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The last erosional stage of the Molasse Basin and the Alps

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The search for the controls on the Alpine increase in sediment discharge at the Miocene-Pliocene boundary has received much attention recently. Here, we present a synoptic overview of the Miocene to present development of the north Alpine foreland basin in view of the contemporaneous increase in sediment discharge. Inversion and erosion of the Molasse Basin started at the same time that the Alpine rivers were deflected towards the Rhone-Bresse Graben which is the southern continuation of the European rift system. This change in the dispersion direction decreased the distance to baselevel by approximately 1000 m, which in turn decreased the average topographic elevation in the Molasse Basin by at least 200 m. Isostatic adjustment to erosional unloading requires at least 1000 m of erosion to account for this inferred topographic lowering. A further implication is that the resulting increase in the sediment discharge at the Miocene-Pliocene boundary reflects the recycling of Molasse units. We consider that erosion and inversion of the Molasse Basin appears to have occurred in response to a shift in the drainage direction rather than because of a paleoclimate change. We do find, however, that climate has imprinted on the Alpine landscape, but presumably not earlier than at the initiation of glaciation at the Pliocene-Pleistocene boundary.
Similar to the foreland, we do not see a strong climate fingerprint on the pattern or rates of exhumation of the External Massifs. In particular, the initiation and acceleration of antiformal stacking due to underplating can be considered solely as a response to the convergence of Adria and Europe irrespective of erosion rates. However, the recycling of the Molasse deposits since 5 Ma and the associated reduction of the loads in the foreland could have activated basement thrusts beneath the Molasse Basin in order to restore the critical wedge. This mechanism could explain the deep-seated earthquakes beneath the Molasse Basin and the backstepping of thrusting into the Subalpine Molasse. In conclusion, we see the need for a more careful treatment of both tectonic and climate forcing on the development of the Alps and the adjacent Molasse basin. In particular, the processes leading to the formation of the Cenozoic European Rift System need to be discussed and analyzed with more detail in the light of the evolving Alps.