Geomorphic evidence for active, co-seismic slip along a low-angle normal fault: Panamint Valley, California

Eric Kirby¹, Israporn (Grace) Sethanant¹, John Gosse², Eric McDonald³, and J Doug Walker⁴
¹Oregon State University, College of Earth, Ocean and Atmospheric Sciences, Corvallis, OR, United States of America (eric.kirby@oregonstate.edu)
²Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia, Canada
³Desert Research Institute, Reno, NV, United States of America
⁴Department of Geology, University of Kansas, Lawrence, KS, United States of America

The mechanical feasibility of co-seismic displacement along low-angle normal fault systems remains an outstanding problem in tectonics. In the southwestern Basin and Range of North America, large magnitude extension during Miocene – Pliocene time was accommodated along a regionally extensive system of low-angle detachment faults. Whether these faults remain active today and, if so, whether they rupture during large earthquakes are questions central to understanding the geodynamics of distributed lithospheric deformation and associated seismic hazard. Here we evaluate the geometric and kinematic relationships of fault scarps developed in Pleistocene – Holocene alluvial and lacustrine deposits with low-angle detachment faults observed along the western flank of the Panamint Range, in eastern California. We combine analysis of high-resolution topography generated from airborne LiDAR and photogrammetry with a detailed chronology of alluvial fan surfaces and a calibrated soil chronosequence to characterize the recent activity of the fault system. The range-front fault system is coincident with a low-angle (15-20°), curviplanar detachment fault that is linked to strike-slip faults at its southern and northern ends. Fanglomerate deposits in the hanging wall of the detachment are juxtaposed with brecciated bedrock in the footwall across a narrow fault surface marked by clay-rich gouge. Isochron burial dating of the fanglomerate using the $^{26}$Al and $^{10}$Be requires displacement in the past ~800 ka. The degree of soil development in younger alluvial deposits in direct fault contact with the footwall block suggest displacement along the main detachment in the past as ~80-100 ka. The geometry of recent fault scarps in Holocene alluvium mimic range-scale variations in strike of the curviplanar detachment fault, suggesting that scarps merge with the detachment at depth. Moreover, fault kinematics inferred from displaced debris-flow levees and from fault striae on the bedrock range front are consistent with slip on a low-angle detachment system beneath the valley. Finally, paleoseismic results from a trench at the southern end of the fault system suggest 3-4 surface ruptures during past ~4-5 ka, the most recent of which (MRE) occurred ~330-485 cal yr BP. Scarps related to the MRE can be traced for at least ~50 km northward along the range front and imply surface displacements of 2-4 meters during this event. Thus, we conclude that ongoing dextral shear along the margin of the Basin and Range is, in part, accommodated by co-seismic slip along low-angle detachment faults in Panamint Valley. Our results have important implications for the
interaction of fault networks and seismic hazard in the region.