

M2 Research Project

Mechanical testing of historical chalk pastels: linking chemical composition, wear behaviour and optical properties

Practical information

Host laboratories:

INPHYNI – Institut de Physique de Nice, Université Côte d’Azur, Nice

CRC – Centre de Recherche sur la Conservation, Muséum national d’Histoire naturelle, Paris

Supervisors: Vincent Bertin (INPHYNI, Nice) & Émeline Pouyet (CRC, Paris)

In collaboration with: Leila Sauvage (University of Amsterdam & Rijksmuseum, Amsterdam)

Duration: 6 months, Paid internship: Yes

Location: The internship will be split between Nice and Paris. The exact schedule is flexible, with at least 3 months at INPHYNI in Nice for the mechanical and wear experiments and at least 1 month at the CRC in Paris for pastel fabrication and characterization.

Candidate profile: Master’s student in physics, mechanics, materials science or a related field, with an interest in experimental work and interdisciplinary research.

Application: Please send a CV and a short statement of motivation to Vincent Bertin (Vincent.BERTIN@univ-cotedazur.fr) and Émeline Pouyet (emeline.pouyet@mnhn.fr).

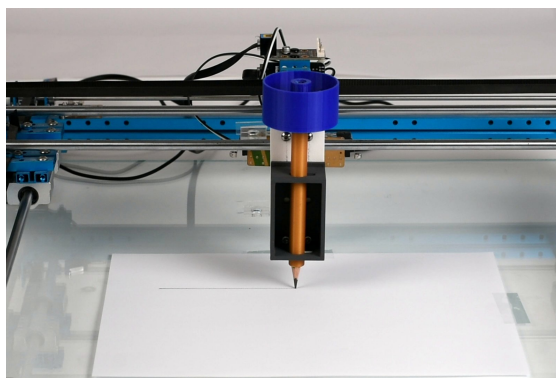


Figure 1. Left: Automated drawing apparatus developed at INPHYNI for controlled mechanical and wear experiments. Right: Historical artist’s pastel box, dated ca. 1840–1890, given to Dr Henri Roche by a friend in 1909. Credit: Maison du Pastel, Margaret Zayer.

Scientific context

Traditional chalk pastels are complex composite materials whose performance depends on the interactions between pigments (organic and inorganic), mineral fillers and organic binders. Historically, artists required a broad range of colours, tonal variations, and hardnesses to achieve different drawing effects. Because pigments cannot be effectively mixed on a palette without producing dull colours, pastel techniques rely on layering, intermingling fine strokes of different hues, and blending ("sweetening") to create the characteristic velvety appearance of the medium. The mechanical properties of the pastel stick are therefore fundamental to both artistic handling and the visual characteristics of the deposited trace. Soft pastels produce thicker, more homogeneous deposits with dispersed particles, whereas harder chalk pastels can be sharpened to fine points, depositing less material and generating strokes that may be visually difficult to distinguish. The proportions and nature of fillers and binders determine the cohesion of the stick, its adhesion to the support, its tendency to

smudge, and ultimately the durability and appearance of the artwork. Despite the importance of these properties, the relationship between historical pastel formulations and their mechanical behaviour has never been systematically quantified.

Recent work has demonstrated that pencil drawing provides a remarkably simple and reproducible model system for studying these wear mechanisms, as both the material removed from the writing implement and the deposited debris field can be directly observed and quantitatively related to the optical appearance of the trace (see [here](#)). This approach opens new opportunities to investigate the relationship between material composition, frictional behaviour, wear processes and visual characteristics during drawing.

Research project

Building upon this concept, this M2 project will investigate traditional chalk pastels prepared according to historical formulations (Fig. 1, right). Pastel sticks will be manufactured at the CRC using mineral fillers representative of historical recipes, including kaolinite, gypsum and calcite, combined with different organic binders (gum arabic, gum tragacanth and animal glue) at varying concentrations. Mechanical experiments will be performed using the automated drawing apparatus developed at the INPHYNI laboratory (Fig. 1, left). The instrument provides precise control of normal load, sliding distance and drawing speed while allowing the pastel stick to move freely in the vertical direction, thereby reproducing realistic drawing conditions while ensuring excellent experimental reproducibility. Material loss, frictional behaviour and transfer to the substrate will be quantified as a function of formulation, allowing the influence of filler mineralogy and binder chemistry on wear mechanisms to be directly assessed.

Following controlled deposition, the resulting traces will be characterised using analytical techniques routinely employed in heritage science. Beyond documenting colour, particle distribution and deposit morphology, these measurements will assess the capability and limitations of non-invasive analytical methods for identifying pastel formulations from the deposited material alone.

By directly correlating composition, mechanical properties, wear behaviour and optical response, the project will provide the first quantitative framework linking historical pastel manufacture to both material performance and visual appearance.