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ANTEFIXES FROM MUSEO PROVINCIALE CAMPANO IN CAPUA. A PROPOSAL FOR A VIRTUAL RECONSTRUCTION

1. Introduction

This paper aims to illustrate the results of a three-dimensional reconstructive study carried out on a group of terracotta finds preserved in the Museo Provinciale Campano of Capua (Minervini 1880; Winter 1978, 27 *et seq*.; Kästner 1984, 66-74; Koch 1912; Johannowsky 1989; Winter 1993; Rescigno 1998). The materials, architectural antefixes dated between the second quarter of the 6th century and the beginning of the 5th BC, were found in a private fund located in Curti, in the province of Caserta, during archaeological excavations started in 1845 and definitively never concluded. The excavation campaign unearthed a sanctuary, today considered one of the most famous places of worship of Capua *vetus* (Rescigno 2009, 29-40).

The studies carried out since the 20th century return a reading and a classification of these materials based on the wide tradition, sedimented on the connection between an artefact and the workshop in which it was produced and whose study cannot ignore techniques and methods through which it has been produced. Specifically, these antefixes were placed on the top of the numerous buildings that populated the sanctuary and were mass-produced inside shops by *fictores,* craftsmen that were specialized in the manufacture of terracotta.

The craftsman shaped a considerable number of prototypes, primary terracotta models from which were made matrices, moulds that bore in negative the shape of the prototype and that allowed to replicate it positively for an indefinite number of times. Sometimes the handicraftsman could choose to make different matrices by combining together parts of existing prototypes, creating antefixes similar to the original model, but different for some details of the frame, of the lath or of the central field.

This modularity, that is reflected in the more or less evident formal variations of the models, constitutes the discriminating factor for the study and identification of types and series.

The classification of these materials has been developed through an alphanumeric coding system and refers to the one already organized and illustrated by Carlo Rescigno, the scientific coordinator of the present work, in his studies about the covering systems of archaic buildings (Rescigno 1998).

The system consists in assigning a code to each series of materials, composed of a first letter that identifies the formal parameters of the finding and therefore the group; then follows a four-digit numerical module in which the first digit identifies the *protome* depicted, the second digit spots the iconography and the last two pinpoint the numbering of series (Rescigno 1998).

A further element of macroscopic classification has been added to this code, following a study program conducted at the beginning of the 2000s by the Department of Humanities and Cultural Heritage (DiLBEC) of the University of Campania Luigi Vanvitelli[1], aimed at grouping together several series having one or more formal variations, but all deriving from the same prototype.

This element, identified in the 'type of series', is marked by a letter of the alphabet and circumscribes further fundamental information in order to catalog these materials: the chronological arc in which the series ascribed to that given type have been produced.

The matrix, as a consequence of a continuous use during production, was subject to a process of attrition that began to manifest through the creation of finds that presented formal details characterized by poor sharpness, until determining the actual breaking of the matrix itself. Accordingly, the need to model a new matrix arose for the craftsman; this was done by using the *surmoulage* technique: through a prototype obtained from a matrix (*patrice*), therefore not a primary model, a new mould identical in shape to the disused one was made, but with slightly reduced dimensions (Fig. 1).

Today, dimensional variations allow us to delineate a 'genealogical' sequence in the production process of the matrices, determining a further classification of finds ascribed to a given series through a grouping by generations, identified by Roman numerals (Cuomo di Caprio 2007, 223-230).

The group of antefixes that has been chosen to be examined here is that of female heads within the nimbus, consisting of about 260 items divided into 30 series, identified by the code C3000 and in turn grouped into 15 types, from letter A to Q. To each series, a minimum of 1 and a maximum of 24 occurrences have been ascribed and a maximum of two generations have been identified. The group also includes a considerable number of non-architectural destination slabs (about 40) characterized by the absence of the roof tile, for which a votive function is likely to assume. These finds have been equally ascribed a different type of series, considering the formal analogies with architectural slabs.

