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Research

A Puzzling Set of Stucco Coffers from Portici: Archaeology and Mathematics Working Together

Abstract. Archaeology and mathematics work together to reconstruct the form and dimensions of a vault originally adorned with a set of twenty-five stucco coffers in the shape of concave octagons, today conserved in the Archaeological Museum in Naples. Measurements were taken to determine the curvature and orientation of the coffers. Two methods used to establish the size of the vault permitted an approximation of the vault width, making it possible to propose limited possibilities for the number of coffers transversally to the vault, and how they were displayed on it. Further studies were made of the decorative scheme in order to suggest a plausible construction process for the coffers with tools and techniques usual at the time, using only arcs of circles. For this, the front side of the coffers was considered to be plane, which led us to establish that they were included in an all-over scheme of squares and that the concentric octagonal frames were very likely drawn from two families of circles. Then differential calculus showed us that the differences due to the plane approximation of the cylindrical shape of the vault were negligible with regard to the precision of the guidelines drawn in situ. Finally we suggest a complete decorative scheme, using various clues such as subject, orientation, curvature and colours of the tesserae decorating the framing.

1 Introduction

A specialist of antique wall plaster is generally confronted with the remains of vanished works, and his/her problem is then to reassemble a jigsaw puzzle from the remaining fragments. The present study aims at giving an example of how the joint work of a mathematician and an archaeologist can help to validate archaeological hypotheses and even suggest new ones. In the present case, one of us (N.B.) is a specialist of Italian Roman stuccoes [Allag et al. 2010; Blanc 2013]; she belongs to a team dedicated to the study of mosaics and paintings, while the other (B.P.) is participating in some of this team research work, especially by working on the construction processes of the geometric mosaics of several European sites. We decided to co-operate on an exemplary case, the stucco ceiling coffers removed from an unknown building, in order to shed some light on both its architecture and its decoration.

2 Archaeological data

The term 'stucco' is applied to the plaster-relief employed for architectural decoration, especially for cornices and vaults. It is composed of a binder – lime or plaster – and an aggregate, generally calcite powder. Mouldings are profiled (with templates), then usually decorated with repeating ornaments which are stamped in the damp plaster, while figures are shaped out by hand and tools.

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The Naples National Archaeological Museum houses an exceptional set of twenty-five stucco ceiling coffers found during the archaeological explorations led by the Bourbons on the seaside near Portici during the 1750s. The excavation technique then in use consisted of digging *cuniculi*, underground galleries, going all over the buildings buried by the 79 A.D. eruption of Mount Vesuvius in order to remove the art works. These included marbles and bronzes of course, but also wall paintings and stuccoes, for which a well-tried technique allowed removing the parts considered worthy of interest [d'Aconzo 2002]. These dismembered remnants have been deprived of most of their scientific content, hence the necessity for the archaeologist to try to restore them to their original context.

The twenty-five coffers were removed with part of the masonry support, then displayed separately in a concave octagonal wooden frame, marked with an inventory number (fig. 1-2). Each of them is decorated with a winged figure – Centaur or Maenad – and they are characterised by a distinctive feature, the polychrome tesserae adorning the frame. The history of the finding was clarified and the coffers were accurately described according to their current presentation in the Museum [Pannuti 1979], but no proposal was ever made about their original arrangement. In his report, Joaquin de Alcubierre (quoted in [Pannuti 1983]), then in charge of the excavations, provided a rough description of the location of the discovery of the Epitaffio site on 24 March 1754, but gave neither the dimensions of the room nor the organization of the removed stuccoes. The Spanish word '*boveda*' used by Alcubierre, confirmed by the slightly curved shape of the coffers, only allows asserting that they didn't adorn a flat ceiling, but a vault. Moreover, whatever the combination, the octagons could not cover the whole surface by themselves, as confirmed by the parallel removal of rosettes, half-rosettes and birds, unfortunately lost (fig. 1).

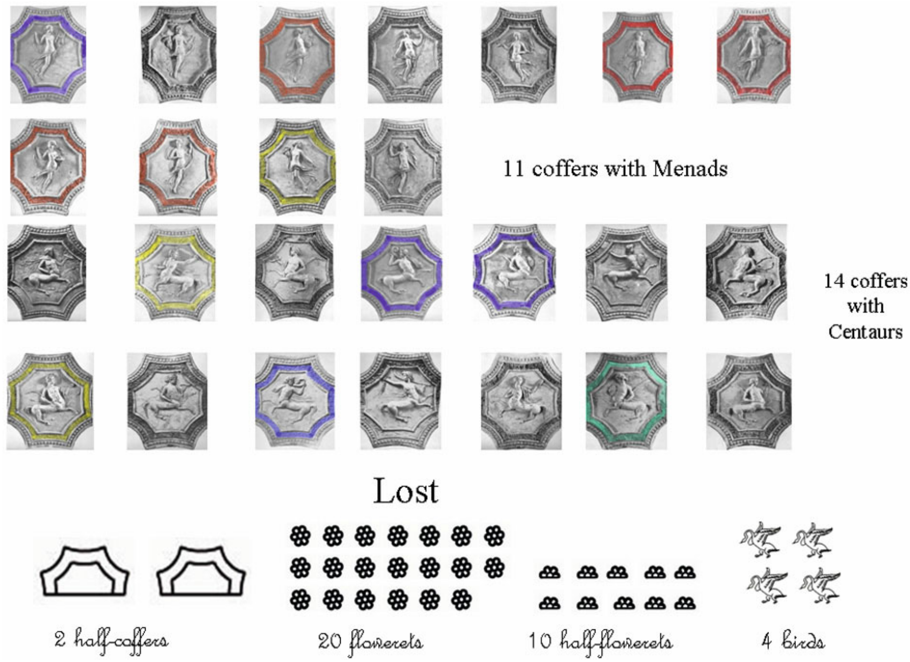


Fig. 1. Portici stuccoes. Photo © MANN from [Pannuti1979], infography authors

Thus there are two questions to be answered: what was the size of the vault? What was the decorative scheme of the whole ceiling?

