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Lithologically controlled detachment strength and steady state since 10 Ma: Exploring the Alpine wedge using critical taper analysis combined with low-temperature thermochronometry

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Although evidence for weak detachments underlying foreland thrust belts exists, very little is known about the lateral variations in effective strength, as well as the geological nature of such variations. Using critical taper analysis, we show that a detailed and systematic measurement of surface slope of the Central European Alps reveals variations in strength along the detachment, based on the argument that the Alps are close to the critical state. We show that the basal detachment is very weak near the deformation front but strengthens towards the hinterland. These changes in detachment strength coincide with changes of detachment lithology in the hangingwall and footwall respectively, emphasizing the dominant role of weak shales. The very low strength values we find in shales in the frontal part of the alpine sole detachment are caused partly by slightly elevated pore pressures but may also require additional mechanisms of dynamic weakening.
Using the constraints on the present day alpine taper, we investigate the change in taper through time. To this end, we produced new apatite fission track and apatite (U-Th)/He data from the Alpine orogenic front, the Austrian Subalpine Molasse. We combine this data set with existing thermochronometry, and reconstruct the Central Alpine pro-wedge geometry at 10 Ma. We show that the taper of the Central Alps has not changed significantly and presumably remained close to kinematic and mass flux steady state since then. This indicates a feedback between ongoing shortening and erosion at low rates during the Late Neogene to present.