Exhumation velocities and topography of the Eastern Alps derived from a low-temperature thermochronology

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Age distributions derived from a low-temperature thermochronology are commonly used to resolve the late history of evolving mountain belts. We present a technique that builds on the age-elevation technique, but allows implementing variable exhumation paths, isotherm perturbation and no-steady exhumation. Cooling age data are interpreted to reflect travel times between the moments when a rock particle crossed the relevant closure isotherm to present. The distance a sample travelled since closure is equal to the integral of the exhumation rate from the present day to the age of the sample. This small, but significant change in the interpretation of cooling age data allows, together with published erosion rate data, the calculation exhumation rates, crustal thickening rates and surface uplift rates for the Eastern Alps since the Oligocene. We used ca. 750 published zircon and apatite (U-Th)/He and fission track data from the Eastern Alps to construct maps, showing the rates of exhumation, crustal thickening and uplift for different time-slices for the last 35 Ma. From this the relief evolution of the Eastern Alps can be estimated.

In the Eastern Alps, and probably in general, high exhumation rates resulted from an erosion and crustal thinning that goes along with a relief destruction and decrease of a mean surface height. The spatially and temporally heterogeneous distribution of exhumation centres suggest that the Eastern Alps are not in isostatic equilibrium, but dynamically supported. Combined view on time-slice maps suggests that the Austroalpine units experienced a major exhumation with mean rate of ca. 0.5 mm/yr prior to ca. 24 Ma. The domain to the west of the Tauern Window was continuously thickened until ca. 12 Ma and maintained high topography, while the Austroalpine to the east of the Tauern Window was continuously thinned since ca. 24 Ma with a late topography built-up during the last 12 Ma. In the eastern Tauern Window and the Seckau Schladming Block exhumation initiated at ca. 20 Ma and the exhumation centre shifted to the western Tauern Window, where highest rates exceeding 1.5 mm/yr were reached at ca. 12 Ma. The Tauern Window was thickened until ca. 16 Ma and continuously thinned thereafter. The topography evolution, estimated from the back-stripping of uplift rates from the present relief suggests an early built-up of mountainous relief from 25–20 Ma along the southern belt, next to the Pariadriatic Lineament, followed by a northward shift of the drainage divide, when the Tauern Window started to exhume (ca. 20 Ma). Western Austroalpine units (Ötztal) maintained high altitudes, whereas eastern sectors (Gurktal Mountains) subsided through a crustal thinning. The eastern Tauern Window together with the Seckau-Schladming Mountains show a major uplift between 20–16 Ma. Rise of the thickening and uplifting Seckau-Schladming Block controlled the formation of the sinsitral W-E trending shear zones, defining the Ennstal depression and the Mur-Mürz Fault system. From 12 million years onwards, a second phase of exhumation along the southern belt occurred with topography built-up in the Karawanken Mountains and gravel deposits in the Klagenfurt Basin, supplied from the Tauern Window and the Karawanken Mountains.