Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37223

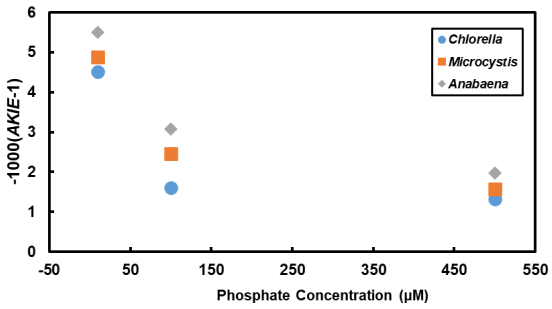
Larger oxygen isotope effects during phosphate uptake in lower-phosphorus water

DR. ZHAO WEI[1], BAOYING WANG[2], LONGCHEN ZHU[3] AND HUIMING BAO[1]

[1]International Center for Isotope Effects Research, State Key Laboratory of Critical Earth Material Cycling and Mineral Deposits, Nanjing University

[2]State Key Laboratory of Pollution Control and Resource Reuse, School of the Environment, Nanjing University

[3]Frontiers Science Center for Critical Earth Material Cycling, School of Earth Sciences and Engineering, Nanjing University



Isotope fractionation during microbial oxyanion reduction (e.g., sulfate, nitrate, and perchlorate) is overwhelmingly dominated by intracellular enzymatic bond-breaking reactions, rendering isotope effects associated with membrane transport largely obscured. In contrast, phosphate (PO_4^{3-}) uptake involves no redox transformation or bond cleavage during translocation across the cell membrane, making it uniquely suited for isolating isotope effects arising solely from transporter binding and translocation. Our recent phosphate oxygen isotope ($\delta^{18}O_P$) data from extremely low-[PO_4^{3-}] lakes (at detection limit of ~0.1 μM) revealed that the apparent kinetic isotope effect (*AKIE*) (1000(*AKIE*-1) ~ -6‰) is nearly twice the previously determined value of ~ -3‰ starting at [PO_4^{3-}] of 200 μM, suggesting the oxygen isotope effect associated with PO_4^{3-} uptake at low-[PO_4^{3-}] conditions could be even larger.

Here we test the hypothesis that the transport *AKIE* associated with PO_4^{3-} uptake through cell membrane scales smoothly with ambient PO_4^{3-} concentration. Micro-molar [PO_4^{3-}] $\delta^{18}O_P$ measurement are now possible, thanks to our recently developed ESI-Orbitrap-MS approach [1,2]. We have conducted a set of culture experiments using a green alga (*Chlorella*) and two cyanobacteria (*Microcystis* and *Anabaena*) under initial PO_4^{3-} conditions of 10, 100, and 500 μM. Residual PO_4^{3-} samples were taken at the respective exponential growth stages. Results show that the 1000(*AKIE*-1) values for *Chlorella, Microcystis* and *Anabaena* change from -1.6‰, -2.5‰ and -3.1‰ to -4.6‰, -4.9‰, and -5.5‰, respectively as the initial experimental PO_4^{3-} concentration decreases from 500 to 100, and to 10 μM (Fig. 1), confirming a higher degree of normal *AKIE* under lower PO_4^{3-} concentrations. Experiments with additional initial PO_4^{3-} concentrations are required to confirm if indeed low-affinity and high-affinity transporters have different fundamental fractionation factors or the observed trend is merely the result of different degrees of backward PO_4^{3-} flux among the different experimental conditions.

References:

[1] Wang Z, Hattori S, Peng Y, Zhu L, Wei Z, Bao H. *Analytical Chemistry* 2024, **96**(11)**:** 4369-4376.

[2] Wei Z, Wang B, Zhu L, Hong Y, Wang Z, Yan H*, et al.*. *Applied Geochemistry* 2025, **194:** 106610.