3 Study of the curvature of the coffers

The curvature of the coffers is slight and not easily discerned because of the relief (fig. 2). For this reason our very first aim was to study their shapes and dimensions.[1]

Fig. 2. Naples, National Archaeological Museum, inv. 9690. Photo: Nicole Blanc

3.1 Existence of two types of coffers

By convention we oriented the coffers in relation to the figure represented on the central medallion, without prejudging of their original position in situ, and we numbered the vertices of the concave octagon clockwise from 1 to 8, as shown in fig. 3.

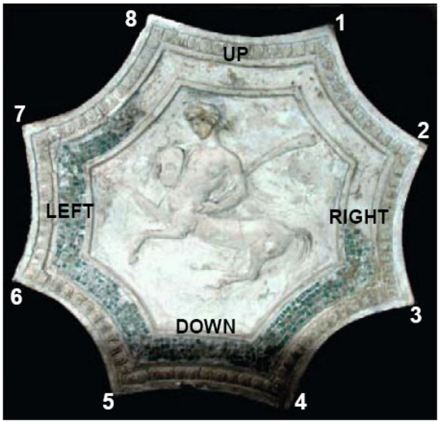


Fig. 3. Coding of coffers (example of coffer inv. 9603). Photo: Nicole Blanc

Each of the twenty-five coffers can be inscribed in a square, the side of which is about 65 cm.

The thickness of each coffer[2] was measured at each of its eight vertices. On this basis a *thickness graph* was then built for each coffer (fig. 4): thicknesses are indicated with regard to the corresponding vertices, following their numbers.

Our first observation was that, for a given coffer, the thickness varies according to the vertex. Besides, a plane support would have led to graphs roughly rectilinear, which was not the case here. Thus, *our first conclusion was that the coffers did indeed adorn a vault,* as asserted in the report of the eighteenth century.

We also noticed that the graphs can be divided into two categories:

- W type graphs, the most numerous (20 coffers) (see fig. 4);
- M type graphs (5 coffers) (fig. 5).

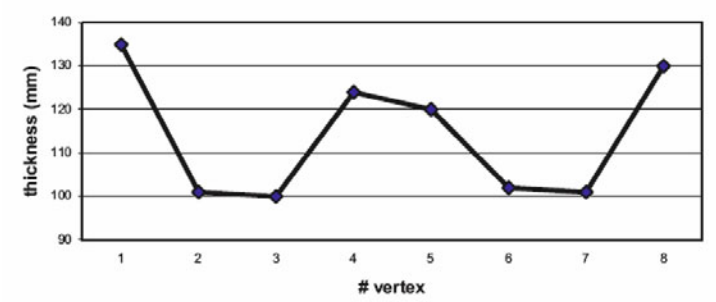


Fig. 4. Example of W type thickness graph (coffer inv. 9723)

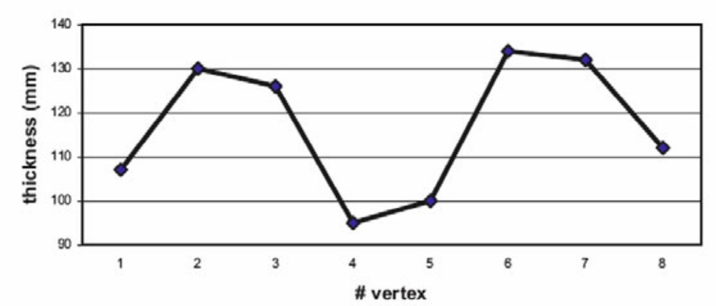


Fig. 5. Example of M type thickness graph (coffer inv. 9713)

Thus, *our second conclusion was the existence of two types of coffers*.

In order to support this, the difference between the mean thickness at vertices 1, 4, 5, 8 and the mean thickness at vertices 2, 3, 6, 7 was calculated for each coffer. The resulting graphical representation (fig. 6) confirms a neat partition of the coffers into two groups, depending on the sign of the difference: positive (for W type coffers) or negative (for M type coffers).

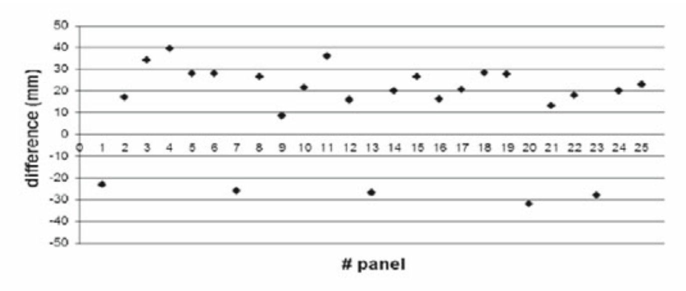


Fig. 6. Differences of thickness (the coffers are numbered from 1 to 25)

For a given coffer, to be of the W type means that its vertices 1, 4, 5 and 8 are more distant from the reference plane (i.e., the bottom of the frame) than its vertices 2, 3, 6 and 7; and of course it is the opposite for an M type coffer. From that observation we deduce that W type coffers were oriented crosswise to the axis of the vault, whereas the M type coffers were oriented lengthways.

