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Defining Holocene activity of the Compton blind-thrust fault, Los Angeles Basin, California

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Compton Fault Results: High-resolution seismic reflection profiles on the back-limb of the axial surface of the Compton Ramp

The Compton thrust fault is a large blind thrust fault that extends northwest-southeast for 40 km beneath the western edge of the Los Angeles basin (figure 1). It was originally identified by Shaw and Suppe (1996), using industry seismic reflection profiles and well data. Despite the fact that this is one of largest and potentially most dangerous faults in metropolitan southern California, the Compton thrust was recently deleted as an earthquake source from the CGS fault database on the basis of earlier SCEC-funded research (Mueller, 1998). This is inexplicable, given that the site examined by Mueller (1998) revealed compelling evidence of young (late Holocene?) folding. In our proposal last year, we suggested that these data indicate that the Compton thrust is active and capable of producing damaging earthquakes. Recognizing that documentation of this major potential seismic hazard should be a high priority for SCEC II, the Center funded us last year to acquire high resolution seismic reflection data as the first step of a 2-stage analysis to define the Holocene activity and earthquake potential of the Compton blind-thrust fault.

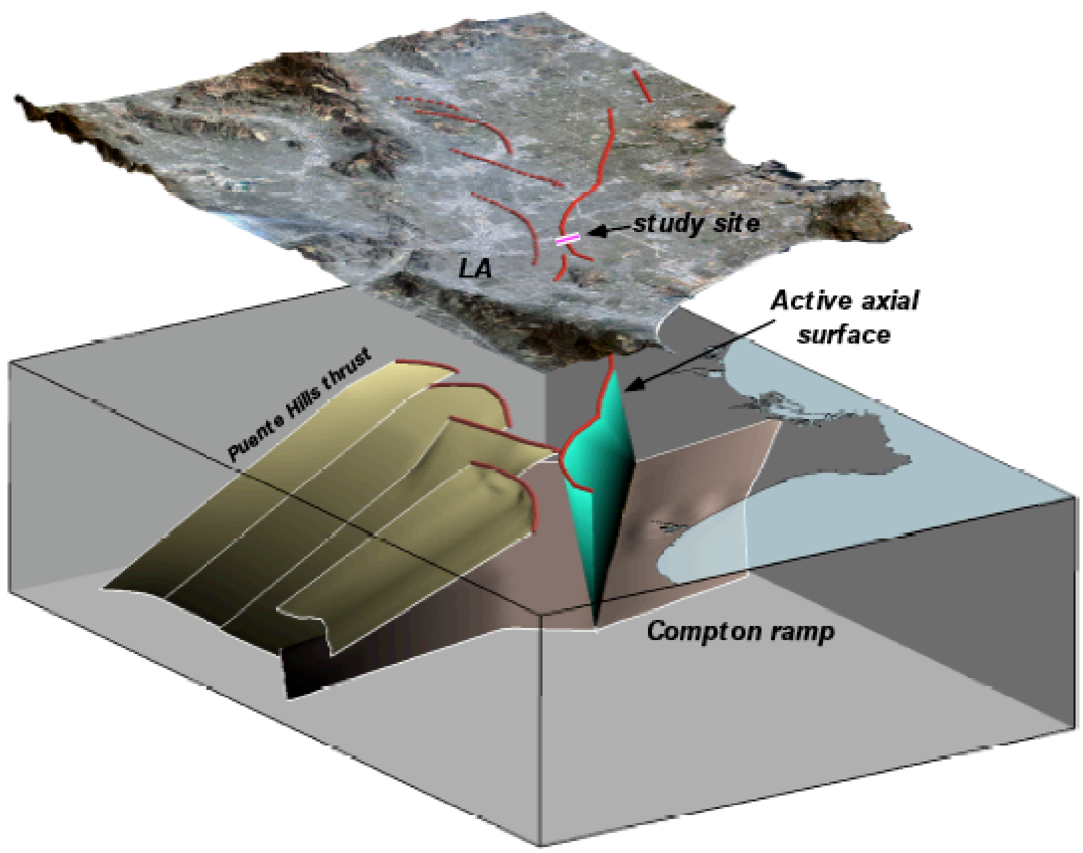

Figure 1. Perspective view of the Compton blind-thrust ramp and major segments of the Puente Hills blind-thrust fault beneath Los Angeles. During June 2005 we acquired high-resolution seismic reflection profiles at our study site along the back-limb active axial surface associated with the base of the Compton thrust ramp. Fault surfaces are provided from the SCEC CFM (version 2.0) (Plesch et al., 2004)

