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Climatic Significance of the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ Variations in Organic Matter: Calibration in Modern Plants and Application to the Paleoclimate Analysis of the Last 3000 Years in Central Europe

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The $^{13}C/^{12}C$-values in organic matter often correlate with a number of environmental factors such as relative humidity and temperature (Stuiver and Braziunas, 1987). Similarly, the $^{18}O/^{16}O$-values of plant cellulose are determined by (1) isotopic composition of waters used by plants, (2) alteration of this isotopic signature by evapotranspiration in leaves (Buhay et al., 1996), and (3) biochemical isotopic fractionation occurring during the synthesis of organic compounds. While the last of these processes thought to remain constant with temperature (DeNiro and Epstein, 1981), the other two link cellulose $^{18}O/^{16}O$ ratios to humidity and temperature.

The accumulation of organic matter, well preserved in peat deposits, constitutes a potential climatic archive in the continental realm. Past peat-based paleoclimate studies, however, have generally relied on analysis of bulk peat material and have not been well calibrated through modern climate-$\delta^{13}C$ and $\delta^{18}O$ relationships. We present here results of such a calibration and its application to paleoclimate analysis by studying the isotopic compositions of individual species in a peat core. Representative species of vascular plants and mosses were sampled along an altitude gradient in the Swiss Alps, which provides a substantial environmental gradient. Isotopic ratios were measured by EA-IRMS on both whole plant material and the α-cellulose fraction for carbon and on the α-cellulose fraction for oxygen.

The response of plant $\delta^{13}C$ to the environmental gradient varies considerably. For most plant species $\delta^{13}C$ increases with altitude. Measurements of both whole plant carbon and α-cellulose show identical though offset trends. The primary control on $\delta^{13}C$ is interpreted to be decreasing CO_2 partial pressure with altitude. Increasing water availability with altitude is likely an additional influence on moss $\delta^{13}C$. We cannot rule out an influence of decreasing temperature. As for carbon isotopes, the response of plant to $\delta^{18}O$ to the climatic changes encountered along the altitudinal gradient varies from species to species. With increasing altitude, the $\delta^{18}O$-values of cellulose from vascular plants and emergent mosses generally decrease, following the trend of isotopic composition of precipitation described by Siegenthaler and Oeschger (1980). The environmental parameters, well constrained along the transect, allow us to test the hypothesis of different models proposed to predict the isotopic composition of terrestrial plant cellulose (i.e. Burk and Stuiver, 1981, Edwards et al., 1985).

A second part of this study investigates the isotopic response of peat species to climatic changes during the last 3000 years. A peat core was then collected at 1200 masl in the Swiss Alps, it was precisely dated (C-14 and 210-Pb) and subsampled at high resolution for identification of individual plant species. The bottom of the core has a radiocarbon age of 3148 ±71 years BP. Two peat species are present throughout the entire core: *Eriophorum vaginatum* and *Sphagnum magellanicum*. Carbon isotope measurements were performed on bulk peat material, on whole plant material from individual species and on the α-cellulose fraction of the species and, the oxygen isotope measurements were performed on the α-cellulose fraction. Bulk $\delta^{13}C$-values vary between -25 and -22‰ with the lowest values in the topmost 10 cm of the core. After a plateau of relatively higher $\delta^{13}C$-values between 10 and 65 cm, carbon isotopic compositions of bulk material decrease again. α-cellulose and bulk plant $^{13}C/^{12}C$ show parallel trends for both *S. magellanicum* and *E. vaginatum* except for the first 10 cm of the core. This difference might be attributed to the effects of diagenesis on C isotopic composition. Again, for both individual species, the amplitude of $\delta^{13}C$-values measured in α-cellulose is higher than the amplitude observed in bulk material. For example, $\delta^{13}C$-values in α-cellulose extracted from *S. magellanicum* range from -25 to -20,5‰ with the highest values at 60 cm, while bulk $\delta^{13}C$-values varies between -24 and -21‰. Similarly to the modern plants, $\delta^{18}O$-values measured for *E. vaginatum* are higher than those measured in *S. magellanicum* (24 to 25.5‰ vs. 20.5 to 23.5‰).

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