Design features, fabrication method, and materials used that expose the Nefertiti bust as a forgery

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Using a 3D model of the Nefertiti bust obtained by optical scanning, the degree of mirror symmetry of the sculpture was determined. The obtained estimate shows that the magnitude of the facial asymmetry does not exceed 2 mm. As follows from the analysis of the X-ray images of the bust, the inner stone core and the outer plaster shell were produced by casting. Given the relatively high symmetry and the small thickness of the plaster shell, the casting used is characterized as precision casting. To create the molds for the core and the shell corresponding to this casting, it was necessary to produce geometrically similar clay models of the core and the shell, for which a 3D pantograph was most likely used. The high degree of facial symmetry, the presence of an artificial-stone core with a relatively thin outer shell, the use of casting and its precision character, the application of low-shrinkage materials, the detachable construction of sculptures from the same excavation, and other features revealed in the course of the present study allow us to confidently assert that the famous bust of Nefertiti is a forgery.

Key words: Nefertiti bust, mirror symmetry, 3D pantograph, artificial stone, casting, Ancient Egypt

1. Introduction

Since the “discovery” of the world-famous bust of Queen Nefertiti[1,2] (see Photo. 1), 114 years have already passed, yet despite numerous direct and indirect pieces of evidence that the bust is a forgery,[3,4] a significant part of the scholarly community still, for some reason, refuses to acknowledge this. Our German colleagues, of course, are the most persistent.

This work represents another attempt to resolve the situation on this issue.[a] Since independent experts currently have no access to the “masterpiece”, the debunking is based on the materials obtained by the custodians of the invaluable bust themselves. If the Nefertiti bust is a forgery, then the entire Amarna collection of sculptures from the workshop of Thutmose,[5] of which the bust is the jewel, is also a forgery.

2. Determining the degree of mirror symmetry in Nefertiti’s face

Since, among all known symmetrical sculptures, only the bust of Nefertiti (shown in Photo. 1) has been optically scanned and its high-quality 3D model[6] is now freely available for download, the author has carried out an assessment of the facial mirror symmetry for this particular object. The symmetry analysis previously performed using photographs[7] is less accurate (the photogrammetry method[8] for these objects has an error of several millimeters at best, which is comparable to the degree of asymmetry being measured). Moreover, the photographs suitable for such measurements are not publicly available. In addition, for many well-known sculptures, even their physical dimensions cannot always be reliably found or measured. This currently makes it impossible for researchers outside the museum community to quantify their asymmetry.

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[a] The considerations presented below, which deny the authenticity of the bust of Nefertiti, were originally set out in the author’s book “Peruvian polygonal masonry: how, who, when and what for” (148 pp., 2025).

Photo. 1. The bust of Nefertiti in the Neues Museum, Berlin, Germany. Height×width×depth: 49×24.5×35 cm. Material: a layer of gypsum plaster over a limestone core. The mirror symmetry of the queen's face is particularly noteworthy. Photo by S. Steiß, smb.museum.

The 3D model of Nefertiti's bust was obtained using a non-contact optical 3D scanning method with structured (striped) light.[9] The distance between the measured points on the bust surface was 0.2 mm, while the error of the surface topography measurement at any given point does not exceed 0.03 mm.[10] Apparently, a surface taken from the right eye and mirror-reversed has been inserted into the empty left eye socket of the 3D model of Nefertiti's bust (no mention of this manipulation is found in the accompanying information for model 6).

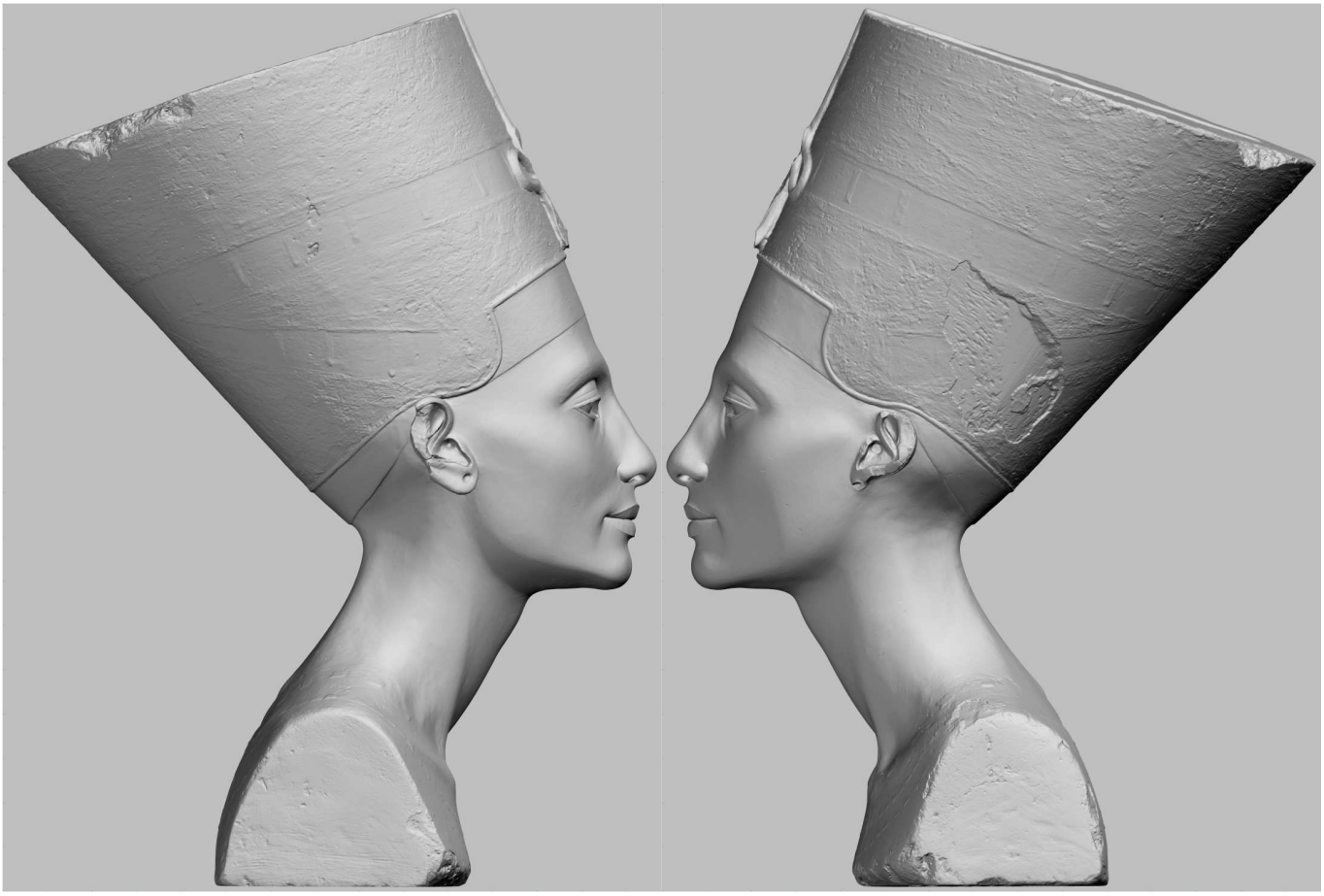
To assess the facial asymmetry of Nefertiti, the frontal grayscale image of the bust (see Fig. 1a), extracted from the 3D model, was mirrored horizontally about the vertical z-axis in a graphics editor (using the "Flip Horizontal" function). Then, the original frontal image and its mirrored copy were made semi-transparent (set to 50% opacity) and superimposed on each other. After superimposition, the images were aligned. The alignment was performed manually, with special care taken to minimize any misalignment of the eyes, nostrils, corners of the mouth, and the oval of the face. The result is presented in Fig. 1b.

