Annual Report, 1999

Paleoseismic Study of the San Andreas Fault at Frazier Mountain

Scott Lindvall, William Lettis & Associates, Inc.
Thomas Rockwell and Timothy Dawson, San Diego State University
John Helms and Kristin Weaver, William Lettis & Associates, Inc.

Introduction

We continued in 1999 to develop the Frazier Mountain paleoseismic site located on the NE flank of Frazier Mountain between the towns of Gorman and Frazier Park. The fundamental purpose of this study is to develop an event chronology for the Big Bend reach of the San Andreas fault. By comparing the timing of past large earthquakes at Frazier Mountain with other paleoseismic records NW in the Carrizo plain and SE at Pallet Creek, we can critically test and better develop models of earthquake recurrence, fault segmentation, and behavior on the San Andreas fault.

The Frazier Mountain site is located about halfway between Pallet Creek and the Carrizo Plain (Figure 1). At the site, a minor right step in the San Andreas fault has formed a closed depression, which has been further enhanced by a small alluvial fan that blocks the drainage outflow (Figure 1). A strand of the fault bisects the sag, with other strands bounding the northern margin of the sag. This central strand is expressed at the surface by a 30-cm-high scarp, as a vegetation lineament, and a ground water barrier (Figure 1). We believe that the central scarp formed during the 1857 Fort Tejon earthquake.

Site History

In 1997, our initial exploratory trench exposed a 2.5 m section of *unsaturated*, well-stratified distal fan and pond deposits. This trench was located at the western end of the dry pond, in order to expose sand deposits of the alluvial fan interfingered with silt and clay pond deposits.

Following the 1997-1998 El Nino winter season, the closed depression was inundated with up to 1.2 m of standing water even as late as June 1998. The resulting pond and saturated ground conditions prevented our opening fault trenches last year, and therefore, our 1998 effort concentrated on (1) de-watering activities, (2) site mapping, (3) radiocarbon dating, and (4) interpretation and analysis of our 1997 exploratory trench. De-watering operations consisted of building a 2-inch diameter siphon to passively remove the surface water, as well as actively removing the water using a gasoline-powered pump. While we were successful at removing the surface water, we could not remove the groundwater and were unable to re-open and extend our original trench as we had planned that year.

In the first half of 1999, we were successful in de-watering the site and actually lowering the groundwater level ~1 m by removing water from a sump trench with a smaller diameter siphon. In September 1999, we extended the 1997 trench southward for an additional 35 m (Figures 1 and 2). By re-opening the southernmost end of the 1997 trench, we were able to accurately tie into the old string grid and vertical and horizontal stationing. This allowed us to extend the same radiometrically-dated stratigraphic section and event horizon across the entire length of trench, which now totals almost 50 m in length. The new section of trench across the northern half of the closed depression exposed the main strand of the fault that bisects the central portion of the pond and forms a small subtle scarp (Figure 2).

Results

Our 1997 exploratory trench exposed a. 2.5 m section of well stratified distal fan and pond deposits interrupted by two discontinuous, weakly developed buried A horizons. Two fault strands cut up section to the same paleosurface, located approximately 1.3 m below the present ground surface. Six radiocarbon samples from units above, below, and within the event horizon share similar dates, with calendar ages between 1450 and 1650 A.D. (2 σ), thus the secondary faults appear to have ruptured during this interval.

The new trench exposure revealed evidence of a more recent event, which we interpret to be the 1857 Fort Tejon earthquake. This event horizon, located ~50 cm below the ground surface, is evidenced by upward die out of the central fault in the middle of the pond as well as two small sand blows (Figure 2). Within the composite trench exposures, the only two events recognized are the A.D. ~1550 (1450-1650) and 1857 earthquakes. We can trace continuous, unfaulted units both above and below the A.D. ~ 1550 event horizon between the two zones of faulting in the trench, and therefore, we do not observe evidence of an event between the 1857 event horizon and the approximately 1450-1650 event horizon. We believe that the A.D. 1812 earthquake probably did not rupture as far north as the Big Bend region (Figure 3). This is consistent with a Jeffrey pine at Mil Potrero which shows no disturbance of tree rings around A. D. 1812 but were disturbed as a result of the 1857 earthquake (Jacoby, 1988).

