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Thrust related relief development and seismicity of the Indian Sub-Himalaya: A critical taper model perspective for the regional seismic hazard

Riccardo Caputo (1), Tejpal Singh (2), and Arun Awasthi (3)

(1) University of Ferrara, Dept. Earth Sciences, Ferrara, Italy (rcaputo@unife.it, +39 0532 974767), (2) CSIR-Centre for Mathematical Modelling and Computer Simulation, Bangalore-560037, India (tejpal@cmmacs.ernet.in), (3) Department of Earth Sciences, Indian Institute of Technology Roorkee, Roorkee-247667, India (prachfes@iitr.ernet.in)

The frontal Himalayan region, India, represents a classical example of relief evolved and evolving within a compressional tectonic setting. Relief-creation processes are mainly induced by dip-slip reverse faulting along major low-angle thrusts and the consequent uplift of the hanging-wall block(s). The most external of these major fault planes, i.e. the Himalayan Frontal Thrust (HFT), also marks the tectonic and topographic boundary between the Himalayan orogen and the Indo-Gangetic alluvial plain representing its foredeep basin. The hanging-wall block of the HFT consists of clastic deposits belonging to the Siwalik Group and geographically coincides with the so-called Sub-Himalayan mountain belt characterized by low-relief hills variably dissected by the ongoing erosion. This major tectonic unit is in turn delimited to the north by the Main Boundary Thrust (MBT). The relatively young age of the Sub-Himalayan hills provides an opportunity to investigate the thrust-related evolution of the relief, especially in the early stages of nucleation and propagation of a thrust as well as the relationships between large-scale topography and local seismicity. The new data presented in this paper mainly pertains to the first order topography of the uplifted hanging-wall block of the HFT. They reveal a marked lateral variation along the strike of the Sub-Himalayan belt, in terms of both topographic features and mean topographic gradient. Two major settings are recognised; the one characterised by a very small mean slope angle (ca. 1°), the other by typically higher values (ca. 3°). Transitions between the two topographies are relatively sharp that allows to distinguish different sectors within the Sub-Himalayan belt roughly reflecting the occurrence of the well-known Kangra and Dehradun reentrants and Nahan salients. Both relief distribution and associated topographic features also show a good correspondence with the peculiar macroseismic field of the M=7.8, 1905 Kangra earthquake, which is characterised by two distinct intensity maxima, separated by a distance of about 100 km, clearly overlapping the two major tectonic reentrants. A similar dichotomy is observed in the distribution of the recent instrumental seismicity. Moreover, based on available geological information and constraints, we analyse the area in terms of critical taper model attempting to clarify the possible correlations between tectonics, morphology and seismicity in the Sub-Himalayan belt. The analysis allows constraining possible seismotectonic scenarios and hence suggesting the existence of a seismic gap in the area corresponding to the Nahan Salient, which may experience an event possibly of significant magnitude.