Growth of drainage basins and sediment transport in the Dehradun Reentrant and Nahan Salient of the NW Sub-Himalaya: a comparative study

Tejpal Singh[1], A. K. Awasthi[2]

[1]Centre for Mathematical Modelling and Computer Simulation, NAL Belur Campus, Bangalore-560037, India
geotejpal@yahoo.co.in
[2]Department of Earth Sciences, Indian Institute of Technology Roorkee, Roorkee-247667, India

The kinematics of deformation within the foreland basins is realtively simple, but may be highly variable in space and time depending on the presence and orientation of pre-existing structures (DeCelles and Giles, 1996). We wish to understand how the variation in the kinematics of deformation and the geological structure effect the development of the surface topography, that in turn governs the evolution of the drainage network, basin geometries and related sediment transport processes.

The Sub-Himalayan belt is a classical example that has been sub-divided into a number of sub-basins based on the tectonic framework and basement geometry (Raiverman, 2002). The main structural entities present in the NW Sub-Himalayan belt include the areas of Kangra Reentrant, Nahan Salient and the Dehradun Reentrant (Figure 1).

Uplift within this belt has given rise to variable structural geometries in the abovementioned areas that manifest variable amount of shortening (Powers and others, 1998; Dubey and others, 2001) and convergence/slip/uplift rates in the NW Sub-Himalayan belt (Kumar and others, 2006). It varies a lot in space and time as demonstrated by the distribution of the topographic elevation (Figure 2). This uplift has given rise to a large number of drainage basins along the mountain front that exhibit variable geometries and surface topography. We integrate the morphometric data of these drainage basins with the field observations to characterize the geometry and surface topography of these basins (Figure 3). The most apparent and significant difference is in the form of basin areas. The basins present on the Mohand ridge

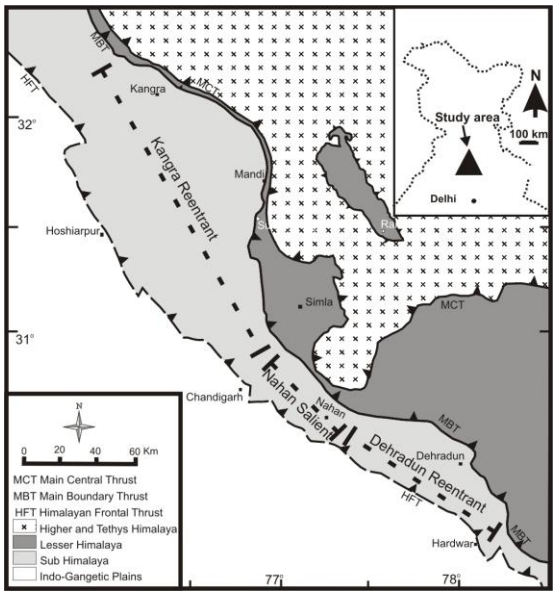

Figure 1. Tectonic sub-divisions of the NW Himalaya marked by the presence of the Kangra and Dehradun Reentrants and Nahan Salient. The study area is located in the Sub-Himalayan belt along the Himalayan front.

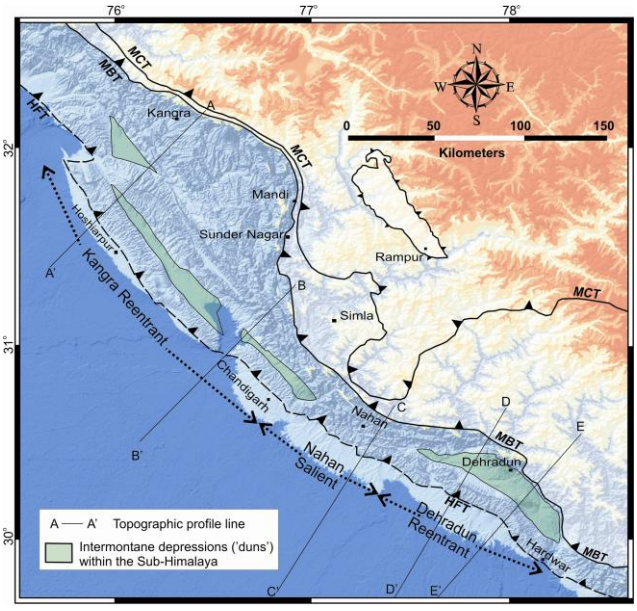

Figure 2. The topography of the NW Himalaya in India with special emphasis on the Sub-Himalayan belt present between the HFT and the MBT. This belt is broadly marked by the presence of the sinuous trace of the MBT giving rise to reentrants and salients.

of the Dehradun area are relatively much smaller (<35 km^2) and highly elongated, in comparison to the basins in the Morni Hills of Nahan area, which are much larger in area (>100 km^2) and poorly elongated. The stream profiles from the Mohand area conform to a second order curve that is relatively steeper towards the head region of the basin. No such distinct change in the gradient of the stream profiles from the Nahan-Morni area has been observed. The difference in the nature of stream profiles in these two areas with structural and topographic differences reflect distinctive differences in their respective stream powers. Stream power controls the sediment transport processes (Burbank and Verges, 1994).

