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The δ13C of terrestrial plant organic matter throughout the Phanerozoic

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Organic matter originating from C3 plants is a significant contributor of organic carbon to terrestrial sedimentary rocks since the emergence of land plants in the Ordovician. It should therefore be possible to use the carbon stable isotope composition (δ13C) of terrestrial organic matter to reconstruct changes in the 13C fractionation behavior of plants, which in turn may relate to changes in the composition of the Earth's atmosphere. However, this approach may be compromised by compositional changes (taphonomic or diagenetic) of plant organic matter during fossilization, which can also affect its C-isotopic composition. This means that the δ13C of fossil plant organic matter is not directly comparable to the δ13C of modern (i.e. non-fossilized) plants. In order to assess the effects of fossilization on the δ13C of plant organic matter, we have analyzed mean δ13C values of fossil wood and coal from several localities and ages, and compared the results with mean δ13C values of fossil resins (amber) from the same locations. The δ13C of the resins is thereby used as an indicator of the original δ13C of the source plant, because resins undergo little chemical and isotopic modification during fossilization due to their isoprenoid skeletal structure, and the average δ13C of resins approximates the average δ13C of source plant tissues. Compared to coal and fossil wood, fossil resins are depleted in 13C by approximately 2‰.This offset can be explained by the preferred preservation of lignin in fossil wood and coal, which is 13C-depleted, and the breakdown of the original cellulose fraction, which is 13C-enriched relative to the bulk plant and resins. With this observed offset as a correction value, we were able to reconstruct the average δ13C of terrestrial plants for the past 450 million years using published δ13C data for terrestrial organic matter. This reconstruction indicates that plants had their most 13C-enriched compositions, with bulk plant δ13C values of around -20‰ during the early Carboniferous, the early Permian, the mid-Triassic, and the mid-Cretaceous. The most 13C-depleted compositions, with δ13C values between -27 and -24‰ are restricted to the Ordovician and Silurian, the late Permian, the late Cretaceous, and the more recent past (Neogene/Quaternary). This novel reconstruction offers significant insights into the co-evolution of plants and atmospheric composition.