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Invasive and non-invasive analyses for knowledge and conservation of Roman wall paintings of the Villa of the Papyri in Herculaneum

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ABSTRACT

The Villa of the Papyri is one of the most imposing architectural examples of Herculaneum dated before the eruption occurred on 79 A.D. During the earliest years of the excavation of the site (18th century), the Villa has been explored through a thick network of tunnels dug into the hard bank of tuff rock. Recent excavations went on discontinuously between 1990s and 2008, until the discovery of a room located in the lower floor of the building, showing serious phenomena of colour change of some areas of the painted walls. Some dark green parts of mural paintings after volcanic mud removal became white and powdered, detaching from the plaster.

During the last restoration works a scientific approach became necessary in order to acquire detailed information about the wall painting technique and the degradation phenomena occurring in some decorative elements in the vault of the Basis Villa (a room in the lower floor of the building); it was established to perform a scientific recognition.

Integrated investigations – carried out by optical microscopy, scanning electron microscopy with X-ray microanalysis (EDS), X-ray diffractometry (XRD), ion chromatography (IC), FT-IR spectroscopy, gas chromatography mass spectrometry (GC-MS) – had primarily the goal to characterize the materials used for the realization of the these impressive wall paintings, as well as to assess their state of conservation.

A second aim of the research was to test the reliability of non-invasive analyses that are sometimes performed *in situ* to study mural paintings, like reflectance spectrometry in the visible range (vis-RS), X-ray fluorescence (ED-XRF) and micro-Raman spectroscopy, as well as imaging analyses like false colour IR (IRC) and visible induced IR luminescence (VIL).

The whole set of analyses allowed to identify a typical Vitruvian plaster with the following pigments: Egyptian blue, red and yellow ochre, goethite and hematite particles, green earth and carbon black particles.

The high content of soluble salts, which is related to the sulphur-rich water in the site located few metres above water level in the walls and floors, caused a worsening in the state of conservation of mural paintings.

1. Introduction

The Villa of the Papyri is one of the most impressive examples of architecture in Herculaneum [1,2] existing before the volcanic eruption of 79 AD. It was discovered almost by accident in April 1750 during the digging of a well. During the earliest years of excavations at Herculaneum and Pompeii (1750–1765), the villa was explored by the engineer Karl Weber through a network of tunnels dug into the hard tuff bedrock [3].

Between 1996 and 1998 [4,5], a portion of the building (about 500 square metres) located in a broad and deep excavation area, whose lowest level is actually below sea level, was brought to light. In addition, a new excavation, between November 2007 and March 2008, was carried out and an area located in the lower floor of the building (called the Northern Area) entirely covered in fresco painting and polychrome stucco was discovered [6]. At this time a portion of Villa excavated in the 1990s became the object of an important conservation project [7], also involving the Getty Conservation Institute [8]. The intervention focused mainly on the mural paintings, plasters and mosaics.

As a matter of fact most of the mural paintings excavated about ten years ago are lost or seriously compromised by phenomena of detachments of the plaster from the wall substrate. During the intervention of restoration it was observed that by removing the efflorescence on the painted surfaces, the reformation of the same takes place in a very short time.

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Fig. 1. A partial view of the Northern room in the Basis Villa with deterioration phenomena on the vault (little white squares in the upper corners and Lotus flowers on the top).

Most of the murals in the areas excavated about ten years ago are in fact lost or severely compromised by disruptive phenomena [9–13] also related to the cycles of salt crystallization.

In some of the decorative elements of the vault of the Basis Villa in Northern area (the little squares in the corners and Lotus flowers, Fig. 1) we can observe a rare deterioration phenomenon; the original dark green parts (Fig. 2a) after solid mud removal have become white, powdered and detached (Fig. 2b). In general crumbling, fracturing, detachment and efflorescences due to salt crystallization cycles interest the paintings; the yellow ochre changed its colour into red, due to the high temperatures of surfaces during the eruption.