Images of the right and left sides of the bust were also used to assess asymmetry (see Fig. 1c, d). The left side was mirrored about the vertical *z* axis, after which the original right side and the mirrored left side were made semitransparent and superimposed on each other. After the images were superimposed, they were aligned. The images were manually aligned using the facial contour. The result is presented in Fig. 1e.

(a) (b)

Fig. 1. Confirmation of the symmetry of Nefertiti's face. (a) The original frontal grayscale image of the 3D model; (b) the original and its mirrored semitransparent frontal images superimposed on each other and manually aligned by the eyes, nostrils, corners of the mouth, and the oval of the face. (c) The original image of the right side of the bust; (d) the original image of the left side of the bust; (e) the original semitransparent image of the right side and the semitransparent mirror image of the left side superimposed on each other and manually aligned by the facial contour. The 3D model of Nefertiti's bust was obtained by non-contact optical scanning using structured light, with a measurement accuracy of 0.2 mm. The estimated degree of facial asymmetry in Nefertiti's bust does not exceed 2 mm.

Since the dimensions of the bust are known, the degree of Nefertiti's facial asymmetry can be determined from the visible misalignment of the facial elements in Fig. 1b and Fig. 1e. The estimated misalignment does not exceed 2 mm. The misalignment is an order of magnitude greater than the stated error of the optical scanning method used to obtain the 3D model of the bust. Thus, using this scanning method to determine the asymmetry of the bust is entirely justified.



(c) (d)

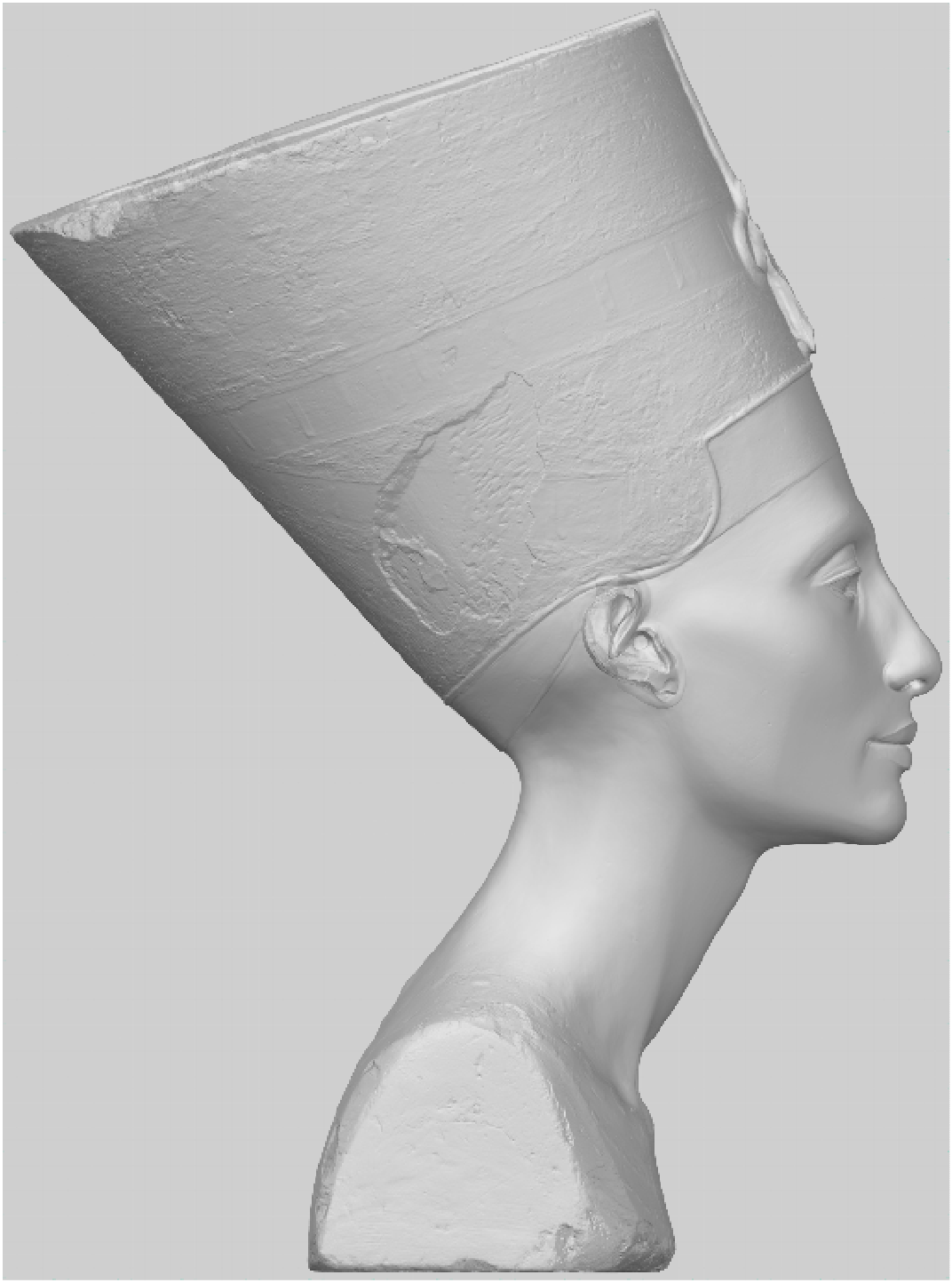
Continuation of Fig. 1.

