Geophysical Research Abstracts
Vol. 18, EGU2016-6239, 2016
EGU General Assembly 2016

Microbially induced and microbially catalysed precipitation: two different carbonate factories

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The landmark paper by Schlager (2003) has revealed three types of benthic carbonate production referred to as ”carbonate factories”, operative at different locations at different times in Earth history. The tropical or T-factory comprises the classical platforms and fringing reefs and is dominated by carbonate precipitation by autotrophic calcifying metazoans (“biotically controlled” precipitation). The cool or C-factory is also biotically controlled but via heterotrophic, calcifying metazoans in cold and deep waters at the continental margins. A further type is the mud-mound or M-factory, where carbonate precipitation is supported by microorganisms but not controlled by a specific enzymatic pathway (“biotically induced” precipitation). How exactly the microbes influence precipitation is still poorly understood.
Based on recent experimental and field studies, the microbial influence on modern mud mound and microbialite growth includes two fundamentally different processes: (1) Metabolic activity of microbes may increase the saturation state with respect to a particular mineral phase, thereby indirectly driving the precipitation of the mineral phase: microbially induced precipitation. (2) In a situation, where a solution is already supersaturated but precipitation of the mineral is inhibited by a kinetic barrier, microbes may act as a catalyser, i.e. they lower the kinetic barrier: microbially catalysed precipitation. Such a catalytic effect can occur e.g. via secreted polymeric substances or specific chemical groups on the cell surface, at which the minerals nucleate or which facilitate mechanistically the bonding of new ions to the mineral surface.
Based on these latest developments in microbialite formation, I propose to extend the scheme of benthic carbonate factories of Schlager et al. (2003) by introducing an additional branch distinguishing microbially induced from microbially catalysed precipitation. Although both mechanisms could be operative in a M-factory, and it is difficult to distinguish their products, their cause is very different. A Mi-factory (“i“ for induced) is predominant under low carbonate saturation in normal seawater; a Mc-factory (“c“ for catalysed) is operative in higher-alkalinity waters. The latter conditions may not only occur in shallow seas restricted from open sea water but may also have occurred in the aftermath of catastrophic events (e.g. P/T boundary) or during the Precambrian, before the onset of metazoan calcifiers. Thus, adding the additional distinction between microbially induced and microbially catalysed precipitation would allow the application of Schlager’s concept of benthic carbonate factories beyond the Phanerozoic and probably over the entire Earth history.