Based on the radiocarbon dates obtained in our study, the penultimate event at the Frazier Mountain site may correlate with a similar aged event at the Bidart site in the Carrizo Plain to the north, as well as event V at the Pallet Creek site to the south (Sieh et al., 1989). Grant and Sieh (1994) dated the penultimate event at Bidart to have most likely occurred between 1405-1510 AD, which is still consistent within our error limits. These new data support the idea that the San Andreas fault may have failed in prior 1857-type earthquakes.

However, event dating at Frazier Mountain remains problematic since the penultimate event falls within a period of carbon-14 calibration curve with multiple intercepts. Given the uncertainties in radiocarbon dating, it is possible that the penultimate event observed at Frazier Mountain may be related to event V at Pallet Creek or the penultimate event at Bidart, but not both together (Figure 3). This is suggested by Biasi and Weldon (1998) who, using Bayesian statistics for refining layer and event dates, date event V at Pallet Creek to have occurred between 1546-1615 AD. We believe that a combination of additional dates and statistical methods such as those employed by Biasi and Weldon (1998) may help further constrain the ~1550 A.D. event chronology between paleoseismic sites. Although, if the San Andreas fault has failed with adjacent segment ruptures closely spaced in time, similar to the North Anatolian earthquakes in August and November of 1999, then these types of events will be interpreted as one large event in the paleoseismic record.

Our 1999 trenches were still greatly impacted by water. Although we were able to remove all surface water and some of the subsurface water, the water table remained high, about –0.4 m, for the entire fall of 1999. As the temperatures began to cool in the late fall, we noticed a rise in groundwater conditions, presumably a result of the decrease in evapotranspiration as the vegetation became dormant for the winter. We were required to pump the water directly our of the trenches while working in them, but even so, could not excavate trench deeper than 2 m due to safety considerations. Consequently, we did not attempt to excavate deeply in the main fault zone, where we expect future studies in dryer years to yield a longer record of earthquakes. We also did not extend the trenches across the entire length of the sag because of there were an insufficient number of SCEC-owned shores. We chose not to attempt another year of SCEC research at this sight at this time because we are uncertain that the water issues will be any better next year. We installed three wells to monitor the water level (Figure 1), and if we observe a marked drop after the expected dry year of 1999/2000, we may consider another phase of work in the final year of SCEC.

Other 1999 Activities

This year, we also completed the Landers paper (Rockwell et. al, 2000 in press) and have nearly completed a manuscript for the Hollywood fault.

References

Biasi, G., and Weldon, R.J., 1998, Paleoseismic date refinement and implications for seismic hazard estimation: in Sowers, J.M., Noller, J.S., and Lettis, W.R. (eds.), Dating and Earthquakes: Review of Quaternary Geochronology and its application to Paleoseismology, p. 3-61 - 3-66.

Grant, L.B., and Sieh, K., 1994, Paleoseismic evidence of clustered earthquakes on the San Andreas fault in Carrizo Plain, California: Journal of Geophysical Research, v. 99, p. 6819-6841.

Sieh, K.E., Stuiver, M., and Brillinger, D., 1989, A more precise chronology of earthquakes produced by the San Andreas fault in southern California: Journal of Geophysical Research, v. 94, p. 603-623.

Publications

Rockwell, T. K., Lindvall, S., Herzberg, M., Murbach, D., Dawson, T., Berger, G., Huntley, D., 2000 in press, Paleoseismology of the Johnson Valley, Kickapoo, and Homestead Valley faults of the Eastern California Shear Zone, Bulletin of the Seismological Society of America.

