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THE *DOMUS* OF *OCTAVIUS QUARTIO* IN POMPEII: DAMAGE DIAGNOSIS OF THE MASONRIES AND FRESCOED SURFACES

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Abstract

Domus of Octavius Quartio occupies the entire insula 2 of Region II in Pompeii, representing one of the most important village of this archaeological site. An interdisciplinary approach has been adopted in order to plan conservative, preventive and restoration actions aimed at the requalification of Pompeii within the frame of "Grande Progetto Pompei" program. 3D Laser scanner surveys and damage diagnosis following Fitzner's method were carried out. The identification and description of weathering forms was carried out using ICOMOS-ISCS and NorMaL 1/88 recommendations, readapted and reinterpreted also for frescoes. Ten different weathering forms were identified; the frescoed room and the fountain are mainly affected by fissures, convex deformations, lacuna, efflorescence, discoloration, moist areas and patinas; the surrounding wall shows back weathering due to the disaggregation of bedding mortars; moreover the blocks are interested by rounding and biological colonization (lichens). Mapping the areal distribution of weathering forms and defining the damage categories, allowed an estimation of the linear and progressive damage index. Actually, a good conservation state of frescoed room (1.5 – 2.0) and fountain (0.7 – 1.2) was identified; a definitely worse conservation state, instead, was observed in the external wall, where the highest progressive damage index value (3) was measured.

Keywords: *Pompeii; Octavio Quartio domus; Damage; Fitzner's method; Weathering forms; Mortars; Travertine.*

Introduction

The ancient town of Pompeii was buried and "preserved over time" by the eruption of Mt. Vesuvius in 79 A.D. However, this catastrophic event gave back to the future researchers an outstanding snapshot of the ancient romans' life. Most of the information and data on the ancient material culture and building technology passes through the built heritage, that needs to be preserved from a constant decay caused by weathering agents and the huge masses of tourists (more than 3.000.000 only in 2015).

To this scope the Soprintendenza Archeologica di Pompeii promoted a large conservation project called "Grande Progetto Pompei" aimed at to a complete mapping of the old town, its damage diagnosis and the restoration of the most severe situations. The present research was developed in the actions carried out within the Regio II that includes the

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Amphitheatre and the Ancient Gym but also some beautiful examples of patrician houses such as the domus of Octavius Quartio (Fig. 1).

Fig. 1. The archaeological site of Pompeii and the *domus* of *Octavius Quartio*: a) location of the insula entirely occupied by the domus of Octavius Quartio (red filling); b) perspective view of the final point cloud 3D model of the entire insula; c) 360° panoramic view of the external wall close to the gym; d) 360° panoramic view of the peristyle; e) 360° panoramic view of the garden.

The domus was investigated by means of a multi -analytical and -disciplinary survey in order to define the state of conservation of the masonries. The method here proposed started with a precise mapping by laser-scanner that provided a precise measured-base for the mapping of geomaterials, weathering forms and damage categories.

It is widely accepted that geo-lithological and decay mapping represents the first step for a quantitative evaluation of the masonry state of conservation [1-6] providing a rapid overview of the types of weathering forms and their distribution as a function of the materials and the architecture [7-12]. Nevertheless, these procedures, except for the weathering forms regulated by NorMaL 1/88 recommendation [13], were not standardised at expenses of the comparability and usability of data and methods.

Parts of these problems were solved by applying the method proposed by Fitzner and Heinrichs [14-16] that evaluates the decay in a strict quantitative way by introducing the concept of damage categories and damage index (see hereafter). The method allows to define and compare the state of conservation of different architectural portions of a monument or different monuments from the same site in order to address as satisfactorily as possible the conservation actions. Moreover, the rate of decay is also calculated by comparing the damage indices measured at different times.

The evaluation of decay of the domus of Octavio Quartio is the aim of the present paper. The masonries reflects both the building choices of the Roman age (e.g. opus reticulatum, opus incertum, multi-layer technology of the plaster) and the local geological sources for the material supplying. Actually, they were made of local stones (tephritic lavas or travertine) jointed by mortars; plasters and frescoes, whenever present, were often preserved. ICOMOS–ISCS [17] and NorMaL 1/88 [13] recommendations were followed to describe the weathering forms and were partially adjusted for the frescoed surfaces.

The present study represent an innovative and holistic approach to the Culture Heritage conservation considering the fully quantitative approach to the decay estimation inferred by a multidisciplinary approach.

