Annual Project Summary Report

Earthquake Hazards of the San Gabriel Valley, Southern California

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Investigations Undertaken

This project focuses on the earthquake hazards of the densely-populated San Gabriel Valley, a tectonic basin immediately east of the Los Angeles basin that has not previously been characterized as to its earthquake potential. The Valley is a triangular-shaped structural basin bounded on the north by the east-trending Sierra Madre reverse fault and Raymond left-slip fault, on the southwest by the Elysian Hills and the East Montebello right-slip fault, and on the southeast by the San Jose Hills and Puente Hills. The LARSE 1 deep seismic crustal profile crossed the basin from southwest to northeast. In support of this profile, gravity data were used to assist in structural interpretation. The margins of the basin have been the sites of five earthquakes: the 1987 Whittier Narrows reverse-fault earthquake on the south, the 1988 Pasadena strike-slip earthquake on the northwest along the Raymond fault, the 1991 Sierra Madre reverse-fault earthquake on the Sawpit-Clamshell cross fault north of the Sierra Madre fault, and the 1988 and 1990 Upland earthquakes on a buried left-slip fault northeast of the San Jose Hills.

The valley has been penetrated by oil-exploratory wells and water wells that comprised the primary data set used in this study. This has been superimposed on recently-acquired geologic mapping at 1:24,000 scale by the Dibblee Foundation and the California Division of Mines and Geology. These maps update older maps at the same scale by A.O. Woodford and John Shelton in the north and by R.F. Yerkes and D.L. Durham of the USGS in the south. I have been constructing structural cross sections that extend across the San Gabriel Valley into the San Jose Hills and Puente Hills to determine the structural relation between the two regions.

With the help of Eric Fielding of JPL, I recently acquired a re-processed USGS 10-m digital elevation model (DEM) which I am analyzing using RiverTools. This model allows visualization of subtle geomorphic features that are strongly influenced by active structures, especially blind thrusts. In addition to the San Gabriel Valley, northern Puente Hills, and San Jose Hills, I am applying this to the rest of the Puente Hills and the Coyote Hills, subjects of recent NEHRP awards.

Results

San Jose fault. The 1988 and 1990 Upland earthquakes occurred on one or more left-lateral strike-slip faults striking NE, a strike similar to that of the San Jose fault. Based on these earthquakes, it was assumed that the San Jose fault is a left-lateral strike-slip fault, and it appears this way in the standard southern California fault model. Detailed surface and subsurface work showed otherwise: the San Jose fault is a reverse fault on the south side of the San Jose anticline, an anticline that verges southward. Geotechnical work at California Polytechnical Institute at Pomona is consistent with this interpretation. The anticline steps left to a western segment, and the fault steps left, too, and dies out downplunte on the south limb of the anticline. This is a return to the original interpretation of John Shelton and A.O. Woodford nearly a half-century ago based on their own surface and subsurface mapping.

Uplift on the anticline has produced the San Jose Hills, although the west plunge of this anticline is probably much older. Cretaceous granitic rocks at the eastern end are overlain westward by Miocene Glendora Volcanics, Topanga Formation, and Puente Formation. The anticline and fault are bounded on the south by the Amar syncline, which follows a topographic low, occupied in its eastern part by San Jose Creek. South of this is the west-plunging Puente Hill anticline, housing the Walnut oil field. This is followed on the south by another syncline, named here the Industry syncline because it passes through the City of Industry and is followed by Valley Boulevard, a major arterial highway.

Accordingly, the northern hills are uplifted along a previously-unknown fold-thrust belt, largely verging southward, The San Jose fault is a reverse-fault earthquake source, and a blind fault underlying the Puente Hill anticline appears to be another earthquake source, both dipping to the north. North of the San Jose Hills, South Hill in Glendora is another anticlinal hill south of the San Gabriel Mountains range front; this may be a third earthquake source.

