Antiquity in plaster: production, reception and destruction of plaster copies from the Athenian Agora to Felix Meritis in Amsterdam
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MOULDING AND CASTING TECHNIQUES IN CLASSICAL ANTIQUITY

(1.) In the first place they [those who imitate famous people] are unlearned persons, though you may find their houses crammed with plaster casts of Chrysippus; for their greatest hero is the man who has bought a likeness of Aristotle or Pittacus.

Juvenal (c. A.D. 60 - c. 130) 8

Introduction

Casting techniques played an essential role in the process of manufacturing copies and casts, which became a common practice during the Roman period. 9 An important contribution to our understanding of the copy technique employed by the Romans was the discovery in 1952 of the debris of a copy-workshop in Baiae, a luxurious bathing resort at the Bay of Naples in the 2nd century A.D. Here hundreds of fragments of plaster casts taken from renowned sculptures were found. This will be addressed in a short survey plus some comments on Christa Landwehr's important book (1985) on these plaster casts from Baiae.

Ancient texts provide scarce but useful information on the technical backgrounds of the production of sculpture in metal and bronze. The utilization of moulds played an essential role in this process. According Pliny the Elder (A.D. 23-79), moulding techniques were invented by the Greeks. They could be used for making masks as fronts to the outer gutter-tiles of roofs (ill. 1a-b-c+2). The modellers who applied them were called plastae. 10 However, we now know that these techniques were in fact a lot older and already employed in Egypt during the pharaonic period. There is evidence that the knowledge of plaster technology even dates back to the Neolithic times. 11

In antiquity casting techniques were widely used by artisans and craftsmen. Much insight on the function and application of moulds and casting techniques in ancient Greece was gained during the excavations in the Athenian Agora (since 1931) conducted by British and American archaeologists. Of further importance are the German excavation campaigns in Olympia, where research was done on moulds and casts that were linked to the cult statue of Zeus. 12 In the ancient Greek and Roman world moulds and casts had many applications. They were used by different craftsmen, including potters, metalworkers, coroplasts, stucco-workers and sculptors. For the archaeologist such moulds and casts offer important information on the transmission of images and for the assessment of certain typologies.

9. The terminology is important here. Strictly speaking a copy is an interpretation of the original, with an overall resemblance, whereas a cast is an exact image of the original. Although some authors use the word copy to describe an exact replica.
11. There were objects recovered made of gypsum-plaster that date from the Neolithic period, this is an indication of an even earlier knowledge of plaster technology, see: Kingery 1988.
1. Sculpture

In the manufacturing of bronze sculpture, heavy terracotta moulds were used by the Greek metal-workers from the 5th-century B.C. onward. Most commonly the ‘lost wax method’ was applied in casting pits to produce a piece of bronze sculpture (ill.3a). First the intended object was modelled in wax, which was built up around a core of sand and clay. Then it was placed in the pit. More clay and sand were added to the outside and metal pins were inserted to hold mould and core in place when the wax was melted out after heating. Molten bronze was then poured in to take the place of the wax, which resulted in a hollow-cast piece of metal or sculpture. During excavations in the Athenian Agora some twenty foundries or smithies were found. In these burning pits numerous fragments of such moulds were located (ill.3b).

Various craftsmen used more delicate moulds as an aid in the creative process of their work. Evidence of such use was found among the debris of a deposit in the direct vicinity of the workshop of the sculptor Pheidias in Olympia. Here many clay moulds were found which are associated with the work on the cult statue of Zeus (ill.4a+b). Of all the mould fragments some sixty could be pieced together. They consist of moulds for both small and large ornaments and moulds for draperies of clothes (ill.5a+b). These moulds were clearly not used for direct casting in metal, for they neither have the weight or character of moulds that were used for direct casting in bronze. This is confirmed by the fact that no traces of casting channels, needed for pouring the metal in and letting the air out, were detected.

