Mid-Wave Infrared Analysis of the Wall Drawing "Saint Joseph with the Child" by Gian Lorenzo Bernini

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1 Introduction

The "Saint Joseph with the Child" is one of the most important witnesses of Gian Lorenzo Bernini's activity in Ariccia. It is a drawing made in 1663 directly on the wall inside the private family chapel of *Palazzo Chigi*. The artist's signature on the lower portion of the drawing makes it a *unicum* of Roman Baroque [1]. From the iconographic point of view, the use of the image of *Saint Joseph* holding the child is a rarity, since the baby *Jesus* is usually depicted in the arms of the Mother. The drawing is made in *sanguigna* (sanguine) and charcoal, being still unclear whether it is a finished work or the draft of an incomplete wall fresco. The importance of this Bernini's artwork led to its inclusion as one of the subjects in the measurement campaigns carried out in the framework of the ADAMO project. In particular, Near Infrared (NIR) and Short-Wave Infrared (SWIR) Reflectography and Ultraviolet (UV) Fluorescence analysis were performed in order to detect possible *pentimenti* and late retouches, respectively. Moreover, spectroscopic investigations, i.e., Fourier-Transform Infrared (FTIR) Spectroscopy, Raman, X-Ray Fluorescence

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S. Ceccarelli et al. (eds.), *Advanced Technologies for Cultural Heritage Monitoring and Conservation*, Digital Innovations in Architecture, Engineering and Construction,
https://doi.org/10.1007/978-3-031-52497-4_6

(XRF), Laser-Induced Fluorescence (LIF) Spectroscopy, were carried out to characterise the constituent materials [2]. The investigations provide clear information about the materials of this artwork, showing that the preparatory layer is composed of calcite and gypsum while the drawing by graphite, high purity hematite and, finally, charcoal to obtain the *chiaroscuro* effect. The use of the *chiaroscuro* artistic technique would seem to exclude the hypothesis that the artwork could be a preparatory drawing for a fresco [2].

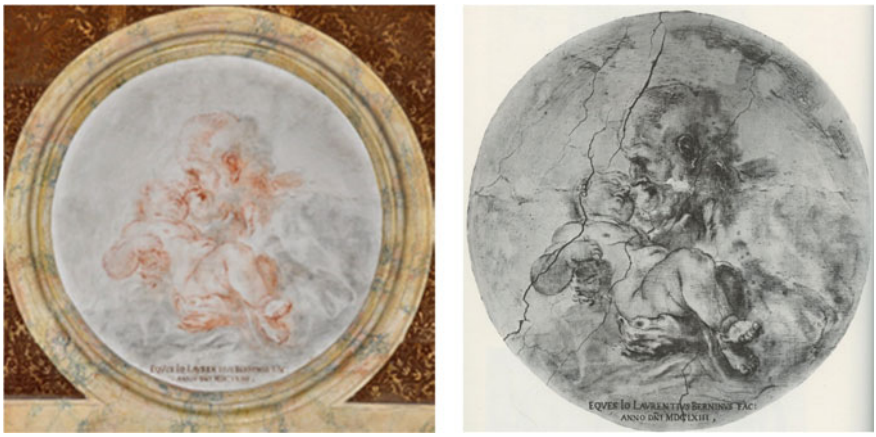
In the same framework, the three-dimensional digitalization of the artwork was obtained by using photogrammetric survey [3]. In this paper, Mid-Wave Infrared (MWIR) Reflectography and Pulsed Thermography (PT) were applied to study the "Saint Joseph with the Child" drawing to better understand the realisation technique and the support state of conservation. In recent years, these two imaging techniques, operating in MWIR spectral range (3–5 μm), have been successfully used for investigations in the field of Cultural Heritage (CH) [4–6]. In particular, PT has proven to be a valuable tool for the non-destructive inspection of subsurface elements of the artworks [7] and for measuring thermal parameters of different materials [8–13]. In the study of pictorial works, PT has been applied to detect underdrawings and graphic features in illuminations and in librarian heritage [14, 15] and paintings [16, 17]. On the other hand, MWIR reflectography (MIR) has been proposed to detect underdrawings hidden beneath the pictorial layer of illuminations and *pentimenti* [18–20]. Hereafter, the MWIR results obtained on the "Saint Joseph with the Child" will be shown for the first time. In particular, the use of PT made it possible to visualise the plastered cracks dated back to the 1998 restoration while MWIR reflectography gave insights into the nature of the constituent materials, providing a valid tool for monitoring and characterising the state of conservation of precious artworks in a non-destructive and no-contact way.