Walnut Creek fault. Where is the southwestward continuation of the fault that was the source of the Upland earthquakes, if not the San Jose fault. Several authors have proposed that the irregular range front of the San Jose Hills and northern Puente Hills is marked by a NW-striking fault that separates the folded Puente Hills and San Jose Hills from the nearly flat-lying deposits of the San Gabriel Valley. This fault has been named the Walnut Creek fault. West of the San Jose Hills, the Walnut Creek fault separates La Vida and Soquel members of the Puente Formation on the south from Topanga Formation on the north in the Texaco Covina 5-1 well. The high-resolution DEM shows some evidence of NW-striking lineations marking breaks in the topography at about the position expected for the Walnut Creek fault.

However, the most compelling evidence is the structural contrast between folded strata of the San Jose Hills and Puente Hills and nearly flat-lying strata of the San Gabriel Basin. This requires considerable shortening of the Puente Hills and San Jose Hills relative to the San Gabriel Valley. The San Gabriel Valley, underlain by crystalline basement rocks,may drive southward as a rigid block against the margin of the Los Angeles basin, accumulating slip on the Walnut Creek fault from north to south. This may account for the fact that the Walnut Creek fault does not continue as far southwest as the westernmost Puente Hills. The relation between this southward-driving San Gabriel Valley block and a decollement beneath the San Gabriel Valley based on interpretation of the LARSE 1 line will be considered in a future report.

San Gabriel Valley block. In contrast to regions to the southwest, south, east, and perhaps north, the San Gabriel Valley block is only gently deformed, and it may not be underlain by a separate earthquake source other than those sources around its edges. The valley is underlain by a sequence up to 2 km thick of nonmarine Plio-Pleistocene gravels, sands, and claystones underlain by a transgressive sequence of shallow-marine sands and clays, commonly referred to as “Fernando”, “Pico,” or “Repetto.” Throughout most of the valley, these deposits rest with angular unconformity on Miocene (Mohnian and Luisian) lower Puente Formation, Topanga Formation, and Glendora Volcanics, which rest on crystalline basement. These coarse-grained deposits are exposed only close to the San Gabriel mountain front, where they are called the Duarte Conglomerate. The marine deposits contain fauna indicative only of facies, and so an age in millions of years or a correlation to the Los Angeles basin has not been successful.

Toward the southwest, the nonmarine sequence is underlain by strata that are more successfully correlated to the Pico and Repetto members of the Fernando Formation, and at Whittier Narrows, a full sequence of this age is preserved on both sides of the East Montebello fault. The base of the nonmarine sequence rises toward the East Montebello fault, either as a facies change to deeper marine strata on the southwest or as an angular unconformity. Unconformity or facies change? The answer to this question is not yet at hand, in part because exposures of the contact between nonmarine deposits and Fernando Formation is not exposed north of the Elysian Hills or Puente Hills.

North-south faults in the western Puente Hills. The Puente Hills anticline at Walnut oil field is cut by a north-south fault that forms the updip trap for oil. This west-side-up fault forms a small east-facing range front that suggests that it may be active. Farther southwest, the Handorf fault marks an east-facing range front in the Turnbull oil field near Hacienda Heights. The range front is especially prominent in the 10-m DEM, not only where bedrock is exposed on the west, but also north of San Jose Creek, where there is a prominent lineation and east-facing scarp between dissected older alluvium and non-dissected younger alluvium. This fault dips east in the subsurface and has normal separation. A third east-facing range front west of Rowland Heights, followed by Fullerton Road and the northern extension of Powder Canyon, is another possible fault, although separation has not been demonstrated at the surface or subsurface.

These faults are not the same as the Workman Hill fault and North Whittier Heights fault that extend NNW from the Whittier fault. These faults, also with normal separation, cut the Miocene Sycamore Canyon Member of the Puente Formation and the Repetto Member of the Fernando Formation, but do not cut the Pico Member in the westernmost Puente Hills. Although surface maps extend these faults into the subsurface of the San Gabriel Valley, there is no well data to support this continuation.

