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Dolomite-type-ordered carbonate nucleation in biofilm of a marine sulfate-reducing bacterium: the role of extracellular polymeric substances

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Microbially induced carbonate precipitation represents a process of prime importance throughout earth's history. However, modalities of high-Mg-carbonate precipitation are still under debate, and to date, it remains unclear if precipitation of dolomite-type-ordered carbonates occurs under modern seawater conditions. During our studies, dolomite-type-ordered carbonate was precipitated under laboratory conditions in a biofilm of the marine sulfate-reducing bacteria strain Desulfobulbus mediterraneus. Growth conditions resembled modern seawater salinity and Mg/Ca ratio. Spatial distribution of crystals within the biofilm was investigated using convocal laser scanning microscopy. Crystal morphology and mineralogy were analyzed with scanning electron microscopy and electron microprobe. Biofilms were imaged after 3 and 14 days of growth. After 3 days of biofilm growth, small sherulites (50 nm to 2 μm diameter) were detectable. Crystals were located exclusively in regions where extracellular polymeric substances (EPS) were present. Electron microprobe analyses on individual crystals in biofilms after 10 days of growth revealed C, O, Ca and Mg as the dominant elements. Mg and Ca were present at an atom ratio of 1, indicating a dolomite-type-ordered carbonate. To date, high Mg-Ca-carbonate precipitation under laboratory conditions has mainly been described for hypersaline or aerobic environments. Our study showed that precipitation of dolomite-type-ordered carbonate is possible under modern seawater salinity and Mg/Ca ratio. The metabolic activity of sulfate-reducing bacteria promoted carbonate production by increasing total alkalinity and complexation of divalent cations. Furthermore, the results indicated that EPS produced by D. mediterraneus served as nucleation sites for crystals. Our findings contribute to recent studies indicating that dolomite-type-ordered carbonates are produced in present marine environments under modern seawater conditions.