The resulting misalignment value indicates a rather high degree of symmetry, which would be difficult to achieve when sculpting the clay models of the core and the shell without the use of a special contrivance such as a 3D pantograph. Of course, the ancient Egyptians could not possibly have had such a device, since a 3D pantograph could only have appeared after the invention of the 2D pantograph in the early 17th century.[11]

The residual asymmetry is most likely related to a number of other factors and, apparently, cannot be further reduced. During the sculpting of the clay model, it slowly deforms under its own weight (“flows”). In addition, the clay model undergoes uneven shrinkage during drying, which, however, can be compensated by applying additional layers of clay. Moreover, the 3D pantograph also contributes to the overall error.

The casting mold incorporates all the errors of the model and additionally introduces its own error associated with uneven shrinkage during drying. After casting, the shell also undergoes uneven shrinkage during the hardening process, although this shrinkage is insignificant due to its small thickness. Besides the aforementioned causes, the asymmetry also increases due to inhomogeneities in the compositions of the materials/mixtures used.

Thus, even if the original model had been perfectly symmetrical from the outset, the factors associated with the casting technology would still have made an additional contribution to the final asymmetry of the bust. To determine the error in facial symmetry as accurately as possible, one should compute the mean surface between the original surface of the 3D model and its mirror image using the least-squares method. This is done by minimizing the root-mean-square difference between the two surfaces during alignment, after which the desired error can be calculated.



(e)

Continuation of Fig. 1.

3. Details of the famous bust's fabrication process that nobody wants to notice

To make the outer shell of the sculpture adhere better to the core, the surface of the core is roughened. Usually, this roughening is achieved by creating sufficiently deep grooves (or other surface irregularities) on the clay model of the core, which is a slightly reduced copy of the final sculpture but lacks fine details.[11] Next, a casting mold for the core is fabricated based on this clay model of the core.

Since the outer shell is comparatively thin, these grooves may appear on the surface of the sculpture as low-contrast strips (in some places, due to accidental displacement, rotation, and/or tilting of the core inside the casting mold, the shell turns out to be thinner than specified). Thus, under certain lighting conditions, striations become visible on the surface of the bust of Ramses II,[7] which may be caused by the aforementioned grooves.

