Reconstructing long-term subsidence and paleoseismic history of the ancient Lake Cahuilla along the southern San Andreas fault in Coachella, California

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ABSTRACT: Potentially the longest paleoseismic records on SSAF

- The most recent ground-rupturing earthquake (MRE) in the southern San Andreas Fault (SSAF) occurred ~300 years ago, just after the last filling of ancient Lake Cahuilla in the Salton Trough.
- This stretch of the SSAF likely has accumulated a large amount of elastic strain since the MRE (**Fig. 1**; Rockwell et al., 2018).
- Other workers have proposed that the lake levels of ancestral Lake Cahuilla likely modulate the regional stress field and tie earthquake occurrence to particular stages of lake fill (Brothers et al., 2011; Rockwell and Klinger, 2019).
- The limited stratigraphic and temporal studies make it challenging to evaluate whether the lack of surface rupture since the MRE on the SSAF is due to the extended dry period in the lake **(Fig. 1)**.

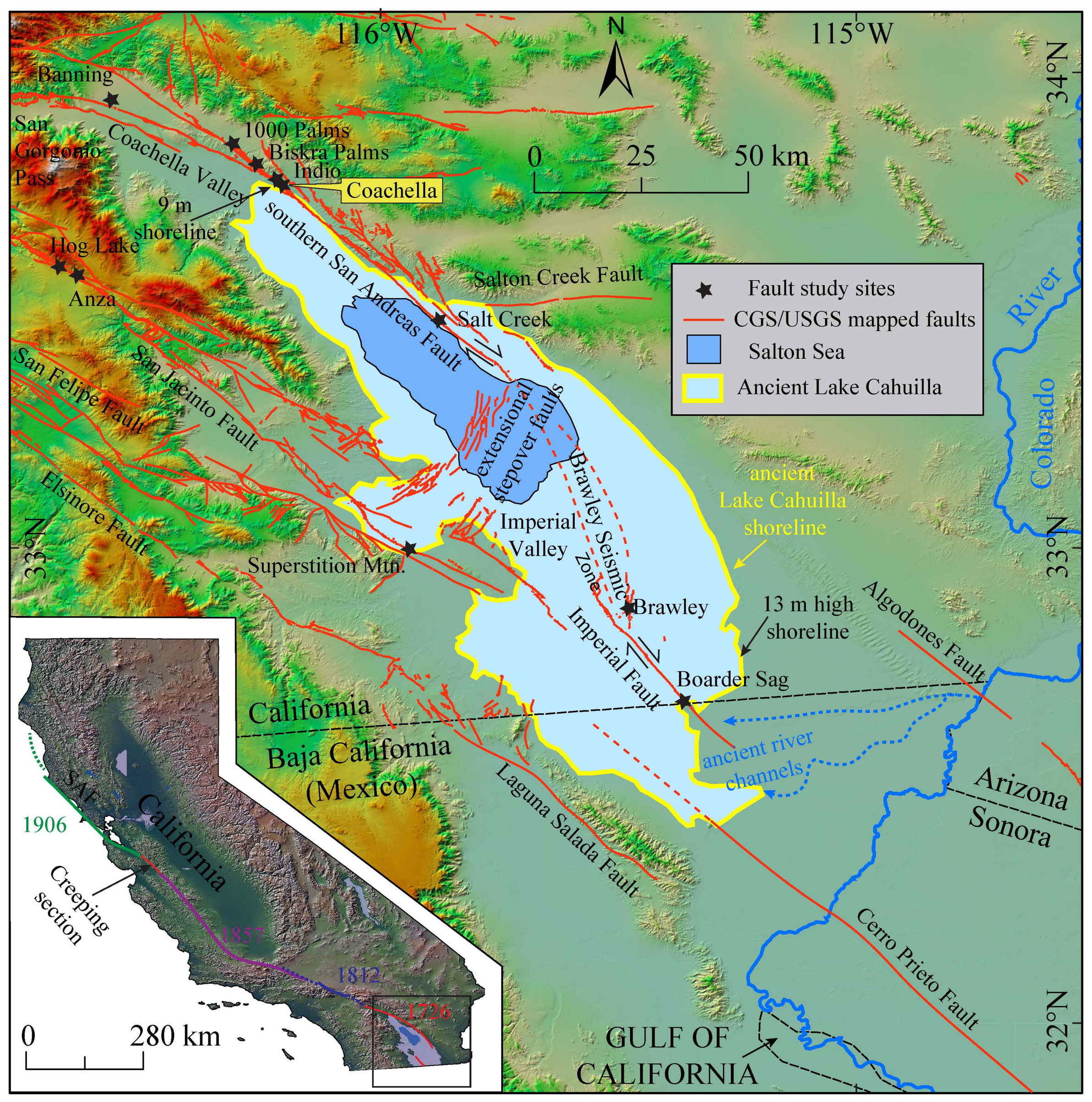

Fig.1. Inset is the hillshade map of CA showing large historical ruptures of the SAF (Philibosian et al., 20111). The shaded relief map of southern California exhibiting the study site (Coachella), the Quaternary faults (USGS & CGS, 2006), major paleoseismic sites in the valley, ancient Lake Cahuilla shorelines, and paleo diverted channels of the Colorado River which periodically filled the lake in the past.

Paleoseismic & Coulomb stress models of the Cahuilla basin suggest high rupture potentiality of these strike-slip and normal faults to rapid stress loading associated with lake filling

Hypothesis: The lake cycles (filling & drying) of the ancient Lake Cahuilla potentially triggered surface ruptures along the southern San Andreas Fault (SSAF).

A continuous sedimentary core **(Figs. 2, 3)** has the potentiality to reconstruct a long-term: (i) lake filling/desiccation chronology, (ii) a subsidence history of the ancient Lake Cahuilla (when combined with cone penetration test), & (iii) sedimentologic context for paleoearthquake and slip rate studies in the Coachella Valley.