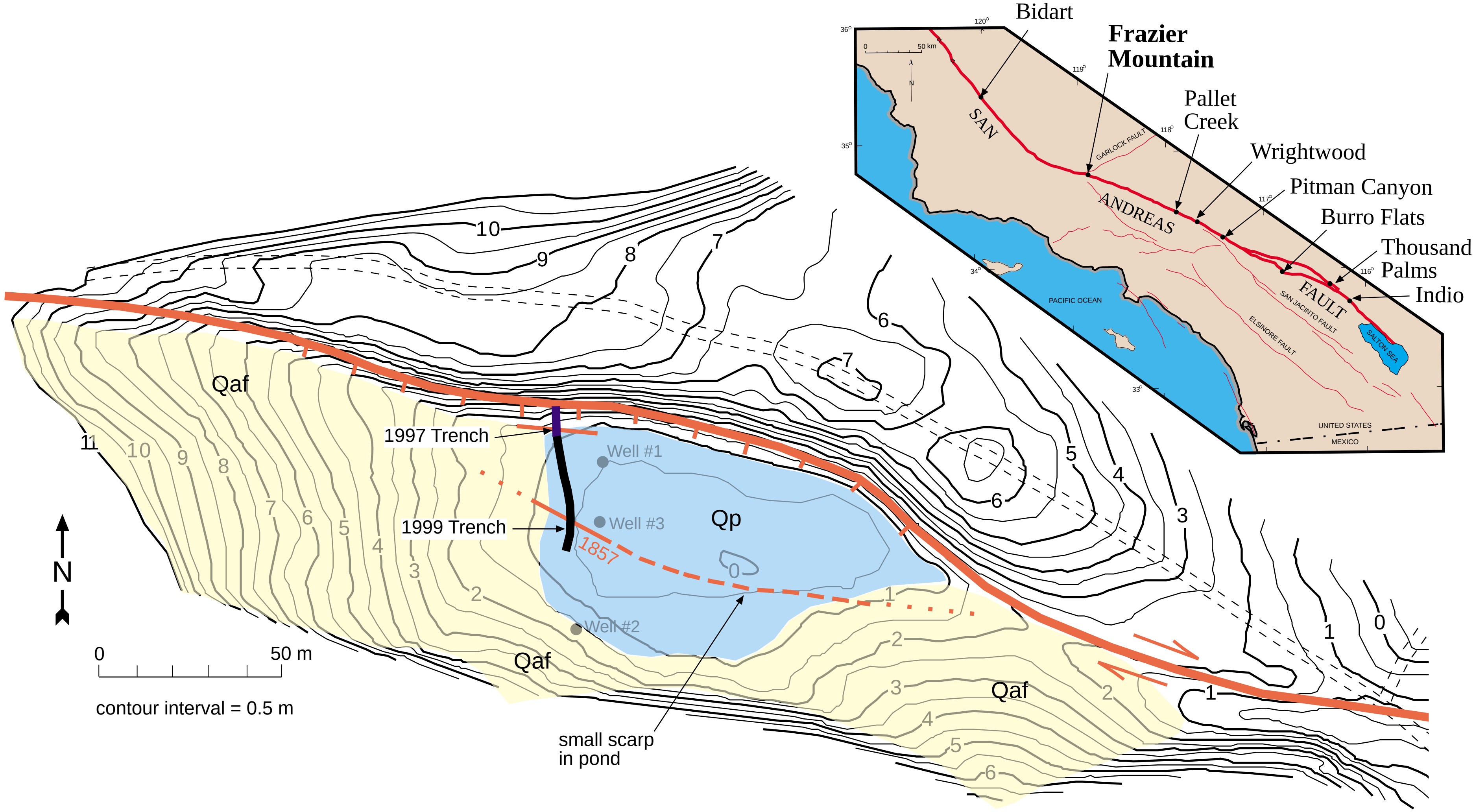

Figure 1. Map of the Frazier Mountain site showing faults, trenches and distribution of young alluvial fan (Qaf) and pond (Qp) deposits.