Many questions concerning the technical process of making a massive cult-statue like the one in Olympia remain unanswered. The same applies to the exact purpose and function of the moulds. Although some could be linked to a specific use. For example the small moulds for ornaments, like palmetto leaves, clearly had a decorative purpose. The recovered casts that belonged to these moulds were made of glass (ill.6a, b, c). The latter is confirmed by the presence of many glass splinters found in the deposit from Pheidias' workshop. One has to realise that in antiquity glass was considered of as valuable as precious stone. The glass was probably imported from Egypt or Syria.

For the use and function of the drapery moulds, several hypotheses have been put forward. Some scholars believe they are part of a small-scale model, because the workshop of Pheidias was obviously too small to house the full size of the Zeus statue. Others conclude that the drapery moulds were used for chasing gold or silver relief work, which was applied, to the statue. However no chemical research on the surface of the moulds, on which particles of gold or silver would have been left in case they were used for this purpose, has been carried out.

Andreas Moritz (1956) pointed out that this explanation is unlikely because of the fragility of the moulds; some parts were only 5mm thick and would not have withstood the hammering

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13. Thompson 1937, 81ff; Camp 1986, 139.
15. Schiering 1991, 139. But this is hypothetical, perhaps the glass was produced locally.
17. Fellmann 1972, 56; Hermann 1972, Anm.605. Not only the door of the workshop limited the size of the statue, but also the width of the space between the columns of the temple.
necessary in this process. It is also thought that the big drapery moulds were used for casting glass, but this is dubious. The inside height of some folds is higher than the edges of the mould, which would have made it impossible to make a good cast.

The discovery of thin glass shapes, of which some fragments could be fitted into the small drapery moulds, lead to the theory of a technique, which the Germans call the Glas-einsinkverfahren (the sinking in of glass). During this process a thin sheet of glass is put over a mould and heated until the soft, but not molten glass, sinks into the mould and takes on its shape (ill.7a). It is very likely that these glass shapes were incorporated in the robe of the statue. Like other cult statues, the Zeus statue was made of gold and ivory on a wooden core, a technique called chryselephantine. The parallelogram-shaped drapery moulds suggest a net-shaped pattern of glass shapes, which would have been held together by wooden or gilded lead strips (ill.7b). But it could also have been done by using metal pins. Another possibility is the use of bitumen as an adhesive to hold the glass onto the wooden core.

2. Relief plaques

During the American excavations from 1931 to 1977 in the Athenian Agora, more than one hundred fragments of large clay ‘moulds’ apparently for relief plaques were found (ill.8a+b). They were mainly located in the fills within the foundations of the three great Hellenistic stoas (the Middle Stoa, the Stoa of Attalos, and South Stoa II). None of these fragments were found in a significant context, nor could they be associated with a workshop where they had been made or used.

Because so far no objects have ever been found that were made from these moulds, we must be sceptical about them being used as such. A function that comes to mind are votive plaques or tablets. Such clay relief plaques are known from many sanctuaries all over the Greek world. They could be dedicated to both gods and heroes, set up on the basis of a shrine or hung on a sacred tree nearby, or more commonly nailed to or hung on pegs from the walls of the sanctuary. Claireve Grandjouan (1989) however believed that the Agora moulds were from an iconographical point of view unsuitable for votive offerings; this is particularly so in the case of the depiction of an animal combat, which indeed form part of the furnishings of a heroön or sanctuary but are seldom dedicated as votive tablets.

