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Dating the collision of India by tracking the evolution of forces on Eurasia

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Resistive forces along convergent plate boundaries have a major impact on surface deformation, most visibly at collisional plate boundaries. Although quantification of these forces is key to understanding the evolution and present state of mountain belts, they remain highly uncertain due to the complexity of plate boundary structures and rheologies. In this study we analyze the evolution of forces along the southern boundary of the Eurasian plate. Our approach to studying the collision is based on mechanical equilibrium of the whole Eurasian plate, meaning that an increase in collision forces must be matched by other plate tectonic forces. We first focus on present-day Eurasia.

We include basal tractions from a global convection model, lithospheric body forces, and edge forces resulting from interaction of the Eurasian plate with neighboring plates. The resulting force distribution is best constrained for the present-day due to the availability of a large amount of stress observations.
Eurasia's stress field turns out to be sensitive to the distribution of collision forces on the plate's southern margin and, to a lesser extent, to lithospheric density structure and normal pressure from mantle flow. Stress observations require collision forces on the India-Eurasia boundary of 7.2 - 10.5 TN/m.

A similar analysis is performed for Eurasia at 20Ma and 40Ma.The geometry is taken from the global Lausanne (Stampfli) reconstruction, as are plate velocities and oceanic ages. Lithospheric body forces are accounted for in a simplified way because we lack detailed enough information on the plate scale topography. For the Miocene, we find $\sim$1.2 TN/m for the collision force on the India-Eurasia boundary. In the Eocene, the collision force we find is $\sim$0.4 TN/m.

We conclude that the collision force increased significantly after 20Ma. From 40-20Ma, the plate contact force on the India/Tibet plate boundary segment was of the same order of magnitude as resistive forces on subduction plate boundaries elsewhere. Our timing of the collision force on Eurasia, is substantially younger than the often quoted collision age of $\sim$50Ma. We discuss possible reasons for this discrepancy.