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The many impacts of building mountain belts on plate tectonics and mantle flow

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During the Cenozoic, the number of orogens on Earth increased. This observation readily indicates that in the same time, compression in the lithosphere became gradually more and more important. Such an increase of stresses in the lithosphere can impact on plate tectonics and mantle dynamics.

We show that mountain belts at plate boundaries increasingly obstruct plate tectonics, slowing down and reorienting their motions. In turn, this changes the dynamic and kinematic surface conditions of the underlying flowing mantle. Ultimately, this modifies the pattern of mantle flow. This forcing could explain many first order features of Cenozoic plate tectonics and mantle flow. Among these, one can cite the compression of passive margins, the important variations in the rates of spreading at oceanic ridges, or the initiation of subduction, the onset of obduction, for the lithosphere. In the mantle, such change in boundary condition redesigns the pattern of mantle flow and, consequently, the oceanic lithosphere cooling.

In order to test this hypothesis we first present thermo-mechanical numerical models of mantle convection above which a lithosphere rests. Our results show that when collision occurs, the mantle flow is highly modified, which leads to (i) increasing shear stresses below the lithosphere and (ii) to a modification of the convection style. In turn, the transition between a “free” convection (mobile lid) and an “upset” convection (stagnant –or sluggish- lid) highly impacts the dynamics of the lithosphere at the surface of the Earth. Thereby, on the basis of these models and a variety of real examples, we show that on the other side of a collision zone, passive margins become squeezed and can undergo compression, which may ultimately evolve into subduction or obduction. We also show that much further, due to the blocking of the lithosphere, spreading rates decrease at the ridge, a fact that may explain a variety of features such as the low magmatism of ultraslow spreading ridges or the departure of slow spreading ridges from the half-space cooling model.