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Effect of biological colonisation of stained glass windows on alteration processes

CHLOÉ BOUTILLEZ[1], ANNE PEREZ[1], AURELIE VERNEY-CARRON[2], YOAN PECHAUD[1], FRANÇOIS GUYOT[3,4], FÉRIEL SKOURI-PANET[5] AND STÉPHANIE ROSSANO[1]

[1]Université Gustave Eiffel - Laboratoire Géomatériaux et Environnement

[2]LISA

[3]Institut de Minéralogie, Physique des Matériaux et Cosmochimie, CNRS UMR 7590

[4]Museum National d'Histoire Naturelle et Institut Universitaire de France (IUF)

[5]IMPMC, Sorbonne Université, CNRS UMR 7590, MNHN

Presenting Author: chloe.boutillez@univ-eiffel.fr

Several studies of the deterioration of stained glass windows have highlighted the colonisation of the surface of glass windows by microorganisms. In extreme environments, bacteria often organise themselves into biofilms to provide increased protection against various aggressions. Moreover, some bacterial strains that oxidise manganese are suspected of being involved in the browning phenomenon, a widespread characterized by the formation of manganese oxides.

To test the influence of glass substrates on their colonisation and alteration processes, a panel of 4 model medieval glasses with variable content of Mn/Fe was submitted to short term (closed system, 7 days), medium term (opened system in bioreactor, 1 month) alteration experiments in an aqueous environment and long term (6 month) bioalteration experiment in a humid atmosphere without liquid water. These experiments were developed in the presence of a model bacteria strain, *Pseudomonas putida*, chosen for its ability to form biofilms and oxidise Mn. The development of bioalteration experiments in reactors or in relative humidity are both pioneering approaches to study glass alteration. The solutions and glass samples were characterised by various analytical methods (ICP-OES, TOC, Spectrophotometry UV, SEM, TEM).

If short-term experiment were useful to target Mn oxidation mechanisms, the experiments designed in bioreactors allowed us to grow substantive biofilm directly on glass surface, to compare their thickness from one glass to another and to detect/or not the browning pathology. The glass containing Mn and no Fe was intensively colonised by bacteria and biomineralised Mn oxides were detected within the biofilm layer. In contrast, the glass containing both Mn and Fe was only covered by a thin layer of biofilm and showed no browning. During bioalteration in a humid atmosphere, no browning was observed, but the bacteria were able to grow and survive on the surface of the four glass compositions for 6 months.

References

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