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Evolving transpressional strain fields along the San Andreas fault in southern California: implications for fault branching, fault dip segmentation and strain partitioning

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The San Andreas fault in southern California records only few large-magnitude earthquakes in historic time, and the recent activity is confined primarily on irregular and discontinuous strike-slip and thrust fault strands at shallow depths of ∼5–20 km. Despite this fact, slip along the San Andreas fault is calculated to c. 35 mm/yr based on c.160 km total right lateral displacement for the southern segment of the fault in the last c. 8 Ma. Field observations also reveal complex fault strands and multiple events of deformation. The presently diffuse high-magnitude crustal movements may be explained by the deformation being largely distributed along more gently dipping reverse faults in fold-thrust belts, in contrast to regions to the north where deformation is less partitioned and localized to narrow strike-slip fault zones. In the Mecca Hills of the Salton trough transpressional deformation of an uplifted segment of the San Andreas fault in the last ca. 4.0 My is expressed by very complex fault-oblique and fault-parallel (en echelon) folding, and zones of uplift (fold-thrust belts), basement-involved reverse and strike-slip faults and accompanying multiple and pervasive cataclasis and conjugate fracturing of Miocene to Pleistocene sedimentary strata. Our structural analysis of the Mecca Hills addresses the kinematic nature of the San Andreas fault and mechanisms of uplift and strain-stress distribution along bent fault strands. The San Andreas fault and subsidiary faults define a wide spectrum of kinematic styles, from steep localized strike-slip faults, to moderate dipping faults related to oblique en echelon folds, and gently dipping faults distributed in fold-thrust belt domains. Therefore, the San Andreas fault is not a through-going, steep strike-slip crustal structure, which is commonly the basis for crustal modeling and earthquake rupture models. The fault trace was steep initially, but was later multiphase deformed/modified by oblique en echelon folding, renewed strike-slip movements and contractile fold-thrust belt structures. Notably, the strike-slip movements on the San Andreas fault were transformed outward into the surrounding rocks as oblique-reverse faults to link up with the subsidiary Skeleton Canyon fault in the Mecca Hills. Instead of a classic flower structure model for this transpressional uplift, the San Andreas fault strands were segmented into domains that record; (i) early strike-slip motion, (ii) later oblique shortening with distributed deformation (en echelon fold domains), followed by (iii) localized fault-parallel deformation (strike-slip) and (iv) superposed out-of-sequence faulting and fault-normal, partitioned deformation (fold-thrust belt domains). These results contribute well to the question if spatial and temporal fold-fault branching and migration patterns evolving along non-vertical strike-slip fault segments can play a role in the localization of earthquakes along the San Andreas fault.