Seismic Velocity Structure From the ASCENT Seismic Array: Implications for Crustal and Mantle Deformation

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In order to study the evolution of the world's largest continental plateau, and the structure of the entire Himalayan-Tibet collision zone, Project INDEPTH (International Deep Profiling of Tibet and the Himalaya) was begun in 1992. The 4th phase of the INDEPTH project includes several key components including the deployment of a very large (600 km by 900 km) grid of seismometers covering nearly the entire northeastern corner of the Tibetan plateau (Figure 1). The northeastern boundary of the Tibetan Plateau is the location of several important tectonic boundaries within the Tibetan plateau including the Kunlun Fault Zone, Jinsha and Bangong-Nujiang sutures. In order to constrain various models for the evolution of the Tibetan lithosphere we have analyzed data from the ASCENT and surrounding arrays throughout the northeastern portion of the Tibetan plateau. Three-dimensional velocity structure derived from surface-wave tomography suggests there is strong heterogeneity within the Tibetan plateau including very slow seismic wave-speeds in the crust and mantle beneath the northernmost edge of the Tibetan plateau. Measurements of seismic attenuation are consistent with these low velocities as we observe much lower than average Lg and Pg Q values for most of the plateau with the exception of portions of the Qaidam basin crust. All these results strongly suggest that there can be little preserved anisotropic fabric in the crust or upper mantle beneath the northeastern corner of the plateau, with the exception of the Qaidam basin which seems to have a substantially thicker lithosphere.

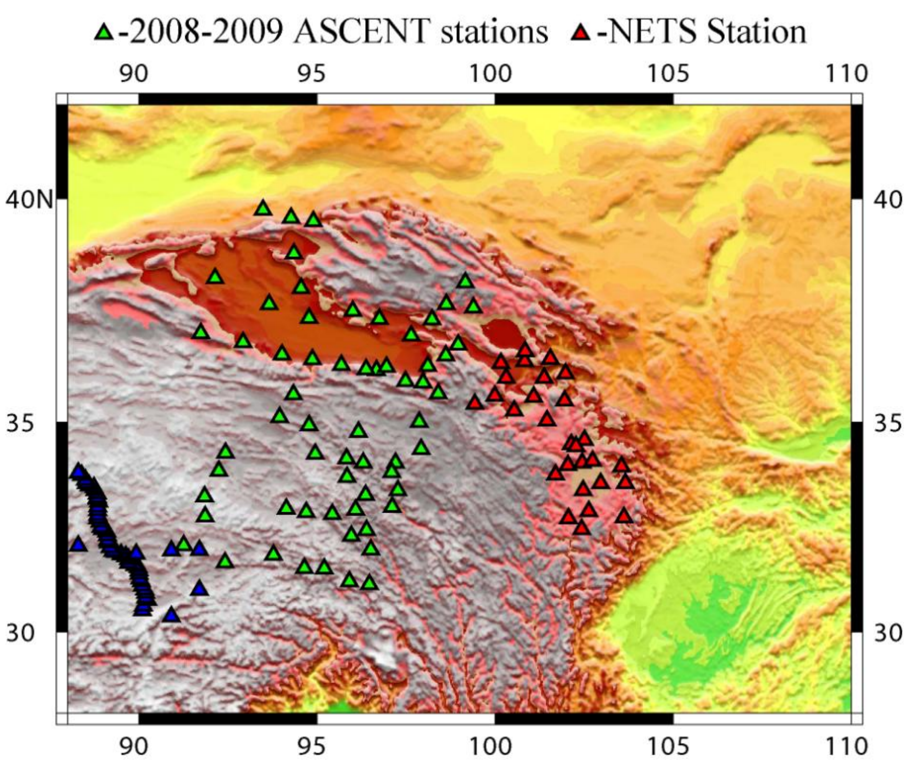

Figure 1. Map of recent temporary broadband seismic stations deployed in the northeastern corner of the Tibetan plateau. The blue stations are the stations deployed as a part of INDEPTH-III. All stations shown are broadband primarily composed of STS-2 and CMG-3T seismic stations. Approximately 50% of the stations, primarily in the north, were deployed for one year while the other half were deployed for two years.

