026

Refining the South-Central San Andreas Fault Slip Rate at the 6 ka Timescale: Phelan Creeks

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I) Abstract

Geologic slip rates of active faults are essential for seismic hazard analysis, and their comparison with decadal geodetic measurements can be used to assess the constancy of strain accumulation and earthquake-modulated strain release. The Phelan Creeks paleoseismic site is located along the San Andreas Fault (SAF) 1.6 km southeast of Wallace Creek (WC) in the Carrizo Plain -- a region with simple fault geometry and the highest millennial slip rate in California (>3 cm yr-1). Despite this, the geologic slip rate of the Carrizo is defined from only a few published sites with limited geochronological age constraints: Van Matre Ranch (VMR), with channels offset ~26 m in ~850 yrs (~31 mm yr-1), and Wallace Creek, with channels offset 128 m in ~3,780 yrs (~34 mm yr-1) and ~475 m in ~13,250 yrs (~36 mm yr-1). The Phelan Creeks area consists of three downstream channel complexes on the southwest side of the SAF that have emanated from a pair of feeder channels ("Little" and "Big" Phelan Creeks) on the northeast of the SAF. These channels have recorded progressive incision, offset, and abandonment along the SAF with offsets of ~16.5 m, ~130 m, and ~230 m. Dating the ~230 m offset channels at Phelan Creeks provides the opportunity to fill a spatio-temporal gap in age-offset constraints (between VMR at 10^3 yrs & WC at 10^4 yrs) and test the hypothesis that there is minimal slip-rate variability along the south central SAF in the Carrizo Plain during the last 15,000 years. We present logs from three trenches in the ~230 m offset channel pair. Trenches exposed complex sequences of cut-and-fill stratigraphy that represent timing of initial incision and subsequent channel processes as they were fault-offset to the northwest and eventually beheaded. Extreme bioturbation precludes dating the uppermost channel deposits which would be useful for timing of last fill before beheading. Stratified alluvial fan material, channel deposits, and interfingering colluvial wedges were sampled for Radiocarbon (14C) and Optically Stimulated Luminescence (OSL) dating. Geochronological constraints will be useful for assessing fault slip rate variability, and understanding the sedimentologic and pedogenic evolution of cut-and-fill sequences in the semi-arid Carrizo Plain.

