Styles of deformation in continent-continent collision

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Continent-continent collision occurs when the intervening ocean has been closed by subduction of the oceanic lithosphere. The fate of the continents and the style of collision depend on driving forces (slab pull, slab push and mantle drag) and the mechanical behaviour of the oceanic and continental lithosphere in response to these driving forces. When the continents meet each other, the question arises as to whether a continent would subduct? And if so, how long does it subduct before subduction ceases? Petrological studies, physical and numerical modelling show that in some cases a continent can go down to depths of 100 to 250 km (Chopin, 1984; Coleman and Wang, 1995; Shemenda et al., 1996; Ranalli et al., 2000). But continent-continent collision can also experience other processes which add more complexity to the system, for example, crustal thickening, formation of thrust nappes, high topography, magmatism in the overriding plate, metamorphism, slab break-off, exhumation, and post-collisional extension (Fig. 1). Toussaint et al. (2004) pointed out that the style of collision strongly depends on temperature of the Moho and convergence rate. They found that continental subduction is favoured for strong lithospheres (T_{Moho} < 550 °C) and fast initial convergence rates (> 5 cm/yr), whereas lithosphere shortening will become a dominant mechanism when the lithosphere is weak and has enough time to warm up by heat conduction. Shortening of the lithospheric mantle can be accommodated by pure-shear thickening, folding (Burg and Podladchikov, 2000; Cloetingh at al., 1999), and gravitational (Raleigh-Taylor) instabilities (Houseman and Molnar, 1997). Beside convergence velocity and temperature, other factors that could play a role in determining the style of continental collision are rheology, subduction geometry, surface processes (erosion and sedimentation), buoyancy, melting, and phase changes (Selzer et al, 2008; Pysklywec et al., 2000; Toussaint et al., 2004; Warren et al, 2008).

We aim to investigate continent-continent collision in a framework that allows us to include near-surface deformation in combination with mantle dynamics. We set up a numerical model with two continents with an intervening oceanic lithosphere. Initial convergence is achieved by kinematic boundary conditions amplified by slab pull as the oceanic lithosphere starts to subduct. Because such a mixed formulation implies that convergence always continues after collision, we will also experiment with set-ups in which the kinematic driving forces are gradually reduced before collision. Our models will focus on rheology strength stratification (through creep flow laws, brittle behaviour and elasticity) and surface processes. We will present first results of dynamic continent-continent collision models, starting from simple setups and progressively increasing models (rheological) complexity.

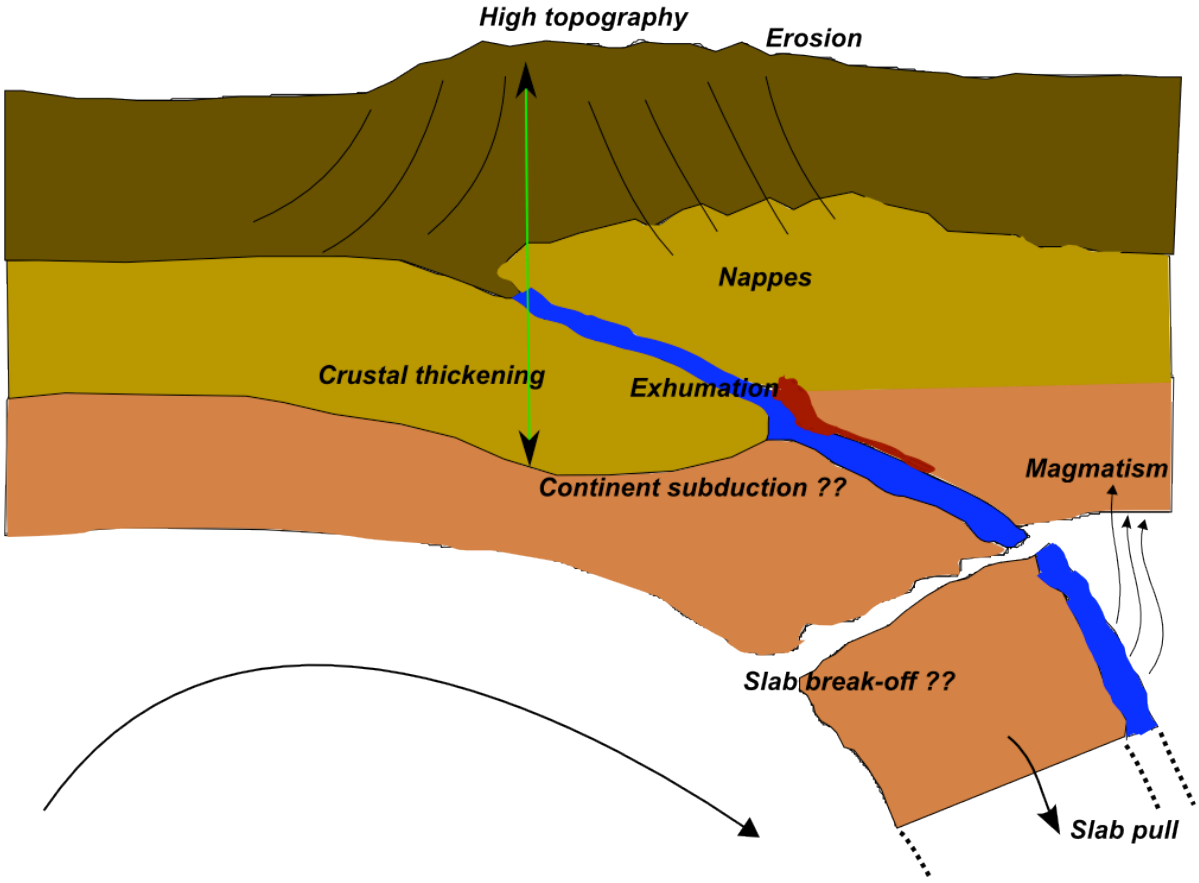

Fig. 1: Possible processes in continent-continent collision

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