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Climatically-driven amplification of topography in the Mont Blanc massif, Western Alps

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The recent (last few My) evolution of topography of the European Alps and its potential climatic controls remains a subject of controversy. Here, we apply numerical thermal modelling (Pecube) to a tunnel transect crossing the Mont Blanc massif in the Western Alps, in order to quantify denudation rates and relief evolution in that area during the last few million years. The estimations benefit from a dense thermochronological dataset of both tunnel and surface samples (Glotzbach et al. 2008), which is complemented by some new apatite fission track (AFT) and apatite (U-Th)/He (AHe) data.
AFT ages are identical within error along the tunnel, with ages around 4 Ma, the same hold true for AHe ages with ages around 1.5 Ma. In contrast, forward modelling assuming a scenario including steady-state topography predicts a clear perturbation of AFT and AHe ages and leads to significant misfit between observed and predicted ages. This discrepancy suggests that at least part of the relief is very young (<4 Ma). To better resolve the timing and amount of relief evolution, we applied an inverse modelling approach using the Neighbourhood Algorithm (NA).
Initial inversions were run to verify if the sample distribution is capable of detecting relief evolution. For this purpose we generate synthetic ages for the used sample locations in a forward model and tried to recover these parameters using an inversion. Resulting predicted parameters are close to the initial parameters (initial and predicted amplification factors of the topography are 0.2 and 0.1, respectively).
In subsequent inversions we used all thermochronological data to predict the best parameters for the relief evolution. Good solutions (low misfit) predict that relief was less pronounced (<0.4 times the modern relief) before 3 to 1 Ma. An inversion based only on the tunnel data (which is more sensitive to relief evolution), yields best solutions for a relief change starting around 1 Ma. We therefore suggest that the main relief change in the Mont Blanc massif happened after around 1 Ma, but probably started to evolve already around 3 Ma. Given this timing and the lack of indications for recent tectonic activity, we suggest that relief development in the Mont Blanc massif is controlled by climate, with intense mid-Pleistocene glaciation leading to rapid valley incision and exhumation.

Glotzbach, C., J. Reinecker, M. Danišík, M. Rahn, W. Frisch, and C. Spiegel (2008), Neogene exhumation history of the Mont Blanc massif, western Alps, Tectonics, 27, TC4011, doi:10.1029/2008TC002257.