6 | The Birth and Second Life of the Minerva of Arezzo

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a

Conservation of the Minerva of Arezzo (figs. 6.1a–b) carried out at the Centro di Restauro of the Soprintendenza per i Beni Archeologici della Toscana, Florence, between 2000 and 2008 offered an opportunity to perform in-depth archaeometallurgical investigations. Thorough analyses were undertaken in order to characterize the statue's state of preservation, understand past restorations, and define the conservation methodology. Technical studies of the interior and exterior, X-radiography, and compositional analyses of the materials revealed several interesting features that shed light on the statue's creation as well as its later reassembly and integration. The results provide a significant contribution to the long-running debate regarding the dating of the Minerva, and present new data on ancient casting techniques as well as information about the restoration approaches of previous centuries.

b

FIGURES 6.1a–b. Minerva of Arezzo, 300–270 B.C. Bronze, H. 155 cm (61 in.). Florence, Museo Archeologico Nazionale (inv. 3). The statue is shown after study and treatment between 2000 and 2008.

Historical Note

The life-size Minerva of Arezzo was part of the famous collection of large bronzes owned by the Medici (the "grandi bronzi medicei"), which also included the Chimaera of Arezzo, the Arringatore (discovered in the environs of Lake Trasimeno), and the Idolino of Pesaro (all Florence, Museo Archeologico Nazionale). The statue was found during the digging of a well in 1541, near the church of San Lorenzo in Arezzo.[1] About a year later it was acquired by Cosimo I de' Medici and brought to the Palazzo Vecchio in Florence.[2] The statue was placed in the open, on the balcony over the *ricetto* of the rooms of Cosimo's Guardaroba until 1559, whereupon it was kept with other finds in the Scrittoio di Calliope (Cosimo's private study). Later on, however, in 1570, the Minerva was documented again in its previous location, where it may have been situated for a long time.[3]

Although there is no surviving documentation regarding this early phase of the Minerva's second life—that is, after it had been brought to light—we can reasonably assume that the statue was restored soon after it was discovered. This would have been necessary in order to remove deposits of earth, to assemble the twenty fragments of which the statue is comprised, and to integrate the missing areas of the lower part.

FIGURE 6.2. Drawing of the Minerva by Giuseppe Menabuoni (Italian, 1708–after 1745), line engraving by Antonio Pazzi (Italian, 1706–after 1768). From Antonio Francesco Gori, *Museum Etruscum*, vol. 2 (Florence, 1737), pl. XVIII

The Minerva is mentioned for the first time in the Uffizi Gallery's inventories in 1676, when the absence of its right arm is noted. This observation is repeated in the inventory initiated in 1704.[4] A reconstructed arm, made of gypsum, was added sometime in the eighteenth century. It is mentioned in the inventory of 1769,[5] but is likely to have been fashioned well before, since it is depicted in an engraving published by Antonio Francesco Gori in 1737 (fig. 6.2).[6] The arm is shown with the elbow and wrist bent, as if to support a lance—a posture iconographically suitable for the goddess.

In 1783, according to the inventory notes, the statue's right arm was missing once again. Two years later the sculptor Francesco Carradori (1747–1824) carried out what is believed to have been the statue's last structural restoration. He attached a new arm in bronze, whose form gave the figure an oratorical posture and strongly altered its overall appearance. The arbitrary oratorical attitude was likely motivated by display purposes, since it would have been considered more harmonious with the poses of the Arringatore and the Idolino. (In 1782 the antiquarian of the Uffizi, Luigi Lanzi, had moved the Minerva from the gallery's Corridoio di Ponente to the Corridoio di Mezzogiorno, where it was exhibited together with the other *grandi bronzi* of the Medici collection.) The sculptor also added the missing part of the snake on the helmet in metal. Since the part is visible in the eighteenth-century engraving mentioned above (see the lateral view of the helmet in fig. 6.2), it might previously have been modeled in gypsum, wax, or another such material. From 1785 to 2000 the Minerva of Arezzo appeared as shown in figures 6.3a and 6.3b.

Attribution and Dating

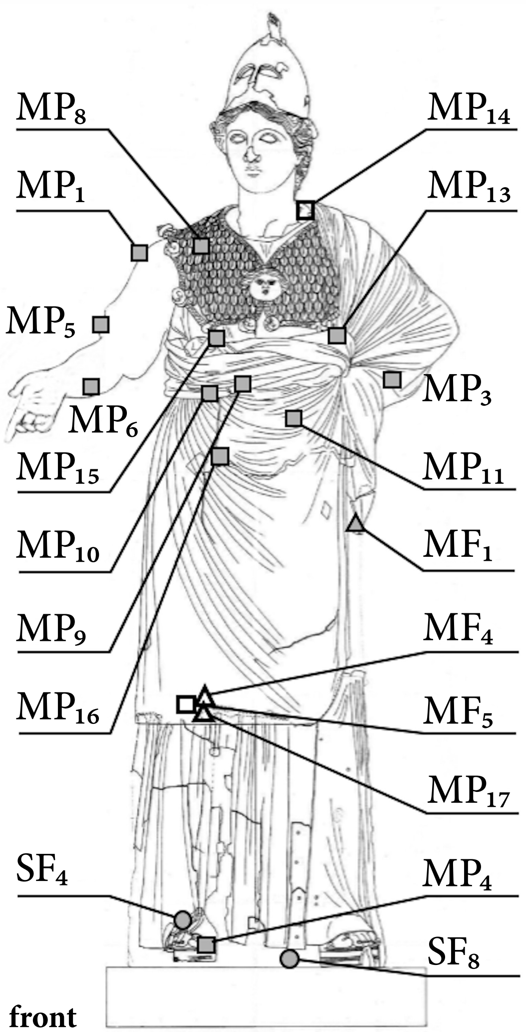
The documents that describe the discovery of the figure report that it was found in an area with a mosaic floor. This archaeological context was interpreted as a temple of Pallas Athena, and the sculpture as a representation of the goddess.[7]

In the second half of the eighteenth century the Minerva of Arezzo was considered, on stylistic grounds, both an ancient Greek sculpture (by Johann Joachim Winckelmann)[8] and an Etruscan work (by Luigi Lanzi).[9] However, since the end of the nineteenth century it has been associated with a group of replicas of the so-called Athena Vescovali, derived from an archetype attributed to Praxiteles (fl. 370–330 B.C.). The Vescovali group includes some thirty representations of the goddess.[10] All are in marble except the bronze Minerva of Arezzo, which has been referred to as a Hellenistic variation of the Praxitelean original.[11] Before the recent analysis and conservation, it remained unclear whether the statue is an original of such a type (dating to 280–270 B.C.) or a later Roman replica (datable to around the first century A.D.). Armando Cherici's study, based on archival documents and a careful examination of the results of an excavation campaign carried out during the 1930s near the church of San Lorenzo in Arezzo,[12] seems to

FIGURES 6.3a–b. The Minerva before the recent conservation project. Yellow dots: screws. Red dots: nail heads. White dotted line: upper border of area of missing ancient metal

support the latter conclusion. Furthermore, Cherici observed that from a stylistic standpoint the Minerva could not be dated before the first century B.C.[13]

The excavations in the 1930s brought to light a Roman domus[14] whose context includes a well, which was still in use up to recent times. These and other elements led Cherici to consider a close association of the site with the one in which the Minerva was discovered in 1541, and hence to attribute the statue to the pre-imperial era. In such a context the Minerva could be considered an ornamental object from a rich Roman house rather than a religious statue. However, opposing hypotheses have been formulated, such as the proposal of Luigi Adriano Milani, who interpreted the hole at the back of the head as a functional element whereby the statue was used as an oracle,[15] and the stylistic analysis by Renate Kabus Jahn and Tobias Dohrn, which dates the sculpture to the first decades of the Hellenistic period.[16] The catalogue of the 2001 exhibition in Arezzo, *Etruschi nel tempo: I ritrovamenti di Arezzo dal '500 ad oggi,* suggests a dating on stylistic grounds between the second and first centuries B.C.[17] However, the studies carried out during the recent conservation work opted for a date around the first decades of the third century B.C.[18]