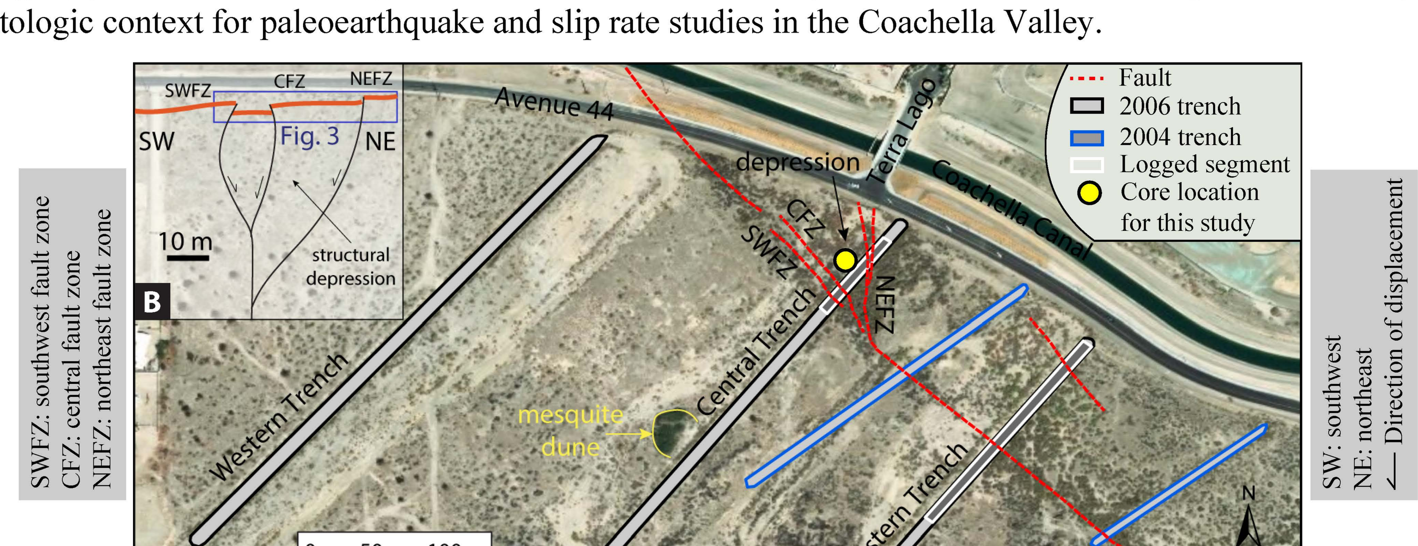

Fig. 2. (A) Google Earth image of the Coachella study site showing the previous paleoseismic trenches (Philibosian et al., 2011). A ~33.5-m-deep continuous sedimentary core (yellow circle) was extracted from the narrow (~30 m wide) structural depression near the shoreline of ancient Lake Cahuilla. Detailed trench stratigraphic logs are available only for specific segments (white rectangles; **Fig. 4**), which are used in this study for stratigraphic logging for the upper ~7 m.. **(B)** Schematic representation of the inferred subsurface tulip fault structure, modified after Philibosian et al. (2009, 2011). We expect thicker sedimentary deposits and limited to none fault displacement at the core site in the sag.

~33.5-m-deep core extracted from Coachella site

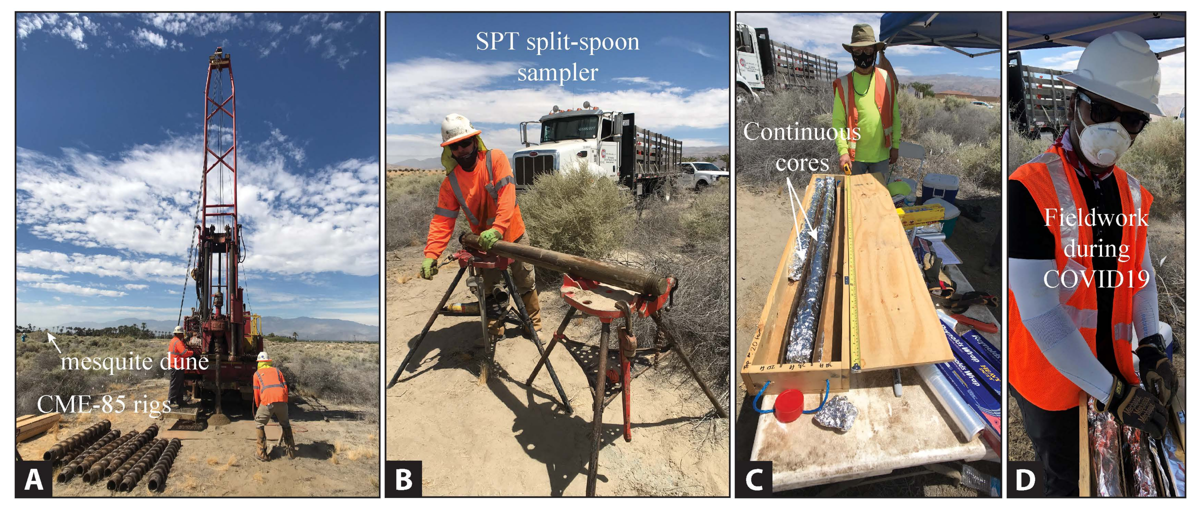

Fig. 3. Filed photos showing the drilling of continuous core segments. **(A)** The rig setup (view looking SW). **(B)** Recovered core with a plastic liner. **(C)** Cores with plastic liners are covered with aluminum foils to minimize sunlight exposure. **(D)** Fieldwork was performed in late May 2020.

