INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 11, Special Issue 1, 2020: 261-270 www.ijcs.uaic.ro

COLORIMETRIC MONITORING OF PALAZZO MARGHERITA, US EMBASSY IN ROME

Andrea MACCHIA[1*], Valeria BRUNORI[2], Laura RIVAROLI[1], Piero CORONAS[3], Cristina BALZANI[3], Natalia ROVELLA[4*]

[1] YOCOCU, Via Tasso 108, Roma,
[2]US Embassy, Via V. Veneto 119/a, 00187 Rome (Italy), OBO/OPS/Cultural Heritage Office brunoriv@state.gov
[3] Kermes s.n.c. Restauro Beni Artistici, Via Della Tribuna Di Tor De Specchi, 00186, Romainfo@kermesrestauri.it
[4] Università della Calabria, Dipartimento di Biologia, Ecologia e Scienze della Terra (DiBEST), Via Pietro Bucci, 87036 Arcavacata di Rende (Cs), Italy

Abstract
The importance of preventive conservation strategies for the built heritage has been debated in the last years, but there is still a limited number of applied researches involving complex architectural sites. The identification and monitoring of the decay processes after the restoration activities can support future preventive conservation strategies. In this study the colorimetric approach made on the façades of Palazzo Margherita, US Embassy Rome's Chancery building is presented. This monument situated in the center of Rome (Italy) is an important case study for the understanding of the interaction between the surfaces and the environment. The main conservation issues have been identified and studied. A non-invasive colorimetric monitoring of selected areas of the façades has been carried out over a two-year period in order to evaluate the measurements of detected surface colour changes using the statistical PCA technique to represent the data.

***Keywords**: Colour alteration; Travertine; Spectrocolorimeter; PCA*

Introduction

The alteration and deterioration of stone materials used on the Cultural Heritage monuments can be reduced though use restoration procedures with the application of protective or consolidating products [1,2]. One important parameter must be considered when choosing these products, since the substrate may undergo changement in the colour caused by the treatment itself. Colour variations are determined by means of the ΔE parameter, which is the variation between each chromatic coordinate (L^*, a^*, b^*) in both treated and untreated specimens. According to Italian guidelines for the restoration of stone buildings [3-7], protective products should not cause chromatic alterations whose ΔE value is higher than 5. Previous studies have demonstrated that colorimetric measurements of monumental stone after treatment with various types of protective products sometimes show visible and irreversible chromatic variations with respect to the original colour [2, 8-11]. At the same time the colour varation can be produced by different degradation phenomena such as, biological colonization [12], salts crystallization [13], black crusts [14], oxalate or using different pigments [15], etc.

In this way the present study is focused on the results of the colorimetric monitoring of

* Corresponding author: info@yococu.com, yococu.yococu@gmail.com

Palazzo Margherita's facades, US Embassy Rome's Chancery building made by the team professionals YOCOCU (YOuth in COnservation of CUltural Heritage). The aim is to define the colorimetric changes induced on the surfaces after the restoration treatment, in order to obtain useful information for a long-term preventive conservation maintenance strategy of the building [16-18]. The deterioration of the materials is closely related to the variation of the surface colour, which is the area of interaction between the artwork and the environment.

The building's facades were restored between February 2017 and July 2018 by the restoration company Kermes S.r.l.; the project was managed by the US Embassy Rome's Office of Facility Management under the supervision of the Italian Ministry for Cultural Heritage and Activities and for Tourism's Superintendence (*Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma*), and with the technical supervision of the US Embassy Rome/ OBO/OPS/CH Office of Cultural Heritage.

The building is on three levels and is composed of a solid tuff (for the foundations), brick and concrete structure, and reinforced concrete slabs, with architectural elements (balcony, columns, door-and window frames, cornices) in travertine on the west (main) façade, which on the side- and rear facades are imitated with plaster/stucco [19].

The project was the first real restoration work of the building since its construction in 1886-1890. Previous projects of unknown date mainly involved damage repair and the addition of several layers of paint and whitewash, which modified Koch's original colour scheme.