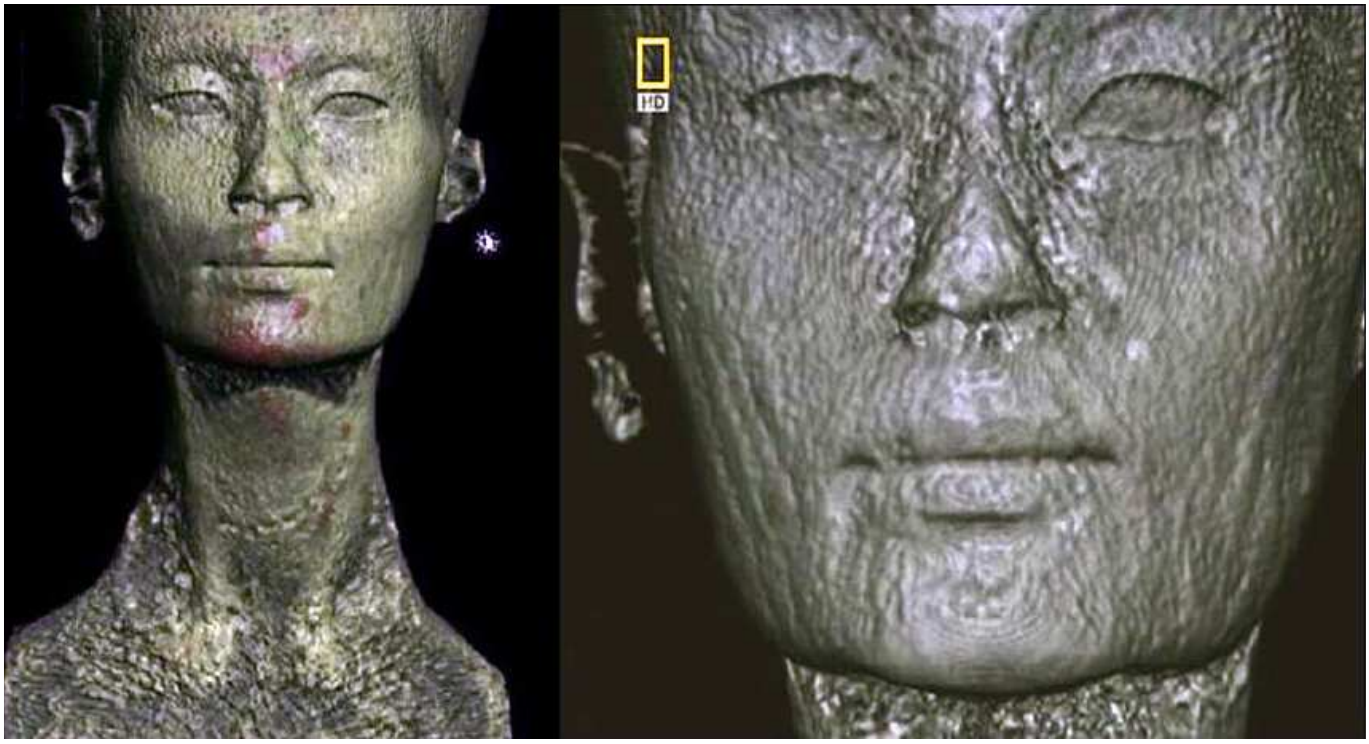


Photo. 2. The rough core discovered beneath a layer of gypsum plaster during X-ray computed tomography scanning of the bust. Vertical grooves on the cheeks and under the eyes are clearly visible, along with the overall high surface roughness. The vertical grooves are not wrinkles on an elderly woman's face, but intentional irregularities deliberately applied to the clay model of the core to improve the adhesion between the gypsum shell and the concrete core. Frame from the documentary "Nefertiti's Odyssey", ZDF television network, 2007.

Since the shell and the core are made of materials that differ both in density and internal structure, these grooves can be detected even when the outer shell is thick, by using X-ray technique. Thus, an X-ray computed tomography[12] (CT) study of Nefertiti's bust showed that it consists of a limestone core and an outer gypsum shell.[13] Although work 13 claims that the core was made of mechanically processed natural limestone, a number of features described in works 3 and 4 strongly suggest that it is in fact an artificial stone (concrete) cast in a mold.

Study 13 also revealed that the queen's face on the core is covered with deep wrinkles (see Fig. 3b in work 13 and Photo. 2[14]). On this basis, an incorrect conclusion was drawn that the core depicts a lifelike portrait of Nefertiti in old age, which was later "rejuvenated" by applying a smooth layer of stucco. However, as is now clear, what appear on the core are not deep wrinkles on the face of an old woman, but simply those very grooves that improve the adhesion between the gypsum shell and the concrete core. Oleg E. Akimov reached the same conclusion in his works 3 and 4.

Of course, the outer shell of the bust was not modeled by hand from gypsum; rather, it was cast using a technique similar to that described in book 11. The point is that gypsum is inconvenient for modelling – it dries quickly, and making corrections is much more difficult than when working with clay. Therefore, sculptures made of this material are cast after first creating an appropriate clay model and then making a casting mold from that model.

To achieve a high degree of symmetry during the manual application of gypsum plaster, it is necessary not only to remove excess material in some areas but also to add new gypsum in others. As a result, the outer shell should have areas with multiple layers of gypsum. Due to its poorer adhesion compared to a single layer, the gypsum in these areas may begin to peel off after some time. However, one should not apply too thick a single layer at once, as this risks subsequent cracking caused by shrinkage. Although, according to work 13, the method of applying plaster to the surface of Nefertiti's bust implies the presence of layers, no layered struc-

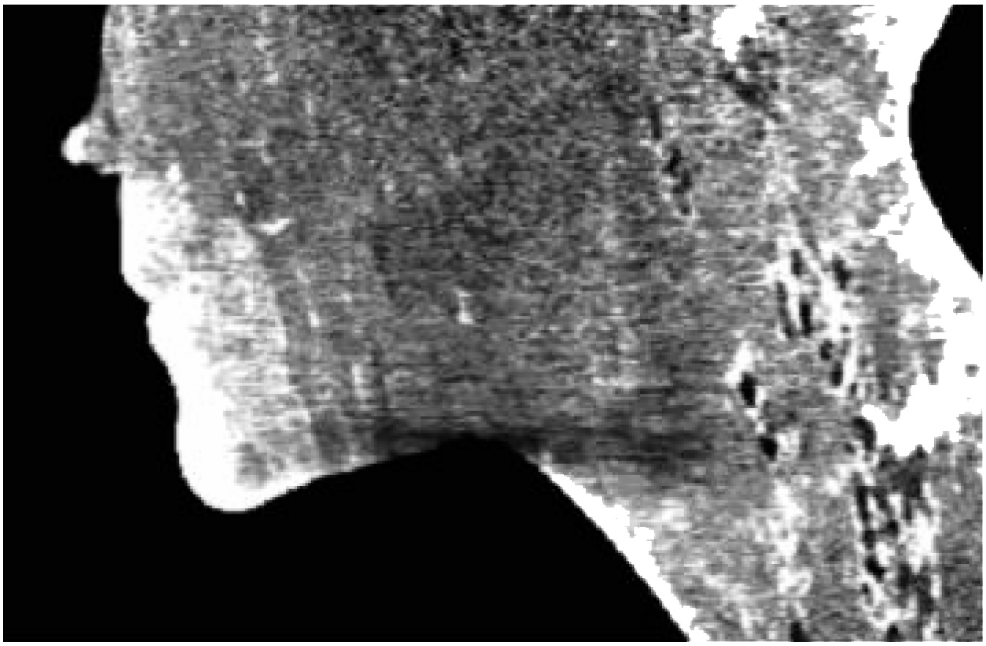


Fig. 2. X-ray tomographic slice of the head in the vertical plane. A series of parallel vertical streaks on the face (see the chin, cheek, and cheekbone) was identified by the authors of work 15 as veins in the natural stone. However, the veins are usually distributed rather chaotically and do not form a layered cylindrical structure. In fact, the observed layered structure resulted from the circular stirring of the already partially set concrete-like mixture inside the casting mold. This figure reproduces Fig. 4 from Ref. 15.

ture of the shell was detected on the face during the X-ray examination of the sculpture.

