Wilshire fault: Earthquakes in Hollywood?: Comment and Reply

Harold R. Lang
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109-8099

Some of the structures that Hummon et al. (1994) reported as new discoveries have actually been reported previously in the literature. Some of their assertions are not supported by available published subsurface mapping and are inconsistent with their own maps.

On the basis of surficial mapping alone, it may be true that the Whittier Narrows earthquake resulted in discovery of a "previously unrecognized zone of blind reverse faults and folds" in the Los Angeles basin. It is not true that the reverse Whittier fault system was unrecognized, on the basis of published subsurface mapping that was available long before the 1987 Whittier Narrows earthquake. Twenty years ago, detailed subsurface maps and cross sections for the Brea-Olinda, Sansinena, Whittier, and Montebello oil fields, including the regional cross section A-B, published by the California Division of Oil and Gas (1974) documented reverse faulting, thrust faulting, and folding on the Whittier fault system.

Figure 1 shows a published alternative (Lang and Dreessen, 1975) to the Hummon et al. (1994) map of northwest Los Angeles basin structure. The Wilshire fault of Hummon et al. (1993) is the same fault mapped as the 6th Street fault by Lang and Dreessen (1975). The strike of the two faults is identical. The trace of the Wilshire fault, modeled by Hummon et al. at −2800 m, falls on the downdip projection of the 6th Street fault plane as mapped by Lang and Dreessen and by the California Division of Oil and Gas (1974), on the basis of data from more than 500 wells in the Salt Lake oil field. Eastward connection of this fault with the Whittier fault system also was proposed by Lang and Dreessen (1975).

Hummon et al.'s assertion that the Wilshire fault is "limited to the west by the Newport-Inglewood fault" (their West Beverly Hills lineament–Newport-Inglewood fault) is inconsistent with their own maps. Westward extension of their mapped trace of the Wilshire fault does not intersect their mapped trace of the West Beverly Hills lineament–Newport-Inglewood fault (Fig. 1). Furthermore, published subsurface mapping (California Division of Oil and Gas, 1974) does not support their assertion that the West Beverly Hills lineament–Newport-Inglewood fault is the Newport-Inglewood fault. Their version of that line would have to cut both the Cheviot Hills and Beverly Hills oil fields (Fig. 1). Subsurface mapping, constrained by dense subsurface control from nearly 300 wells in these fields (California Division of Oil and Gas, 1974), precludes the existence of any fault with the trace that Hummon et al. showed for the West Beverly Hills lineament–Newport-Inglewood fault.

Hummon et al.'s assertion that the Hollywood fault is the northeastward continuation of the Santa Monica fault is inconsistent with published subsurface mapping. Hummon et al. mapped the surface trace of the Hollywood fault northwest of the subsurface trace of the Santa Monica fault as mapped by Lang and Dreessen (1975) (Fig. 1). This implies that the Hollywood fault is a different fault from the Santa Monica fault. I believe that Hummon et al. missed the Santa Monica fault in their interpretation of their Figure 3 cross section. According to Lang and Dreessen's mapping, the Santa Monica fault should cut Hummon et al.'s cross section in the area below the Hollywood basin where Hummon et al.'s Figure 3 interpretation shows question marks at the top of basement and an anomalously thick lower Puente section.

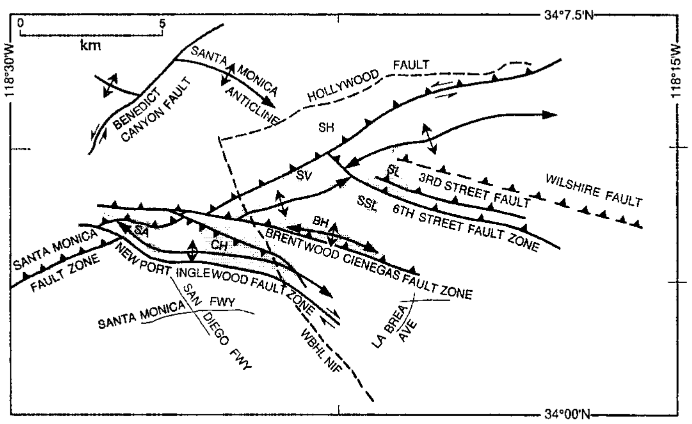

Figure 1. Subsurface structure of northwest Los Angeles basin, on top of Topanga Formation (after Lang and Dreessen, 1975, Fig. 3). Trace of Santa Monica fault follows −2700 m (below sea level) fault plane contour. Dashed-line traces of West Beverly Hills lineament–Newport-Inglewood fault (WBHL NIF) (at ground surface), Hollywood fault (at ground surface), and Wilshire fault (at 2800 m below surface) are from Hummon et al. (1994) Figures 2 and 4. Trace of 3rd Street fault is from California Division of Oil and Gas (1974) Salt Lake oil field map. Shading shows productive limits of oil fields; SH is Sherman, SL is Salt Lake, SV is San Vicente, SSL is South Salt Lake, BH is Beverly Hills, SA is Sawtelle, and CH is Cheviot Hills.

