Rayleigh-Wave Phase Velocities and Azimuthal Anisotropy in Tibet and Surrounding Regions from Ambient Noise Tomography

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Tibet is our planet's natural laboratory for studying how continents interact and deform in response to the collision between the Indian and the Eurasian plates. Although numerous seismic studies of Tibet have been performed, there remain fundamental disagreements in first-order questions about crustal deformation; e.g., whether the crust deforms coherently vertically or is perhaps coupled to the mantle. The reason is that existing models either do not model the crust effectively or only model the crust beneath parts of Tibet due to limitations in the distribution of seismic stations.

In this study, we have applied ambient noise tomography, which provides new and pervasive constraints on crustal structure, to the significant data resources now available across all of Tibet and the surrounding regions. These resources include data from the permanent Federation of Digital Seismographic Networks (FDSN), several temporary US PASSCAL installations in and around Tibet, and the Chinese provincial networks surrounding Tibet. These networks comprise ~600 stations on which ambient noise cross-correlations are performed from 2003 to 2009. Inter-station Rayleigh wave dispersion curves are measured from cross correlations of vertical components. These dispersion measurements are used to invert for isotropic phase velocity maps and azimuthal anisotropy of Rayleigh waves. Phase velocity maps display features that correlate well with surface geology. Major basins, including Tarim, Qaidam and Sichuan, are all well delineated by slow phase velocities at short periods (8-15 sec). Crustal thinning from Tibet to the surrounding regions is manifest as a phase velocity increase at periods from 25 to 40 sec. Patterns of Rayleigh wave azimuthal anisotropy at periods from 10 to 30 sec differ only at small scales, meaning either that anisotropy in the shallow crust dominates both maps or that the mechanism of anisotropy extends from the shallow to the middle crust. In much of eastern Tibet, the fast directions of Rayleigh waves are similar to the strikes of left lateral planes of shear constrained from Quaternary fault slip rates and GPS measurements, consistent with the position that the azimuthal anisotropy from surface waves manifests upper-crustal shear. The fast directions of surface waves bifurcate around the Sichuan Basin, which may suggest a relation between anisotropy and crustal flow that has been proposed to explain the growth of the Tibetan Plateau and the variation of topography in eastern Tibet.

Cite as: Yang, Y., Zheng, Y. and Ritzwoller, M.H., 2010, Rayleigh-Wave Phase Velocities and Azimuthal Anisotropy in Tibet and Surrounding Regions from Ambient Noise Tomography, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 1 p. [http://pubs.usgs.gov/of/2010/1099/yang/].