Phosphorus cycling in a low sulfate euxinic ocean analogue, Lake Cadagno, Switzerland

YIJUN XIONG[1*], ROMAIN GUILBAUD[2], CAROLINE L. PEACOCK[1], RAYMOND P. COX[3], MICHAEL D. KROM[1,4], SIMON W. POULTON[1]

[1] School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK

[2] Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK

[3] Institute of Biology, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark

[4] Department of Marine Biology, Haifa University, Rehov Aba Koushy, Haifa, Israel

From ~2.7 billion years onwards, as oceanic sulfate concentrations progressively increased, euxinic (anoxic and sulfidic) conditions became a more significant feature of anoxic oceans. Despite overall rising sulfate through Earth history, lower sulfate than at present is envisaged for much of the Precambrian, while Phanerozoic episodes of ocean euxinia are also increasingly considered to have been characterised by low sulfate. However, mineralogical controls on P cycling under low sulfate, euxinic conditions remain poorly constrained, despite the fact that P is commonly considered to be the ultimate limiting nutrient on geologic timescales, with major implications for primary productivity, organic carbon burial, and hence Earth's oxygenation history. Sulfate availability ultimately exerts a major control on the generation of sulfide, and hence limits the extent to which sulfide affects the cycling of P during diagenesis. This, in turn, controls whether P is either retained in the sediment as an authigenic phase, or whether P is recycled to the overlying water column, thus fueling further primary production.

Here, we present new data from the water column and sediments of Lake Cadagno, Swizerland, which is considered a low-sulfate, sulfidic ocean analogue. We focus on P cycling in different parts of the basin, including the deeper euxinic waters, shallower oxic waters, and a site where the chemocline intersects the deposited sediments. We combine Fe and P speciation data with bulk geochemical and mineralogical analyses, to provide evidence that in the water column, Fe(II) phosphate forms transiently at the chemocline, while in sediments deposited under euxinic conditions, phosphate is removed permantly as Fe(II) phosphate. This ultimately provides a negative feedback on P recycling, which was likely prevalent during low sulfate euxinic episodes throughout Earth history.