Geophysical Research Abstracts
Vol. 12, EGU2010-3713, 2010
EGU General Assembly 2010

Quantifying Transient Topography in Glaciated Orogens with Thermochronology and Inverse Thermal and Landform Evolution Modeling

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Field and modeling studies of orogen topography suggest that under some conditions topographic steady-state can develop. However, regions experiencing large changes in climate driven erosion or tectonic uplift can produce topographic transients. Quantifying these transient topographies has proven difficult in many orogens. Thermochronometer data – such as apatite fission track (AFT) and (U-Th)/He (AHe) – are sensitive to upper crustal rock cooling and offer the potential to quantify recent topographic change. In this study we present an integration of thermochronometer data with a simple 3D iterative thermal and landform evolution model to quantify paleotopography. Our emphasis is on glaciated orogens where large changes in topography likely occurred in response to Cenozoic cooling. We assume an initial steady-state topography and compare predicted and observed AHe ages on the modern landscape. Based on this comparison, we calculate a topographic correction to predict a paleotopography that is used as the initial condition in a subsequent simulation. Done iteratively, predictions can be made until a statistically significant fit with the data is achieved. We tested this method by performing a suite of simulations using synthetic topographies that varied (1) topographic wavelength, (2) lateral shift of ridges (phase change), (3) topographic relief change, and (4) valley deepening and widening due to glaciation. Results of these tests suggest the method is most sensitive at the 1 [U+F073] level to lateral (phase) changes in topography. Such changes correspond to migrating drainage divides and other shifts in topographic highs. Finally, the method was applied to the Mt. Waddington region of the Coast Mountains, British Columbia, where AHe and AFT data suggest large lateral changes in the topographic high-point of the range. Model results provide an estimate of the 3D paleotopography of the region prior to the onset of glaciation.