Thermochronological age – elevation profiles, denudation rates and relief development

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Sampling age – elevation profiles has become a standard technique in thermochronology to determine temporal variations in denudation rates. In general, however, these analyses have considered the problem as one-dimensional, implicitly assuming that the samples record a common thermal history because the profile is vertical or denudation rates are regionally constant, and thus neglecting potential effects of topography or laterally varying denudation rates on age-elevation profiles. Although the influence of temporally steady-state topography on thermochronological age-elevation profiles is well understood, the potential effects of transient topography have not as yet been addressed in detail.

We explore the capacity of low-temperature thermochronology data, in particular thermochronological age-elevation profiles, to provide joint constraints on the denudation and relief history of mountain belts. To answer the question whether we can differentiate regional changes in exhumation rate from relief changes by analyzing thermochronological age-elevation profiles, we combine a three-dimensional thermal-kinematic model to predict thermal histories and thermochronological ages from an input denudation and relief history, with an inversion scheme based on the neighborhood algorithm. We explore both synthetic data and a new thermochronological (zircon and apatite fission-track, apatite (U-Th)/He) dataset collected along an age-elevation profile in the French western Alps, a region that has experienced modest tectonic activity but intense glaciation during the last few myr. Our results suggest that multiple thermochronometers are required along an elevation profile to discriminate between different denudation and relief history scenarios, and that relief has increased significantly in our study area over the last few myr, possibly resulting from focused glacial valley erosion during Quaternary glaciations.

Blueschist-facies rehydration of eclogites: Constraints on subduction channel fluid-rock interaction from the Tian Shan (China)

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Exhumed eclogites from orogenic belts may show a retrograde blueschist-facies overprint with still preserved eclogite-facies relics. This overprint occurs during uplift when infiltrating fluids cause the growth of hydrous minerals such as sodic amphibole, epidote and white mica. We are studying this rehydration process and its P-T-X conditions to unravel the source of the retrograde subduction fluids and the exhumation path.

In eclogites from the Tian Shan, garnet, omphacite and rutile represent the assemblage of the eclogite stage. If a blueschist-facies overprint has occurred, omphacite and garnet are partially replaced by glaucophane, white mica and epidote. This rehydration was associated with massive growth of carbonate, pointing to an infiltration of an H_2O- and CO_2-rich fluid. Whole-rock major and trace element analyses show an increase of LILE (K, Cs, Rb and Ba) and volatiles in the rehydrated blueschist, presumably incorporated in white mica. The increase of Mn, Mg, Fe and CO_2 leads to the precipitation of ankerite. Partially dissolved apatite, epidote minerals and garnet released significant amounts of REE, Pb, Sr, U and Y into the infiltrating fluid. From mass-balance calculations it is evident that up to 25 % of the REE were mobilized while the eclogite has been transformed to blueschist.

Based on geothermobarometry, the P-T evolution during rehydration under blueschist-facies conditions is characterized by contemporaneous cooling and decompression. The most likely uplift path is the so called ‘subduction channel’ which is the serpentinized part of the mantle wedge above the downgoing slab. Fluids can infiltrate eclogites, rehydrate them and force their uplift because of reduced density and the resulting buoyancy. In addition, this process is aided by the high H_2O-content and the modified rheology of the mantle wedge. The observed data indicate that the subduction channel fluids do not only change the petrophysical properties due to metamorphic reactions, they also induce metasomatic changes in the reacting rocks.