3D crustal structure of the Tibetan Plateau revealed by ambient noise tomography: implications for the deformation and growth of Tibet

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The Tibetan Plateau results from the collision between the Indian and Eurasian plates, which has been an ongoing process since the Late Cretaceous to Early Paleocene. The physical processes that have controlled the deformation and growth history of Tibet, particularly the potential localization of deformation either in the vertical or horizontal directions remain subject to debate. Two general models are commonly proposed, although there are finer distinctions between them. The first is the shortening and thickening model, and the second is the mid/lower crustal channel flow model. Seismic evidence can help to discriminate between these competing models. In particular, it is important to provide constraints on whether Tibet deforms in a way that honors the surface expression of crustal blocks and faults and whether pervasive, interconnected weak layers or channels in the crust are observable.

In this study, we address these two questions by producing a 3-D model of crustal shear wave speeds inferred from Rayleigh wave dispersion observed on cross-correlations of long time series of ambient seismic noise. Based on 1–2 years of continuous observations of seismic ambient noise data obtained at more than 600 stations in and around Tibet, Rayleigh wave phase velocity maps are constructed from 10 s to 60 s period. A 3-D Vsv model of the crust and uppermost mantle is derived from these maps. The 3-D model exhibits significant apparently inter-connected low shear velocity features across most of the Tibetan middle crust at depths between 20 and 40 km. These low velocity zones (LVZs) do not conform to surface faults. The prominent LVZs are coincident with strong mid-crustal radial anisotropy in eastern Tibet and probably result at least partially from anisotropic minerals aligned by deformation of horizontal shearing. Our observations support the internal deformation model in which strain is dispersed in the deeper crust into broad ductile shear zones, rather than being localized horizontally near the edges of rigid blocks.