Slip Rate Studies Along The Sierra Madre-Cucamonga Fault System Using Geomorphic And Cosmogenic Surface Exposure Age Constraints: Collaborative Research with Central Washington University and William Lettis & Associates, Inc.

NEHRP External Grant Award Number 03HQGR0047

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Program Element III. Research on earthquake occurrence, physics and effects

Key Words: Paleoseismology, rupture characteristics, trench investigations, Quaternary fault behavior

Investigations Undertaken

This project is designed to provide a reliable slip rate estimate for the Sierra Madre-Cucamonga (SMC) fault system that bounds the southern margin of the San Gabriel Mountains (Figure 1). We proposed to (1) produce digital elevation models using the early 1920's USGS 6 minute topographic map series (5 foot contour intervals), (2) produce detailed maps of fault scarps and Quaternary geomorphic surfaces, (3) determine the age of these surfaces using cosmogenic surface exposure age dating techniques, and (4) calculate uplift rates and slip rates across the SMC fault system in the San Fernando and San Gabriel Valleys.

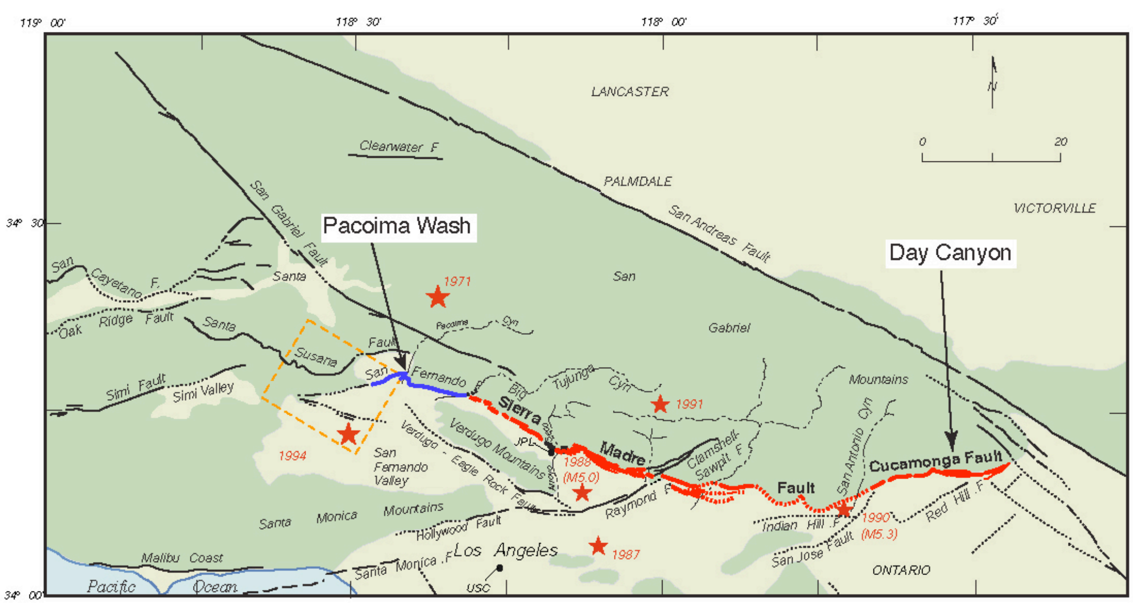

Figure 1. Map of southern California showing location of study areas, major faults and epicenters of selected earthquakes since 1971. The Cucamonga-Sierra Madre fault system (SMC) is shown as red heavy lines; the 1971 surface rupture along the San Fernando fault shown in heavy blue line. The 1994 Northridge earthquake fault patch shown as a orange dashed box. Fault map from Crook et al. (1987) and Jennings, (1994).

