

Temporal evolution of surface rupture deduced from coseismic multi-mode secondary fractures: Insights from the October 8, 2005 (Mw 7.6) Kashmir earthquake, NW Himalaya

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Detailed rupture–fracture analyses of some of the well-studied earthquakes have revealed that the geometrical arrangement of secondary faults and fractures can be used as a geological tool to understand the temporal evolution of slip produced during the mainshock. The October 8, 2005 Mw 7.6 Kashmir earthquake, surface rupture provides an opportunity to study a complex network of secondary fractures developed on the hanging wall of the fault scarp. The main fault scarp is clearly thrust-type, rupture length is $\sim 75 \pm 5$ km and the overall trend of the rupture is NW–SE. We present the results of detailed structural mapping of secondary faults and fractures at 1:100 scale, on the hanging wall of the southern end of the rupture in the vicinity of the Sar Pain. Secondary ruptures can be broadly classified as two main types, 1) normal faults and, (2) right-lateral strike-slip ‘Riedel’ fractures. The secondary normal faults are NW–SE striking, with a maximum 3.3 meter vertical displacement and 2.5 meter horizontal displacement. Estimated total horizontal extension across the secondary normal faults is 3.1–3.5%. We propose that the bending moment and coseismic stress relaxation can explain the formation of secondary normal faults on the hanging wall of the thrust fault. The strike-slip ‘Riedel’ fractures form distinct sets of tension (T) and shear fractures (R', R, Y) with right-lateral displacement. Field observations revealed that the ‘Riedel’ fractures (T) cut the secondary normal faults. In addition, there is kinematic incompatibility and magnitude mismatch between the secondary normal faults and strike-slip ‘Riedel’ fractures. The cross-cutting relationship, and geometric and magnitude incoherence implies a temporal evolution of slip from dip- to strike-slip during the mainshock faulting. The interpretation is consistent with the thrust fault plane solution with minor right-lateral strike-slip component.