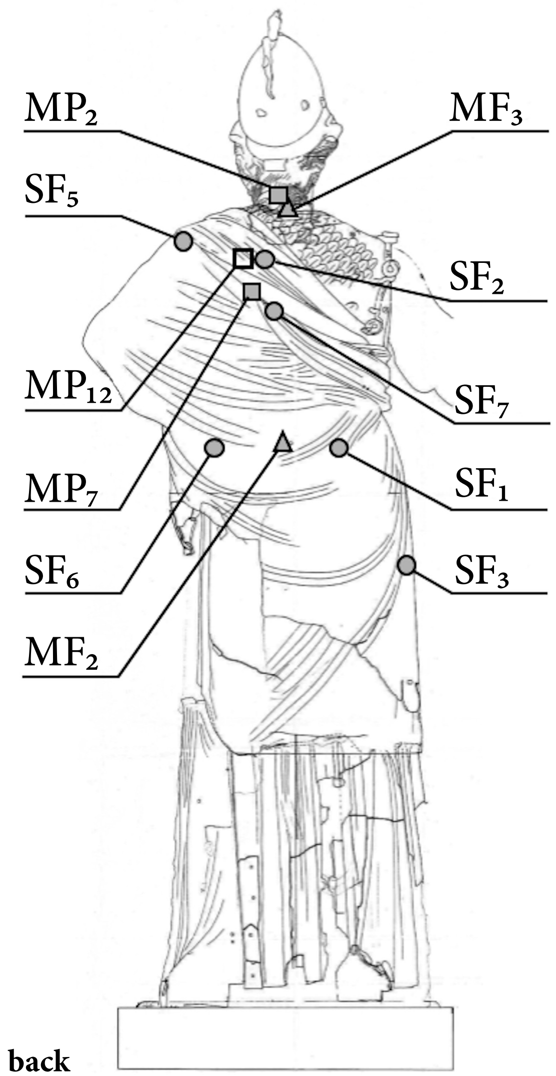


FIGURE 6.4. Locations used for material sampling

Methods of Study

The decision to study and conserve the Minerva of Arezzo was motivated by the need to perform an overall static consolidation of the sculpture, along with the removal of unstable materials used in previous restorations. At the outset of this project it had not been decided whether Carradori's eighteenth-century integrations should be removed.

The statue was thoroughly studied through technical examination, X-radiography, and compositional analysis. X-radiographic investigations were carried out both before conservation work began (in order to document the structural interventions in previous centuries) and after the many pieces composing the statue were dismounted (to assist in interpreting the means by which the statue was made in antiquity).

The modern patinations of the sculpture were analyzed using optical microscopy, scanning electron microscopy with energy dispersive X-ray (SEM-EDX), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and gas chromatography, while the chemical analyses of the alloy were achieved by means of atomic absorption spectroscopy and SEM-EDX with wavelength dispersive X-ray spectroscopy. Several material samples were also taken from the figure, including stratification fragments (SF_n), metal fragments (MF_n), and metal burr (MP_n) produced by means of a microdrilling device, collected from the sites indicated in figure 6.4.

A report on the main features of the state of conservation before the recent intervention follows, providing information about the different restoration approaches of the sixteenth and late eighteenth centuries. The essay then focuses on the interpretation of the peculiar casting and assembling procedures used to craft the Minerva in antiquity.

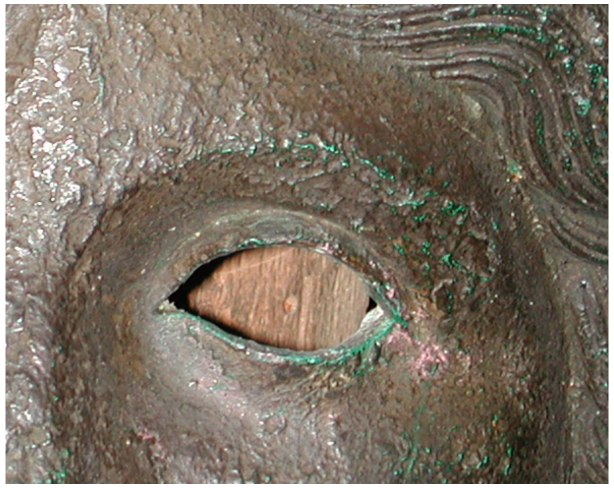


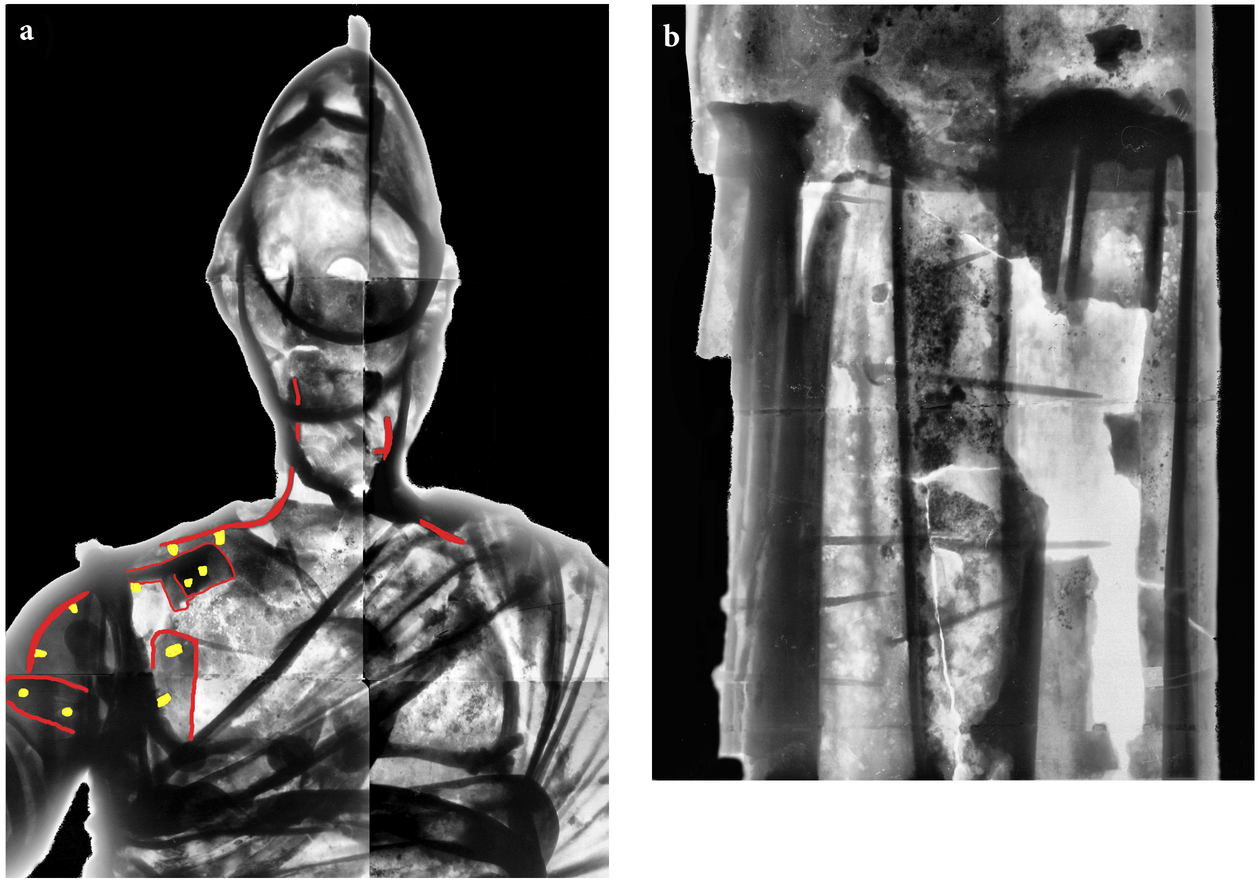
FIGURE 6.5. Detail photograph taken before disassembly of the statue, showing the internal wood support visible through the aperture of the left eye, along with details of the dark brown surface

State of Conservation

Before the conservation project began in 2000, the lower part of the Minerva was a reconstruction, made using stucco (lime, sand, and organic fibers), gypsum integrations, and organic filling (as is arguable from some whitish areas, which are visible in figs. 6.3a, 6.3b). In particular, the ancient metal was missing in a large area of the back, below the pelvis (see the white dotted line in fig. 6.3b).