The industry seismic reflection data define a growth fault-bend fold associated with the Compton thrust ramp, which, in combination with well data, reveal compelling evidence for its Pliocene and Pleistocene activity (Shaw and Suppe, 1996). The industry data, however, do not image deformation in the uppermost few hundred meters, the area of most interest for determining the recent seismic history of the fault. In order to bridge this gap, we acquired high resolution seismic reflection profiles on the back limb active axial surface of the fault-bend fold above the Compton thrust ramp (Figure 2).

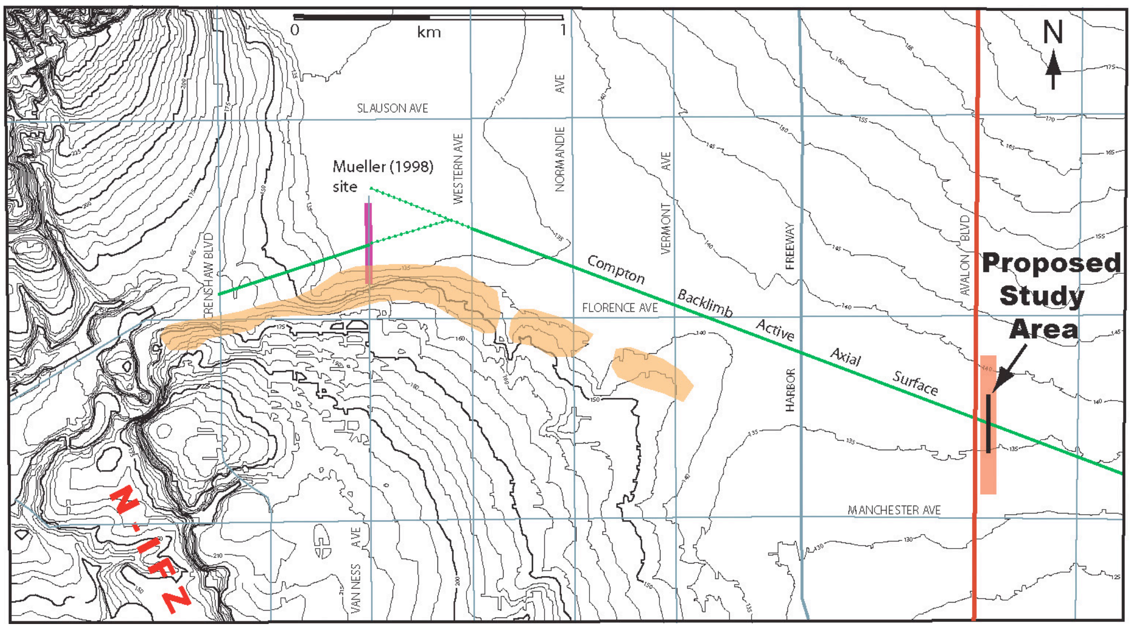

Figure 2. Detailed topographic map showing study area along Stanford Avenue in South-Central Los Angeles. North- to northeast-facing scarp above Compton backlimb axial surface shown by orange shading (note Mueller (1998) study site [purple line]). Wide pink line shows 2005 weight-drop high-resolution profile; black line within pink shows proposed (2006) borehole transect above hammer-seismic profile. Location of Avalon Blvd. industry seismic reflection profile in figure 3 denoted by red line. Thin green lines show the surface projections of the backlimb axial surface based on analysis of petroleum-industry seismic reflection data. Contour interval is 5 feet (1.5 m). Base map redrafted from USGS 7.5-minute Inglewood quadrangle.

