

Understanding the browning phenomenon of medieval stained-glass windows: impact of bacteria and bacterial exudates on the dissolution of a Mn-bearing glass

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UNDERSTANDING THE BROWNING PHENOMENON OF MEDIEVAL STAINED GLASS WINDOWS: IMPACT OF BACTERIA AND BACTERIAL EXUDATES ON THE DISSOLUTION OF A Mn-BEARING GLASS

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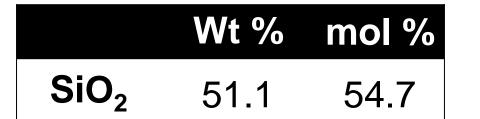
Laboratoire de Recherche des Monuments Historiques





Glass

Medieval stained glass windows have a **potash-lime-silica** composition because of the use of plant ashes as flux.



LERM

Production of glass representative of medieval stained glass windows in a high temperature furnace.

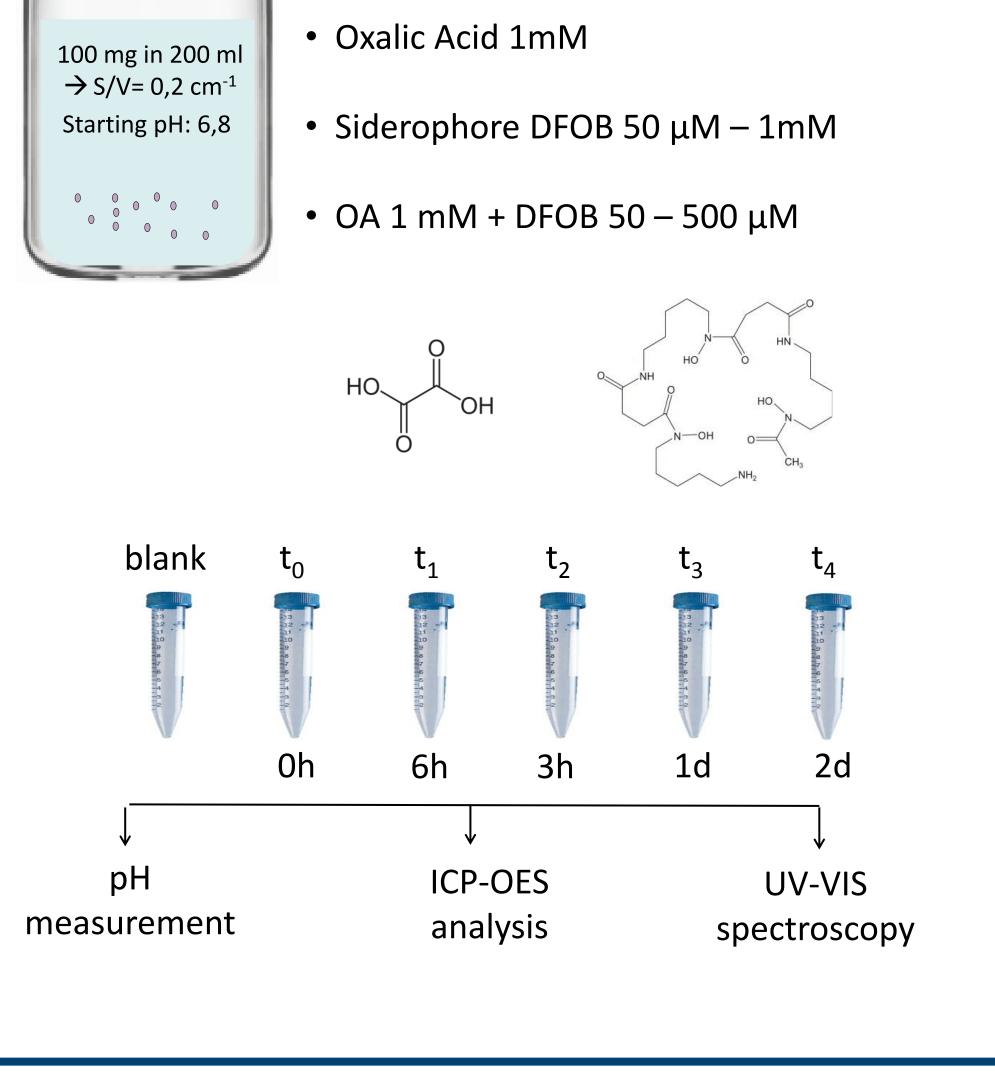
The role of micro-organisms

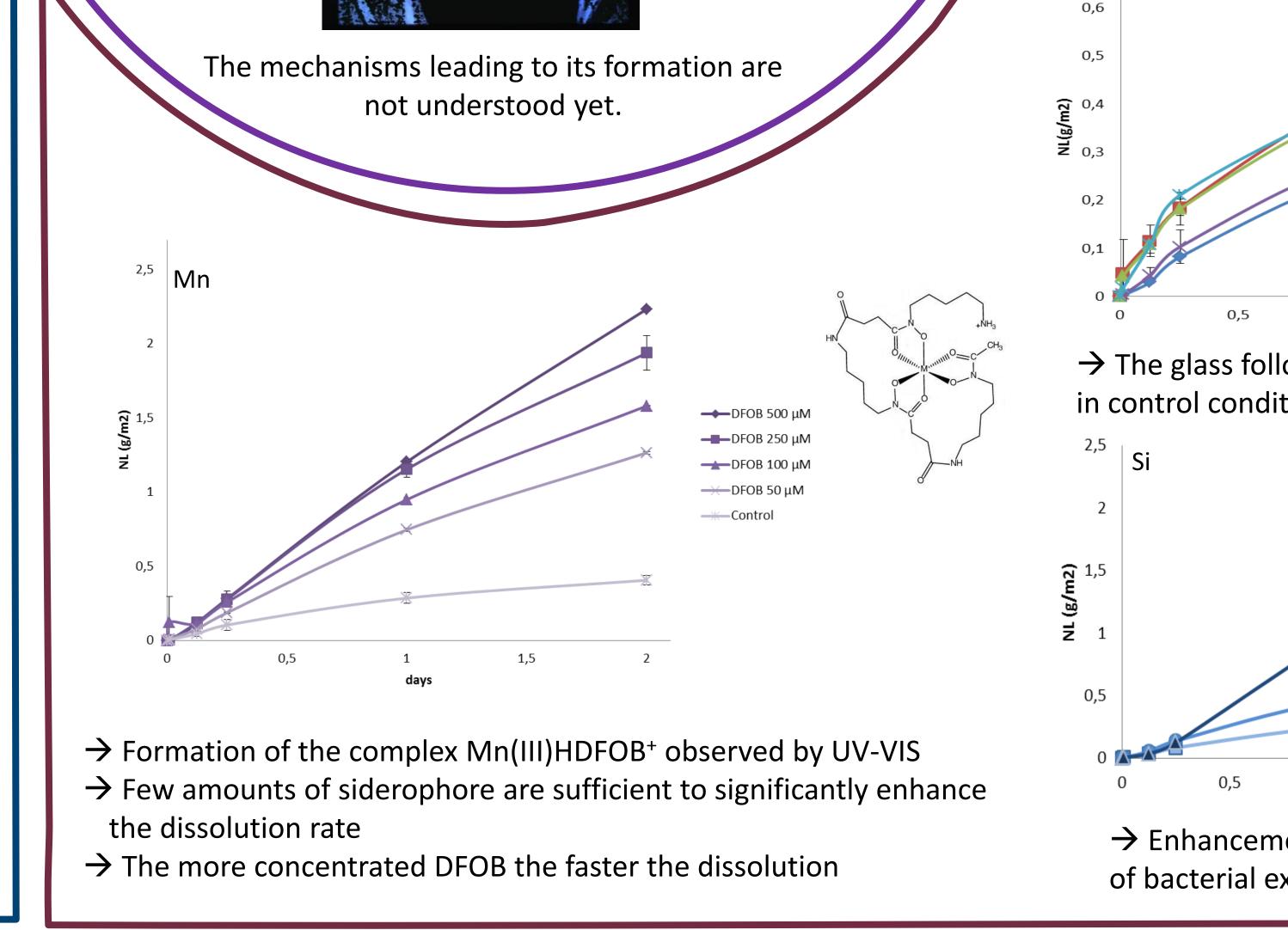
Previous studies revealed enrichment in Mn in the browned areas and some of them have suggested that manganese migration to the surface, oxidation and/or precipitation might be linked to biological activity.