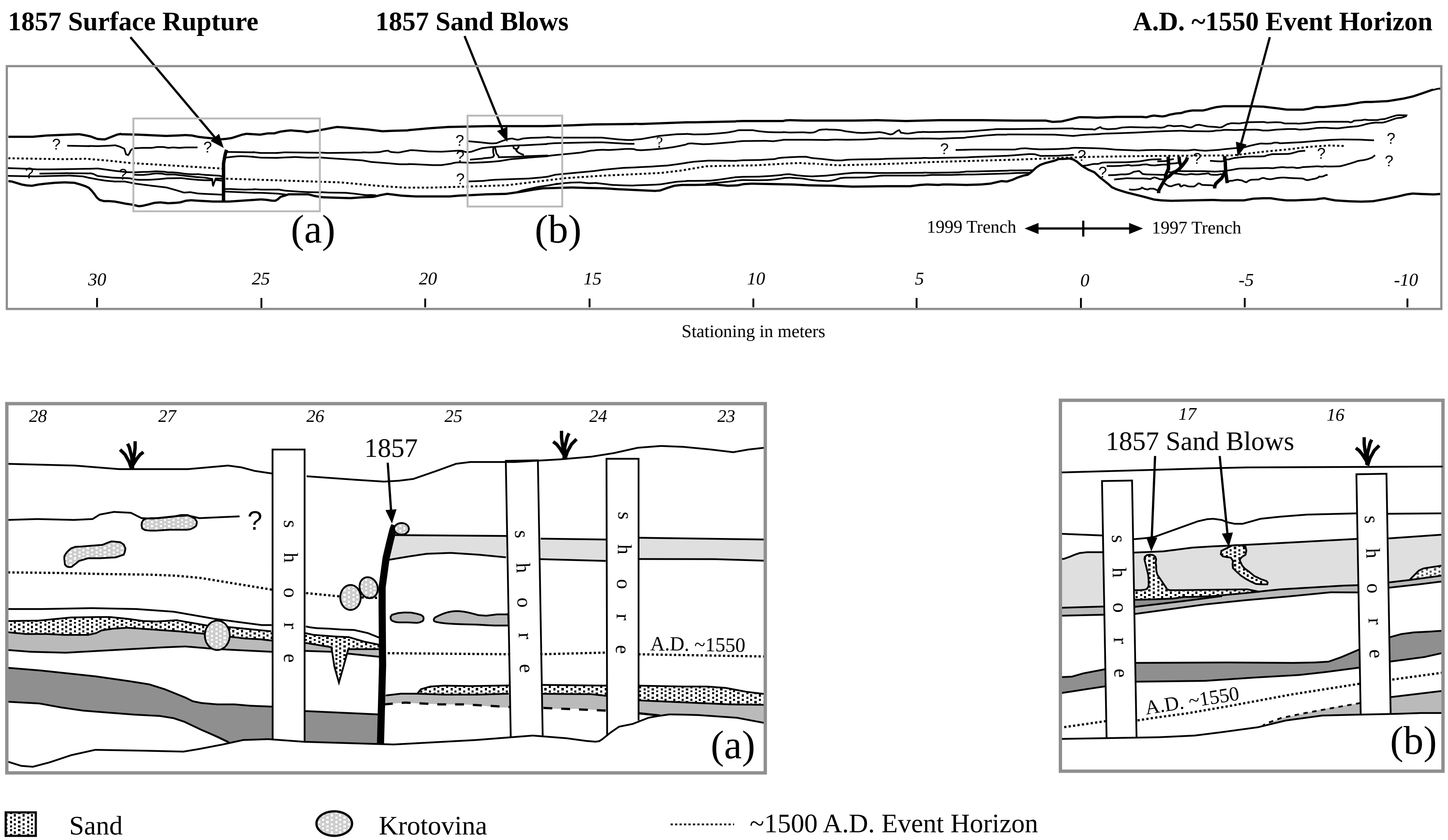

Figure 2. Composite trench log of the 1997 and 1999 trenches at the Frazier Mountain site. Details (**a**) and (**b**) illustrate evidence for the most recent surface rupture. A single fault cuts to within 50 cm of the present ground surface in detail (**a**) and displaces the A.D. ~1550 event horizon (dotted) documented in the 1997 trench. Detail (**b**) shows two sand blows that reach to the same event horizon as the fault in (**a**). Based on stratigraphic position and radiocarbon dates, we interpret these features to represent the 1857 surface rupture. In these exposures, no evidence was found for ruptures occurring between A.D. ~1550 and 1857.

