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Fingerprinting slab breakoff by topographic signal: numerical modelling

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In order to understand coupled dynamics of slab breakoff and topography development, a set of continental collision experiments were run using I2ELVIS code (Gerya & Yuen, 2003). Setup of the experiment involves convergence of two continental plates separated by an oceanic segment. Subduction is imposed by a weak zone and the plates are pushed during a limited timelapse, afterwards continental collision evolves spontaneously under the slab pull. A systematic parameter study is carried out by independently varying the oceanic plate age and convergence rate in 25 numerical experiments.

Results display various continental collision zone behaviour combining several key processes including systematic slab breakoff. Evolution of each model is characterized by a unique topographic pattern where every geodynamic process involved (subduction, collision, breakoff, slab steepening, rollback, eduction etc.) has a specific signal. As reflected by its sharp topographic signal (within <1 Myr) slab breakoff turns out to be a crucial parameter for orogenic structure, topography and evolution.

Slab breakoff can occur from shallow depths (<40 km) to deeper levels (>400 km) depending on the activation of different driving rheological mechanisms (dislocation creep, Mohr-Coulomb failure and Peierls plasticity). Shallow slab detachment are likely to occur within young slabs at fast convergence rate whereas deep detachment mainly affects old slabs. A variety of intermediate behaviours is observed between those end-members.

At lithospheric scale, shallow breakoffs are linked to narrow orogens with moderate topography whereas deep breakoff scenarios produce wider and higher orogens. Narrow orogens mainly remain stable after breakoff while large orogens undergo such a large isostatic response that they are likely evolve into eduction and extension.