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The Ups and Downs of extension-parallel folding: Stratigraphic evolution of a constrictional rift basin during oblique opening of the Gulf of California

Christian Seiler (1), Mark Quigley (2), and John Fletcher (3)

(1) School of Earth Sciences, The University of Melbourne, Victoria 3010, Australia (seilerc@unimelb.edu.au), (2) Dep. of Geological Sciences, University of Canterbury, Christchurch 8140, New Zealand, (3) Dep. de Geologia, CICESE, Carr. Tijuana–Ensenada, Ensenada, BC 22800, Mexico

Oblique opening of the Gulf of California provides a unique opportunity to study the mode of deformation in transtensional rift systems. Sedimentation in rifted basins is primarily controlled by the characteristics of the basin-bounding fault and the available sediment supply, and can thus be used as a proxy to understand tectonic processes during oblique shear. Transtensional basins are generally seen as composites between rift and pull-apart basins, with facies distributions that are controlled by interacting normal and strike-slip faults. Yet, transtensional shear may also be accommodated by more distributed constrictional strain that is not localised along fault zones. The Santa Rosa basin, located in the Sierra San Felipe of northern Baja California, is one of a series of transtensional syn-rift basins along the oblique-divergent plate boundary of the northern Gulf of California. The basin represents an asymmetric half-graben in the hanging wall of the Santa Rosa detachment, a low-angle normal fault with ∼4-5km of E- to SE-directed displacement. The basin-fill dips NW into the detachment and displays form lines that mimic the corrugations of the detachment. The basin is broadly sigmoidal in shape, is truncated in the south by a dextral transfer zone and pinches out against the hanging wall basement in the north. The syn-rift stratigraphy is dominated by a sequence of alluvial fans shed from the hanging wall and footwall that interfinger with fine grained playa deposits. Stratigraphic analysis reveals systematic basin-scale variations in facies distributions, both along and across the axis of the basin. In a transverse direction, the basin-fill records a fining-upward cycle from conglomerate at the base to alternating sandstone-mudstone in the depocentre, which in turn interfingers with the proximal fault-scarp facies of the Santa Rosa detachment. Facies patterns also vary parallel to the basin axis even though finite displacement on the detachment was comparable along the length of the basin, indicating that different depositional environments were active at any one time. Importantly, the depocentre facies evolved progressively further upsection and thus later towards the southern Santa Rosa basin, where the detachment enters a broad synformal domain. Moreover, only the proximal (conglomeratic) fan facies developed in the eastern part of the basin, which lies adjacent to a major antiformal corrugation of the detachment. These relationships suggest that changes in the depositional environment are genetically linked to the corrugations of the detachment fault, which represent upright open folds that formed in the N-S constrictional strain regime of the transtensional plate boundary. The upward vertical deflection caused by antiformal folding led to increased uplift in both foot- and hanging wall, thereby choking the basin with coarse conglomerate and breccia. By comparison, the downward deflection in the synformal domain resulted in a lowering of the surface and the development of a well-established depocentre in the southern Santa Rosa basin.