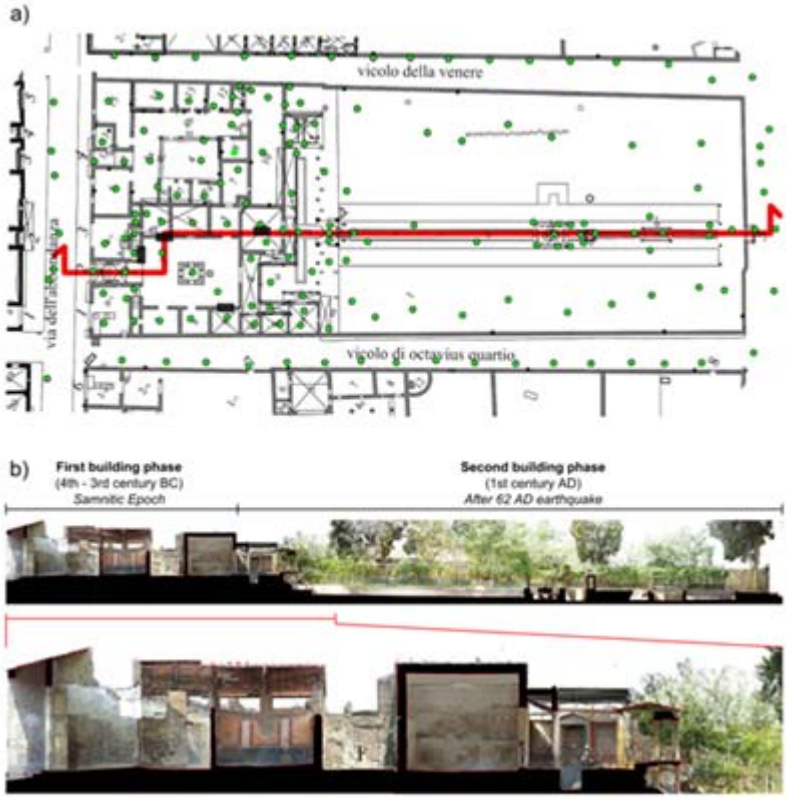

Fig. 2. The *domus* of *Octavius Quartio*: a) Plan view of the *domus* showing the scans station and the longitudinal section; b) longitudinal section reporting the two building phases of the *domus* with detailed zoom of a portion of the longitudinal section.

Archaeological background

The *domus* of *Octavius Quartio* almost entirely occupies the insula 2 of Regio II, very close to the Amphitheatre of Pompeii (Fig. 1a). In a first instance, it was erroneously attributed to *Loreius Tiburtinus* due to the presence of some election ads at the wall sides; however, the *domus* definitely belonged to *D. Octavius Quartio* as suggested by the seal-ring found in a room [18-20].

The *domus* was discovered by Vittorio Spinazzola during the excavations carried out in 1916-1921; further archaeological campaigns interested the house in 1933, 1935 and finally in 1971. The present architectural style reflects the modifications operated to the complex between the 62 AD earthquake and the 79 AD eruption; so far, it has been considered a paradigm of housing typology of the Pompeian *élite* before the catastrophic eruption. Actually, similar architectural and decorative solutions can be observed in other important aristocratic houses in Pompeii (such as “Villa dei Misteri” and “Villa di Diomede”) and in neighbouring areas [20-24].

The *domus* was built during the Middle Samnitic Epoch and for a certain period it also included the adjacent house (Fig. 2a). After the 62 AD earthquake the building and its decorations were renovated (Fig. 2b) and during these restoration works the arcaded terrace (loggia) and the large garden were likely completed.

The entrance of the *domus* faced on *Via dell'Abbondanza*, gave access to a rectangular *atrium* (Fig. 1d and 2a, room 2) centred by a marble *impluvium* then re-adapted to flowerbed with a fountain. Several rooms overlooking the *atrium* were decorated with 4th style frescoes; in the southern side a little perystyle/*viridarium* bordered by bricks columns is present, instead of the *tablinum*.

The 4th style frescoes probably made by the painter's workshop from *Via di Castricio* decorated the *cubicula* located on the western side (Fig. 2a, rooms d and e) [25-27]. On the same side an important room was also located, an *oecus* probably used as *sacellum* (Fig. 2a, room f); this is likely suggested by the painting of *Diana at bath* (south) and *the Actaeon torture* (north).

The western wall showed the painting of an Isis'celebrant (probably depicting the portrait of the owner) in the act of offering goods to the god; the paintings of this room were attributed to the *Vetii* workshop [25-27]. On the opposite side of the peristyle a *triclinium* is sited (Fig. 2a, room h, and Figs. 2b, room c, and 3a); here a beautiful and complex fresco entirely covered the walls. The fresco showed scenes from Iliad (*Funeral games in honor of Patroclus* and *Achille in his tent that welcomes Priam*) on the lower part made of imitation marble. The upper layer, instead, offered beautiful scenes from the myth of Hercules (*Hercules with the Trojan king Laomedonte*) [20].

An arcaded terrace overlooked the large garden in the southern zone of the peristyle (Fig.1e); the walls were decorated by paintings of *Orpheus with the animals* and *Venus in the shell*; herms and animal, muse, gods statuettes decorated the *euripus* (a narrow tract of water) that flowed from east to west [28].

