Impact of changing weatherability on CO_2—climate coupling during the late Paleozoic

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A new multiproxy pCO_2 record for the late Paleozoic ice age (~315 to 270 Ma) refines existing CO_2 estimates and documents linkages between pCO_2, glaciation history, and repeated turnovers of terrestrial biomes. In particular, a 10-Myr interval of minimum pCO_2 (160 to 300 ppm) in the earliest Permian (300 to 290 Ma), coinciding with maximum ice-sheet extent, introduces a new paradigm given the loss of prevalent Carboniferous CO_2 sinks. Here we use the spatially resolved, intermediate complexity GEOCLIM model to evaluate the relative importance of CO_2 sinks and sources (e.g., uplift of the Central Pangaean Mountains (CPM), intensifying low-latitude aridification, and changing mafic-to-granite ratio of outcropping rocks) on steady-state atmospheric CO_2 during the ice age and its turnover into a permanent greenhouse. Enhanced weatherability provided by uplift of the CPM could lower pCO_2 below the Carboniferous threshold for ice sheet initiation; increasing the surface extent of mafic rocks drives CO_2 levels toward snowball Earth conditions. Conversely, a substantial increase (up to 4-fold) in surface mafic rocks is needed to sustain the 10-Myr CO_2 nadir in the earliest Permian. This shift in mafic-to-granite rock ratio across the Carboniferous—Permian transition is further supported by the strong correspondence between proxy and simulated seawater $^{87}Sr/^{86}Sr$ values. Overall, these findings suggest a major reorganization of the predominant factors influencing weatherability in the tropics across the Carboniferous to Permian transition. Increasing magmatic degassing through the remainder of the early Permian, even under substantially increased mafic-to-granite rock ratios, had the potental for CO_2-forcing of the demise of the late Paleozoic ice age.