Annual Reports for 1999

Characterization of Active Faults in East Los Angeles and **Relationship of Aftershocks to Mainshock Rupture of the Landers Earthquake**

Kerry Sieh and Egill Hauksson

During 1999 we completed final revisions of our paper on the surficial expression of the **Elysian Park thrust** in east and downtown Los Angeles, following review by the Bulletin of the Geological Society of America. The abstract of the paper appears below. The paper will appear in the July 2000 issue of the Bulletin.

During 1999, we also wrote up the results of our structural study of the **Landers aftershock sequence**. This manuscript will be submitted to the Bulletin of the Seismological Society of America in February 2000. We expect publication late in 2000. The current version of the abstract appears below.

Fault-zone structure inferred from aftershocks of the 1992 Mw7.3 Landers earthquake, California

Jing Liu, Kerry Sieh and Egill Hauksson

We analyze the spatial relationship of relocated aftershocks to the surface rupture of the Mw7.3 1992 Landers mainshock. Far less than half of the aftershocks (those within 0.5 km of the mainshock rupture planes) are candidates for re-rupture of the mainshock planes (Figure 1) and most of these have small magnitudes (M<5). Instead, as one would expect from geologic observations, aftershocks appear to delineate a broad structural damage zone surrounding the mainshock rupture plane. Furthermore, nominal slip from aftershocks near the mainshock plane is inadequate to smooth out irregularities in the mainshock slip distribution. Aftershocks preferentially cluster where individual segments of mainshock ruptures terminate or lessen, suggesting that aftershocks are more frequent where mainshock rupture has led to increased stress (Figure 2).

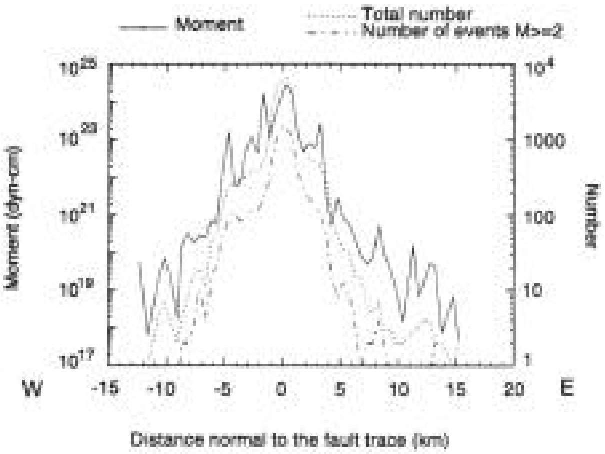

Fig. 1 Distribution of Landers aftershocks as a function of distance normal to the surface traces of the principal mainshock fault ruptures, using relocations by Hauksson (2000). Relocations by Richard-Dinger and Shearer(1999) give similar results. Only a small percentage of aftershocks occurred close enough to the principal ruptures to be candidates for re-rupture of the principal mainshock fault planes