Data Acquisition

Our study site is located in South-Central Los Angeles on Stanford Avenue, east of the 110 freeway ~ 6 km south of downtown Los Angeles. Stanford Avenue is parallel to, and approximately 100 m east of the industry profile along Avalon Boulevard (Figure 2). We chose this site for several reasons: (1) the back limb axial surface of the Compton ramp is exceptionally well defined in this area on petroleum industry seismic reflection profiles and with dipmeter data (Figure 3). The bed dips imaged in the industry seismic data dip more than 20°NE, while the axial surface dips ~ 75°SW and extends downward to at least 5 km depth; (2) the site is far removed from deformation associated with the Newport-

Inglewood fault zone (Figure 2); and (3) the site is located in a previously marshy, mixed floodplain-alluvial site that should yield well-bedded, fine-grained sediments; excavations observed over the past several years in the area south of USC confirm the presence of well-bedded, fine-grained sediments in this area.

We acquired two profiles along Stanford Avenue at different frequencies. We used a truck-mounted, weight-drop source together with a 60-channel seismic system to delineate the axial surfaces of the fold from ~ 50 m downward to ~600 m to overlap with the upper part of the industry reflection data (middle image on figure 3). This 1.15-km-long seismic reflection profile extends from the intersection of Manchester Avenue and Stanford Street to just south of 76th Street. We also acquired a ~740-m-long, higher-resolution sledgehammer seismic reflection profile along Stanford Avenue in order to image the 10 to100 m depth range (upper image on figure 3). This higher-resolution profile overlaps with the central portion of the weight-drop profile, extending from 84th to 78th Street (Figure 2).

The weight-drop source was a Geometrics power-assisted, 45.4 kg (100 lb) source mounted on a half-ton flat bed truck. We recorded ~2000 sec of data (~1000 impacts), summing four impacts at each source-point (5 m spacing) along this flat, straight road. For the hammer profile, we used a 4.5 kg (10 lb) sledgehammer and summed four impacts at and between each recording station (1 m spacing), to suppress the substantial electrical and traffic noise. During acquisition of the sledgehammer profile, each impact was manually triggered due to equipment problems. Routine data processing for seismic reflection profiles (Yilmaz, 1987) included residual static's corrections, pre- and post-stack deconvolution, eigenvector filter, Stolt time migration, and time-to-depth conversion. The signal-to-noise ratio was increased by stacking adjacent traces.

Collectively, the high-resolution and industry seismic reflection profiles (Figure 3) provide a complete image of folding above the Compton ramp from <20 m to > 5 km depth (Figure 3). This folding is manifested by an upward-narrowing kink band that exhibits an upward decrease in bedding dip, from ~30° at 1 km depth, to ~12° at 150 m, to only a few degrees in the upper 50 m. Specifically, the weight-drop profile (Figure 1; middle image) reveals evidence for folding in the 100-250-m depth range, above the shallowest reflectors revealed in the industry profile. Prominent on the weight-drop profile is a well-defined reflector at 100 m depth on the southern part of the profile. This reflector is flat from the south end of the profile to ~ meter 400. In contrast, between meter 360 and meter ~680, the reflector dips 12° NE. It is flat-lying from meter 680 to the north end of the profile at meter 1200. This fold occurs directly above the axial surface imaged from 250m to 5 km depth on the industry profile (Figure 3), and exhibits about 65 m of structural relief over a zone ~300 m wide at 150 m depth. Similarly, the higher-frequency hammer-source profile (Figure 3; topmost image) shows a southern zone of flat-lying reflectors from m 0 to ~m 300, a central zone north-dipping reflectors from m 300 to m 600, and a northern zone of flat-lying reflectors from m 600 to the north end of the profile at m 760. The shallowest folded strata imaged by the high-resolution reflection data are well within the reach of the conventional, continuously cored boreholes.

