Sustainable Strategies for Street-Art Preservation

INTRODUCTION

Contemporary muralism, a key element in urban social and political communication, faces rapid deterioration due to environmental factors such as sunlight, rain, pollutants, and temperature fluctuations. These can cause cracks, material loss, and discoloration (fading is the most common form of deterioration). However, studies on how parameters like temperature affect colorimetric changes in murals are scarce due to high costs and the technical challenges of collecting long-term data.

This project uses machine learning (ML) to study temperature distributions on outdoor paint mockups and their impact on color changes, focusing on: (1) paint composition's effect on deterioration, (2) wall orientation's role in degradation, (3) predicting surface temperatures and their link to damage, and (4) assessing a solar-protective coating. The findings aim to support conservation strategies for preserving urban murals.

MATERIALS & METHODS

Sample preparation

Paints

PVA

Green RAL 6024 (KROMO)
TiO_2
Calcite

Pink RAL 4010 (KROMO)
TiO_2
Calcite
Silica

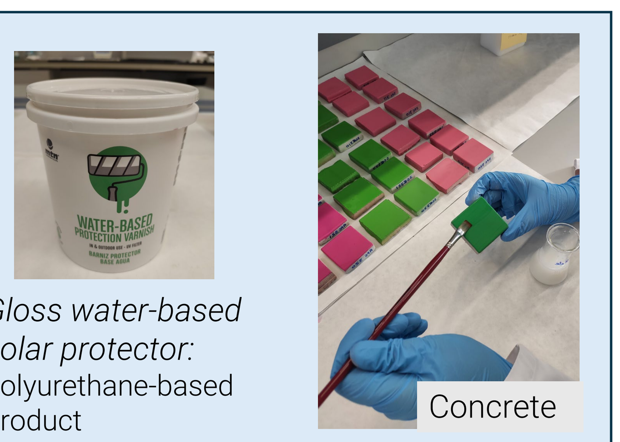
Alkyd

MTN 94 Valley Green RV 6018
TiO_2
Goethite

MTN 94 Tutti Frutti RV 151.
TiO_2
Goethite

Solar Protector

Gloss water-based solar protector: polyurethane-based product



Exposition

Control degradation

Colour Changes & Surface Temperature Monitoring

✓ Colour Spectrometry (Minolta CM-700d Spectophotometer): **CIELab** & **CIELCH** color spaces

Measurement of **L*** (lightness), **a*** (-a*: green to +a*:red) and **b*** (-b*:blue to +b*: yellow)

Parameters variations and Color difference (ΔE^*_{ab})

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2}$$

✓ Online Surface Temperature recording (**10-minute** frequency)

Chemical & Textural Analyses of Aged Samples

✓ Stereomicroscopy
✓ Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM-EDS)
✓ Fourier-Transform Infrared Spectroscopy (FTIR)

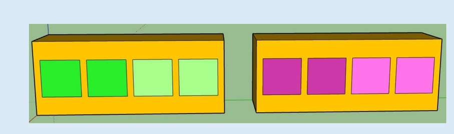
ML model for temperatures

Missing data prediction

✓ **Meteorological data** (ambient temperature, relative humidity, global radiation)

MeteoGalicia stations
Kriging interpolations

✓ Estimation of incident radiation (based on sample orientation). **TRNSYS** model.



✓ **Machine Learning** model for predicting surface temperature

RESULTS

Color Changes vs Temperature Gap (ΔT)