Terracotta relief plaques were also applied to protect wooden framed buildings. The Agora moulds fit remarkably well in this genre. Another hypothesis is that they served as moulds for plaster or stucco reliefs. The Agora moulds, with their deep border and self-contained

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21. For an elaborate discussion on the hypothesis of the use and application of these glass shapes, see: Schiering 1991, 130-156.
22. About the chryselephantine statues, Lucian, Somn., 24.(tr.: H.W.Fowler & F.G.Fowler, III, Oxford 1905, 121) remarks: ‘But take a peep inside, and what have we? One tangle of bars, bolts, nails, planks, wedges with pitch and mortar and everything that is unsightly, not to mention a possible colony of rats and mice’. For technical aspects see: von Gerkan 1955/56, 55-58; Leipen 1971, 19ff.; for the reception of the Athena Parthenos statue, see: Nick 2002
23. For the use of bitumen as an adhesive see: Strommenger & Hirmer 1962, Taf. 78 (Melker freeze from Tel Ubaid, here limestone figures are fitted onto bitumen); Schiering 1991, 131, n.75.
25. Perhaps the best known group is the one recovered from a sanctuary in Locri, see: Prückner 1968; Boardman 1954; Grandjouan 1989, n.1.
27. Grandjouan, 34.
designs going to the edge of the frame, seem unsuitable for the more spacious style of stucco reliefs. Arulae (altar- or table shaped clay artefacts) or sarcophagus decorations, despite the general similarity, do not resemble the moulds; none of these types could be traced to an Agora mould. Neither were they used to produce relief wares or for instance as cake moulds.

3. Metalwork

Metalworkers also utilized moulds for the various objects they produced. The types of moulds they applied were impressions in clay or plaster, often taken from different kinds of metalwork or small sculpture. Such impressions in clay were found on the Athenian Agora, the majority of the metalwork from which they were taken dates from between 410 and 380 B.C. Only one of the impressions was made of a statuette, the rest of the impressions were taken from metal relief’s that mostly belonged to the handles or bodies of vessels. Others were taken from armour, horse decorations, jewellery, a decorative or votive relief and a mirror. Some form a complete unit in itself (ill.9).

Later Alexandrian types (ill.10) that influenced Roman art were mainly found in two places: at Memphis (Mit Rahîneh) in Egypt, and Begram in Afghanistan. Most of the plaster casts that were recovered were taken from silverware or from for horse harnesses (ill.11). In Begram several Alexandrian import-objects were found, like bronze statuettes of Serapis and Harpokrates or porphyry ware. This confirms that ties of commerce existed with the Egyptian cities. These clay impressions are small and were not used for direct casting in metal; they have to be considered as ancient trial casts, or models. Before a cast in precious metal was made the mould was tested with the cheaper material, like plaster or wax. This type of cast, therefore, was not made as a means of mechanical reproduction, but as an aid to the metal worker who used them to make alterations in the composition. It is likely that these impressions and casts functi-

30. One impression from the Athenian Agora was found in the debris of a metalworking establishment, see: Thompson 1939, n.23.
31. Reeder Williams 1976, 45.
32. Reeder Williams 1976, 41ff. This article is a summary of a doctoral thesis on clay impressions taken from Greek metalwork; it complements the studies from Dorothy Thompson. For a review of a rich collection of Greek moulds, mostly for casting in bronze, see: Edgar 1909.
33. The material dates from the Hellenistic and Roman period and was first published by Otto Rubensohn in 1907. But since the initial publication, several pieces have been added to the main group, e.g. see: Lunsingh Scheurleer 1984, 359ff. For a comprehensive study see: Reinsberg 1980.
34. Möbius 1964, 10ff. A plaster cast of tendril decoration on a helmet from Memphis (now in Hildesheim) has similarity with tendril decorations from the Macedonian sphere which proves an axis ‘Macedonia-Egypt’, see Pfrommer 1993, 175.
35. Thompson 1939, 312; Also see: Reinsberg 1980. Carola Reinsberg wrote a dissertation on the find of Mit Rahîneh, where a large number of plaster casts from the Hellenistic period were found. Her approach to the material is mainly stylistic, with an analysis of different typologies. What is missing is a chemical analysis of the material which could have answered questions about the origin of the plaster and, moreover, would have shed some light on more technical aspects of the manufacturing process. An overall conclusion is that the casts and moulds were used by metalworkers who produced small-scale products. The find was for the larger part bought by the Pelizaeus-Museum in Hildesheim in 1907. It was first described Rubensohn in by 1911. Additional information is found in an extensive chemical research that was carried out by de Keizer (1983) on plaster casts from the collection of the Allard Pierson Museum in Amsterdam.
oned as prototypes for craftsmen and customers; some believe they were used as an inventory record of what a metal workshop had produced.\textsuperscript{36}

