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Conference Abstract

The Impact of Phosphorus Level on Vivianite Precipitation during Microbial Reduction of Ferrihydrite

Xiaoqing Shao[‡], Zach DiLoreto[‡], Huan Liu[§], Xiancai Lu[§], Maria Dittrich[‡]

‡ University of Toronto, Toronto, Canada
§ Nanjing University, Nanjing, China

Corresponding author: Maria Dittrich (m.dittrich@utoronto.ca)

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Abstract

Iron minerals play a pervasive role in the cycling of phosphorus (P) within both terrestrial and aquatic environments. The behavior of P, especially in oxygen-depleted environments, is frequently regulated by changing redox conditions and the associated phase transformations of Fe (III) (hydr)oxides (Borch and Fendorf 2007). Although the stability of Fe (III) hydroxides under changing redox conditions is well established, the relationship between specific minerals and their influence on the mechanisms of P retention and release remain unclear. In particular, the minerals vivianite ($Fe_3(PO_4)_2 \cdot 8H_2O$) and ferrihydrite ($Fe_2O_3 \cdot 0.5H_2O$) are of interest. Vivianite crystallization in sediments has attracted increasing attention as a major contributor to P retention during early diagenesis (Slomp et al. 2013) and ferrihydrite reduction has been linked to fluctuating P concentrations which can impact vivianite crystallization. Additionally, there exists strong biological controls on these minerals as the reduction of Fe (III) oxides by dissimilatory iron-reducing bacteria may result in the formation of a suite of Fe (II)-bearing secondary minerals (O'Loughlin et al. 2021). To better understand the biogeochemical mechanisms behind these interactions, we examined the effects of fluctuating P concentrations on the reduction of ferrihydrite by *Shewanella putrefaciens* CN32 and resulting vivianite formation.

In this study, bio-reduction experiments were conducted under sterile conditions in serum bottles containing 80 mL of mineral medium, with 80 mM Fe (III) in the form of Ferrihydrite, and various P concentrations (0, 1 mM, and 10 mM). The bottles were placed on a roller drum (180 rpm) and incubated at 30 ^{o}C in the dark for 15 days. Dissolved Fe (II), P concentrations, pH, and optical density (OD) values throughout the experiments were also measured. Our results showed that during incubation, *Shewanella putrefaciens* CN32 accelerated Ferrihydrite reduction as the dissolved iron (Fe^{2+}) concentration increased significantly when compared to other bacterial and ferrihydrite treatments, as well as the control treatment. Additionally, P in both the 1mM and 10mM treatments was depleted after 5 and 7 days, respectively, and resulted in crystalline precipitates. Scanning electron microscopy (SEM) analyses of precipitates showed well-formed and highly crystalline vivianite particles of up to 30 μm in length in high P level. Some crystalline precipitates were confirmed as vivianite through SEM and Raman spectroscopy matching a known vivianite reference (Taylor et al. 2008), but only within the 10mM P incubations. After 15 days of incubation the morphology of the vivianite changed from aggregates of lath-shaped crystals to acicular crystals (Fig. 1). Based on our results, fluctuating P concentrations do indeed have a pronounced effect on ferrihydrite reduction and thus vivianite formation.

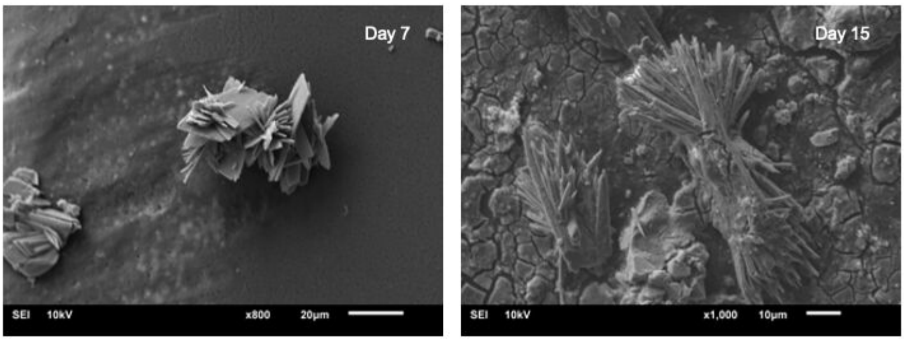

Figure 1. doi

Figure 1. SEM imaging on the Ferrihydrite surface of treatment (Bacteria + Ferrihydrite + 10 mM P) during 15-day (Day 7 and Day 15) incubation with *Shewanella putrefaciens*.

Keywords

crystallization, oxygen-depleted, Raman spectrum, dissimilatory iron-reducing bacteria

Presenting author

Xiaoqing Shao

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Conflicts of interest

The authors have declared that no competing interests exist.

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