Geophysical Research Abstracts
Vol. 15, EGU2013-4712, 2013
EGU General Assembly 2013

3D numerical modeling of India-Asia-like collision

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One of the most striking features of plate tectonics and lithospheric deformation is the India-Asia collision zone, which formed when the Indian continent collided with Eurasia, around 50 million years ago. The rise of the abnormally thick Tibetan plateau, the deformation at its Eastern and Western syntaxes, the transition from subduction to collision and uplift and the interaction of tectonics and climate are processes not fully understood.

Though various geophysical methods have been employed to shed light on the present structure of the Indian-Asian lithosphere, the driving mechanisms that uplifted the Tibetan plateau remain highly controversial and different hypotheses imply contradictory scenarios. Models for double crustal thickness include: wholescale underthrusting of Indian lithospheric mantle under Tibet (Argand model), distributed homogeneous shortening or the thin-sheet model (England and Houseman, 1986), slip-line field model to also explain extrusion of Eastern side of Tibet away from Indian indentor (Tapponier and Molnar, 1976) or lower crustal flow models for the exhumation of the Himalayan units and lateral spreading of the Tibetan plateau (Royden et al., 1998, Beaumont et al., 2004). The thin-sheet model has emerged as a more successful (or at least more widely used) model, but one of its major shortcomings is that it cannot simultaneously represent channel flow and gravitational collapse of the mantle lithosphere (Lechmann et al., 2011), since these mechanisms require the lithosphere to interact with the underlying mantle, or to have a vertically non-homogeneous rheology. Of those who favour a layered structure of the lithosphere beneath Tibet, some attribute the lack of substantial seismicity underneath the Moho as evidence that all the strength of the lithosphere resides in the upper crust and the mantle is weak – the crème brulée model (Jackson, 2002), while others point out that some processes can be well explained if the crust resides above a strong mantle lithosphere – the jelly sandwich model (Burov and Watts, 2006).

3D models are thus needed to investigate these hypotheses. However, fully 3D models of the dynamics of continent collision zones have only been developed very recently, and presently most research groups have relied on certain explicit assumptions for their codes. Here, we employ the parallel 3D code LaMEM (Lithosphere and Mantle Evolution Model), with a finite difference staggered grid solver, which is capable of simulating lithospheric deformation while simultaneously taking mantle flow and a free surface into account. We here report on first lithospheric and upper-mantle scale simulations in which the Indian lithosphere is indented into Asia.

Acknowledgements. Funding was provided by the European Research Council under the European Community's Seventh Framework Program (FP7/2007-2013) / ERC Grant agreement #258830. Numerical computations have been performed on JUQUEEN of the Jülich high-performance computing center.

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