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Paleoseismic Studies of the San Andreas Fault in the San Bernardino Area

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My students and I have continued to work at the Plunge Creek paleoseismic site on the San Andreas fault, near San Bernardino (figure 1). In 1999 we deepened trench 8 from 2.8 to 4.0 meters. Safaa Dergham, a master's degree student at CSU Long Beach has been working on trench 8 for her master's thesis. The deepening of trench 8 has revealed important results that confirm previous results from Trench 7. In trench 7, the most recent earthquake horizon that was exposed in the trench is dated between A.D. 1440 and 1640, on the basis of radiocarbon dates on detrital charcoal (McGill and others, 1998). However, in trench 7 there was a possibility that a younger earthquake could have ruptured higher in the stratigraphic section, if that rupture was confined to a 1-m-wide zone in which there was no well-defined stratigraphy in the trench.

For this reason, we excavated trench 8 in an attempt to find well-defined stratigraphy that spans the entire width of the fault zone (Figure 2a). Trench 8 was excavated to a depth of about 2.8 meters in 1998, and was deepened to about 4.0 meters in 1999. Fault strands are only visible in the deepest tier of trench 8 (2.8 to 4.0 m beneath the surface). A calibrated radiocarbon date on detrital charcoal from the faulted sediments indicates that the most recent earthquake on this part of the San Andreas fault occurred sometime after a date within the range A.D. 1411-1621(2-sigma). Some of the fault strands are capped by unfaulted stratigraphy in the middle tier of the trench (1.4 to 2.8 m beneath the surface). One of these strata has been dated as A.D. 1452-1636 (calibrated, 2-sigma). The middle tier is poorly stratified, however, so it is not possible to determine whether all of the fault strands are capped by unbroken sediments of the middle tier, or whether some of the fault strands may have ruptured after the sediments of the middle tier were deposited. Nonetheless, the sediments of the upper tier (0.0 to 1.4 m beneath the surface) are well stratified, and are clearly unfaulted along the entire length of the trench. A calibrated radiocarbon date on detrital charcoal from an unfaulted layer about 1 m beneath the ground surface indicates that the most recent earthquake on this portion of the San Andreas fault occurred prior to a date within the range A.D. 1437-1632 (2-sigma). These dates indicate that the **most recent** earthquake on this portion of the fault occurred between 370 and 560 years ago, which is consistent with our previous results from trench 7.

The most surprising thing about the results from both trench 7 and from trench 8 is that there is no evidence for earthquakes younger than AD 1630 at Plunge Creek. Not only is there no evidence for the AD 1812 earthquake that is known to have ruptured the San Andreas fault in Wrightwood (Jacoby and others, 1988), but there is also no evidence for the event that occurred around AD ~1700 at both Wrightwood and Pitman Canyon (Fumal and others, 1993; Seitz and others, 1997). Wrightwood and Pitman Canyon are about 55 km and 29 km northwest of Plunge Creek, respectively.

If the slip rate on the San Andreas fault near Plunge Creek is comparable to the 25 mm/yr rate measured near the northwestern end of the San Bernardino segment, in Cajon Pass (Weldon and Sieh, 1985) then at least 9.25 m of dextral slip (370 years x 25 mm/yr) may be waiting to be released in the next earthquake on San Bernardino segment of the San Andreas fault.

Alternatively, the slip rate on the San Bernardino segment may be less than 25 mm/yr if more slip is transferred to the San Jacinto fault (or other faults) than was previously thought. I have identified an offset channel wall of Plunge Creek that may useful in measuring the slip rate of this portion of the San Andreas fault (figure 1). The channel wall appears to be offset about 266 m right laterally, as measured from aerial photographs. Reconnaissance field work will be necessary to test the proposed correlation across the fault and to determine if it will be possible to constrain the age of the channel wall to get a slip rate. A small part of my 2000 SCEC proposal will request funds to investigate the feasibility of this and other potential slip rate sites along the San Bernardino segment of the San Andreas fault.

