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Oxygen-Isotope Behaviour of Silica Phytoliths in Prairie Grasses Across the Great Plains of North America

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Information regarding climatic conditions during terrestrial plant growth is preserved by the oxygen-isotope composition of biogenic silica (phytoliths) deposited in grasses. Calamovilfa longifolia was collected across the Great Plains of North America. These samples were used to investigate the effects of natural variations in relative humidity, evapo-transpiration, temperature and soil-water oxygen-18 enrichment on the oxygen-isotope composition of phytoliths. Phytoliths at all sites showed a similar pattern of oxygen-isotope behaviour within an individual plant. Non-transpiring tissues contained silica with oxygen-isotope compositions controlled by soil-water composition and temperature, whereas the oxygen-18 content of silica in leaf and inflorescence tissues was enriched further by processes related to transpiration. The oxygen-18 enrichment of leaf silica relative to stem silica increased as the average relative humidity of the growing season decreased.

Accurate calculation of growing temperatures was possible only when both the oxygen-isotope compositions of stem silica and soil water were known for a particular locality. Potential proxies for the oxygen-isotope composition of soil water, such as summer precipitation, local surface water and shallow groundwater, produced progressively less reliable results, with the difference between measured temperatures and those calculated from stem silica-water pairs becoming larger as relative humidity decreased. This behaviour reflects the increased evaporative enrichment in oxygen-18 of soil water used by plants in more arid regions.

Once plant organic matter decays, the phytoliths from all plant parts are largely transferred to the soil. The temperature and soil-water signals carried by the oxygen-isotope composition of silica from non-transpiring plant parts (stem, rhizome, sheath, root) are therefore partially masked by the phytoliths from transpiring plant parts (leaves, inflorescence), which are variably further enriched in oxygen-18 depending on relative humidity. However, the overall oxygen-isotope composition of a soil-phytolith assemblage can still be related to temperature and relative humidity, using an empirical relationship based on temperature and the difference between soil-phytolith and estimated soil-water oxygen-isotope compositions.