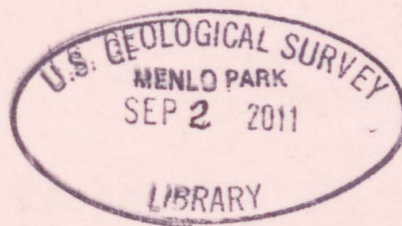


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Evidence for tectonic movement  
on the Las Positas fault,  
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By  
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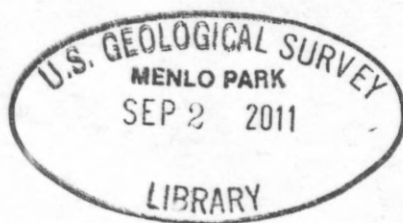
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EVIDENCE FOR TECTONIC MOVEMENT ON THE LAS POSITAS FAULT,  
ALAMEDA COUNTY, CALIFORNIA

by

Darrell G. Herd and Earl E. Brabb



OPEN-FILE REPORT 79-1658

This report is preliminary and has not been  
edited or reviewed for conformity with  
Geological Survey standards and nomenclature



## INTRODUCTION

On October 29, 1979, a new exposure of the Las Positas fault zone near Livermore, California, was created by excavation of a creek bank along Arroyo Seco. The face of the bank was cleaned by geologists of Lawrence Livermore Laboratory (Livermore, California) to obtain a better and more complete view of the fault. The excavation was undertaken by Lawrence Livermore Laboratory as part of a larger review of the earthquake hazards of the laboratory site. The Las Positas fault zone extends along the south side of Livermore Valley, passing just south of Lawrence Livermore Laboratory.

The exposure revealed new evidence concerning not only the width of faulting in the Las Positas fault zone, but also its recency, style, and origin.

## LAS POSITAS FAULT ZONE

Livermore Valley, an east-trending valley in eastern Alameda County, is bound on the south by the Las Positas fault zone (Herd, 1977). The fault zone extends from the southeast corner of Livermore Valley (where it abuts the Greenville fault zone) southwest to near San Antonio Reservoir, where the Las Positas fault apparently joins the Verona fault (fig. 1). The trace of the fault south of Livermore is delineated by a prominent northwest-facing scarp in Livermore Gravels of Pleistocene and Pliocene age, and aligned northwest-facing scarps in late Pleistocene alluvial terraces.

Geomorphic and structural relations at a fault-created ground-water barrier in late Pleistocene alluvium about 2 km southwest of the new exposure along Arroyo Seco suggested to Herd (1977) the possibility for strike-slip movement along the fault. Arroyo Seco makes a pronounced left-lateral jog in its course where it crosses the fault zone southeast of Livermore, but there are no distinctive rock associations or rock outcrop patterns across the fault

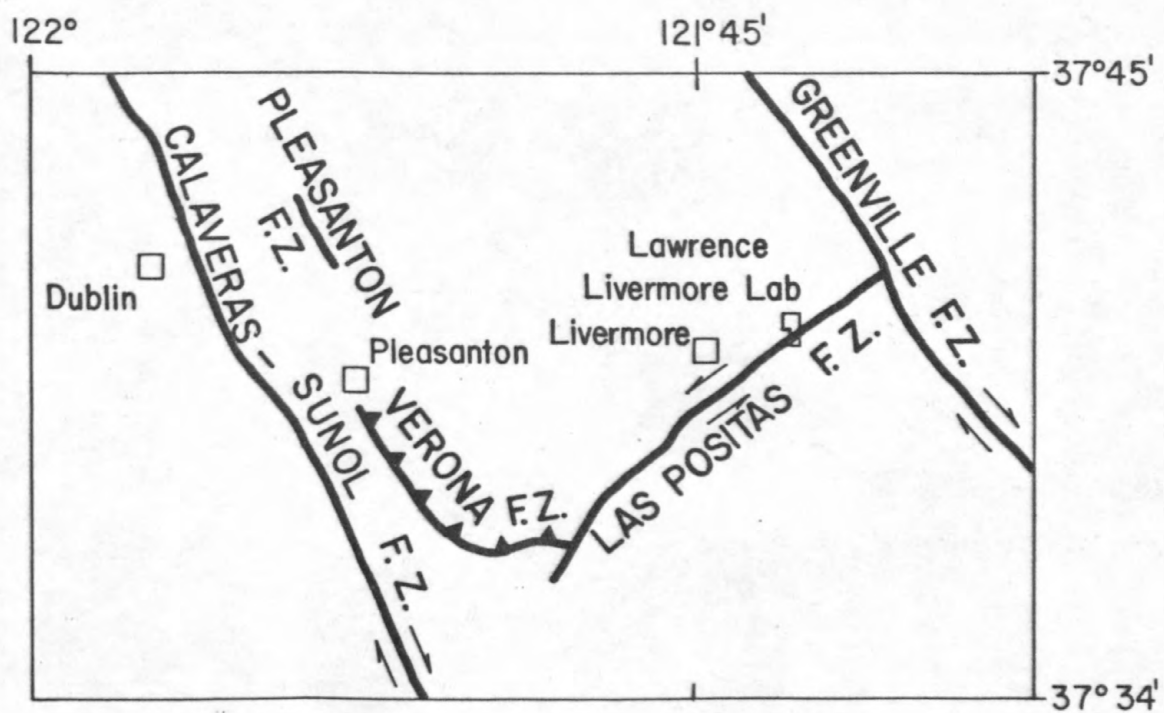


Fig. 1.--Tectonic framework of Livermore Valley. The new exposure on the Las Positas fault zone is just south of Lawrence Livermore Laboratory.

