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Inversion of ^{39}Ar diffusion data to constrain the Oligocene thickness of the Alpine orogenic lid

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The *AlpArray* has provided quantitative information as to the present 3D geometry of the Alpine orogen. There has been some effort to explain how this 3D geometry came to pass. However, to accurately go back in time, it is necessary to: i) provide quantitative constraints as to the timing of relative movement on geological structures; and ii) to monitor the exhumation history of individual units. Exhumation can be tracked using temperature as a proxy for depth, determining the temperature-time variation for individual rocks in critical localities. In this aspect there has been some advance, using temperature-controlled furnace-step-heating ^{40}Ar/^{39}Ar geochronology, measuring the diffusional release of ^{39}Ar during such experiments to produce Arrhenius data, and then inverting these data to constrain the temperature-time history in and adjacent to major geological structures. These data yield constraints that challenge some prior concepts as to the thickness of the Alpine orogenic lid at the time of the Eocene–Oligocene transition, 35–30 million years in the past.

At the time of the Eocene–Oligocene transition, the hot metamorphic rocks of the Lepontine culimination were dragged from beneath the orogenic lid, and transported westward. Today, the cold upper levels of the orogen are preserved as relatively thin disrupted sheets, exposed above extensional low-angle normal detachment faults associated with extensional ductile shear zones, originally of large areal extent. The nature of the orogenic lid of the European Alps has long been disputed, with the prevailing theory that it was cold and thick, floating above northward extruding hot metamorphic rocks which now outcrop in the Lepontine and Tauern culminations. We tested this hypothesis by inverting Arrhenius data for ^{39}Ar released from potassium feldspar step-heating diffusion experiments, first determining diffusion parameters, and thereafter, establishing admissible pressure-temperature-time (P-T-t) paths for rocks at the base of the orogenic lid. The results require the base of the orogenic lid as exposed in the Maloja Pass to have been no more than 150°C at the time that the underlying hot metamorphic rocks were drawn from beneath it and exhumed. This means that the orogenic lid was less than 5-6 km thick in the Early Oligocene, compared to 30-35 km thick as postulated in previously published models. These data can be explained by an alternative hypothesis, namely that the Lepontine and Tauern culminations are metamorphic core complexes formed by extreme extension, because the Alpine crust was horizontally stretched during westward roll back of the lithosphere of the PalaeoPo basin, with extension lineations formed at low-angles to the trend of the mountain belt.