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Paleoseismologic Studies along the Eastern California ShearZone

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Variations of fault slip per event on the Carrizo Segment, San Andreas fault: Is the repetition of fault slip characteristic through time?

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A tenet in probabilistic earthquake forecasts is the assumption that large earthquakes occur by repeating characteristic slip along a fault [Working Group on California Earthquake Probabilities, 1988; Working Group on California Earthquake Probabilities, 1995]. The presumption that we can model source recurrence as regular progression of repeatable earthquakes began with H. F. Reid's formulation of elastic rebound theory [1910]. The basis for such an understanding is intuitive, where seismicity on a fault is represented by repeating slip patterns that reflect along strike differences in fault friction [e.g. Stuart, 1986; Rundle, 1988, and Ward, 1993]. The underlying assumption is that earthquake recurrence intervals are controlled by relatively uniform stress buildup and complete strain release. If, on the other hand, strain release rates are irregular, models of source recurrence and calculations of earthquake probabilities will need to be modified.

The southern Wallace Creek site on the San Andreas fault provides an excellent opportunity for testing uniform or non-uniform slip models in the middle of a geometrically simple fault segment (Figure 1). The excavations are located at the Carrizo section of the San Andreas fault, 300 meters southeast of the famous Wallace Creek (Figure 1b). It is in this region that we have recently documented small offset gullies and alluvial fans that are not disturbed by post-1857 bioturbation. Here, an ephemeral stream channel cuts across the San Andreas fault (Figure 1c). During an earthquake, the channel is dextrally offset and abandoned. During periods of fault dormancy, a new straight channel forms and is offset by subsequent earthquakes. Fault parallel three-dimensional excavations across the downstream offset channels at the Carrizo plain are completed (Figure 2).

Evidence for prehistoric earthquakes in upstream trench wall exposures comes from nested alluvial channels and ponded alluvial deposits. Upstream trench wall exposures reveal very-fine grained laminated silty alluvium, that most likely represent suspended load deposits within each nested alluvial channel. A thin organic layer is commonly stratigraphically exposed above the silty alluvium. We interpret the fine-grained alluvium as representing ponded alluvium, that formed upstream from a small shutter ridge or uphill-facing fault scarp. The capping organic material probably represents organic material (e.g. grasses, etc.) that settled out of the water column. The presence of a thin organic layer that immediately overlies the fine-grained alluvium and burn layers will allow us to precisely date past earthquakes using radiocarbon techniques. IRSL techniques will be used to constrain the ages of the very-fined grained laminated siltly alluvium. On the downstream side, the beheaded channels spread out and are not extensively bioturbated. Because of the excellent trench wall exposures in the upstream and downstream excavations, we can determine precise offset along the older offset gullies, farther northwest from source channels. By matching the corresponding channels on both sides of the fault, we can precisely determine slip-per-event at centimeters accuracy (Figure 2). Our preliminary results show that the offset for the last 3 prehistoric earthquakes are about 8m per event; for the prior two prehistoric earthquakes, about 4 – 5m per event (Figure 3 and 4). One of the most intriguing results from the three-dimensional restorations are the variations of vertical sense of slip-per-event through several earthquake cycles. For the most recent three events, vertical offset was NE side-up. In contrast, during the last three events, vertical offset was SW side-up (Figure 4). Perhaps temporal changes of source parameters or fault interaction between the reverse faults of the Temblor Range and San Andreas fault explain such vertical variations.

The paleoseismic study is in collaboration with Jing Lui, Yann Klinger and Kerry Sieh and will form the basis for Jing Lui's Ph.D. dissertation at Caltech.

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Hydraulic Trench Shoring for Paleoseismic Studies in Southern California

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Twenty one hydraulic shores with hydraulic pumps, tools, and connectors were purchased from Trench Shoring Corporation in Los Angeles, California. The company has given SCEC a substantial price discount. The shores are stored at Kresge Laboratory, a few miles from the Seismological Laboratory, Caltech and at San Diego State University. Kresge has proved to be an ideal storage facility; it is a secure location and is easily accessible and located close to freeways. Two sheds, one with a new concrete pad are used at the laboratory for storage. The shores have been used in numerous SCEC supported research projects (e.g., Burro Flats and Carrizo plain sites along the San Andreas fault and the Mesquite Lake and Sierra Madre faults).

