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Linked Shifts in Glacial-Interglacial CO_2, Climate and Terrestrial Carbon Cycling During Earth's Last Icehouse

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Earth's last icehouse (325 to 260 Myr) is considered the longest-lived and most acute of the past half billion years, characterized by widespread continental ice sheets and possibly tropical low-elevation glaciation. This atypical climate has long been attributed to anomalous radiative-forcing promoted by a 3% lower incident solar luminosity and sustained low atmospheric CO_2 (≤300 ppm). Existing late Paleozoic CO_2 reconstructions, necessary to resolve this radiative-forcing conundrum and to better understand paleoclimate dynamics, are of insufficient resolution and poorly constrained. We present an integrated pedogenic carbonate and fossil cuticle reconstruction of atmospheric CO_2 through 16 million years of the latter half of the Pennsylvanian and earliest Permian developed using a cyclothem series in the Illinois Basin as well as a subset of samples from the Appalachian and Donets basins. Overall, reconstructed CO_2 falls below the modeled threshold (560 ppm) for late Paleozoic glacial inception, well within the range of ice sheet stability during the LPIA (up to 840 ppm). The suborbital resolution reveals CO_2 variations between ~200 and 700 ppm with an apparent long eccentricity pacing. Short-term CO_2 fluctuations are superimposed on a 10^6-yr CO_2 trend that varies in-step with major sea level changes and glacial advances and retreats inferred from Donets Basin and Midcontinent stratigraphic trends. Comparison of the CO_2 reconstruction with published paleobotanical records for tropical Euramerica indicates a coincidence between CO_2 changes and repeated restructuring of Pangaean tropical forests. Integration of these empirical records with modeled vegetation shifts for the late Paleozoic indicate a more dynamic carbon sequestration history than previously considered and a major role for terrestrial vegetation-CO_2 feedbacks in driving eccentricity scale climate cycles of the late Paleozoic icehouse.