Our study included the following specific tasks:
Task 1: Expand earlier tectonic geomorphic analysis and mapping.
Task 2: Sample collection
Task 3: Cosmogenic dating

Task 4: Determine minimum uplift and dip-slip rates across the fault zone
During the past year, we have completed the first round of sampling and cosmogenic dating of surface samples collected from the abandoned geomorphic surfaces along the 1971 San Fernando surface rupture (Figure 2) and along the Cucamonga fault (Figure 4). CWU graduate student, Jake Horner, processed and analyzed Be and Al isotopes at the Center for Accelerator Mass Spectrometry at LLNL from samples collected from alluvial surfaces in the Pacoima Wash area. These samples help constrain fault slip rates along the San Fernando segment of the Sierra Madre fault system. Three quartz-rich cobbles from the active Pacoima Wash yield modern ^{10}Be and ^{26}Al ages, which indicate zero inheritance from the source area. Preliminary analyses of using ^{10}Be and ^{26}Al surface dating methods on alluvial cobbles from the Qt4 Pacoima Wash surface of Lindvall et al. (1995) yield surface exposure ages of 33,240 ±1564 yrs, 31,195 ±1287, and 31,024 ±1073 (Figure 2). This gives a mean surface exposure age 31,820 ± 2292 years. The minimum vertical separation across Qt4 surface includes the 1971 surface rupture and two older scarps that offset Qt2-Qt5 is 27 m ± 1m.

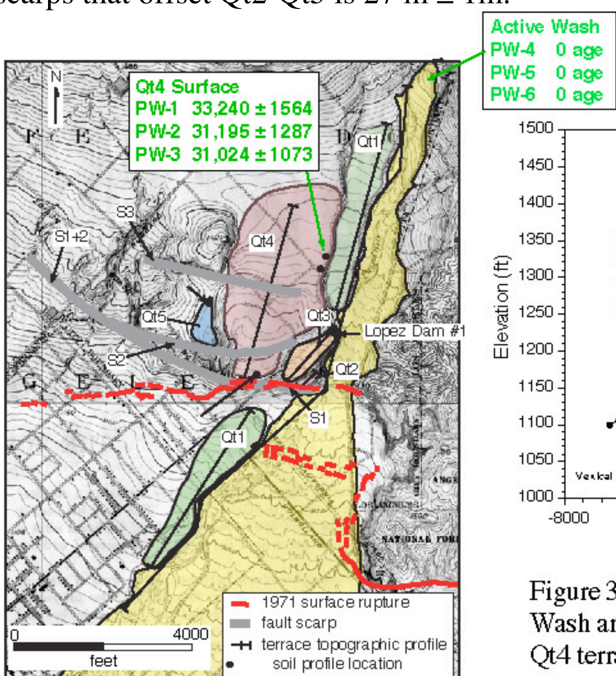

Figure 2. Uplifted alluvial surfaces at Pacoima Wash along the 1971 surface rupture of the San Fernando earthquake. The 1971 rupture and additional fault scarps collectively displace Qt2 - Qt5 alluvial surfaces. Geology modified from Lindvall et al. (1995); topographic base map from the 1924 6 minute USGS quadrangle map series.

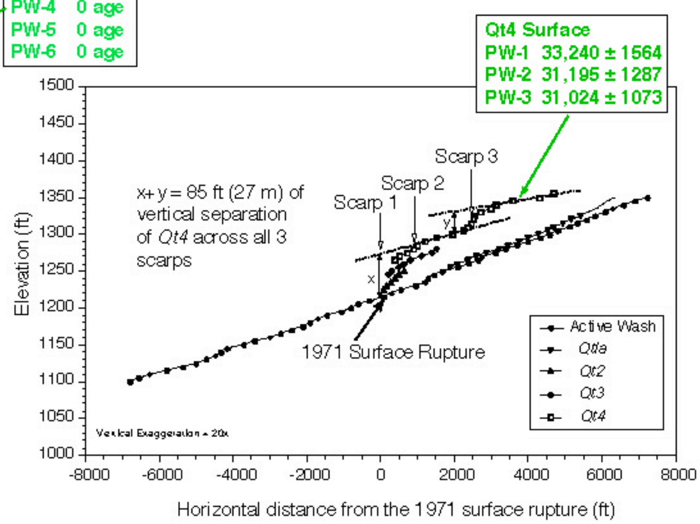

Figure 3. Topographic profiles across the active Pacoima Wash and late Quaternary alluvial surfaces illustrate that the Qt4 terrace surface has been vertically separated a minimum of 27 m across all fault scarps.

This gives a minimum vertical uplift rate of 0.85 +/- .08 mm/yr. Additional sampling by the PI's and Jake Horner (graduate student) will provide additional age control to the Qt4 surface, as well as, other alluvial surfaces near crystalline range front faults.

