Eccentricity Paced CO_2, Climate and Terrestrial Carbon Cycling During Earth's Penultimate Icehouse

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Earth's last icehouse (325 to 260 Myr) was the longest-lived and likely most acute of the past half billion years attributed in large part to the anomalous radiative-forcing created by a 3% lower incident solar luminosity and sustained low atmospheric CO_2 (≤300 ppm). We present an integrated pedogenic carbonate and fossil cuticle reconstruction of atmospheric CO_2 through 16 million years of the late Paleozoic ice age developed using a long-eccentricity cyclothem series in the Illinois Basin (central USA) as well as a subset of samples from the Appalachian (eastern USA) and Donets (Ukraine) 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 inferred major sea level changes and glacial advances and retreats. Warmest average monthly air temperatures inferred from Δ_{47} of soil-formed carbonates vary with CO_2 and indicate interglacial MAATs of between 11 and 30°C.

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.