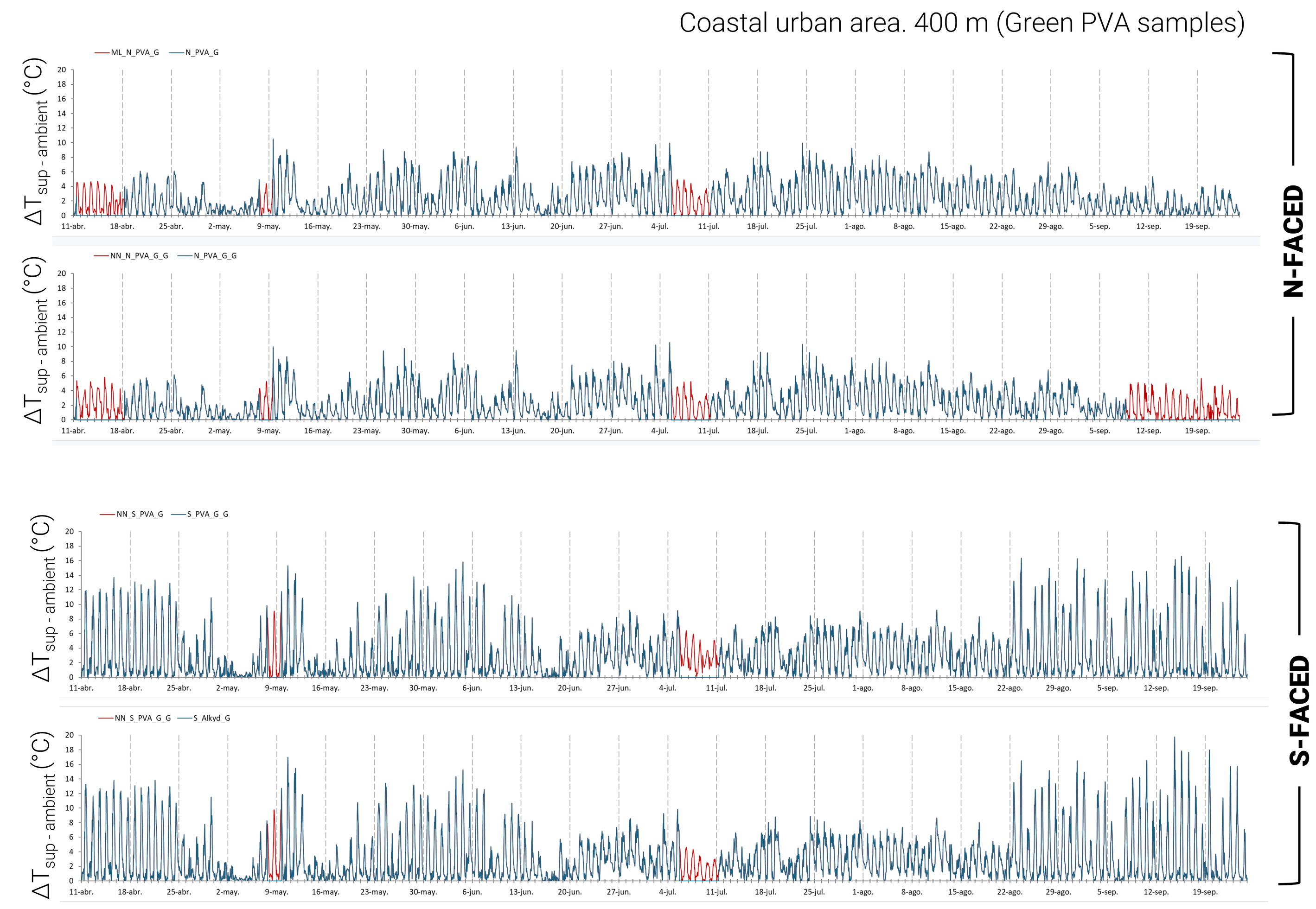
ΔE^*_{ab} evolution over time

Coastal urban area. 400 m

*Samples submitted to chemical & textural analyses.

Filling missing values during T_{sup} monitoring with ML models

Coastal urban area. 400 m (Green PVA samples)



original

ML- estimated

S-faced samples showed considerably higher ΔT values than their corresponding N-faced ones. Temperature profiles revealed greater solar radiation exposure, faster surface heating, and more intense thermal cycles for S-oriented samples compared to N-faced samples.

Are ΔT and color parameters correlated?

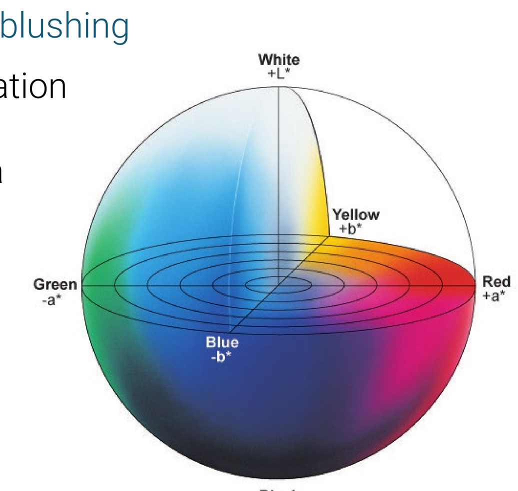
✓ **ΔE^*_{ab}** is not significantly correlated to ΔT

✓ **ΔL***: moderate-to-strong correlation with ΔT : higher ΔT → **darkening** (regardless paint composition, location, orientation or protection).