Ancient literary sources testify about the popularity of luxurious metalwork by the end of the 5th century. Socrates deplored the contemporary rage for gilded armour.\textsuperscript{37} Xenophon mentions the array of foreign metal objects, which his troops brought, took with them back to Greece.\textsuperscript{38} The inventory of the treasury at Delos (before 454 B.C.) also testifies to the existence of many luxury objects made from precious metal.\textsuperscript{39}

During the 440s and 430s the best metal craftsmen must have been attracted to Athens in order to work on the Athena Parthenos statue.\textsuperscript{40} Only a small number of metal relief ware that can be attributed to Attic workshops of the 5th- and 4th-century B.C. has survived.\textsuperscript{41} The specimens prove that Attic metalwork in this period had the same high quality as contemporary Attic sculpture and vase painting.

Another aid for the metalworker were small bronze moulding plates in low-relief (ill.12). Gold- and silversmiths used them as a matrix to emboss gold and silver mountings for lamps, vessels, jewellery and pieces of armour like helmets etc.\textsuperscript{42} (ill.13) This chasing work was made of thin, pressed gold and silver plates that were generally mounted onto another material. Some were even used as decorative ornaments on funeral shrouds.\textsuperscript{43} Early examples date from the 8th-century B.C., such as golden plaques with figures in repoussé found in Athens, or gold diadems from a later period found on Crete, in Euboea and Rhodes.\textsuperscript{44} Archaeological finds confirm Pliny's statement that relief vessels sometimes were so thin that no casts (exemplaria) could be taken from them.\textsuperscript{45}

Some of the moulding plates were made of stone and were used for both casting and embossing small objects like jewellery. They provide an insight into the technical processes of casting and embossing.\textsuperscript{46} The technique of casting small metal objects with stone moulding plates was not new, though, and can be traced back to the Aegean Bronze Age. Such moulds for casting finger rings were found in Mallia on Crete.\textsuperscript{47} (ill.14a, b, c) Since the 4th-century B.C. casting techniques were used to make jewellery imitations of gilded terracotta or stucco.\textsuperscript{48} (ill.15) Although these fragile ornaments were not made to be used

\begin{itemize}
\item Reeder Williams 1976, 44.
\item Xen. \textit{An.}, III 10,9-15.
\item Xen. \textit{An.}, I, 2, 27; I, 8,29; IV, 3,26; IV, 4,22; VII, 2,23; VII, 3,18,27.
\item For elaboration see: Hamilton 2000.
\item Reeder Williams 1976, 47.
\item Reeder Williams 1976, 47.
\item Kriseleit 1980, 193. In her article Kriseleit gives two examples of such bronze moulding plates which are now in the Museum of Antiquities in Berlin (Misc.Inv.7037; Inv.31311), the first from the Roman period, the second from outside of Italy, possibly south Russia.
\item Kriseleit 1980, 195.
\item Ohly 1953, p.49, Abb. 25-27.
\item Plin. \textit{HN.}, XXXIII, 156.
\item Kriseleit 1980, 195: Two Late Minoan examples of stone matrix plates used for repoussé work are now in the Museum of Antiquities in Berlin (Misc.Inv.7473, Inv.31573). Also compare a lime stone half mould for casting primitive implements (early Greek period?), now in the British Museum (No.528). An extensive history on matrices and hammering techniques applied by metal workers like jewellers and toreutics is found in Treister 2001, also see Treister 1990.
\item Effenterre 1980, 479ff: The British Museum also has an example of a steatite mould for a ring of the Mycenean period (No.532). A steatite figurine mould that dates from the 18th-century B.C. was found in Kültepe, Karum Kanesh, Turkey (now in the Museum of Anatolian Civilisations, Nr.11969).
\item Kriseleit 1977, 13ff. The focus of Kriseleit's article is on the almost forty gilded terra-cotta jewellery objects gathered in the collection of the Staatliche Museen zu Berlin.
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by the living, but in a funerary context.\(^{49}\) It was customary in Greece to display the body of the deceased for the duration of one day. After it had been washed and scented with oils, it was dressed in white robes and laid out in an ornate bed. In most cases a shroud was hung over the dead, adorned with gilded terracotta or stucco ornaments of which many were retrieved (ill.16).

