Two-layered oceanic lithosphere beneath the Japan Basin, the Sea of Japan

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Formation of the new ocean basin provides a unique observational window into the structure and deformation of the oceanic lithosphere. Using ocean-bottom seismometers deployed in the young Japan Basin, the Sea of Japan, we extract S receiver functions and seafloor Rayleigh wave ellipticities from teleseicmic records. Along with previous ambient-noise dispersion curves, the newly obtained observations are jointly interpreted in a Bayesian trans-dimensional framework to obtain 1-D shear wave velocity models. Our results suggest a distinct structural discontinuity in the mid-lithosphere beneath the Japan Basin. Additional analyses indicate the upper layer shows strong positive radial anisotropy, whereas the lower layer is more isotropic. We interpret that the upper layer was formed during the back-arc opening at 20-15 Ma, where the olivine lattice-preferred orientation (LPO) fabric induced by passive upwelling contributes to the positive radial anisotropy. The lower, less anisotropic layer may be solidified after the sudden cessation of the opening. Small-scale convection (SSC) from such a major tectonic event could randomize the LPO enough to reduce anisotropy before cooling down of the asthenosphere, leaving a radially anisotropic discontinuity in the mid-lithosphere. The proposed formation mechanism of the lithosphere beneath the Japan Basin illuminates an important role of the small-scale convection in modifying the structural fabrics of the asthenosphere in terms of radial anisotropy. Such an SSC-induced radial anisotropy drop could also occur at the base of the lithosphere for regions with ongoing seafloor spreading. The radially anisotropic discontinuity enhances the velocity drop of the horizontally polarized shear wave, facilitating the detection of the Gutenberg discontinuity by SS precursors beneath the Pacific.

Keywords: Japan Basin, Lithospheric structure and deformations, Seafloor Rayleigh wave ellipticity, Trans-dimensional inversion, Small-scale convection