Geophysical Research Abstracts
Vol. 20, EGU2018-1805, 2018
EGU General Assembly 2018

Low strength of collision megathrusts from fault geometries and implications for the Alpine orogeny

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In the last decades, geophysical and geodetic observations from active subduction zones have provided detailed insights into the physical properties of convergent plate boundaries. In particular, it has been demonstrated that the large thrust faults that form along the plate interface, called megathrusts, are mechanically exceptionally weak. Whether this applies also to megathrusts that form along collision zones has, however, remained poorly constrained, not least because of methodological limitations. Yet, it is often argued that collision megathrust must be stronger than subduction megathrusts because of the poorer dehydration potential of continental crust than oceanic crust.
Here I present a Coulomb wedge approach that allows to reliably constrain the strength of megathrusts by taking the geometry of wedge internal faults, like major out-of-sequence thrusts, into account. I apply the approach to the European Alps and Himalayas and show that the collision megathrusts are similarly weak as subduction megathrusts. The inferred strengths imply that the megathrusts transfer only little stress into the overlying orogenic wedge. Using the example of the European Alps, I discuss how this may have favored the onset of extensional tectonics in the interior of the orogenic wedge around 20 Ma (for example, along the Simplon low angle normal fault), when the Alps grew to or exceeded mean elevations of $\sim$2,000 m.