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Comparison between modeled, measured, and predicted $\delta^{13}C$ and pCO_2 values from terrestrial sediments

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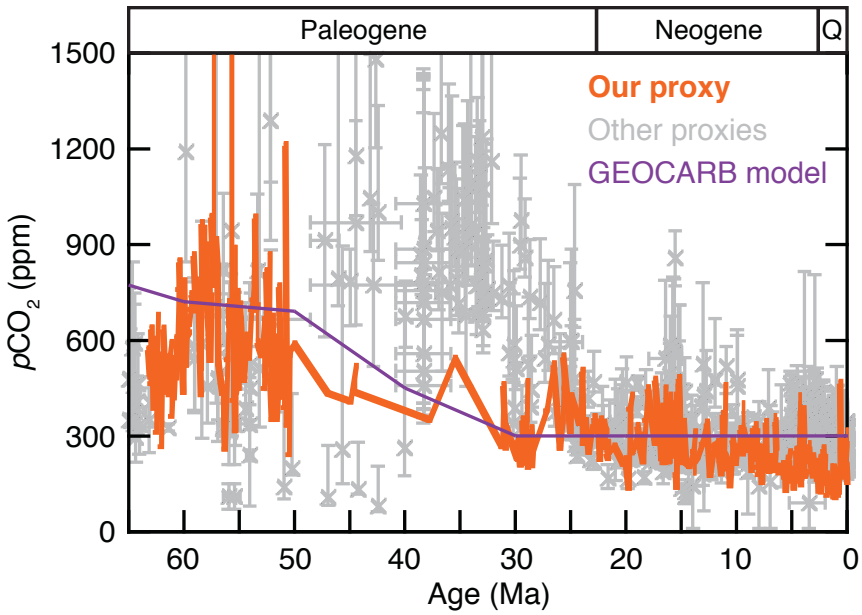
A multitude of proxies and models exist for reconstructing past levels of atmospheric carbon dioxide (pCO_2), yet each of these methods are limited by their temporal and/or spatial resolution. Here we present a new geochemical proxy for reconstructing paleo-pCO_2 based upon the $\delta^{13}C$ value of C_3 plant content within terrestrial organic matter. We have shown that this method accurately predicts pCO_2 level across a wide range of temporal resolutions and depositional environments *via* three independent tests. First, we tested the proxy's ability to reconstruct small (<100 ppm) changes in pCO_2 from $\delta^{13}C$ measurements made on fossil leaves, bulk organic matter, and *n*-alkanes across the Last Glacial Maximum through the Holocene (30,000 to 100 years BP). Comparison of our predicted pCO_2 levels to pCO_2 values measured from ice core records showed that all three terrestrial substrates accurately reconstruct the well-documented pCO_2 change, but greatest precision is provided by measurements made on fossil leaf material. Second, we tested the proxy's potential for improving models of atmospheric carbon release during carbon isotope excursions events by constraining estimates for the absolute minimum and maximum pCO_2 levels reached during these brief intervals of rapid pCO_2 rise and global warming. Third, we tested the potential for this proxy to reconstruct pCO_2 levels across large intervals of Geologic history with a preliminary reconstruction of pCO_2 across the entire Cenozoic Era (see Figure). Our reconstruction indicates the highest pCO_2 levels of the last 65 million years occurred during the early Paleogene, followed by a significant drop in pCO_2 levels to the relatively low pCO_2 levels experienced throughout much of the Neogene and Quaternary, as is consistent with models of long-term carbon cycling and previous proxy estimates. Each of these three examples suggests a wholly new way of interpreting changes in the $\delta^{13}C$ value of terrestrial substrates, and demonstrates the wide-ranging potential of using this proxy to reconstruct pCO_2 levels across the last 400+ million years of Earth history by exploiting the abundant terrestrial organic matter in the geologic rock record.



Reconstruction of pCO_2 across the Cenozoic Era (65-0 Ma). Our pCO_2 reconstruction using the $\delta^{13}C$ value of terrestrial organic matter (orange) follows similar trends observed in other published proxy values (gray) and a model of long-term carbon cycling (purple).