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The use of Interferometric Microscopy to assess 3D modifications of deteriorated medieval glass.

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Due to low durability, Northern European medieval glass undergoes the action of the atmospheric environment leading in some cases to a state of dramatic deterioration. Modification features varies from a simple loss of transparency to a severe material loss. In order to understand the underlying mechanisms and preserve this heritage, fundamental research is necessary too. In this optic, field exposure of analogues and original stained glass was carried out to study the early stages of the glass weathering.
Model glass and original stained glass (after removal of deterioration products) were exposed in real conditions in an urban site (Paris) for 48 months. A regular withdrawal of samples allowed a follow-up of short-term glass evolution. Morphological modifications of the exposed samples were investigated through conventional and non destructive microscopy, using respectively a Scanning Electron Microscope (SEM) and an Interferometric Microscope (IM). This latter allows a 3D quantification of the object with no sample preparation.
For all glasses, both surface recession and build-up of deposit were observed as a consequence of a leaching process (interdiffusion of protons and glass cations). The build-up of a deposit comes from the reaction between the extracted glass cations and atmospheric gases. Instead, surface recession is due mainly to the formation of brittle layer of altered glass at the sub-surface, where a fracture network can appear, leading to the scaling of parts of this modified glass. Finally, dissolution of the glass takes place, inducing the formation of pits and craters.
The arithmetic roughness (Ra) was used as an indicator of weathering increase, in order to evaluate the deterioration state. For instance, the Ra grew from few tens of nm for pristine glass to thousands of nm for scaled areas. This technique also allowed a precise quantification of dimensions (height, depth and width) of deposits and pits, and the estimation of their overall distribution. Finally, IM allows the quantification of the volume of lost matter due to scaling, by studying the surface coverage of the different depths.
The preliminary studies show that IM is a very effective, non-destructive and non-intrusive technique for the quantification of glass weathering, to be used complementarily to other investigations. Further applications, especially to the description of the depositions, are currently under way.