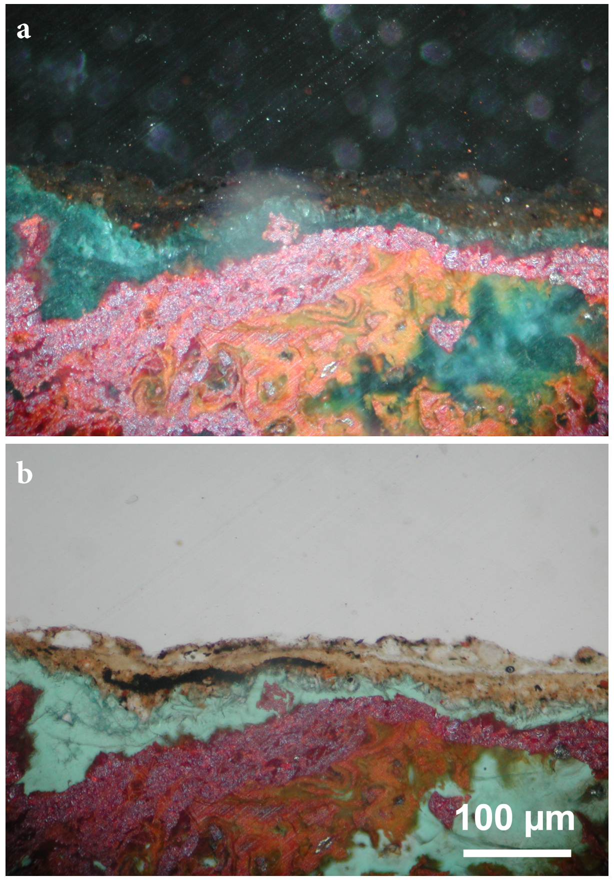
The preliminary visual inspection and radiography indicated that the statue was composed of a number of pieces assembled on an internal wood support—visible through the apertures of the eyes (fig. 6.5) and the hole at the back of the head. The radiographic images show the mounting of the head and right arm by means of iron sheets and screws (fig. 6.6a), along with the connection of the many fragments of the lower part to the wood support using square-sectioned iron nails of different sizes (fig. 6.6b).

The longest nails were used to consolidate and support the whole figure and the largest fragments, while shorter nails carefully fixed some of the smaller fragments. At the top of the left thigh, two large nail heads that passed through a large transverse fracture on the front were also visible to the naked eye.



FIGURES 6.6a–b. X-radiographs (negative rendering) of the upper (a) and lower (b) parts of the sculpture. In figure 6.6a, iron sheets and screws are highlighted in red and yellow, respectively.

The outer surfaces of the Minerva appeared to be almost uniformly coated with dark brown patinations (see figs. 6.3a, 6.3b, 6.5), which were applied during restorations following the statue's discovery. On the back, significant hard earth concretions were still present (see fig. 6.3b), with a thickness of up to approximately one centimeter in the folds of the himation. These indicate that the cleaning operations carried out on the back soon after the discovery were relatively light in contrast to those on the front. Such a disparity was likely motivated by display considerations: Renaissance artists usually left unfinished the rear of statues to be exhibited in niches or up against a wall.



FIGURES 6.7a–b. Metallographic cross sections under reflected light showing representative stratigraphy of a corroded bronze surface with two superimposed patination layers (6.7a: black field; 6.7b: bright field)

The stratigraphies of the SF_n samples taken from the metal revealed the presence of at least two patination layers of similar composition, including gypsum, silicates, calcite, and calcium oxalates in an organic binder, along with ocher and black carbon pigments, to achieve the dark brown appearance (figs. 6.7a–b). Further indications of multiple applications were obtained by analyzing the surface finish of the wood base, where patinations were sometimes separated by gypsum layers. Figure 6.8a, for example, is a cross-section detail of the sample SF_8, taken from the restored base, showing two similar brown patinations separated by a white gypsum layer. At the outermost level a thin whitish wax layer is also recognizable.

Gas chromatography and FTIR of a powdery sample collected around the site of SF_8 by scraping demonstrated that the binder used was linseed oil. The analysis also indicated the presence of spermaceti and beeswaxes, likely used for polishing. Others who have studied the Minerva have also pointed out the presence of colophony,[19] though it was not found in the sample directly analyzed by us.

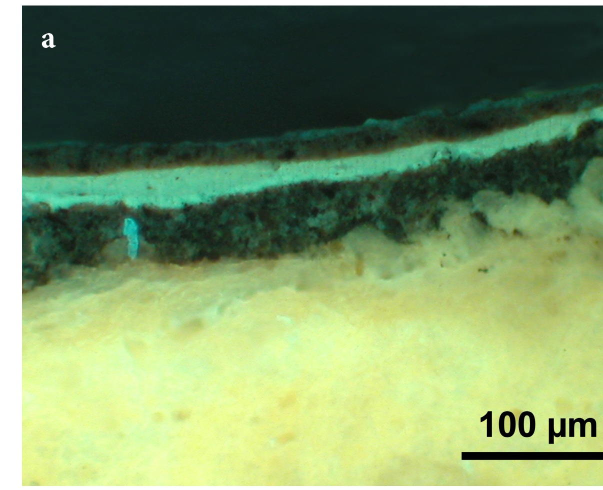


FIGURE 6.8a. Cross section of the sample SF_8 (from the base) showing two main patination layers separated by a gypsum layer

It is worth noting that, apart from some differences among the relative component fractions and binders, this type of coating, which is commonly known as bronzelike patination,[20] has also been found on Florentine marble and bronze masterpieces of the Renaissance, such as the *Quattro Santi Coronati* by Nanni di Banco (church of Orsanmichele),[21] the *David* by Andrea del Verrocchio (Museo Nazionale del Bargello),[22] and the *David* by Donatello (Bargello).[23] The first explicit reference to such organic-binder patination has been found in archival documents of the eighteenth century.[24]

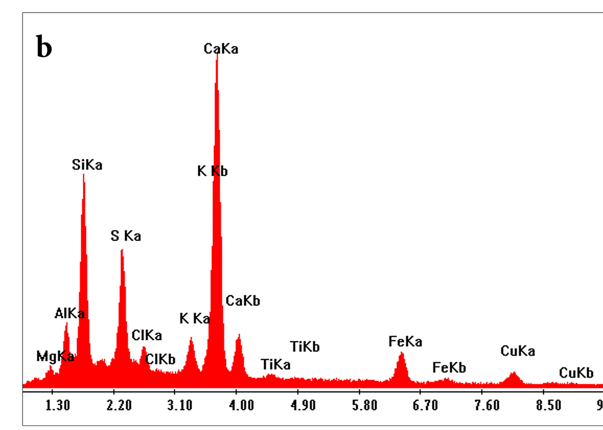


FIGURE 6.8b. Representative EDX spectrum of the patinations

The patination and waxing layers were separated from the metal substrate by earthy concretions and mineral deposits, which indicates that they had been applied to a surface that had not been fully cleaned. As clearly shown by optical and SEM-EDX examinations (fig. 6.8b), encrustations were mainly of calcite (calcium carbonate), with some incorporated sand (silicates). A significant amount of lead was found in the corrosion layers above the ancient metal substrate, and was identified by XRD as cerussite, along with quartz, calcite, aragonite, and malachite. In a backscattering electron microscopy cross-section detail of the sample SF_2, taken from the back of the sculpture (fig. 6.9), the lead distribution is evidenced by the white spots. Similar features were found in other cross sections, as well as in some metallographic samples including encrustation layers.

The bronze substrate preserved beneath the patination and encrustation layers was moderately to heavily corroded, corresponding to the level of surface mineralization, which ranged from tens to several hundreds of microns in thickness. Figures 6.7a–b represent a case of heavy corrosion. Besides such heavily corroded areas (which allowed for the recognition of only a rough trace of the original surface), better-preserved areas were also identified, such as in figure 6.10 (MF_2 was the only sample taken by coring), which exhibits a thin oxidation layer and low chlorine content. These factors may have inhibited further corrosion. For this and the other metal fragments investigated here, typical bulk corrosion phenomena usually encountered in ancient bronzes were also observed, with an apparent predominance of intergranular and interdendritic corrosions.

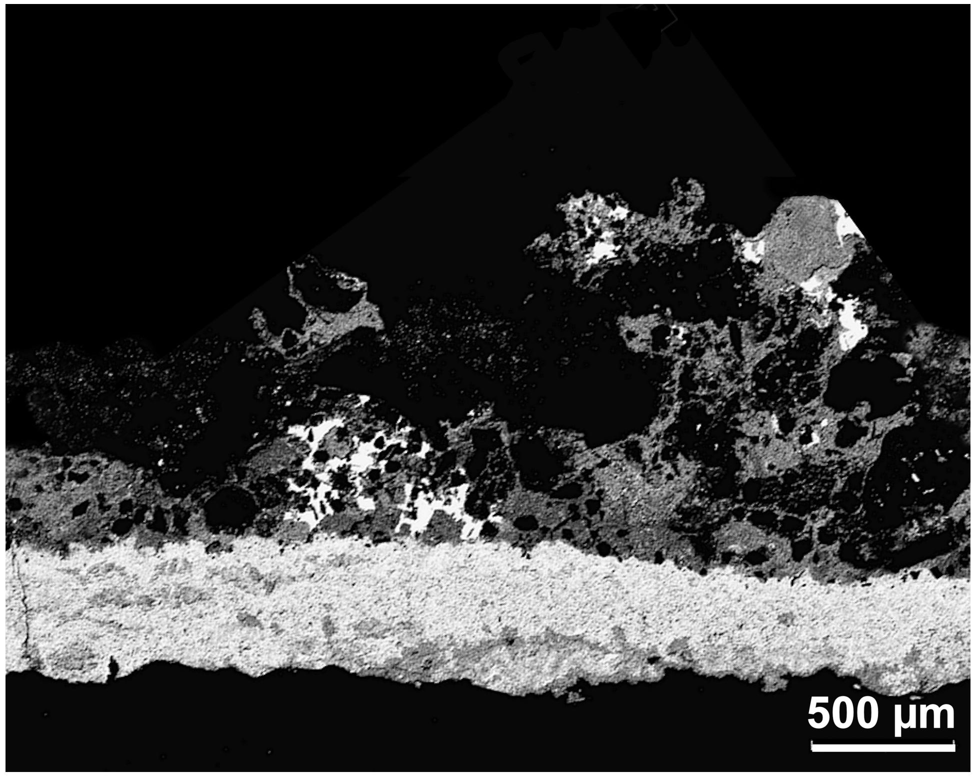


FIGURE 6.9. Cross section (SEM, backscattering) of a mineralized metal sample (from the back), with earthy concretions (SF_2) embedding lead minerals (white spots)

