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COMMUNITY FAULT MODEL VALIDATION WITH ELASTIC MODELS OF TOPOGRAPHY AND DEFORMED GEOLOGIC MARKERS

Fault surface representation in three-dimensions is imperative for understanding how regional fault networks accommodate strain, interact, and are organized internally. Moreover, fault surfaces comprising the Community Fault Model (CFM) are a key input in seismic hazard assessment characterization. In 2003, we developed an integrated geologic and modeling evaluative approach and analyzed the northeastern Los Angeles Basin using the Community Fault Model (CFM). Our results demonstrate that where the faults are well constrained through the seismogenic crust (i.e. the Puente Hills thrust fault of Shaw et al. (2002), mismatch between deformed geologic markers in the upper crust and the models is primarily controlled by uncertainty in the direction and magnitude of horizontal contraction. In 2004, we extended the scope of our analysis to the northern Los Angeles in order to investigate the nature of the mismatch between CFM-based models and deformed geologic markers, mismatch that is apparently controlled by the fault definitions. Our work this year explored plausible alternative fault configurations in 2- and 3- dimensions. We view validation of the CFM via methodologies such as the one we are developing that integrate geologic observations with mechanical models as an essential contribution to the long-term SCEC goals of developing a CFM, a vertical motion database, and RELM.

<u>Methods</u>

Thirteen structural cross-sections constrained by well and outcrop data were used to compile a structural contour map of the base of the Pico Formation (~2.9 Ma) across ~50 km of the northern LAb from the Coyote Hills on the east to Pacific Palisades on the west (Figs. 1 and 2). Each cross-section was constrained by numerous wells. Well control typically extended to ~3 km depth, which constrained tightly the structural geometry of the Pico Member and the base of the Quaternary sediments. A map of rock uplift was constructed from these data by measuring the structural relief relative to the central trough of the LAb, a long-lived northwest-trending structural low that lies to the northeast of the Newport-Inglewood fault. Dividing rock uplift by 2.9 Ma, the approximate age of the base of the Pico Formation, allowed for rock uplift rate to mapped over the region. (Fig. 3). These maps served to constrain the spatial pattern of rock uplift and rock uplift rate in time.

Three-dimensional Boundary Element Method (BEM) models containing fault surfaces defined by the SCEC Community Fault Model working group are used to simulate deformation of the northern LAb (Griffith and Cooke, 2004) (Figs. 1 and 3). Fault surfaces are composed of triangular elements within the BEM, which permits simulation of non-planar surfaces and irregular fault intersections such as are observed in the subsurface. The faults are weak in shear and slip in response to a combination of tectonic loading (determined from geodesy) and interaction with nearby faults.

With our methodology, we are able to test a broad range of models that simulate deformation under variations in fault intersection, tectonic loading and linkage between faults in order to assess the sensitivity of uplift pattern and magnitude to these variations. Although there is uncertainty in the contraction directions and magnitudes determined from different geodetic studies, from 56 mstrain/yr at N36E (Bawden et al, 2001) to 100 mstrain/yr north-south (Argus, personal communication), we found that the later values yield model patterns and rates of uplift consistent with those constrained geologically. Furthermore, the subsurface seismic data has left uncertainty as to whether the echelon segments of the PHT are directly linked at depth or remain discrete fault surfaces (Shaw et al, 2002). Each of these variations is explored with the numerical models and the resultant uplift compared to geologic observations.

Model descriptions

Competing models of three-dimensional fault topology, starting from the SCEC Community Fault Model (CFM), were tested for viability using numerical Boundary Element Method (BEM) models and patterns of rock uplift by folds in the northern Los Angeles basin (LAb). Six models were tested against patterns of rock uplift across the northern LA basin (Fig. 3). Model 1 was based on the CFM, whereas models 2-5 representative alternative fault configurations in areas of mismatch between observation and model predictions (Fig. 3a). CFM alternatives were constrained by published interpretations of the crustal geometry of faults (i.e. Fuis et al. 2001; Meigs et al., 2003).

Models 1 and 2 used the CFM v. 1.1 and compare 60° and ~30° ramp dips for the Las Cienegas fault (referred to as the Los Angeles fault segment in the CFM, Figs. 3a and b, respectively). In model 3 the Las Cienegas fault is represented by a 20˚ north-east-dipping ramp below 12 km depth (Fig. 3c). The Las Cienegas faults is characterized as a 60° ramp that merges with a 20˚ ramp (termed the lower Elysian Park in the CFM) below 14 km at depth in Model 4 (Fig. 3d). Model 5 includes a steep upper Elysian Park fault and omits the 20˚ ramp at depth in oreder to test the influence of the lower ramp on uplift (Fig. 3e). Extension of the lower Elysian Park fault to the west was modeled to determine the influence of a LARSE-like detachment on uplift rate (Fuis et al. 2001) (Fig. 3f). Model-data compatibility was evaluated on the basis of structural trend, spatial variation in rates and location of major structures (i.e. key near surface folds). Splays of the Santa Monica fault missing from the CFM account for mismatch between post 2.9 Ma rock uplift and the model results in the west. All models are consistent with the location and uplift pattern of the Coyote Hills and Santa Fe Springs structures, the location and orientation of the central trough, and a North-trending structure separating Santa Fe Springs on the east from Montebello to the northwest. Omitting the lower Elysian Park, has the effect of decreasing uplift of the Montebello and Santa Fe Springs anticlines thereby increasing mismatch. Model 4 shows remarkable agreement in vertical displacement of the Elysian Park, Montebello, Santa Fe Springs, and Coyote Hills anticlines and the central trough. This supports the interpretation of steep rather than shallow dips for the Las Cienegas and upper Elysian Park faults.

Discussion

None of these models simulate satisfactorily the Las Cienegas anticline position, orientation, or uplift rate, suggesting that the 20° ramp may extend farther to the west than represented within the CFM. However, a fifth BEM model that includes this suggestion produced greater uplift in the region of the Las Cienegas anticline. If correct, our models are consistent with the emerging paradigm that the northeastern boundaries of the LAb's central trough are flanked by deep (> 10 km) and low-angle (<30˚) fault ramps.

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