Previous paleoseismic work on the southern San Andreas fault has indicated that the recurrence interval between surface-rupturing earthquakes is between 100-150 years for the northwestern end of the San Bernardino segment (Pitman Canyon site: Seitz and others, 1997), and for the southeastern end of the Mojave segment (Wrightwood: Fumal and others, 1993; Pallett Creek: Sieh and others, 1989). Our results suggest that, at the Plunge Creek site, either the *average* recurrence interval is several times longer than this, or the San Bernardino segment is well overdue for a very large earthquake. Recent paleoseismic work at Burro Flats, about 30 km southeast of Plunge Creek, also indicates a long elapsed time since the most recent event, and the recurrence interval at that site is longer than 100-150 years (Yule and others, 1999; Streig, 1999).

During 1999, I have also been trying to determine the recurrence interval at the Plunge Creek site, to see whether the 370-560 elapsed time since the most recent earthquake is anomalous in the paleoseismic history of this site or whether this is comparable to the average recurrence interval for this site. In an effort to document and date older earthquakes at the Plunge Creek site we excavated a new trench (T4R) on the site of a trench that had been excavated by Stephen C. Suitt in 1991 as part of an Alquist-Priolo study of the property (Suitt, 1992). Whereas trench 8 was located on the edge of a very young alluvial fan in order to capture the most recent event, "trench 4 revisited" (T4R) was located off the edge of the fan on the flood plain of Oak Creek (figure 1), in an attempt to uncover some of the older events without having to dig through 2-3 meters of unfaulted sediment.

In the summer of 1999 trench 4R was excavated to a depth of about 2.5 meters, and was logged by Kelly Schmoker, a SCEC intern and undergraduate geology major at CSU San Bernardino. Another CSUSB undergraduate, Jennifer Townsend, has also assisted with the work in this trench. In October of 1999, we deepened trench 4R to a depth of about 5-6 meters. The new exposure has not yet been logged in detail, due to the urgent need to map the surface rupture of the Hector Mine earthquake. However, a preliminary sketch of the relationships exposed in trench 4R is shown in figure 2b. The southwestern and upper portions of the trench expose well stratified, moderately to moderately well sorted deposits that are rich in granitic detritus. I interpret these as channel deposits from Oak Creek. These channel deposits interfinger with poorly sorted, poorly stratified to unstratified sediments that are rich in gneissic detritus and which dominate the northeastern and lower portions of the trench. I interpret these deposits as colluvium derived from the mountain front. Several faults are visible in the lower half of the trench, but the deposits in the upper half of the trench are clearly unfaulted. So far, no clear evidence for multiple faulting events (*i.e.*, for events older than the most recent event) has been found, but in the process of producing a detailed log of the lower half of the trench we may discover such evidence.

Numerous charcoal samples have been collected from trench 4R, but only one of these has

been dated so far. (Trench 4R was beyond the scope of my 1999 proposal). This sample, from near the base of the trench, has an age of AD 1205-1290 (figure 2b). In addition, two charcoal samples from near the top of the consultant's original trench 4 were dated when I began work at the Plunge Creek site (figure 2b). If the recurrence interval for large earthquakes on the San Andreas fault at Plunge Creek is comparable to the 100-150 year interval documented at Pitman Canyon, Wrightwood and Pallet Creek, then one would expect to see evidence for 4-7 prehistoric earthquakes in trench 4R. Detailed logging of the lower half of trench 4R may reveal some evidence for older events, however, the poorer stratigraphy in the lower half of the trench may prevent us from obtaining a complete record of prehistoric earthquakes in trench 4R, and so I am proposing to dig a new trench this year, at a location where the fault zone may lie completely within the well-stratified channel deposits of Oak Creek (see proposal).

In addition to work at the Plunge Creek site, I have spent 12 days so far helping to map the surface rupture of the 16 October 1999, Hector Mine earthquake and surveying manmade and geomorphic features that were offset by that rupture.

