On Reverse Weathering, Climate Stability and Cooling

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The Precambrian is marked by apparent climate stability with and rare catastrophic glaciations. Consistent with proxy reconstructions, nearly all solutions to the Faint Young sun paradox requires an elevated atmospheric CO_2 baseline (> 5-10 times preindustrial levels). However, mechanisms that sustained this persistently CO_2 rich atmosphere, remain debated. Here we propose that elevated rates of reverse weathering—the consumption of alkalinity (HCO^{3-}) and the release of carbon dioxide (CO_2) accompanying clay authigenesis—could have acted as a stabilizing feedback mechanism that resulted in a warm and stable climate. Although dampened by sluggish kinetics today, more prolific rates of reverse weathering would have persisted under the silica-rich conditions that dominated early oceans. We estimate that, as little as 20% of Si removal via reverse weathering (of the total marine export flux) would have been required to maintain the warm ice-free environment that characterized most of the Precambrian. Further, varying rates of reverse weathering may provide an unexplored means to trigger widespread glaciation. With a dissolved Si dependence on reverse weathering, it is possible to have cooling driven by waning carbon dioxide fluxes linked to clay authigenesis concurrent with a drop in terrestrial weathering rates and terrestrial to marine Si fluxes.