We have combined both surface waves and body waves in order to estimate the three dimensional pattern of seismic anisotropy within the northeastern portion of the plateau. In general we observe a clockwise rotation in the fast directions of split SKS waves that is consistent with upper-mantle flow around the eastern Himalayan syntaxis. Azimuthal anisotropy from surface waves strongly indicates that this anisotropy is not confined to the lithosphere but extends into the asthenosphere. We observe significant azimuthal anisotropy (~2%) in the lower crust with fast directions that tend to follow the fast directions from the SKS measurements. We also observe evidence of asthenospheric flow along the eastern edge of the Tibetan plateau possibly affected by the lithospheric roots beneath the Sichuan basin and Ordos plateau.

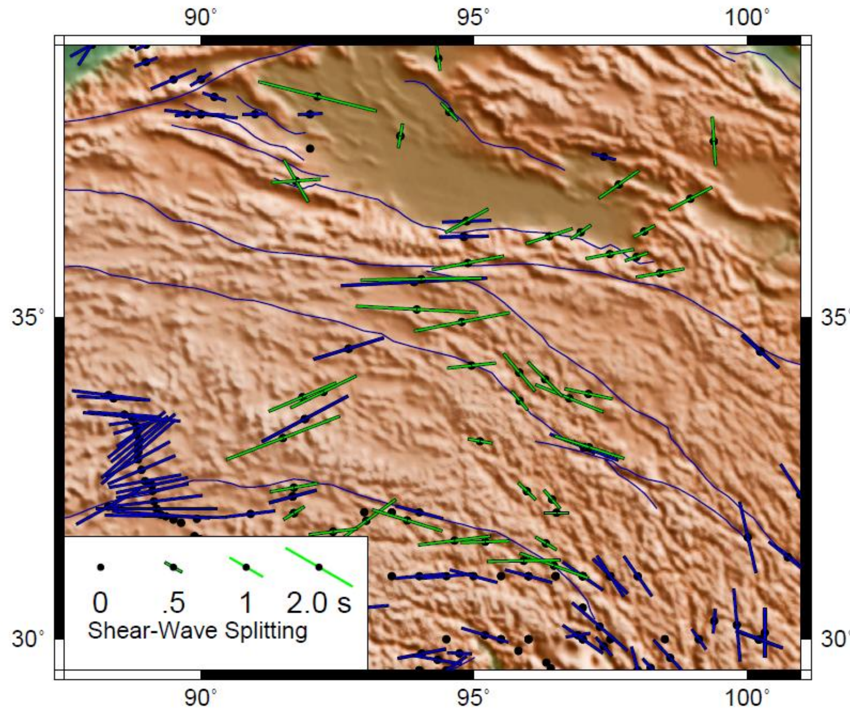

Figure 2. Map summarizing shear-wave splitting values for the Tibet plateau. The green (light) vectors are new unpublished results and the blue (dark) are previously published shear-wave splitting values. Note how most of the fast directions parallel the major fault zones and sutures.

We can interpret seismic anisotropic fast directions as indicative of present-day mantle strain patterns due to the observed low seismic wave-speeds throughout most of the northern Tibetan plateau excepting the Tarim and Qaidam basins. To first order we observe a fairly good agreement between our fast directions and the strike of the major fault zones outside of the Qaidam basin. This indicates a reasonable correlation between the strain fields of the Tibetan crust and the upper mantle. The geodynamic implications of this vertically coherent deformation (VCD) are currently being debated. Some have interpreted it as indicating a strong mechanical coupling between the crust and the mantle lithosphere, which is discordant with the evidence of a weak, flowing lower crust under Tibet. While the pattern of shear-wave splitting from this new and expanded datasets is in general agreement with previous results, we found important local variations, especially across the Bangong-Nujing suture zone, and significant azimuthal anisotropy in the lower crust. These variations indicate lithospheric heterogeneities between various terrains within the plateau. Recent numerical results show that the general coherence between crustal and mantle deformation can be attributed to the particular tectonic boundary conditions around the Tibetan Plateau which force both crustal and mantle material to flow coherently eastward as the consequence of the Indo-Asian collision. In this case the Tibetan VCD is consistent with a weak and flowing lower crust.

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