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Focus on soluble salts transport phenomena: The study cases of Leonardo mural paintings at Sala delle Asse (Milan)

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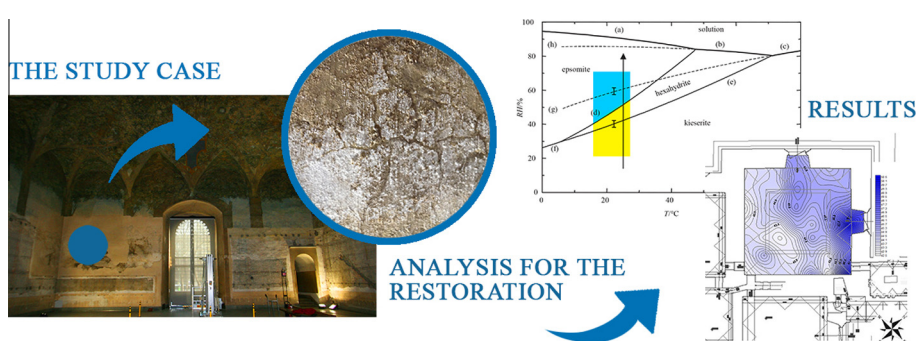
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HIGHLIGHTS

- The decay of Leonardo mural paintings requires the highest integration of investigations.
- Authors identified the soluble salts together with their transport phenomena.
- The analysis correlated the salts distribution and the thermal-hygrometric variations along 4 years.
- Innovative use of statistical analysis of the changes of salts phases for evaluating of risk factors.
- Considering salts soluble and their transport phenomena prevents the use of water for restoration.

GRAPHICAL ABSTRACT



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ABSTRACT

The program of investigations on “Sala delle Asse”, which hosts a monochrome landscape attributed to Leonardo, in the Sforza Castle in Milan recently concluded the first step. Results of the analytical tests for the characterization of materials and their damages showed the high diffusion and concentration of nitrates and sulphates on the surface of the monochrome at the edge with the restoration mortars, on the right side of the north-western wall. On the base of the scientific literature and laboratory tests, the researchers identified a threshold of RH above which deliquescence of salts could easily occur. Microclimatic monitoring results informed that during the most humid days in spring, summer and fall, RH trespasses this threshold, with a frequency of about 30 events/year. After an accurate analysis of air temperature (T °C) and relative humidity (RH) resulted that the exterior changes especially affect the interior climate at some summer conditions as middle-high speed of wind and, especially, its direction due to some cracks and holes in the north western exterior wall of the hall.

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1. Introduction

The historical documentation regarding Sala delle Asse, located in one of the corner towers in Sforza Castle (Milan; Fig. 1), reports

that Leonardo had the task of decorating the hall in 1498. Currently, it is not known if the artist accomplished the task alone or if somebody else completed the decoration, nevertheless Sala delle Asse was his second huge job, as a mural painter in Milan, overshadowed by The Last Supper alone. One year later, after the defeat of Milan’s Duke, Leonardo left the town and, probably, his unfinished painting in Sala delle Asse. Under the French

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Fig. 1. Sforza Castle. Milan; credits of the website of the protection of CH, Region Lombardy <http://www.lombardiabeniculturali.it/blog/articoli/1815/>.



Fig. 2. Sforza Castle. Milan. Sala delle Asse, view of the north eastern side, with the monochrome on the left and with part of the vault, before restoration (December 2012).



Fig. 3. Sample 1 C. Monochrome wall: white efflorescences are mainly located alongside the border of a patch composed of a different cement mix compared to the surrounding matrix.

domination, from 1499 the castle went under a wide-ranging refurbishment, to host the army headquarter. Sala delle Asse became a horse stable and several layers of whitewash coated the paintings.

Luca Beltrami, in charge of restoration works, as the castle was turned into a museum, discovered the ornamental paintings in 1893, based on Paul Müller-Walde plaster removal trials; Beltrami removed the whitewash, unveiling the poor condition of the paintings. Although he did not document the remains of the decoration



Fig. 4. Polychrome vault: white efflorescences are unevenly distributed forming a whitish covering layer.



Fig. 5. Polychrome vault: soluble salt crystal aggregates morphology.



Fig. 6. Sample 1. White efflorescence analysed by X Ray diffraction (see Fig. 7).

that appeared underneath the whitewash, his decision to intervene on the paintings took place quite soon, and eight years after, the painter Ernesto Rusca had the task of integrating and repainting the remains, completing the works in 1902. Beltrami and Rusca did not recognize Leonardo's monochrome painting remnants on

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