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Origin of phosphate stromatolite formed after the snowball Earth

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The sedimentary rocks formed after Neoproterozoic snowball Earth distribute near Irece, Bahia, Brazil. Salitre Formation is one of them, and contains unique phosphate (apatite) stromatolites. They show dense columnar shape, and are surrounded by laminated dolomite. The relationship between stromatolite and dolomite is mostly sharply bounded, although some parts appear transitional. Stromatolite contains various shape of microfossils. Filamentous microfossil (5-10 μm diameter, about 300 μm long) is most abundant and resembles to filamentous cyanobacteria, and thus, photosynthetic microorganisms such as cyanobacteria are considered to be involved in the formation of stromatolite.

In order to understand the influence of microbial photosynthesis on apatite precipitation, saturation state of apatite after removing 200 μM of CO_2 from seawater was calculated by Phreeqc. The result indicated that photosynthesis can significantly increase saturation state of apatite, when the concentration of dissolved phosphate is at least1 μM. Although the saturation state of $CaCO_3$ is also increased by photosynthesis, its degree is much smaller than that of apatite. As a result, apatite is more likely to precipitate than carbonate, and phosphate stromatolite is formed.

The concentration of dissolved phosphate is extremely low at the surface ocean due to the uptake by phytoplankton, and its concentration is as high as several μM even at the deep ocean. At the time of post-snowball Earth, similar situation is expected for the surface ocean, while the concentration of phosphate in the deep ocean is considered to be much higher than today. If occasional upwelling transported such water mass to the shallow sedimentary basin where cyanobacterial mat is developed, phosphate stromatolite will be formed even if dissolved phosphate concentration is several μM.