Different responses of terrestrial C_3 plant groups to paleo-pCO_2, pO_2, and implications for photosynthetic fractionation of stable carbon isotopes

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The extent to which atmospheric CO_2 (and O_2) concentrations affect photosynthesis and resulting stable carbon isotopes in terrestrial plants is currently under investigation. Recent plant chamber experiments and paleo-studies have shown that CO_2 concentrations have a clear effect on $\delta^{13}C$ values of C_3 plants, independent of changes in environmental variables such as precipitation, temperature, and vapour pressure deficit. Other new research shows the effect varies by C_3 plant group (angiosperm/gymnosperm), and there is also intriguing and contradictory evidence for variation of $\delta^{13}C$ values in response to changing CO_2:O_2 ratios. These studies present a growing body of evidence that simple, widely-used models of photosynthetic fractionation do not accurately represent all fractionation processes, particularly over disparate geological timescales and C_3 plant species (most of Earth's vegetation). The uncertainty affects how we model biogeochemical flows of carbon, and how we interpret $\delta^{13}C$ values in the geologic record.

Using an updated high-resolution compilation of Cenozoic and historic isotopic data, integrated with ice core records and climate model predictions of past hydrological changes, this study places constraints on the contribution of of different fractionation processes (diffusion, carboxylation, photorespiration) to the stable isotope composition of C_3 plants, under changing pCO_2 and pO_2. We identify key differences in fractionation processes which vary with C_3 plant group (angiosperm/gymnosperm). Finally, we provide a brief discussion of implications for the geobiological record.