Neogene exhumation history of the Bhutan Himalaya quantified using multiple detrital proxies

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Proper sampling to constrain the evolution of fault geometries and kinematics, and quantify erosion rates in active orogens using *in situ* bedrock thermochronological data is often difficult, due to logistical and infrastructural challenges in high-elevation areas. Detrital thermochronology of modern river sands is an appealing alternative that has been used successfully in many instances, but typical assumptions that underlie the interpretation of detrital data, such as uniform catchment-wide erosion rates, can introduce bias in detrital data interpretation. Numerical tools able to predict detrital cooling ages subject to differential exhumation rates across individual catchments are now available (e.g. Whipp et al., 2009; Braun et al., 2011) to overcome some of these limitations. The aim of this paper is to quantitatively test whether the detrital thermochronometer record from modern river sands supports the tectonomorphic scenario extracted from *in situ* thermochronometer data along the Bhutanese range front (Coutand et al., 2014). In a second step, we use various topographic indices (e.g., channel steepness, relief, specific stream power) to test how topographic expression correlates with predicted exhumation patterns.

Our study focuses on the Bhutanese Himalaya, where the spatial and temporal evolution of Neogene exhumation was recently constrained by inverting a large dataset of strategically located *in situ* multi-thermochronological ages using a modified version of the 3-D thermokinematic model Pecube (Coutand et al., 2014). We have collected 18 sand samples from the modern channels of the main rivers draining the Bhutan Himalaya and processed them for apatite and zircon fission-track thermochronology (AFT and ZFT, respectively), cosmogenic radionuclide dating (CRN) and sandstone petrography. Measured thermochronometer age distributions are first compared to predicted age distributions generated using the preferred fault kinematics and thermal parameters from Coutand et al. (2014) using the approach of Whipp et al. (2009). Preliminary results suggest the measured age distributions are statistically equal to ≥99% predicted age distributions from Monte Carlo sampling of predicted basin ages for 12 of 14 basins dated thus far. Predicted age distributions from the other 2 basins show a poor fit to the measured ages; <2% of the predicted age distributions are statistically equal to the measured ages.

It is important to note that our predicted detrital ages are from a thermokinematic model that is not coupled to a surface process or landscape-evolution model; as a consequence, the model topography does not evolve through time and exhumation is exclusively controlled by a combination of modern steady-state topography and the underlying fault kinematics/geometry (i.e., tectonic processes, Coutand et al., 2014). To identify and quantify the contribution of surface processes to exhumation in each catchment, we compare the measured detrital thermochronologic ages and CRN records to a number of geomorphic indices including channel steepness, relief, and specific stream power (Bookhagen and Strecker, 2012). Ultimately, this research will help to understand how transient landscape evolution in active orogens affects erosion rates measured at different temporal and spatial scales.

References

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