Goblets and vessels were also cast from moulds. Such hard stone moulds that were especially manufactured for this purpose, have been recovered.\(^{50}\) (ill.17) Romans, not the Greeks, made a practice of casting silver vessels from wax models.\(^{51}\)

### 4. Pottery

Potters also applied moulds and casts for the decoration of drinking cups and vases. The tradition of vase decoration with reliefs is just as old as the tradition of painted decoration. Although a typology of relief vases has not been established mostly for the reason that no homogeneous evolution could be established from one group to another.\(^{52}\)

The missing links between the different groups are provided by other related crafts, like metalwork. The earliest examples date from the 7th- and 6th-century B.C. and were found in Etruria on *bucchero* and some coarse wares. Here the decorations consist of simple incisions or impressed stamping. Parallel in time is a group of Greek examples found in Rhodes and Crete. Such great amphorae, or relief-*pithoi* of which examples are known in Minoan times (ill.18), are decorated with stamped bands of repeated patterns. Although such large rough-surfaced pots have little relevance to the new system of impressed decoration that was developed in Athens.

During the second quarter of the 5th-century B.C. a new system of vase decoration came into fashion. The outside surface of some Attic stemless cups with black insides (Sotades painter) was embellished with simple units of ornamentation. They were incised freehand with some help from the potter’s wheel and perhaps a ruler, though the stamped palmetto was also used. By the end of the 5th century more elaborate motifs from Attic workshops linked palmettes, ovulos and also tongues.\(^{53}\)

The most distinguished type of relief ware was developed in Athens during the Hellenistic period, known by the (deceptive) name Megarian Bowls.\(^{54}\) This bowl, without foot or handles, is decorated all over its exterior surface with designs and figures in relief. It was made by pressing clay into a concave terracotta mould-bowl; then the whole inside was covered with clay and turned on the potter’s wheel so that a thin, even wall was created. When dry after it had shrunken, the cast could be taken out. The rim was then shaped on the potter’s wheel and a base attached to the body of the bowl. It is believed that they were inspired by Alexandrian prototypes.\(^{55}\) Many fragments of such mould-bowls were found among the pottery dumps from the

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\(^{50}\) Kriseleit 1980, 197, Abb.7.

\(^{51}\) Thompson 1939, 312.

\(^{52}\) For elaboration see: Courby 1923.

\(^{53}\) Cook 1960, 215.

\(^{54}\) The term ‘Megarian bowl’ resulted from an archaeological misunderstanding. In 1883 Otto Benndorf published a number of casts of hemispherical mould-made bowls. The originals of these casts were in various collections in Athens, but were said to have come from Megara. Benndorf mistakenly identified them, also on the basis of literary sources, as a type of bowl used by the Megarians. ‘Megarian bowl’ is a general term used for mould made bowls; for an elaborate study see: Rotroff 1982, 1-120.

\(^{55}\) Rotroff 1982, 11. Others (Cook 1960, 216, 329) believe that because of the quality of the Attic products this is an indigenous invention, or rather, an adaptation from metalwork.
third, second and first century B.C. Several good examples were found on the Athenian Agora (ill. 19a+b).