2 The "Saint Joseph with the Child" Wall Drawing

The investigated artwork is the only drawing on wall signed by the famous artist Gian Lorenzo Bernini (Fig. 1a). It represents Saint Joseph with the Child and it was completed by Bernini in 1663, as stated in the signature below, for the chapel on the first floor of the *Palazzo Chigi* in Ariccia (Rome, Italy). This is a 'mixed work' obtained by using both drawing and painting techniques, inserted in a round painted-faux-marble stucco frame of a diameter of 111,50 cm [21–23].

On the occasion of the last restoration in 1998, the artwork was restored by repairing the diagonal cracks of the plaster and other small-sized defects of the wall structure, clearly visible in old photographs (Fig. 1b).

The aim of the artwork and the meaning of its iconography are still objects of debate among scholars [24]. Although it was part of Bernini's practice to sketch his own extemporaneous intuitions in charcoal on the wall, the work has a complete and autonomous character, also thanks to the symmetrical insertion in the centre of the wall above the window of the old sacristy. However, the use of sanguine and the rough



(a) (b)

Fig. 1 Gian Lorenzo Bernini, drawing on wall, "Saint Joseph with the Child", 1663, *Palazzo Chigi*, Ariccia (Rome, Italy): **a** current aspect of the artwork; **b** image dated back to 1931

plaster on which the composition is executed do not exclude the possibility that it was a true 'sinopia' or outline for a fresco. Nevertheless, it was hypothesised that, given the surprising result obtained by Bernini, Alexander VII and the Cardinal Flavio Chigi probably asked not to change the work any further, so the artist completed his work by finishing it in white lead and mixed technique, producing to all intents and purposes an autonomous work.

3 Non-Destructive MWIR Survey

In the following sections, the PT images will be compared with MWIR reflectograms for each selected area. In particular, the drawing was entirely investigated by dividing the acquisition area into 20 framings. Thus, thermographic and reflectographic images were recorded with the same framing, ensuring a pixel-by-pixel correspondence.

3.1 Pulsed Thermography

PT is based on the monitoring of the time dependence of the emitted IR radiation in the Mid-Wave Infrared spectral range (3–5 μm) from an object after a heating induced within the sample volume by the absorption of a visible light pulsed stimulation [25].

The emitted radiation is then recorded by means of an IR camera sensitive in the MWIR range, which provides a sequence of images, called thermograms, giving

information about the temperature distribution at the sample surface and highlighting the presence of hidden elements of different nature. In fact, the presence of sub-surface features affects the heat propagation, thus providing the thermal contrast in the recorded thermograms. Therefore, the thermograms allow to distinguish features located at different depths: the larger the time-delay with respect to the light pulse, the deeper the observed features. In the present study, the thermal stimulus was induced by the absorption of the visible (Vis) light pulse provided by two flash lamps (Bowens Estime 3000, maximum power 3 kW), for approximately 2 ms. The lamps were positioned at a distance of about 0.4 m with their axes at 45° with respect to the wall. The thermographic sequences have been recorded by a Cedip JADE camera for 2 s in full frame mode with frame rate of 150 Hz.

3.2 MWIR Reflectography

MWIR reflectography has been just recently introduced in CH investigations with interesting results, extending the exploited spectral range in comparison to the well-known Near Infrared (NIR) Reflectography. In the MWIR spectral range, pigments usually have different absorption and scattering properties with respect to the ones in the NIR range. For this reason, MWIR Reflectography enables the detection of elements of different composition and located at greater depths within the artefact in comparison to those detected by the NIR Reflectography. In the reflectographic setup, the sample illumination is carried out by means of two carbon filament IR sources, positioned at about 1 m from the target and directed at 45° incidence angle, which showed an emission range corresponding to the spectral sensitivity of the employed IR camera. Special care was taken to reduce the exposure time (~0.1 s) and the power of the incident IR radiation (<100 W) to minimise the sample heating and, correspondingly, the MWIR radiation emitted by the sample. Thus, the image contrast mainly derives from local differences in the IR radiation reflected by the object layers. For MWIR reflectographic investigations, the same Cedip JADE camera and software of the PT analysis was used, thus ensuring the pixel-by-pixel correspondence of the images of the same areas recorded by the two techniques for more reliable post processing elaborations.

4 Results

In the following section, the results are presented by comparing the thermograms and the reflectograms, discussing the outcomes about materials and structural issues.