Regarding their distribution on the vault, we propose, by analogy with what can be observed at other places, to set the M coffers on the axial line of the vault. Such a distribution induces a bi-directional reading of the motifs: frontal, in the vision axis of the onlooker entering or walking out of the room, and lateral for the two springings, in front of which he/she will move in turn; thus the motifs have three different orientations. Such a composition is imperative when the number of rows of coffers is odd. As examples we can cite, for instance, a room of a tomb in Ephesus [Vetters 1985] and the Valerii tomb in Roma [Mielsch 1975, 177-179, K 124, pl. 85]: the Nereids and Sea Centaurs inscribed in the seven rows of circles face each other symmetrically on three rows on both sides of the central row, while those surrounding the woman on a griffin are oriented along the axis of the lunette (fig. 7).

Fig. 7. Triple orientation of the coffers on the vault of the Valerii tomb. Via Latina, Rome. Photo: authors

3.2 Dimension of the room: first estimation

We can now try to imagine the shape of a theoretical coffer. The concave octagon has four vertices on a same plane, the other four being on a plane parallel to the first. Let us consider a transverse section of the coffer along the central up-down axis [PQ] (fig. 8). In the diagram, point P corresponds to vertices 1 and 8; point X corresponds to vertices 2 and 7; point Y corresponds to vertices 3 and 6; point Q corresponds to vertices 4 and 5.

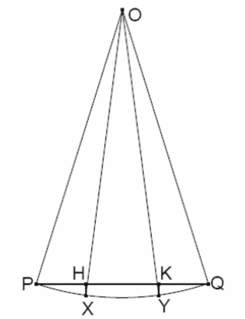


Fig. 8. Case of a W type coffer

For such a theoretical coffer, we take for HX and KY the mean value of the differences of level between the upper and lower vertices, let HX = KY = 2.3 cm (putting together the W and M types coffers). Moreover, we have PQ ≈ 63.5 cm.

The geometrical construction process that we propose hereafter for the coffers is such that PH ≈ 17.2 cm. Distance OP (radius of curvature) can be calculated or evaluated by a simulation using a geometry software; this leads to estimating OP at about 170 cm. *This corresponds to a semi-cylindrical vault, the width of which is about 3.4 m.* But of course this value should only be considered a rather wide approximation.

3.3 Dimension of the room: second estimation

In order to support this result, the right and left profiles of each coffer were drawn, so as to determine their curvature. The thickness of a coffer, with regard to its lower side, is quite relative and certainly not in accordance with its original thickness with regard to the vault; in fact, it depends on how the removal was operated. This is why we decided to refer to the upper side of the coffer.

The coffer laying flat on a horizontal plane, the vertices of the concave octagon belong theoretically to two horizontal squares, ABCD (upper side) and A′B′C′D′ (lower side). However, seen from above, the images of the eight vertices of the concave octagon belong to a same square (fig. 9).

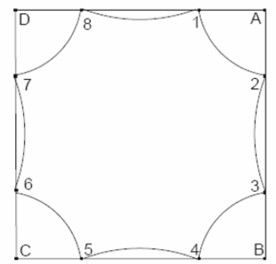


Fig. 9. Theoretical view from above

Now in order to fix our ideas, let us focus on the profile of a W type coffer. Vertices A, B, 2, 3 are on a same vertical plane (fig. 10).

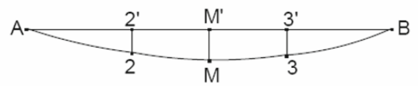


Fig.10. Right profile of a W type coffer

From the distances from points 2 and 3 to (AB) (i.e., 22′ and 33′) we can establish an approximate right profile of the coffer by interpolation. This profile can then be used to estimate height MM′ (sagitta).

The same process is used with the left profile, as well as with the right and left profiles of the M type coffers.

The results show that for the whole of the W type coffers the mean sagitta is 3.0 cm. It can be noticed that the variation is rather high, which is of course linked to the inexactitudes of the setting up of the vault and the stucco layer as well.

Besides, in spite of the small number of M type coffers, one can notice that their sagittae are similar to those of the W type coffers. This is in accordance with the extant Roman vaults and enables us to suppose a constant curvature, i.e., a half-barrel vault.

The question is now to estimate the radius of curvature of this vault. It is possible to calculate (by trigonometry) the radius of curvature of the ideal coffer from the lengths of its side and sagitta. With 63.5 cm as side and 3.0 cm as sagitta one gets a radius of about 170 cm, that is, a diameter of about 3.4 m. Of course, according to our hypotheses and the relatively low precision of the estimations, and although we found the same result as with our first estimation, this result as well must be considered only a rough estimate.[3]

4 In search of the setting up of the décor

These stucco ceiling coffers were not fashioned separately then fixed to the vault, as their present condition might lead one to believe, but worked out directly in the fresh coating of plaster laid on the masonry. To do this, the craftsman began by incising on the bottom the guidelines of the décor which would help him setting up the relief [Ling 1976].

