Tectono-Geomorphic and Climatic Controls on Landscape Development in the Lesser Himalaya

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Large annual precipitation, fluvial erosion and high sediment flux cause sensitivity to interactions and possible feedbacks between tectonic, geomorphic and climatic processes, leading to along-strike variations and asymmetric development of the Himalaya. This paper discusses the formation of antiformal/domal structure in Sikkim and the role of complex out-of-sequence thrusting (OST) and normal and strike-slip faulting in the Main Central Thrust (MCT) zone, and related neotectonic activity from Garhwal to Sikkim and into the Eastern Himalaya. GIS-based geomorphotectonic study indicates that there is high tectonic activity and uplift in the study area especially along the MCT-III and that OST and normal and strike-slip faulting in the area are the main factors for developing the current landscape morphology, organization and formation of the drainage network. The EPM model (Erosion Potential Method, Gavrilovic, 1988) depicted areas of high or low sediment yield and its relation with tectonic activity. On the other hand, along the thrusts and faults, sediment yield estimated pixel-by-pixel showed that the tectonic zone around the MCT-II is highly active. The erosion rate for the Sikkim area is twice that of the Garhwal area (2.2mm/yr for Sikkim and 0.9 mm/yr for Garhwal). Incision/erosion rates are highest around the out-of-sequence MCT-III as calculated by the SPL model (Stream Power Law, Whipple and Tucker, 1999 and 2002). Active tectonic regions and major knickpoints of the rivers lie on the hanging wall of the out-of-sequence and near MCT-III, supporting the view that this stretch of valley is undergoing rapid exhumation. It is possible that the knickpoints along the rivers have been produced by differential uplift corresponding to movement of the thrusts.

The exhumation rates derived by from available P-T-t data indicate that the Garhwal area between MCT-I (Vaikrita Thrust) and MCT-II (Munsiari Thrust) was active up to ~10 Ma (exhumation <1 mm/yr) whereas the area between the Munsiari Thrust (MCT II) and MCT III (Srinagar Thrust/Ramgarh Thrust) was active between ~2.65 to 1 Ma (exhumation >1 mm/yr). Incision rates obtained from by ^{10}Be dating indicate that out-of-sequence MCT-III areas are very active, with exhumation rates about 6–10 mm/y.

The relation between linear factors and areal factors shows the real-time changes in landforms that are caused due to active tectonics in and around Gangtok and the out-of-sequence thrusts. Ratios of valley floor width to valley height (V_f) values, being one of the best morphometric parameters for tectonic studies, were calculated along the Gangtok river and its tributaries, especially in the vicinity of thrusts. V_f values at the intersection of the OST/ MCT-III are 12 to 18 times less than for the MCT-I. Fission-track ages and Rb/Sr ages of biotite and muscovite confirm the exhumation data.

Along the Himalayan range, the interplay between topography and the Indian summer monsoon circulation profoundly controls precipitation distribution, erosion, sediment transport, and river discharge. In the study area the amount and trend of precipitation is controlled by the tectonic settings and topography of the area.

References

Gavrilovic, Z., 1988, The use of an empirical method (erosion potential method) for calculating sediment production and transportation in unstudied or torrential streams, International Conference of River Regime, 18–20 May, Wallingford, England, 411–422.

Whipple, K. X. and Tucker, G.E., 1999, Dynamics of the stream-power river incision model: implications for height limits of mountain ranges, landscape response timescales, and research needs, Journal of Geophysical Research, 104, 17661–17674.

Whipple, K. X. and Tucker, G.E., 2002, Implications of sediment-flux dependent river incision models for landscape evolution. Journal of Geophysical Research, 107, 2039.

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