In correspondence of the Child figure (Fig. 2a), PT detects a wide and long crack, a smaller one and an area of probably past detachment of the plaster, not visible to the naked eye thanks to the restoration (red and yellow arrows, blue circle in Fig. 2b, respectively). On the other hand, MWIR Reflectography highlights the superficial

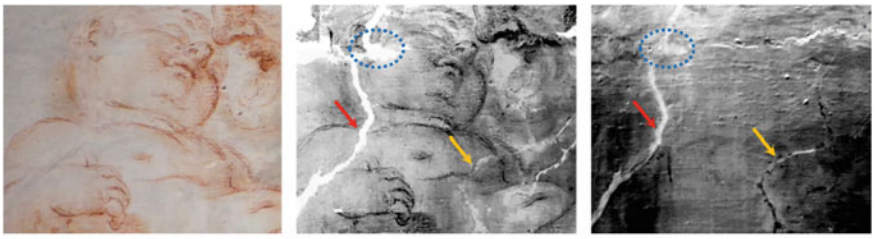


Fig. 2 **a** Detail of Fig. 1; **b** the thermogram recorded 0.6 ms after the light pulse shows the cracks and the repaired detachments (arrows and circle, respectively); **c** the MWIR reflectogram displays the relief of the same cracks of the surface

relief of the cracks and the plastered areas (red and yellow arrows, blue circle in Fig. 2c, respectively). For what concerns the drawing parts, while the thermography is able to detect the sanguine material, the Reflectography does not display the red traits of the drawing. Such spectral behaviour is consistent with the nature of the two kinds of material of the drawings: while iron-based sanguine is not visible in the reflectographic mode in this spectral range, carbon-based materials, indeed, such as the graphite, persist and are visible in MWIR reflectograms. It is worth noticing that all the drawing traits of both the materials remain visible in the PT images thanks to the contrast generated after the heating stimulus.

Similar results were obtained also in correspondence of the area of the Child feet (Fig. 3a), where the PT images detect superficial crack and small repaired detachments at short delays (red arrow and blue dashed circles in Fig. 3b) and deeper defects at larger delays (dashed arrows and blue dashed circle in Fig. 3c). MWIR reflectogram provides the in-depht extension of such defects (dashed arrows and blue dashed circle in Fig. 3d). Also in this area, the drawing traits are clearly detected only by Thermography due to the heating effects.

In the area of *Saint Joseph* face (Fig. 4a), two main elements were characterised: the geometry of the restored lacuna and the different spectral response of the red/black drawing materials. In particular, the thermogram reported in Fig. 4b shows the very contrasted drawing traits and highlights structural damage elements (a lacuna and several cracks). The close-ups of the reflectogram of *Saint Joseph* face corresponding to the forehead area (green rectangle, Fig. 4c) and eyes-nose-cheek area (yellow rectangle, Fig. 4d) allow to characterise the different materials of the artwork and the roughness of the lacuna, respectively. Indeed, the difference in composing materials of the red and the black traits is clearly visible from the reflectogram, where the arrows point to the black contouring of *Saint Joseph*'s hair, with the respect of the red traits, not visible in the MWIR reflectogram details.

The analysis of all the thermographic and reflectographic images have provided precious information on both the state of preservation and the materials of the drawing. First, the results excluded further extensions of the cracks or detachments after the last restoration, thus confirming the good conservation conditions of the

