India-Asia Collision Tectonics Constrained from Full-Waveform Seismic Tomography

Chujie Liu[1] (lcj2012@utexas.edu), Stephen P. Grand[1], Rupak Banerjee[2], Supriyo Mitra[2], Eric Sandvol[3], Xiaofeng Liang[4]
[1] Department of Geological Sciences, University of Texas at Austin, Austin, TX 78712, USA
[2] Department of Earth Sciences, Indian Institute of Science Education and Research Kolkata, Kolkata, India
[3] Department of Geological Sciences, University of Missouri, Columbia, MO 65211, USA
[4] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

The Tibetan Plateau, the world's largest and highest, has long been recognized to have been created by the continental collision between the Indian and Eurasian plates that started between 60-50 Ma. However, the mechanism for accommodating over 4,000 km post-collision convergence remains uncertain. The upper mantle beneath Tibet has been extensively investigated by receiver function analyses and many different kinds of tomography studies, however, due to discrepancies among seismic models, the fate of the Indian Continental Lithosphere (ICL) and the evolution of the Tibetan lithosphere over time are still uncertain. Here, we conducted a full-waveform inversion study of the crust and mantle beneath Tibet and surrounding regions. Our model shows a strong and sharp sub-horizontal fast anomaly in the upper mantle above ~ 220 km depth beneath southern Tibet and northern India, indicating underthrusting of the ICL beneath Tibet. Below and to the south of the underthrusting ICL we observe isolated fast anomalies down into the lower mantle, which we interpret as fragments of subducted Greater India lithosphere. Fast anomalies are also imaged beneath north-central Tibet at depths from 200 to 420 km. These anomalies are not connected to the ICL, and we interpret them to be delaminated Tibetan lithosphere. We present a self-consistent tectonic evolution model of the India-Asia collision zone for the past 40 Ma. Our analysis reveals that the Indian cratonic lithosphere collided with Asia at ~25 Ma, leading to the thickening and deformation of both plates. Notably, the ICL is underthrusting beneath Tibet without subducting into deeper mantle, while the weaker Tibetan lithosphere has undergone significant deformation and began to detach and sink around 15 Ma. Prior to the hard collision, non-cratonic Greater Indian lithosphere subducted beneath southern Tibet and northern India. Our interpretation is supported by various geological and geophysical observations and provides valuable insights into the tectonic processes associated with post-collision plate convergence.