The conservation project, which was prepared by a planning phase, allowed to restore the original colours of the surfaces. The restoration project, which included a preliminary study of the building, of its characteristics, construction techniques and original materials, and a thorough condition assessment, documentation, and understanding of the deterioration phenomena, based on visual inspection and on a diagnostic campaign, was carried out by the architecture studio DDM Architetti Associati. Moreover, during the restoration, upon careful evaluation by a team of conservation professionals and scientists, it was decided not to apply a protective coating on the stone surfaces. During the project the most significant decisional phases have been addressed collectively with Professor Giovanni Carbonara's and Professor Marisa Laurenzi Tabasso's scientific counselling, together with Architect Massimo Dionisi, from the studio DDM Architetti Associati, and the Area Manager from the Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma, Engineer Claudio Baldani.

The palace was commissioned at the end of the 19th century by Prince Rodolfo Boncompagni Ludovisi to the noted Roman architect Gaetano Koch (1849-1910) [20].

The family owned the 62 acres estate since 1621-22, when Cardinal Ludovico Ludovisi, nephew of the newly elected Pope Gregory XV, purchased and unified four properties on the area of the ancient *Horti Sallustiani*, creating the renowned and much-admired Villa Ludovisi. The Cardinal, a connoisseur and patron of antiquities and arts, engaged notable architects and artists, such as Carlo Maderno and Domenico Zampieri to plan the restoration of his new property and gathered, over the course of a few years, one of the most remarkable collections of ancient statuary and paintings in Rome. The period of splendour of the famed Villa came to a halt with Gregory XV's death in 1623. The property was administered initially by Cardinal Ludovisi's brother Niccolò, Prince of Piombino since 1634, and then by his descendants, including his daughter Ippolita, who in 1681 married Gregorio Boncompagni, starting the Boncompagni Ludovisi lineage.

With the election of Rome as the new capital of the united Italy in 1871 major projects modified the city topography to accommodate its new role and the rapidly increasing population. At that time, Prince Rodolfo Boncompagni Ludovisi, head of the family and sole owner of the estate, decided to sell most of the property in lots, associating himself with the *Società Generale Immobiliare di Lavori di Utilità Pubblica ed Agricola* (General Real Estate

Company for community services and agriculture), with the goal of gathering the funding necessary for the construction of a new palace [21]. Rodolfo commissioned Gaetano Koch to design the new palazzo, which was to be constructed as a continuation of the existing buildings' west end, two villas and the *orangerie*; the buildings were erected between 1886 and 1890, at the cost of the destruction of the renowned Ludovisi gardens. Since the investment did not give the expected results, Prince Rodolfo asked Koch to submit, during the planning phase, two different cost estimates, aiming at reducing construction costs. The goal was achieved by substituting the window frames and cornices on the side and rear facades, as well as the main upper cornice, with plaster elements imitating the travertine and by using tufa instead of brick for the bearing portion of the wall.

The family Boncompagni Ludovisi, though, could enjoy the new property for a period of only 18 months, as a consequence of the general building crisis and of unfortunate economic investments. The property was taken over by the Bank of Italy, creditor to the family, in 1892.

The palace owes the name, which still identifies it, to Queen Margherita di Savoia, who – as the Queen Mother – lived in the palace that became her Roman residence from 1900 until the year of her death, in 1926. Her only major modification to the palace consisted in the addition of a small building on the rear (east) façade's north end, which accommodated a dining room and served as a connection between the main palazzo and the gardens.

On June 5, 1928, the National Fascist Union of Farmers (*Confederazione Fascista degli Agricoltori*) established itself in the Palazzo Margherita, after purchasing it from the Savoia. Between 1930 and 1931, the American Diplomatic Mission purchased the two smaller villas and established here its Consulate and Embassy. On August 3, 1946, the Government of the United States of America purchased the entire compound for 281,250,000 Italian lire from the Union of Farmers. Between 1948 and 1951, the building underwent major renovations, including the creation of an additional level through the division of the third floor; the opening of windows in the frieze of the upper cornice to illuminate the newly created attic space, with consequent removal of the Ludovisi heraldic symbol from the upper frieze, and; the addition of office-space through the construction of a new wing designed by the architect Mario de Renzi (1897-1967). The latter addition constructed behind the palazzo, between villa Ludovisi and the gardens, irreversibly destroyed the elegant access to the Renaissance building [22, 23].

