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Lithospheric structure of the North American Craton constrained by full waveform inversion

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Cratonic lithosphere is believed to be rigid and less deformed during a long period of time. However, the detailed structure of Cratons may bring information of the complex formation and assemblage process of the continental lithosphere. Here, we present the seismic radial anisotropic structure of the North American Craton (NAC) constrained by a regional full-waveform inversion (FWI) with 465,422 high-quality frequency-dependent travel time misfit measurements with the shortest period of 15 s from both the body wave and surface wave recordings of 5,120 stations and 160 earthquakes located in the contiguous U.S and surrounding regions. Started from an initial model constructed by combining US.2016 and Crust1.0 in the crust and S40RTS (isotropic) in the mantle, we are able to have the optimized crustal structure in terms of initial waveform similarity and get rid of existing features from other radially anisotropic mantle models.

Our new model reveals the NAC lithosphere with about +2% voigt shear wave speed anomaly and an average thickness of 200–250 km beneath the Superior Craton, and becomes thinner towards the eastern, the southern, and the southwestern margins with a thickness decreased to 100–150 km. The radial anisotropy manifests a layer of higher horizontal shear wave speed V_{SH} ($\xi=V_{SH}^2/V_{SV}^2>1$) beneath the core of Superior Craton down to around 160 km, where the higher vertical shear wave speed V_{SV} ($\xi<1$) is observed beneath 160 km. Such radial anisotropy layering is also observed in the margin of continental lithosphere but with shallower depth. The radial anisotropic layer matches the receiver function results of mid-lithosphere discontinuities of the Craton cores, and the lithosphere conductivity result. The radial anisotropy layering observation confirms the two-layered lithosphere structure of the NAC, where the upper layer likely represents the original radial anisotropy fabric related to the cooling of the craton core, while the lower layer might be related to the tectonic processes more recently, e.g., accretion . The lithospheric thinning beneath the NAC margins indicates the deformation of the lithosphere and is likely controlled by the large-scale mantle convection, therefore relates to the further modification process of the NAC.