2. Virtual Reality and 3D reconstruction

Commonly, we tend to identify virtual representations as illusory and imaginary realities, but virtual reality has nothing to do with illusion; it is rather a form of reality that can be artificially represented by the use of a

[1] The reconnaissance and study project of the architectural materials preserved in the Museo Provinciale Campano of Capua was coordinated by Carlo Rescigno and has led to the drafting of some thesis works, such as: Esposito Palmieri L. a.a. 2002-2003, *Le antefisse arcaiche del Museo Campano di Capua. Le serie nimbate ed entro fiore di loto a testa femminile*, Seconda Università degli Studi di Napoli, Facoltà di Lettere e Filosofia, Tesi di Laurea quadriennale; Grassia A.M. a.a. 2002-2003, *Le antefisse arcaiche del Museo Campano di Capua. Le serie nimbate a maschera gorgonica*, Seconda Università degli Studi di Napoli, Facoltà di Lettere e Filosofia, Tesi di Laurea quadriennale.

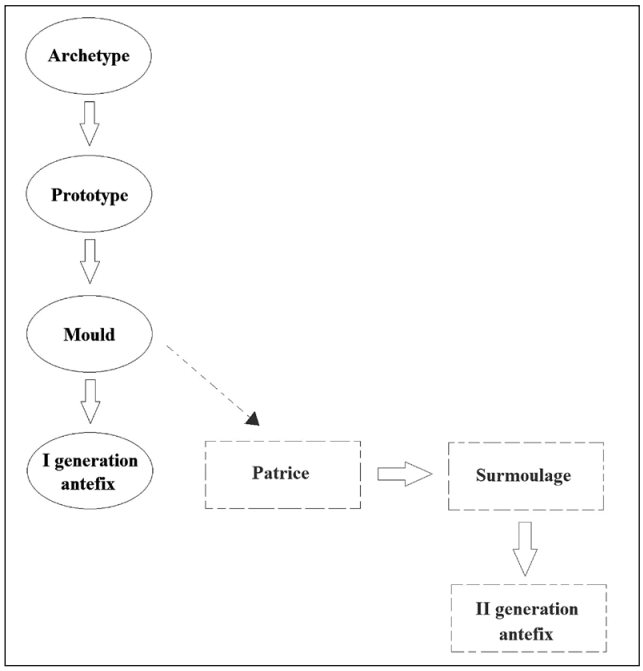

Fig. 1 – Diagram of the working process of an antefix.

computer and only through the trespassing of three physical dimensions. Far from being immaterial, it has its own consistency, made up of numerical and chromatic entities, geometric quantities and physical dimensions.

Virtual Reality in the cultural area is a method of representation complementary to Virtual Restoration, a discipline that was born in the mid-nineties with the main purpose of returning their original assets to movable or immovable property. Its aim is to optimize their accessibility and use as well as to restore values of the civilization's historical record and testimony. (Bennardi, Furferi 2007; Gabellone 2010; Limoncelli 2012).

Although every 3D restoration activity takes place in a virtual environment, it is good to remember that the methodological approach adopted by Virtual Restoring, exactly like the traditional discipline of Restoration, requires us to act on an asset in full compliance with the principles of reversibility, recognition, minimum intervention and compatibility, already codified in the Athens Charter for the Restoration of Historic Monuments, produced in 1931 (Strassoldo 2007).

When we talk about Virtual Restoration, we associate it with all those conservative interventions necessary to bring the property back to an optimal

condition of readability, without necessarily intervening on gaps and *lacuna*s, except in those cases where the lack of integration unavoidably compromises the use of the property object of the restoration.

On the other hand, when, for reasons of readability and usability or even just for the purpose of facing a mere reconstructive study, it is necessary to integrate chromatic gaps or material lack to give back its formal integrity to the property. In this case, 3D reconstruction comes into play and can be framed as a micro-area of the Virtual Restoration. It is the working modality that proposes to return to the property its formal unity, through the correspondences of data deriving from graphic models acquired through digital surveys developed in Handmade Modeling modality, Procedural modality, Laser Scanning or Photomodelling (Migliari 2001).