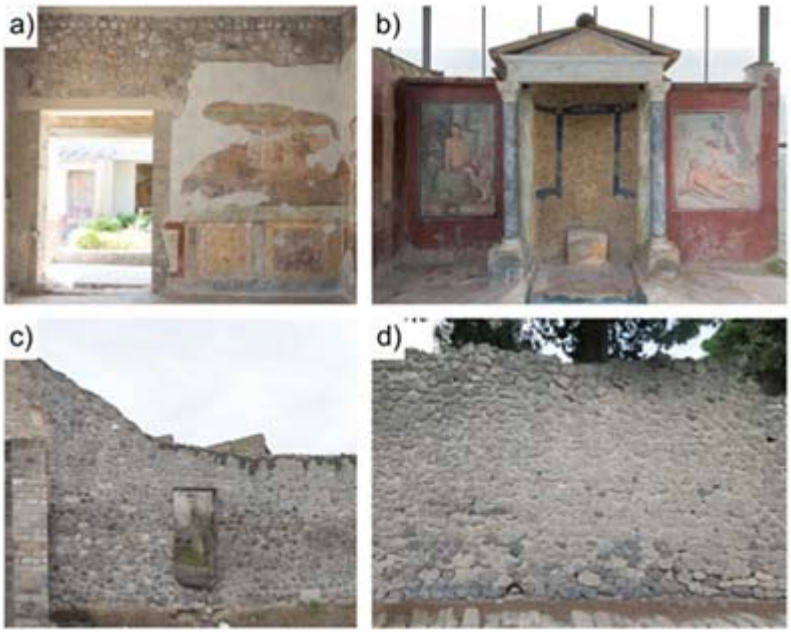

Fig. 3. Some portion of the investigated masonries by Fitzner and Heinrichs methods [14-16]; a) western wall of frescoed room h (*triclinium*); b) the aedicule with fountain; c) external wall, part 1; d) external wall, part 2.

In the westernmost side a *biclinium* (for external meals) and an aedicule adorned as a cave with gravel of travertine and a fountain (a kneeling satire) were present (Fig. 2a, room d and k'). On both sides of the aedicule, the painter *Lucius* made the frescoed surfaces *representing Narcissus looking at himself in the water* and the *Pyramus and Thisbe suicide* (Fig. 3b) as inferred by the signature *'Lucius pinxit'* [18, 20].

In the centre of the loggia another aedicule was dedicated to *Diana and* Actaeon, here the water gushed and flowed in the lower *euripus* crossing the garden from north to south [29]. In particular, in the garden the narrow channel was bordered by trees and plants and decorated by statuettes, bas-reliefs and a monumental fountain.

Worth to note is that the domus of *Octavius Quartio* has been already interested by collapses of the structures, the last episode dating back to 2011, as well as many others *domus* of Pompeii.

The *domus* covers a wide time span, as it was built during Samnitic Epoch and, after the 62 AD earthquake, underwent intense structural and architectural modifications. The most important changes concerned the peristyle and the construction of the beautiful garden with the *euripus*. The final appearance, as preserved by the 79 AD volcanics, is one of the most outstanding examples of patrician houses found in ancient Pompeii thus, suitable of great attention for conservation.

Experimental

3-D Laser scanner

A three-dimensional survey of the *insula* was performed by means of a phase-shift technology laser scanner (Faro Focus3D-X Series) with integrated camera. In order to avoid parallax errors, the integrated camera had the same nodal point of the laser emitter. This equipment has a field of data acquisition of more than 100m (range of 0.6 - 130m) and provides resolution and accuracy in the order of millimetres. Compactness and lightness of the instrument combined with the speed of acquisition of 3D points (the maximum is 976000 points/second) permitted quick campaign operations despite numerous scan stations were needed. In fact, in order to produce a detailed and reality-based 3D model of the entire *insula*, 177 scans were performed and about 60 scan stations were required for the survey of the external perimeter wall (Fig. 2a).

The choice of numbers and positions of laser stations was planned in order to create a 3D model as complete as possible without gaps of information or shadow areas. The grid of the minimum resolution of each individual scan was set with a step of 6mm (point-to-point distance) to a distance of 10 m from the scanner (usually scanner-object distance was no more than 10m). Completeness of data acquired and appropriate resolution to reconstruct all needed details, were both factors that contributed to the extraction of good quality orthoimages from the point cloud model [30].

The first step of the standard pipeline of laser scanner data post-processing is the registration of the scans in the same coordinates system. Infect each scan performed by the different station points, has a different reference system and spatial orientation, even if already represents a model in real form and size, and thus measurable.

The alignment step was performed by the different station points, those station points were aligned in the same coordinates system using high-reflective spherical targets placed in the site. This target allowed a good detection of the spherical shape from all scanning directions. In order to have same fixed point to reference the survey data of different days, precision measuring point disk was used to attach and block spheres in the same position. Subsequently, the scans were georeferenced with the support of a topographic survey. In fact, some reference targets were replaced with a specific mini prism that has the same centre of the sphere.

Furthermore, at the same time of the measurements, the integrated camera allowed to acquire also the colour data, in order to associate the corresponding RGB value at the coordinate of points (X, Y, Z). The result is a 3D point cloud model, measurable and coloured, of the entire *insula* (Fig. 1b).

Damage diagnosis

On the basis of the type and distribution of building materials, three representative locations of the *domus* were selected for the implementation of the Fitzner's method: a frescoed room (Fig. 3a), selected for the extensive presence of mural paints; the aedicule (Fig. 3b), where

more decorative elements appear; the surrounding wall on the west side of the *domus* (Fig. 3c and d). The external wall also shows all the structural elements from the Samnitic Epoch throughout the roman epoch until the modern restorations occur. Damage diagnosis of the masonries and frescoed surfaces of the *domus* of *Octavius Quartio* were carried out following the widely-accepted quantitative approach proposed by Fitzner and Heinrichs [14-16], also taking into account the presence of refined 4th style mural paints. For this purpose, an accurate mapping for a quantitative evaluation and distribution of geomaterials, weathering forms and damage categories was performed. Worth to note is that the method here proposed has never been carried out in the old town of Pompeii.

