Steepness Maxima and Transitions along the Modi Khola do not Correspond to Differences in Apatite Fission Track and (U-Th)/He Ages

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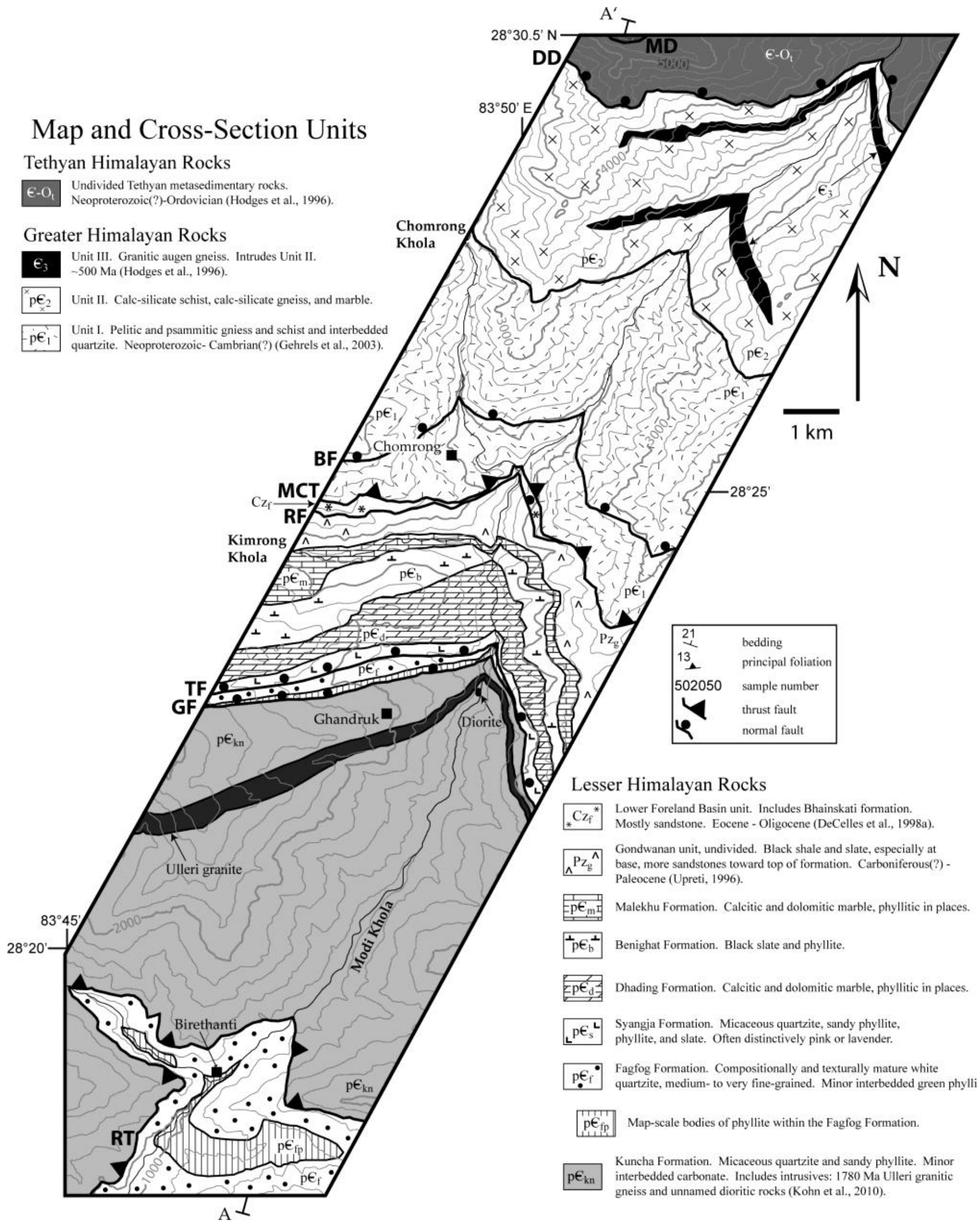
Two of the classical foci of studies in tectonic geomorphology are steepness changes and maxima on major bedrock river systems. These studies typically identify multiple such features in large bedrock streams (recent examples from central Nepal include Kirby and Whipple, 2001; Wobus and others, 2003; 2005; and Hodges and others, 2004). Bedrock river systems are thought to respond quickly to even small-magnitude rock uplift, making steepness studies using them more sensitive indicators of rock uplift than most other techniques. Thus one of the main goals of many such studies is detection of active faults. However, several other processes can cause steepness changes on streams, including along-stream changes in lithology and precipitation, tributary junctions, and glacial or landslide damming of the river. In the absence of other data, generally it is not possible to discriminate among these possibilities.

We studied the Modi Khola, located in the western Annapurna Range of central Nepal, near and below the high elevations in the range because other workers, using data from other rivers in central Nepal, have suggested recent motion on faults at this position (Fig. 1; Wobus and others, 2003; 2005; and Hodges and others, 2004). We started with elevation contour lines digitized from topographic maps and interpolated using a multiquadric radial basis function to obtain a digital elevation model with 25 meter resolution (Hardy, 1990; Buhmann, 2003). Using freely available software (Whipple and others, 2007), we identified a high concavity zone on the river and steepness transitions and maxima within this high concavity zone. The steepest reach of the river is located near or directly downstream from the Bhanuwa fault, a normal fault within Greater Himalayan rocks. The largest change in steepness overlaps spatially with the Romi fault, a normal fault within Lesser Himalayan rocks.

In order to assess whether any of these steepness features may be caused by active faults, we obtained apatite fission-track and (U-Th)/He (AHe) ages from fifteen Greater and Lesser Himalayan pelites and quartzites at nearly constant elevation, 2220 meters above sea level. Fission track ages are mostly c. 0.8 Ma, and large uncertainties mean outliers cannot be distinguished with confidence to have a different age. AHe ages are mostly near 0.5 Ma, also with large uncertainties. Neither type of age shows any apparent difference between the fifteen samples. We modeled cooling paths of the samples using AHe ages and fission track ages and lengths and likewise find no statistically robust difference in cooling histories between any of the samples. Thus at the temporal resolution of the apatite fission-track and He data, we find no support for motion on faults in this region of the Modi Khola valley in the past c. 1 million years, and suggest that the steepness maxima and transitions on the river likely result from other causes.

Figure 1 (following page). Geologic map of part of the Modi Khola valley showing the study area. The detailed geologic map allowed comparison of structural and lithologic features with steepness maxima and changes on the river. Modified from Martin and others (2010).



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