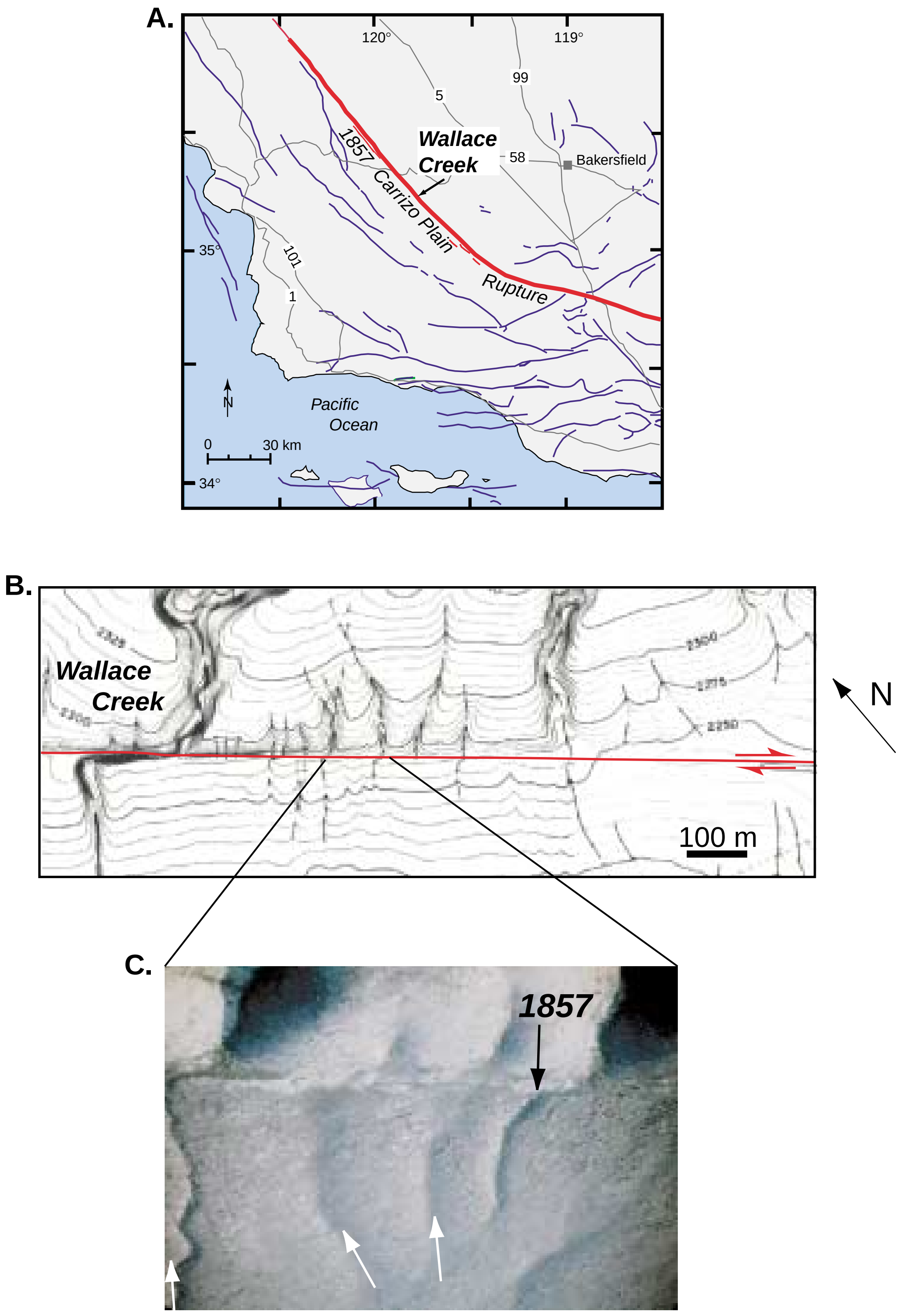