Experimental

Condition assessment, before the restoration

In general, the condition of the facades was heavily compromised by different deterioration factors impacting on the original materials: the crack mapping was rather severe, with complete or partial detachment of plaster portions. The main issues found on the stucco and travertine surfaces included built-up of solid and partially solid deposits, stains caused by rainwater run-off, oxidations, copper salts, biological patina and black crusts. On the brick surfaces erosion and disintegration of the jointing mortar were found.

Paint analysis revealed the presence of three different layers of whitewash on the facades: the most recent one was dark gray, imitating the travertine; underneath this layer a yellow one was found, and lastly; an ivory-colored layer (probably the original patina) could be identified. Additionally, a non-original whitewash was found on the travertine, probably applied with the intention of covering the areas stained by deposits and other substances, and thus creating a uniform colour and enhancing the surfaces

Conservation treatment

The first step of the conservation treatment was about the stabilization of the different materials (Stuccoes, travertine elements, brick):

Stuccoes: the stucco elements have been stabilized through the injection of pre-mixed mortars, accompanied by the insertion of stainless-steel pins, applied both on the existing elements and on the missing and reconstructed ones, and by the use of reinforcement membranes. In cases of deep abrasions, the superficial disintegration was stabilized through the application by brush of a semi-liquid stucco (grout).

Travertine elements: the detached or detaching elements were secured by means of an epoxy resin and, where necessary, reinforced through the insertion of stainless-steel pins.

Brick: the stabilization was obtained mainly through the restoration of the mortar joints, which play a key role both, in the reinforcement of the wall fabric where the original mortar joints were disintegrating, and in case of fractures; in the latter case, the restoration of the mortar joints serves the purpose of strengthening the wall and of insulating the deeper layers, avoiding any risk of water infiltration.

After consolidation, a differentiated cleaning treatment was carried out based on the different materials and the damage typologies.

Microbiological growths: microorganisms were found in restricted areas. On all surfaces the removal of microorganisms was carried out by applying the products twice, before and after the removal of the superimposed layers: in fact, biofilms were found also underneath and in between the different layers.

Inadequate fills and whitewashes: fills and whitewashes were removed from the travertine surfaces mechanically by means of scalpels, chisels and vibrating precision cutters; on stuccoes and brick surfaces a low-pressure water washer was also used. In case of resistant layers, cellulose pulp compresses with an ammonium carbonate solution were applied.

Solid and semi-solid deposits: deposits were removed using different procedures depending on the surface to be treated: on the travertine elements the JOS cleaning was used, complemented by a localized chemical cleaning with cellulose pulp compresses and ammonium carbonate solution.

The last restoration phases were to search a correct methodology on the reconstruction of the elements, the filling and the aestetich presentation.

Reconstruction of elements and fillings: missing travertine elements were reconstructed using hydraulic lime-bound mortars with aggregates imitating the original materials both, in colour and granulometry; in particular, yellow river sands with different granulometries was used. In cases of pitting the fillings were performed slightly under level. Joining mortars on brick surfaces were restored using a hydraulic mortar with red and black pozzolana and gray river sand, whereas the losses on the bricks themselves were reconstructed by means of a custom-formulate mortar prepared by the company Calceforte, which included the addition of red or yellow brick-powder, depending on the portion to be reconstructed. The stucco surfaces were treated with a grout applied by brush on the areas affected by superficial erosion and with Calceforte mortars (three different types of mortars were used depending on the depth of the loss). In some cases, the shape of tridimensional decorations had to be reconstructed: for large reconstructions a reinforced self-supporting mortar, having the same characteristics as the original materials, had to be composed. For this purpose, a fiber-reinforced lime-bound mortar was formulated. In these cases, support structures made of stainless-steel netting and pins were secured to the original, sound material (micro-structures).

Chromatic reconstruction: a chromatic surface treatment, obtained with the application of a pigmented patina, was performed only on the stucco elements, respecting the original colors and aiming at providing the stuccoes a similar appearance as the travertine elements. In order to achieve this goal, the following layers were applied: a primer, a layer of white silicate providing the texture, and finally an ivory colored layer, finished through the application of three subsequent silicate glazing, of different colors, applied using natural sponges.

