Microbially Induced Formation of Various Carbonates by Bacteria Enriched from a CO_2 Repository Candidate Site

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Microbial metal reduction and mineral formation/dissolution not only play an important role in cycling of metals, carbon, and nitrogen, but also impact on the speciation and the fate of various trace metals and nutrients in anoxic subsurface environments. The objectives of this research were to study microbial diversity of aerobic and anaerobic bacteria enriched from sedimentary rock collected from the deep subsurface environments and to examine the forming capability of Fe-/Ca-/Mg-/Sr-/Cd-carbonate minerals in aerobic and anerobic environments.

The microorganisms were enriched from sedimentary rock samples collected at 670 ~ 1000 m depths of a candidate site for CO_2 geologic sequestration (Pohang-si, S. Korea). The enriched bacterial strains were cultured in anaerobic medium containing various electron donors (i.e., acetate, glucose, hydrogen, lactate, and pyruvate) respectively and subsequently cultured in aerobic medium at 30°C and then analyzed by next generation sequencing (NGS) to characterize microbial diversity. The aerobic and anaerobic bacteria were used to investigate a possibility of Fe-/Ca-/Mg-/Sr-/Cd-carbonate biomineralization coupled to Fe(III) reduction using buffer solutions of $NaHCO_3$ (30 □ 240 mM). The precipitated or transformed phases produced during metal reduction and biomineralization by the aerobic and anaerobic bacteria were examined using XRD and SEM-EDS analyses.

The anaerobic and aerobic bacteria were able to use the different electron donors while reducing Fe(III)-citrate at 30°C. NGS analysis showed that anaerobic bacteria included *Shewanella* sp., *Clostridium* sp. and aerobic bacteria included *Shewanella* sp., *Providencia rettgeri*. The anaerobic and aerobic bacteria exhibited precipitation minerals such as siderite ($FeCO_3$), monohydrocalcite ($CaCO_3{\cdot}H_2O$), huntite [$Mg_3Ca(CO_3)_4$], strontianite ($SrCO_3$), Mg-rich calcite ($Mg_xCa_{1-x}CO_3$) and cadmium carbonate ($CdCO_3$) .

Therefore, given the abundance of Fe/Ca/Mg/Sr/Cd ions, the carbonate mineralization process by enriched bacteria can provide us potential to mineral trapping of CO_2 for geologic sequestration. Microbial processes on the formation of carbonate mineral under aerobic and anaerobic conditions will significantly advance management of carbon in diverse environments.