We have also sampled, processed, and analyzed cobbles from the Day Canyon fan, which is offset by the Cucamonga fault. Preliminary analyses using ^{10}Be and ^{26}Al surface dating methods on alluvial cobbles from the Qyf1 surface (West Fan of Morton and Matti, 1987) yielded ages of 39,738 ± 1054, 35,230 ± 1162, 33,183 ± 1168, 41,331 ± 1082, and 40,910 ± 1218 years. These five samples yield a mean surface exposure age of 38,078 +/- 2,291 mm/yr. To the east, seven quart-rich cobbles from the Qyf1 surface (East Fan of Morton and Matti, 1987) yield cosmogenic surface ages of 27,233 ±883, 26,411 ±906, 28,578 ±958, 23,458 ±956, 22,110 ±760, and 26,242 ±1069 years and yields a mean surface exposure age of 25,672 +/-2,270 mm/yr.

The surface ages for the Qyf1 surface are substantially older than the ~13 ka estimate of Morton and Matti (1987). Additional sampling and cosmogenic dating of quart-rich cobbles from the two Qyf1 surfaces will be performed. We will also complete a detailed topographic survey across the Qyf1 offset surfaces.

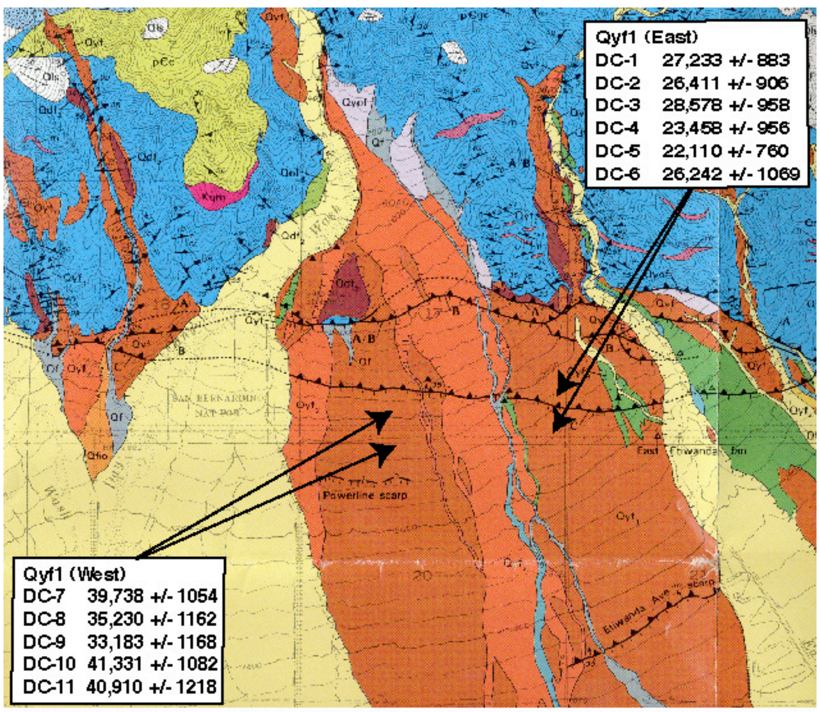

Figure 4. Preliminary ages of faulted Qyf1 surface of Day Canyon Fan. Geologic mapping from Morton and Matti (1987).

During the past year, we began to produce digital elevation models (DEMs) using the early 1920's USGS 6-minute topographic map series (5 foot contour intervals). INTEC Americas Corporation is presently producing 400 dpi 8-bit cropped geo-referenced scans of the following USGS 6-minute topographic maps, (1) 1927 Pacomia (surveyed 1924-1925), (2) 1939 Little Tujunga (surveyed 1933-1934), (3) 1942 Sunland (surveyed 1924-1925 and 1933), and (4) 1935 Sylmar (surveyed in 1925 and 1929). We will transfer our detailed maps of fault scarps and Quaternary geomorphic surfaces from the Pacomia area to these 5 m DEMs.

Non-technical summary

This project is designed to determine slip rates across the Sierra Madre fault system, a key element in forecasting future seismic activity and accurately mapping seismic hazards. These data will help us to better understand how strain is accumulated and released on reverse faults in the greater metropolitan Los Angeles region.

Reports Published

None.