Evaluation of Full-Plate reconstructions of the Neoproterozoic using Hf Isotopes in Zircon

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It has been argued that plate motion is fundamentally linked to mantle convection with numerical models attempting to recreate plate motions by simulating mantle convective conditions. Recent work coupling supercontinents and superplumes described a two-stage mantle convection model with: (1) degree-1 mantle convection with a single superplume and an antipodal downwelling zone leading to continent amalgamation, and; (2) degree-2 mantle convection, with two antipodal superplumes separated by a downwelling expressed as a subduction girdle. The subduction girdle of the degree-2 condition is comparable to the modern circum-Pacific system (flanked by the African and Pacific superplumes), which has arguably existed for the entire Phanerozoic. Reconstructions for the Neoproterozoic, however, are debated. Current plate reconstructions rely on paleomagnetic data, which indicate where and when plates moved, but not how the plates interacted with one another during orogenic cycles. Thus, an understanding of Neoproterozoic orogens is required to evaluate the Rodinia-Gondwana supercontinent cycle. Hf isotope analysis of magmatic zircon differentiates between accretionary orogens, formed at subduction girdles external to a supercontinent, and collisional orogens internal to a supercontinent. To test plate reconstructions, U-Pb-Hf data from global Neoproterozoic magmatic rocks were used to reconstruct internal and external orogens during the Rodinia-Gondwana transition. This clarifies the location of plates where paleomagnetic data is lacking. Most importantly, the data reveals that a subduction girdle did not establish around Rodinia. Rather, a disconnected system of magmatic arcs progressively encircled Rodinia and circum-supercontinent subduction did not stabilize until 580-550 Ma. Thus, the global Hf isotope record suggests that the Neoproterozoic was dominated by the degree-1 condition, an entirely different mantle convection pattern to that which characterizes the Phanerozoic era.