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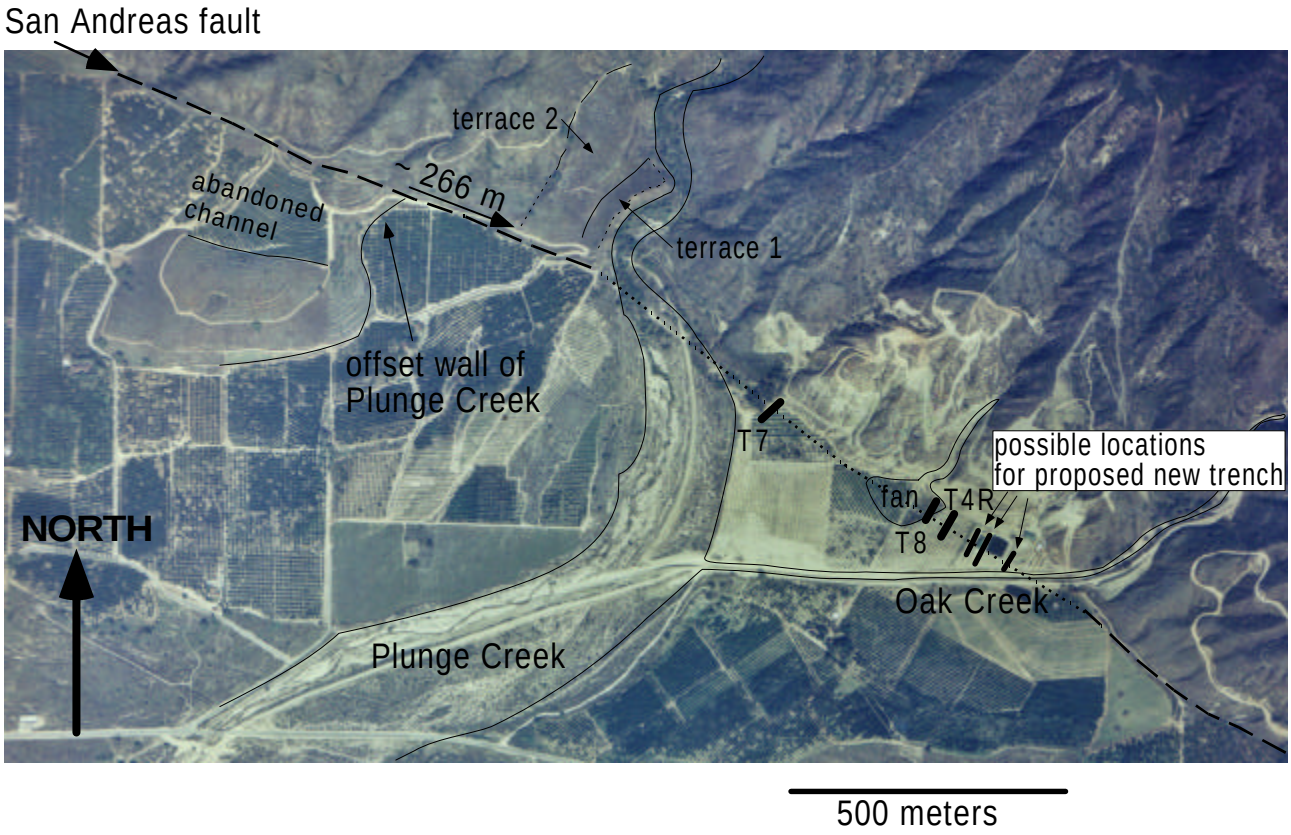

Figure 1: Aerial photograph of the Plunge Creek site showing fault location, trench locations, and selected geomorphic features, including an offset channel wall of Plunge Creek.

South (main) branch, San Andreas fault. Dashed where approximately located, dotted where concealed.

Geologic contact, dashed where approximately located, dotted where projected.

