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Extraordinary triple oxygen isotope fractionation in equisetum: Breaking the -1800 per meg mark

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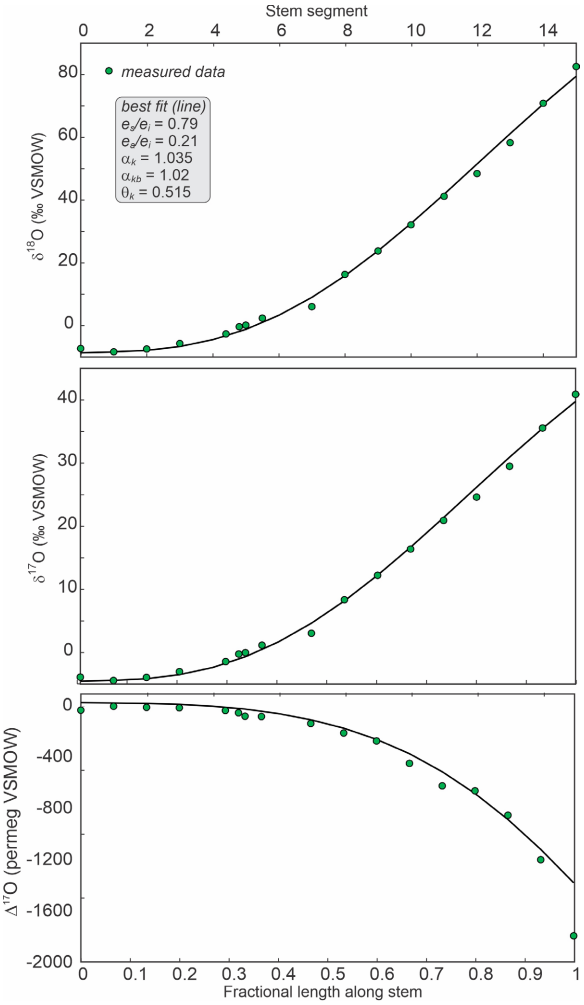
Equisetum (horsetails) are primitive vascular plants with fossil ancestors dating back to the Devonian. They consist of a slender stalk with 14-15 jointed photosynthetic stems. Nearly the entire surface of the horsetail stems is densely dotted with stomata [1]. As such, equisetum act as a perfect distillation column along the nodes, with potential constriction at the internodes. The triple oxygen isotope composition along the stem ranges from ambient soil water values at the base to $\delta^{18}O$ = 82 ‰ and $\Delta'^{17}O$= −1800 per meg at the stem tip. The lowest $\Delta'^{17}O$ values are over 1000 per meg lower than anything previously measured on Earth. We are able to model the isotopic variation along the stem using a modified leaf evaporation model [2] combined with a 'chain of lakes' model (Fig. 1). A best-fit is obtained with e_s/e_i and e_a/e_i of 0.79 and 0.21 and a_k, a_{kb}, and θ_k of 1.035, 1.02 and 0.515, respectively. These values are very well constrained based on the simultaneous best fit for $\delta^{17}O$, $\delta^{18}O$ and $\Delta'^{17}O$ values. It is not clear if larger equisetum reaching 8 meters in length (*E. giganteum* and *E. myriochaetum*) [3] scale with length and therefore show similar enrichments or have even larger isotopic shifts.

Preliminary measurements of coexisting phytoliths (amorphous silica within the cells) show near silica-water equilibrium at the base, but significantly lower-than-expected fractionations towards the stem tip. This is probably the result of continuous phytolith crystallization as the equisetum grows. Early phytolith precipitation occurs near the base with light water while the final growth occurs after the stem has grown and elongated, and is therefore equilibrating with much heavier water. The phytoliths are probably strongly zoned. Devonian ancestors of equisetum (*Archaeoequisetites lindlarensis, Archaeocalamites antiquus*) reached heights of 18 meters. If their phytoliths are preserved, they might show extreme isotope values that could constrain environmental and physiological conditions.



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