The grid mapping out a network of coffers is always the same: the craftsman draws on the fresh coating an orthogonal outline of squares, as a basic module on which all the figures of the décor will be inscribed with rulers and compasses or, on the curved surface of a vault, with strings, possibly used also as compasses.[4] This is confirmed by Vitruvius in VI 3, 9: *Praeterea supra coronas curva lacunaria ad circinum delumbata*, meaning "above the cornices coffers are adjusted on the arch with compasses". This grid, incised on the background plaster, can sometimes be seen when the stucco relief has fallen away: the square pattern can easily be followed on a square-coffered vault of Ardea [Mielsch 1975, 156 K82] (fig. 11 left), and the construction of circles at the intersections of squares on the entrance vault of the Ostia theater [Mielsch 1975, 182 K129] (fig. 11 right). Let us add that, whatever the support and the material – painting, mosaic or stucco –, all the construction lines are based on straight lines and circles.[5]

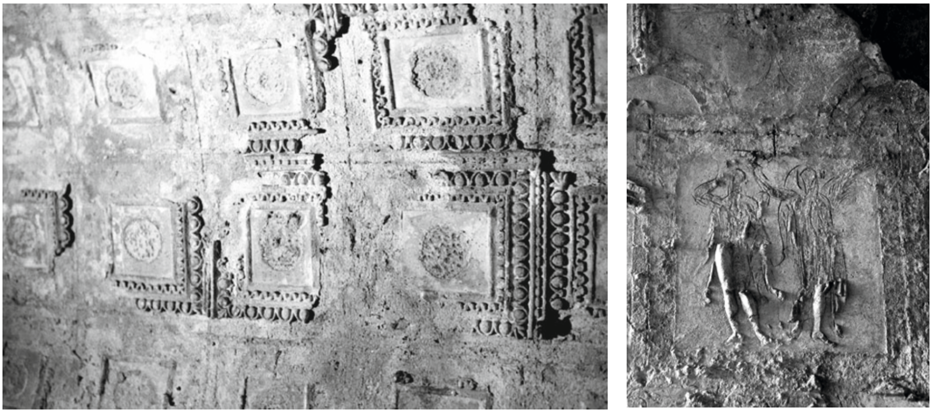


Fig. 11. Preparatory lines: orthogonal grid in Ardea (left) and circles at the corners in Ostia
Photos: authors

We believe that, for setting up geometric décors, antique craftsmen made use of configurations which could be implemented from a small number of points and lines easily obtained by elementary geometric processes which, for this reason, could be memorized and possibly modified [Parzysz 2009].

In order to try to determine the process used for the setting up of the décor, we then examined the geometric elements of the Portici coffers, that is the frame surrounding the figures. As seen above, the coffers show a curvature, leading us to think that they adorned a vault; however, since this curvature is slight, we shall first act –as a first approximation

– as if they had been carried out on a plane surface. Then, after having proposed a construction process based on this hypothesis, we shall evaluate the difference appearing when the process is performed on a barrel vault.

4.1 Plane approximation

Each coffer is framed with mouldings consisting of three fillets enclosing a row of leaves on the outer side and a broad band of polychrome mosaic on the inner side (fig. 3). We considered especially the inner and outer fillets, since they give the outline of the pattern, and provided the basis for the hypothesis that both are made of eight arcs of circles presenting the symmetries of a square.

For each coffer, we first tried to locate the centers of their circular elements empirically, in order to determine a uniform geometric structure for all the coffers (fig. 12).

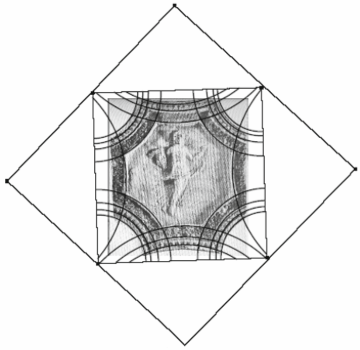


Fig. 12. Example of coffer inv. 9576. Photo © MANN from Pannuti1979, infography authors

The comparatively small differences noticed from one coffer to another allowed us to propose the theoretical process described hereafter. These differences can be explained by the difficulties of setting up a precise grid on an irregular vault, and following it exactly in the making of the coffers. Above all they are marks for guiding the gauges which drag the paste. For instance a vault of Augustus's house, in Rome, still shows preparatory lines that do not always fit with the coffers (fig. 13).

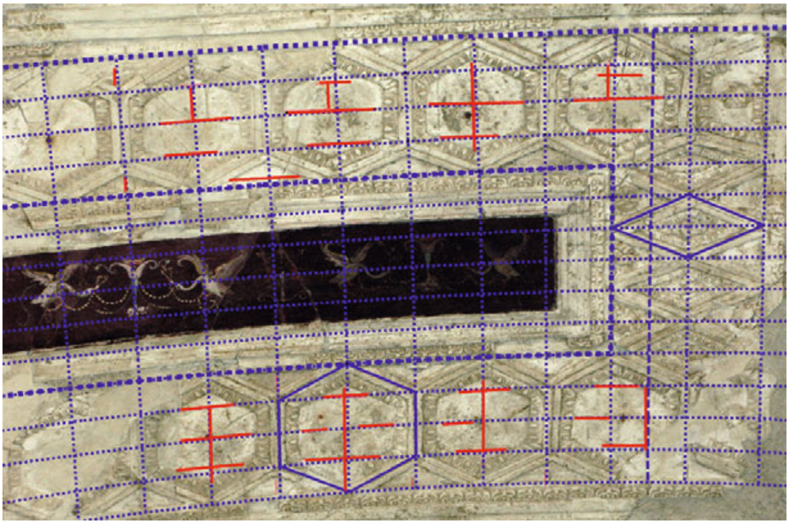


Fig. 13. Vault of the cubiculum of Augustus's house (Rome). Preparatory lines in dotted line, theoretical grid in full line

When looking at a coffer, one first notices that the radius of the arcs constituting the up, down, left and right sides of the same concave octagon is larger that the radius of the other four arcs (see fig. 12).

