Multi-scale heterogeneities in continental lithosphere and their implications for lithospheric discontinuities

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Lines of evidence from recent seismological observations have revealed the nature of large-scale and fine-scale heterogeneities in the continental lithosphere. Large-scale 3-D images of the continental lithosphere have been constrained primarily from surface waves, which indicate the fast waves speed anomalies of the cratonic lithosphere with the typical lithospheric thickness of about 200 km. Surface wave observations in Australia also provide the evidence of strong radial anisotropy with faster SH wavespeed than SV, particularly at the shallower depth above 90 km as well as in the asthenosphere, while the strength of radial anisotropy tends to be weak in the middle to lower lithosphere (Yoshizawa, 2014, PEPI).
Discontinuities in the lithosphere have been well constrained by the body-wave receiver functions that indicate the wave conversions and reflections underneath seismic stations. One of the striking features in the S-wave receiver function analysis in Australian cratons is the clear signals of discontinuities in the mid-lithosphere at around 70-90 km (Ford et al., 2010, EPSL), which might indicate the rapid velocity drop or change in the character of radial anisotropy at the middle depth of the continental lithosphere where the wave speed is highest in general. This estimated depth of the enigmatic mid-lithosphere discontinuity (MLD) from receiver functions coincides well with the rapid change in the strength of radial anisotropy derived from surface waves (Yoshizawa & Kennett, 2015, GRL).
The latest observations from high-frequency P-wave reflectivity profiles derived from the auto-correlograms of ambient noises in the vertical component (Kennett, 2015, EPSL) provide us with an additional constraint on the nature of the lithospheric heterogeneity. The P reflectivity profiles have suggested vertical changes in the characters of fine-scale structures in the Australian continent, indicating stronger reflectivity in the crust and upper lithosphere underneath the cratons. Such observations support the existence of fine-scale laminated heterogeneity in the lithosphere, as suggested by the numerical simulations for high-frequency scattering of seismic waves for the paths in the cratonic areas (Kennett & Furumura, 2008, GJI; 2016, G-cubed). The existence of such horizontally laminated fine-scale heterogeneity in the upper lithosphere causes equivalent effects as the shape preferred orientation, which may eventually generate apparent change in the radial anisotropy as well as apparent discontinuities in the mid-lithosphere. Linking all these independent observation from a variety of seismic signals with different frequency band will be of help in the further understanding of the nature of lithospheric heterogeneity and anisotropy.

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