Life-water-mineral interactions and their products

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Studies of modern and ancient microbial deposits on the Earth have demonstrated that the traces of microbial life are preserved as various kinds of minerals via life-water-mineral interactions. They include carbonates, phosphates, iron oxides, and manganese oxides, and their recent knowledge is introduced in the presentation.

For carbonates, cyanobacterial photosynthesis can produce $CaCO_3$ minerals to form deposits like stromatolites. However, their depositional fabrics are strongly influenced by the acidity of EPS (extracellular polymeric substances) secreted by cyanobacteria. In some cases, $CaCO_3$ minerals formed by cyanobacteria exhibit specific traces.

For phosphates, phosphorites are generally produced via degradation of organic matter during diagenesis. In the case of high phosphorus concentration in the euphotic zone, however, microbial photosynthesis potentially produces phosphate minerals to form phosphate stromatolites. Such process may occur after the snowball Earth glaciations in the Neoproterozoic as well as in the Paleoproterozoic.

For iron oxides, microbial Fe(II) oxidation is effective only when O_2 concentration is below ca. 50 μM, and inorganic process prevails above this level. The trace of iron-oxidizing bacteria is potentially preserved in the structure of iron oxide minerals.

For manganese oxides, substantial Mn(II) oxidation does not occur inorganically even under O_2 concentration equilibrated with the modern atmospheric level, and microbial processes are essential for it. In addition, manganese oxides adsorb various metals that potentially sustain metal-dependent microbial ecosystems in organic matter-deficient settings.

The knowledge about microbial traces on the Earth would provide valuable information for exploring extraterrestrial life.