Our further observations led us to state the first two hypotheses:

– H1: the coffers are inscribed in square panels;
– H2: all the fillets are obtained from two families of circles: one family centered at the centers of the panels and the other one centered at the corners of the panels;

The question was then to find the radii of these circles, and especially the inner and outer circles outlining the frame.

The inner fillet determines the space in which the central figure will be inscribed. Our observations led us to formulate two further hypotheses (fig. 14):

– H3: the four arcs centered at the corners of the panel are tangent to the circles centered at the opposite corner and passing through the nearest corners;
– H4: the four arcs centered at the centers of the adjacent panels pass through the two nearest corners of the panel.

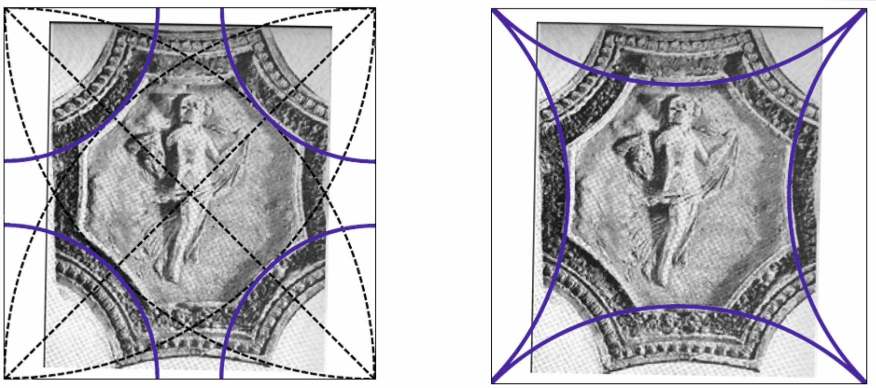


Fig. 14. Inner edge (coffer inv. 9576). Photo © MANN from Pannuti1979, infography authors

Similarly, for the outer fillet we were led to formulate two last hypotheses (fig. 15):

– H5: the extremities of the four arcs centered at the corners of the panels are the vertices of the regular octagon inscribed in the panel;
– H6: the four arcs centered at the centers of the adjacent panels are tangent to the circle tangent to the four latter arcs.

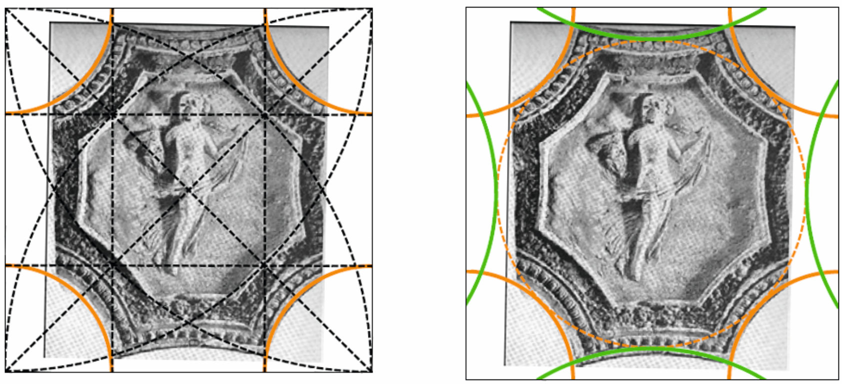


Fig. 15. Outer edge (coffer inv. 9713). a, left) shows a construction of the octagon based on circles already drawn. Photo © MANN from [Pannuti 1979], infography authors

By this we provide, in accordance with Vitruvius's indications and archaeological evidence, a construction process composed solely of straight lines and circles.

4.2 Discussion

With regard to our hypotheses, a comparison with other stuccoed vaults (see figs. 11 and 13), together with the greater ease of setting up a square grid on a plane surface in comparison to setting up on a barrel vault, make our hypothesis H1 most probable. The same reason of simplicity applies also to H2, which ensures a constant width to the frame on the corner sides and can be controlled with several circles by the craftsman. Moreover, this process creates, at the corners of the panels, small circular zones – surrounded by fillets as well – which quite possibly included a motive (most probably the rosettes found together with the coffers). Similarly, a single circle provides the median arcs of four panels (economy principle).

Of the other hypotheses, H4 is also very probable. H6 is necessary if the width of the fillet is to be constant all over the eight sides, although this is more difficult to check on the grounds of the available documents.

H3 cannot be verified with much accuracy, but is indirectly confirmed by a geometric property: the midpoints of the eight arcs composing the inner edge of the frame are all on the same circle (fig. 16). By this the construction process clears a circular "useful space" at the center of the panel, in which the figure will be placed.

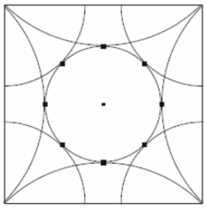


Fig. 16

Finally, H5 is the least ensured of our six hypotheses. However, since the fillets are octagonal, a reference to the regular octagon is plausible (see also § 4.4).

4.3 Proposal for a construction process

Under these hypotheses certain actions must be performed prior to others, but several orders remain possible. We propose here a possible sequence (fig. 17), coming after drawing the diagonals and medians of the square panel which will be used as guidelines.

