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The pattern of (oblique) thrust reactivation of Miocene low-angle (oblique) normal faults, Inner California Borderland

Identification of the problem and implications

The near offshore between Santa Monica and San Diego includes right-lateral faults with several mm/yr. combined slip rates. Regional-scale low-angle Miocene normal faults are imaged that dip beneath the mainland coast. The extent of contractional folding and its relation to regional low-angle faults affects the probability of major thrust earthquakes vs. the <M6 historic thrust quakes. Obviously a thrust rupture extending 200 km along the linked Santa Monica Bay-Catalina Island detachment-30 Mile Bank “thrust”, or a 100 km thrust rupture on the Oceanside “thrust”, both extending farther into Mexican waters, would have strong ground motion and tsunami consequences. Alternatively, thrusting focused in the north, or strike-slip faulting with thrusting only on restraining segments, could still produce damaging earthquakes, but the spatial extent and duration of strong ground motion, and the extent and size of tsunamis, would be very different.

Summary of Approach

We analyzed several thousand kilometers of deep-penetration industry multi-channel seismic reflection data (MCS), high resolution U.S. Geological Survey MCS profiles, bathymetry, and published and Bureau of Ocean Energy Management interpretations of well and core data. Interpretations of faults and Plio-Quaternary stratigraphic horizons through all the MCS data were gridded and depth-converted. The known 3D fault attitude and structural relief of a 1.95 Ma horizon were inputs to trigonometric displacement modeling using ranges of directions and magnitudes of the hanging-wall above a fault.

Results

The San Mateo-Carlsbad fault forms a downward-converging transpressional “flower structure” geometry with the right-lateral Newport-Inglewood fault. South of latitude 33°, several left-stepping en-echelon strands of the Coronado Bank fault zone form a transtensional (negative) flower structure geometry with the Descanso fault in Miocene through Quaternary strata. There is an ~18 km-wide right stepover between the northern and southern flower structures. The trigonometric modeling indicates between 0.6 and 1.0 km of post-~1.95 Ma pure right-lateral displacement at the northern bend of the stepover. Similar patterns of deformation of four post-780 ka horizons suggest that slow right-lateral slip continued through late Quaternary time. This stepover marks a boundary between regional Quaternary transpression in the north and transtension in the south. Thus, either there is little thrust hazard south of latitude 33°, or thrusting is too young and/or too slow to build significant structure. The Palos Verdes anticlinorium overrides the low-angle faults north of latitude 33.5°, but the upper, southwest parts of these faults have not been significantly thrust-reactivated, except locally associated with bends in right-lateral faults.