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Thermal and exhumation histories from borehole thermochronometer samples in the Swiss Molasse Basin

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In the last decade, significant interest has emerged to better understand the links between the foreland basin evolution and the erosion history of the Alps. For this, the European Alps are indeed a well-suited study region since the hinterland and the Swiss Molasse basin erosion rates and timing were extensively studied using basin analysis, and low-temperature thermochronology 1-4,5,6. However, the driving mechanisms for the post-Miocene erosion of the Swiss Molasse basin remains controversial, and several papers discuss whether global climatic changes1 or local variations of base level7,8,9 have controlled the erosion of the basin.

With this study, we add quantitative constraints on the late-stage history of the basin by presenting new AFT and AHe dataset (respectively 16 and 19 samples) from two boreholes located ∼30 km apart from each other, one located close to the center (Sonnengarten, depth of 3500 m) and one located to the North (Benken, depth of 100 m) of the basin. The data are derived from Triassic to Pliocene sand deposits as well as the underlying gneissic basement rocks and both AFT and AHe results are ranging from Pliocene to Triassic ages.

The two dataset present very different age patterns which make the direct interpretation difficult. Therefore, thermal models using the QTQt software10,11 have been performed. This software is capable to evaluate cooling rates and timing using multiple samples from a single borehole. To test the robustness of the simulations, several runs for each borehole based on different data sets were performed, and showed some discrepancies between the resulting thermal histories. We provide, based on the simulations results, the most probable erosion estimates which are in the same range as the ones proposed in previous studies in the basin. For the borehole Benken, we reproduce a long and slow erosion phase starting at 23 Ma, with an overall estimate of the amount of eroded sediments ranging between 1.2 to 2 km. For the central borehole (Sonnengarten), the thermal modeling suggests compatible amounts of total erosion, with estimates of ∼2 km, but with also a higher erosion rate from 3 Ma to present. We conclude that these values support much lower erosion rates in the Northern part than in the central or Southern parts of the basin as the samples from the borehole Benken were clearly less affected by the Pliocene erosion phases. These erosion estimates are also discussed, considering some inconsistencies with preserved thicknesses of Pliocene sediments still outcropping in the basin. Finally, this study also points out the limitations of the modeling technique on a complete dataset that incorporates a large number of bedrock and detrital samples on large (>2km) vertical profiles.