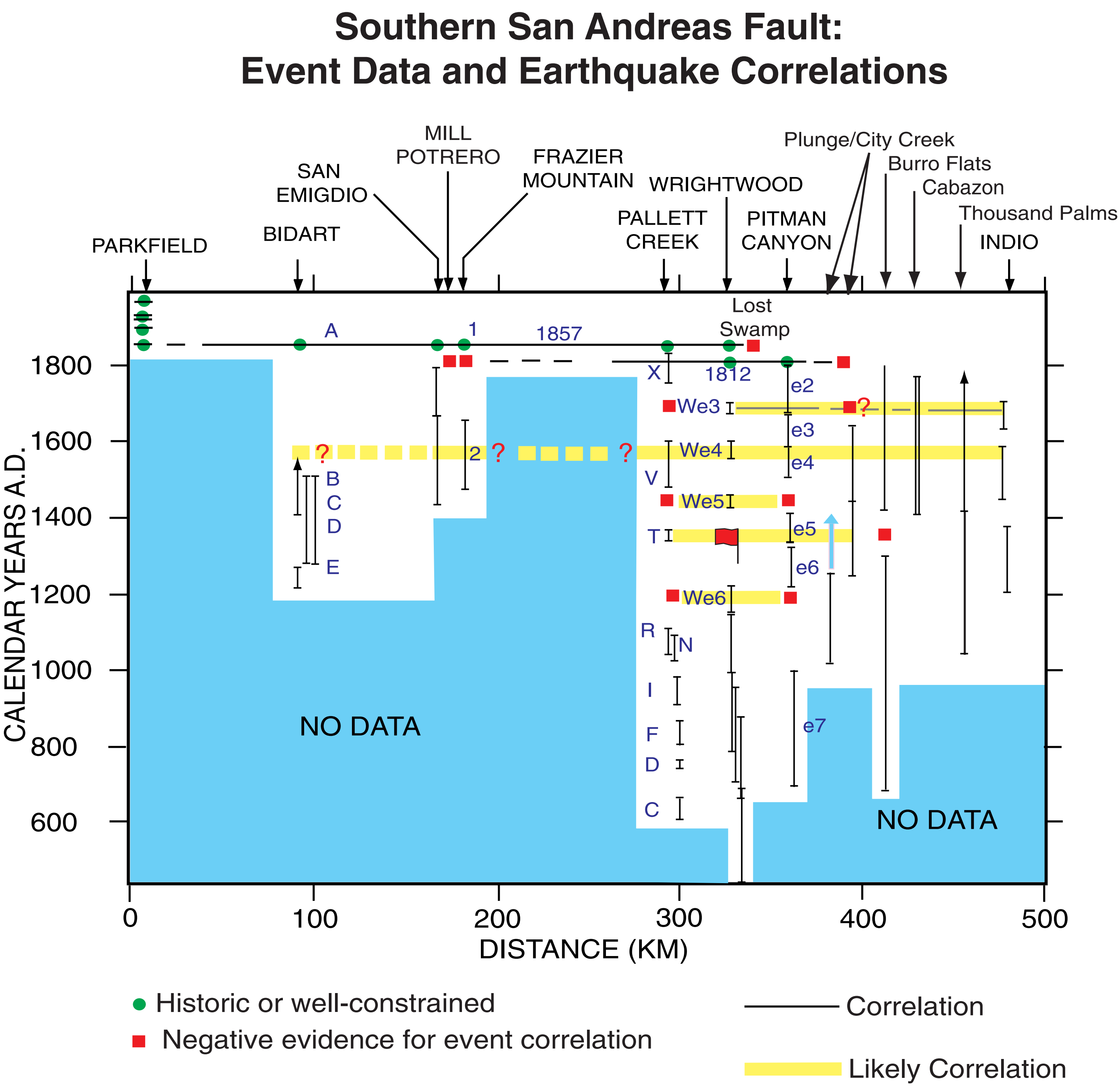

Figure 3. Event data and earthquake correlations along the southern San Andreas fault zone.