In this process only elementary operations take place (drawing straight lines and circles[6]), most of which can be controlled, either visually (parallelism) or with the help of elements previously drawn (circles).

The linking of operations can be reconstructed as follows:

1. Set up the square grid on the whole of the vault.

Then, in each square:

2. Draw the diagonals to set the center.
3. Mark the vertices of the regular octagon inscribed in the square, using the circles centered at the vertices of the square and passing through its center.

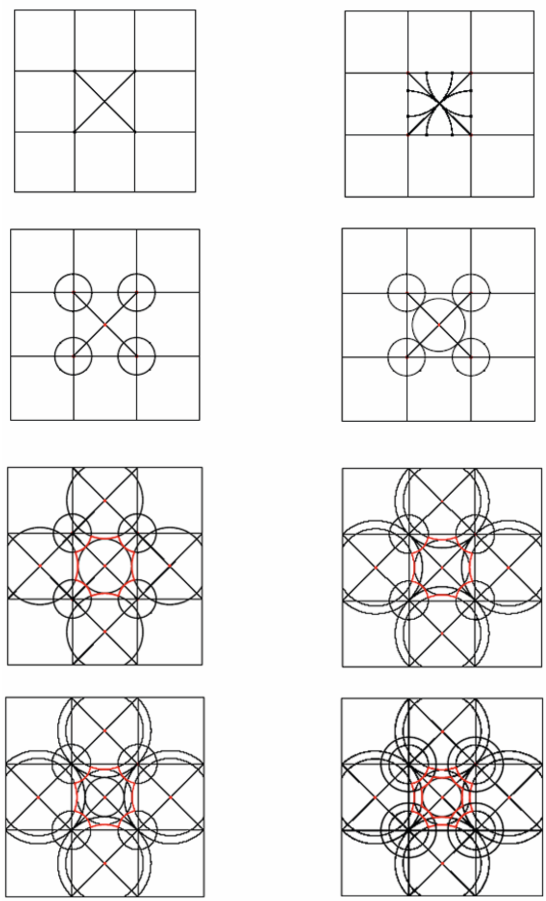


Fig. 17. Proposal for a construction process of the listels

4. Draw the circles centred at the vertices of the square and passing through the nearest vertices of the octagon.
5. Draw the circle centered at the center of the square and tangent to the previous circles.
6. Draw the circles centered at the centers of the adjacent squares and tangent to the previous circle.

By so doing, the outer fillet is drawn. For the inner fillet:

7. Draw the circles centered at the centers of the adjacent squares and passing through the nearest vertices of the square.
8. Draw the circle centered at the center of the square and tangent to the previous circles.
9. Draw the circles centered at the vertices of the square and tangent to the previous circle.

By so doing, the inner listel is drawn.

Let us notice that our proposal is, so to speak, a "maximal" one, for it is quite possible that the craftsman used shortcuts to complete the construction process. For instance, drawing the inner central circle is not necessary when the diagonals of the octagon parallel to the sides of the square have been set up (fig. 15a). And, once the inner fillet has been completed, the craftsman might well set up the outer fillet just by drawing circles similar to those of the inner fillet, but with radii increased of a constant length (the width of the frame).

The apparent complexity of the proposed process lies in the linking of these operations. But, after having routinely drawn the guidelines (diagonals and medians), it can be decomposed into two similar and interchangeable phases, namely the constructions of the inner and outer fillets. Moreover, each one of these phases consists of twice a sequence of the same three gestures: draw the first four circles, then draw the central circle tangent to them, and then draw four other circles tangent to this one.

4.4 Comparison

After this we undertook the research of similar constructions likely to support our hypotheses. But none of the preserved stucco vaults shows exactly the same geometric structure, even if octagons with four concave sides (and four straight sides) are quite frequent. However, a vault in the thermae of Stabies (Pompei), coeval with the Portici vault, shows an even more complex design of equidistant circles and concave octagons inscribed in dodecagons [Mielsch 1975, 142-146, K54b, pl. 51-52] (fig. 18). Wall paintings offer no more testimonies. In fact, this lack of comparison, the usual basis for archaeological hypotheses, was the starting point of our co-operation.

Only mosaic patterns provide some parallels to the Portici vault, but they are more recent (second or third century A.D.)

Fig. 19a shows an example of a mosaic found in Hellin (Albacete area, Spain) [Blazquez Martinez et al. 1989: 49-54, n°39, pl.34] (fig. 19a). It is also based on a square grid and has a central concave octagon. The study shows that its sides are constructed on the sides of the regular octagon. More precisely, the outer fillet is obtained in the following way (fig. 19b):

1. Draw the regular octagon inscribed in the square.
2. Draw the circles centered at the vertices of the square, passing through the nearest vertices of the octagon (this gives the first four sides of the fillet).
3. Draw the circle circumscribed to the square and extend its medians.
4. With their intersection points as centers, draw the circles passing through the nearest vertices of the initial octagon (this gives the last four sides of the fillet).

(For the inner fillet the craftsman may have acted like suggested above.)

If now we compare this process with the one proposed for Portici (fig. 19c), we can notice that they are somewhat similar, the main difference being that here the eight arcs have the same radius. A consequence is that all the vertices of the concave octagon are on the sides of the square, and on the median areas of the sides of the square small spindles appear.

Another example in mosaic comes from Bulla Regia (Tunisia) (fig. 20a) [Balmelle et al. 1985, pl. 245 d]. Here the process begins like in Portici and Hellin (fig. 19), but the four last circles are centered at the centers of the adjacent squares (as in Portici) and pass through the extremities of the first circles (as in Hellin) (fig. 20b). Thus we have two variations (Portici, Bulla Regia) on a same decorative scheme (Hellin).