The monitoring focused in particular on the travertine decoration, being it more easily attacked by environmental agents.

Results and discussion

Monitoring of the facades with the intention of assessing its condition was carried out for over two years, through six colourimetric survey campaigns. The measurements were performed on the four facades: NORTH; WEST (main); SOUTH and EAST.

During the six campaigns, spectra were acquired for 64 areas on all surfaces, each of which, given the heterogeneity of the surface, was obtained by averaging different measurement spots in neighboring areas. The analysis was carried out in correspondence with three different support types: travertine, stucco finished to imitate the travertine and bricks.

Measurements were performed at different heights to understand the different interactions of the facades with the environment induced by the different expositions, over the course of 6 different campaigns: 4 in the year 2018, carried out every three months, and 2 in 2019 at a distance of about 6 months. Each facade was divided in five different levels and spectra were collected on protected and unprotected horizontal planes, vertical planes and decorative elements. Limitations in the definition of areas were the inhomogeneity of travertine and the unevenness of the surfaces. Each measurement campaign was accompanied by a specific photographic and graphic documentation in order to record the measurements over the course of time (Fig.1).

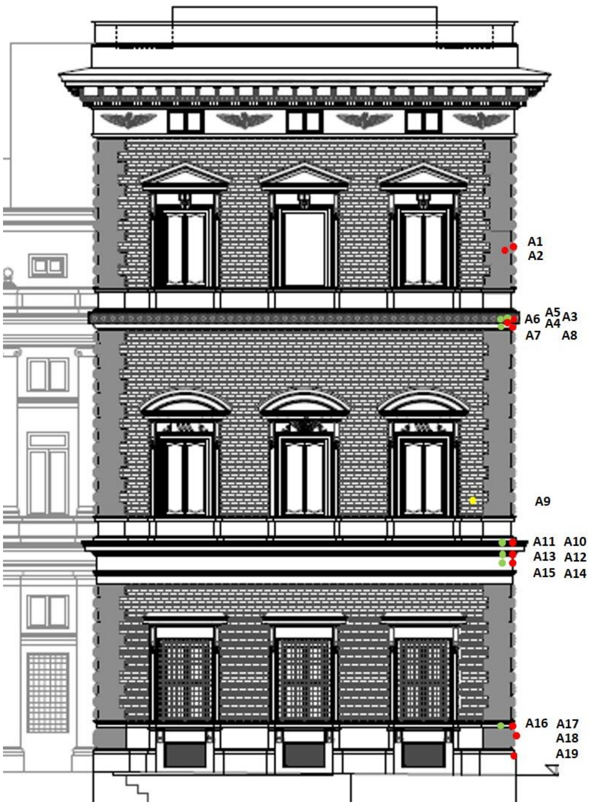

Fig. 1. Graphic documentation of sampling areas related to North façade. A=Area of sampling

The spectra (400-700 nm) were collected by means of a YS3060 spectrophotometer by 3n (a matching measurement aperture: 8mm, SCI component included, automatic average for each analyzed zone was based on 5 measurement). In order to determine the colour of the areas, 5 spectra on neighboring zones were acquired. The colour has been identified using the CIELAB coordinates. CIELAB is the mainstream colour space coordinate system, which was defined by the International Commission on Illumination (CIE) in 1976. In this chromatic space the colour is defined through three coordinates: L* indicates lightness, a* is the red/green coordinate, and b* is the yellow/blue coordinate. Colour differences were defined as the numerical comparison of the same area in several campaigns using the formula

$$\Delta E = ((\Delta L*)2 + (\Delta a*)2 + (\Delta b*)2)1/2 \qquad (1)$$

A multivariate statistical technique, Principal Component Analysis (PCA), was applied to compare the data (approximately 5000 measurements for all campaigns) reducing the number of dimensions' data to describe possible changes in the colour of the facades.