~12 lake highstands identified from 16.8 m core

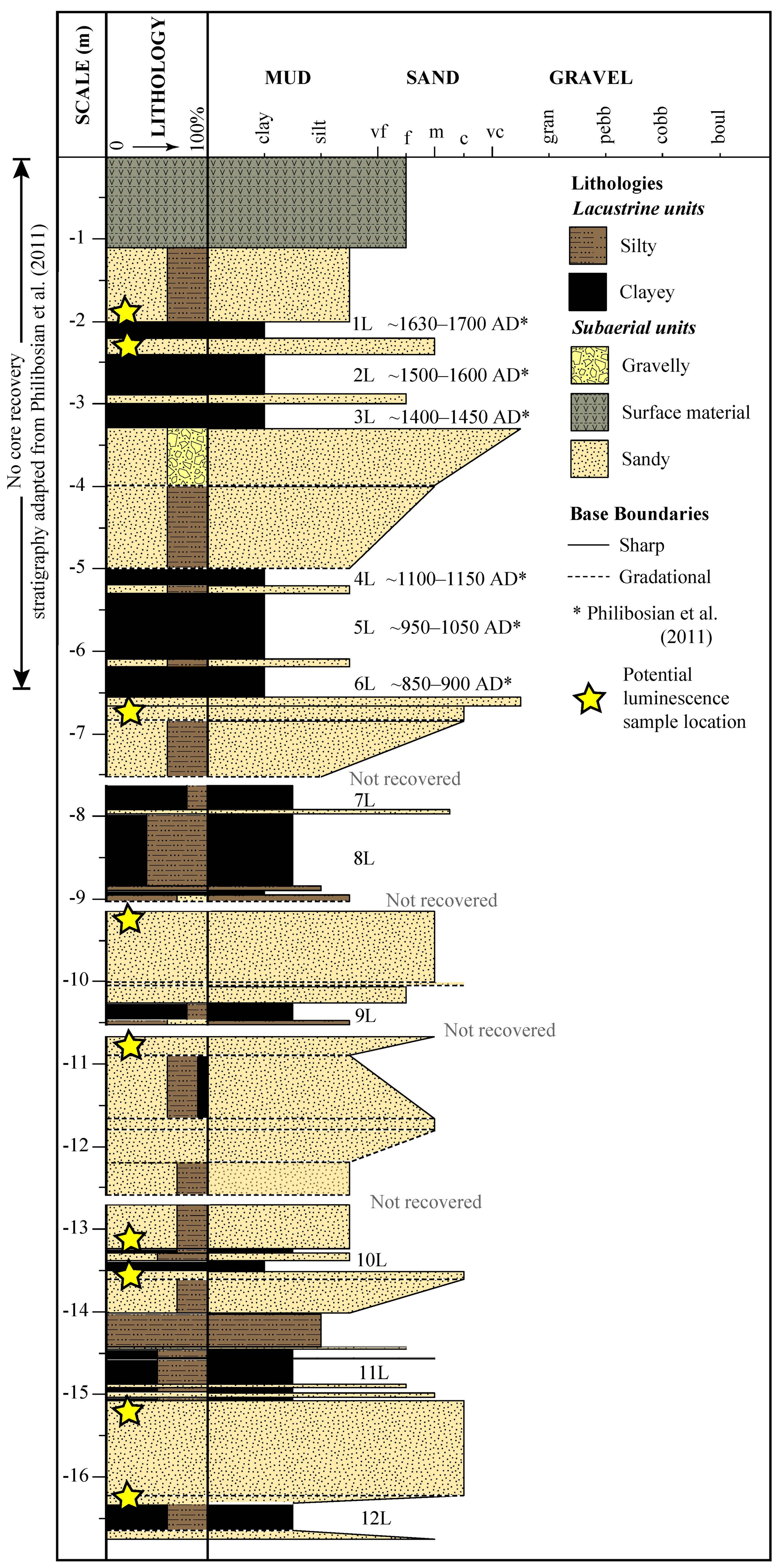

Fig. 6. Core stratigraphic log (preliminary) showing the subaerial & lacustrine units. As much as 12 lacustrine units are identified of the 50% analyzed. Sandy-rich layers are interpreted as subaerial & clay-silt rich layers as lacustrine (after Philibosian et al.,2011). Upper ~7 m of the lake stratigraphy was adapted from the trench log **(Fig. 4)**. Luminescence and ^{14}C samples will be collected from suitable units. Coupled with cone penetration test (CPT) survey, the data will be used to test whether lake cycles bear any correspondence with the earthquake cycles on SSAF (e.g., **Fig. 5**).