In the case of sculptures, and more specifically of terracotta ones, that include antefixes, the 3D reconstruction allows you to make a reinstatement of missing parts that can be reconstructed through two approaches: where the find has been preserved into a fragmentary but complete state, it is possible to work by reassembling it and correcting the presence of any cracks; where instead the fragments are not sufficient to recompose the find in full, but they contain a sufficient amount of formal data, it is possible to work by reconstructing the sculpture through a series of interpolations, always considering the philological-reconstructive principles, essential to achieve a historical restoration (Vaccari 1996).

Finally, there are areas of intervention in a virtual environment that, although they do not lead to a 3D reconstruction and often not even to a properly so called intervention, they are fundamental because they are preparatory to any restorative approach: preliminary analysis of the asset and damage assessment; neither of the two operations involves the direct approach to the property.

To evaluate the entity of the work to do, it is important to execute a precise and detailed survey that can return one or more virtual models such as to guarantee an exact calculation of the real find's physical properties: mass, surface, height, width, depth and modular measurements where needed.

On the other hand, the damage assessment operation can be performed by means of a two-dimensional survey and is externalized in an analysis, expressed as a percentage, of the gaps relating to the pictorial and material surface of the artefact (Limoncelli 2011; Gabellone 2020, 107-121).

3. Antefixes with a female head within the nimbus

The case study examined here, that will be part of a larger PhD research project aimed at reconstructing the prototypes of all the groups of archaic antefixes preserved in the Museo Provinciale Campano of Capua, consists of a virtual reconstruction of the group of antefixes with a female head within the nimbus.

For taxonomic and methodological reasons, six elements articulated in three series also converge in this analysis. Two of these series belong to the group of antefixes with a female head without frame and one is associated with the group of antefixes with a female head and straight *palmette*. The first two series, F3201 and F3203, include four antefixes with a female head without a frame modeled almost all-round with a clear Dedalic type (Koch 1912; Mingazzini 1938; Johannowsky 1989, 185; Rescigno 1998, 130-132).

The other one, series C3101, has formal elements similar to the group of antefixes with a straight *palmette,* but a female head with Dedalic kind is inscribed on a leaf (Koch 1912; Rescigno 1998, 84-85).

To complete what has been said in the previous paragraphs, the modularity and seriality used by the artisans specialized in modeling these materials are the essential characteristics that contribute to the realization of 3D reconstruction, because they offer the possibility of ideally overlapping the slabs received in a fragmentary state, until a virtual formal unit composed of elements belonging to a plurality of real finds is reached.

The first phase of the work involved the beating of about 130 three-dimensional surveys, in order to obtain virtual models of the artefacts.

The main tools of the preliminary phase of survey are two: a database that organizes and makes all information relating to materials being studied easily accessible and a Laser Scanner. As already discussed in the previous paragraph, the main techniques for carrying out a three-dimensional survey of an object are Photomodelling and Laser Scanning. The second methodology of survey was used for this study (Bernardini, Rushmeier 2000, 41-62; Peloso 2005, 219-24; Bianchini 2009).

The Laser Scanning is a digital survey technique based on the principles of reverse engineering. The scanner receives the metric data of an object in the form of an input and returns a CAD model as output (Limoncelli 2012, 134-139).

Here, a laser scanner for small objects equipped with structured light has been used. Structured light is a 3D survey technique that consists in projecting horizontal and vertical beams of light on a scene to calculate its depth and other information about the surface.

The laser beam (Light Amplification by Stimulated Emission of Radiation) is fired on the object through the interpolation of a series of four white LEDs positioned around each of the three digital cameras, one of which is a color camera that allows the beam to be reflected in all directions, useful for detecting the entire surface.

The tool used here promises a margin of error between 0.01 and 0.05 mm, guarantees the simultaneous acquisition of the texture with a resolution between 50 and 200 DPI, thanks to the presence of a projector with white light pattern, that can detect objects up to 50 cm and offers the possibility to

export the mesh instantly (Bartolucci 2009), without generating it from a point cloud. The significant number of scans realized was determined by the need to survey each element in two different moments: the front and back side.