II) Introduction

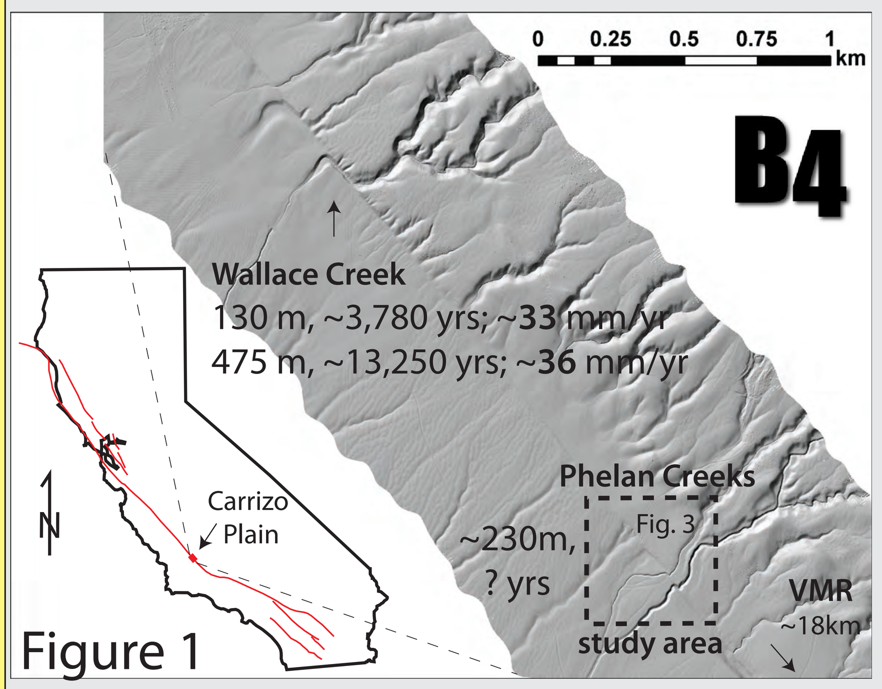

Figure 1

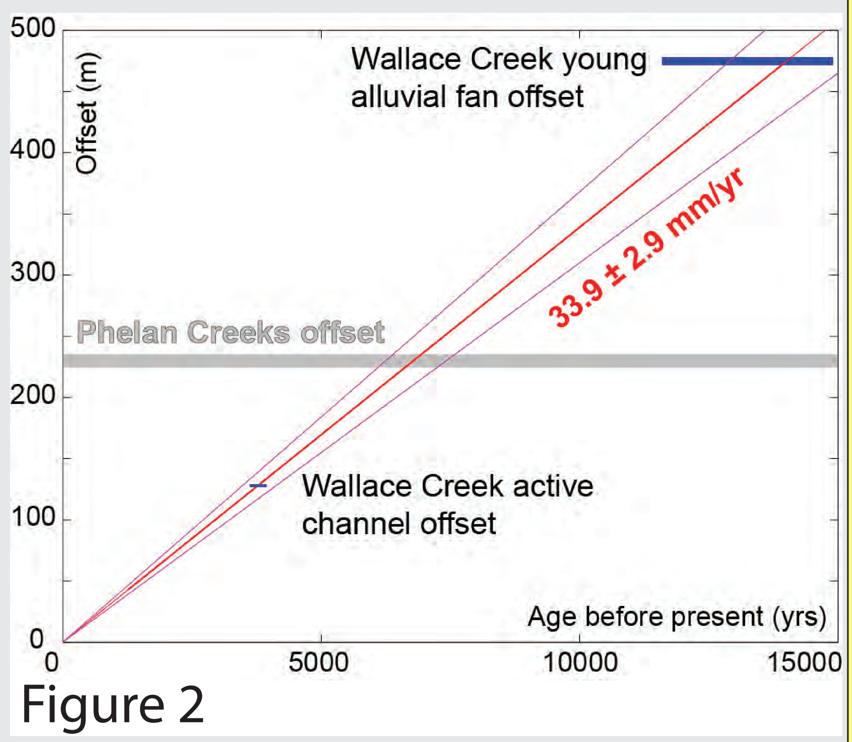

Figure 2

Figure 1

The Phelan Creeks paleoseismic site is located 1.6 km southeast of Wallace Creek along the South-Central San Andreas Fault (SAF). The Carrizo Plain (between Parkfield and the Big Bend) has simple surface geometry and the highest slip rate in California (>3 cm yr-1). This investigation focuses on Little and Big Phelan Creeks: the largest in a series of offset and beheaded channels. Three sets of fault displaced channels record progressive incision, offset and abandonment along the San Andreas Fault in offsets of ~16.5, ~125, and ~230 m. Hillshade generated using B4 LiDAR data, dashed black box shows location of Figure 3. VMR – Van Matre Ranch.

RESEARCH QUESTION (Figure 2)

Is the SAF slip rate in the Carrizo Plain steady over the millennial time scale? The targeted offset of ~230 m at Phelan Creeks fills the spatio-temporal gap in a pair of age-offset constraints at Wallace Creek. The offset pair (shown as horizontal blue bars) and the inferred 3,700 year slip rate (shown as red line) (3.39 +/- 2.9 cm yr-1, Sieh and Jahns, 1984) shown above. The Phelan Creeks paleoseismic site was investigated extensively in the early 1990's (Sims et al., *unpublished manuscript*) but the history of the ~230 m offset was never fully explored.