The dark green colour of the mural paintings has been preserved during the centuries, but after the exposition to the light and the air, phenomena of colour alteration occurred.

During the most recent treatments, a diagnostic campaign was carried out to characterize materials, as well as to assess their conservation status identifying degradation products. A second aim of the research was to acquire more information about pigments and test the reliability of non-invasive analyses that are sometimes performed *in situ* to study mural paintings, including scarcely used ones like reflectance spectroscopy in the visible range (vis-RS) and imaging techniques like false colour IR (IRC) and visible induced luminescence (VIL).

The use of a multi-analytical approach, including invasive [14] as well as non-invasive exams [15], was deemed necessary in order to identify pigment materials and organic components, with the goal to obtain full data about the techniques of execution and the conservative problems, and to compare them with the specific literature about Roman mural paintings [16–18].

2. Experimental

2.1. Sampling

Restorers with the aim to study their original composition and the state of conservation have collected twenty-five micro fragments of constitutive materials and salts. The samples P2–P13, C1, and C2 were obtained from already detached fragments found in deposits; P1 sample was taken from the North-East wall in the Room D; P15 and P16 were taken from the altered areas of the vault of the northern room Basis Villa (Figs. 1–2); samples S1–S7, C3–C4 and M1 were collected using micro scalpel and brush [19]. The description of their colour, typology and location is given in Table 1.

The samples labelled with 'C' constitute the inner plaster sampled on wall coverings. The 'P' samples are fragments of wall paintings chosen as representative of the chromatic range present in the rooms (Fig. 3). The 'S' ones consist of samples of efflorescences collected from the inner plaster, mural paintings and mosaics [20].

2.2. Imaging diagnostics techniques

A macro-imaging diagnostic analysis was performed in the visible, UV and IR range, using a Sony digital camera with silicon CCD detector (5 Mpx), a removable IR blocking filter, and a resolution above 10 pixel/mm.

Visible induced luminescence (VIL) was performed in order to identify the presence and distribution of Egyptian blue pigment [21]. A white Philips LED lamp was used as excitation source to stimulate luminescence in the NIR band, whilst IR radiation was collected with an interferential 850 nm high-pass filter. False colour IR images (IRC) [22], useful to detect the distribution of some pigments like the blue ones, were carried out using a halogen lamp (1000 W) and an interferential 850 nm high-pass filter.

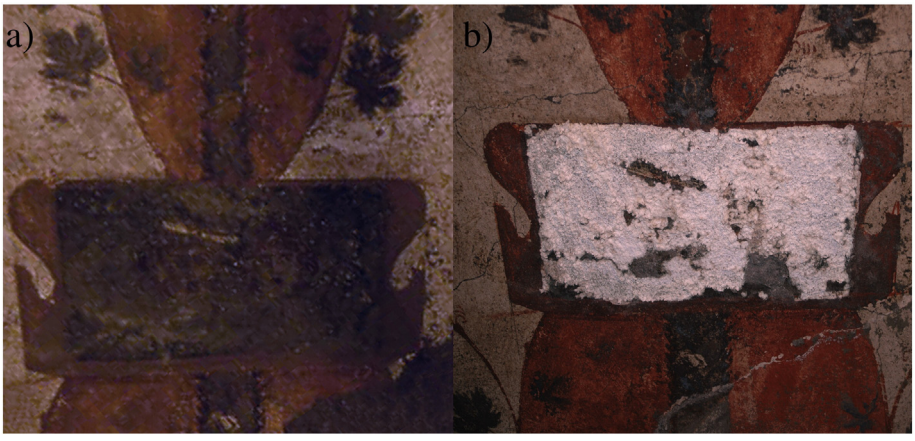

Fig. 2. a) A detail of the mural painting of Fig. 1 not yet deteriorated in 1998; b) the same element deteriorated in 2008. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)