Microbial polyphosphate metabolism: A 2 billion-year-old shunt in the phosphorus cycle?

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Because of its paucity in many habitats, phosphorus can limit primary productivity, even influencing atmospheric oxygen levels over geological time scales. The biosphere itself is a major reservoir of phosphorus. In addition to the P incorporated into biomolecules, some organisms store substantial P intracellularly in the form of polyphosphate. While polyphosphate plays many roles in diverse organisms, those microbes that accumulate high intracellular polyphosphate stores are thought to primarily use it as an energy reserve under changing redox regimes. However, the significance, controls on, and evolution of polyphosphate as a major biological P pool remain incompletely understood.

Recent research has implicated polyphosphate-accumulating sulfide-oxidizing bacteria in the precipitation of apatite minerals in modern phosphogenic sediments. Interestingly, phosphatic mineral deposits first appear in the rock record about 2 billion years ago—trailing the Great Oxidation Event. A second major phosphogenic episode roughly coincides with the spread of oxygen to the deep ocean during the Neoproterozoic. Both Neoproterozoic and Paleoproterozoic phosphorites contain fossils that have been interpreted as chemolithotrophic bacteria of the kind that are known to accumulate polyphosphate in response to changing redox conditions.

Did the development of oxic/anoxic transition zones during the oxygenation of the atmosphere and oceans create niches for polyP-accumulating bacteria? Did these bacteria then generate conditions favorable for the phosphogenic episodes that mark these intervals? Investigations of phosphorites in the ancient rock record, as well as of polyphosphate utilization by extant microbes in modern sediments, will be needed to further test these hypotheses.