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Constraining drivers of basin exhumation in the Molasse Basin by combining low-temperature thermochronology, thermal history and kinematic modeling

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Due to a wealth of geological and thermochronology data the northern foreland basin of the European Alps is an ideal natural laboratory for understanding the dynamics of foreland basins and their interaction with surface and geodynamic processes. The northern foreland basin of the Alps has been exhumed since the Miocene. The timing, rate and cause of this phase of exhumation are still enigmatic. We compile all available thermochronology and organic maturity data and use a new thermal history model, PyBasin, to quantify the rate and timing of exhumation that can explain these data. In addition we quantify the amount of tectonic exhumation using a new kinematic model for the part of the basin that is passively moved above the detachment of the Jura Mountains.

Our results show that the vitrinite reflectance, apatite fission track data and cooling rates show no clear difference between the thrusted and folded part of the foreland basin and the undeformed part of the foreland basin. The undeformed plateau Molasse shows a high rate of cooling during the Neogene of 40 to 100 °C, which is equal to >1.0 km of exhumation. Calculated rates of exhumation suggest that drainage reorganization can only explain a small part of the observed exhumation and cooling. Similarly, tectonic transport over a detachment ramp cannot explain the magnitude, timing and wavelength of the observed cooling signal.

We conclude that the observed cooling rates suggest large wavelength exhumation that is probably caused by lithospheric-scale processes. In contrast to previous studies we find that the timing of exhumation is poorly constrained. Uncertainty analysis shows that models with timing starting as early as 12 Ma or as late as 2 Ma can all explain the observed data.