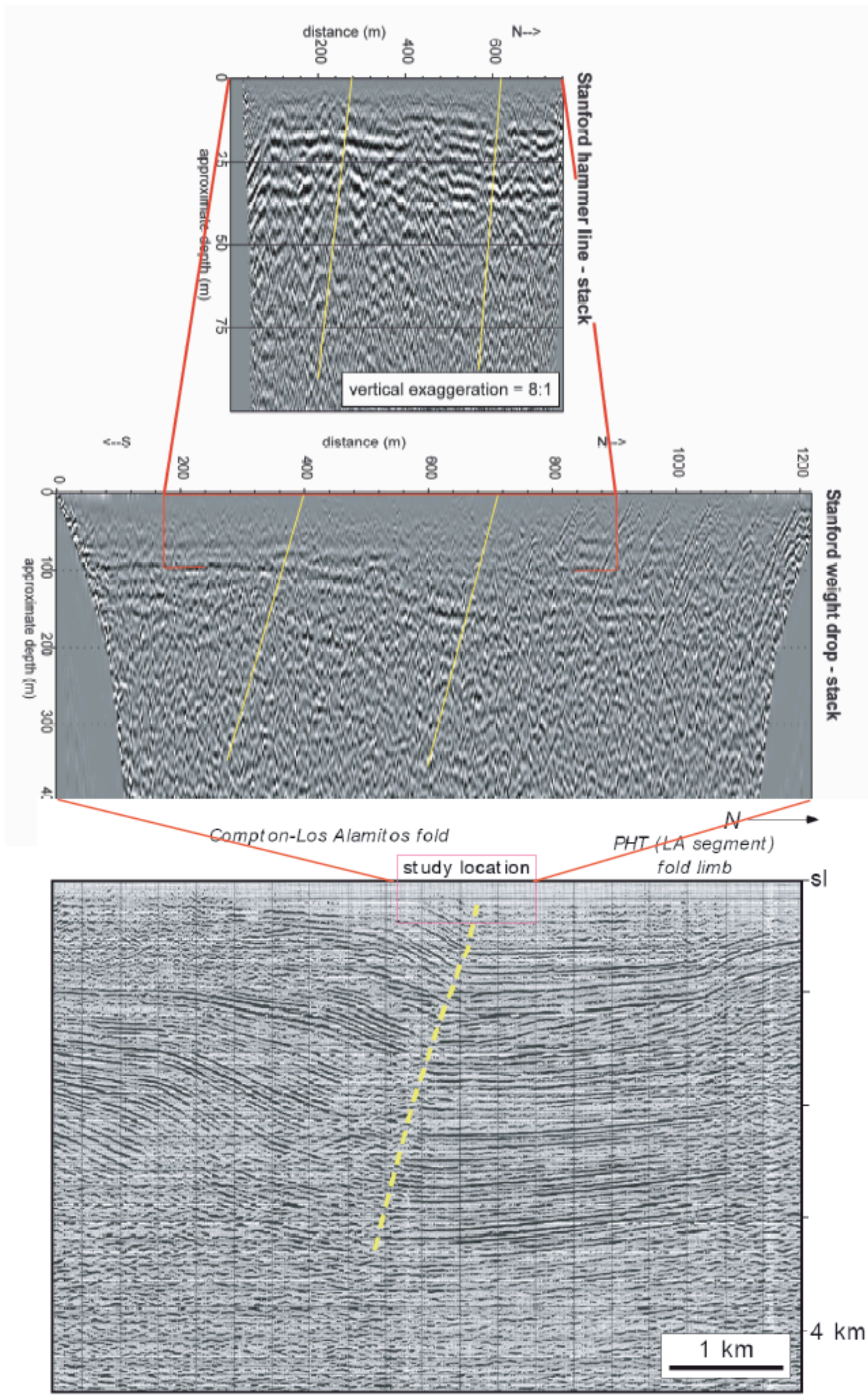

Figure 3. Stanford Avenue migrated seismic reflection profiles show discrete anticlinal and synclinal axial surfaces (yellow lines) that define and upward-narrowing kink band at the back limb of the fold above the Compton Fault. The hammer line has an 8x vertical exaggeration, other profiles have no exaggeration. Red lines show the relative locations of hammer, weight-drop, and industry seismic reflection profiles with respect to each other.

Puente Hills Fault Results: High resolution seismic reflection profile on the Los Angeles segment

While we had the source and receivers in Los Angeles, we took the opportunity to collect a 1.5-km-long weight-drop profile across the Los Angeles segment of the Puente Hills thrust fault (PHT), as no high-resolution imagery of recent deformation in the uppermost 250 m had previously been acquired across this structure. The study site is located along Budlong Avenue in central Los Angeles, ~ 6 km SSW of downtown Los Angeles and ~2.5 km south of USC.

