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Multiproxy evaluation of tectonic regime variability and crustal reworking throughout Earth history

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Changes in upper crustal composition and tectonic processes yield first-order influences on biogeochemical cycles and Earth's surface environment. Here we integrate a multiproxy zircon isotopic (U-Pb-Hf) and trace elemental dataset with thermochronologic data that help elucidate secular changes in crustal composition and variation in tectonic regimes for over 4 billion years of Earth history. These data indicate the formation of thick stable continental interiors and a corresponding shift from mafic to felsic upper crust took place across the Archean—early Paleoproterozoic. The Mesoproterozoic is noted for a general reduction in magmatism through thickened crust and an overall decrease in crustal assimilation, which corresponds with a long-lived interval of supercontinent formation. Multiple geochemical proxies indicate a transition towards enhanced juvenile magmatism with relative increases in pelagic sediment contributions to magmas throughout the Neoproterozoic and Phanerozoic, consistent with a shift to tectonic regimes with steep deep subduction and slab-rollback. These changes in subduction dynamics led to increased extensional tectonics with island arc and back-arc basin formation. Transitions between extensional and compressional tectonics increase lateral continental growth via accretionary processes at the margins. Importantly, enhanced juvenile magmatism and back-arc basin development influences sedimentary processes, degrees of crustal reworking, and biogeochemical cycles—especially the carbon and phosphorous cycles—that would contribute to the evolution of the Neoproterozoic–Phanerozoic surface system.