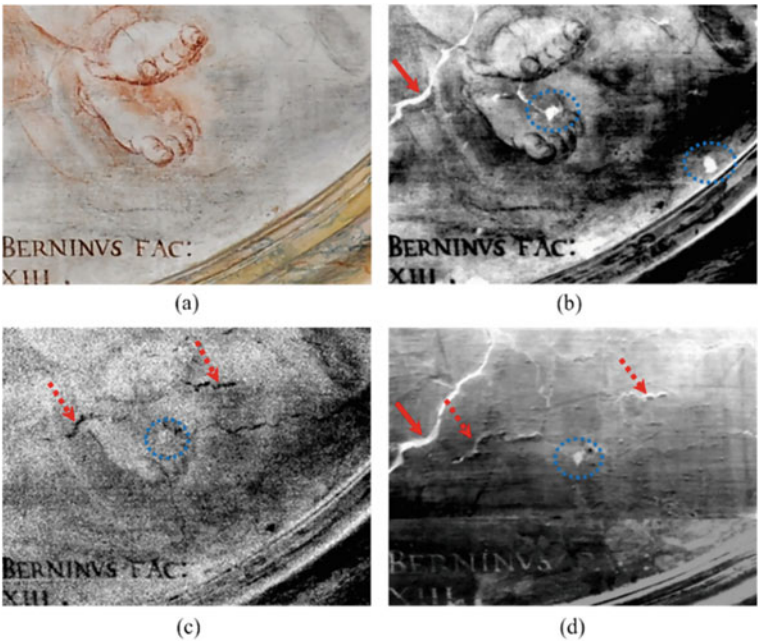


Fig. 3 **a** Detail of Fig. 1; **b** the PT image recorded just after the light pulse detects superficial crack and small repaired lacunas (red arrow and dashed circles, respectively); **c** the PT image recorded at larger delays shows deeper defects (dashed arrows and dashed circles); **d** the MWIR reflectogram provides the relief of such defects

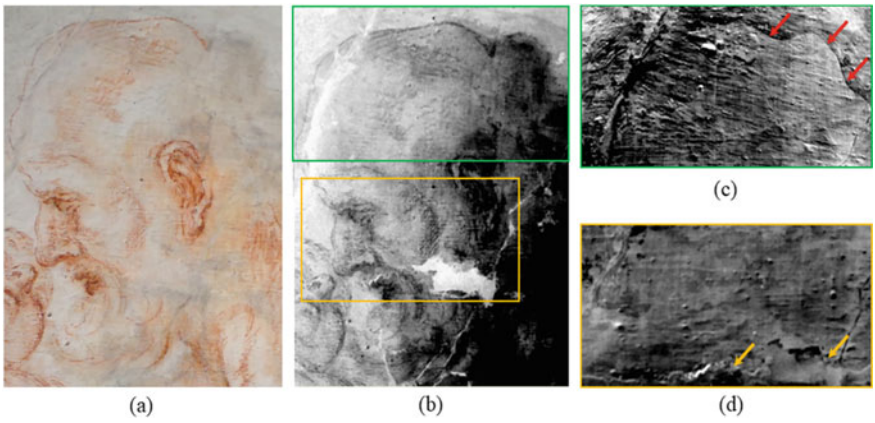


Fig. 4 **a** Detail of Fig. 1; **b** the PT image recorded just after the light pulse shows the whole drawing, also in the area of the head where the two materials are present (green rectangle), and a large and repaired lacuna in the eyes-nose-cheek area (yellow rectangle); **c**, **d** the MWIR reflectograms highlights the only charcoal traits, indicated with red arrows in (**c**), and the geometry of the lacuna, marked with yellow arrows in (**d**)

artwork. Secondly, this study also gave insights into the nature of the materials, which had the spectral behaviours typical of sanguine and graphite, denoting a choice by the author in clearly distinguishing the sections of the drawing with the different materials and the well-defined traits. Indeed, the kind of materials and the sharpness of the traits could confirm previous studies in literature that define the artwork as an accomplished work, probably originally intended as a *sinopia* for a fresco but later left in the state of a drawing with an autonomous character.

5 Conclusions

In this paper, the results obtained within the ADAMO project framework on Gian Lorenzo Bernini's "Saint Joseph and the Child" preserved at the *Palazzo Chigi* in Ariccia (Italy) have been presented. This wall drawing has been investigated for the first time by means of Pulsed Thermography and Mid-Wave Infrared Reflectography in order to characterise surface, sub-surface and structural features. Both techniques allow to obtain images in the MWIR spectral range in a non-destructive way. The complementary use of these techniques allowed to obtain some useful information on the artwork: (i) PT detected several cracks which are not visible after the restoration, the main ones at the head of the Child and Saint Joseph; (ii) MWIR Reflectography highlighted the plastered areas, in part visible by the simple optical inspection, and also shown roughness of the wall substrate; (iii) MWIR Reflectography revealed the difference between the materials used to obtain the red and black strokes, providing insight into their composition. In fact, while iron-based sanguine is not visible in the MWIR spectral range, carbon-based materials maintain their contrast. All this information enabled the evaluation of the conservative status of the restored areas, excluding the development of additional cracks with the respect of those documented before the restoration works. The results of the described analysis confirm the success of the employed techniques in monitoring, documenting and characterising a peculiar and unique artwork, in a complete non-destructive approach and without any contact, in relatively short acquisition timing, also providing a starting point for long term documentation of a unique Bernini's masterpiece.

Acknowledgements The measurements have been carried out during a PhD fellowship in the Department of Industrial Engineering of Tor Vergata University of Rome.

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