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Geological signatures of slab shear-off during ongoing India-Asia convergence

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Much of our understanding of the dynamics of slab break-off and its geological signatures rely on numerical models with a simplified set-up, in which slab break-off follows arrival of a continent in a mantle-stationary trench, the subsequent arrest of plate convergence, and after a delay time of 10 Ma or more, slab break off under the influence of slab pull. However, geological reconstructions show that plate tectonic reality deviates from this setup: post-collisional convergence is common, trenches are generally not stationary relative to mantle, neither before nor after collision, and there are many examples in which the mantle structure below collision zones is characterized by more, or fewer slabs than collisions.

A key example of the former is the India-Asia collision zone, where the mantle below India hosts two major, despite the common view of a single collision. Kinematic reconstructions reveal that post-collisional convergence amounted 1000s of kms, and was associated with ~1000 km of trench/collision zone advance. Collision between India-Asia collision zone may provide a good case study to determine the result of post-collisional convergence and absolute lower and upper plate motion on mantle structure, and to evaluate to what extent commonly assumed diagnostic geological phenomena of slab break-off apply.

In addition to the previously identified major India, Himalaya, and Burma slabs, we here map smaller slabs below Afghanistan and the Himalaya that reveal the latest phases of break-off. We show that west-dipping and east-dipping slabs west and east of India, respectively, are dragged northward parallel to the slab, slabs subducting north of India are overturned, and that the shallowest slab fragments are found in the location where the horizontally underthrust Indian lithosphere below Tibet is narrowest. Our results confirm that northward Indian absolute plate motion continued during two episodes of break-off of large (>1000 km wide) slabs, and decoupling of several smaller fragments. These slabs are currently found south of the present day trench locations. The slabs are located even farther south (>1000 km) of the leading edge of the Indian continental lithosphere, currently underthrust below Tibet, from which the slabs detached, signalling ongoing absolute Indian plate motion. We conclude that the multiple slab break-off events in this setting of ongoing plate convergence and trench advance is better explained by shearing off of slabs from the downgoing plate, possibly at a depth corresponding to the base of the Indian continental lithosphere, are not (necessarily) related to the timing of collision. A recently

proposed, detailed diachronous record of deformation, uplift, and oroclinal bending in the Himalaya that was linked to slab break-off fits well with our kinematically reconstructed timing of the last slab shear-off, and may provide an important reference geological record for this process. We find that the commonly applied conceptual geological signatures of slab break-off do not apply to the India-Asia collision zone, or to similar settings and histories such as the Arabia-Eurasia collision zone. Our study provides more realistic boundary conditions for future numerical models that aim to assess the dynamics of subduction termination and its geological signatures.