Analysis of colourimetric data

During the first phase measurements were recorded on data sheets, including a photograph and a brief description of the area, as well as a chart documenting the different measurements taken on the area, as shown in Figure 2. The data were analyzed both with reference to the individual areas, to capture possible chromatic differences, and to define the colour of the travertine.

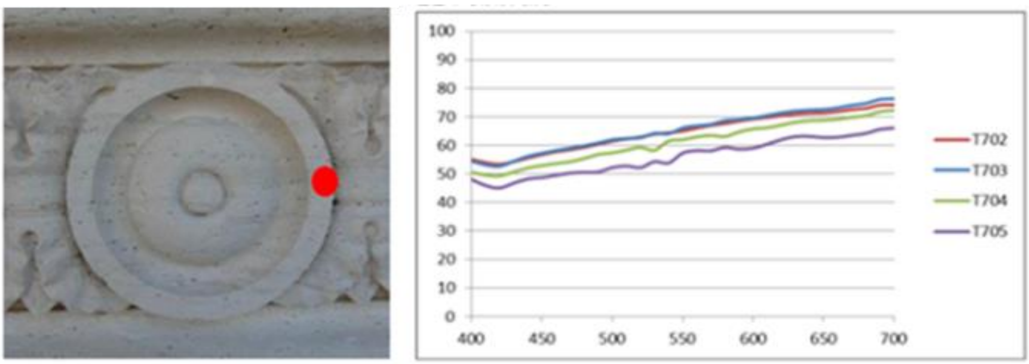

Fig. 2. Representation of data for each area

The data have been treated to eliminate spectra that are not representative of the surface or characterized by errors generated by the imperfect adhesion of the instrument to the surface and by the previously described difficulty in taking the measurements caused by the inhomogeneity of the surface.

The data collected are expressed in a chart showing in the abscissa the wavelength expressed in nanometers (nm), ranging between 400 and 700 nm, and in ordinate the reflectance% (R%). For each area of sampling, the average and the standard deviation were calculated to compare the date. Following in table 1 and 2 are reported the data related the same areas (A) of North Fac obtained during the first and last montoring campaigns.

The comparison of data acquired during the different campaigns showed chromatic alterations induced after 1 year, in particular on the areas characterized by the use of stucco, which changed to a slightly darker shade, as defined by the decrease of the L* component, and more yellow tones, due to an increase in the b* component and a decrease of the a* coordinate.

The phenomenon was observed in particular on the WEST and NORTH facades. At the same time, also the L* value on the travertine increased slightly, as shown in Fig. 3.

Table 1. North façade. Spectrocolorimter parameters related to areas characterized by Travertine, collected during the first and the last monitoring campaigns. Av=Average; SD=Standard Deviation

Area	Parameter	First Monitoring			Last Monitoring		
		L*	a*	b*	L*	a*	b*
A1	Av	82.8	2.4	11.4	82.5	2.5	8.8
	SD	1.8	0.3	2.9	1.5	0.9	2.7
A2	Av	81.5	2.3	10.5	83.0	2.1	7.3
	SD	1.4	0.3	0.4	2.8	1.3	2.7
A3	Av	80.8	2.5	8.8	84.0	0.8	9.5
	SD	0.9	0.4	1.9	3.3	1.8	2.3
A4	Av	81.0	2.5	8.5	83.2	1.5	9.2
	SD	0.2	0.1	1.0	3.3	0.1	0.5
A8	Av	82.1	3.1	9.8	83.7	2.0	8.0
	SD	1.0	0.8	0.3	2.2	0.1	0.3
A10	Av	80.6	3.1	10.6	81.4	3.5	10.1
	SD	0.4	0.6	1.0	0.4	0.0	1.2
A12	Av	80.6	3.1	10.6	82.3	1.4	7.1
	SD	0.4	0.6	1.0	2.3	0.3	1.6
A14	Av	80.6	2.2	10.4	81.2	2.3	9.2
	SD	1.2	1.4	0.5	n.d.	n.d.	n.d.
A16	Av	80.1	1.9	9.4	80.6	3.0	11.5
	SD	1.6	0.3	1.3	1.4	0.4	0.5
A18	Av	80.6	2.1	8.2	80.4	1.8	7.7
	SD	0.5	0.1	0.3	0.3	0.5	1.0
A19	Av	79.8	2.6	10.5	80.8	2.4	9.1
	SD	1.7	1.0	1.3	0.7	0.2	0.7