My best explanation at present is that the north-south faults with geomorphic expression represent east-west extension of the Puente Hills accompanying north-south contraction across the fold-thrust belt. They are relatively short, and their displacement is small, suggesting that they are not independent earthquake sources.

Other discoveries using the 10-m DEM. Myers et al. (in prep.) have shown that the Coyote Hills are generated by a north-dipping blind thrust with a slip rate slightly greater than 1 mm/yr. The southern margin of the Coyote Hills is marked by a prominent south-facing scarp along the north side of Malvern Avenue in Buena Park and Fullerton. Brea Creek is an antecedent stream that cuts through the rising Coyote Hills. At the southern edge of the hills, Brea Creek turns abruptly west, following the contact between dissected older alluvium and non-dissected younger alluvium. I interpret this south-facing scarp as a fold scarp. It is sharp enough that it may be possible to date the fold rate by closely-spaced CPT borings, high-resolution seismic profiles, and possibly even trench excavations.

The Chino fault is generally characterized as a right-lateral strike-slip fault taking up part of the slip northwest of the Elsinore fault, with additional slip being taken up on the Whittier fault. However, in the Chino Hills, the fault has reverse separation and dips west. The Chino Hills are formed by uplift of the Mahala anticline, and the drainage is in part controlled by this anticline. Could the Chino fault be a misunderstood reverse fault like the San Jose fault?

The 10-m DEM shows otherwise. The Chino fault is clearly expressed as a relatively straight break in the topography in which streams crossing the break are consistently displaced right laterally. South of Los Serranos at Country Club Drive, the Chino fault is at the range front, with subdued triangular facets in older alluvium. Farther northwest, the straight course of Chino Creek adjacent to the Corona Freeway is controlled by the Chino fault as a range-front fault. This allows the Chino fault to be traced farther northwest than has been possible previously, although future subsurface work under a new NEHRP grant may allow refinement in the location of the fault. Clearly, the fault does not extend to the San Jose Hills, which cross the northwest projection of the fault without any expression of it.

Summary statement. The use of subsurface petroleum-industry data, water well data, and detailed DEM analysis has permitted for the first time the delineation of earthquake fault sources in the northern Puente Hills and adjacent San Gabriel Valley, thereby improving the fault model for the eastern Los Angeles metropolitan area.

Non-Technical Summary

The earthquake potential of the eastern Los Angeles metropolitan area has been poorly understood, despite the large population at risk there. Using subsurface data from the petroleum industry, new surface geologic mapping, and detailed computer-generated topography of the Puente Hills and San Jose Hills, we have identified two new earthquake source faults beneath the San Jose Hills and northern Puente Hills. The boundary between the hills and the San Gabriel Valley may be another earthquake source fault. The San Gabriel Valley itself is apparently not underlain by an earthquake source fault except around its margins.

Reports

Myers, D.J., 2001, Structural geology and dislocation modeling of the East Coyote anticline, eastern Los Angeles Basin: Corvallis, Oregon State University MS thesis, 49 p.

Myers, D.J., Nabelek, J.L., and Yeats, R.S., in prep., Dislocation modeling of blind thrusts in the eastern Los Angeles basin, California, to be submitted to *Journal of Geophysical Research.*

Tsutsumi, H., Yeats, R.S., and Huftile, G.J., 2001, Late Cenozoic tectonics of the northern Los Angeles fault system, California: *Geol. Soc. America Bull. 113*:454-468.

Yeats, R.S., 2000, The 1968 Inangahua, New Zealand, and 1994 Northridge, California, earthquakes: Implications for northwest Nelson: *New Zealand Journal of Geology and Geophysics 43*:587-599.

Yeats, R.S., compiler, 2001, Active faults in the Los Angeles metropolitan region: Southern California Earthquake Center Group C Legacy Document, 60 p.

Availability of Data

The SCEC Legacy Document is posted on my website and the SCEC website. Access to the SCEC document is password-limited. This annual report will be posted on my website at the same time it is submitted to USGS.