Clay authigenesis (reverse weathering) as a pH-thermostat and its role in the evolution of climate stability

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Despite a Sun with lower luminosity, Earth's early climate was marked by apparent stability with rare catastrophic glaciations. Here, we demonstrate that elevated rates of reverse weathering—the consumption of alkalinity and the generation of acidity accompanying clay authigenesis—released a flux of CO_2 to the atmosphere that would have sustained a significantly elevated $p$$CO_2$ baseline. Although dampened by sluggish kinetics today, more prolific rates of reverse weathering would have persisted under the pervasively silica-rich conditions that dominated early oceans. We estimate that ~20-30% of marine dissolved silica burial through the reverse weathering sink would have successfully maintained the equable and ice-free environment that characterized most of the Precambrian. During this time, the establishment of a potent negative feedback between marine pH and authigenic clay formation (a pH-stat) greatly enhanced climate stability by mitigating large swings in atmospheric CO_2 levels. Subsequently, the ecological rise of siliceous organisms alleviated the reverse weathering buffer, forcing the destabilization of Earth's climate system and lowering of baseline $p$$CO_2$ levels.