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Cenozoic exhumation patterns of the Sierra Nevada de Santa Marta, northern Colombia, through bayesian modeling of detrital thermochronometric data

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Thermochronometry of modern river sands exploits the natural downstream sampling of detritus in a river catchment to infer plausible regional exhumation patterns. When combined with available bedrock thermochronometric information, this form of detrital thermochronometry can provide a better understanding of spatially variable denudation rates and improved inference of the potential controlling mechanisms.

We have developed a Bayesian inversion approach to modeling both detrital and bedrock thermochronometric data. Following the approach presented in Gallagher (2012), we use Markov chain Monte Carlo to sample many candidate thermal histories models. We use the present day hypsometric curve in a drainage basin as a starting point to sample age-elevation profiles predicted for each candidate thermal history. From these we can then predict the detrital age distribution for a detrital sample representative of the catchment. We can accept candidate thermal histories by quantitatively comparing the predictions to the bedrock profile data, the detrital sample data or both. In principle, discrepancies between the predictions from these models allow us to refine the sampling of the age-elevation profile and infer a detrital sampling distribution different to that implied from the hypsometric curve.

Application of the method of new and existing bedrock apatite fission track data (AFT) and new detrital apatite (U-Th)/He, AFT and zircon fission-track (ZFT) data from small (< 900 km2) river catchments from the Santa Marta Sierra Nevada in northern Colombia documents the long-term Cenozoic exhumation rates associated to dextral convergence of the Caribbean plate along the northern South American margin. Located 85 km to the SE of the Caribbean abyssal plain and with elevations up to 5.8 km, the Santa Marta Sierra Nevada is the highest coastal range on Earth, with a topographic relief in excess of 9 km. Our data reveal spatially variable, episodic exhumation with a major peak in middle to late-Miocene (30-15) and decreasing rates southeastwards, away from the collision boundary. Ongoing work allow to hypothesize that the range′s high topography and relief are the result of a recent (< 2Ma) pulse of rapid uplift whose rates surpasses the rates of erosion, thus precluding the thermochronometric signal associated to rock cooling to have reached the surface, hence portraying an example of denudational immaturity.

Gallagher, K., (2012) Transdimensional inverse thermal history modelling for quantitative thermochronology, J. Geophys Res. 117, B02408, doi:10.1029/2011JB00882