Is there a strong correlation between lake loadings & past earthquake ruptures in the Cahuilla basin? While some workers found no such relationship (Fig. 5A), others showed correspondence with lake cycles & earthquake cycles (Fig. 5B)

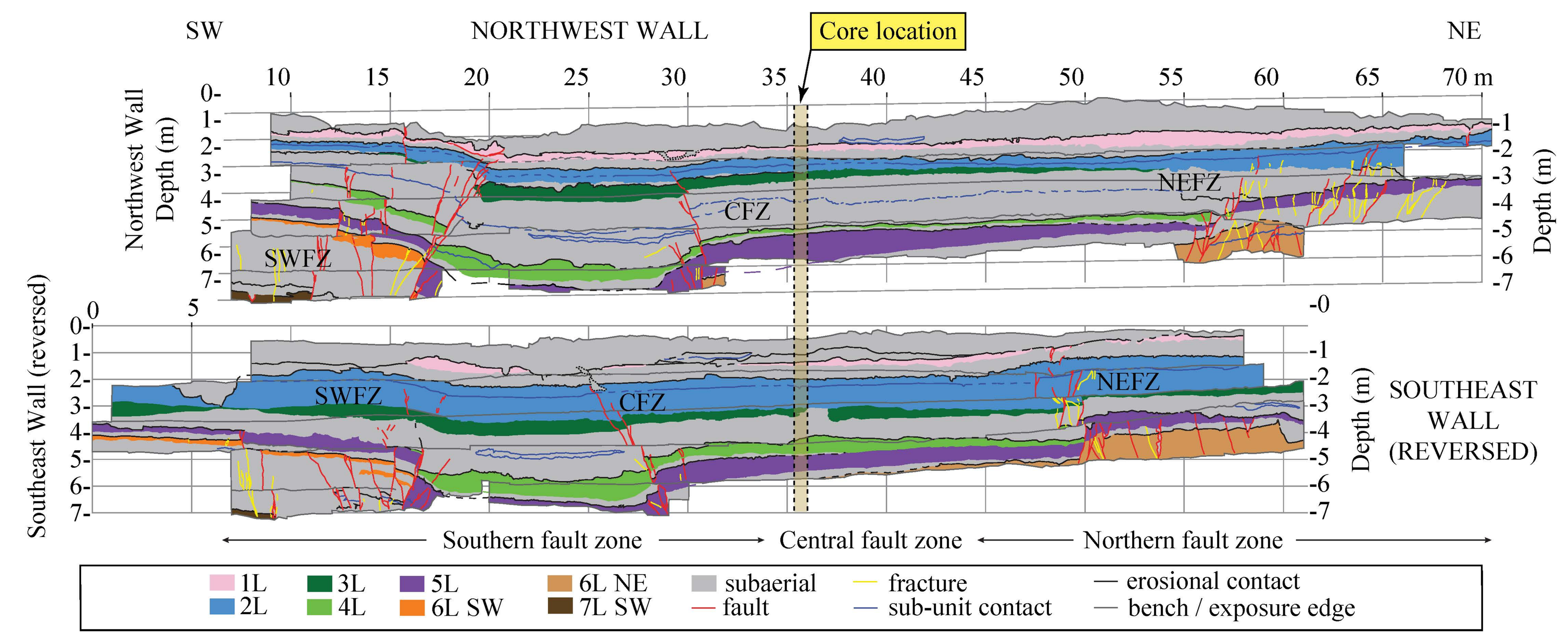

Fig. 4. Stratigraphic logs of the structural depression of the Central trench (both walls) at the Coachella site, modified after Philibosian et al. (2011). The logs display the fault structures, overall geometry, the thickness, & the vertical displacement of the sedimentary units. The upper ~7 m of the trench log at was used to supplement the lost core.

