FORUM

Comment and Reply on "Structural transect of the western Transverse Ranges, California: Implications for lithospheric kinematics and seismic risk evaluation"

COMMENT

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I am compelled to express doubt about the general applicability of the retrodeformable cross-section technique to the interpretation of geologic structure in California because much of this region is within a simple shear regime of steeply dipping right-slip faults, between the Pacific and North American plates. Although the technique (Rich, 1934; Suppe, 1985) is useful in fold-thrust belts, as in the Canadian Rocky Mountains, it appears unable to incorporate strike-slip movements. The technique may not even be adaptable to the folds and reverse faults of the Transverse Ranges, as shown by Namson and Davis (1988a), because some of the faults, including the San Andreas, have substantial components of strike slip (Dibblee, 1982). The great earthquakes of 1857, 1872, and 1906 were caused by strike, or oblique, slips on steeply dipping faults, and the large seismic events of 1933, 1952, and 1971 were also generated by steeply dipping faults with strong strike-slip components. Furthermore, the rapidly accumulating focal mechanism solutions, including those very small earthquakes, indicate a preponderance of strike slip on steeply dipping faults. Therefore I doubt the implication by Namson and Davis (1988a) that thrust faults have a high potential for generating large earthquakes (the 1983 Coalinga and 1987 Whittier Narrows events are historically unique). The relative importance of thrust faults in California requires geologic evidence, perhaps only attainable with more and better reflection seismic surveys. (Many of the thrusts in balanced cross sections are artifacts of the technique.) I applaud Namson and Davis for writing, and *Geology* for publishing, this paper because it stimulates the pursuit of geologic truth.

REPLY

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Hill doubts the use of balanced cross sections in the Transverse Ranges and other parts of California because of the presence of strike-slip faults and reverse faults with strike-slip components, and the dominance of oblique-slip earthquakes. He suggests that the 1983 Coalinga and 1987 Whittier Narrows thrust earthquakes are unique and unrepresentative. We address these doubts as follows.

1. The San Andreas fault is the only late Cenozoic strike-slip fault with demonstrated large offset that occurs in our regional transect. The amount and sense of slip on the Santa Ynez fault are equivocal (Namson and Davis, 1988a). Although strike-slip faults are common in the western Transverse Ranges, demonstrated lateral offsets are no more than a few kilometres and/or predate late Pliocene and Quaternary compression (e.g., Newport-Inglewood zone <3 km, Hill, 1971; Whittier fault <0.8 km, Gourley, 1971). We (Namson and Davis, 1988b) presented a kinematic model that accommodates major offset along the San Andreas fault (and associated earthquakes; 1857, 1906) and contemporaneous compression. The model is consistent with the balanced cross-section technique and recently published analyses of the state of stress in California (Mount and Suppe, 1987).

2. Detailed analyses of the late Pliocene–Quaternary Pleito thrust (Davis and Namson, 1987) and Morales thrust (Davis et al., 1988) show little or no strike-slip (<1 km) and large dip-slip (5–15 km) offsets. Documentation of late Cenozoic strike-slip offsets on reverse faults is lacking, and we interpret many of these faults as Miocene to Pliocene basin-edge normal faults that have been folded into a reverse-fault geometry by late Cenozoic compression (e.g., Santa Monica fault system, Jacobson and Lindblom, 1987; Whittier fault, Yerkes, 1972; Oak Ridge fault, Namson, 1987; White Wolf fault, Davis and Namson, 1987).

3. The 1952 Arvin-Tehachapi earthquake had a major component of dip slip and a minor component of left-lateral slip. The earthquake is interpreted to be on a thrust ramp responsible for the anticline at the north Tejon oil field (Davis and Namson, 1987), and the left slip can be accounted for by north-south compression relieved along a northeast-striking ramp. The 1971 San Fernando earthquake had a minor component of strike slip (Whitcomb et al., 1973), and this earthquake is interpreted to be on a thrust ramp that is constructing the south flank of the San Gabriel Mountains (Davis and Namson, 1988). The 1933 Long Beach earthquake is thought to have occurred on the Newport-Inglewood fault zone. The small offset on this zone suggests that these types of events are infrequent and that strike-slip deformation has played a minor role relative to compression. Focal mechanism maps of the Transverse Ranges show a predominance of compressional earthquakes, except along the San Andreas and San Jacinto faults (Yerkes and Lee, 1979; Yerkes, 1985), and recent moderate-sized earthquakes also show dominantly dip-slip motion (1973 Pt. Mugu, Ellsworth et al. [1973]; 1978 Santa Barbara, Corbett and Johnson [1982]; 1979 Malibu, Hauksson and Saldivar [1986]; 1987 Whittier Narrows, Hauksson et al. [1988]).

4. Abundant geologic evidence for compression and compressional seismicity suggests that the 1983 Coalinga and 1987 Whittier Narrows thrust-related earthquakes are typical in the Transverse Ranges and Coast Ranges of California. Our interpretations integrate the surface and subsurface data, seismic reflection data (Namson and Davis, 1988a; Davis et al., 1988), and earthquake characteristics into a testable and viable structural solution that we feel is an improvement over previous work. We also feel that the success of balanced cross sections in oil and gas exploration and seismic risk evaluation in California strongly support its application.

We thank Hill for expressing his doubts about our new ideas on California structural geology in this forum.

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