This beating method proves to be decisive when, given the monochrome surface of the terracotta and the loss of pictorial film where chromatic variations existed, the tool cannot detect differences of volumes and therefore is unable to return an output. This method guarantees that each scan is quickly completed but requires more operation during data processing. In this case, it has been possible to reattach the two sides of each antefix through a non-automated function of Vxelements, the execution program of the Laser Scanner, but it is emphasized that it is possible to achieve the same results through any other 3D Modeling program.

The next step is to export the file in 3D format. Here, OBJ format has been used, the most compatible with Modeling software among all the existing formats. Once the meshes in OBJ format have been obtained, it is possible to proceed with the actual reconstruction of the prototypes.

3.1 *Reconstruction of fragmented antefixes*

Case study: prototype of the series C3220 (Type E, 525-500 BC) (Fig. 2).

The prototype was rebuilt on the basis of a very large amount of data, since 24 elements are attributed to the series in question, some of which have been preserved in their material surface in a percentage higher than 50%. Reconstruction was realized from finds models nos. 100/029, 100/015 and 100/190, which was fragmented into four mating parts and was reconstructed into a unitary model. Other examples of similar cases of elements recovered fragmented and reconstructed are nos. 100/030, 100/059, 100/199. The reattachment of the fragments was realized through a manual geometric processing technique, the Polygonal Modeling that acts through the manipulation of vertices and faces of the mesh in order to obtain complex surfaces that are then combined through Boolean unions.

All the reconstructions have been carried out exploiting the combined use of 3D Modeling programs: Maya, Rhinoceros, Meshlab and Autodesk Meshmixer (Rocchini *et al.* 2001; Limoncelli 2012, 131-139).

3.2 *Two variants of prototype reconstruction*

Case study: prototype of the series C3202 (Type C; 550-540 BC) (Fig. 3).

This case is the example of reconstruction of a series prototype that has at least two variants, that differ from each other for some details, a sign that the craftsman has used the same matrix to create the central field of all the slabs of the series, but he has modulated from time to time different matrices for laths, frames and a nimbus.

Fig. 2 – Series C3220 - Starting models and prototype reconstruction.

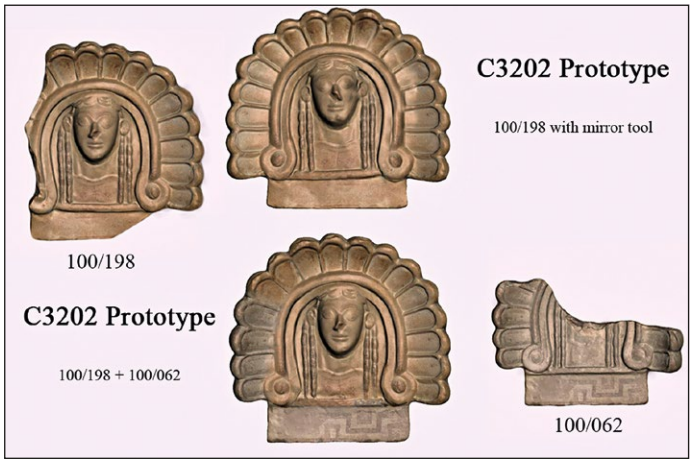

Fig. 3 – Series C3202 - Starting models and two variants of prototype reconstruction.

