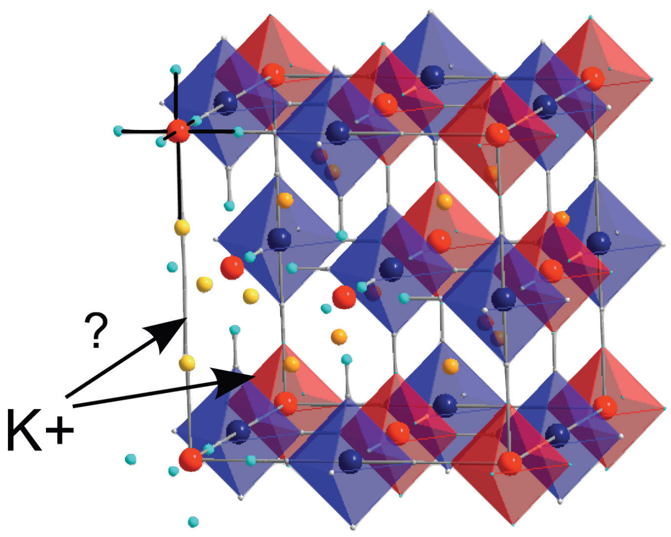
HKB HEAB
Hochschule der Künste Bern
Haute école des arts de Berne

Research area
Materiality in Art and Culture

‘New techniques for ancient materials’ – Scientific investigation of cultural objects and their degradation processes by synchrotron and simulation techniques

Abstract

This project aims at developing a multidisciplinary approach to study fundamental chemical and physical processes responsible for the degradation of ancient materials. This will be done by means of advanced analytical procedures with an emphasis on synchrotron and computational techniques. Our motivation lies in filling the current gap between conservation and basic academic research. Two research projects are presented, both focusing on the potential sensitivity of the material to the environment, namely: (1) The influence of the substrate on the light- and anoxia-induced fading of Prussian blue and (2) The simulation of water transport in corroded archaeological iron objects. The two projects are expected to emulate further research in the domains of pigment-substrate-environment interactions and transport phenomena in porous ancient materials, respecitvely.



Idealized structure of soluble Prussian blue, highlighting the various disorders inherent to the structure: presence of iron vacancies, cations, coordinated and uncoordinated water molecules. (Image: Claire Gervais)

From a material point of view, objects of cultural heritage ‘have it all’: they are complex, composite, often precious and fragile, generally with an unknown material history. Their conservation is, however, of primary importance, as they offer testimonies of human history, culture and art.

The analysis of cultural objects requires the use of state-of-the-art, non-destructive techniques that maximize the amount of information usually contained in a tiny, precious sample generally composed of a complex and composite material. Synchrotron techniques and computational tools are two promising approaches to reach this goal. Although powerful and employed more and more in the cultural heritage community, their sophistication requires an expertise that may hamper their full exploitation.

In this research, we intend to focus on the characterization of the physico-chemical processes taking place during the degradation, specifically by means of state-of-the-art synchrotron and computational techniques.

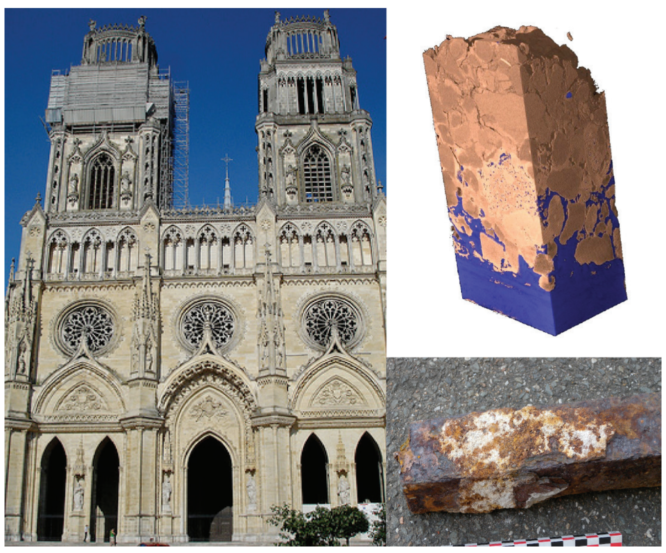
The main underlying idea is to provide general, fundamental knowledge about the materials of which the cultural objects are constituted, about their degradation processes and their sensitivity to the environment – knowledge which in turn can be used by conservation scientists to examine specific cases efficiently.

Project #1. Analysis of pigment-substrate-environment interactions: Light and anoxia-induced fading of Prussian blue.

Contradictory fading behaviour has been observed for Prussian blue objects subjected to intense light or anoxia exposure. This apparent lack of coherence can be explained by the capacity of the substrate to modify the Prussian blue structure and its fading behaviour. To understand these processes in Prussian blue paper systems, we will analyse model samples by the following series of steps: a) Characterization of the structure of Prussian blue powder on substrate, before and after light/anoxia exposure, b) Quantification of cellulose and lignin degradation of paper, c) Visualization of the distribution of Prussian blue within the paper matrix.

Project #2. Porosity and transport phenomena in archaeological corroded iron.

Studies on long-term altered systems have shown that iron corrosion products developed in soil or in anoxia are organized in multilayers with a thickness of several hundred microns to some millimeters depending on their age. They exhibit a significant porosity which influences the penetration and migration of the electrolytes towards the metal, determines the amount and type of surface potentially reactive to the corrosion process and controls the transport of chemical species and thus the local chemistry. This project aims at developing an approach based on the coupling of high-resolution 3D visualization of corroded iron layers with numerical simulations of diffusion and transport. We will develop porosity characterization and simulation tools based on X-ray computer tomographic data of archaeological and model iron artefacts.



18th century corroded metallic rebards from the Cathedral of Orléans (France) and 3D visualization of the corrosion interface (blue: metal, orange: binder). Their investigation may help to better understand long-term corrosion processes and compare corrosion product patterns in the case of atmospheric corrosion and corrosion in binders. (Image credit: LAPA)

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