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Spheroidal dolomite texture as proxy for microbially mediated dolomite

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Microbial culture experiments have been demonstrated to produce primary dolomite under Earth's surface conditions (Vasconcelos et al., 1995). Nevertheless, a link between microbial activity and primary dolomite formation during most of Earth's history is difficult to demonstrate. Based on the observation that culture experiments produced spherical and dumbbell shaped dolomite crystals, it seems tempting to use the spheroidal-shape as indicator for microbially mediated dolomite formation in the geological record. However, several studies have shown that the spherical shape is a result of precipitation kinetics (Fernández-Díaz et al., 2006; Meister et al., 2011) and, as such, not necessarily indicative of a microbial effect.

Nevertheless, spherical aggregates of Ca,Mg-carbonates are commonly observed to form in micritic laminae of modern calcifying microbial mats, such as in the coastal sabkhas of Abu Dhabi (Bontognali et al., 2010), and similar observations were made in stromatolites from the geological record (e.g. Mastandrea et al., 2006; Perri and Tucker, 2007). We observed nanospheroidal aggregates of dolomite ranging in diameter from 50 to 170 nm associated with dark micritic laminae in Middle Cambrian stromatolites from northwestern Tarim basin (China), and larger, 470 - 660 nm, formed of nanocrystal aggregates diameter of 50-100 nm of dolomite, occurring within and between syn-sedimentary dolomite crystals. Moreover, the thick sheet-like structures with an irregular filamentoustextured surface cross between crystals, several micrometers long, form a sub-polygonal network reminiscent of EPS (extracellular polymeric substance).

We calculated palaeo-temperatures from δ^{18}O values (data from Wang et al., 2011 in the same outcrop in Middle Cambrian) described by the following equation:

1000 lnαdolomite-water=2.73 * 10^6T^{-2}+ 0.26,

where T is temperature(Vasconcelos et al.,2005).

Assuming Cambrian seawater temperature is 20˚C, Cambrian seawater δ^{18}O composition from Veizer et al., 1999(the measurements for LMC shells(brachiopods, belemnites, oysters, foraminifera) show the value of δ^{18}O about -8‰$PDB)inCambrian)arearound22.5℃, whichwouldbeconsistentwithanearlyandprimaryformationofdolomitesinmicr$

In order to better understand the factors (both abiotic and microbial) controlling precipitation kinetics and thus indirectly the crystal shape of Ca/Mg carbonates, we currently are conducting precipitation experiments using different ionic solutions and monitoring precipitation rate, crystal shape and mineralogy. Effects of temperature, Mg and SO_4^{2-} concentration, organic compounds, microbial EPS, and living microbes on precipitation kinetics and crystal shape are being recorded. We use microsensors to measure microgradients of Ca, DIC, and pH at the crystal surface while crystal growth is being monitored at different time steps by petrographic microscopy, X-ray diffraction and Raman spectroscopy. This approach will allow for a better differentiated consideration of processes controlling crystal morphology than previous studies and will provide a fundamental and quantitative understanding how to interpret the morphology of primary and penecontemporaneous Mg,Ca-carbonates in the geological record.

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