Geophysical Research Abstracts
Vol. 17, EGU2015-5676, 2015
EGU General Assembly 2015

Co-precipitation of phosphate and carbonate minerals: geological and ecological implications

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Microorganisms play an important role in natural environments by controlling the metal cations (e.g., Ca2+, Mg2+, Fe2+) and the anions ($CO_3$2-, NH4+, PO43-) that precipitate as biominerals (e.g., carbonates, phosphates). In contrast to phosphate minerals, precipitation of carbonate minerals by bacteria has been widely studied in culture experiments and in natural environments. Moreover, studies of sedimentary phosphate minerals and their geological and ecological implications are rare. Nevertheless, phosphate minerals frequently co-precipitate with carbonates in culture experiments and in natural systems. In the present work, we investigate how microorganisms control the mineralogy and geochemistry of phosphate and carbonate minerals. For this, culture experiments were performed to study the co-precipitation of phosphate and carbonate minerals using aerobic heterotrophic bacteria at sedimentary Earth's surface conditions. Ca-Mg carbonate (dolomite, Mg-calcite) and/or Mg-carbonate (hydromagnesite) precipitated with Mg-phosphate (struvite). In most of the cultures, phosphate was the dominant mineral phase found in the bacterial precipitates and carbonates precipitated after phosphate phases. Notably, in all the cultures, we found a mixture of phosphate and carbonate minerals. This study shines new light into the microbial diagenetic processes involved in the co-precipitation of phosphate and carbonate minerals and links the P and C cycles.