✓ **Δb***: moderate-to-strong correlation with ΔT regarding locations:

- Coastal urban area above level sea: higher ΔT → yellowing
- Coastal urban area at sea level: higher ΔT → blushing

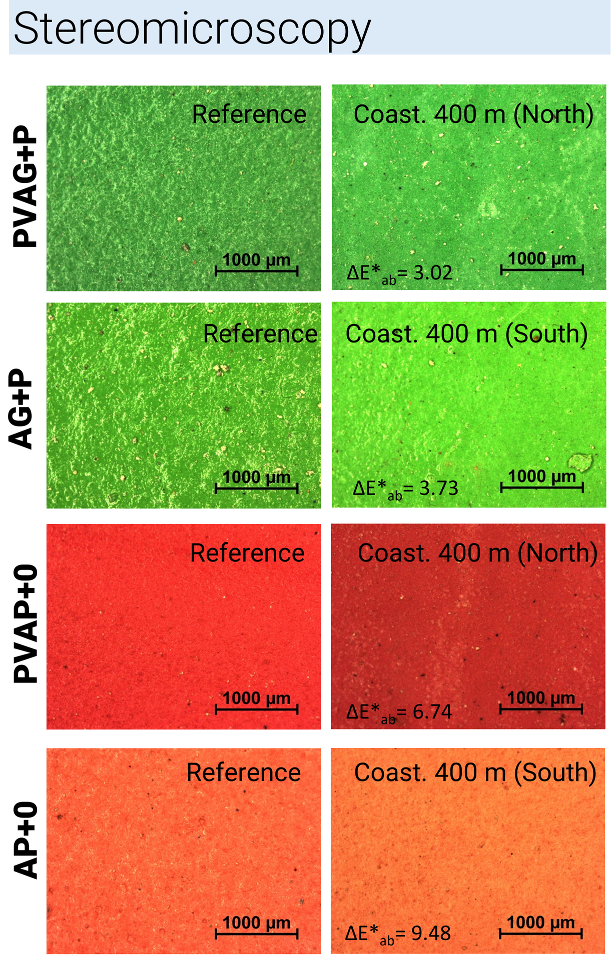
✓ **Δa***: strong correlation with ΔT just in the coastal urban area at sea level: higher ΔT→ reddening



CIELab color space.
Source. Konica Minolta Sensing

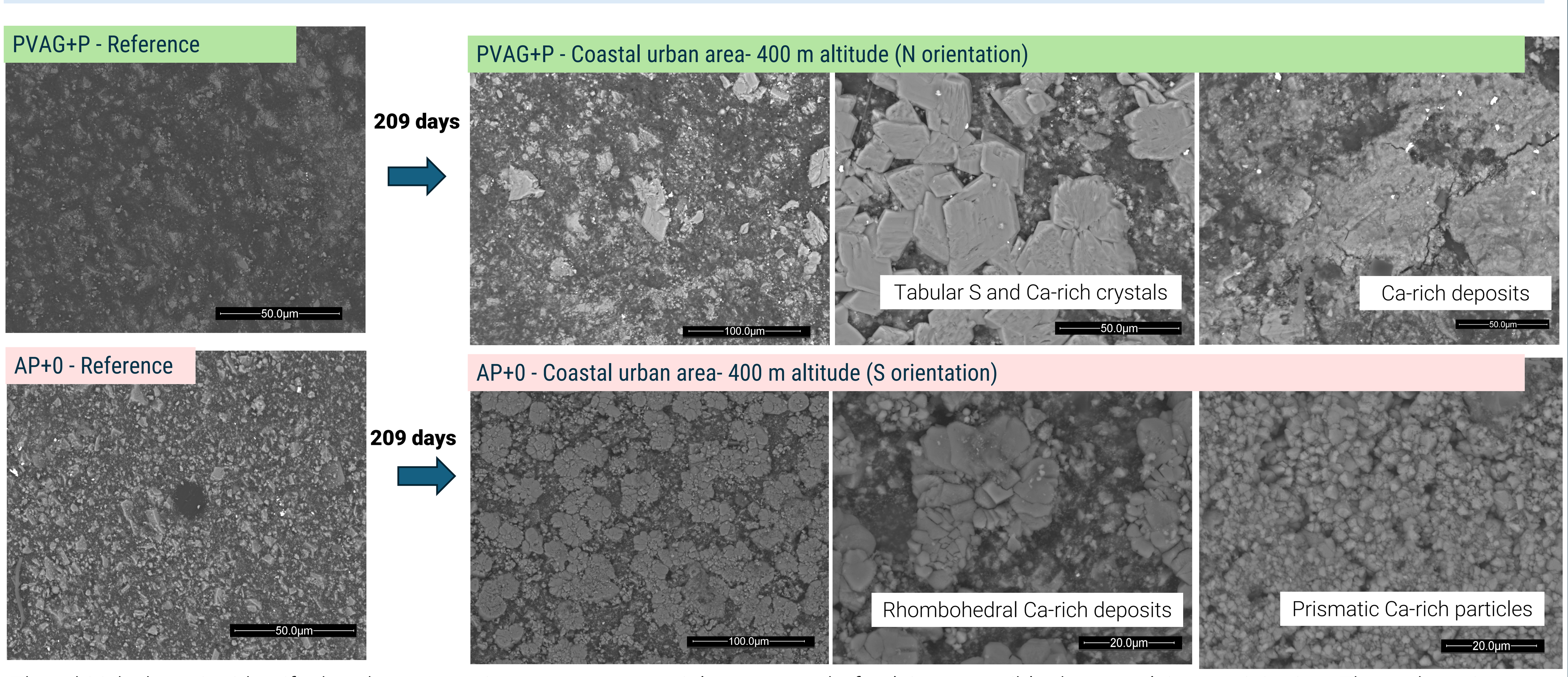
Chemical & Textural Analyses of Aged Samples

