LI Zhonghai, XU Zhiqin, GERYA Taras and BURG Jean-Pierre, 2013. Dynamics of India-Asia Collision from 2-D and 3-D Numerical Modeling. *Acta Geologica Sinica* (English Edition), 87(supp.): 142.

Dynamics of India-Asia Collision from 2-D and 3-D Numerical Modeling

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Flat and steep subduction are end-member modes of oceanic subduction zones with flat subduction occurring at about 10% of the modern convergent margins and mainly around the Pacific (Lallemand et al., 2005). Continental (margin) subduction normally follows oceanic subduction with the remarkable event of formation and exhumation of high- to ultrahigh-pressure (HP-UHP) metamorphic rocks in the continental subduction/collision zones (Liou et al., 2004; Zheng, 2012). We first used 2-D thermo-mechanical numerical models to study the contrasting subduction/ collision styles as well as the formation and exhumation of HP-UHP rocks in both flat and steep subduction modes (Li et al., 2011, 2012). In the reference flat subduction model, the two plates are highly coupled and only HP metamorphic rocks are formed and exhumed. In contrast, the two plates are less coupled and UHP rocks are formed and exhumed in the reference steep subduction model. A comparison of our numerical results with the Himalayan collisional belt suggests a spatially differential subduction/ collision model, which indicates that steep subduction dominates in the western Himalaya, while flat subduction dominates in the extensional central Himalaya.

Continental collision has been extensively investigated with 2-D numerical models as above, assuming infinitely wide plates or insignificant along-strike deformation in the third dimension. However the corners of natural collision zones normally have structural characteristics that differ from linear parts of mountain belt. Therefore we further conducted 3-D numerical simulations to study the dynamics of a continental corner (lateral continental/ oceanic transition zone) during subduction/collision (Li et al., 2013). The results demonstrate different modes between the oceanic subduction side (continuous subduction and retreating trench) and the continental collision side (slab break-off and topography uplift). Slab break-off occurs at a depth (⩽100 km to ~300 km) that depends on the convergence velocity. Numerical lateral extrusion of the overriding crust from the collisional side to the subduction side is a recognized phenomenon around natural collision of continental corners, for instance around the eastern corner of the India-Asia collision zone. Model results also indicate that extrusion tectonics may be driven both from above by the topography and gravitational potentials and from below by the trench retreat and asthenospheric mantle return flow, which supports the link between deep mantle dynamics and the shallow crustal deformation.

Key words: Continental Subduction, Collision, Exhumation, Lateral Extrusion, Slab Break-off, Numerical Modeling, Himalaya

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