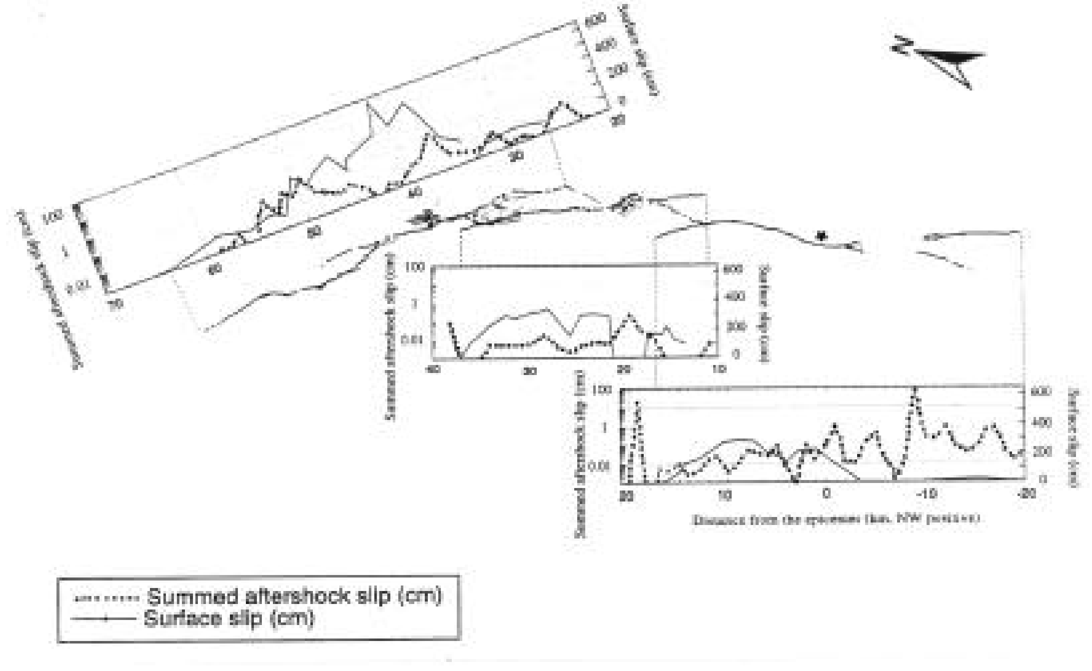

Fig.2 Comparison of mainshock surficial right-lateral slip and cumulative aftershock slip. We smoothed the mainshock slip distribution by retaining the points with the maximum slip in a 1-km non-overlapping moving window. Cumulative aftershock slip (d) was calculated by conventional formula of $d=\Sigma Mo/(\mu A)$ *assuming* $\mu=3.0x10^{11} dyn/cm$*. Aftershock slip is high where mainshock slip is low and low at places of high mainshock slip. This is consistent with earlier studies (e.g. Mendoza and Hartzell, 1988).*

Active parasitic folds on the Elysian Park anticline: Implications for seismic hazard in central Los Angeles, CA.

Michael Oskin, Kerry Sieh, Thomas Rockwell, Grant Miller,
Paul Guptill, Mathew Curtis, Steve McArdle, Paul Elliot

We characterize the seismic hazard of the Elysian Park fault, a blind reverse fault beneath central Los Angeles, by analysis of the Elysian Park anticline, which overlies it (Fig. 3). New shallow-subsurface geotechnical data, combined with other surficial stratigraphy and geomorphology (e.g. Fig. 4), reveal that the Elysian Park anticline is an active, 20-km-long structure. From the style and rates of deformation of parasitic folds on the southern limb of the anticline 1,2,3, and 4 on Fig. 3), we estimate a contraction rate of 0.6 to 1.1 mm/yr. This rate provides a basis for estimating a rate of contraction of the entire Elysian Park anticline, which, in turn allows us to estimate a 0.8 to 2.2 mm/yr time-averaged rate of slip on the underlying fault. At this rate of slip, rupture of the Elysian Park fault could produce a nominal M_W 6.2 to 6.7 earthquake every 500 to 1300 years, on average (Fig. 5). Although this Elysian Park earthquake would recur infrequently, its size and recurrence interval may be similar to those estimated for the sources of the destructive 1971 San Fernando and 1994 Northridge earthquakes.