For the nomenclature and description of the weathering forms, ICOMOS-ISCS [17] and NorMaL 1/88 [13] recommendations were considered, whereas the intensity of the decay was chosen in relation to quantitative and qualitative observations, following the scheme in Table 1. Six damage categories (from 0 to 6) were determined as a function of the intensity and extent of each weathering form, as well as the structural role of the geomaterial and its aesthetic value. Furthermore, two damage indices have been determined in order to highlight the rating of the damage [16, 31]: the linear damage index (DI_{lin}) representing an average of damage categories, and the progressive damage index (DI_{prog}), that emphasises the higher ones [16, 31]. These indices range between 0 and 5, and can be calculated as follow:

$$DI_{lin} = [B + (C * 2) + (D * 3) + (E * 4) + (F * 5)]/100 \quad (1)$$

$$DI_{prog} = \sqrt{[B + (C * 4) + (D * 9) + (E * 16) + (F * 25)]/100} \quad (2)$$

Where B is the percentage area of damage category 1, C is the percentage area of damage category 2, D is the percentage area of damage category 3, E is percentage area of damage category 4 and F is percentage area of damage category 5. The extension or damage category 0 is irrelevant for the determination of damage indices.

Finally, on the products of granular disintegration of bedding mortars in the external wall and on the efflorescence salt of the frescoed room, in situ Fourier Transform Infrared Spectroscopy measurements in Attenuated Total Reflectance (ATR/FT-IR) were performed with a Bruker ALPHA-R instrument, collecting 32 scans for each sample with a resolution of 4 cm^{-1}, in the 4000-400 cm^{-1} mid-infrared range.

Table 1. Groups of weathering forms and intensity evaluation parameters

Group of weathering form	Weathering form	Parameters of classification	Intensity	
			Low	High
GROUP I. *Crack and Deformation*	Fissure	Width	<1 mm	>1 mm
	Convex deformation	Fissures	No	Yes
GROUP II. *Detachment*	Disaggregation	Cohesion	Yes	No
GROUP III. *Loss of material*	Lacuna	Depth	<3 mm	>3 mm
	Rounding	Morphology	Sub-Angular	Sub-Rounded
GROUP IV. *Discoloration and deposits*	Efflorescence	Surface coverage	Partial	Total
	Moist area	Darkness	Low	High
	Discoloration	Definition of figure	High	Low
#	Patina	Darkness	Low	High
GROUP V. *Biological colonization*	Lichen	Colour change	No	Yes

Results and Discussion

3-D Laser Scanner

The final outputs of the laser scanner survey were: a detailed points cloud model of the whole *insula* (Fig. 1b); a navigable project to display the individual scans as spherical panoramas or 3D point clouds (it is like a virtual tour among the scan stations); significant

elevation sections (Fig. 2b, represents one of these); orthoimages of the external walls and frescoed walls of the interior. The orthoimages have been extracted from the coloured model points, selecting planes of projection parallel to the walls. Selected georeferenced orthoimages with millimeter resolution were used for distribution of geomaterials and weathering forms mapping.

The final point cloud of the insula is a metric and detailed 3D model so it can be used to take measurements and study the heritage in remote mode. Therefore, there are open source web-based viewers (e.g. "potree" project) that allow the upload of the points cloud model and its on-line free exploration. Instead, the virtual tour project allows you to move from one scan station to the other, viewing the scan as an immersive 360° panorama or as a 3D point cloud. Either way, you also interact with 3D models, exchanging the exploration mode, creating a plan section, taking linear measurements, etc. The virtual tour, as the final 3D cloud, can be shared on web thus allowing its fruition for any user.

These techniques of web visualization of digital models and their related products (e.g. orthoimages, graphic elaborations, perspective view, video, virtual tour, etc.) are used for dissemination and divulgation purposes, allowing to interesting and fascinate the viewer. In the orthoimage (detail in Fig. 2b) is possible to recognise the three levels of the *triclinium* fresco: 1) the marble false imitation on the lower part, 2) scenes from Iliad above this and 3) scenes from the Hercules myth on the upper layer [2]. In the same orthoimage are also visible the frescos on the two sides of the aedicule that represent Narcissus and the Pyramus and Thisbe suicide. Graphic elaboration and digital representation, extracted from the 3D model, help to understand form and structure of the archaeological site and allow reproducing the real scene and its 'atmosphere'.

Nevertheless, reality based survey and digital models are the first step to develop more complex application of Virtual and/or Augmented Reality that are increasingly used for the promotion of cultural heritage.

Damage diagnosis

As far as the frescoed room is concerned (Fig. 3a - examined area: 74.4m^2) it was almost entirely covered by frescoes mural painting and mortars from the restoration, except in southern and western walls (Table 2; Fig. 5a) where travertine and bedding mortar masonries could be observed.

In this room, six individual weathering forms were identified (Table 3; Fig. 5b). Being the walls originally frescoed, the gaps were considered as *lacunae*. This type of weathering form was the most representative for this room and reaching the higher intensity and extension on the northern wall (Table 3; Fig. 5b). Convex deformations and fissures were usually ascribed to rising damp of salt solutions as suggested by the presence of moist areas and efflorescence phenomena observed along the margins and at the base of the walls.