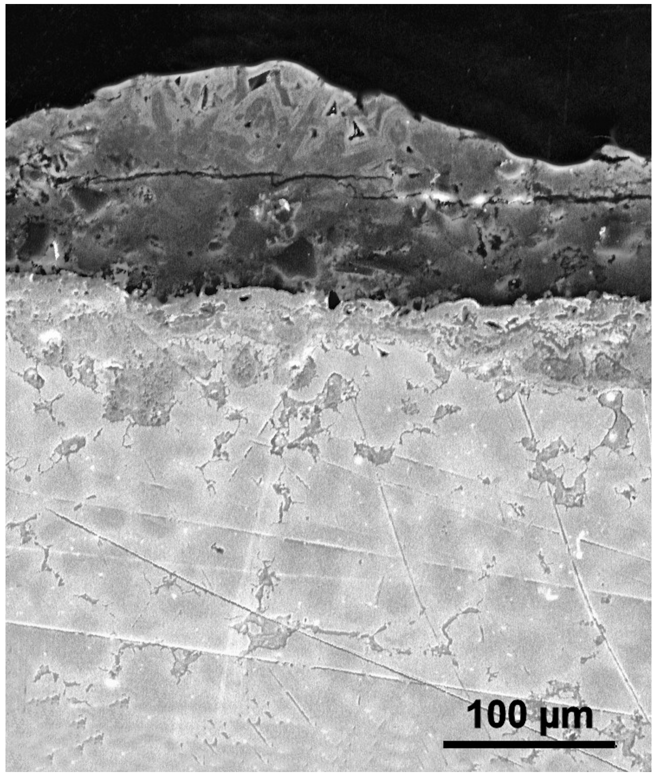


FIGURE 6.10. Cross section (SEM) of the sample MF_2 showing moderate surface corrosion under the earthy concretion

FIGURE 6.11. Preliminary cleaning treatment carried out by the conservators Renzo Giachetti and Manuela Nistri

Dismounting the Minerva and Uncovering the Surface

The structural and analytical investigation summarized above helped to define the conservation of the Minerva of Arezzo, which included the removal of the historical patinations and the stucco integrations, together with the replacement of the internal wood support. Tests to uncover the surface began during the first half of 2001, while the dismounting started in the second half of 2002, following the decision to remove the right arm (it was still not yet decided whether this would ultimately be remounted).

Mechanical and laser ablations along with a chemical treatment were used to remove the earthy encrustations and patinations. These were mainly carried out before the disassembly of the many fragments (fig. 6.11), but the final refinement was performed on single pieces subsequent to their dismounting, primarily with a scalpel. Concurrent with the early cleaning treatments, the ancient fragments were gradually set free from the restorers' stucco and nails (figs. 6.12a–d).

During the disassembly it was noted that those who had restored the sculpture in the past had fitted the fragments together with a high degree of accuracy. This was true even for some pieces only a few centimeters in size that constituted the folds of the peplos and the lower border of the left side. Figure 6.13 displays all the fragments (apart from head and bust), with the numbering used during the conservation project. The circles mark the holes through which the nails were inserted in the wood core.

The dismounting of the head and right arm was more complex, since they were firmly fixed with four iron sheets and fifteen screws. In particular, the head was secured with two L-shaped lateral iron sheets connecting the neck to the shoulders, while the right arm was anchored to the right shoulder and scapula by means of two almost orthogonal T-shaped iron sheets, as seen in figure 6.6a. They were dismounted by removing the screws after drilling them through, as shown in figure 6.14.

FIGURE 6.13. 2000–2008 project: fragments dismounted

FIGURE 6.14. Right arm with screws removed, and detail of one of the screws

FIGURES 6.12a–d.
(a) Uncovering of the mineralized bronze surface from the dark patinations in the area of two large nails at the top of the left thigh.
(b) Early phases of the removal of stucco integrations in the area of the right foot.
(c, d) Examples of a fragment of the himation set free from the stucco integrations and nails.

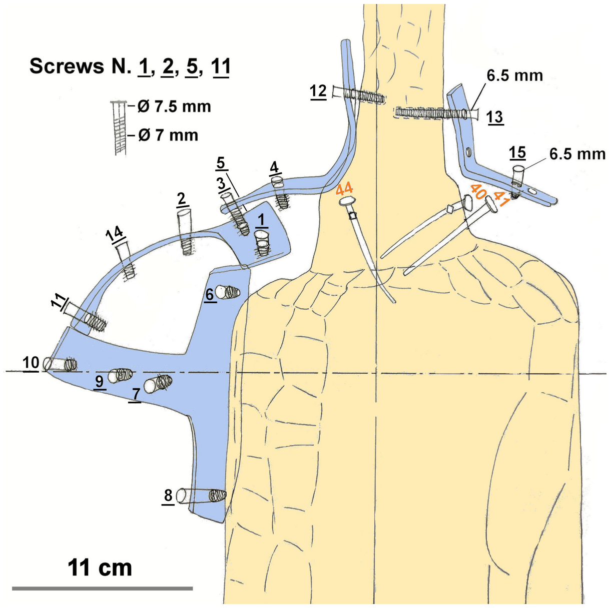


FIGURE 6.15. Supports of the head and right arm made by Francesco Carradori

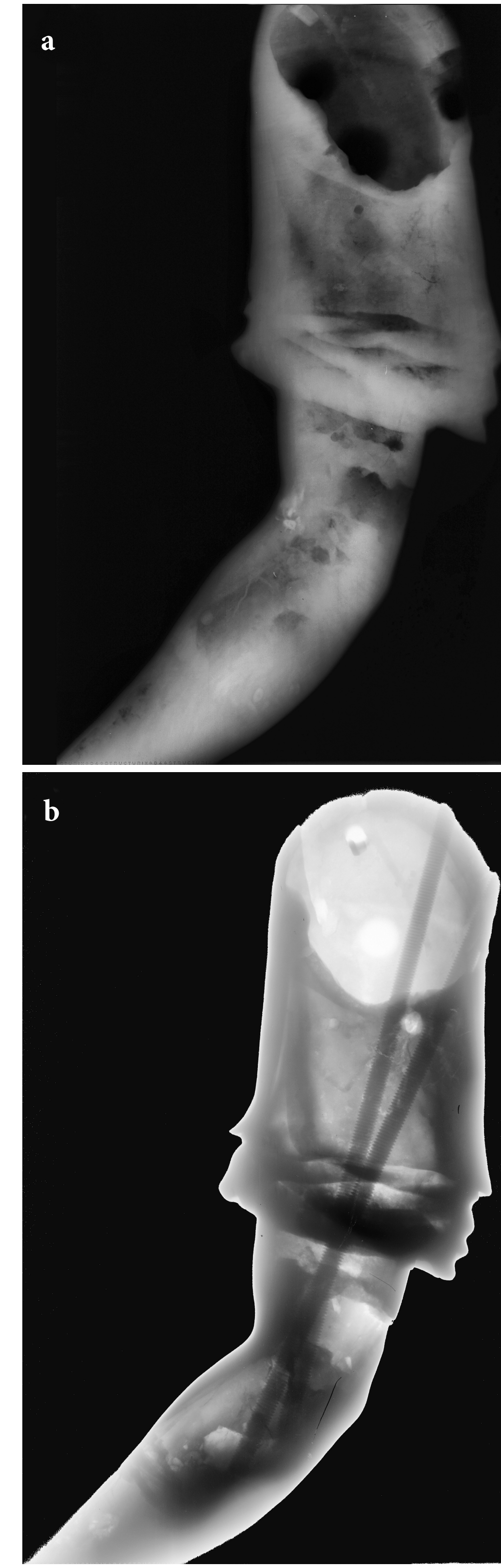
These screws did not penetrate the internal wood support. Conversely, the two horizontal screws that secure the neck also entered through the upper part of the wood core. The drawing in figure 6.15 precisely documents the shapes and sizes of the two supports made by Carradori. As mentioned above, he also added the part of the snake on the helmet that was missing. This was directly screwed onto the helmet.