Oskin, et al. Figure 2

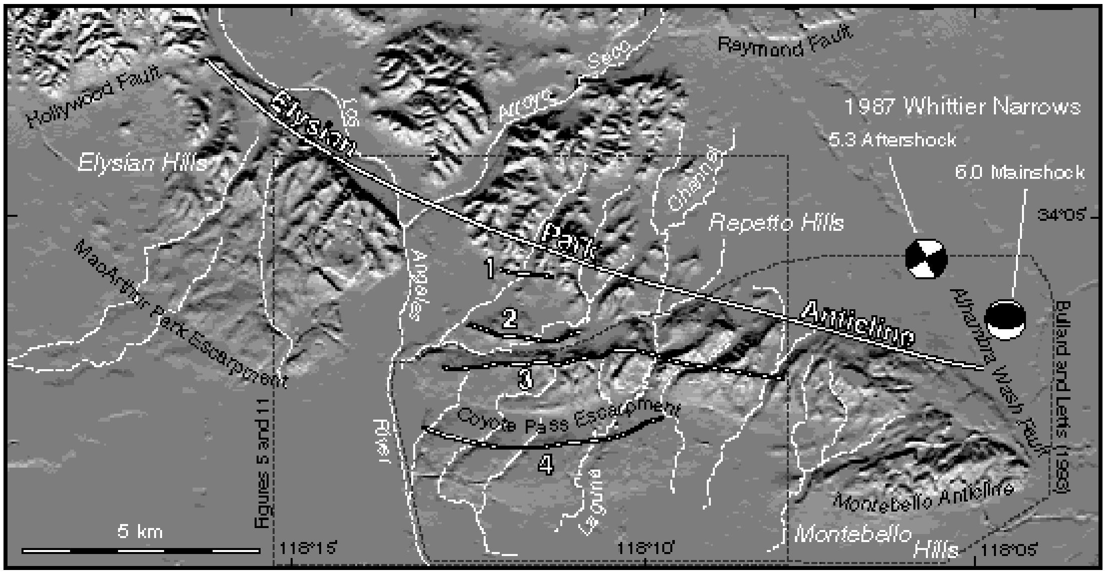

Figure 3. Shaded relief map of the Elysian Park anticline shows the relationship of topography to folding. Topographic relief correlates with the areal extent of the anticline and with the trends of parasitic secondary folds. Parasitic fold axes are depicted by thin white lines numbered 1 through 4. The Elysian Park anticlinal axis is delineated by the thicker white line. Drainages crossing all or part of the Elysian Park anticline are shown as white dash-dot lines. The box at the center of the figure surrounds the area of downtown and east Los Angeles detailed in Figures 6 and 11 of the paper. The irregular-shaped box at the lower right surrounds the area studied by Bullard and Lettis (1993). This image is derived from 30m-pixel U.S.G.S. digital elevation models for the Hollywood, Los Angeles, and El Monte 7.5-minute quadrangles.