REFERENCES CITED

California Division of Oil and Gas, 1974, California oil and gas fields, Volume II, South, central coastal and offshore California: Sacramento, California Division of Oil and Gas Report TR12.

Hummon, C., Schneider, C. L., Yeats, R. S., Dolan, J. F., Sieh, K. E., and Huftile, G. J., 1994, Wilshire fault: Earthquakes in Hollywood?: Geology, v. 22, p. 291–294.

Lang, H. R., and Dreessen, R. S., Jr., 1975, Subsurface structure of the northwestern Los Angeles basin: Sacramento, California Division of Oil and Gas Technical Papers, Report TP01, p. 15–21.

REPLY

Cheryl Hummon, Craig L. Schneider, Robert S. Yeats
Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506
James F. Dolan, Kerry E. Sieh
Seismological Laboratory, California Institute of Technology, Pasadena, California 91125
Gary J. Huftile
Department of Geosciences, Oregon State University, Corvallis, Oregon 97331-5506

Lang implies that we included the Whittier fault in the "previously unrecognized zone of blind reverse faults and folds" that were in part reactivated by the 1987 Whittier Narrows earthquake. The west-northwest–striking Whittier fault has reverse separation, but recent motion has been predominantly right-lateral strike slip (Rockwell et al., 1991), whereas the Whittier Narrows earthquake occurred on a pure dip-slip reverse fault with east-west strike (Hauksson et al., 1988). The difference in strike and sense of slip between the earthquake main shock and the Whittier fault indicates that the Whittier fault was not the source of the earthquake (Davis et al., 1989).

Lang's comparison of our location of the Wilshire fault with faults that were mapped by Lang and Dreessen (1975; cf. Fig. 1 of his Comment) is inappropriate for two reasons. (1) The Wilshire fault is beneath well control; its position is based on dislocation modeling and fault-bend-fold modeling of the fold deforming the base of Quaternary marine gravels, whereas Lang and Dreessen's work is based on well penetrations. (2) The map presented by Lang is based on contours on top of the middle Miocene Topanga Formation, which was deformed first by normal faulting (Schneider, 1994) and then by reverse faulting and folding prior to deposition of the Quaternary marine gravels. This is clear from the difference in structure between the top of the Topanga Formation and the base of the Quaternary marine gravels in Figure 3 of Hummon et al. (1994). Schneider (1994) prepared a structure contour map of the top of the Nodular Shale, the lowest member of the Puente Formation that overlies the Topanga Formation. The structure at this level is very different from that at the base of the marine gravels because of the longer deformational history of the Nodular Shale.

Lang's map presents one interpretation of the structure (for others, see Wright, 1991; Schneider, 1994), but it is difficult to evaluate Lang's interpretation because well control is not presented on the map or on diagrammatic cross sections in Lang and Dreessen (1975). Lang suggests that the Wilshire fault is downdip from his 6th Street fault, which is shown as a major structure more than 8 km long with 915 m separation of the top of the Topanga Formation (Lang and Dreessen, 1975). However, the description of the Salt Lake oil field in which this fault was originally identified (California Division of Oil and Gas, 1974) shows a fault with less than 100 m separation that is mapped for a distance of only 1 km at the southern edge of the Salt Lake oil field. Previous publications (Soper, 1943; Crowder and Johnson, 1963) did not recognize a fault in that area, and Schneider (1994), using a complete subsurface database, found no evidence for a throughgoing 6th Street fault as mapped by Lang and Dreessen (1975).

The West Beverly Hills lineament is an east-facing, 10–20-m-high topographic escarpment that was mapped using 5 ft contour-interval maps of the Sawtelle and Hollywood six-minute quadrangles published in 1934 and 1926, respectively, by the U.S. Geological Survey. The lineament is oriented parallel to, but several hundred metres west of, the northern projection of the Newport-Inglewood fault in the Baldwin Hills and Inglewood oil field. The lineament represents a fundamental geomorphic feature of the northern Los Angeles basin, separating a low-lying, young alluvial apron to the east from a zone of older, uplifted alluvial fans and marine terraces on the west. The presence of the scarp requires a tectonic explanation; it is the product of either late Quaternary folding or dip-slip faulting. It is possible, as Lang and Dreessen's (1975) map suggests, that right-lateral slip on the Newport-Inglewood structural zone terminates near Beverly Hills as the fault bends into a series of west-northwest–striking contractional structures (Wright, 1991; Tsutsumi et al., 1994). Alternatively, small strike-slip offsets along the West Beverly Hills lineament could be too small to be seen in structure contour maps prepared from oil-field data. The slip rate on the northern Newport-Inglewood fault is extremely slow, <0.1 mm/yr (Shaw and Suppe, 1993), and any northwest continuation of the Newport-Inglewood fault zone would likely have small total offset.