The whole sculpture was thus completely dismantled and its original surfaces carefully uncovered. Figures 6.16a–b display the exposed wood support (which was identified as linden wood)[25] with the iron sheets, and figure 6.16c shows thirty-two of the forty-four nails extracted. Fifteen of the nails were fixed through the metal wall, while the remaining twenty-nine were fixed around the edges of the fragments, supporting rather than passing through them.

The right arm added by Carradori was carefully studied in order to interpret the method of its production. Figures 6.17a–b are two radiographic plates made after the arm was dismounted. Figure 6.17a features the arm alone, while figure 6.17b shows it with two lengths of thread rod that had been inserted into the hollow to demonstrate its extent. They indicate that the cavity extends to at least the middle of the forearm. The thickness of the metal wall is highly variable and the inner surface profile differs with respect to the outer one. Furthermore, two round internal thickenings are clearly recognizable in the radiographic plates, just above the elbow and at the middle of the forearm.

All these features indicate that Carradori crafted the right arm in situ on the figure, in order to guarantee a perfect match between his new addition and the ancient shoulder. He then cast

FIGURES 6.16a–c. The Minerva's internal wood support (and Carradori's iron armatures for the head and right arm) and main stucco integration (a–b); thirty-two of the forty-four fixing nails extracted during the dismounting of the sculpture (c)



FIGURES 6.17a–b. X-radiographs of the right arm

the arm using a direct lost-wax casting procedure. Its hollowness suggests that the wax was modeled onto a core that was later removed. The arm's textured surface, visible in figure 6.14, was not created post-casting but modeled in the wax. A powdery green color was present upon cleaning of the dark patination, suggesting that even this eighteenth-century addition had undergone natural corrosion.

One more important observation concerns the assembly of the front fragments of the peplos. As displayed in figures 6.16a–b, the wood support was carefully modeled before the metal fragments were fixed on it. In particular, a long vertical groove was hollowed out and four small wood strips were nailed on in order to fit precisely with the main folds of the peplos. Finally, the space between the metal and wood, as well as the spaces between the wood strips, was mostly empty, apart from small quantities of stucco that had entered during past restorations. All the structural features of the Minerva before the recent intervention are summarized in figure 6.18.

I will discuss in more detail below the differences in approach between Carradori's restoration and the previous mounting of the many fragments on the modeled wood shaft. Before doing so, however, I will consider the means by which the Minerva was produced in antiquity.

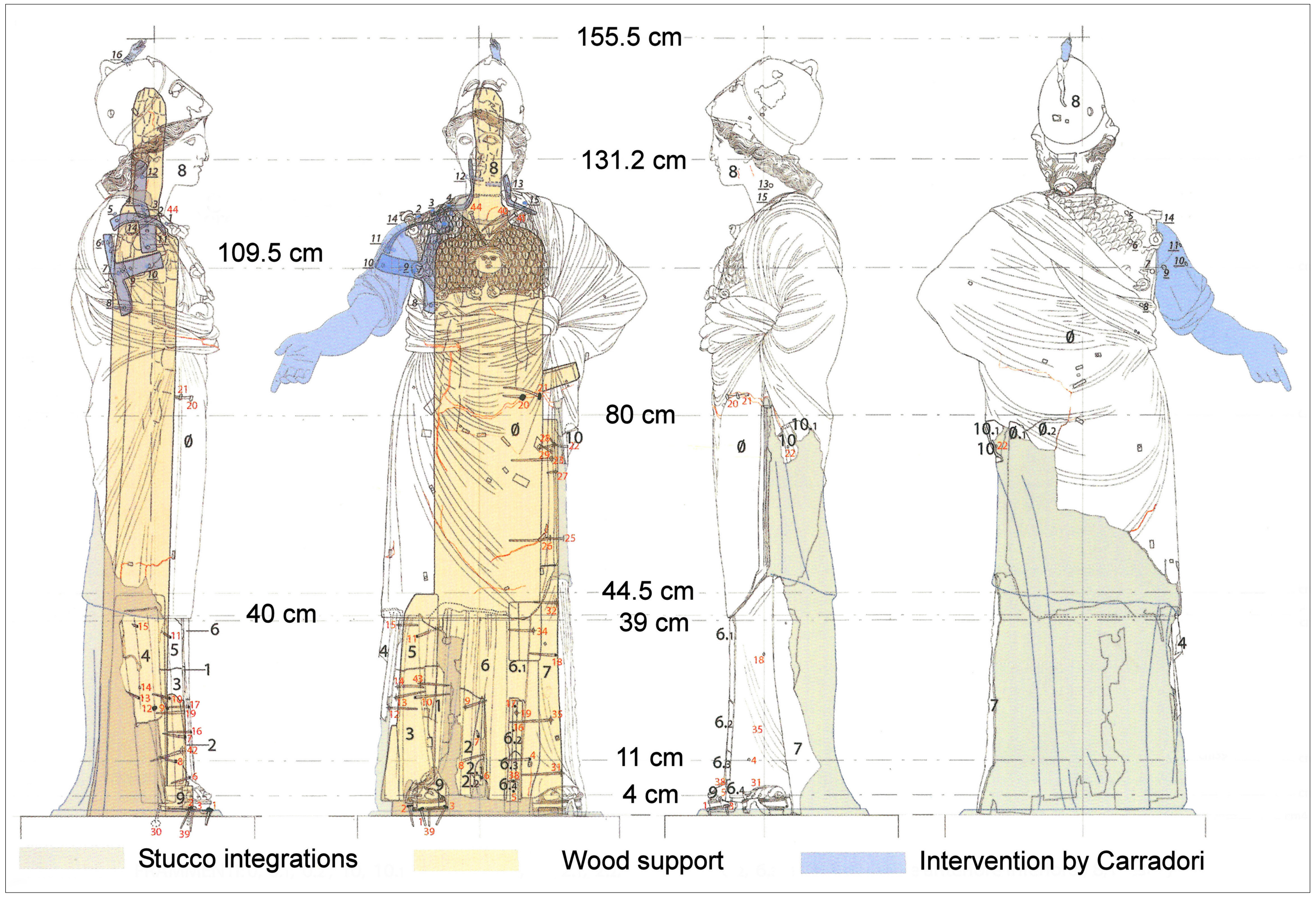


FIGURE 6.18. Plans including all the elements of the Minerva's assembly before the recent restoration. Fragments: bust, 0, 0.1, 0.2, 10, 10.1; head, 8; peplos, 1, 2, 2.1, 2.2, 3, 4, 5, 6, 6.1, 6.2, 6.3, 6.4, 7, 9
Nails: 1–44. Through holes drilled in the bronze walls: 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 22, 38
Screws: 1–16
Adapted from Marida Risaliti, "Documentazione grafica," in *La Minerva di Arezzo*, ed. Mario Cygielman (Florence, 2008), p. 134

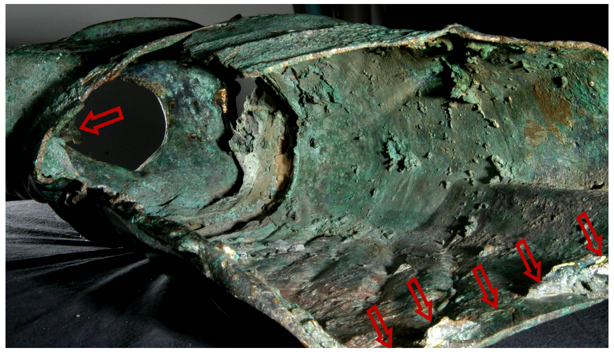


FIGURE 6.19. Inner surface of the bust. Arrows indicate hard brazing zones.

FIGURE 6.20. 2000–2008 project: early phase of intervention on the lower part of the peplos

Interpreting the Processes of Manufacture

Visual observation of the surfaces provided a great amount of information regarding the production of the Minerva. Much was revealed about two fundamental aspects in particular: the assembly of the separately cast pieces, and the preparation of the waxes.

Assembly

As noted, the Minerva consists of twenty ancient parts: head, bust, fourteen fragments composing the peplos from the knee to the feet, and four small fragments of the himation at the level of the upper part of the left buttock (numbered 0.1, 0.2, 10, and 10.1 in figs. 6.13 and 6.18). The height of the statue was about 151 centimeters, and this remained almost unchanged after the reassembly undertaken during the recent treatments. The sculpture is a hollow lost-wax casting, with relatively thin metal walls, the representative thickness of which varies between 2 and 6 millimeters. The total weight of the original fragments is about 49.5 kilograms.