Oskin, et al. Figure 9

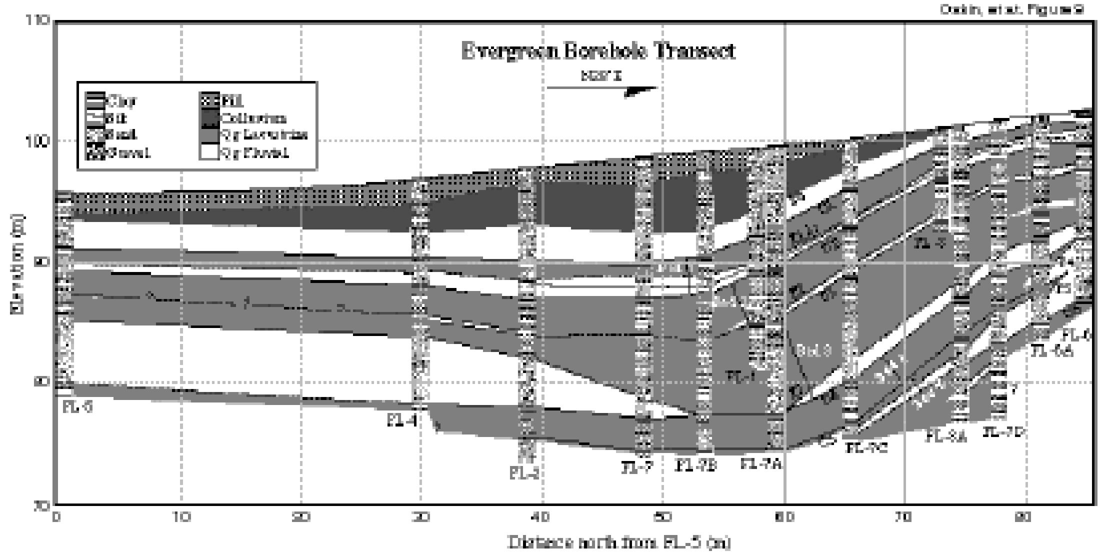

Figure 4. Evergreen Avenue borehole transect shows a sequence of lacustrine and fluvial Qg deposits folded across the Coyote Pass escarpment. The thickness of fluvial/lacustrine deposits form the basis of correlations. These deposits show a repeated and distinct pattern of fining-upward packages. Secondary

characteristics, especially the presence and grain size of fluvial deposits, as well as occasional smaller, distinctly colored or textured beds provide secondary ties between boreholes. Horizons labeled C1, C2, C3, etc., represent the top of lacustrine layers, and horizons labeled F0, F1, F2, etc., represent fluvial to lacustrine transitions. Borehole transect adapted from GeoTransit Consultants (1996).

Oskin, et.al. Figure 14

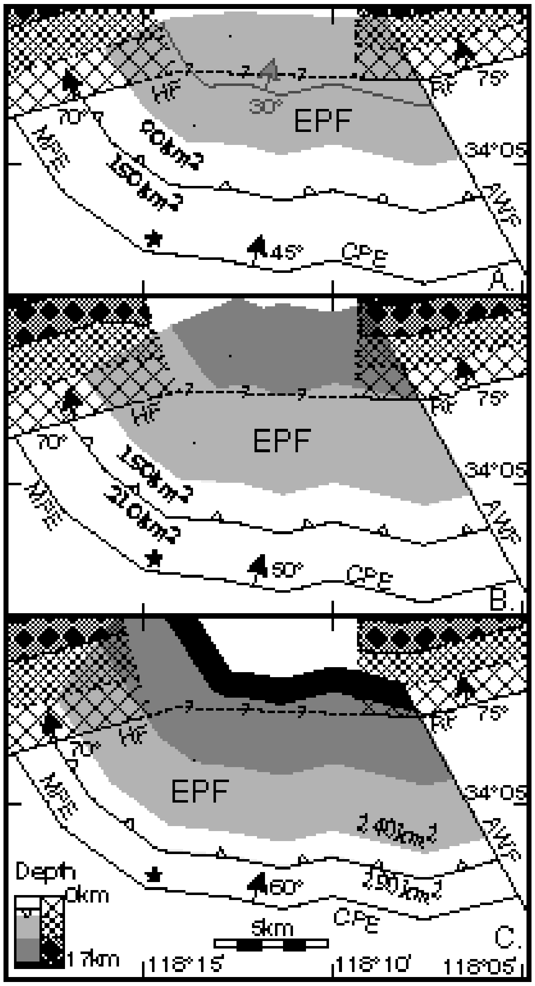

Figure 5. Three possible configurations for the Elysian Park fault. Each panel presents a shaded structure-contour image of the fault plane. ***A****. Interpretation of the Davis et al. (1989) model, with a change in dip from 45° to 30° at 7.5 km depth.* ***B****.,* ***C****. Steeper-dipping models with constant dip. The fault plane area between 5 km and 17 km depth, and 3 km and 17 km depth, are depicted in each panel. We restrict the extent of the Elysian Park fault by the location, and down-dip extension of bounding fault planes. Cross-hatch pattern denotes the down-dip extent of the Hollywood and Raymond faults. The star symbol in each panel indicates the location of downtown Los Angeles. AWF, Alhambra wash fault; CPE, Coyote Pass escarpment; EPF, Elysian Park fault; HF, Hollywood fault; MPE, MacArthur Park escarpment; RF, Raymond fault.*