4. The self-exposure of German scientists

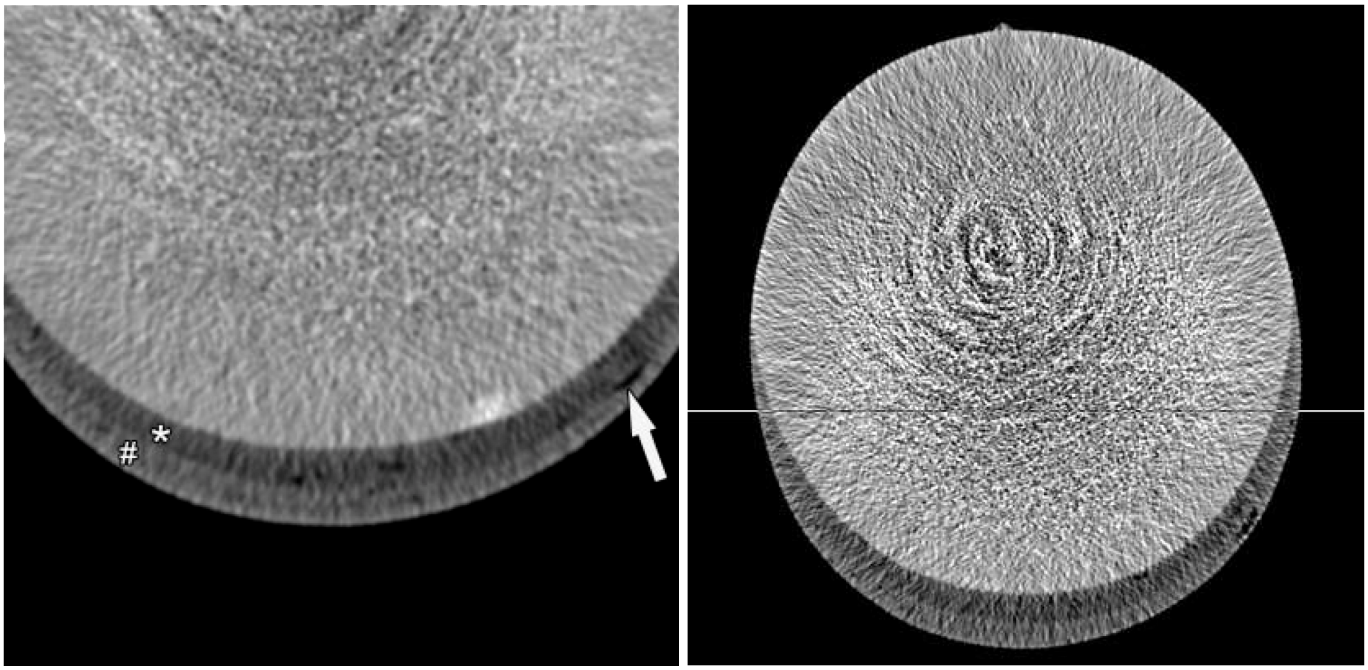
Although work 15 appears to criticize several conclusions drawn in work 13, it denies the existence of a second “aged” face inside the bust of Nefertiti. The term “plaster layer” is proposed to refer simply to a very thin layer of primer applied to the stone surface before painting. Although the authors of the article could not see this primer layer, they insist that it exists. The article does not explain on what basis the authors concluded that the primer layer exists.

According to the authors of paper 15, the inner face with wrinkles (see Photo. 2) is entirely virtual. This inner face appears due to an incorrect setting of the optical density range of the limestone during 3D image reconstruction, as well as due to a number of artifacts inherent to the X-ray CT method. In his study 4 (part 5, starting at 5:57), O. E. Akimov provides several clear examples of X-ray CT scans of stone sculptures. Surprisingly, neither the artifacts nor the noise inherent to the X-ray CT method prevented a detailed examination of the internal layers, cracks, inhomogeneities, inclusions, and material structure of the sculptures in these examples.

According to the authors of paper 15, the parallel vertical streaks they discovered on the queen’s face (see Fig. 2) are not wrinkles on the surface of the inner limestone core, but veins in the natural stone. However, true veins in natural stone are distributed rather chaotically and do not form a layered cylindrical structure. In fact, the layered structure observed on the vertical slice is, of course, not veins at all, but rather the result of the circular stirring of a thickened mixture that had been poured into the mold.[3,4] The layers twisted into circles and spirals are clearly visible in Fig. 3. It is quite obvious that natural limestone cannot possibly have such a structure – especially one located almost exactly in the center of the crown.

Even if we assume that we are dealing with some absolutely unique natural stone with layered cylindrical veins, no sculptor would ever choose it as the core for his sculpture. The point is that there is no guarantee that such a stone will not fall apart during mechanical processing.