Two hard brazing zones are clearly recognizable on the interior surface of the bust (see arrows in fig. 6.19). These extend to the vicinity of the neckline and the lower margin of the himation at knee level. They suggest that the figure was cast in three separate parts, which were then joined together: the head with the neck; the part between the neck and the knees (fig. 6.19), hereafter referred to as the bust; and the lower part of the sculpture (the drapery of the peplos and the feet shown in fig. 6.20).

Of these three parts, only the head was found to be from a single casting. Copper lips, and eyes (and probably eyelashes) of a nonmetallic material, were likely applied, in accordance with what has been observed for other large Greco-Roman bronzes.[26] It was not possible to confirm whether there was a break along the ring that binds the hair on the nape (which would have implied that a final lock or suchlike is missing); most of the surface of the ring seems to be finished rather than broken.

The peplos and the bust bear evidence of independent castings and metallurgical joining. These casting traces and joins are located on a large part of the band of drapery that extends around the figure's waist and shoulders, as well as on a few fragments of linear drapery below.

The identification of the traces of castings inside the bust is more complex. Particularly evident, however, is the cutting of the wax model at the level of the abdomen and on the back, where the band of drapery would subsequently have been anchored at several points.

Localized castings can be observed on the statue's interior, recognizable thanks to the presence of areas with characteristic oxidized macrodendritic structures produced by rapid cooling in the air. The most obvious is located just below the right armpit, and corresponds to an overhanging of the drapery with deep undercutting (figs. 6.21a–b). Another casting point is located behind the

FIGURES 6.21a–b. Housing area of the right arm (a) and a detail (b) of the corresponding inner surface indicated by the red dot

FIGURE 6.22. Gap in the drapery on the chest, lit from within

drapery. In these two cases, visual observation alone does not clarify whether these are joins or hot patches (that is, ancient repairs of casting flaws using molten bronze). Nonetheless, the joining of separately cast elements is evident. Several areas of the himation are not fully attached to adjoining sections (see the deep undercuts of fig. 6.21a). This is particularly true of the most prominent fold of drapery that runs across the chest (from the left flank and upward to the right), where there are points of connection in the deep recesses of the folds, as well on the surface. To highlight this more clearly, the photograph in figure 6.22 has been taken by lighting the statue from within.

A similar situation can be seen in the drapery on the back. However, the corresponding form of the interior differs from what was seen on the chest. There are at least three or four castings of small quantities of metal that seem to have produced, to some extent, a leveling of the surface. In addition, it seems that at least two of the folds of the drapery have been cast separately and then joined.

Preparation of the Waxes

Visual observation of the interior of the Minerva suggests that the wax model used for casting the himation, peplos, and bust was created by assembling wax sheets. These were made to a preliminary thickness, then cut according to the various dimensions and shapes needed, and subsequently joined. The joins were mostly achieved by applying and spreading a strip of wax along the line of contact between the sheets. Inside the bust, for example, small linear protuberances at the junctions of the wax sheets are visible (fig. 6.23), which would have been produced by flattening the small wax strips along the seams. Some other joins, however, were accomplished simply by blending the sheets' edges with a hot blade. One instance is located on the left flank, where the left hand gathers the folds of the himation. As figure 6.24 shows, the juxtaposition of four wax sheets that had first been modeled forms a prismlike shape. The joins have defined edges, rather than ridges that would have indicated the use of wax strips, leading us to conclude that the edges were blended with a hot blade. Also visible in figure 6.24 is the interior of the left arm. The surface has rounded profiles that follow the folds on the exterior, with several linear creases whose morphology is suggestive of thin wax sheets.

No wax joins are visible in the forearm/hand, whereas the join relative to the drapery folds on the left shoulder is apparent. The entire curvature of the arm within the folds of the himation seems to derive from a single piece of wax that was connected to the body at the convergence of the joins shown in figure 6.24. This observation might lead one to suppose that the wax piece forming the left arm was slush-cast. However, the presence—even if obscured by the oxidation layer—of defined edges; inexplicable protuberances; the direction of the flow of melted wax (orthogonal to the folds, which is anomalous for a slush cast); and fingerprints all argue against this. Further conceptual obstacles to slush casting are noted below.

FIGURE 6.23. Protruberances marking junction of wax sheets

FIGURE 6.24. Juxtaposition of four wax sheets in the area of the left flank and arm

The execution of the drapery of the peplos by assembling wax sheets is evident. Here, the parallelism between the exterior and interior surfaces of the bronze and the regularity of the profile are striking. Even where there are variations in thickness, the morphology is nonetheless reminiscent of the use of sheets. In addition to the regularity of the thickness of the bronze and the presence of seams, the acute angles of the folds of the drapery further support the use of wax sheets. These features would not be apparent if the wax had been slush-cast or applied with a brush.

In many areas the inner surfaces of the peplos and the bust (including the inside of the left arm) have linear grooves that were produced by manipulating the wax with a toothed implement. These grooves have also been noted at and around the wax joins, as, for example, in figure 6.23. Here, the tool was likely used to level the joins and to remove any accidental drips, imprints, or irregularities from the wax sheet.

As far as the internal surface of the head is concerned, there are a few traces of manipulation of the wax, most notably the groove from a scraper at the entrance to the neck. There are also undulations and furrows along the pigtail and signs of shaping in the temporal region. The use of wax sheets to create the head does not appear likely, but the morphology of the interior surface also leads us to exclude slush casting.

An Unusual Feature

A series of square-sectioned chaplets (mostly closed with metal patches) accord well with what is described in the literature on ancient bronze production. However, strange types of bronze pins and clips were observed in the fragments of the drapery of the peplos and in the upper part of the bust.

The pins, found in the peplos, can be seen in figures 6.25a–b. Long and narrow, they have a circular section with a diameter of about one millimeter and a length that could originally have reached more than five centimeters, considering the protruding features and the thickness of the walls. The clips, found in the bust, have a flattened section, again on the order of a few millimeters, and protrude from the metal wall by only one to two millimeters. (fig. 6.25c).

The most plausible hypothesis is that these metal components were useful in assembling the waxes. They could not have been used to immobilize the core, both because they were too thin or short (those in the bust) and because they were made of bronze (the composition of a pin was measured).[27] In other words, in addition to the wax joins, the assembly of the model required some mechanical connections such as a type of pinning in the lower part and clipping in the upper (though the function of the latter is not immediately identifiable). A good number of these clips can also be recognized on the left arm, above all on the apical line of the shoulder-elbow-hand, which could not have any function in a model formed by slush casting.

FIGURES 6.25 a–c. Pins emerging from the inner surfaces of the peplos (a–b) and clips in the shoulder (c)

Radiographic Examination

X-rays taken after the statue was disassembled added further information to the initial radiographic campaign and confirmed and clarified many of the observations presented above. In addition, they demonstrated the joining of separately modeled wax sheets on the left side of the chest. Another important feature emerged from the careful examination of the area inside the right armpit (see figs. 6.21a–b). This zone was interpreted as having been remelted, to allow the corresponding bulge in the himation to be anchored in place. This had been achieved by partially removing some of the core material before joining, to allow for the molten metal to fill the void.

Composition and Microstructures of Alloys

The main alloy of the bust is a binary alloy—89.74 to 90.08 percent copper, 8.84 to 9.99 percent tin, with only traces of lead—and it thus very similar to the so-called classical alloy (90 percent copper, 10 percent tin).[28] The composition of the head and that of the lower part of the peplos coincide: 90.01 percent copper and 9.62 percent tin, and 89.37 percent copper and 9.26 percent tin, respectively. The folds added with heat joins seem to have a slightly higher lead content, though it is difficult to say whether this indicates a difference in alloys, or is simply a result of diffusion or contamination from the corresponding welds. In fact, in the welds, lead is definitely higher: 3.83 percent and 4.8 percent for the join of the head and for that of the lower part, respectively. Notably, Carradori utilized an alloy for the right arm that is very close to the Minerva's. This should be taken into account by scholars who still base technological dating on alloy composition alone.

Metallographic samples displayed varying microstructures indicating areas of unaltered casting, such as a metal core sample, MF_2, taken from the lumbar area. Others indicate annealing or heating for joining, such as the MF_1 sample, which came from the break of the drapery on the left side: while remaining for the most part dendritic, it had evident recrystallization nuclei, indicating moderate heating that can be associated with the joining process.

Conclusions

Ancient Manufacture

There seems to be little to no evidence that the statue was produced with the indirect lost-wax technique. If the figure were to have been created from molds, we would not expect to find the confluence of wax sheets at the prismlike feature evident in figure 6.24, or the uniform thickness throughout the multiple undulations of the drapery and breasts. Nor would we anticipate the anomaly of dividing the essentially flat parts (on both the front and the back) below the abdominal area. Moreover, the application of bronze clips in the upper part of the bust, and pins in the peplos (see figs. 6.25a–c), cannot be reconciled with any known production contexts.