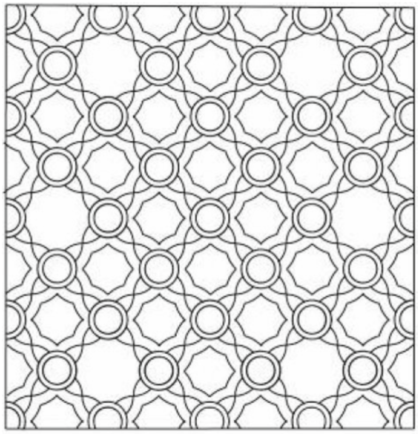


Fig. 18. Vault of the apodyterium of the thermae of Stabies (Pompei). a, left) Detail of the vault; b, above) theoretical sketch. Photo and drawing: authors

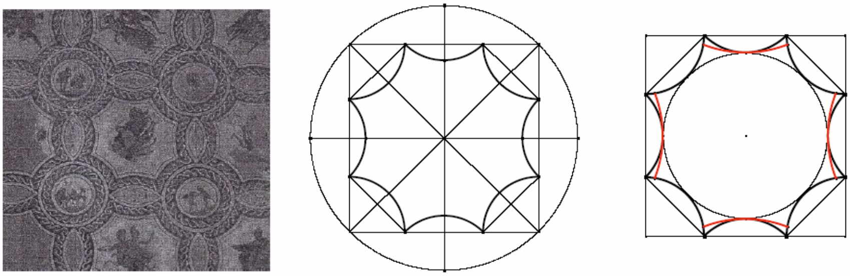


Fig. 19. a left) Mosaic from Hellin (Spain); its geometry (b, center) compared compared with that of the Portici vault (c, right). A: Photo from [Blazquez Martinez et al. 1989]

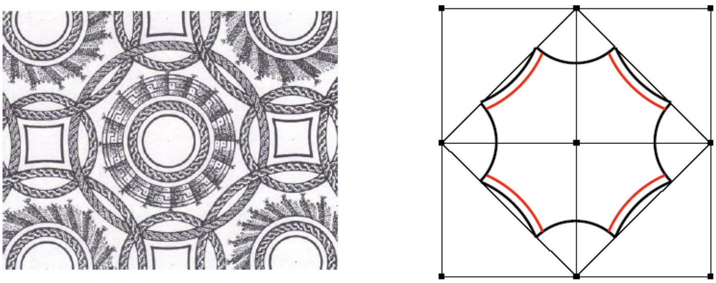


Fig. 20. Mosaic from Bulla Regia (Tunisia) (a, left) compared with the Portici vault (b, right). Note that in the present case the grid is rotated 45°

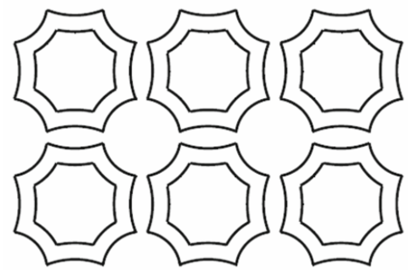
4.5 Adaptation to a cylindrical surface

Let us now assume that the vault is supported by a cylinder (half-barrel vault). In order to quantify the distance induced by implementing the previous process on the new shape of the vault, we estimated the errors made on the radii of some of the circles determining the frame, according to the way used by the craftsman to transfer the module of the pattern on the vault, either in straight line or following the vault.

The calculation, based on expansions of functions, showed that, in both cases, the differences from drawing on a plane surface are negligible in comparison with the precision of the layout. Thus we were led to assume that the craftsman used a plane process on a curved surface, similar to those used by mosaicists.

5 Scheme of the décor as a whole

On the basis of the construction described above, the organization of the coffers is the one shown on fig. 21 and the vault looks like on the schematic diagram of fig. 22.



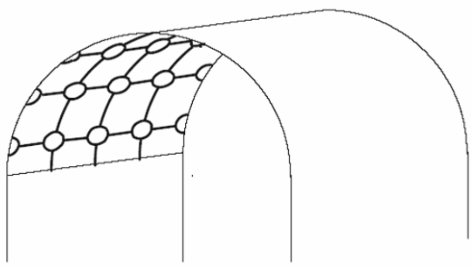


Fig. 21. (left). Schematic diagram of the vault

Fig. 22 (right). Organization of the coffers

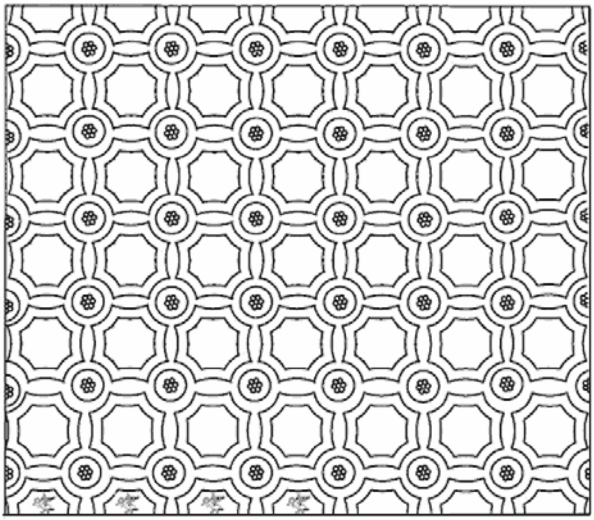
What are the consequences for the vault?

