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Shortening accommodated by extension-parallel folding of detachment faults during oblique rifting in the Gulf of California

Christian Seiler (1) and John Fletcher (2)

(1) School of Earth Sciences, The University of Melbourne, Victoria 3010, Australia (seilerc@unimelb.edu.au), (2) Dep. de Geologia, CICESE, Carr. Tijuana-Ensenada, Ensenada, BC 22800, Mexico

Large-scale fault corrugations or megamullions are a common feature of detachment faults and form either as original fault grooves, displacement-gradient folds or constrictional folds parallel to the extension direction. In highly oblique extensional settings such as the Gulf of California, horizontal shortening perpendicular to the extension direction is an inherent part of the regional stress field and likely forms a key factor during the development of extension-parallel fault corrugations. However, the amount of horizontal shortening absorbed by megamullions is difficult to quantify, and constrictional folding is not normally thought to accommodate significant strike-slip deformation. The Las Cuevitas and Santa Rosa detachments are two low-angle normal fault systems exposed on the Gulf of California rifted margin in northeastern Baja California, Mexico. The two detachments accommodate between ∼7-9km of SE-directed extension and represent the next significant set of faults in direction of transport from the rift breakaway fault. Fault kinematics are highly complex, but suggest integrated normal, oblique- and strike-slip faulting, with kinematics controlled by the orientation of faults with respect to the regional transtensional stress field. Both fault systems are strongly corrugated, with megamullion amplitudes of ∼4-7km and half wavelenghts of between ∼15 to 20km. Differential folding of the syntectonic basin-fill of the supradetachment basins strongly suggest that the observed megamullions formed largely, though not exclusively, due to constrictional folding associated with the transtensional stress regime of the plate boundary. This is consistent with basin-scale facies variations that record differential uplift and subsidence in antiformal and synformal megamullion domains, respectively. Compared to the two detachments, the San Pedro Martir fault – the master fault of the rift system at this latitude – shows more subtle fault corrugations with amplitudes of <3km. Unlike the Las Cuevitas and Santa Rosa detachments, though, there is no evidence for constrictional folding on the San Pedro Martir fault. Instead, the observed corrugations likely represent original grooves of the fault plane, formed as adjacent fault nuclei joined along-strike during fault growth. Comparison between the sinuosity of the San Pedro Martir fault (1.08), attributed entirely to original fault asperities, with the sinuosity of the two detachment systems (Las Cuevitas detachment: 1.17, Santa Rosa detachment: 1.22), suggests that about 10% of shortening occurred on each of the two detachments due to synextensional constrictional folding. This corresponds to a combined total of ∼8km of N-S shortening, or ∼10km of dextral shear resolved in direction of the relative plate motion, and occurs in addition to ∼21km of right-lateral strain accommodated by clockwise vertical-axis block rotations. Thus, strain in this part of the rift system was partitioned between discrete extensional faulting on the two detachment systems, and significant right-lateral shear accommodated by distributed volume deformation.