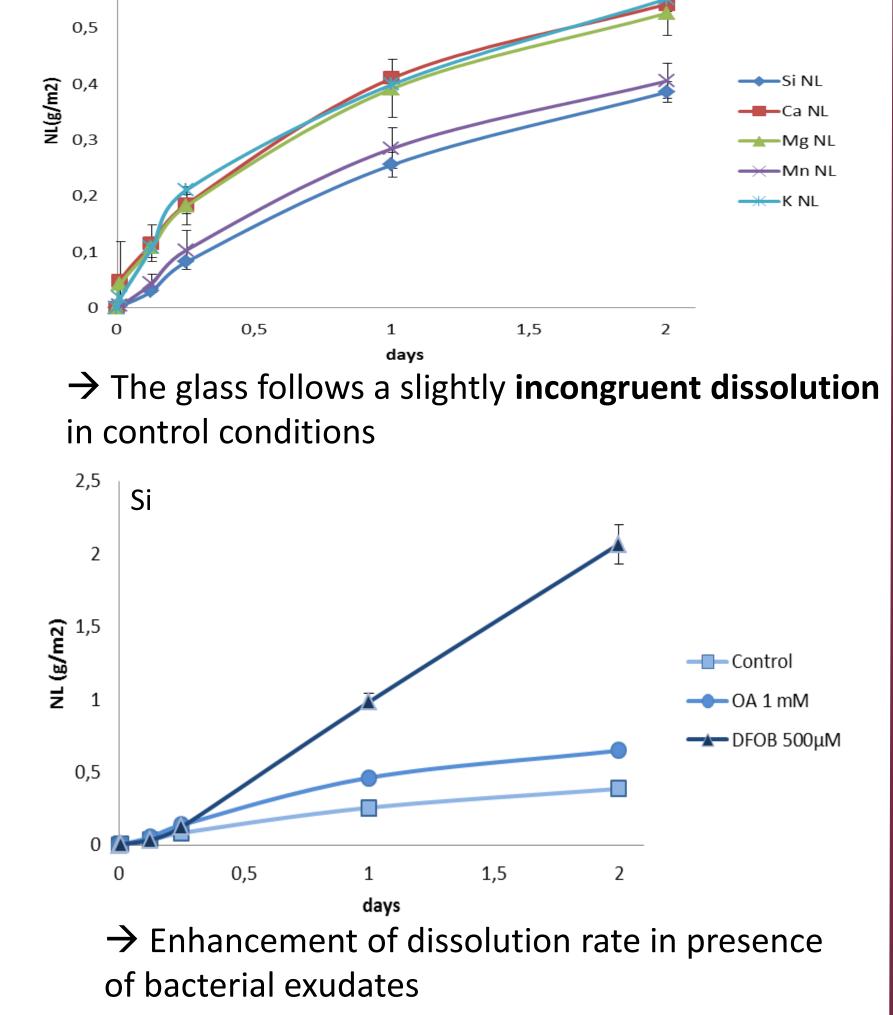
In natural environment, bacteria have an important role in biogeochemical cycles of elements such as C.S. P. Ca. K. Fe. Mn. They



AI_2O_3 P_2O_5	1.8 3.6	1.1 1.6	Ingnitemperature rumace.	elements such as C, S, P, Ca, K, Fe, Mn. They strongly influence the weathering of minerals and the bio-mineralization.
Na ₂ O	1,2	1.3	Glass casting	
CaO	17.2	19.8	at 1500 °C	The glass support can be a source of micro and DIRECT macro nutriments for micro-organisms. INTERACTION
MgO K2O	4.2 18.8	6.7 12.9		macro nutriments for micro-organisms.
MnO	2.08	1.9		
			Grinding and sieving: 100-200 μm fraction	The browning phenomenon The browning of medieval stained glass windows
				appears as dark Mn-rich spots inside the altered
		VS10001		appears as dark Mn-rich spots inside the altered ayer on the surface of the glass. It leads to a loss of transparency.
	Batch	vs10001		As Mn was introduced as a (da)ealeurent the
phenome	to imp non and	prove ou investiga	ution tests ar understanding of this te the direct and indirect	As Mn was introduced as a (de)colourant, the browning is often located on faces $Results$
phenome	to imp non and n of micr	prove ou investiga oorganisr	ution tests If understanding of this te the direct and indirect ns, weathering experiments	As Mn was introduced as a (de)colourant, the browning is often $NORMALIZED MASS LOSSES$ Concentration results are normalized to the reactive surface and to the glass composition: $NL_i = \frac{V \times [i]}{S \times x_i}$

