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Three-dimensional Vp and resistivity model of the crust and upper mantle beneath Namche Barwa: Insight on the geodynamics of eastern Himalayan syntaxis

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On the eastern margin of the Himalayan orogen, rapid uplift of the Namche Barwa metamorphic terrane and sudden transition in the the Yarlung Zangbo suture zone occur. This terrane is marked by strong tectonic stress, rapid rock uplift and exhumation, sudden transition in the Yarlung Zangbo rivers, and intense Cenozoic metamorphism and anatexis. Although several plausible models such as indenter corner, crustal folding, duplex thrusting, and channel flow have been proposed to explain the evolution of the Namche Barwa, the formation mechanism of the Eastern Himalaya Syntaxis (EHS) is still debated. To preferably understand the lithospheric structures beneath the EHS, we deployed 83 magnetotellurics (MT) sites and 35 broadband seismic stations around the Namche Barwa (NB) peak during the period 2009-2014.

The three-dimensional (3D) MT model show contrasting electrical variations in the upper to middle-lower crust beneath the Namche Barwa. The features of near-surface resistivity model are associated with the thermal structure. The resistivity model near the NB massif shows relatively resistive upper crust underlain by a more conductive middle to lower crust, an accumulation of hydrous melting at a depth of 13-17km, and localized interconnected paths or large reverse-fault systems for rapid decompression melting. The tectonic aneurysm proposed by Zeitler et al. (2001) may be a reasonable model for exhumation mechanism of metamorphic rocks. Both surface processes and local tectonic responses may play a vital role in the evolution of Namche Barwa.

The 3D teleseismic tomographic P-wave model demonstrates complex Indian subduction style with slab fragmentation beneath the eastern Himalaya. In the western region, the Indian slab flatly subducts under southern Tibet and might extend to the Bangong-Nujiang Suture. In contrast, a steep subduction occurred in the eastern region of EHS. The contrasting subduction styles result in tearing and fragmentation of the Indian lithosphere between the flat and steep subducting slabs beneath the EHS. Consequently, the hot asthenospheric mantle may rise through the slab window, which might further lead to the rapid uplift of Namche Barwa and the formation of EHS. The comparison between the 3D resistivity model and teleseismic P-wave velocity images at the 40km depth slice also confirms the results.

The middle and lower crust contain fairly widespread conductors to the west and north of the NB that have also been similarly observed along several MT transects across some regions of the Tibetan Plateau, which can provide additional evidence to the “crustal flow” model. The crustal widespread conductive zones may be favorable conditions for crustal flow to develop and can provide transitive ductile and warm material from southern Tibet and form long-lasting partial melting of enriched metasomatic layers beneath the NB. The uplifted Moho beneath the EHS and the existence of partial melting in the crust might be associated with the localized upwelling of hot mantle material caused by a slab tear of the India plate, which can provide sustained heat source for the local thermal–rheological system.