Basins in Motion: Tectonic Inversion and Evolution of Migrating Releasing Step-Overs

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Bends and step-overs along strike-slip faults create localized basins or push-up ridges. The basins created by releasing bends can be source and reservoir for hydrocarbons. The current working model for the evolution of releasing bends does not correlate with field observations. The traditional model states that a bend or step-over grows in structural relief with progressive slip on the principle strike-slip fault. Such a relationship cannot explain basin deposits outside the current basin, the average 1:3 ratio of basin width to length, nor the fact that fault boundaries change with time. Wakabayashi (2004, 2007) recently proposed that the location of bends and step-overs migrate along strike of the primary strike-slip fault. The migrating step-over hypothesis proposes that at a step-over, one fault tip propagates in one direction faster than the relative far field motions, whereas the other side of the fault dies out. Thus, the step-over basin migrates at a different rate than regional crustal velocities. When the bend or step-over migrates it creates a new active basin and abandons former basin deposits. This model predicts that when migration occurs, this leaves a 'tectonic wake' of former basin deposits that are no longer in the active bend or step-over. I conducted a field test of a suspected migrating releasing and restraining bend pair in Fish Lake Valley, California/Nevada. Uplifted and shortened playa deposits demonstrate that the southern Fish Lake Valley transitioned from extension and subsidence to shortening and uplift. The localized tectonic inversion is a result of a releasing bend and a restraining bend to its southeast, both migrating northwest. Hypsometry of drainage basins draining the upland area southeast of Fish Lake Valley shows progressively more mature topography southeastward of Fish Lake Valley over 7 km of the Sylvania Mountains. This is consistent with northward migration of a restraining step-over, causing progressive uplift and shorting during northward migration. The migrating step-over hypothesis proposes that many pull apart basins may have evolved differently than traditionally thought, predicting different relationships between fault slip, basin geometry, and time-burial history of sediments. This implies that areas of petroleum reserves may exist where not currently sought. This could open up new reserve opportunities in petroleum-bearing pull-apart basins.