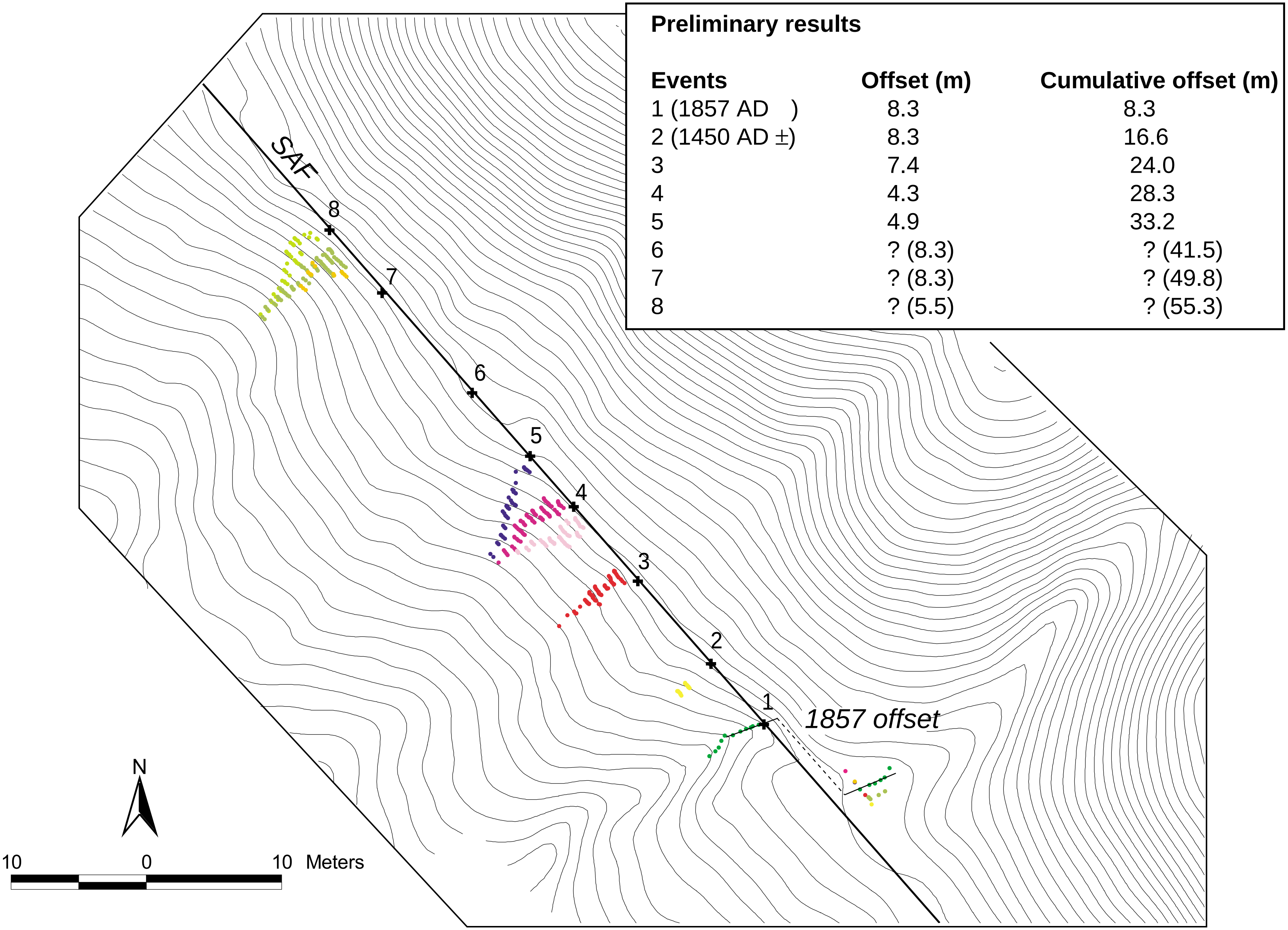