Investigation of the sediment present within the basin bounds as well as their fans clearly indicates significant differences in the growth of basins, character of sediments and the related transport processes in the Dehradun and Nahan Morni areas. Stream profiles in the Dehradun area indicate that the basins grow by headward erosion; most of the sediment is sand size and is transported out of the basin by active streams. The slopes are mantled by a thin veneer of regolith and the structure of the underlying bedrock is clearly apparent. All the material is dumped at the towhead where it is consequently incised and forms terraces. The valleys are steep and narrow and mainly occupied by active channels. In contrast, in the Nahan-Morni area the basins grow by coalescence. They have broad valleys with very small active channels. The sediment are relatively coarser in nature mainly varying from sand to boulders larger than 50 cm. The slopes are covered by abundant loose regolith. Exposures of the bedrock are minor. These indicate that the main transport mechanism is debris flow during high discharge. Incision is dominant and broad flat terraces that completely cover the bedrock are prevalent all through the basins.

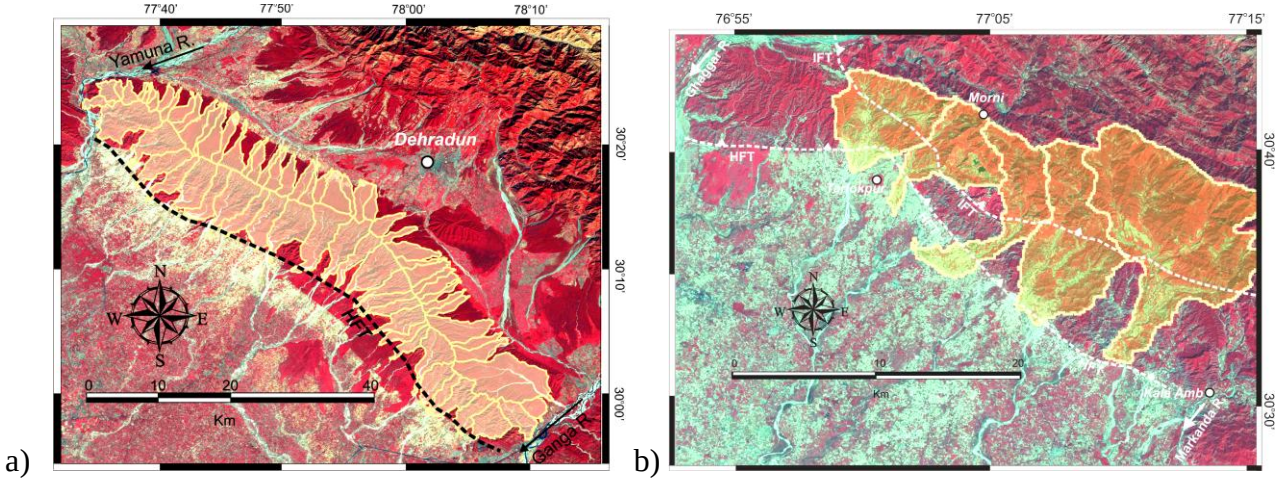

Figure 3. Drainage basins of (a) Dehradun Reentrant and (b) Nahan Salient.

References

Burbank, D.W., and Verges, J., 1994, Reconstruction of topography and related depositional systems during active thrusting, Journal of Geophysical Research, 99, 20281-20297.

DeCelles, P. G., and Giles, K. A., 1996, Foreland basin systems, Basin Research, 8, 105-123.

Dubey, A..K., Misra, R., and Bhakuni, S. S., 2001, Erratic shortening from balanced cross sections of the western Himalayan foreland basin: causes and implications for basin evolution, Journal of Asian Earth Sciences, 19, 765-775.

Kumar, S., Wesnousky, S.G., Rockwell, T.K., Briggs, R.W., Thakur, V.C., and Perumal, R.J., 2006, Paleoseismic evidence of great surface rupture earthquakes along the Indian Himalaya, Journal of Geophysical Research, 111, B03304, doi: 10.1029/2004JB003309.

Powers, P.M., Lille, R.J., and Yeats, R.S., 1998, Structure and shortening of the Kangra and Dehradun Reentrants, Sub-Himalaya, India. Geol. Soc. Am. Bull., 110, 1010-1027.

Raiverman, V. 2002, Foreland sedimentation in Himalayan tectonic regime: A relook at the orogenic process, Bishen Singh Mahendra Pal Singh Publishers, Dehradun, India, 371.

Cite as: Singh, T. and Awasthi, A.K., 2010, Growth of drainage basins and sediment transport in the Dehradun Reentrant and Nahan Salient of the NW Sub-Himalaya: a comparative study, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 2 p. [http://pubs.usgs.gov/of/2010/1099/singhtejpal/].