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Examining the utility of carbon isotopes in cellulose and whole wood as a proxy for environmental change

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The carbon isotope ($\delta^{13}C$) composition of modern and fossil wood is widely used as a proxy for environmental and climatic change. Isotopic analysis on chemically extracted cellulose is commonly preferred over whole wood due to the potential for diagenetic alteration of whole wood. However, cellulose extraction is prohibitively time consuming for wide applicability in high-resolution studies, and cellulose is not preserved in all fossil wood specimens. We examine whether cellulose extraction is necessary for the detection of environmental and climatic signals in fossil wood by performing a meta-analysis of studies on modern and sub-fossil (mummified) trees across a large range of ages, plant types, and environmental settings. The $\delta^{13}C$ value of cellulose and whole wood is highly correlated in modern wood ($r = 0.93$, $p < 0.001$, $n = 979$ pairs) and pre-industrial sub-fossil wood ($r = 0.95$, $p < 0.001$, $n = 205$ pairs), suggesting that early diagenesis does not affect the isotopic offset between whole wood and cellulose. To test for longer term diagenetic affects, we extracted cellulose from early Eocene fossil wood recovered from Banks Island, Canada. The $\delta^{13}C$ offset between cellulose and whole wood is larger in the Eocene samples than in modern and sub-fossil trees, which we attribute to loss of cellulose. However, the strong correlation between cellulose and whole wood $\delta^{13}C$ values is preserved in the Eocene samples ($r = 0.86$, $p < 0.001$, $n = 14$ pairs). Taken together, we conclude that the integrity of paleoenvironmental signals is preserved in $\delta^{13}C$ values of fossil wood, and cellulose extraction is unnecessary for most deep-time applications.