Alteration mechanisms of medieval stained glass windows in atmospheric medium

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Abstract

Medieval stained glass windows from the Northern Europe are sensitive to the atmospheric medium that causes degradations due to the low durable composition of the glass (SiO2 content around 50 wt.% and high K2O and CaO content). The alteration appears as pits or as a flat continuous layer whose thickness can reach 200 μm. In order to determine the formation mechanisms of this altered layer, different isotopic tracers were used. Furthermore, as the atmospheric medium is characterized by a variable relative humidity and rainfall events, different experimental devices were set up. In order to understand the alteration mechanisms during rainfall events, a dynamic experiment was performed with a solution doped in 29Si. This allowed Si coming from the glass and Si coming from the solution to be discriminated. The analysis of the Si isotopic signature of the gel layer by SIMS highlighted that diffusion, but also hydrolysis/condensation reactions, are involved in the formation process. In unsaturated medium, experiments at different relative humidity values were carried out on model glass. The results have shown that interdiffusion is predominant in the first stages of alteration. Furthermore, in order to investigate the alteration mechanisms on ancient stained glass samples (once the altered layer is formed), these latter were exposed to a rainwater (in a first experiment) and to a water vapor (in a second experiment) both doped in deuterium and 18-oxygen. NanoSIMS analyses have highlighted that the alteration continues at the interface between the altered layer and the pristine glass, mainly by interdiffusion. Associated kinetics were also determined. Their extrapolation over 650 years are consistent with the range of alteration thicknesses observed on ancient stained glass windows.

Keywords: stained glass, cultural heritage, alteration, atmosphere

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