from which strike-slip movement can be directly assessed. The fault zone is nearly vertical in all exposures, and has an apparent normal (north side down) component of displacement.

The existence of the Las Positas fault zone and its origin were recently questioned by Wright and others (1979), Earth Science Associates (1979), and John A. Blume and Associates (1978). Wright and others concluded that the Las Positas fault is a localized, shallow tensional feature resulting from subsidence related to oil- and ground-water withdrawal or local extension between NW-trending strike-slip faults.

#### THE EXPOSURE

The Las Positas fault zone was first recognized in the west bank of Arroyo Seco (Herd, 1977, fig. 2), just south of Lawrence Livermore Laboratory in sec. 13, T. 3 S., R. 2 E. There the creek cuts into the terrace of alluvial unit 3 (of late Pleistocene age) (Herd, 1977), which is visibly terminated to the north in a northwest-facing scarp along the fault zone. In its subsequent excavation in 1979 by geologists of Lawrence Livermore Laboratory, a number of previously unrecognized fault breaks in the zone were exposed.

Figure 2 is a rough sketch showing segments of the Las Positas fault zone at the newly uncovered exposure. At least four segments of the fault zone, A, D, E, and F, are clearly visible, but the principal break is probably covered and is thought to be located a few tens of meters northwest of this exposure at the foot of the terrace front. Additional shears are in the vicinity of B and C in the figure, and more detailed work is likely to reveal even more faults.

The sediments southeast of fault segment A consist of silt, sand, clay, and gravel mapped by Herd (1977) as the Livermore Gravel of Pliocene and

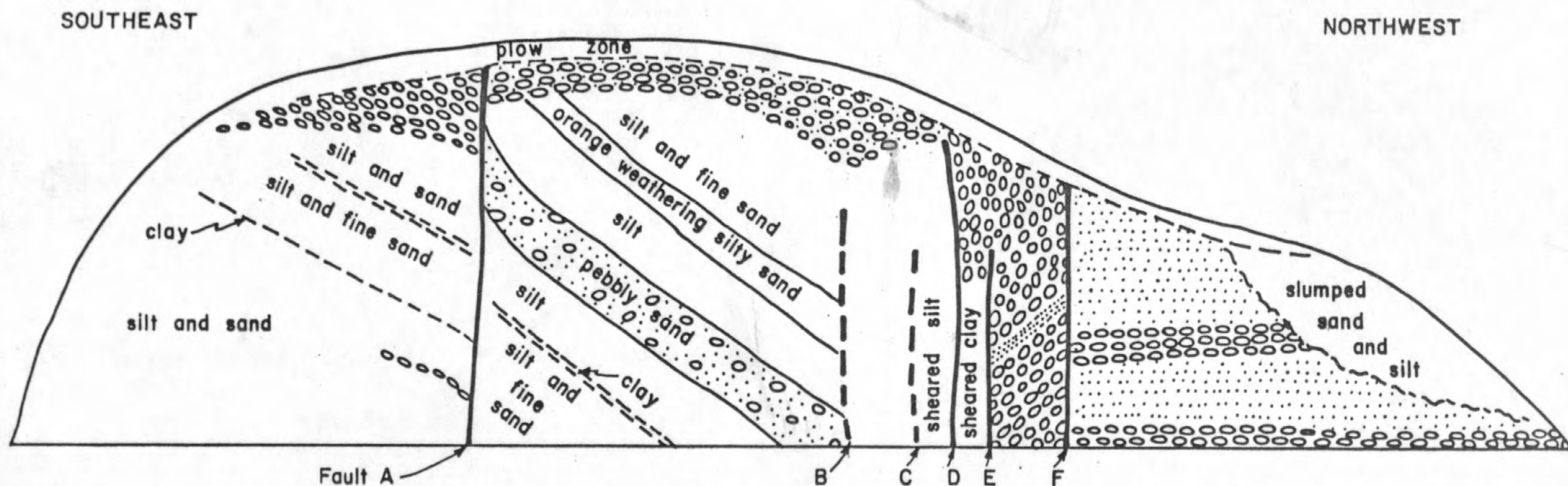
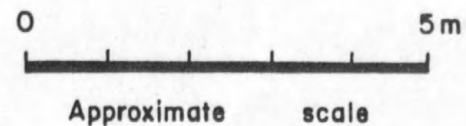


Figure 2.--Sketch looking southwest showing segments of the Las Positas fault in the vicinity of Arroyo Seco between Greenville Road and East Avenue.



