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Salt Weathering on Buildings and Stone Sculptures

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The role of gypsum in the phenomenon of spalling of stones

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ABSTRACT

The white tuffeau is the main stone used in the castle of Chambord and in the most of the monuments built along the Loire valley in France. This highly porous limestone (porosity about 45%) is very sensitive to atmospheric conditions.

The degradation phenomenon is related to the nature of the stone (mineral composition, morphology of the porous media), the climatic conditions (temperature, humidity, rain, wind, air pollution), the morphology and the exposure of the building.

Spalling is the most common form of degradation in the case of tuffeau, and the most damaging. It concerns carved stones, but also vertical facings. Over time, thick plate (one to three centimetres thick) gradually forms on the surface of stone. Once the plate is dropped, the resulting stone surface turns into powder.

Samples with different stages of degradation were collected in various areas of the castle of Chambord, located at different heights, and subjected to different climatic conditions (wind, rain, sunshine, etc). Spalling is initiated by a cracking network parallel to the surface of stone. The analysis of the stone, along the depth, shows the presence of gypsum mainly located in cracks. The aim of the present work is to study the formation process of spalling. A particular point is to analyze the role of gypsum in this decay (neutral, enhancing or triggering factor).

The characterization of weathered samples is coupled to the characterization of laboratory-aged samples. The stone degradation is analysed by several complementary techniques of characterization in a multi-scales approach: mechanical resistance (compressive strength test), capillary absorption (imbibition test), mercury intrusion porosimetry (MIP), chemical analysis (ICP-AES, ATG, ionic chromatography), SEM image analysis, X-ray diffraction (XRD).