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One billion years of stability in the North American Midcontinent following two-stage Grenvillian Structural Inversion

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The North American craton interior preserves a >1 Ga history of near surface processes that inform ongoing debates regarding timing and drivers of deformation and erosion. It has been proposed that far-field effects of the Grenvillian orogeny caused crustal-scale inversion of the late Mesoproterozoic Midcontinent rift. However, poor age constraints have allowed a range of tectonic interpretations including one- and two-stage Grenvillian inversion, as well as post-Grenvillian inversion. Here, we test various structural models on a segment of the Midcontinent Rift along the Douglas Fault in northern Wisconsin, which accommodated 10–20 km of vertical slip. The thrust fault juxtaposes ca. 1100 Ma rift volcanic rocks in the hanging wall with post-rift sandstone of the Bayfield Group deformed by drag-folding in the footwall. To constrain the timing of fault movement, we used U-Pb geochronology on vein calcite from the fault zone and detrital zircon from folded strata in the hanging wall and footwall. We constrain the timing of progressive movement on the Douglas Fault using Δ47-based calcite thermochronometry to construct a time-temperature and erosional history of the region. We determine that ≥90% of shortening took place in the Ottawan phase and ≤10% in the Rigolet phase of the Grenvillian Orogeny. Following two-stage Grenvillian inversion and re-cratonization of the midcontinent by ca. 995–980 Ma, our compiled geological observations and thermal history suggest that <1 km of surface strata have been deposited or removed since – demonstrating protracted stability in the craton interior and lack of support for a Neoproterozoic glacial origin of the Great Unconformity.