Table 2. North façade. Spectrocolorimter parameters related to areas characterized by Stucco collected during the first and the last monitoring campaigns. Av=Average; SD=Standard Deviation

Area	Parameter	First Monitoring			Last Monitoring		
		L*	a*	b*	L*	a*	b*
A5	Av	84.3	9.6	16.8	81.0	2.6	11.1
	SD	0.3	0.3	1.0	0.3	0.1	0.2
A6	Av	86.6	11.0	15.9	79.4	2.9	9.5
	SD	1.4	0.1	1.4	2.6	0.2	0.3
A7	Av	86.6	13.0	20.9	79.2	2.3	9.3
	SD	1.4	0.1	1.4	0.9	1.1	0.5
A11	Av	85.6	7.4	15.5	80.6	3.0	10.9
	SD	0.5	0.2	0.3	1.4	0.1	1.4
A13	Av	86.4	11.5	16.1	80.6	3.0	11.9
	SD	0.2	0.7	0.3	1.4	0.1	1.4
A15	Av	82.7	13.3	11.1	80.0	1.3	12.8
	SD	n.d.	n.d.	n.d	1.4	0.1	1.4
A17	Av	87.3	13.9	13.4	80.3	2.4	9.9
	SD	1.9	0.9	3.2	2.8	0.7	1.7

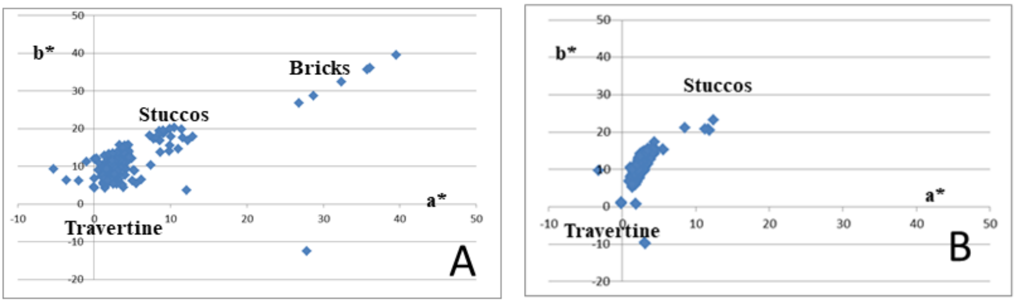

Fig. 3. Data plots related to 2018 with the bricks (A) and All campaigns related to 2019 (B).

This interesting result can be attributed to the natural settlement of the stone after the restoration treatment, due to elimination by rain of dust particles deposited on the surface. The result of the chromatic alteration of the stuccoes and the travertine was an improved chromatic balance between the two materials.

The PCA allowed to define the wavelengths responsible for the chromatic variation of surface colour and to better understand the variance of the data as shown in the loading plots (figure 4). The 2019 score plot confirms the smaller variance of data in comparison of 2018 (figure 5).

Figure 4. Loading Plot all spectrocolorimeter data about the 2018 (A) and all 2019 (B).

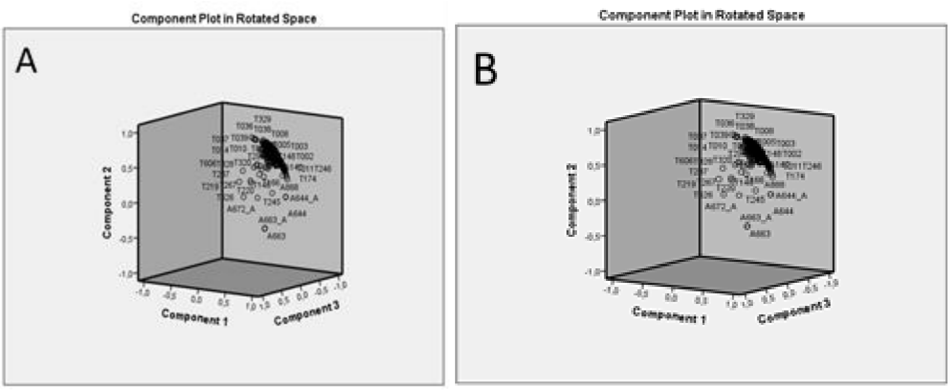

Figure 5. Loading Plot all spectrocolorimeter data about the 2018 (A) and all 2019 (B).

