Answer to Anonymous Referee #1

In their manuscript, the authors investigated the calcification processes of modern cyanobacteria for understanding the presence/absence of microfossils in the rock records as well as for recognizing biotic/abiotic origin of "microfossils". This topic closely relates with the studies of life history and paleo-environment, and potentially has significant impact on a wide range of readers. The authors tackled this interesting topic by applying advanced microscopic techniques, which was mostly successful.

Nevertheless, I have some questions and comments as listed below.

1) As the authors described, their studied microbialite was mostly composed of hydromagnesite, which is rare mineral as a constituent of microfossil and microbialite in the rock record. Although the authors focused on the peripheral aragonite parts, the origin of hydromagnesite should be discussed (ex. biotic, abiotic or diagenetic etc.), because it may relate with the fate of aragonite. If hydromagnesite is the diagenetic product of peripheral aragonite, it would become difficult to apply the result of this study to the rock records.

We agree with the reviewer that this is an interesting issue since it has been proposed that biomineralized aragonite could replace hydromagnesite in some microbialites including those from Alchichica (Coshell et al., 1998; Kaźmierczak et al., 2011). *This assumption has been made mostly based on textural analyses of the two mineral phases. If the fate of aragonite could be the replacement by hydromagnesite it is however not always the case.. For instance, we have observed in some cases galleries inside Alchichica microbialites that have been dug by endolithic microorganisms within hydromagnesite. Interestingly, aragonite precipitated inside these galleries in contact with hydromagnesite, showing that in these cases aragonite forms after hydromagnesite and questioning the idea that it is always the other way around. Moreover the "brown" type of fossil microbialites described by (Kaźmierczak et al., 2011) are mainly composed of aragonite, indicating that aragonite can be preserved through time. The fact that one see nowadays aragonite mostly at the periphery of immersed microbialites indicates that the chemical conditions that have been prevailing in the lake most recently lead to aragonite precipitation but this has not always been the case. At this point, we cannot conclude whether hydromagnesite precipitation occurred outside of the biofilm (abiotic), inside (biotic) or is replacing aragonite (diagenetic). Indeed the aim of this paper is not to explain how Alchichica microbialites form but to well-describe a modern case of cyanobacterial calcification. This point is now clarified in the manuscript.*

2) The authors used the term "organic matter (OM)" in the Abstract, while the term EPS was used in the most part of the manuscript. The usage of EPS is recommended here, too.

We agree with the reviewer and replaced OM by EPS in the abstract.

3) For CLSM study, the authors conducted simultaneous excitation by three lasers. However, the emission spectrum of DAPI is very broad (about 400-600 nm), and simultaneous excitation and image acquisition by three channels will cause severe crosstalk. Indeed, the quality of Fig. 1C looks not good.

The three excitation wavelength and recording channels have been chosen to excite and observe simultaneously the auto-fluorescence of cyanobacterial pigments including chlorophyll, phycocyanin and phycoerythrin. We agree with the reviewer that crosstalks could happen, however even if we cannot discriminate between the different pigments for this reason, the fluorescence associated with the Pleurocapsales cells (possibly a mix between autofluorescence and DAPI signals) is clearly different from the DAPI emission spectrum. In Fig 1C, the "blue" photons recorded in the channel 425-475 nm are mainly associated with aragonite. This signal is not the fluorescence of DAPI but depends on the excitation wavelength. This phenomenon has already been observed using this experimental design (Gerard et al., in press) and explains the bluish background in Fig 1C but does not interfere with our conclusion We now refer to(Gerard et al., in press) and explain the rendering of Fig 1C in the manuscript.

4) The authors concluded that Type 1 aragonite precipitated due to photosynthetic modification of local chemistry (p.3327, l. 5-6), while they discussed that pH increase by photosynthesis (=photosynthetic modification of local chemistry) is negligible in their study site (p. 3324, l. 15-p. 3325, l. 2). To avoid this contradiction, the result of following literature would be useful: Shiraishi (2012, Geochim. Cosmochim. Acta 77, 157-174). In his study, the occurrence of photosynthetic $CaCO_3$ precipitation was recognize even under high DIC condition.

We read the paper suggested by the reviewer. As developed by (Arp et al., 2001)*, the theoretical model developed by (Shiraishi, 2012) shows that photosynthesis-induced carbonate precipitation is not favored at high DIC, however they observed it experimentally. However we did not aim to say that the pH increase due to photosynthesis was negligible, but that a pH increase only would not be enough to explain the precipitation of aragonite over hydromagnesite. Hydromagnesite being even more oversaturated than aragonite with a pH increase. We clarified this point in the discussion part (4.3). We also cited the paper (Shiraishi, 2012) in the discussion part (4.2) along with the model developed by (Arp et al., 2001) to state that it has already been shown that the increase of pH due to photosynthesis is not the only parameter to take into account to predict if photosynthesis-induced carbonate precipitation will occurs or not .*

5) Typing errors p. 3315, l. 18-19: (Arp et al., 2001 mention: : : p. 3326, l.23: Mg"2+" should be superscript.

This has been corrected.

Bibliography

Arp, G., Reimer, A. and Reitner, J.: Photosynthesis-Induced Biofilm Calcification and Calcium Concentrations in Phanerozoic Oceans, Science, 292(5522), 1701–1704, 2001.

Coshell, L., Rosen, M. R. and Mcnamara, K. J.: Hydromagnesite replacement of biomineralized aragonite in a new location of Holocene stromatolites , Lake Walyungup , Western Australia, Sedimentology, 45(6), 1005–1018, 1998.

Gerard, E., Menez, B., Couradeau, E., Moreira, D., Benzerara, K. and Lopez-Garcia, P.: Combined three-dimensional Raman and molecular fluorescence imaging reveal specific carbonate-microbe interactions in modern microbialites, Isme Journal - in press, n.d.

Kaźmierczak, J., Kempe, S., Kremer, B., López-García, P., Moreira, D. and Tavera, R.: Hydrochemistry and microbialites of the alkaline crater lake Alchichica, Mexico, Facies, 57(4), 1–28, 2011.

Shiraishi, F.: Chemical conditions favoring photosynthesis-induced CaCO3 precipitation and implications for microbial carbonate formation in the ancient ocean, Geochimica et Cosmochimica Acta, 77, 157–174, 2012.