The authors of works 13 and 15 studiously ignore the structure consisting of layers twisted into circles and spirals – a structure that clearly indicates casting – and refuse to see it even when it



(a) (b)

Fig. 3. X-ray tomographic slices of the crown in the horizontal plane. The tomograms clearly show a structure consisting of concentric circles and spirals. Furthermore, the center of the structure is located almost exactly in the center of the crown. It is obvious that the observed structure is not characteristic of natural stone and was formed by circular stirring of the already partially set concrete-like mixture inside the casting mold. This figure reproduces (a) Fig. 2c from Ref. 13; (b) Fig. 9 from Ref. 15.

is staring them right in the face. And it is understandable why. The ancient Egyptians neither produced sculptures consisting of a core and a shell, nor did they cast sculptures from artificial stone (concrete). Thus, the detected feature is irrefutable evidence that Nefertiti's bust is a fake.

To make the structure consisting of layers twisted in circles and spirals (see Fig. 3a) less conspicuous, the authors of work 13 showed not the entire horizontal slice of the crown, but only the part where this structure is least pronounced. To make the layered structure less obvious, the authors of work 15 demonstrate the change in material density within the crown by taking a vertical slice of the tomogram at the edge of the structure (see the horizontal line indicating the cut location in Fig. 3b; the section itself is shown in Fig. 10 of work 15), where the structure is only weakly manifested. The X-ray images presented in both articles are of very low quality (compared to what CT method can provide), which is a typical sign accompanying all cases of concealment and falsification.

It should be noted that the absence of any scale bars on the X-ray images presented in Ref. 15 makes it impossible to assess the physical dimensions of the observed elements of the bust. In general, work 15 looks like an attempt to cover up a number of unwelcome discoveries that slipped into the documentary "Nefertiti's Odyssey"[14] (ZDF television network, 2007) and article 13 due to misunderstanding and/or oversight. Currently, the documentary film "Nefertiti's Odyssey" has been removed from the Internet; instead, a "corrected" version titled "The Mystery of Nefertiti's Bust" is being shown.

5. The one-eyed symbolism reveals the commissioner of the forgery

What else gives away the fact that Nefertiti's bust is a fake and of recent origin? Studies conducted by German scientists using X-ray tomography showed that the queen's left eye socket originally contained no eye.[13] The point is that, unlike the right eye socket, the left one lacks the necessary base at the bottom to hold the eye in place. Thus, what we see here is nothing more than a demonstration of one-eyed symbolism – the Eye of Horus.

Many will say: well, everything is fine – ancient Egypt, the pharaoh's wife, the ancient Egyptian god Horus and his Eye – so what's the problem? The problem is that, among all the ancient

Photo. 3. Head of a queen (Neues Museum, Berlin). Height×width×depth: 29×14.9×16.5 cm. Material: quartzite. Composite sculpture. A crown was meant to be placed on the square tenon. Note the thickness of the ears. Photo by S. Steiß, smb.museum.

Egyptian monuments discovered so far, there are no sculptures or bas-reliefs that were originally conceived and executed with an empty left eye socket. Apparently, the commissioners behind the creation, covert insertion, and subsequent promotion of this “masterpiece” are those who have actively employed similar symbolism in contemporary history. And this is one of the reasons to question whether what we have before us is really the bust of the personage whom everyone collectively refers to as Nefertiti.

The Egyptian land is generous and rich; I am sure it will give birth to similar statues for us again and again – both with normal eyes and with no eyes at all. Once this source of “antiquities” appeared, it will never run dry. Now it’s clear whose ears are sticking out behind all this farce.

6. When the ears speak for themselves

The queen’s ears (see Photo. 1) should be completely absent from the concrete core. Otherwise, given that the plaster shell consists of two 2-mm-thick layers, the ears on the core would have to be made extremely thin. Compare the thickness of Nefertiti’s ears with the thickness of the ears on other ancient Egyptian stone sculptures. Even the sculptures from the same excavation (and of the same provenance) as Nefertiti’s bust have thick ears (see, for example, Photos. 3, 4).

To strengthen the ears, besides increasing their thickness, the stone material behind them was often left in place, the ears were “pressed” against the head, or they were made an integral part of the wig or crown. Most likely, there are depressions where the ears should be in the core of Nefertiti’s bust, similar to those seen in the sculptures in Photo. 5.[16,17] The depressions are needed to allow the ears of the cast shell of gypsum to hold better on the head.

The absence of ears on the stone core is confirmed by the X-ray image of the bust in Photo. 6a,

Photo. 4. Statue head of Queen Nefertiti (Neues Museum, Berlin). Height×width×depth: 24× 16×16.3 cm. Material: granodiorite. Composite sculpture. A crown was intended to be placed on the square tenon with noticeably rounded edges. Note the thickness of the ears. Photo by S. Steiß, smb.museum.

which, due to an oversight, inadvertently appeared in the documentary “Nefertiti’s Odyssey”. In the image, all elements of the stone core are visible except for the ears. This image completely refutes the conclusion of the authors of article 15 that there is no layer of gypsum plaster at all, and that instead only a thin, invisible priming coat intended for painting exists on the outside. If we follow these authors, then, taking into account Photo. 6a, it turns out that the protruding ears of the queen in Photos. 1 and 2 are precisely that thin, invisible layer of primer?

The X-ray image of the bust in Photo. 6a is completely inconsistent with that in Photo. 2. Although in both cases it is the same limestone core, the former has no ears, while the latter has them in place. The point is that the X-ray image in Photo. 2, despite the assurances of the authors of article 13, does not correspond to the image of the core surface. The actual surface of the core is located somewhat deeper. That is precisely why the plaster ears are still present in this image.

But then why do we see a rough surface – grooves on the cheeks and other “wrinkles”, you may ask? The point is that these irregularities of the core simply show through the plaster shell layer, which is more transparent in the X-ray range. They show through in exactly the same way as the coarse striations of the core show through the thin outer shell in the case of the bust of Ramses II[7] under ordinary light. It seems that due to the complex, highly developed interface, the software used in the tomograph has not quite correctly separated the shell from the core here.

