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Top-down versus bottom-up: deciphering the dispersal of the Nuna supercontinent during Earth's Middle Age

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The cyclic assembly and breakup of supercontinents have profoundly shaped Earth's geological and environmental history, driven by the interplay of surface processes and deep mantle dynamics. A key to understanding these cycles lies in deciphering the relative roles of 'top-down' mechanisms (e.g., lithospheric stresses from subduction and slab retreat) and 'bottom-up' mechanisms (e.g., mantle plumes and upwelling). For instance, the breakup of Rodinia and Pangea has been attributed to top-down processes, where subduction-generated stresses led to widespread lithospheric extension and continental rifting [1]. Conversely, others argue that circum-supercontinent subduction could drive mantle return flow beneath the supercontinent and trigger hot upwelling, initiating volcanism and rifting through bottom-up processes [2]. The breakup of Nuna — which was likely Earth's first supercontinent and assembled between approximately (ca.) 2.0 and 1.8 Ga — remains enigmatic due to the fragmentary geological record from the Precambrian. Recent advances in geological and geochemical data from cratonic blocks during Earth's 'Middle Age' (1.8–1.0 Ga) provide a unique opportunity to evaluate the mechanisms driving Nuna's dispersal. In this study, we integrate geological histories of key cratons, Laurentia, Baltica, North China Craton, and Australia, and analyse the temporal-spatial relationships of arc magmatism, high-temperature anorogenic (A-type) magmatism, sedimentary deposition, and large igneous province (LIP) emplacement during the Paleo-Mesoproterozoic. Our time-space plots reveal that the development of interior rift basins and A-type magmatism coincided with accretionary orogens along Nuna's periphery between ca. 1.8 and 1.4 Ga. This was followed by the emergence of global LIPs at 1.4–1.3 Ga, with some localized near pre-existing weak zones and some not. These findings suggest that tectonic-driven rifting localized mantle upwelling (top-down), while mantle plumes also created new weak zones, further facilitating breakup of the Nuna supercontinent (bottom-up). This highlights the combined role of both processes in Nuna's dispersal. We also highlight that Earth's Middle Age was not a period of tectonic stagnation, but rather a time of diverse tectonic activity.

References:

[1] Cawood, P. A. *et al. Earth and Planetary Science Letters* **449**, 118-126 (2016).

[2] Zhong, S. *et al. Earth and Planetary Science Letters* **261**, 551-564 (2007).