The first prototype reconstruction was realized starting from the union of the finds nos. 100/198 and 100/062 and has a 16-leaf nimbus and the lath obtained from the find no. 100/062, taller and wider (tot. ht. 32.5 cm; tot. w. 34 cm; ht. lath 5.6 cm; w. lath 22.7 cm); the second prototype reconstruction, on the other hand, was carried out through one of the most common

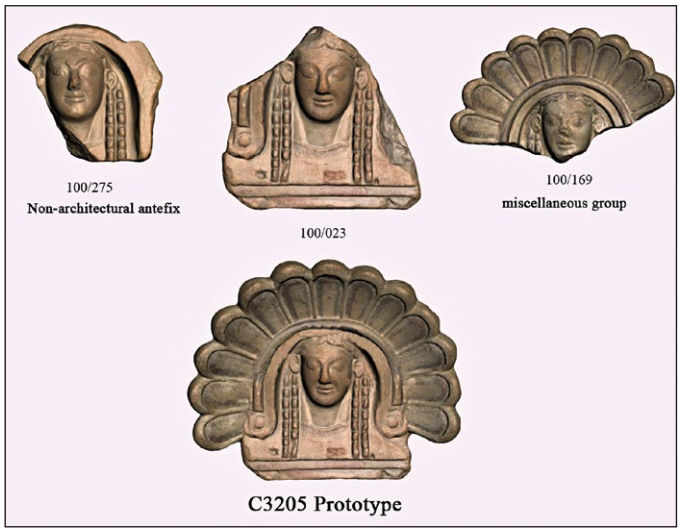

Fig. 4 – Series C3205 – Starting models and prototype reconstruction.

techniques of Polygonal Modeling, the mirroring of single find no. 100/198. Prototype has a 17-leaf nimbus and a lower and narrower lath, that determines a lower height of the entire slab (tot. ht. 31.9 cm; tot. w. 34 cm; ht. lath 5 cm; w. lath 21.7 cm).

3.3 *Reconstruction through non-architectural antefixes*

Case study: prototype of the series C3205 (Type C; 550-540 BC) (Fig. 4).

This reconstruction differs from the previous ones because it has been made through the modulation of three finds, two of which are not strictly attributable to the series C3205, but one of these is included in the group of non-architectural antefixes relating to the series C3205 and the other one is part of a miscellaneous collection of antefixes that present formal characteristics similar to the whole Type C, but, for reasons generally linked to the non-optimal state of conservation or to the small size of the fragment, it has not been possible to ascribe them exactly to a series.

3.4 *Reconstruction of II generation prototypes*

Case study: prototype of the series C3214 (Type H; 500-480 BC) (Fig. 5).

The case analyzed below, intends to illustrate the reconstruction of II generation series prototype, therefore undersized compared to the other elements ascribed to the same series that did not save sufficient formal data to reconstruct the I generation prototype.

Fig. 5 – Series C3214 – Starting model, prototype reconstruction and 3D modelling phases.

To reconstruct the *protome*, the frame and the nimbus of leaves, slab no. 100/235 was used, almost fully preserved, except for part of the lath; to rebuild it, slab no. 100/235 was modeled together with slab no. 100/064. It is emphasized that find no. 100/235 belongs to the group of non-architectural antefixes of the Type H. For this reason, the roof tile was reconstructed through the mirroring of the one saved on the back of the antefix no. 100/064.

The image (Fig. 6) illustrates an example of a generational gap that materializes in a reduction of dimensions between I and II generation slab: the ι module (distance between eyes) has a 0.6 cm size gap, while the η module (distance between the hairline and the chin) differs by 1 cm.

Another example of II generation prototype reconstruction is that of the one relating to the series C3219, reconstructed through the modeling of finds nos. 100/199 (preserved in a fragmented state and previously reconstructed) and 100/043.

Fig. 6 – I and II generation finds: comparison of models and modules.

3.5 *Partial prototype reconstruction*

Case study: prototype of series C3101 (Type B; 560-550 BC) (Fig. 7).

The case in the figure is an example of reconstruction prototypes of series that count only one occurrence, therefore there is not enough data to be able to obtain a complete formal reconstruction. On this prototype a reconstruction work was advanced just based on the data obtained from the find no. 100/038. Through the use of Polygonal Modeling tools, such as mirroring, duplication of the mesh and cutting planes, the rectangular section belt and a leaf of the nimbus were reconstructed.