In Photo. 6b, not only are the ears missing, but also the ear canals, whose depth noticeably exceeds the declared 2 mm shell thickness. The depth of the canals, and consequently the thickness of the gypsum shell in this part of the sculpture, is probably at least 1 cm. From this fact it follows that the X-ray image shown in Photo. 6b corresponds to the internal virtual surface of the stone core, located deeper than its rough real surface. That is precisely why we do not see

(a) (b)

Photo. 5. Examples of sculptures in which the stone core has noticeable depressions at the ear positions, allowing the ears to be more securely attached to the head. (a) Bust of Prince Ankhhaf (The Museum of Fine Arts, Boston). Height: 50.5 cm. Material: limestone covered with a layer of plaster. (b) Head of an Osiride statue of Hatshepsut (Metropolitan Museum of Art, New York). Height: 22 cm. Material: limestone. Photo from (a) mfa.org, (b) metmuseum.org.

deep grooves (“wrinkles”, see Photo. 2), but rather observe internal inhomogeneities of the artificial stone and traces of circular stirring of the setting concrete mixture of the core, as shown in Fig. 2.

Photo. 7 shows a stone specimen of Nefertiti’s head[18] in which ears are not provided for at all (yet another miraculous find by the same German archaeological expedition). Here, apparently in order to improve the preservation of the ears, they were planned to be made as an integral part of a separately fabricated wig or crown. Perhaps the sculptor simply lacked the skill to make a proper wig or crown; perhaps the forgers thought that it would suffice as it was. As a result, the “beauty” remained forever earless and with a stub on her head.

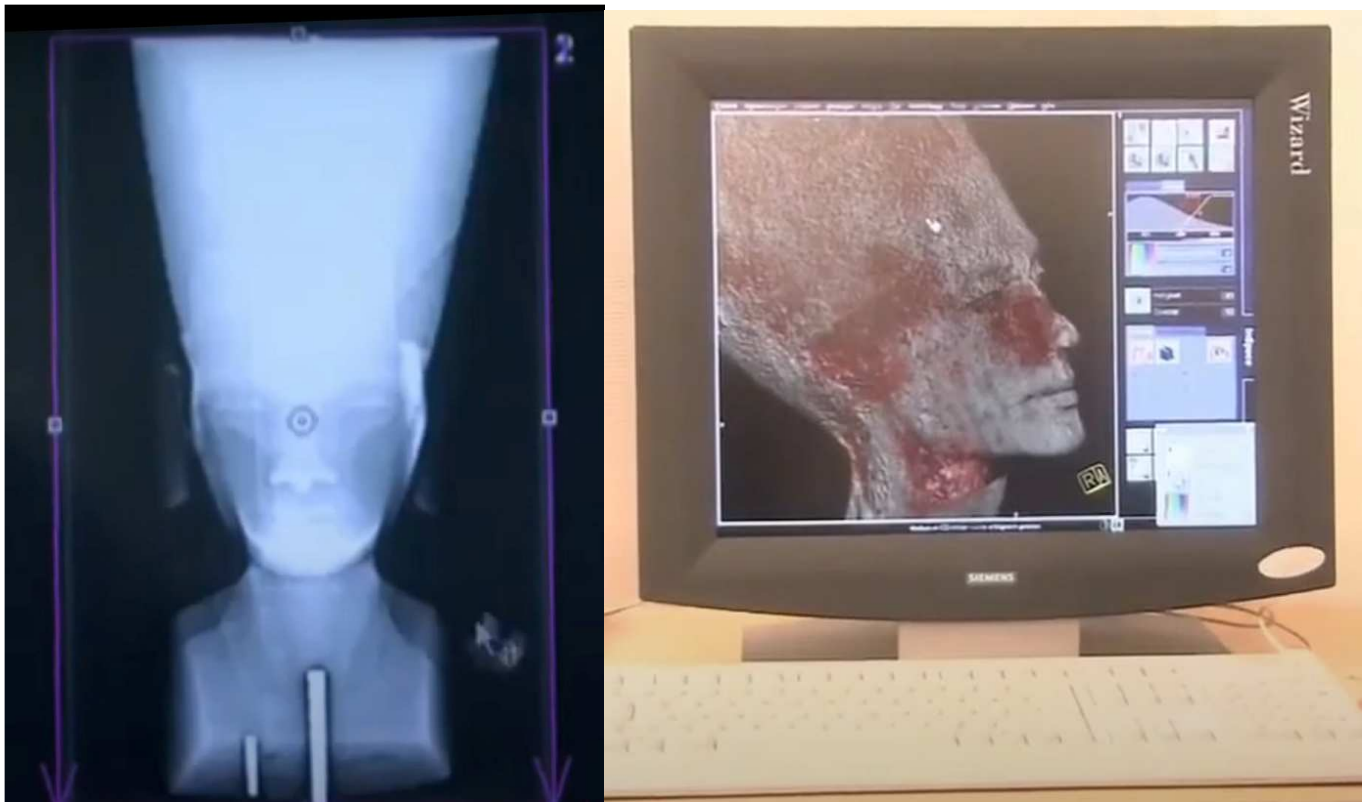
When examining the heads in Photos. 3, 4, and 7, do historians, archaeologists, and art historians really not see that the objects from the so-called workshop of the sculptor Thutmose[5] are modern sculptures!?

