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Mid-lithospheric discontinuity and its roles in the dynamic evolution of the craton–example from the North China Craton

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Detailed knowledge of lithospheric structure is essential for understanding the long-term evolution and dynamics of continents. We present an integrated lithospheric structural image along an E-W profile across the North China Craton (NCC) derived from the teleseismic data recorded at two dense seismic arrays in combination with other geophysical and geological observations. Our S- and P-receiver function images show substantial undulations of the lithosphere-asthenosphere boundary (LAB), from 60-100 km in the eastern NCC to ∼160-200 km in the central-western NCC, and <150-km in the Qilian orogenic belt further to the west, accompanying marked lithospheric structural variations. This agrees with previous studies that suggest the occurrence of fundamental destruction in the eastern NCC but localized lithospheric thinning and modifications in the central-western NCC. A negative velocity discontinuity is identified at the depth of ∼80–100 km within the thick lithosphere of the central-western NCC, spatially coincident with the top interface of a relatively low velocity layer in the overall high velocity mantle root imaged by surface wave tomography. Detailed data analyses show that this mid- or intra-lithospheric discontinuity has considerably larger S-to-P and P-to-S conversion amplitudes than the LAB below, which provides observational constraints to further decipher the origin of the discontinuity. Our imaging results corroborate recent seismic studies that reveal similar discontinuities at ∼100 km depth under stable continental regions worldwide, suggesting the common presence of vertical heterogeneities and layering in the sub-continental lithospheric mantle (SCLM). The ∼100-km depth discontinuity and the corresponding velocity decrease in the SCLM may indicate an ancient, mechanically weak layer within the overall strong cratonic lithosphere, which probably also existed beneath the eastern NCC before its Mesozoic destruction. The presence of such a weak layer could have facilitated simultaneous lithospheric modification at the base and in the middle of the lithosphere in the eastern NCC, especially under the strong influence of the Mesozoic Pacific subduction, eventually leading to the severe lithospheric thinning and destruction recorded in this part of the craton. The weak layer probably did not strongly affect the stability and evolution of the central and western NCC and other cratonic regions where effects from plate boundary processes were weak. Our seismic images, integrated with geological data, provide new insights into structural heterogeneities in the subcontinental lithospheric mantle and their roles in the dynamic evolution of continents.