Thermochronometric constraints on paleoaltimetry and paleotopography – case studies from the Colorado Plateau, Tibet, and Labrador

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Despite the the devlopment of exciting direct and indirect methods to constrain ancient topography, the quantitative understanding of the relationships between uplift histories, topography development, climate evolution, and erosional history of orogens remains a major challenge. Knowledge of the elevation evolution is crucial to constrain the internal force balance and potential energy budget of an orogenic system through time and therefore can be used to differentiate between competing tectonic models. In particular the geodynamic evolution of large-scale orogenic plateaus has long been contested and the focus of the development of fundamental tectonic models attempting to elucidate lithospheric processes. Although, the theoretical relationship between surface uplift, rock uplift, and exhumation is well understood, our quantitative understanding of these interactions have traditionally been elusive. While thermochronometric techniques have become powerful tools to quantify the temporal and spatial aspects of exhumation by erosional and/or tectonic processes, the history of rock uplift is often difficult to quantify and incomplete to due the lack of a recorded absolute reference datum (e.g., sea level). Therefore surface uplift reconsructions based on this theoretical relationship are only as good the rock uplift records. Low-temperature thermochronometry alone cannot directly constrain magnitudes of surface uplift, but can shed important light on surface uplift by elucidating the history of topographic relief generation. This approach yields minimum relief estimates, since the topographically induced cooling recorded by thermochronometers is dampened with depth and maximum short-wavelength relief can not be resolved. Nevertheless, quantitative thermochronometry has been shown to be a powerful tool in reconstructing evolving topography in modern and ancient orogenic systems and in directly constraining the timing of relief generation. It is important, however, to note that erosional exhumation, in particular major river incision, in mountain ranges or orogenic plateaus does not have to coincide temporally with surface uplift. Erosional incision and relief generation might be absent in orogenic plateau settings or might temporally lag behind surface uplift due to uplift-independent climatic or geomorphic effects (e.g., integration of river systems). In fact, many of these geodynamic and geomorphic hypotheses become directly testable in settings where the timing and magnitude of surface and/or rocks uplift and exhumation can be independently constrained.