7. Another inconsistencies from the German scientists

According to the conclusions of article 13, the sculptor manually applied a 1-2 mm layer of gypsum plaster to the face over a roughly worked stone core. On the other hand, according to the estimate made above, the degree of facial asymmetry does not exceed 2 mm. It turns out that the degree of facial asymmetry and the thickness of the gypsum layer are comparable. It is clear that in this case it is very difficult to achieve a symmetrical face without exposing the stone core in some places. So, how did the sculptor manage to achieve symmetry and completely cover the core with a layer of plaster at the same time? If we set aside the impossibility of hand-modelling with gypsum, then this would be possible at least only if the plaster layer on the face were several times thicker than the declared thickness.

It should be noted that the 2 mm thickness of the plaster layer on the face claimed in article 13 is not confirmed in any way by the X-ray CT scans presented in that article. Firstly, there is no proper contrast between the plaster layer and the core on these scans. Secondly, no scale bar is provided. In this connection, it is completely unclear how the reviewers of the article could have failed to notice such obvious oversights by the authors.

In the documentary “Nefertiti’s Odyssey”, the thickness of the plaster layer is reported to be several centimeters. However, it is not entirely clear which part of the bust is being referred to.



(a) (b)

Photo. 6. Images of the inner limestone core obtained by X-ray CT method. (a) But where are the ears? The absence of the ear canal in image (b) indicates that the thickness of the gypsum shell in this area of the bust is several times greater than the declared 2 mm. Frames from the documentary “Nefertiti’s Odyssey”, ZDF television network, 2007.

As noted above, gypsum is not suitable for the precision modeling of three-dimensional objects; therefore, casting remains the only option. For a bust of this size, the casting would still remain a precision process even if the shell were several times thicker than the 1-2 mm specified in article 13.

It should be understood that even a slight misplacement of the cast core inside the casting mold for the thin shell will cause the rough core to protrude beyond the boundaries of the finished product’s external shell. In light of the above, it is utterly inconceivable that precise casting, an original symmetrical model, concrete for the core, geometrically similar casting molds for both the core and the shell, low-shrinkage materials for these molds, and a suitable non-shrinking gypsum mixture could have been created and used in Ancient Egypt.

8. Were the ancient Egyptians capable of creating composite sculptures?

Let us consider Nefertiti’s heads made of quartzite and granodiorite (see Photos. 3, 4, 7). The heads of the first two sculptures feature tenons with a square cross-section and rounded edges, while the tenon on the head of the third sculpture is circular in shape. The tenons are designed to attach a headdress (crown) or a wig, which in turn have corresponding matching recesses (mortises). Besides the tenon protruding from the parietal region, the first two sculptures have curvilinear recesses at the temples, which, together with the remaining upper part of the head, form a mounting surface of complex curvilinear shape.

Despite a search conducted among the holdings of the British Museum, the Louvre, the Neues Museum in Berlin, the Cairo Museum, the Museum of Fine Arts in Boston, the Metropolitan Museum of Art in New York, and the Egyptian Museum in Turin, no ancient Egyptian sculptures with a similar complex detachable (composite) design – unrelated to the fake workshop of the sculptor Thutmose in Amarna[3,4] – were found.

Sculptures with detachable parts require a high degree of fabrication precision to ensure a reli-

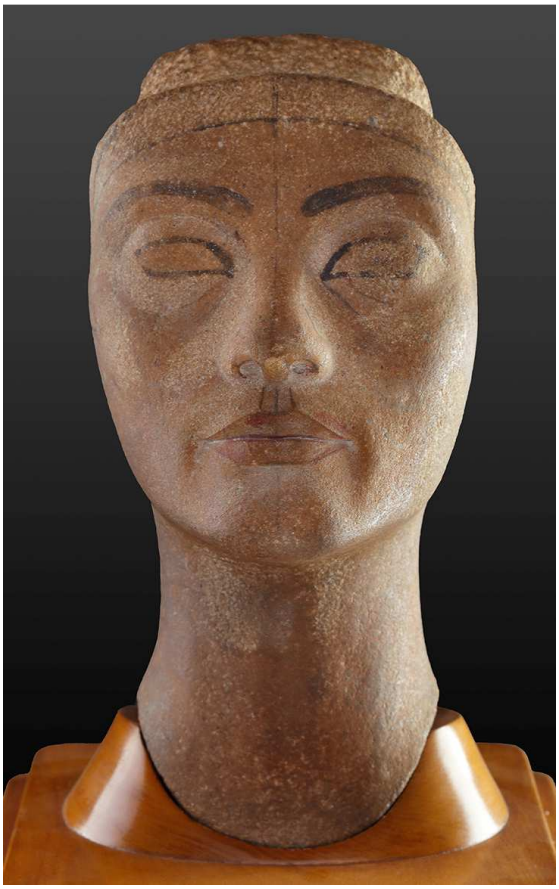


Photo. 7. Unfinished head of Nefertiti, Egyptian Museum, Cairo. Height: 35.5 cm. Material: quartzite. Composite sculpture. An upper part in the form of a wig or headdress was to be mounted on the round tenon. The missing ears were supposed to be hidden under the wig (or headdress) or to made part of it. Photo from egyptianmuseumcairo.eg.

able connection between the components, typically without the use of any adhesive. Moreover, the parts of such sculptures are joined and lapped together with such high precision that even an experienced sculptor is not always able to detect the separation line or understand how the sculpture is disassembled. Such a technique was complex and expensive even for the 20th century.

Therefore, it is not surprising that no suitable headdress (or wig) was found for any of the excavated heads. Moreover, the mounting surfaces on the heads themselves are too far from the required perfection. The sculptor-forger never dared to create any reasonably suitable crown or wig. It is possible that he lacked the necessary qualification; it is also possible that the fabrication process proved too expensive and labor-intensive for such a forgery.

Taking into account the high technical requirements for the final fabrication precision and the quality of the mating surfaces, the detachable sculptures under consideration cannot be attributed to ancient Egyptian art.

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