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Extensive Surface Fault Rupture Associated with the 2005 MW 7.6 Pakistan Earthquake

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The 8th October 2005 Pakistan earthquake caused appalling devastation with reportedly more than 86, 000 fatalities over mountainous Kashmir and the North-West Frontier regions. Teleseismic analysis suggests that large thrusting event occurred north of the local capital city of Muzaffarabad, with seismic moment release equivalent to Mw 7.6 (USGS). We here present the results of our reconnaissance field investigation conducted in late January 2006, which revealed a 65-km-long surface rupture with up to 5.5 m vertical separation, mostly along the pre-existing active fault trace. The NW-trending surface rupture extends from Balakot (N34d33.2m, E73d20.9m) in northwest, via just north of Muzaffarabad, to northwest of Bagh (N34d04.6m, E73d44.6m) in southeast. Typical surface expression of faulting is a NE-side-up fault scarp or warp with surface shortening features at its base and tension cracks on its crest. Minor right-lateral slip is also observed at some places. Electronic distance meter profiling across those scarps suggests vertical separation ranging from 1.5 to 5.5 m along the 50-km-long main section from Balakot to Dhallan. In the middle of the main section, just north of Muzaffarabad, we found an ENE-striking 2-to-3-km-long lateral ramp connecting left-stepping main fault strands, collectively producing an S-shaped surface geometry. We measured large vertical displacement of 4-5 m and horizontal shortening of up to 9 m there. In contrast to the general minor right-lateral strike-slip sense elsewhere along the fault, the lateral ramp section is associated with minor left-lateral component. The southeasternmost 15-km section between Dhallan and northwest of Bagh is characterized by discontinuous small surface ruptures as we found en-echelon cracks and mole tracks with small right-lateral offset less than several tens of cm at two sites along that section. Location, extent, and amount of displacement of the surface rupture are consistent with both the subsurface source process based on seismographic data, and surface deformation analyzed from satellite observations. One important feature of the surface

rupture is that it faithfully follows a pre-existing active fault trace deduced from cumulative geomorphic expression (such as displaced terrace surfaces and offset streams), some of which had been mapped earlier (Nakata et al., 1991). For instance, at Malsi Pain, 20 km southeast of Muzaffarabad, a terrace surface standing 50 m above present riverbed shows cumulative vertical separation of 40 m, where we found a 4.5-m-high fault scarp associated with the 2005 earthquake. Another intriguing observation is extremely severe house damage confined within a rather narrow zone along the surface fault ruptures. This appears to be attributed to ground failure due to surface faulting as well as extraordinarily strong ground shaking adjacent to the source fault.