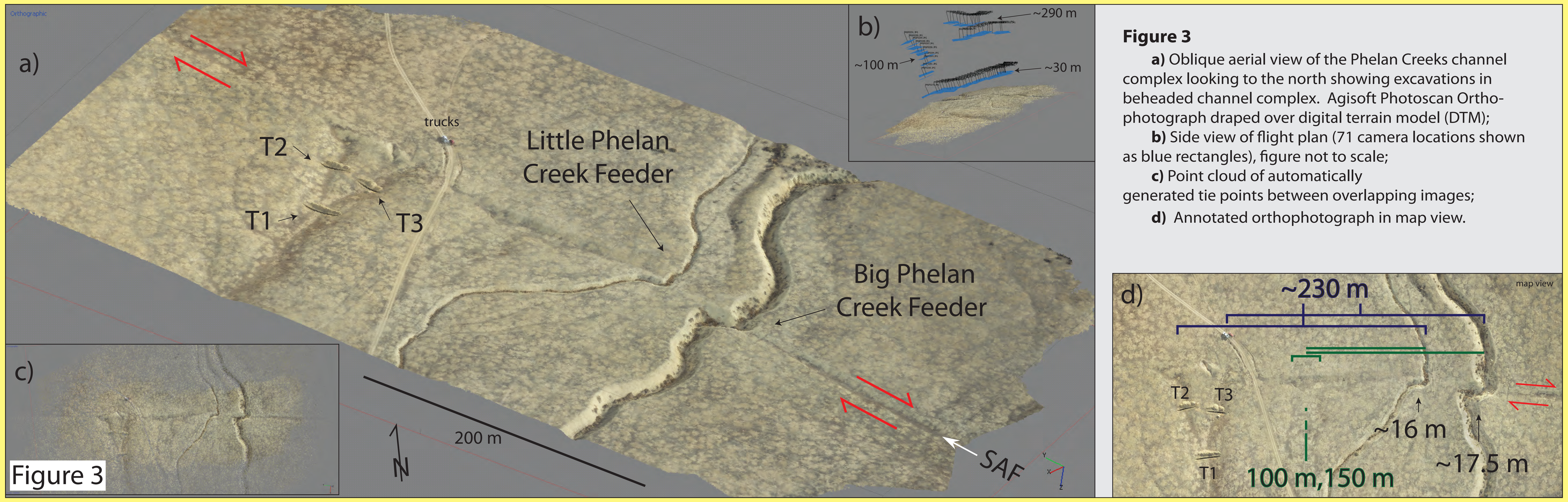

Figure 3

a) Oblique aerial view of the Phelan Creeks channel complex looking to the north showing excavations in beheaded channel complex. Agisoft Photoscan Orthophotograph draped over digital terrain model (DTM);
b) Side view of flight plan (71 camera locations shown as blue rectangles), figure not to scale;
c) Point cloud of automatically generated tie points between overlapping images;
d) Annotated orthophotograph in map view.