Stereomicroscopy



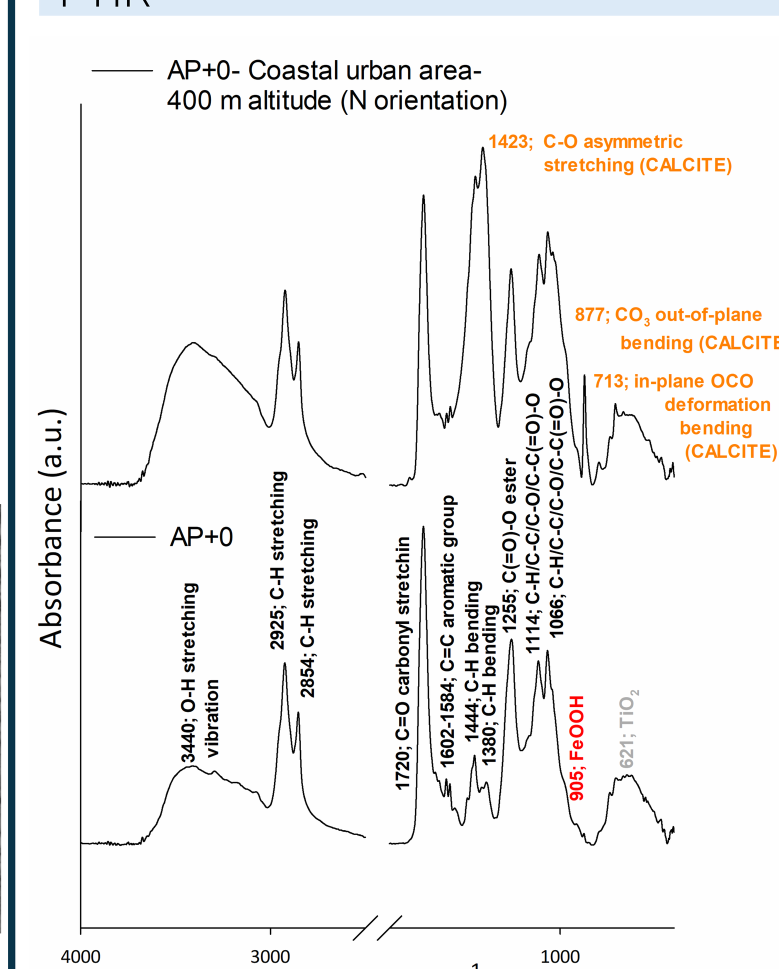
White deposits and surficial fading were detected on the surfaces.
No noticeable differences were identified considering paint composition, location, orientation or protection.

SEM



The whitish deposits identified under stereomicroscopy were mainly composed of calcium, possibly due to calcite precipitation. These deposits were found in all samples; more extensive on the AP+0 sample exposed in a coastal urban area above the sea with a S orientation (this sample showed the highest ΔE^*_{ab}). Only sulphur and calcium-rich crystals, identified as gypsum due to their tabular habit, were found on the PVAG+P sample located in a coastal urban area above sea level with a N orientation (this sample showed a ΔE^*_{ab} lower than 3.5 CIELab units, which is the threshold for highlighting a clear difference in color).

FTIR



Calcite grains were identified on the exposed surfaces with the highest ΔE^*_{ab}.

References:

- R. Pérez-Orozco, J.S. Pozo-Antonio, M. Cordeiro, J. López-Bértolo, P. Eguía, T. Rivas. *Monitoring of thermal and colorimetric changes in outdoor exposed acrylic and alkyd paints: influence of environment, paint composition and wall orientation.* 2024 IEEE International Conference on Metrology for Archaeology and Cultural Heritage (MetroArchaeo 2024). 7-9 Oct 2024, Valletta (Malta).
- R. Pérez-Orozco, J. López-Bértolo, M. Pazo-Rodríguez, M. Cordeiro, J.S. Pozo-Antonio. *Reconstruction of Missing Data in Mural Degradation Studies: Evaluating Bayesian Networks vs. Artificial Neural Networks.* 14th National and 5th International Conference in Engineering Thermodynamics (14CNIT). 4-7 June 2025, Zaragoza (Spain)