FIGURE 6.26. Waxing of fabric by the conservator Stefano Sarri

FIGURE 6.27. Direct modeling of the missing parts of the peplos and himation

Seen from within, the lower section of the figure displays folds that flow in a regular manner, without joins that could be related to piece casting, and with acute angles, which would be difficult to reproduce in a mold. If the lower part were created using the indirect method, it should present traces of numerous molding plugs, or clear evidence of slush casting of the wax. But this is not so. Finally, the head shows a heavy manipulation of the wax and a probable joining line on the temporal arc within the interior. This opens up the possibility that it may have been composed from at least two pieces of wax modeled or molded separately.

All this leads me to conclude that the Minerva is not a reproduction of an earlier model. The evidence presented above also supports its stylistic dating to the pre-Imperial period.[29] Its wax model was obtained by utilizing a technique that cannot be defined as either direct or indirect. The wax sheets known to have been used for the lower part of the bust would have been difficult to manipulate in a mold, and would have been more easily worked in the positive. For the upper part of the bust, and in particular for the drapery around the left arm, I conclude that the modeling likely started from a composition made of fabric, which produced the extraordinarily realistic rendering. The drapery was probably modeled around a temporary support, which would have been given a minimum of plasticity with wax. The drapery folds seem to have been realized by adapting the thin material to the sculptor's design, attaching it gently to the support using small metal clips. Subsequently the wax was brought to a desired thickness by working it with a brush on the outer side or on both sides. To begin with fabric itself would have been the best way for the sculptor to denote the natural undulations of the drapery. The process proved suitable for modeling the drapery of the peplos during the recent conservation and reassembly undertaken at the Centro di Restauro of the Soprintendenza per i Beni Archeologici della Toscana (figs. 6.26, 6.27). After the surface was finished, the integration was cast in carbon composite material (see figs. 6.1a–b).

The missing bronze parts that would have been pertinent to the solid metal structure of the statue have, along with the snake on the helmet, been reconstructed as part of the recent conservation project (see figs. 6.1a-b). Any other elements were likely to have been separate parts and were probably made of various materials. This is true particularly for the right arm, with its peculiar housing (see fig. 6.21a) and the strange large tortile pin on the inside (see fig. 6.21b). The arm could have been movable and the pin may have served as a sort of hook for blocking the arm's movement. Similarly, if there had been a continuation to the present ending of the hair, this was perhaps an independent accessory. In future archaeological and stylistic reexaminations of the Minerva these important features, which could assist in refining the attribution and dating of this important masterpiece, should be taken into account.

Historical Restorations

According to the technical examination and the archival information described above, three distinct interventions can be hypothesized for the restoration of the Minerva of Arezzo.

The first was likely carried out soon after its discovery in order to assemble the many fragments on the linden support, which was suitably prepared for fitting them with nails. In the second campaign, carried out between the end of the seventeenth and the first decades of eighteenth century, the missing right arm was integrated in plaster. Finally, in 1785 Carradori cast in bronze a new right arm and the then-missing portion of the snake on the helmet.

We cannot know all the operations in detail, but one hypothesis can be formulated on the basis of the available data about the two earlier interventions. The careful carving of the wood support in correspondence to the lower part of the peplos and the addition of strips on it in order to fit the metal fragments (see figs. 6.16a–b), along with the lack of a stucco preparation beneath the fragments, lead us to propose that the stucco integrations might have been applied later—perhaps during the second restoration phase, together with the plaster right arm. In other words, at the time of Cosimo I (i.e., at the first intervention), the Minerva could simply have been assembled from its surviving ancient parts alone. The reconstruction could have been carried out only with nails and perhaps a small amount of tar.[30] All this is congruent with the data collected, though no direct evidence has been found.

It is worth nothing that none of the restoration interventions discussed here involved foundry techniques, such as casting-on or heat-joining additions. I believe this testifies to the importance that the Florentine antiquarian tradition attributed to what was already recognized during the Renaissance as an ancient masterpiece. Notably, the first intervention—in which the fragments were assembled on the internal wood support—is much more in line with a modern conservation approach (based on the general principle of the preservation of the artwork's authenticity) than the later integrations in the eighteenth century.

We know from archival data that the missing arm was not added in the sixteenth-century restoration. This accords with what is emerging from recent studies of bronze figurines from the Medici–Lorraine antiquities collections.[31] These findings seem to confirm from the material-analysis standpoint what is known historically about the "taste for the fragment"[32] that characterizes the rediscovery of ancient art during the Renaissance and Mannerist periods.

On the basis of previous considerations, we can reasonably hypothesize that the initial form of the Minerva after its rediscovery was to some extent similar to its appearance today, following the recent conservation—without the arm and bit of snake, and perhaps without the stucco integrations of the lower part.

That an intervention carried out in the sixteenth century was so philologically correct and respectful of even minute fragments is interesting and surprising, and it could be seen as the embryonic stage for the modern approach to the conservation of cultural heritage. In subsequent centuries a tendency to integrate missing parts of archaeological finds (or what was considered missing) is made evident not only by large bronzes such as the Minerva and the Chimaera of Arezzo but also by a number of statuettes in Florence's Museo Archeologico Nazionale.[33]

With the crafting of the right arm of the Minerva and the tail of the Chimaera, Carradori made two of the many pastiches produced between the seventeenth and nineteenth centuries. That said, it seems he did not intervene with parts that had previously been restored, such as the lower part of the figure. He mounted the right arm without exploiting the internal wood support, and used the support for improving the stability of the head (see fig. 6.15).

Several corroborating historical documents as well as material data allow us to associate a bronzelike patination with the eighteenth-century restoration.[34] It is not possible to say definitively that the earlier intervention(s) included a similar application. However, the presence of at least two intentional brown layers (see figs. 6.7a–b, 6.8a–b) makes this a possibility, and would be compatible with the taste of that period. Most probably, the intervention by Carradori also provided the occasion for an overall coating of the statue, as he had to apply a patination to the new arm that he had crafted. Such a conclusion is supported by two documents, dated prior to 1785,[35] in which the bad condition of the Minerva's outer surface is noted. These documents may also testify to the presence of a previously applied dark coating.

A manuscript by Luigi Lanzi, of uncertain date but before 1783, states: "Corridor. A Minerva of natural proportions, dressed with a long peplos without sleeves . . . they say it had a snake, of which only a fragment remains, in front of which there is an owl or similar bird, in relief on the helmet. . . . The right arm is replaced and other parts of the robes are consumed and appear touched by fire."[36] The final observation is also included in the above-mentioned inventory note of 1783: "A bronze Minerva, which has suffered fire, without the right arm."[37] I suggest—as a working hypothesis for future studies—that in both cases the writers could have confused the dark areas in which a previous patination with significant carbon-black content was still preserved with the effects of fire.

Finally, let us consider in more detail the right arm integrated by Carradori in 1785 in order to better understand his manufacturing processes. As already mentioned, I believe he used a direct method, that is, shaping the wax for casting on a preliminarily prepared core structure.[38] This is supported by radiographic examination (see figs. 6.17a–b) as well as by the morphology of the bronze surface (fig. 6.28a). The right arm has a variable texture, from almost flat (fig. 6.28b) to very rough (fig. 6.28c). The softness of the details is consistent with their having been added in

FIGURES 6.28 a–c. Right arm (a) and details of the right arm (b, c)

the wax, and there is no evidence that the marks were produced by mechanical tools after casting. This suggests that Carradori fashioned the arm with the intent of harmonizing his work with the irregular surface of the ancient masterpiece.

Besides being a sculptor and restorer, Carradori was an instructor of sculpture, between 1786 and 1821, at Florence's Accademia di Belle Arti. He also wrote a brief handbook for his students (*Istruzione elementare per gli studiosi della scultura*, 1802),[39] which is a valuable source of information on artists' techniques before the industrial era. Unfortunately, this book does not contain any specific reference to the restoration carried out on the Minerva and the Chimaera, but it does include some useful information about Carradori's ethical and technical approaches to the restoration of ancient statues. He writes that after cleaning the figure, the restorer should think about the possible shape of a missing sculptural element, making a drawing to see if it will be successful.[40] In particular, the sculptor describes clay modeling on a marble sculpture; the same can be applied to bronze statues, where wax modeling could represent a better choice. Carradori considers the latter suitable for "sketches of ideas, architectural ornamentation, works in silver, or any other work of this nature"[41] This conceptual and technical approach is in keeping with his direct casting in bronze of the Minerva's right arm.