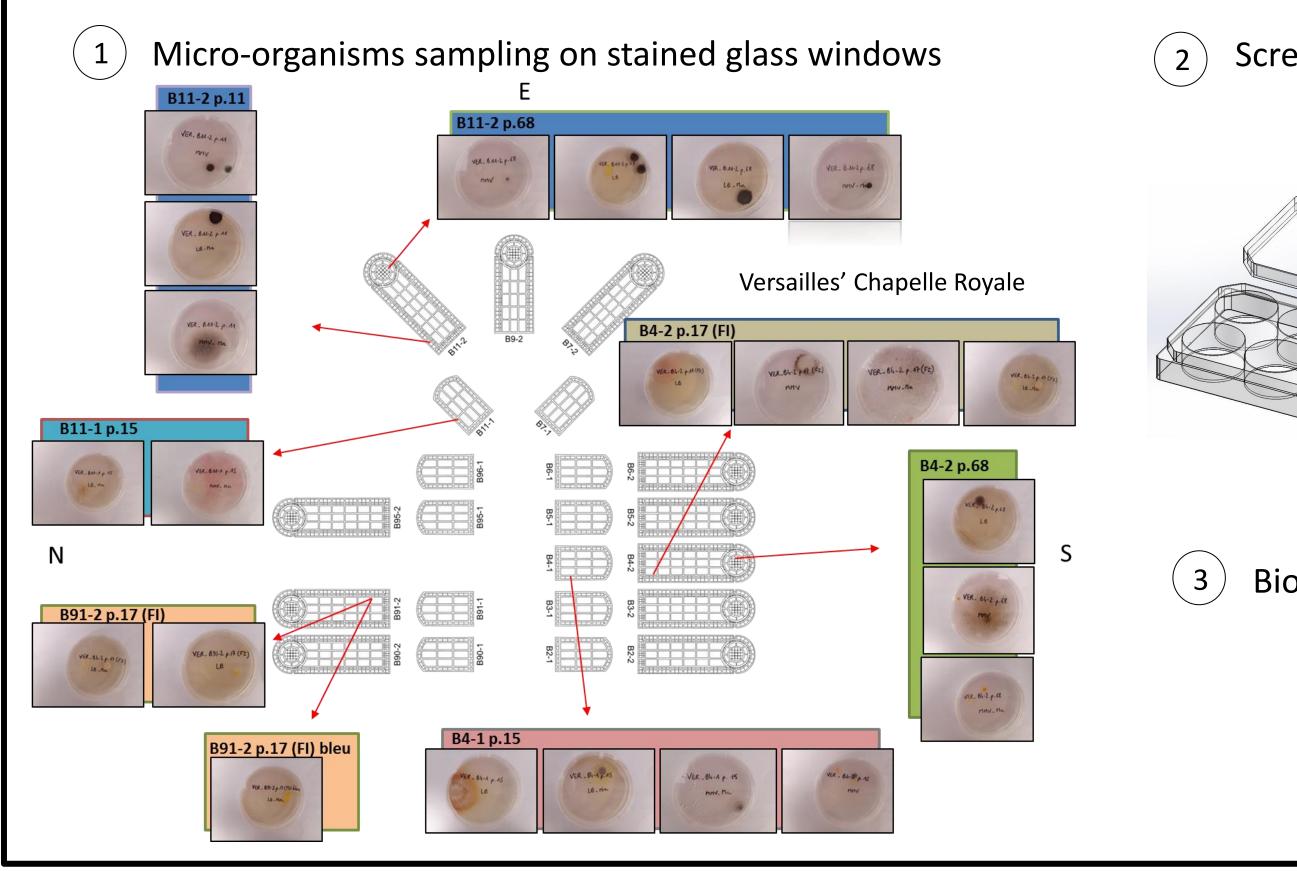






Actually running tests and perspectives

Conclusion





The results show that the presence of bacteria and bacterial exudates modifies the dissolution mechanisms and kinetics, increasing dissolution rates and changing dissolution stoichiometry. This highlights that a biological activity could be involved in the solubilisation of Mn in a Mn-bearing glass, which is the first step of the appearance of the browning phenomenon.

References

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