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Catastrophic craton destruction via wholesale lithosphere delamination

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The nuclei of continents, manifested as cratons, are the most long-lived parts of Earth's lithosphere. However, ancient cratons in some areas can be substantially destructed with mechanisms not fully understood. Here, we use experimentally calibrated geobarometers to calculate the equilibrium pressures of mafic magmas in the North China Craton, which directly constrain the evolving depth of the lithosphere-asthenosphere boundary beneath the craton through time. We show that the lithospheric thickness of the eastern part of the craton decreased from ~200 km to ~35 km in the early Cretaceous (Fig. 1B). This intense destruction took place within a short time interval of ~10 Myr, at least locally. Following this destruction, the lithosphere gradually rethickened and stabilized as the upwelling asthenosphere cooled and formed a juvenile lithosphere. We suggest that this catastrophic lithosphere thinning resulted from wholesale lithosphere delamination. The lithospheric mantle needs to be denser than the underlying asthenosphere so it can delaminate. Because melt depletion decreases the density of the lithospheric mantle, the strongly depleted cratonic mantle is widely thought to be positively buoyant with respect to the asthenospheric mantle. However, the lithospheric mantle is also cold compared with the asthenospheric mantle, which would increase the density of the lithospheric mantle due to thermal contraction. By calculating the surface subsidence/uplift along three west-to-east crustal profiles (Fig. 2A), we show that the systematic westward surface subsidence of the North China Craton suggests that the lithospheric mantle is denser than the underlying convective asthenospheric mantle (Fig. 2B). It is this inherent negative buoyancy of the lithospheric mantle that drive the wholesale lithosphere delamination. As a consequence of this catastrophic loss of thick mantle roots, the eastern part of the North China Craton may have undergone a rapid crust rebound and surface uplift as seen by the regional unconformities formed between 130-120 Ma in the destructed area (Fig.1A).

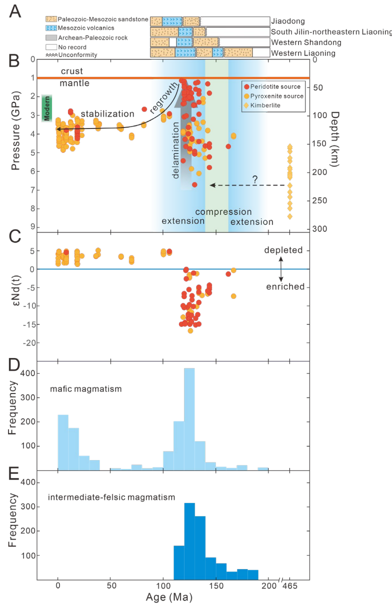

Fig. 1

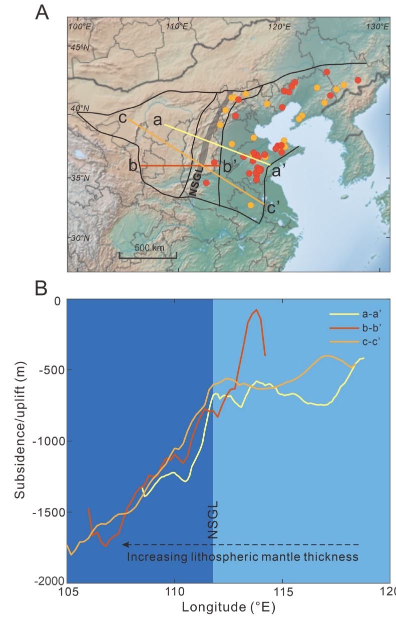

Fig. 2