“Noise interferometry from crust to core”

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Seismic imaging of the Earth’s interior had relied almost exclusively on the illumination from energetic sources, such as earthquakes or controlled sources. However, the ability to image the earth with noise, including ambient noise from the Oceans or the reverberations from earthquakes, has revolutionized the field of seismology in the recent decade. The basic idea is that a random field contains coherent signals traveling between the receivers, which can be stacked and amplified while all other arrivals are canceled out in the cross-correlation or the autocorrelation. In particular, surface waves have been found to be most easily retrievable from noise correlations. The extraction of body waves is much more difficult, but recent successes have allowed imaging of the deep Earth. Here I discuss our recent efforts in imaging the Asian lithosphere, particularly the Tibetan Plateau, and the Earth’s inner core using noise interferometry methods.

Models for the growth and deformation of the Tibetan Plateau have been a subject of great debate for decades. A critical information is structure at depth. We shed lights on the debate with high-resolution imaging from surface-wave tomography and joint inversions. Beneath the Tibetan Plateau (TP), pronounced S-wave mid-crustal low velocity zone (LVZ) is observed under the margins (Himalaya and Qiangtang blocks), but less so under its interior (the Lhasa Block). The mantle lithosphere beneath the TP shows strong lateral variation with evidence for the “tearing” of Indian lithosphere beneath two zones in the central and western TP. The mantle variations correlation with crustal velocity variations as well as Vp/Vs ratios. The observations support the existence of a proto-Tibetan Plateau core and the outward growth of the margins at a later stage after the India-Eurasian collision. The crust and mantle lithosphere act mostly as a coherent unit. The LVZ in northern TP shows strong correlation with the region of the mid-Miocene to Quaternary potassic magmatism, suggesting that delamination of lithosphere may have played an important role in the rise of the TP.

The Earth’s inner core poses strong seismic anisotropy, which shows a complex pattern laterally and with depth. All the previous inner core anisotropy models have assumed a cylindrical anisotropy with the symmetry axis parallel (or nearly parallel) to the Earth’s spin axis. However, we have recently found that the fast axis in the inner part of the inner core is close to the equator from inner-core waves extracted from earthquake coda. We obtained inner core phases, PKIIKP2 and PKIKP2 (round-trip phases between the station and its antipode that passes straight through the center of the Earth and that is reflected from the inner core boundary, respectively), from stackings of autocorrelations of the coda of large earthquakes at seismic station clusters around the world. We observed large variation of up to 10 s along equatorial paths in the differential travel times PKIIKP2 – PKIKP2. The observations can be explained by a cylindrical anisotropy in the inner-inner core (IIC) (with a radius of slightly less than half the inner core radius) that has a fast axis aligned near the equator and a cylindrical anisotropy in the outer-inner core (OIC) that has a fast axis along the north-south direction. More recent observations confirm the early results. The results may suggest a major shift in the tectonic regime of the inner-core formation and growth.