In situ ATR/FT-IR measurements (Fig. 4a) [32-33] demonstrated that the efflorescence was mainly constituted by thenardite ($NaSO_4$). This saline compound represents, along with other magnesium and sodium sulphates, one of the most dangerous salts affecting the durability of building materials [12, 34]. Furthermore, frequent discoloration phenomena compromising the aesthetic value of frescoes were observed (Table 3; Fig. 4c).

Data of damage categories (Table 4; Fig. 4c) generally highlighted a good state of conservation for the room h', except for the eastern wall where damage indices reached 2.2 D_{lin} and 2.5 D_{prog} value, respectively.

The *aedicule* with the fountain (Fig. 3b - examined area: 7.7m^2) showed a wider and more selected variety of geomaterials (Table 2; Fig. 6a). The internal surface of the votive *aedicula* was covered by travertine fragments (with a diameter of about 10cm) and green/blue glass mosaic *tesserae*. Others geomaterials observed were white marble for the *capitella*, alabaster for tympanum, black marble for the columns and bricks on the top of the *aedicula*.

The weathering forms here observed were convex deformations, fissures and *lacunae* (Table 3; Fig. 6b), as well as minor *patinae* on the marbles. Although the overlapping of different weathering forms gave back some minor areas with damage categories 4 and 5 (Table 4; Fig. 6c), the damage indices were relatively low, 0.7 D_{lin} and 1.5 D_{prog}, respectively. Nevertheless, the discrepancy between the two indices is due to the fact that D_{prog} emphasises the weight of higher damage categories in the calculation [16].

Table 2. Quantitative results of geomaterials distribution for the three selected rooms.

Room	Frescoed room				Fountain	External wall	
						Part 1	Part 2
Wall side	East	Nord	West	South	East	West	West
Restoration mortar	40.7	62.9	18.1	12.4	4.8		
Fresco	59.3	30.8	37.7	34.1	56.8		
Brick					1.7	0.3	0.1
Marble					10.4		
Travertine		3.1	19.4	21.7	21.8	11.0	57.3
Tephritic lava		0.1	0.5	0.5		41.1	3.4
Plaster			1.6	2.4	1.3	0.5	3.6
Tuff			7.7	9		4.0	
Bedding mortar		3.1	12.3	16.5		42.2	35.6
Cement			2.7	3.4		0.9	
Mosaic					3.2		
TOT (%)	100	100	100	100	100	100	100

Table 3. Quantitative analysis of the weathering forms and their distribution as a function of the intensity for each wall of the three selected rooms.

Room			Frescoed room				Fountain	External wall	
								Part 1	Part 2
Wall side			East	Nord	West	South	East	West	West
Group	*Weathering form*	*Intensity*	**%**	**%**	**%**	**%**	**%**	**%**	**%**
I	Convex deformation	Low	11.0	2.6	6.3				
		High	12.9	3.8	4.7	7.5	9.1		
	Fissure	Low	23.8	14.1	4.8	7.5	16.6		
		High			1.9				
II	Disaggregation	Low							
		High						12.7	35.7
III	Lacuna	Low	1.2	5.2		2.0	5.0		
		High	40.7	62.9	18.1	12.4	8.0		
	Rounding	Low							
		High						9.3	
IV	Efflorescence	Low	7.1	6.3	11.8	11.5			
		High							
	Moist area	Low	4.0	9.7					
		High	8.3	2.4		0.2		4.5	
	Discoloration	Low							
		High	14.4	1.1	11.3	6.9			
	Patina	Low					0.4		
		High					1.7	9.5	
V	Lichen	Low						1.3	11.3
		High							
	Damaged surface	*%*	70.6	93.4	52.3	39.2	31.7	37.2	47.0
	Undamaged surface	*%*	29.4	6.6	47.7	60.8	68.3	62.8	53.0

Travertine and tephritic lava blocks jointed with mortar formed the external wall (Figs. 3c and d - examined area: 266.5 m^2). However, the distribution of geomaterials (Table 2; Figs. 7a and 8a) and the textural properties of the bedding mortars [35] allowed distinguishing two different parts of the wall. In the first part (alongside the rooms a_{-1}, b_{-1}, 4, a, b, d, e, f, m; Fig. 2a) the masonry was formed mainly by leucite-bearing tephritic lava blocks jointed by cohesive grey mortar made with abundant volcanic and cocciopesto aggregates. On the other hand, in the second part of the wall the travertine was prevalent and the bedding mortars were yellowish, friable and frequent unmixed white lumps occurred [24, 36].

These lumps are usually referred in literature as defects in the preparation of mortar and could suggest the presence of pozzolanic raw materials that reduce the setting time of mortar hindering a complete mixing of the components [24]. In the entire external wall, minor amount of bricks and tuff (original and modern), as well as some beams of modern cement, were found within relict portions of plasters (Table 2; Fig. 7a).

Table 4. Damage categories and indices.