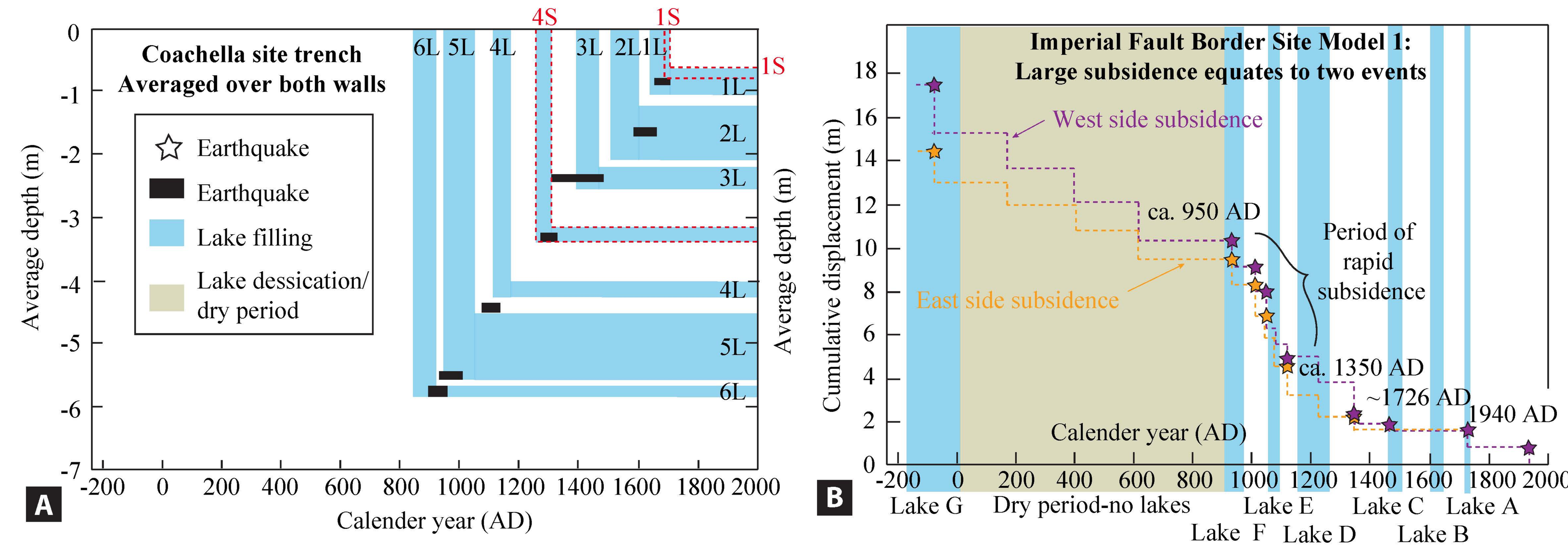

Fig. 5. Lake highstands versus earthquake & subsidence history in the Cahuilla basin. **(A)** Lake highstand & earthquake chronology at the Coachella site, modified after Philibosian et al. (2011). Rockwell and Klinger (2019) reinterpreted the 1S & 4S as lacustrine units (in red). If this is true, of the seven past surface ruptures at the Coachella site, as many as six (~86%) occurred when the lake was high.**(B)** Lake filling & subsidence history at the Boarder site sag pond, modified after Rockwell and Klinger (2019), showing strong correspondence between lake loadings and earthquake cycles.

SUMMARY: A work in progress

- Of the 50% analyzed, as much as 12 lacustrine units are recorded in the core stratigraphy **(Fig. 6)**.
- The rest of the core is currently being dried & stratigraphic logs are prepared.
- With a ~5 mm a^{-1} sedimentation rate (Philibosian et al., 2011), we expect to extend the lake cycles back to the Mid-Holocene (~7–6 ka).
- Subaerial (sand-rich) units, bounding the lacustrine units, will be targeting for single-grain post-Infrared Infrared Stimulated Luminescence (p-IR IRSL) dating.

FUTURE PLANS: Grain size measurements, CPT survey, dating

- Continuous grain-size measurements to supplement stratigraphic log & assist in geophysical data interpretation.
- Independent dating techniques (e.g., ^{14}C) will be useful to cross-correlate the different dating results for a robust chronostratigraphic reconstruction of the core stratigraphy.
- An age model (age-depth relationship) will be used to show the continuous temporal variations in grain sizes.
- Subsurface geotechnical engineering survey (e.g., CPT) will be used at the sag to capture the longest rupture/subsidence, & slip triggered by the movement along the SSAF.

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Acknowledgements

Thanks to SCEC for providing funding for the project (award 20144). We also thanks Cascade environmental for drilling the core. Thanks to USGS for providing funding for the drilling.