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Craton Evolution: Origin, Destruction and Restoration

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Cratons are Earth's ancient continental nuclei, preserving invaluable records of planetary evolution and hosting significant mineral resources. Their origin remains debated, with dominant models invoking vertical accretion via plume upwelling, lateral accretion via subduction slab stacking[1], or combined plume-sagduction processes[2]. Despite their formation in the deep past and typical long-term stability, some cratons, like the eastern North China Craton (NCC), experienced profound lithospheric thinning and destruction. Mantle xenolith studies reveal the NCC's transformation from a thick, refractory Archean-Paleoproterozoic mantle root in the Paleozoic to a thin, fertile oceanic-type mantle by the Cenozoic, peaking during the Early Cretaceous (120–130 Ma). This destruction was primarily driven by Paleo-Pacific slab subduction, involving stages of flat subduction, rollback, thinning, and replacement[3,4]. Systematic comparison with the South China Craton indicates that prolonged pre-weakening (>500 Myr) of the lithosphere by earlier subduction is a critical precursor[5], explaining the rarity of craton destruction globally.

Mantle plume upwelling also drives lithospheric thinning, correlating with mass extinctions and large igneous provinces. However, the frequency of plume events contrasts with the preservation of most cratons. We resolve this paradox through **recratonization**—the post-plume re-stabilization of cratonic roots—as demonstrated in the Slave craton following the 1.27 Ga Mackenzie plume event via integrated geochemical-geophysical-numerical evidence[6]. Similar recratonization is inferred for other cratons (e.g., Kaapvaal, Tarim)[7,8]. Plumes may also act as stabilizing agents, welding continental terrains to form refractory cratonic roots[8]. This series of work reveals a dynamic framework of craton evolution, governed by destructive (subduction, plume) and restorative (recratonization, plume welding) processes.

[1] Pearson et al. (2021), Nature 596, 199-210. [2] Zhang et al. (2025), Science Advances 11, eadr9513. [3] Wu et al. (2019), AREPS 47, 173-195. [4] Liu et al. (2019), Earth-Science Reviews 196, 102873. [5] Xu et al. (2025), PNAS 122, e250261822. [6] Liu et al. (2021), Nature 592, 732-736. [7] Zhang et al. (2022) EPSL 598, 117838. [8] Xu et al. (2023), Geology 51, 209-214.