The Budlong weight-drop profile reveals a spectacularly clear image of young folding above the Los Angeles segment of the PHT (Figure 4). A well-defined kink band is imaged between 100 m and 400 m depth. At ~350 m depth, the growth triangle is ~350 m wide, and exhibits ~60 m of structural relief. The kink band narrows upwards, and at 150 m depth, it is ~150 m wide with ~30 m of structural relief. These data clearly demonstrate that much of the shortening associated with earthquakes on the Los Angeles segment of the PHT is expressed in the near surface as folding within a narrow zone with discrete structural boundaries (axial surfaces). This result, which is similar to our earlier work on the central, Santa Fe segment of the PHT (Shaw et al., 2002; Pratt et al., 2002; Dolan et al., 2003), suggests that the Budlong site is an attractive target for future acquisition of higher-resolution seismic reflection and continuously cored borehole data to determine the recent slip rate and the ages and displacements of paleo-earthquakes on this portion of the fault.

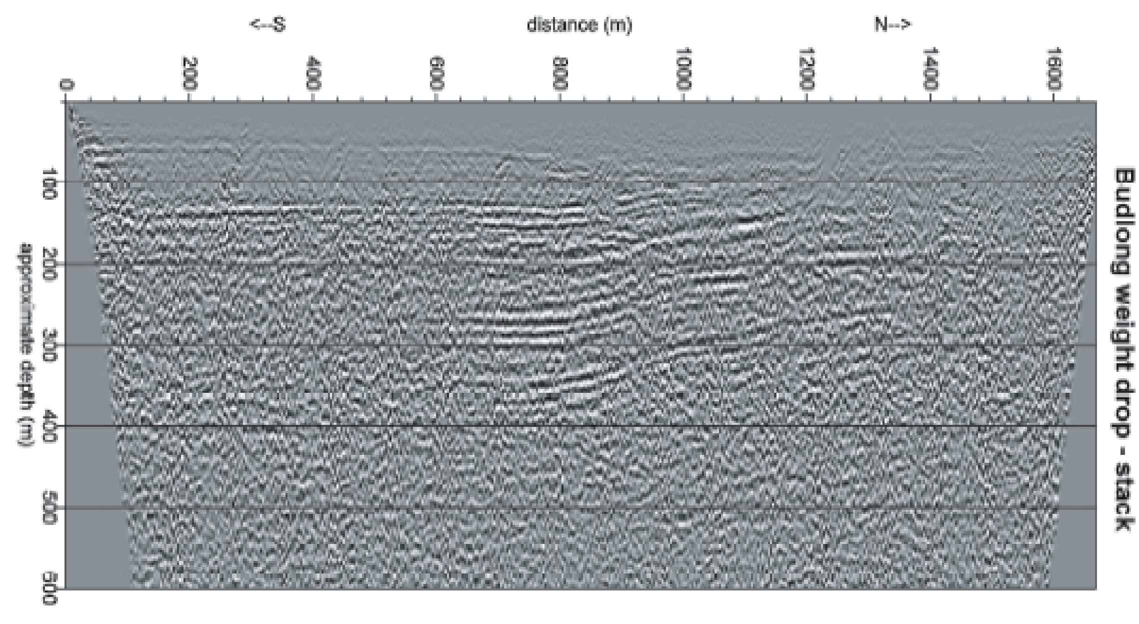

Figure 4. Budlong Avenue migrated seismic reflection profile shows a narrow zone of dipping strata with discrete anticlinal and synclinal axial surfaces that define the upward-narrowing kink band of the fold growing above the upper tip of the ramp of the Los Angeles segment of the Puente Hills thrust fault.

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Publications from This Project:

Leon, Lorraine A., Pratt, Thomas L., Dolan , James F., and Shaw, John H., 2005, High resolution seismic reflection Data to determine Holocene activity of the Compton –Los Alamitos blind-thrust fault, Los Angeles basin, California: Fall 2005 SCEC meeting [abstract]