MICROBIAL ECOSYSTEM EVOLUTION: BIOGEOCHEMICAL NUTRIENT SCAVENGING IS A PREREQUISITE

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We are studying geochemical and microbiological processes which might have played a role in ecosystem evolution during precambrian times. In the course of this study we discovered the self-trophication process of ecosystems.

Nutrient scavenging from dilute aquatic environments is a prerequisite for biosynthetic processes. It must occur before cells and ecosystems can evolve. Early earth conditions were probably such that there was no lack of C, H, O, N and S containing precursor compounds for biosynthesis, but it remains unresolved where the phosphorous compounds came from and how P could be concentrated from dilute solutions to amounts needed for the synthesis of the phosphate-containing biomolecules.

Microbial ecosystem evolution was studied in Jöri lake XIII (2640m), which evolved in only a few decades from an oligotrophic glacial lake into a mesotrophic aquatic habitat. The nutrient concentrations and the microbial diversity and abundances are much higher in this lake than in comparable remote high-mountain lakes worldwide. The bioproductivity of the system is driven by the iron cycle. Although the seasonal geochemical cycles in this lake depend on oxygen today, the system is still a good model mimicing the precambrian iron redoxcycle.

Today, the hypolimnion becomes anoxic while the lake is ice-covered and phosphate and ferrous iron are released from the sediment. They are not assimilated since photosynthesis is absent in the darkness at greater depths below the ice. In the more oxidizing water layers ferrous iron gets oxidized, thereby scavenging ions (e.g. phosphate) by incorporating them into its oxyhydroxide matrix. Under these conditions, phosphate is stripped from the water column and retained in ferric iron oxyhydroxide colloidal nanoparticles. As a consequence, free P is limiting biosynthesis. During the summer, when the oxidation zone is compressed at the lake bottom, the ferrous iron is reoxidized at the sediment water interface while the phosphate can escape into the water column; P no longer limits biosynthesis.

During ecosystem evolution phosphate gets originally enriched through the geochemical iron cycle. Constant cycling between the ferrous and the ferric forms assures that phosphate is retained and that microorganisms can make use of the iron-oxyhydroxide phosphate trap.

Geochemical entrapment of dissolved molecules is a likely paradigm for nutrient enrichment mechanisms which might have prevailed in early ecosystem evolution.