Pleistocene age. They are overlain unconformably by highly oxidized terrace gravel of late Pleistocene age, unit 3 of Herd (1977). A similar sequence is present between faults A and D except that gravel is more abundant in the Livermore Gravel and none of the Livermore Gravel beds can be matched with those southeast of fault A. The beds northwest of fault F consist of flat-lying gravel, sand and silt that appear to be stream terrace deposits younger than unit 3 of Herd (1977). These beds are slumped at the northwest end of the outcrop.

The sediments between faults E and F consist mostly of a highly oxidized pebble and cobble gravel--probably unit 3 (Herd, 1977). Near the center of the outcrop, a finer-grained and sandy bed shows that at least some of the bedding in this block dips moderately to the southeast.

Sheared clay occurs in the lower part of the exposure between faults D and E. The clay is overlain by oxidized gravel of unit 3. The sediments between faults B and D are mostly silt. The silt has been extensively sheared between faults C and D, and less sheared between faults B and C.

Fault A strikes between  $N35^{\circ}E$  and  $N50^{\circ}E$  and it dips about  $85^{\circ}$  to the southeast. Well-developed slickensides, each at least 50 cm in length, plunge about  $25^{\circ}$  NE. The beds southeast of fault A appear to be bent downward as they approach the fault, whereas those northwest of the fault are clearly bent upward. The dip slip separation of the Livermore Gravel is more than 4 m and the overlying terrace deposit has a dip slip separation of about 65 cm.

Faults B, C, D, E, and F and minor faults not shown on figure 2 strike about  $N55^{\circ}E$  and they are nearly all vertical. The dip-slip separation along fault F is at least 4 m.

Faults A and F are traceable upward to within about 0.5 m of the ground surface, where the faults are truncated by a historic plow zone. Although



cultivation has largely disturbed the A horizon of the surficial soil mantle, the unplowed part of the A horizon is apparently offset by at least fault A. Very dark brown silty clay which surrounds the oxidized terrace gravel downthrown on the south side of fault A appears to be the lower portion (an A3 horizon) of the surficial A horizon. Plowing atop fault F has thoroughly disturbed the entire A horizon.

#### DISCUSSION

The near-vertical dip of the fault planes in the exposure, the slickensides with a low plunge ( $25^{\circ}$ ) on fault A, the juxtaposition of contrasting stratigraphies across the faults, and the opposing sense of drag folding in beds of Livermore Gravel across fault A indicate a predominant component of near horizontal (strike-slip) movement along the Las Positas fault zone. The slickensides on fault A and the apparent south-side down displacement of the overlying late Pleistocene terrace gravels cut by that fault suggest that the block north of fault A moved upward as it was displaced southwestward along the fault. These structural data indicate that the Las Positas fault zone is primarily a left-lateral strike-slip fault zone. This direction of movement is consistent mechanically with the fault zone's general  $N45^{\circ}E$  strike at an angle of about  $60^{\circ}$  E to the strike of most other right-lateral strike-slip faults in the San Francisco Bay region (fig. 1). The north-facing scarps in Livermore Gravels and the younger terrace deposits require, however, some normal oblique movement along the Las Positas fault zone--Livermore Valley being downthrown as it moves southwest along the fault.

The conclusion that the Las Positas fault zone is predominantly a left-lateral strike-slip fault zone is structurally compatible with evidence (Brabb and others, 1979) that the Verona fault zone is a northeast-dipping thrust fault. That fault appears to turn southeastward into the Las Positas fault.

The upper plate of the Verona fault has been repeatedly displaced westward. The Verona fault must be the west edge of the Livermore Valley block which moved southwestward along the north side of the Las Positas fault.

The structural relations observed at this outcrop indicate that the movement on the Las Positas fault cannot be related to oil- and ground-water withdrawal or local extension between northwest-trending strike-slip faults, as postulated by Wright, Harding, and Yadon (1979). Slickensides on fault A indicate that at least the last movement was nearly horizontal strike-slip, a movement incompatible with the tensional and compressional dislocations related to oil- and ground-water withdrawal. The dip slip movement of the block between faults A and D is up with respect to the block southeast of fault A, but it should have been down if the fault was due to subsidence in the valley to the northwest. The recurrent movement on fault A and its inception prior to the deposition of the terrace gravel establish that movement along the Las Positas fault began sometime during the Pleistocene after the deposition of the Livermore Gravels, and continued after the deposition of alluvial unit 3 of Herd (1977).

#### ACKNOWLEDGMENTS

We wish to thank Jim Scheimer, Dave Carpenter, and the staff of Lawrence Livermore Laboratory for their cooperation in obtaining this new exposure on the Las Positas fault zone. We also thank Sandia Laboratory for permission to visit the outcrop.

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