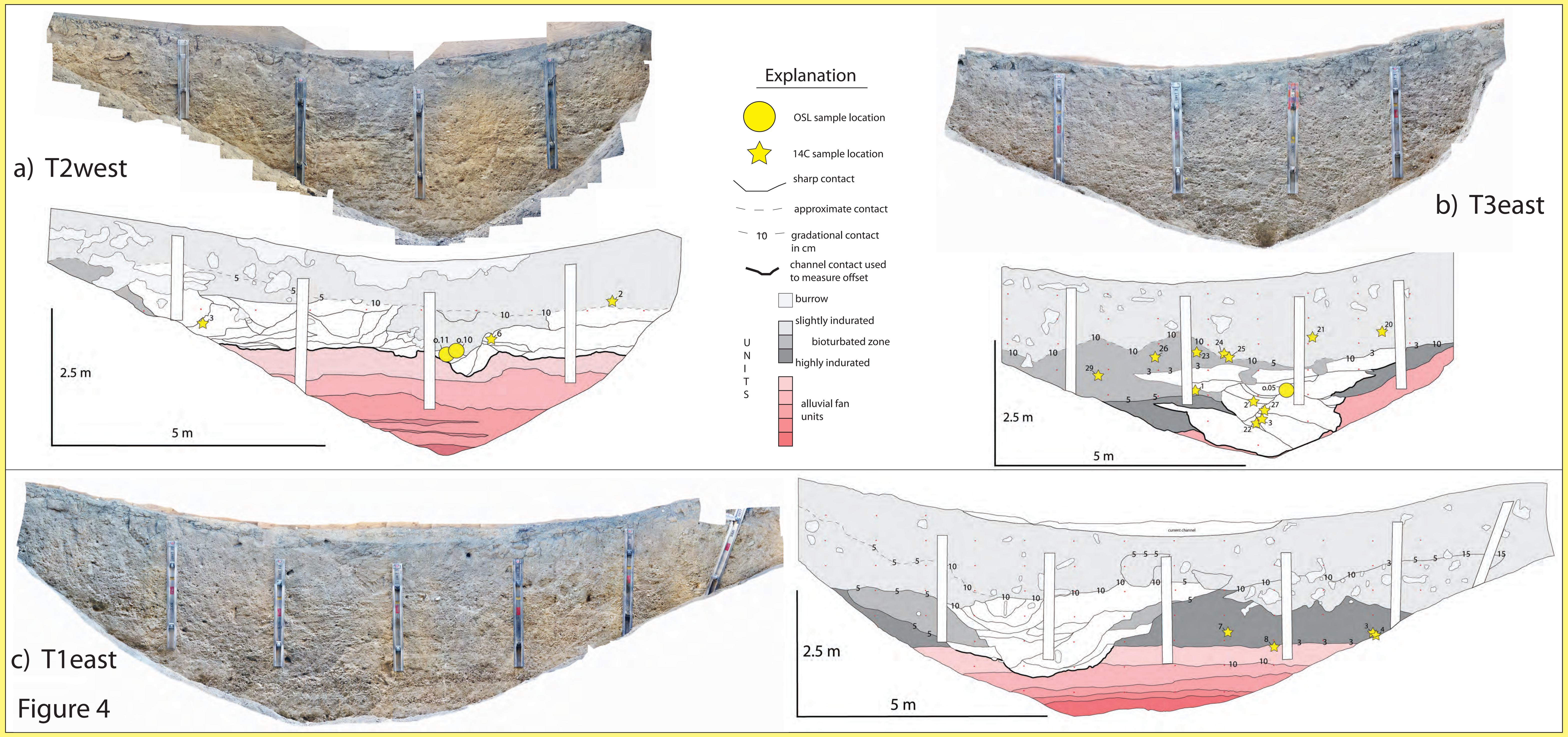

Figure 4

Select walls from each of three excavations. Pairs show Agisoft trench mosaics and intrepreted field logs: a) Trench 2 west; b) Trench 3 east; and c) Trench 1 east. Note that the bold channel contacts are those used to measure total offset from Little and Big Phelan Creek feeders. Sample locations shown.

III) Methods: Paleoseismic Excavation and Structure From Motion (SfM) topography

Three fault parallel trenches were opened across the abandoned channel pair: one in the downstream equivalent of Little Phelan creek feeder (Figure 4a), one in the downstream equivalent of Big Phelan creek feeder (Figure 4b), and one ~12m downstream of the confluence of the two beheaded channels (Figure 4c). Once opened and cleaned (and sampled for 14C and OSL), trench walls were photographed with ~40% sidelap and endlap using a 14 megapixel digital Pentax. We use Agisoft Photoscan to build continuous mosaics of the trench wall stratigraphy that were printed at 1:20 (for complete trench overview) and 1:10 (for channel cut/fill sequences) for logging (Figure 4). The software's algorithm identifies points common to neighboring photographs and determines relative camera positions using parallax, which is the difference in apparent position of an object viewed along two different lines of sight. This method is not only useful for high-quality photomosaics, but it can also be used to generate high-resolution orthophotoraphs. We use a balloon photography system (photos taken on a downward pointing picavet system at 10 sec intervals from elevations of ~30, ~100 and ~290 meters) to photograph the Phelan Creek site (max ~0.25 km^2) and generate a sub-decimeter digital terrain model (a TIN) and corresponding orthophotograph (Figure 3).

IV) Discussion

Key questions regarding the overall behavior of the SAF that can be addressed at Phelan Creeks:

- Does the simplicity of the SAF geometry between Parkfield and the Big Bend promote a long-term slip rate that is constant and not sensitive to along-fault rate fluctuations and interactions with nearby structures?
- We expect that the 14C and OSL samples bracketing the basal incision surface to provide age control for the ~230 m offset. Does the time-constrained ~230 m offset support the hypothesis that slip is constant at the millennial scale for the south-central SAF in the Carrizo Plain?

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