mylonitic foliation pole (Z axes) but the other two axes of the magnetic ellipsoid K_{max} and K_{int} can differ from X and Y strain axes.

We have studied two different orthogneiss bodies, the Central Gneiss of the Tauern Window and the Tschigot Granodiorite, hosted by the Texel Unit. Both orthogneisses belong to units which underwent a polyphase tectonometamorphic evolution. On outcrop and sample scale the studied rocks show strain partitioning and intensive deformation being localized in cm to decametre wide shear zones. While the sheared parts are characterized by a strong and coherent mylonitic foliation, intensity of deformation varies significantly in the surrounding rock. Within the shear zones there is perfect agreement between the AMS and structural data. There Kmax and the measured stretching lineation are parallel and the pole of Kmin fits the pole of the mylonitic foliation. The less deformed parts are more complicated due to the presence of different generations of competing foliations and lineations. By combining structural and AMS data we distinguish between different foliations and lineations some of which are not observable at outcrop scale. Thus, some lineations which due to the field observations were assumed as stretching lineations, after the interpretation of AMS data are reinterpreted as intersection lineations. The latter is the intersection of either two macroscopically defined foliations or a macroscopically defined foliation and an optically invisible but magnetically defined foliation.

The parallelism between magnetic and field structures in the shear zones shows that the intensive shearing fully overprints and reorients the preexisting structural and magnetic features. In less deformed orthogneisses combination of structural and AMS data can be used to decipher macroscopically undetected penetrative features and thus to detect different generations of deformation.

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Early exhumation of the Aiguilles Rouges and Mont Blanc massifs, European Alps

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Although the exhumation history of the external crystalline massifs of the European Alps has been studied in detail, little is known about the timing and kinematic of the initiation of exhumation. Here we present new zircon fission track, apatite fission track and apatite (U-Th-Sm)/He data from the central Aiguilles Rouges massif, collected from the NW prolongation of the densely sampled Mont Blanc tunnel transect. This profile together with another densely sampled profile through the NW Aiguilles Rouges and Mont Blanc massif along the Rhône valley are used to investigate the (early) exhumation history of the Mont Blanc and Aiguilles Rouges external crystalline massifs. We use a variety of methods with increasing complexity and parameterisation to infer the exhumation history: (i) the age-elevation approach, (ii) transdimensional inverse thermal modelling, (iii) 1D thermal-kinematic modelling, and (iv) state-of-the-art 3D numerical-kinematic modelling (Pecube).

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

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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.