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Influence of paleo-heat flow variations on estimates of exhumation rates

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Deriving exhumation estimates from thermochronological data requires assumptions on the paleo-thermal field of the Earth's crust. Existing thermal models take into account heat transfer by diffusion and advection caused by the movement of the crust and erosion as well as changes in geothermal gradient over time caused by changes in structure or thermal properties of the crust, surface temperature and elevation. However, temperature field of mountain belts and basins may vary not only due to tectonic activity or landscape evolution. We present a high-resolution thermochronology data set from the foreland fold-and-thrust belt of the European Alps that shows substantial variation of cooling rates probably caused by hydrothermal flow in the subsurface in the past. Tectonic blocks with uniform exhumation history show variations in cooling of up to 50°C. In addition, changes in cooling between two different fault blocks show opposite trend than expected by models of their tectonic history. The observed historic changes in paleo-geothermal gradients are equal in magnitude to a present-day thermal anomaly caused by the upward flow of warm fluids in the distal part of the foreland basin. The strong variations in geothermal gradients by fluid flow imply that straightforward interpretation of landscape evolution rates using thermochronology is not possible, unless the thermal effects of fluid flow are taken into account. This is of particular importance to studies where the amount of thermochronology data is limited and local hydrothermal anomalies could easily be interpreted as regional exhumation signals. On the other hand, our findings suggest that thermochronology offers new opportunities to constrain magnitude and timing of paleo-heat flow variations in the upper crust.