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Zooming into the Hindu Kush slab break-off: a rare glimpse on the transition from subduction to collision

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The transition from oceanic subduction to continental collision involves the entrainment of continental lithosphere into the subduction system. The opposing forces of the sinking slab and the buoyant continent then stretch the subducted lithosphere and ultimately lead to its break-off. Although many orogens show geological indications for such events, slab break-off is currently rarely observed as the final pinching-off is thought to be a fast process. The deep seismicity under the Hindu Kush mountains in Central Asia is such a rare case. Here, we use new data from a four years lasting seismic network to create a high resolution picture of slab break-off and infer its dynamics.
Travel time tomography resolves a near-vertically dipping subducting slab beneath the Hindu Kush down to 600 km and subduction of continental crust down to ∼180 km. The subducted slab is critically thinned at ∼200 km, where also seismicity is most intense (e.g. five Mw>7 earthquakes in the last 30 years). Earthquake source mechanisms indicate sub-vertical extension in the entire slab but highest seismic strain rates occur in the deeper seismogenic portion of the slab, below the subducted crust. Extending our data set to larger time-spans by including and relocating the largest earthquakes of the past 30 years, we calculate a stretching rate of ∼40 km/Ma. From this combined seismicity distribution and the rupture mechanisms we further deduce that the break-off advances along-strike of the Hindu Kush seismic zone at the base of the subducted continental crust. The dominant deformation mechanism in the subducted mantle lithosphere changes along-strike from simple to pure shear. The fastest detachment rates and largest earthquakes occur during the simple shear dominated stage. Smaller and less frequent earthquakes above the rapidly extending slab might be triggered by processes related to the subduction of crustal rocks.