Conclusions

At the end of the second year of monitoring it possible that the color of the travertine surfaces remained unchanged ($\Delta E<5$). The greatest chromatic difference can be seen in the horizontal surfaces. The areas in travertine have no obvious color changes, while the areas in stucco are characterized by a slightly darker color than the color of the travertine. The monitoring performed at the end of 2019, confirming the good conservation of travertine that is characterized by the following values $L^* = 81.8 \pm 1.4$, $a^* = 1.6 \pm 1.1$, $b^* = 10, 6 \pm 1.1$, while the stucco is represent by the values $L^* = 81.5 \pm 1.2$, $a^* = 1.3 \pm 0.9$, $b^*=11\pm 2.2$.

References

[1] G., Barone, E. Campani, A. Casole, M.F. La Russa, A. Lo Giudice, P. Mazzoleni, A. Pezzino, The Cathedral of St. Giorgio in Ragusa Ibla (Italy): a case study of the use of protective products, **Environmental Geology**, 54, 2008, pp. 1501-1506.

[2] G. Barone, M. F. La Russa, A. Lo Giudice, P. Mazzoleni, A. Pezzino A, The Cathedral of S. Giorgio in Ragusa Ibla (Italy): Characterization of construction materials and their chromatic alteration. **Environmental Geology**, 55, 2008, pp. 499-504.

[3] G. Alessandrini, A. Aprile, A.M. Mecchi, R. Peruzzi, P. Rossi Doria Rota, U. Santamaria, G. Vigliano, in Proc. 1st Int. Cong. **Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin**, vol. II, Catania-Siracusa, 1995.

[4] G. Wyszecki, W.S. Stiles, Color Science: **Concepts and Methods, Quantitative Data and Formulae**, 2nd edn, Wiley, New York, 1982.

[5] M. F. La Russa, G. Barone, C.M. Belfiore, P. Mazzoleni, A. Pezzino, Application of protective products to "Noto" calcarenite (South-eastern Sicily): a case study for the conservation of stone materials, **Environmental Earth Science**, 62, 6, 2011, pp. 1263-1272.

[6] C. Belfiore, M.F. La Russa, A. Pezzino, E. Campani, A. Casole, The Baroque monuments of Modica (Eastern Sicily): Assessment of causes of chromatic alteration of stone building materials. **Applied physics A-Materials Science & Processing**, 100, 2010, pp. 835-844.

[7] A. Macchia, F. Mangini, S. A. Ruffolo, M. Muzi, L. Rivaroli, M. Ricca, M. F. La Russa, F. Frezza, A novel model to detect the content of inorganic nanoparticles in coatings used for stone protection, **Progress in Organic Coatings**, 106, 2017, pp. 177-185. doi 10.1016/j.porgcoat.2016.11.004.

[8] V. Pelin, I. Sandu, S. Gurlui, M. Branzila, V. Vasilache, E. Bors, I.G. Sandu, *Preliminary investigation of various old geomaterials treated with hydrophobic pellicle*, **Color Research And Application**, 41 (3), 2016, pp. 317-320. DOI: 10.1002/col.22043.

[9] I.C.A. Sandu, F. Paba, E. Murta, M.F.C. Pereira, L. Dias, J. Mirao, A.E.G. Candeias, *Two Recipes From Portuguese Tradition Of Gilding On Wooden Support Between Laboratory Reproduction And Analytical Investigation,* **International Journal of Conservation Science**, 6(SI), 2015, pp. *541-556*

[10] V. Pelin, I. Sandu, S. Gurlui, M. Brinzila, V. Vasilache, I.G. Sandu, *Evaluation of the Artificial Aging Rate Through UV Radiation Exposure of Indigenous Carbonate Rocks, Treated with Water-solvated Nano-dispersions, with the Interest of Consolidation and the Formation of a Waterproof Character,* **Revista de Chimie**, 67(12), 2016, pp. *2568-2572*