Prototypes of series C3207 (Type E; 525-500 BC), series C3208 (Type E; 525-500 BC), C 3215 (Type I; end of V BC), series C3218 (Type C; 550-540 BC), series C3221 (Type E; 525-500 BC), series C 3223 (Type I; end of VI BC) (Fig. 8):

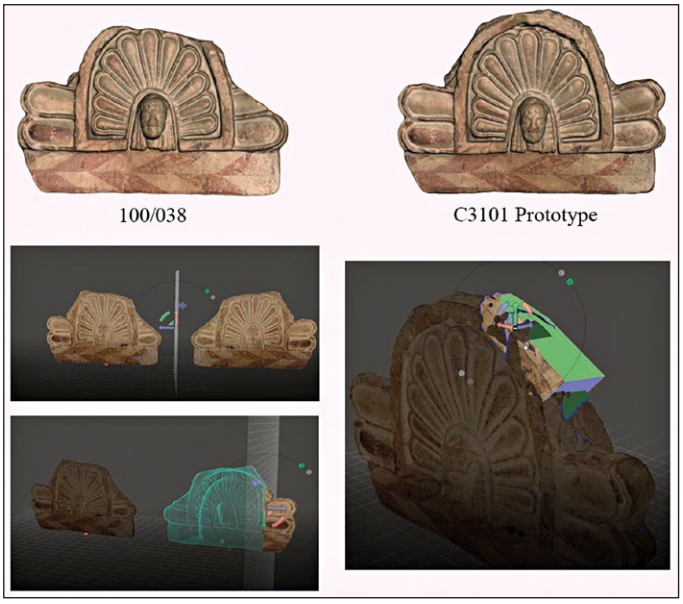

Fig. 7 – Partial prototype reconstruction and 3D modelling phases.

Fig. 8 – Prospect of examples of partially reconstructed prototypes.

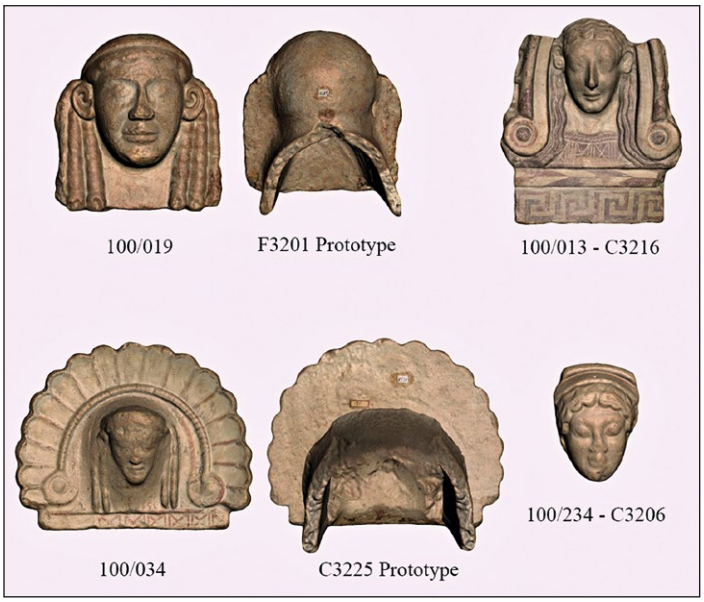

Fig. 9 – Examples of whole finds and non-reconstructable prototypes.

The image summarizes other cases of partial reconstruction of prototypes of series to whom is attributed a single find.

3.6 *Whole finds and non-reconstructable prototypes*

Case studies: prototype of series F3201 (Type A; 575-550 BC), C3225 (Type M; uncertain chronological arc), C3216 (Type I; end of VI BC), C3206 (Type D; 530 BC approx.) (Fig. 9).

The figure shows two cases of prototypes that cannot be reconstructed (no. 100/013 – series C3216 and no. 100/234 – series C3206) as they are related to series for each of which a single fragment of reduced size has been saved or, as in the case of slab no. 100/013, as they are in a conservative state that does not allow satisfactory reconstructive studies. Then, following cases of finds preserved in full, that do not require any formal reconstruction, but that can instead be used for a reconstructive work of the pictorial film, through cleaning of any accumulations of *patinas* or non-original grouting, optimization of the texture and integration of possible gaps (Limoncelli 2012, 51-89). Find no. 100/034 should also be noted, which has been saved intact except for the horseshoe-shaped roof tile, that was instead modeled based on the information obtained from roof tiles preserved intact within the same type.

