Age-elevation relationships yield apparent exhumation rates of ≤0.05 km/Myr between 230 and 23 Ma, increasing to ≥0.4 km/Myr since 15 Ma. The low slope of >23 Ma old zircon fission track ages is interpreted to be the result of prolonged stay within the partial annealing zone during burial due to nappe emplacement. The timing of initiation of exhumation most likely happened between 23 and 15 Ma. Transdimensional inverse thermal modelling results further suggest that burial due to nappe emplacement must have occurred rapidly during less than 10 Myrs. According to 1D thermal modelling exhumation of the external crystalline massifs initiated before 20 Ma at rapid rates (~1 km/Myr) and decreased before 10 Ma to moderate rates (~0.4 km/Myr). 3D thermal kinematic-modelling reveals that the thermochronological data are best fitted with a burial/exhumation scenario with rapid burial (~0.6 km/Myr) from ~33 Ma to ~20 Ma followed by rapid exhumation at ~1.3 km/Myr until 10 Ma and final exhumation at ~0.6 km/Myr up to present. Modelling further reveals a strong gradient in burial and early exhumation normal to the orogen, whereas burial/exhumation rates are lowest in the external Aiguilles Rouges massif and approximately half as much as in the Mont Blanc massif.

Deciphering the driving forces of short-term erosion in glacially impacted landscapes, an example from the Western Alps

Glotzbach, C.[1], van der Beek, P.[2], Carcaillet, J.[2] & Delunel, R.[3]

[1] Institute of Geology, Leibniz University Hannover, Callinstr. 30, 30167 Hannover, Germany glotzbach@geowi.uni-hannover.de)
[2] Institut des Science de la Terre, Université Joseph Fourrier Grenoble, BP 53, 38400 Grenoble, France (pvdbeek@ujf-grenoble.fr, julien.carcaillet@ujf-grenoble.fr)
[3] Institute of Geological Sciences, University of Bern, Baltzerstr. 1+3, 3012 Bern, Switzerland (romain.delunel@geo.unibe.ch)

Tectonic uplift is the main driver of long-term erosion, but climate changes can markedly affect the link between tectonics and erosion, causing transient variations in short-term erosion rate. Here we study the driving forces of short-term erosion rates in the French Western Alps as estimated from in-situ produced cosmogenic 10Be and detrital apatite fission-track thermochronology analysis of stream sediments. Short-term erosion rates from 10Be analyses vary between ~0.27 and ~1.33 mm/yr, similar to rates measured in adjacent areas of the Alps. Part of the data scales positively with elevation, while the full dataset shows a significant positive correlation with steepness index of streams and normalized geophysical relief. Mean long-term exhumation and short-term erosion rates are comparable in areas that are exhuming rapidly (>0.4 km/Myr), but short-term rates are on average two-three (and up to six) times higher than long-term rates in areas where the latter are slow (<0.4 km/Myr). These findings are supported by detrital apatite fission-track age distributions that appear to require similar variations in erosion rates. Major glaciations strongly impacted the external part of the Alps, increasing both long-term exhumation rates as well as relief. Based on our data, it seems that glacial impact in the more slowly eroding internal part is mainly restricted to relief, which is reflected in high transient short-term erosion rates. The data further reveal that normalized steepness index and ridgeline geophysical relief are well correlated with (and could be used as proxies for) short-term erosion, in contrast to slope, corroborating studies in purely fluvial landscapes. Our study demonstrates that climate change, e.g. through occurrence of major glaciations, can markedly perturb landscapes short-term erosion patterns in regions of tectonically controlled long-term exhumation.