The surface traces of the active Santa Monica and Hollywood faults in Figure 2 of Hummon et al. (1994) are based on trenching, geotechnical borings, high-resolution reflection profiling, and the presence of fault scarps on the older contour maps (Dolan and Sieh, 1991, 1992; Dolan et al., 1993; J. Dolan and K. Sieh, unpublished; cf. Fig. 14 of Wright, 1991). We observed no geomorphic evidence to support the contention of Lang and Dreessen (1975) that the Santa Monica fault extends east of the West Beverly Hills lineament into the alluvial plain of Beverly Hills. Rather, our studies show that the active Hollywood fault east of the lineament surfaces at the range front of the Santa Monica Mountains. The structurally high basement beneath the Hollywood basin at the north end of our cross section (Fig. 3 of Hummon et al., 1994) could be bounded on the south by a fault, shown as the eastern extension of the Santa Monica fault by Lang and Dreessen (1975) and Lang (Comment above). However, as shown in Figure 3 of Hummon et al. (1994), this fault, if present at all, would predate the base of the marine gravels on which evidence for the Wilshire fault is based.

REFERENCES CITED

California Division of Oil and Gas, 1974, California oil and gas fields, Volume II, South Salt Lake oil field (2 unnumbered pages).

Crowder, R. E., and Johnson, R. A., 1963, Recent developments in Jade-Buttram area of Salt Lake oil field: California Division of Oil and Gas, Summary of Operations—California Oil Fields, v. 49, no. 1.

Davis, T. L., Namson, J., and Yerkes, R. F., 1989, A cross section of the Los Angeles area: Seismically active fold and thrust belt, the 1987 Whittier Narrows earthquake, and earthquake hazard: Journal of Geophysical Research, v. 94, p. 9644–9664.

Dolan, J. F., and Sieh, K. E., 1991, Structural style and geomorphology of the Santa Monica–Hollywood fault system: Constraints on kinematics of recent fault movement: Eos (Transactions, American Geophysical Union, supplement, fall meeting abstracts), p. 319–320.

Dolan, J. F., and Sieh, K., 1992, Paleoseismology and geomorphology of the northern Los Angeles basin: Evidence for Holocene activity on the Santa Monica fault and identification of new strike-slip faults through downtown Los Angeles: Eos (Transactions, American Geophysical Union, supplement, fall meeting abstracts), p. 589.

Dolan, J. F., Sieh, K., Guptill, P., Miller, G., Rockwell, T., and Smirnoff, T., 1993, Structural geology, fault kinematics, and preliminary paleoseismologic results from the Hollywood fault: New data from continuously cored borings and geotechnical trenches, Hollywood, California: Eos (Transactions, American Geophysical Union, supplement, fall meeting abstract), p. 427.

Hauksson, E., and 17 others, 1988, The 1987 Whittier Narrows earthquake in the Los Angeles metropolitan area, California: Science, v. 239, p. 1409–1412.

Hummon, C., Schneider, C. L., Yeats, R. S., Dolan, J. F., Sieh, K. E., and Huftile, G. J., 1994, Wilshire fault: Earthquakes in Hollywood?: Geology, v. 22, p. 291–294.

Lang, H. R., and Dreesen, R. S., Jr., 1975, Subsurface structure of the northwestern Los Angeles basin: California Division of Oil & Gas Publication TP01, p. 15–21.

Rockwell, T. K., Gath, E. M., and Gonzalez, T., 1991, Sense and rate of slip on the Whittier fault zone, eastern Los Angeles basin, California [abs.]: 35th Annual Convention of the Association of Engineering Geologists, 35th, Proceedings, p. 679.

Schneider, C. L., 1994, Pre-Pliocene structural geology and structural evolution of the northern Los Angeles basin, southern California [M.S. thesis]: Corvallis, Oregon State University, 72 p.

Shaw, J. H., and Suppe, J., 1993, Earthquake hazards of active blind thrust faults in the Los Angeles basin, California, *in* Shaw, J. H., Active blind-thrust faulting and strike-slip fault-bend folding in California [Ph.D. thesis]: Princeton, New Jersey, Princeton University, 216 p.

Soper, E. J., 1943, Salt Lake oil field: California Division of Mines Bulletin 118, p. 284–286.

Tsutsumi, H., Schneider, C. L., Hummon, C., Yeats, R. S., and Huftile, G. J., 1994, Subsurface structure and tectonic evolution of the northern margin of the Los Angeles basin, southern California: Geological Society of America Abstracts with Programs, v. 26, no. 2, p. 99–100.

Wright, T. L., 1991, Structural geology and tectonic evolution of the Los Angeles basin, California, *in* Biddle, K. T., ed., Active margin basins: American Association of Petroleum Geologists Memoir 52, p. 35–134.