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Constraining residual topography by virtual deep seismic sounding (VDSS)

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How topography is supported at depth remains a key issue in geodynamics. In order to isolate contributions from mantle processes, a valuable indicator is residual topography, or the difference between observed elevation and that supported by crustal buoyancy. To this end, a particularly robust method is VDSS, a variant of wide-angle reflection. Instead of manmade sources, VDSS uses *S*- to *P*-wave conversion from natural earthquakes near each seismic station as virtual sources.

VDSS has many distinct advantages over traditional methods. In particular, at distances between about 30°-55°, the virtual source of VDSS leads to a post-critical reflection off the Moho (seismic phase *SsPmp*) whose large amplitude stands out even when signal-generated noise is present. Moreover, the trade-off between crustal thickness and *P*-wave speed inherent in seismic reflections is negligible for estimating crustal buoyancy based on VDSS, once the relationship between *P*-wave speed and density of crustal rocks is taking into account (the Birch's law).

In central Tibet, a zone of disrupted Moho under the Bangong-Nujiang suture zone [1], is also where marked, lateral changes in overall crustal thickness occur (Figure 1). Moreover, this zone roughly coincides with the northernmost edge of underthrust Indian lithospheric mantle (GI) detected by high-resolution, multi-scale travel-time tomography [2]. Generally, there is also a notable change from a well-defined Moho to a gradual crust-mantle transition toward the east. An overall trend of northward thinning of crust is confirmed, consistent with thermal support of high topography from a particularly warm upper mantle northward from the vast heat sink of underthrust GI [3].

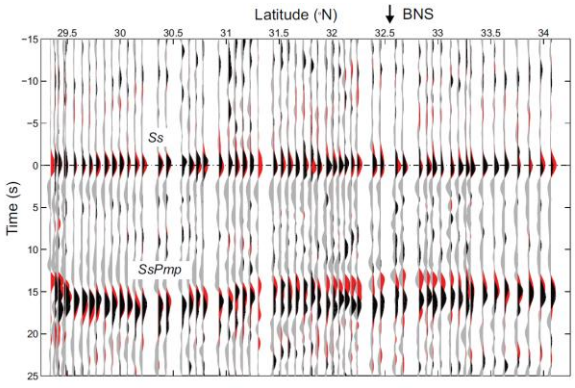

Figure 1: Comparison of two VDSS profiles straddling the Hi-CLIMB linear array. Back-azimuths of the two profiles approximately line up along ~N115°E. Note the consistency between the two profiles except a zone of marked lateral change in crustal thickness beneath the Bangong-Nujiang suture zone (BNS).

We also completed high-resolution estimate of crustal buoyancy over the entire western US. Positive residual topography is particularly pronounced on the edges of the Colorado Plateau (including the northern and southern Rocky Mountains, and the Snake River Plains) and the Basin and Range Province, indicating strong mantle support, from either thermal buoyancy or dynamic processes, of high elevations there.

References:

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