Room	Frescoed room				Fountain	External wall	
						Part 1	Part 2
Wall side	East	Nord	West	South	East	West	West
Damage Category	**%**	**%**	**%**	**%**	**%**	**%**	**%**
0	3.8	7.5	47.5	56.9	72.7	62.8	53.1
1	29.3	62.9	18.1	23	8.1	15.2	11.3
2	33.1	20.4	21.3	13.9	3.3	12.7	
3	18.2	5.6	6.4	0.3	6.9	9.3	
4	9.8	3.6	6.7	6.0	8.2		
5	5.8				0.9		35.6
TOT	100	100	100	100	100	100	100
D_{lin}	2.2	1.3	1.1	0.8	0.7	0.7	1.9
D_{prog}	2.5	1.6	1.6	1.3	1.5	1.2	3.0

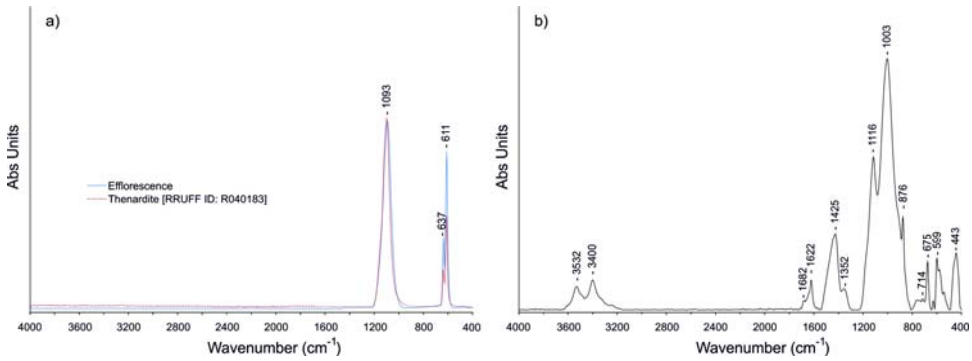

Fig. 4. ATR/FT-IR spectrum of: a) efflorescence products of frescoed room compared to thenardite IR spectra; b) bedding mortar from the part 2 of the external wall.

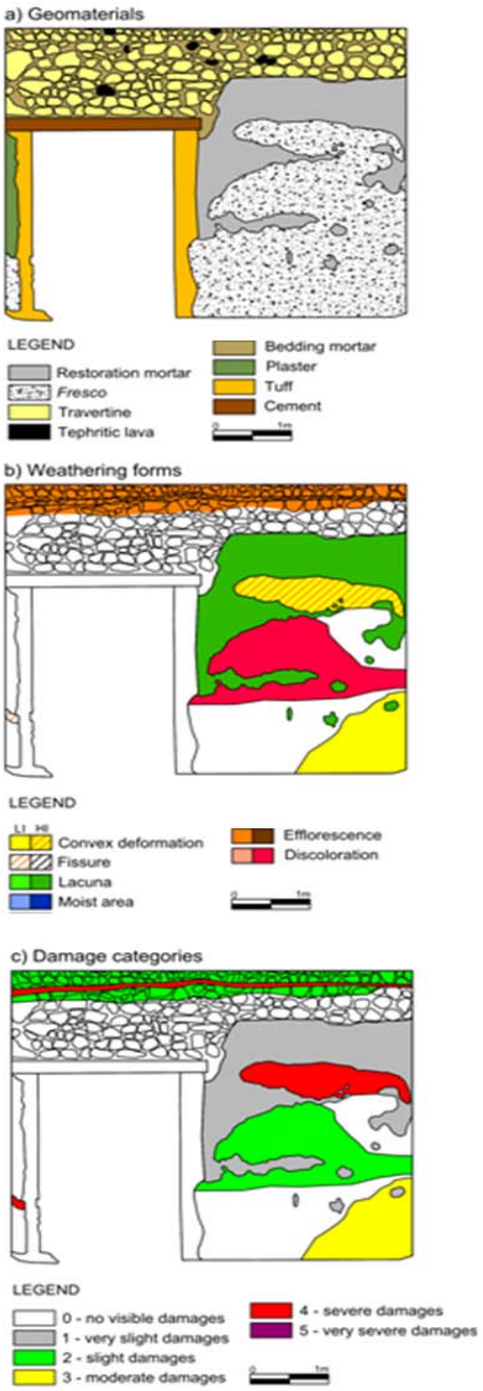

Fig. 5. Damage diagnosis of the western wall of frescoed room h (*triclinium*): a) geomaterials (lithological mapping); b) weathering forms and related intensities (HI = High Intensity, LI = Low Intensity; c) damage categories and decay evaluation.

