Technical studies of historical earthen plasterers: a case study on the earthen plasters from the inner-wall of the Longhu Hall in the Yuzhen Palace of Ancient Building Complex in the Wudang Mountains

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Introduction

Some facts about the Yuzhen Palace:
- Location: Southeast of the Danyangzhou City, Hubei Province, China
- An imperial construction built under the order of Yongle Emperor in the Ming dynasty (1421-1423 A.D.)
- One of the 9 palaces in the Ancient Building Complex of Wudang Mountains (UNESCO world heritage site, birth place of Wudang Martial Art-Rich, famous for Tourism)
- Consisted of 3 gates (west palace gate, east palace gate, main palace gate), Longhu Hall, east and west-side corridors, hallways.
- Built with black bricks dressed with exterior earthen plasters (outter wall surfaces have been painted red)

As a result of the planned National South-North Water Diversion project by the Government of China, the water level in the Danyangzhou Reservoir that surrounds the Yuzhen Palace will rise approximately 15 meters.

To avoid submersion permanently in the water:
- Three gates (Gate K, L and M in the floor plan) were elevated by 15 meters in 2012-2013
- Other buildings were dismantled and will be re-erected in the near future

Questions of archaeological and conservation science importance:
- What is the construction technology of this imperial building?
- How many layers of plasters make up the wall preparation and what are the main constituents (raw materials) in each layer?
- Are there any plant fibers? Are these of plant or animal origin?

Materials and Methods

Archaeological fragments of the earthen plasters were sampled from the inner wall of Longhu Hall.

Size: 3.5 cm in length, 2.3 cm in thickness

Characterization Techniques: 1. Optical Microscopy (OM); 2. Polarized Light Microscopy (PLM); 3. X-ray Florescence (XRF); 4. Scanning Electron Microscopy- Energy dispersive spectrometry (SEM-EDS); 5. X-ray diffraction (XRD); 6. Fourier Transform Infrared Spectroscopy (FTIR); 7. Thermogravimetric Analysis (TGA)

Results

The stratigraphy of the earthen plasterer samples consists of 4 different layers:

Layer A: Surface lime wash (250-380 μm)
Layer B: Intermediate layer (> 340 μm)
Layer C: Fine earth layer (~ 3.5 mm)
Layer D: Coarse earth layer (> 5 mm)

Layers A and C were 3 cm in thickness, layers D 5 cm in length, 2 cm in thickness.

Cross-section: 1:1
Stratigraphy of the earthen plaster sample: Showing a four-layer structure

Layer A (surface lime wash) Analysis

- OMT of the Layer A
- SEM of the Layer A (left) and cross-section (right)
- PLM of the Layer A

Layer C (fine earth layer) Analysis

- OMT of the Layer C
- Cross-section of fine plant fiber

Cross-section: 1:1
Stratigraphy of the earthen plaster sample: Showing a four-layer structure

Layer B (intermediate layer) Analysis

- OMT of the Layer B
- SEM of the Layer B
- PLM of the Layer B

Layer D (coarse earth layer) Analysis

- OMT of the Layer D
- SEM of the Layer D
- PLM of the Layer D

Plant Fibers Analysis

- SEM of plant fiber
- PLM of plant fiber
- FTIR spectrum

Conclusions

1. A comprehensive analysis of historical earthen plasterers from Yuzhen Palace has been performed.
2. The inner wall earthen plasters consist of four layers (from top to the bottom):
   A. Surface lime wash (lime binder + sand-aggregates + muscovite/mica)
   B. Clay + proteinaceous matter (calcium carbonate)
   C. D: earthen plaster layer, containing goethite, calcite, quartz, muscovite
   Layer C has a Fe concentration higher and an average size smaller than layer D. The lime humps and ramie & straw fibers were added on purpose during the preparation.
3. The extraction of the organic additives within mortars and analysis is under progress.

Acknowledgements

This project is a collaborative research between Anhui University of China, Hubei Provincial Institute of Cultural Relics and Archaeology, and the Molecular and Nano-Archaeology Laboratory as well as the Conservation IDP and the Cotsen Institute of Archaeology at the University of California Los Angeles. We would like to acknowledge financial support from the Ralph C. Altman award granted by Fowler Museum at University of California, Los Angeles.

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