Trench location

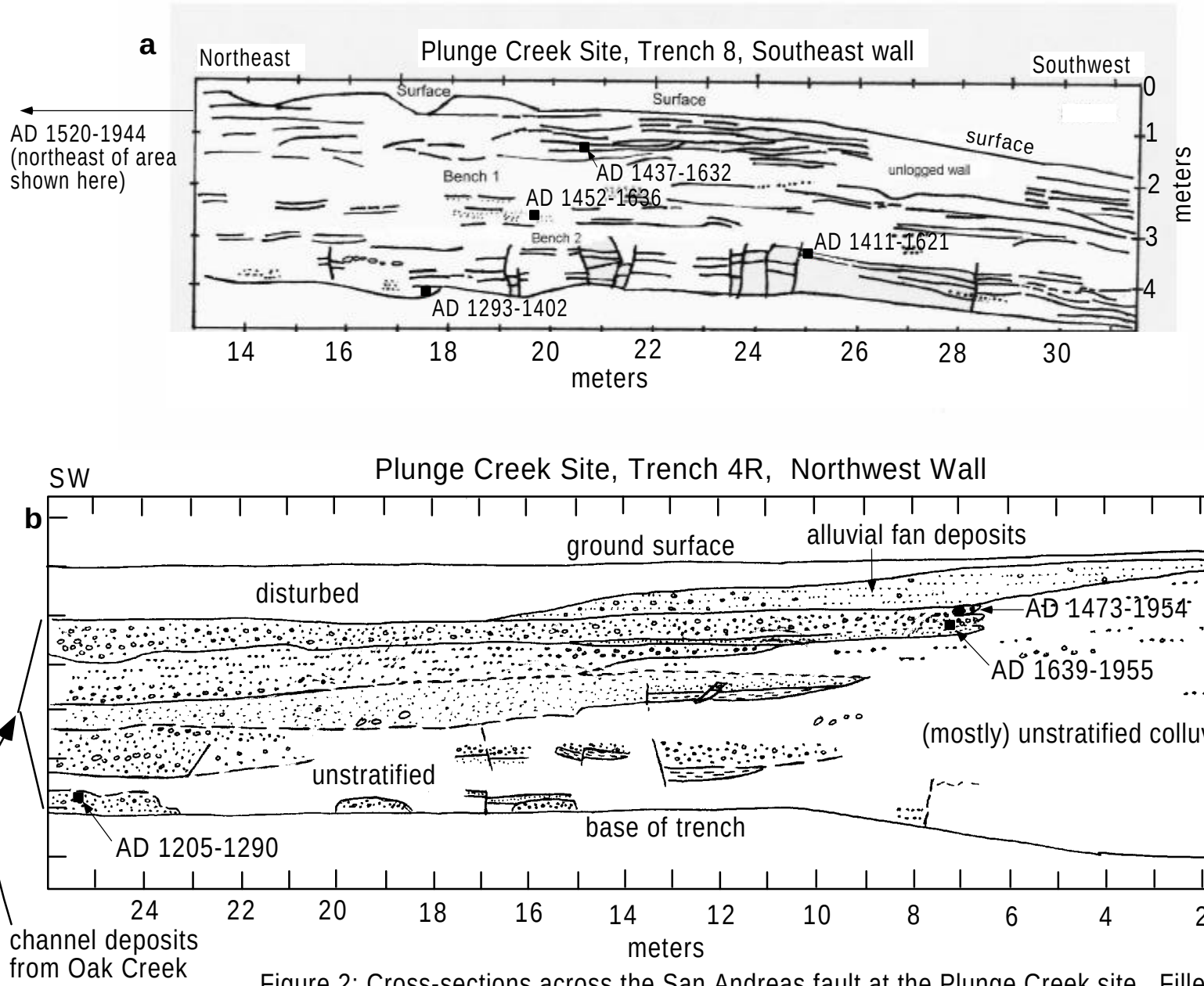

Figure 2: Cross-sections across the San Andreas fault at the Plunge Creek site. Filled squares mark the locations of charcoal samples that have been radiocarbon dated. (a) Log of trench 8; (b) preliminary sketch of trench 4R.