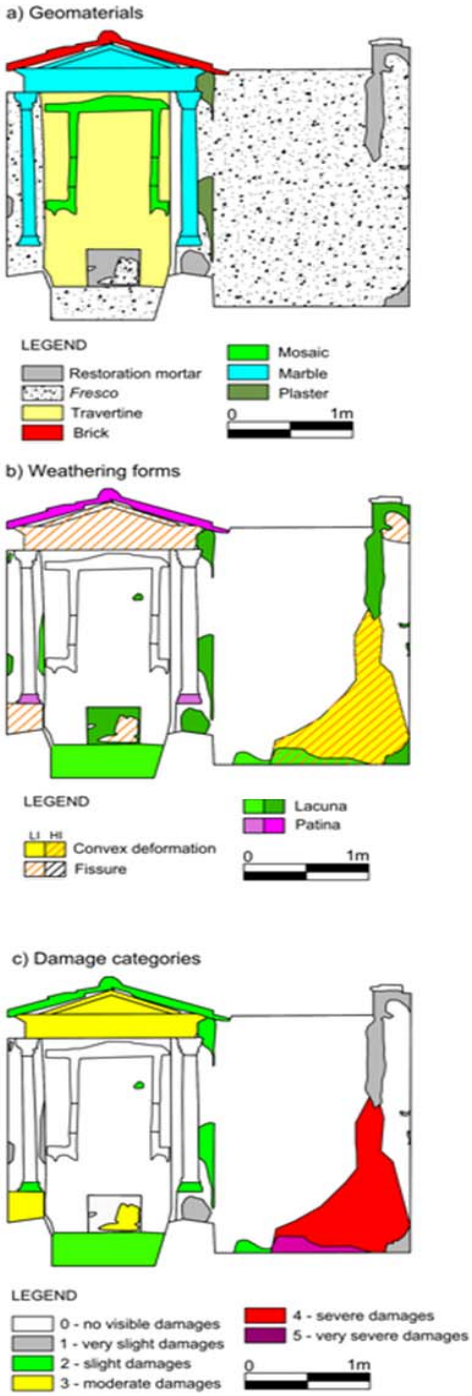

Fig. 6. Damage diagnosis of the aedicule with fountain: a) geomaterials (lithological mapping); b) weathering forms and related intensities (HI = High Intensity, LI = Low Intensity; c) damage categories and decay evaluation.

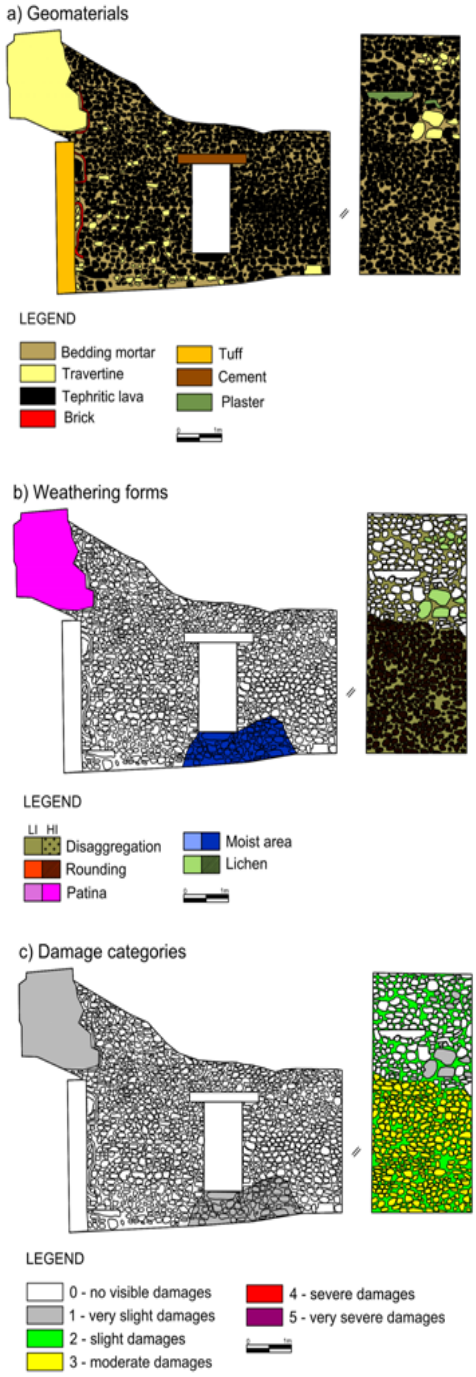

Fig. 7. Damage diagnosis of external wall, part 1: a) geomaterials (lithological mapping); b) weathering forms and related intensities (HI = High Intensity, LI = Low Intensity; c) damage categories and decay evaluation.

