Holocene Slip Rate of the Concord Fault at Galindo Creek in Concord, California

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The heavily urbanized Concord fault is the little-studied southern portion of what appears to be the Green Valley-Concord structure within the San Andreas system in the East Bay. This project is a continuation of the first paleoseismic work begun on the Concord fault in 1994. That project focused on the north side of Galindo Creek, uncovering a 5.7-ka channel fill ("Channel Fill B") on the west side of the fault. This phase of the project sought to discover the eastern counterpart to that channel fill.

In this project year, trenches T-8 through T-18 were excavated. T-8 was a fault-parallel trench excavated to determine the precise location of the hypothesized eastern piercing point formed by the 1939 creek channel prior to its burial during channelization in 1984. T-9 and T-17 were cross-fault trenches excavated to determine the precise location of the hypothesized eastern and western traces of the fault at the south end of the study site. T-10 was a fault-parallel trench excavated to uncover any channel fill deposits younger than 5.7 ka. T-11 was a cross-fault trench excavated to determine the precise location of the fault at the southern margin of Channel Fill B. T-12 was a cross-fault trench excavated to determine the location of the fault immediately north of the modern concrete-lined channel and to examine the soils on an older alluvial remnant. T-13, T-15, and T-16 were shallow trenches used to constrain the southerly extent of alluvial deposition on the east side of the fault. T-14 was a fault-parallel trench excavated to uncover the northern margin of the young channel fill ("Channel Fill D") discovered in T-10. And finally, T-18 was a fault-parallel trench excavated to uncover the eastern piercing point formed by the northern and southern margins of Channel Fill B.

Channel fill deposits on the east side of the fault lie at higher elevations than those of the same age on the west side of the fault. In cross fault exposures, it was apparent that previously horizontal sedimentary units were drag folded to higher elevations by up to 3 m along the fault plane. Also, on the west side of the fault, the top of Channel Fill B (5.7 ka) was about 1.6 m lower than the top of Channel Fill D (2.4 ka). The median value for various measures of vertical slip was 0.45 ± 0.6 mm/yr. This rate was taken into account when matching units across the fault for determining the horizontal slip rate.

Many of the trenches required for this phase of the study were used to constrain or eliminate possible candidates for the eastern version of Channel Fill B. During our explorations we were especially surprised to find that one of the main reasons for selecting this site, a pronounced 24-m right-lateral bend in the historic channel of Galindo Creek was not produced by fault movement. This eliminated a possible eastern trace of the fault and decreased the post-6 ka offset by up to 65 m. In addition to locating the only trace of the fault precisely, other trenches south of Galindo Creek showed that no candidates for the eastern version of Channel Fill B were in that area. Instead, soil and sedimentary characteristics as well as ^{14}C ages indicated that the eastern counterpart of Channel Fill B exists in T-18 and T-12 north of the creek. Piercing points derived from projections along the northern margin of Channel Fill B3 (an inset channel fill dated at 6.0 ka on both sides of the fault) had an offset of 20±3 m, while points from the southern margin had an offset of 19±0.3 m. These offsets yield a horizontal slip rate of 3.4±0.3 mm/yr.
We obtained a nearly complete cross section through 11-m wide Channel Fill D, which was abandoned at 2.4 ka. Unfortunately, this channel fill existed only on the west side of the fault. However, by assuming a constant width and by using a well-defined piercing point developed from the northern margin, we were able to relate its position to the historical channel of Galindo Creek on the east side of the fault. Modern debris and bedrock scour in trench T-13 constrained the southern extent of the creek channel on the east side of the fault. A piercing point derived from the scour location and the historical trend of the creek constrains the 2.4-ka offset to 13 m, yielding a maximum horizontal slip rate of 5.4 mm/yr.

Drag Folding

The Concord fault at Galindo Creek dips between 71° and 47°SW. Because there has been up to 3 m of vertical slip during the last 6.4 ka, many of the features seen in the trench exposures exhibit drag folding along the fault. Trench T-11 clearly shows the tendency for older units on the west to be dragged upward along the fault. We sampled cross sections through various drag-folded sedimentary units in trench T-11 and T-12. Particle size distribution analyses implied that the units were first deposited horizontally, later achieving their west-dipping orientation via tectonism. The analyses provided no support for the hypothesis that the steeply dipping features were a result of infilling within fissures produced during catastrophic earthquakes. Drag-folded units within the main shear zone are seldom discretely offset. In the cross fault exposures observed, drag folding was confined to a zone within 75 to 150 cm of the fault plane. Oblong clasts whose long axes were parallel the dipping fault plane appeared so only because the bed in which they were originally deposited was drag folded parallel the fault. Clasts did not appear to rotate independently of their surrounding matrices.

The horizontal slip rate (3.4 mm/yr) on this central segment of the Concord fault is about the same as the creep rate (2.6-3.5 mm/yr) measured a kilometer to the north. Thus a tentative conclusion might be that these drag features are especially characteristic of dipping faults that seldom, if ever, experience catastrophic ground rupture. On the other hand, fault traces just south of Galindo Creek are widely dispersed and creep evidence is scarce. The Galindo Creek site may not be representative of the hazard presented by the northern half of the fault.