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Detrital Mineral Cooling-Age Signal Variability and Erosion Rates, Marsyandi Valley, Central Nepal

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Detrital mineral cooling ages from modern rivers have been used as a proxy for long-term erosion rates because they integrate bedrock cooling ages from the contributing basin. In theory, each age represents a particle's vertical travel time from the steady-state closure isotherm, such that, for a basin eroding at a constant, uniform rate that balances uplift, the shape of the predicted distribution of ages mimics the contributing area's hypsometry, and its width is defined by the erosion rate if uniform chronometer distribution and insignificant sediment transport/storage time requirements are satisfied. Based on our interpretation of new $^{40}\text{Ar}/^{39}\text{Ar}$ ages for >300 individual detrital muscovite grains from central Nepal, we suggest that results for this approach to estimating long-term erosion rates can vary significantly by grain size, sample size, site selection, and year-to-year sediment redistribution within a single tributary basin.

Large samples ($n > 80$) of fine muscovite (250-500 microns), coarse muscovite (> 500 microns), and smaller samples dated by previous workers from the Marsyandi River and its tributaries were compared in order to quantify natural detrital cooling-age signal variability and to explore the degree to which model requirements are met. While the present study's trunk stream age distributions generally agree with the spread of previously dated grains, distinct populations were found in a single tributary basin for fine and coarse size fractions, samples collected in different years, and samples from nearby locations. This variability is equally consistent with significant sediment storage time due to landslide or flood, spatially or temporally variable erosion rates, unevenly distributed lithologies, and/or transient topography. In addition, no uniform steady-state vertical erosion rate can account for the entire signal in any sample from this study, highlighting the need to assess independently natural sampling variability and the likelihood of steady state at the catchment scale before this or any more complicated erosion model can be used to interpret detrital cooling ages in terms of erosion rates.

It is unlikely that simple thermal/erosion models can be used to infer surface process rates from modern detrital cooling-age distributions in this setting. However, combined with structural mapping in the contributing basin, detailed bedrock thermochronology and characterization of older sedimentary deposits derived from the catchment, this type of dataset can be used to explore differential erosion, erosion-rate increase/decrease and the appropriate temporal and spatial scales for steady state.