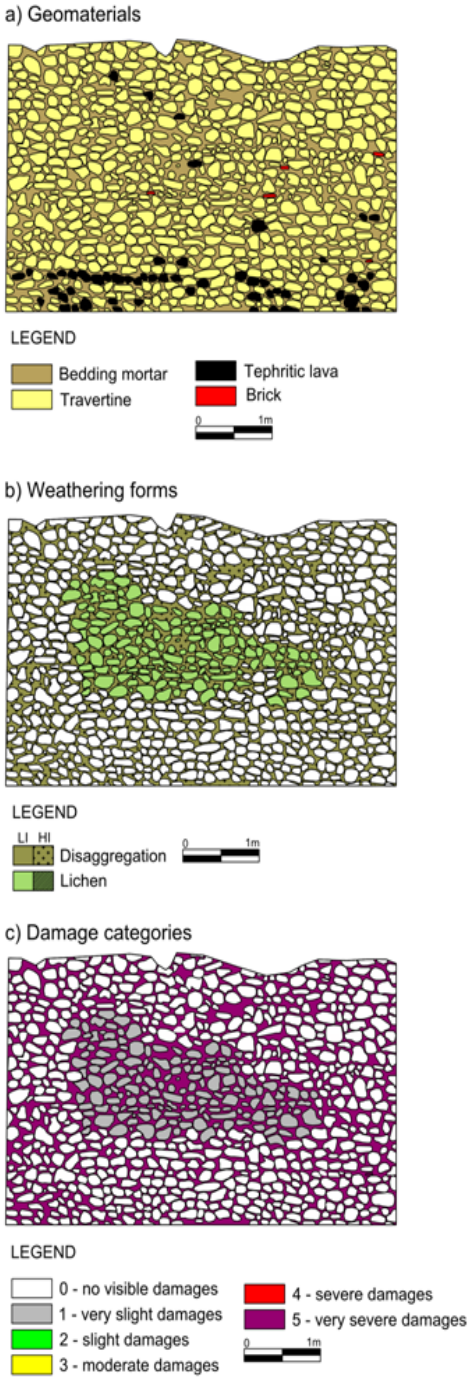

Fig. 8. Damage diagnosis of external wall, part 2: a) geomaterials (lithological mapping); b) weathering forms and related intensities (HI = High Intensity, LI = Low Intensity; c) damage categories and decay evaluation.

The different types of geomaterials and their different distribution in the two parts of the external wall unavoidably influenced the conservation state of the masonry. In facts, in a portion of the external wall, a slight and localised concave-parallel back weathering of bedding mortar was noted probably due to a granular disaggregation (Table 3; Fig 7b). This pathology was accompanied by a rounding of tephritic lava blocks, as well as other less extended and less intense weathering forms, such as: patinae on travertine, biological colonisations (lichens) and moist areas (Table 3; Fig 7b).

A deeper disaggregation affecting the bedding mortar in another portion of the external wall (Table 3; Fig. 8b) defines a severe damage for this surface. In situ ATR/FTIR measurements performed on the products of granular disaggregation of bedding mortars showed the constant presence of calcite and silicate phases, as well as the presence of gypsum (Fig. 4b). Calcite was witnessed by the bands around 1425cm^{-1} (asymmetric stretching of C-O) as well as by bands at 876 and 713cm^{-1} (out-of-plane and in-plane vibrations) [37]. The bands at 1003 cm^{-1} and 443cm^{-1} were related to bending and stretching in SiO_4 tetrahedra of silicates. The bands at 3532, 3400, 1682, 1622, 1116, 675 and 599cm^{-1} indicate the presence of gypsum [33, 37] likely due to sulfation phenomena [34, 37] justifying the friability of mortar in this sector of the wall.

Taking into the account the structural role of bedding mortar in a masonry, this weathering form has been precautionary classified as a damage category 5 (Table 4; Fig. 8c) thus, the high value of damage indices (1.9 D_{lin} and 3.0 D_{prog}) infer a urgent intervention.

Conclusions

The research here presented was a part of the "Grande Progetto Pompei" that interested the Regio II; in particular in the insula 2, the *domus* of *Octavius Quartio* was selected for the quantitative damage diagnosis of the masonry. This study concerning conservation and valorisation accounted for a multi-disciplinary fully quantitative approach involving archaeologists, historians, engineers and geologists.

The laser-scanner survey provided an accurate and precise base for lithological and damage mapping, moreover, the huge amount of acquired data and their high feasibility are suitable for remote measurements and valorisation by open source web-based view (e.g. virtual tours).

The building materials strictly reflected the local availability; tephritic lavas and travertine (Calcare del Sarno) are the most used followed by tuffs and marbles. The mortar-based materials mostly hark back to the ancient Roman technology; bedding mortars contained abundant pozzolanic materials (volcanics and *cocciopesto*) whereas the plasters inferred an accurate multi-layer technology necessary to provide a correct support to the frescoes.
The frescoed surfaces covered large portions of the masonries; made by different workshops in the 4th Pompeian style they confirm the importance of the *domus*.

As far as the state of conservation is concerned, the frescoed surfaces were interested by large *lacunae*, nevertheless, the previous restoration acted as a good consolidation of the existing parts. More problems were observed in the lower parts of the frescoed surfaces; actually, the water uptake causes convex deformation sometimes evolving in fractures; moreover, the water circulation favoured the thenardite deposition that caused the efflorescence phenomena.

The present study highlighted the importance of the mortar-based materials in the stability of the masonries. Different types of bedding mortars were observed showing at the same time, different state of conservation. Particularly, the bedding mortars in their original recipe (abundant volcanics plus *cocciopesto* aggregate) maintained their cohesion and adherence features. These properties were noticed in the bedding mortars of the internal walls and in the part 1 of the external wall; conversely moving southwards along the external wall on *Octavio Quartio* alley the properties of the bedding mortars get worse. This is due to a different recipe probably used for the restoration mortars that resulted in a low-cohesive material, as testified by the occurrence of frequent unmixed lumps due to the lack of a correct amount of aggregate.

As far as the stone elements of the walls (lavas and travertine) and the valuable parts of the aedicule are concerned, the state of conservation was quite good since they are affected only by slight biological colonisation and patinae.

Finally, the present research is the first attempt of a quantitative evaluation of the state of conservation carried out on a patrician *domus* in the ancient town of Pompeii. Such a multi-disciplinary approach may provide a substantial improvement in view of any action finalized to the conservation and valorisation of Cultural heritage.

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