The technical descriptions and conclusions reported here were the result of my productive interaction with the staff of the Centro di Restauro of the Soprintendenza per i Beni Archeologici della Toscana, the institution in charge of the conservation work on the Minerva of Arezzo. In particular, I thank my close collaborator Marcello Miccio for many useful discussions; the conservators Renzo Giachetti, Manuela Nistri, and Stefano Sarri, the designer Marida Risaliti, and the radiographer Roberto Pecchioli for their kind and enthusiastic collaboration; and last but not least, Mario Iozzo and Mario Cygielman for having entrusted me with the present study.

1 See M. Cristofani, "Per una storia del collezionismo archeologico nella Toscana Granducale: I grandi bronzi," *Prospettiva* 17 (1979), pp. 4–15; A. Cherici, "Alcuni appunti di monumenti archeologici di provenienza aretina," *Atti e memorie dell'Accademia Petrarca di Lettere, Arti e Scienze* 48 (1986), pp. 3–15; L. Beschi, "Atena di Arezzo," in *Capolavori e restauri*, exh. cat. (Florence: Cantini, 1986), pp. 255–56; M. Cygielman, "La Minerva di Arezzo: Il restauro," in *Etruschi nel tempo: I ritrovamenti di Arezzo dal '500 ad oggi*, ed. S. Vilucchi and P. Zamarchi Grassi, exh. cat. (Florence: Nuova Grafica Fiorentina, 2001), pp. 67–73; V. Saladino, "La Minerva di Arezzo: Vicende collezionistiche, iconografia e stile," in *La Minerva di Arezzo,* ed. M. Cygielman, exh. cat. (Florence: Nuova Grafica Fiorentina, 2008), pp. 13–29.

2 See Saladino, "Minerva di Arezzo" (note 1).

3 G. De Tommaso, "La Minerva da Palazzo Vecchio al Museo Archeologico," in *La Minerva di Arezzo*, ed. M. Cygielman (Florence, 2010), pp. 47–49.

4 Inventory of 1676, no. 3; inventory of 1704, no. 2920, cited in Cristofani, "Storia del collezionismo archeologico" (note 1), p. 11.

5 Inventory of 1769, no. 186, cited in Cristofani, "Storia del collezionismo archeologico" (note 1), p. 11.

6 A. F. Gori, *Museum Etruscum*, vol. 2 (Florence, 1737), pl. XVIII.

7 See Cherici, "Monumenti archeologici" (note 1).

8 J. J. Winckelmann, *History of the Art of Antiquity*, trans. Harry Francis Malgrave (Los Angeles, 2006), p. 164.

9 See Cristofani, "Storia del collezionismo archeologico" (note 1), p. 4.

10 V. Saladino, "Vicende e stile della Minerva di Arezzo," in *La Minerva di Arezzo*, ed. M. Cygielmann (Florence, 2010), p. 30.

11 Beschi, "Atena di Arezzo" (note 1).

12 Cherici,"Monumenti archeologici" (note 1).

13 Cherici,"Monumenti archeologici" (note 1), p. 12

14 Cherici also states that evidence of an extensive fire was found at this archaeological site. He mentions traces of burning on the Minerva, as well as on a set of figurines found in a lararium of the Roman domus—apparently an assumption by him, to provide important material support to his thesis. However, during the recent restoration, no secure traces of burnt material were found on the Minerva.

15 Cherici, "Monumenti archeologici" (note 1), p. 12.

16 Beschi, "Atena di Arezzo" (note 1), p. 255; M. Cygielman, "La Minerva di Arezzo," in *La Minerva di Arezzo*, ed. M. Cygielman, exh. cat. (Florence: Nuova Grafica Fiorentina, 2008), p. 10.

17 G. Maetzke, "La Minerva di Arezzo," in *Etruschi nel tempo: I ritrovamenti di Arezzo dal '500 ad oggi*, ed. S. Vilucchi and P. Zamarchi Grassi, exh. cat. (Florence: Nuova Grafica Fiorentina, 2001), p. 65.

18 Saladino, "Minerva di Arezzo" (note 1); Cygielman, "Minerva di Arezzo" (note 16).

19 G. Giachi and P. Pallecchi, "Materiali di integrazione e di finitura superficiale," in *La Minerva di Arezzo*, ed. M. Cygielman, exh. cat. (Florence: Nuova Grafica Fiorentina, 2008), pp. 169–73.

20 On modern patinations, see Luisa Fucito in this volume.

21 S. Siano et al., "The *Quattro Santi Coronati* by Nanni di Banco: Cleaning of the Gilded Decorations," *Journal of Cultural Heritage* 4, supp. 1 (January 2003), pp. 123–28.

22 S. Siano, M. L. Nicolai, and S. Porcinai, "Verrocchio's David: Characterization and Conservation Treatments," in *Verrocchio's David Restored*, G. M. Radke et al., eds., exh. cat. (Atlanta: High Museum of Art, 2003), pp. 97–109.

23 S. Siano et al., "David di Donatello: Indagine sul procedimento esecutivo," in *Donatello: Il David restaurato*, ed. B. Paolozzi Strozzi, exh. cat. (Florence: Firenze Musei, 2008), pp. 168–83.

24 See A. Giusti et al., "Documentary and Analytical Analogies in the Study of Patinas of the 'Quattro Santi Coronati' by Nanni di Banco," in *Proceedings of the Ninth International Congress on Deterioration and Conservation of Stone*, ed. V. Fassina (Amsterdam, 2000), pp. 671–78; A. Giusti, "Ghiberti's Gold: Restoration of the Gates of Paradise," in *The Gates of Paradise: Lorenzo Ghiberti's Renaissance Masterpiece*, ed. G. M. Radke, exh. cat. (Atlanta: High Museum of Art, 2007), p. 100.

25 G. Giachi and S. Lazzeri, "Il sostegno centrale," in *La Minerva di Arezzo*, ed. M. Cygielman, exh. cat. (Florence: Nuova Grafica Fiorentina, 2008), p. 173.

26 See, for example, E. Formigli, "La tecnica di costruzione delle statue di Riace," in "Due Bronzi da Riace," ed. L.V. Borrelli and P. Pelagatti, Serie speciale, *Bollettino d'arte* 3 (Rome, 1984), vol. 1, pp. 107–42.

27 Both pins in the peplos were found to be annealed. One pin (MF7) has a completely different microstructure from that of the metal that incorporates it. It was found to have been successively hammered and annealed, confirming that such pins were utilized for the construction of the waxes and were not casting features derived from a replacement of organic materials, the filling of the holes in the core, or anything comparable. Their composition is similar to that of the alloy associated with the joins described below.

28 The chemical analysis of the alloys was carried out on a series of burr samples and metallic fragments (MP and MF in fig. 6.4). Most of the samples were taken from the bust, in order to identify the main alloy, verify the possible compositional differences of separately cast parts, and characterize the filler used for the joins and the composition of possible recastings.

29 The study of the Minerva also included the analysis of a singular possible black ancient patination made of tenorite, which came to light on large areas of the figure. I will address this in another study, but I can say that its composition and intentionality strengthen my thesis.

30 Some amounts of tar were found in the region of the neck of the peplos.

31 See S. Siano et al., "Authentication of Copper Alloy Statuettes: Florence's Antiquarian Collections," in *A Quest for Authenticity,* M. L. Vitobello and T. Rehren eds., (London, 2009), pp. 105–18.

32 Archaeological finds were exhibited almost as found, without integrating the missing parts. This "taste for the fragment" or for "the relic" is further evidenced by the production of incomplete counterfeit objects of ancient style, particularly small figurines without arms or with broken legs, and headless busts with broken arms.

33 See Siano et al., "Copper Alloy Statuettes" (note 31).

34 See Giusti et al., "Analogies in the Study of Patinas" (note 24); Siano, Nicolai, and Porcinai, "Verrocchio's David" (note 22); Giusti, "Ghiberti's Gold" (note 24), pp. 98–109.

35 Saladino, "Minerva di Arezzo" (note 1), p. 26.

36 Quoted in Saladino, "Minerva di Arezzo" (note 1), p. 26.

37 Quoted in Saladino, "Minerva di Arezzo" (note 1), p. 27.

38 One more archival document mentions "another mold of the model used for remaking in bronze the arm of the statue of the Etruscan Minerva" (quoted in Saladino, "Minerva di Arezzo" [note 1], p. 27). this reference need not refute the use of a direct method, since the mold mentioned could have

been cast on the wax model for safety reasons (that is, for replicating the metal casting in case of irreparable damage during the foundry operations), as well as for documentation or educational purposes.

39 F. Carradori, *Elementary Instructions for Students of Sculpture*, trans. M. K. Auvinen (Los Angeles, 2002).

40 Carradori, *Elementary Instructions* (note 39), p. 40 (article 11).

41 Carradori, *Elementary Instructions* (note 39), p. 25 (article 4).

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