4. Conclusions

The methodological approach used to develop series prototypes of these antefixes, based on analogical-comparative criteria, would seem to guarantee convincing results as it regards classes of mass-produced ceramic materials, although the work is still nearing completion and therefore remains subject to improvements and modifications.

However, it remains to be considered that this kind of production is not always characterized by criteria of absolute symmetry as it regards parts that make up the single find, which sometimes makes it necessary to create more than one reconstructive proposal for the same prototype, in order to bring with absolute certainty, among the possible hypotheses the intention of the craftsman too.

It is considerable above all other example cases, the one relating to nimbus leaves: they never appear identical in terms of width and thickness and sometimes even in odd quantities, which often makes it difficult to identify the exact number of leaves, subject to variations among the finds belonging to the same series.

Therefore, as we have already had the opportunity to analyze, even that analogical-comparative criterion existing between finds belonging to the same series, may sometimes not be present, leaving room for a variety of details that make slabs similar but not identical. In this case it is possible to resort to the realization of several reconstructive hypotheses too. The work on this group of 260 finds that are articulated into 30 series has allowed us to realize a total prototype 3D reconstruction for 10 series and to achieve a partial result for 11 prototypes[2]. About the remaining series, finds have been preserved in a far too fragmentary state of conservation (often only the female head has reached us) to be able to put forward any reconstructive hypothesis that has a scientific basis.

As already anticipated, the 3D survey of the slabs was developed by working in two different moments on the two faces of each find, which entailed the need to carry out 152 scans in order to obtain the 3D models of 76 antefixes. This mass of data, consisting of both models taken from originals and prototype 3D reconstructions, will give rise to a unitary virtual *corpus* of architectural materials preserved in the Museo Provinciale Campano of Capua.

This digital repertoire, cataloged on the basis of the methodological criteria that contribute to the study and classification of serial productions, will flow into a platform that allows the sharing of the data collected and those

[2] It is emphasized that this work will flow into a unitary study still in progress that analyzes further groups of antefixes preserved at the Museo Provinciale Campano of Capua, which makes it liable to implementations and adjustments.

obtained through 3D modeling, becoming a tool for scientific publication, knowledge, study, but also for monitoring, conservation and protection, in order to contribute to the implementation of the sector of experimentation with new forms of documentation and Cultural Heritage editions.

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ABSTRACT

The paper aims to illustrate an intervention of digital restoration carried out on different groups of antefixes coming from excavations started in 1845 in a private fund today located in Curti, near Caserta and pertaining to sacred building roofs of a sanctuary whose oldest phase is dated to the 6th century BC. Nowadays, finds are preserved in the Museo Provinciale Campano, located in Capua. Particularly, two hundred and fifty antefixes belonging to the group named 'female heads within the nimbus', have been studied, articulated into thirty different series, filed in a database created *ad hoc*, and the digital restoration of their prototypes has been completed. Issues relating to seriality and traceability of these finds to individual archetypes will be explored, features that make a faithful 3D reconstruction of a prototype possible, based on the combination of physical data of fragmented antefixes pertaining to each series. Furthermore, phases and techniques of detection and scanning of an archaeological find using a laser scanner for small objects will be particularly analyzed. It will show how to achieve a mesh from a scanning file and how to elaborate it. Lastly, processing steps necessary to the realization of a 3D restoration will be illustrated through modeling techniques and collation of different 3D scannings. These kinds of technological experimentations contribute to diversify our memory transmission modes. They offer the chance to create digital and implementable catalogs, useful for a dynamic documentation of the Archaeological Heritage, but also and above all, fundamental tools for the monitoring, conservation and fruition of analyzed *corpora*.