[11] V. Pelin, O. Rusu, I. Sandu, V. Vasilache, S. Gurlui, A.V. Sandu, M.M. Cazacu, I.G. Sandu, *Approaching on Colorimetric Change of Porous Calcareous Rocks Exposed in Urban Environmental Conditions from Iasi – Romania,* **IOP Conference Series-Materials Science and Engineering**, 209, 2017, art. 012080. DOI: 10.1088/1757-899X/209/1/012080

[12] M.F. La Russa, S.A. Ruffolo, M. Malagodi, D. Barca, R. Cirrincione, A. Pezzino, G.M. Crisci, D. Miriello, Petrographic, biological and chemical techniques used to characterize two tombs in the Protestant Cemetery of Rome (Italy). **Applied Physics A-Materials Science & Processing,** 100, 2010, pp. 865-872.

[13] M. F. La Russa, S. A. Ruffolo, C. M. Belfiore, P. Aloise, L. Randazzo, N. Rovella, A. Pezzino, G. Montana, Study of the effects of salt crystallization on degradation of limestone rocks. **Periodico di Mineralogia**, 82, 1, 2013, pp. 113-127.

[14] M.F. La Russa, P. Fermo, V. Comite, C.M. Belfiore, D. Barca, A. Cerioni., M. De Santis, L.F. Barbagallo, M Ricca, S.A. Ruffolo, The Oceanus statue of the Fontana di Trevi

(Rome): The analysis of black crust as a tool to investigate the urban air pollution and its impact on the stone degradation, **Science of the Total Environment**, 593-594, 2017, pp. 297-309.

[15] M. F. La Russa, G. Barone, P. Mazzoleni, A. Pezzino, V. Crupi, D. Majolino, Characterisation and differentiation of pigments employed on the facade of "Noto's Valley" monuments (Sicily), **Applied Physics A-Materials Science & Processing**, 92, 2008, pp. 185-190

[16] K. Beck, S. Janvier-Badosa, X. Brunetaud, Á. Török, M. Al-Mukhtar, Non-destructive diagnosis by colorimetry of building stone subjected to high temperatures, **European Journal of Environmental and Civil Engineering**, 20, 6, 2016, pp. 643-655, DOI: 10.1080/19648189.2015.1035804.

[17] A. Macchia, M. Laurenzi Tabasso, A. M. Salvi, M. P. Sammartino, S. Mangialardo, P. Dore, P. Postorino, Analytical characterization of corrosion products of copper and its alloys on stained stone surfaces, **Surface and Interface Analysis**, 45, 7, 2013, pp. 1073–1080.

[18] * * *, "Rome, Italy; U.S. Embassy Chancery; Palazzo Margherita and Twin Villas" (PDF). **US Department of State, Bureau of Overseas Building Operations,** 2010, Retrieved 2017-08-16.

[19] V. Heras Barros, A. Wijffels Cardoso, A. Vandesande, M. Santana Quintero J. Van Orshoven, T. Steenberghen, K. Van Balen, A Value-Based Monitoring System to Support Heritage Conservation Planning., **Journal of Cultural Heritage Management and Sustainable Development**, 3 (2), 2013, pp. 130-147.

[20] C.V. Manfredi, L'opera di Gaetano Koch architetto di Roma Capitale. **Costruzione e trasformazione della città**, Roma, 2015, pp. 89-99.

[21] C. Benocci, Villa Ludovisi, **Istituto Poligrafico e Zecca dello Stato**, Roma 2010, pp. 299.

[22] F. Giovannetti, 'La sistemazione di Piazza Colonna', in **Architettura e urbanistica. Uso e trasformazione della città storica**, Roma, settembre-novembre 1984, pp. 379-405.

[23] V. Brunori, **Art evening at palazzo Margherita**. A walk through the history and art collection of the Embassy of the United States of America in Rome / Serata d'arte a palazzo Margherita. Una passeggiata attraverso la storia e la collezione d'arte dell'Ambasciata degli Stati Uniti d'America a Roma 2002.

Received: December 7, 2019
Accepted: February 25, 2020