Exquisite examples of Calene pottery with relief decoration are the phialai mesomphaloi (ill. 20). They owe their name to the ancient settlement of Cales and were produced by potters with Latin names around the second half of the 3rd century B.C. The paterae or phialai have relief decorations on the inside, as a medallion or around an omphalos. They were an alternative for those who could not afford precious relief ware of silver and gold. Calene pottery was made with the use of moulds; the technique is similar to that of the Megarian Bowl. Some of the moulds were taken from Greek proto-types of silverware that date from the 5th-century.

The Megarian moulding technique was adopted by the Roman potters. It was used for red pottery (Terra Sigillata), which was the standard, better quality ware used at the table. A particularly beautiful example is a Roman mould-bowl manufactured from the workshop of Bargathes (=Perrennius III, c. 10 B.C.) in Arezzo, with erotic scenes. The moulding stamp used for making the relief decoration was also retrieved (ill. 21a+b). The relief decorations could also be made separately of clay and attached onto the vessel before it was given its coating of highly purified red clay slip and baked in the oven.

In some cases moulds were not solely used as a technical makeshift to manufacture the final product, but were themselves manufactured as independent objects for commercial purposes. These types of moulds, also known as ‘cake moulds’, were found all over the Mediterranean (ill. 22); most of them date from around the 3rd-century A.D., although some examples may date from an earlier period.

One of the richest finds was made in 1906 by Angiolo Pasqui in Ostia (Italy). Here some 400 of these bipartite moulds, of which many in pairs, were found in an ancient warehouse. Of all the moulds that were recovered almost none could be related to the workshop of a potter or coroplast. Most finds came from houses, baths, harbours and warehouses. Tests proved that the contents of the moulds usually corresponded in weight with one Roman pound. It is likely therefore that these moulds were made for a use in the kitchen. It has been suggested that they have to be linked to the tradition of handing out cakes and bread shaped in symbolic figures during festivals. This is confirmed by the fact that in the direct vicinity of these moulds vessels were found that had a content of three-fourth of a litre. Epigraphic evidence to support this theory originates from inscriptions that mention crustum (cakes) and mulsum (honey wine), which were handed out in Roman Italy during festivals and public games. The graffiti in Latin found on several of this type of mould, plus iconographic arguments, make it unlikely that they originated in Athens. There are cases where such moulds could be related to a ceramic workshop or were applied by potters or coroplasts, but this would be in fact an improper use.

56. Thompson 1934, 451-459; Greifenhagen 1963, 75ff; Rotroff 1982, 1-120.
57. For a basic study on Calene ware, although outdated, see: Pagenstecher 1909. For added corrections see: Richter 1941.
58. Richter 1941, 383-9. Here Richter offers conclusive evidence of the relation between Calene ware and Greek silver phialai from the 5th century B.C.
59. E.g. see Pagenstecher 1913, Taf. XLIX, LI, L.
60. Salomonson 1972, 88ff.
62. The quantities correspond with what was handed out to contestants of public games, see: Salomonson 1972, 101; Drexel 1916, 17ff; Bieber 1961, 241.
63. Salomonson 1972, 102.
64. Salomonson 1972, 101.
5. Small plastic art

The little figurines of terracotta and sometimes of plaster usually had a ritualistic function. During the Roman period they were brought to the temples as votive dedications to the gods, while some took their place in domestic lararia. They could also be found in niches and above doors to keep away the evil eye. Quite often they accompanied their owners to their graves. They were also used as simple objects of interior decoration, or as toys (sigilla) for children to play with. Figurines and plastic lamps were the luxuries of the poor man. They were cheap and were sold at fairs and festivals, beside shrines and around theatres.65

As has been mentioned before, the coroplast manufactured small sculpture like terracotta figurines and oil lamps (ill.23), which were commonly in use during antiquity. Moulds were part of the production process. A fine example is a terracotta mould for a rare type of herm, found in a Hellenistic deposit on the Athenian Agora.66 (ill.24). Moulds for small terracotta figurines could also be made from plaster, like a plaster key mould for the reverse of a figurine of Demeter-Isis (ill.25).