Figure 1. A. Location map of Wallace Creek, along the 1857 rupture of the San Andreas fault. Fault map from Jennings [1975]; B. Topographic map of Wallace Creek and nearby small offset streams; contour interval = 5 feet; C. Oblique aerial photos of small channels and their offset downstream segments



Preliminary results

Events	Offset (m)	Cumulative offset (m)
1 (1857 AD)	8.3	8.3
2 (1450 AD ±)	8.3	16.6
3	7.4	24.0
4	4.3	28.3
5	4.9	33.2
6	? (8.3)	? (41.5)
7	? (8.3)	? (49.8)
8	? (5.5)	? (55.3)

Figure 2. Projection of channel thalweg from trench wall exposures to the surface along the eight offset stream gullies. Same color coding for offset channels used in Figures 3 and 4. SAF, San Andreas fault.

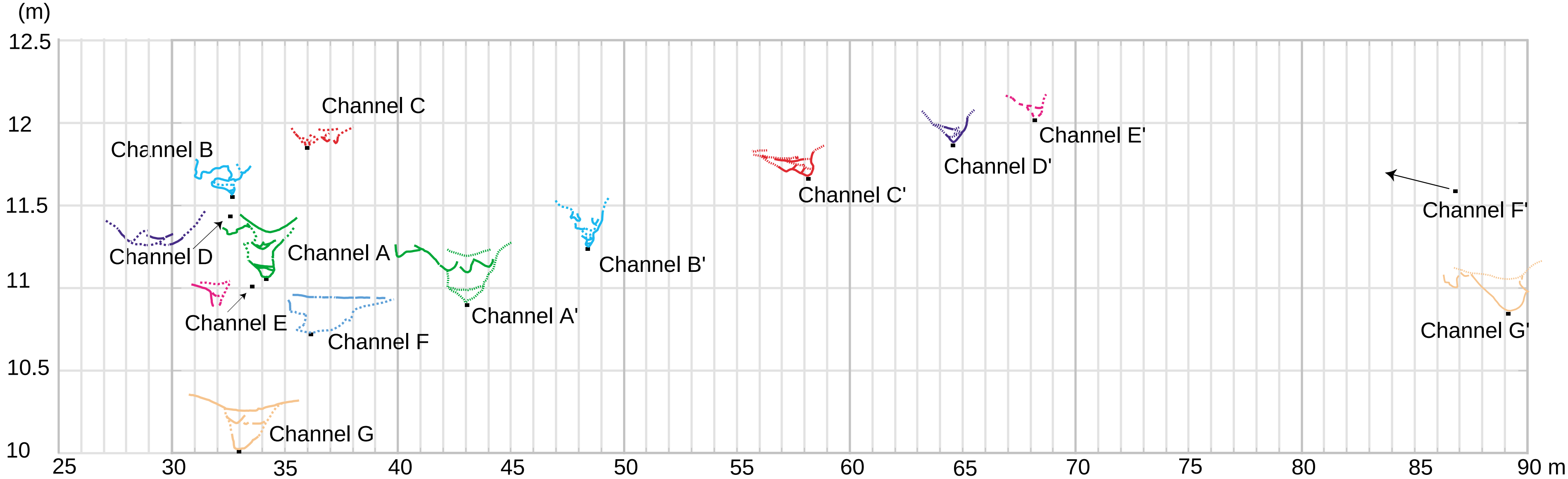


Figure 3. Positions of the offset channels where they intersect the N 40°-41° W trending fault plane. The black dots represent the lowest points of each channel. Paired letters shows the separation of the same channel on two sides of the fault, both horizontal and vertical, in meters.

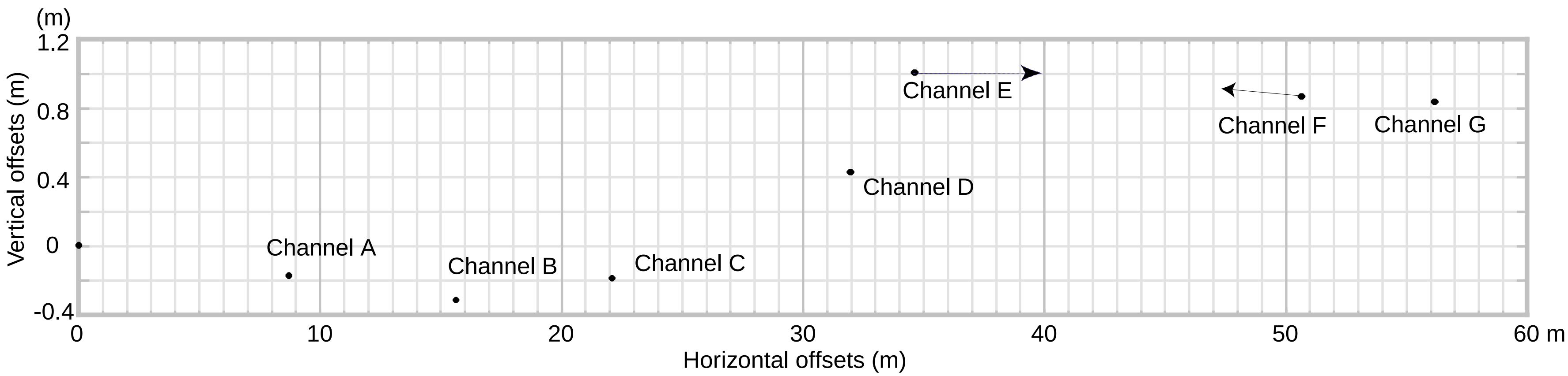


Figure 4. Horizontal and vertical offsets of the seven channels. The offset in individual event is the difference between two neighboring black dots. Positive vertical offset is downstream side up (SW side); negative vertical offset is upstream side up (NE side). Channels E and F offsets are preliminary and may change in the direction shown by the arrows.