Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.16866

’Visible phosphorus’ in shallow, calcareous Lake Balaton (Hungary)

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Despite a long history of research [1], the mechanism of phosphorus (P) release at the sediment-water interface in calcareous lakes is still not completely understood. Lake Balaton is a prime example where a major algal bloom in 2019 was triggered by anoxic conditions that mobilized P from the calcite-dominated sediment [2]. Sequential chemical extractions provide useful but indirect data on P-bearing fractions [3]; thus, we used scanning transmission electron microscopy (STEM) with energy-dispersive X-ray (EDS) mapping to characterize ‘visible P’ (i.e., particles with P concentrations exceeding the detection limit of EDS, ~1 wt% P).

Three distinct categories of visible P were identified. In suspended matter collected during algal blooms we found (i) copious amounts of P in the form of polyphosphate inclusions inside the cells of various algae, and (ii) amorphous, P-rich nanoparticles outside but next to cells (as in Fig. 1, near fragments of a silica shell). In contrast, (iii) sedimentary P-bearing particles included both amorphous and crystalline P granules, the latter having structures consistent with tricalcium phosphate and apatite. While the particles in the three groups shared some basic features, their compositions, size distributions and electron-beam sensitivities slightly differed. A general and distinct feature of sedimentary P-bearing particles was their adherence to clay minerals (primarily smectite). Our results offer two contrasting scenarios for the formation of sedimentary ’visible P’: either the biogenic polyphosphate inclusions age and transform into the observed sedimentary particles after the decomposition of algae in the sediment, or dissolved phosphate precipitates on clay mineral surfaces and ages from amorphous material into apatite through a sequence of intermediate phases. Currently we are experimentingboth with algal cultures and inorganic precipitation to understand which of the above mechanisms is active in the lake, and whether the P in the observed particles is biologically available [4].

[1] Boström et al. (1988) *Hydrobiol.* 170, 229-244. [2] Istvánovics et al. (2022) *Freshwater Biol.* 67, 1091-1106. [3] Wang et al. (2013) *Limnology* 14, 147-157. [4] Support from NKFIH under grants RRF-2.3.1-21-2022-00014 and K134559 are acknowledged.