Structural Analysis of Active Blind Thrusts and Folds in East Los Angeles

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Introduction: This report presents results of work completed in 1998 on compressive fault-related folds in east Los Angeles. This project is a continuation of work initiated in 1996 with K. Sieh and M. Oskin at Caltech. A series of cross sections completed for the initial phase of this study (see 1997 SCEC annual report) were compared with fold trends and segment boundaries defined by the most recent surface maps produced from the Caltech effort. A number of segment boundaries in fold trends indicated significant uncertainty in subsurface structural geometry based on the method of projection used for the sections completed in 1997. In response to these problems, two of the existing cross sections were projected using the new fold trend criteria, and reinterpreted, and an additional section was constructed where well control allowed simpler projection across fold segment boundaries.

Structural Geology: Results of the our analysis suggest that structures mapped at the surface (herein referred to as Structures #1-4, in accordance with Oskin et al., submitted) can be further constrained by subsurface structure. Our sections strike NNE and are labeled #1-3 from W. to E.

<u>Structure #1</u> is partly defined on one section, the westernmost line labeled Section #1. Repeated Miocene strata was identified near the top of the “Massive sand” section (local oilfield terminology, part of Mohnian section) that indicated ~ 60m of vertical separation. The upward extend of the south vergent, high-angle thrust interpreted in the section is unconstrained. The south-dipping flank of Structure #1 dips 45-60^o based on dipmeter logs, consistent with surface exposures.

<u>Structure #2</u> is largely undefined given available well data. This structure is better defined by surface outcrops of Puente Formation as defined by Dibblee (7.5 min Los Angeles Quad).

<u>Structure #3</u> is the elongate E-W trending fold that extends from the LA River to within 4 or 5km of the Chino Fault. Structure #3 is defined by the Coyote Pass escarpment on its south flank, which is defined by numerous boring profiles and trenches (Oskin and others, in review). Cross section #1 defines the geometry of structure #3 with 5 deviated wells drilled to produce the Union Station Oilfield. A fault was not penetrated by any of the Union Station wells; this is interpreted to indicate a relatively steep fault geometry (e.g. > 65^o dip) between the northernmost wellbore and wells in the center of the field. The monocline defined at the surface by the Coyote Pass escarpment is apparent at depth as a limb dipping as much as 70^o based on dipmeter logs. The footwall is defined by gently south dipping strata. Structure #3 is also defined on cross section #2 by the Chevron Blanchard, Friend and BEW wells. A fault is interpreted to cut uppermost Mohnian strata in at least one well with ~100m of vertical stratigraphic separation; dipmeter data from the four closely spaced well varies widely, with many attitudes dipping steeply north. These data were repeatedly checked for accuracy and determined to reflect either a small-scale fold which is not apparent at the surface, nor resolvable at depth given available well-spacing. Alternatively the dipmeter data could be interpreted to record a drag fold as much as 100m wide formed immediately above a blind thrust. Cross section #3 does not have sufficient well data to further define structure #3.

Structure #4 is expressed at the surface as a broad wavelength fold with a nearly flat north-dipping limb and a gently south-dipping limb incised by south trending drainages (e.g. Laguna Channel, Oskin et al., in review). Structure #4 is defined in cross section #1 by the Chevron Kohler wells (CH1, RD1, OH) and and the Chevron So Pac. 57-1 well. The base of the Los Angeles River gravels are clearly uplifted; both wells also contain repeated section consistent with a north-dipping blind thrust. The dip of the thrust is unknown but at least $>45^0$ given available well control. The So. Pacific well exhibits 460m of repeated section (vertical separation) in strata of Repettian and Delmonian age.

Structure #4 is also defined by cross section #2 in the Union San Antonio EH1 well where 295 m of vertical separation is apparent. The same fault appears to repeat 145m of Fernando Formation in the Chevron Fresno Rec Center well. The dip of the fault is poorly defined because of uncertainty in its strike relative to the geometry of repeated strata in the two deviated wellbores. Structure #4 is not defined by wells in section #3.

Implications for Seismic Risk: The recency and rates of shortening and fault slip across the foldbelt exposed in East Los Angeles has been defined by the geotechnical and dating studies completed by Oskin et al. (in review). Data discussed here add to the growing understanding of active structures in east LA by defining the geometry of active faults and by confirming subsurface structure that matches folds mapped at the surface. Future efforts aimed at developing credible earthquake scenarios should consider structures #3 and #4 to be south vergent, fault-related folds developed above steeply north dipping blind thrusts (dips could range from $55\text{-}70^o$). The lateral extend of the folds defined by the surface mapping is the criterion required for defining fault length.

We consider the folds and blind thrusts defined in East Los Angeles to pose a significant seismic risk to the densely populated regions they underlie, however only for the area defined by these folds. We do not necessarily agree that they record slip on the “Elysian Park Thrust” as interpreted by Davis and others (1989) and Oskin et al. (in review) unless shortening on all the high-angle blind thrusts is fed as slip into a single fault at depth.

As part of our structural analysis we also attempted to define portions of the Miocene section that might record growth across the north-dipping blind thrusts during a prior period of extension. We were able to correlate Miocene strata as gradually increasing in thickness towards the basin center (north to south) for all the sections. This argues for growth of the blind thrusts as new faults, rather than as reactivated Miocene structures. We attribute current segment boundaries in the fold trends to record coalescing of originally smaller structures; this is supported by the variation in topographic relief of the folds relative to their length. Relief is thus define (i.e. fault displacement) as very low relative to the length of the two larger structures (#3 and #4). This is in contradiction to folds known to grow continuously as single structures (e.g. Mueller and Talling, 1997).

References Cited

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