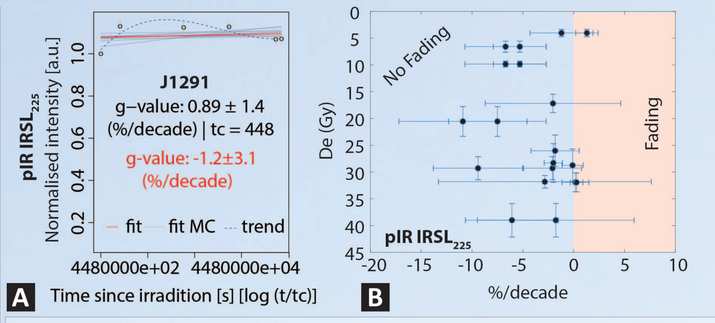


Fig. 4: No significant fading (i.e., % loss per decade) was observed for all samples at pIR IRSL$_{225}$. A) % loss per dace for sample J1291. B) Biplot showing De on the y-axis and % loss per decade on x-axis at the laborstory time-scale at IR225 °C.

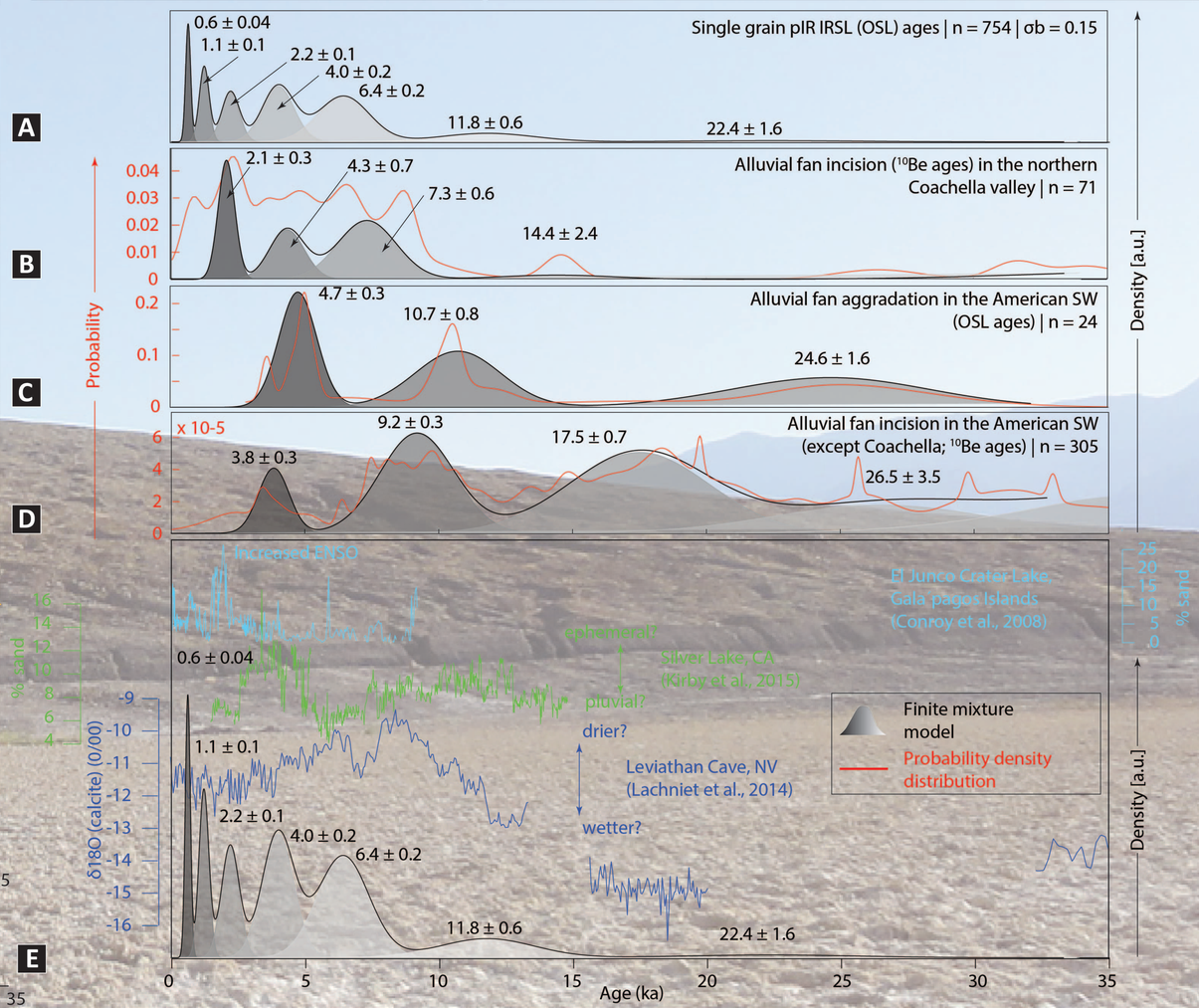


Fig. 5: Diagram showing alluvial fan age distribution (in ka), single-grain post-IR IRSL ages of the 18th Ave paleoseismic site (in ka), and proxy climate data of the American Southwest. Note that the finite mixture model is used to show the distribution of population peaks. Probability density distribution is also shown for reference. A) 754 single-grain super-K feldspar were dated using pIR IRSL method at the 18th Ave trench site in the northern Coachella Valley. At least seven single-grain IRSL age groups were identified in all 17 samples dated at the trench site. B) Timing of alluvial fan incisions in the Mission Creek and Whitewater River catchments (study area) based on (recalculated here) cosmogenic ^{10}Be ages of fan boulder surfaces; after Owen et al., 2011. Note ages >35 ka are not shown here. C) Chronology of alluvial fan aggradations elsewhere in the American Southwest based on quartz and feldspar OSL ages. Ages are compiled form DeLong and Arnold (2007); Mahan et al. (2007); Sohn et al. (2007); and Miller et al. (2010). D) Timing of alluvial fan incisions elsewhere in the American Southwest (except the study area) based on (recalculated here) ^{10}Be ages. Note that the peaks of fan incisional ages follow the peaks of the aggregational ages, at least since MIS 2 which is expected. Ages are compiled form Bierman et al. (1995); Zehfuss et al. (2001); Matmon et al. (2005, 2006); van der Woerd et al. (2006); Benn et al. (2006); Duhnforth et al. (2007); Frankel et al. (2007a, b); Le et al. (2007); DeLong and Arnold (2007); Spelz et al. (2008); Owen et al. (2011); Behr et al. (2010); Kent (2011); Blisniuk et al. (2012). E) Comparing single-grain pIR IRSL ages of the 18th Ave trench site to the climate proxies. Climate proxies include lake records (Conroy et al., 2008; Kirby et al., 2015) and speleothem records (Lachniet et al., 2014).

Summary -

* There is a linkage between climate-driven selective sediment evacuation and aggradation in the study area *(Fig. 5)*.
* Qualitative correlation may be observed in the data *(Fig. 5)*.

Future goal -

* Future paleoseismic sites: *Indio Hills, Upper Mission Creek, San Jacinto, Santa Rosa, and Mammoth site.*
* Multiple elevated temperature post-IR IRSL (METpIRIR) signals.
* Distinct single-grain feldspar responses will be measured at IR50°, IR95°, IR140°, IR185°, and IR-230 °C (McGuire and Rhodes, 2015a, b).

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Acknowledgement -

This project was funded by the USGS project EHP Award G18AP0004.