Let us first notice that, according to our hypotheses (refer to fig. 17), the module of the square grid can be estimated to be about 70 cm (the coffers were cut off close to the outer fillet). And, going back to fig. 8, our measures and calculation give $\angle POQ \approx 21.6°$ for an "ideal" coffer, which becomes 23.4° for a panel 70 cm wide.

From the results in § 3.1 we proposed an odd number of rows of complete coffers on the width of the vault: one row (M type) along the axis and an equal number of rows (W type) on each side. Since the theoretical values of $\angle POQ$ are 25.7° for 7 panels, 22.2° for 8 panels and 20.0° for 9 panels, we are inclined to favour the first two possibilities.[7] But, being given the lack of archaeological data, it is impossible to decide conclusively.

The width of the vault would then be 3.14 m in the first case and 3.58 m in the second case, both being quite in accordance with our former results (fig. 22).

From the size and curvature of the coffers we could deduce that there were seven or eight coffers on the width of the vault. Together with the mention of half-coffers by Alcubierre, we were led to propose two possibilities: in the first hypothesis, three rows of coffers on each side of the central row (fig. 23a); in the second hypothesis: three rows of coffers on each side of the central row <u>plus</u> a row of half-coffers on each side (fig. 23b).



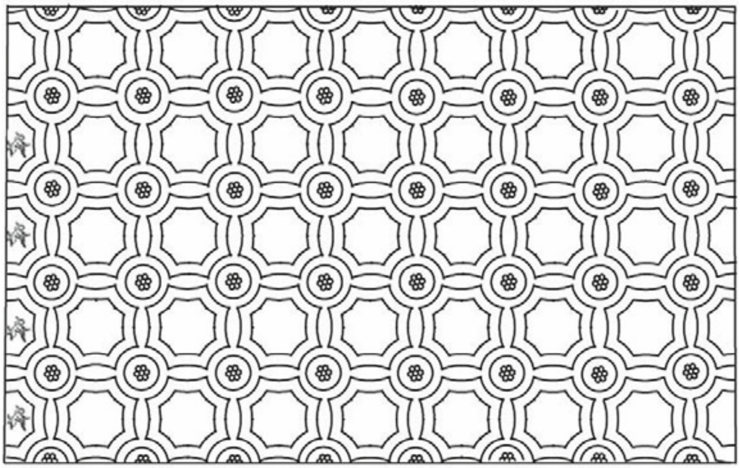


Figure 23. Two proposals for the organisation of the panels: a, above) 3 rows of coffers on each side of the central row; b, below) 3 rows of coffers on each side of the central row plus a row of half-coffers on each side

6 Conclusion

The condition in which the coffers have come down to us, torn off from the masonry, does not allow us to cite archaeological evidence to support our proposal. Nevertheless it has a strong likelihood, as far as all the operations necessary for the layout are attested in other places. But the paths followed to implement the construction are not so ascertained. In fact, there is evidence that the craftsmen did not always draw all the guidelines; they could content themselves with marks for guiding the gauges. In any case, this study provides us with elements for thinking about the status of this décor. We do not know what kind of building was adorned by this vault, but the excavation report mentions other rooms, also vaulted, in which numerous pieces of lead pipes, together with a great variety of precious marble plaques, columns and capitals, were found. On these grounds the hypothesis that the building was a vast thermal complex was formulated [Pannuti 1979: 261]. However, the complexity of the setting up of the scheme and its rarity confirm the luxury of this décor, which adds to the quality of the modelling and the polychrome mosaics of the framing. If this was indeed a bathing complex, it most certainly must have belonged to a richly decorated seaside villa, such as used to line the coast.

Post scriptum

We had just concluded this research when we came across, in the *Rivista di Studi Pompeiani* [Pagano 1999], a brief note indicating the discovery of a square room explored by the Bourbons in Portici, on the Epitaffio site. The author identifies it with the room with stucco coffers and its dimensions – 3.94 m – is in accordance with our hypotheses. However the vault does not show any marks of removal. Moreover, the *cunicolo* leads only into this room, whereas we know that the Bourbons explored several rooms, searching for other stuccoes that they did not find. Although it is undoubtedly in the same area visited by Alcubierre – as the pit sunk for going down and the opening in the wall which allowed them enter the room testify –, it is unlikely to be the same room.

Notes

1. The authors would like to thank Dott.ssa Valeria Sampaolo, the Director of the National Archaeological Museum of Naples who provided them with all facilities to study the coffers stored in the museum. They also thank Hélène Eristov (CNRS-ENS, UMR 8546) who participated in the research and is collaborating, as a specialist of the Bourbonic excavations, on a forthcoming article dedicated to the archaeological aspects of the problem.
2. That is, the difference between the levels of the top and bottom sides.
3. For instance, a difference of 1 mm for the sagitta implies a difference of 20 cm or so for the width of the room.
4. Such summary compasses are made of a string, at each end of which a point is fastened: one of them is used as axis and the other allows drawing (arcs of) circles.
5. For instance, the so-called “elliptic” shape of the Roman amphitheaters is in fact an oval, composed of four arcs of circles [Parzysz 2008].
6. Let us remark that most of the time there was no need to draw the full circle, a small arc, and even possibly a single point, being quite sufficient.
7. In the second case there would have been half-coffers (mentioned in Alcubierre’s report but not preserved) toward the springing of the vault.

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