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The 3-D dynamics of slab break-off and implications for continental collision zones

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Some of the world best studied mountain ranges are a result of continental collision, such as the Himalayas, Zagros mountains, and the Alps. Continental collision forms the last stage of the closure of an oceanic basin, and leads to the slow-down or complete cessation of the subduction process. Previously subducted slab material will experience a period of thermal warming (Gerya et al., 2004) and/or a larger tensile stress, and will eventually weaken, yield and sink into the mantle. This process has potentially important implications for the thermal and stress regime of the overlying convergence zone, and has been held responsible for various phenomena such as late-stage magmatism (Davies and von Blanckenburg, 1995) and surface uplift or depression (van der Meulen et al., 1998, Buiter et al., 2002). Even though the collision process itself is relatively short-lived compared to the preceding oceanic subduction, its remnants are often preserved, and probably provide a valuable window into the plate tectonic process during the Proterozoic and perhaps the Archaean (e.g. Calvert et al., 1995).

The three-dimensional nature of this break-off process has previously been discussed with conceptual models. E.g. slab break-off has been suggested to propagate laterally through an advancing tear (Wortel and Spakman, 2000). In this study we present 3D numerical results of the evolution of slab break-off. We focus on the development and evolution of a laterally migrating slab tear, and present results on the sensitivity of this process to the geometry of the closing oceanic basin, the tensile stresses in and the rheological properties of the slab, and the thermal state of the surrounding mantle. By comparing our numerical results to previously published analogue results (Regard et al., 2004) and various tomographic, structural, and magmatic observations of well-studied subduction collision systems, we are able to extract valuable insights in to the dynamics and strength of subducting oceanic and continental lithosphere.