The manufacturing process is as follows. From an archetype, possibly created independently by a specialised craftsman, one or two clay moulds -the Romans also used plaster- was made. From these moulds, while still fresh, several casts were taken and set aside to serve later as secondary archetypes (patrix). The moulds were then used for production until they became worn. At this point they might be refreshed by intaglio (even in the hard clay) to continue service for some time (ill.26). There were casts recovered, that dated from the Roman period, of which it is obvious that they were taken from worn moulds. Perhaps the loss of detail was compensated with paint, in order that they could be sold cheaply. When worn down they became useless and were thrown away after which new moulds were made either from one of the secondary archetypes or directly from one of the last figurines produced. The whole process thus started again with these ‘second generation’ moulds, which, owing to the shrinkage during firing, produced slightly smaller casts. It is occasionally possible, therefore, to trace series of as many as four or five generations of figurines, each made from moulds increasingly smaller in size and increasingly more linear in style due to the successive intaglio freshening.67 An exquisite clay mould of a protome bust of Cybele holding a cymbal was found in Olynthos (4th-century B.C.), presently on display in the Museum of Thessalonike (ill.27a+b).

6. Gypsum-plaster: utilization and material aspects

In antiquity plaster (gypsum in Latin, γυψός in Greek) and stucco were the most common materials for making vaulted ceilings and decorations such as relief mouldings. The manufacturing process of stucco utilized for making ornamented ceilings has changed little through time. It remains basically a mixture of burnt plaster (calcium-sulphate), and lime (calcium-carbonate). Sometimes other substances like sand or milk are added; the latter was to slow down the hardening process, which enabled the stucco-worker to model the material over a

66. The majority of the moulds recovered in the excavations of the Athenian Agora were of clay. The use of plaster moulds was nothing new because this technique was already applied in Egypt, but no complete plaster mould has yet been found in Athens, although small plaster moulds for making terracotta figurines were retrieved from other excavations (see ill 25). Fragments of a plaster mould for a life size statue (inv.T3631) were found on the Athenian Agora during excavations in 1959 in the context of the late 3rd century B.C., see: Grandjouan 1961, 3.
67. Grandjouan 1961, 3; For the analysis of technical processes, see also Nicholls 1952, 217-226.
longer period and to make the decorations. Powdered marble could also be added when extra smoothness of the surface was required.

Gypsum-plaster is made by burning gypsum, a soft mineral (CaSO₄.2H₂O[1]), associated with sedimentary rocks, to produce hemihydrate, a heavy white powder. When mixed with water the paste hardens to a crystalline substance. Plaster expands while hardening, then contracts slightly just before hardening completely. This makes plaster excellent for use in moulds. Nowadays gypsum is also called ‘Plaster of Paris’, named after the hill of the Parisian suburbs of Monmartre where deposits were found in the second half of the 19th-century. The terminology can be confusing for plaster is sometimes inaccurately called gesso. Gesso, though, is any white, water-based primer, usually made by mixing glue and plaster for preparing the surface of wooden panels to paint on.68

The utilization of stucco on walls was common in ancient Egypt, Greece and Rome. The Egyptians applied clay- and gypsum-plaster to decorate houses; it provided a suitable surface for painting on. The use of clay-plaster dates from pre-dynastic and early dynastic times. In Tell al-Amarna it was applied not only in private houses but also in the palaces, the painting was done directly on the clay-plaster. There were two qualities: first, ordinary Nile alluvium was a mixture of clay and sand in varying proportions with generally a small natural admixture of calcium carbonate (carbonate of lime) and occasionally small proportions of gypsum. Secondly, the better quality called hîb which was a mixture of clay and limestone both in a very fine state of division found in hollows and pockets at the foot of hills and plateaux. Gypsum-plaster (also termed ‘lime-plaster’ being always gypsum until a later date) was also used to decorate walls and ceilings of houses as well as palaces and temples. The walls would first be plastered with clay, and were generally coated with gypsum-plaster (to cover up faults and to provide a smooth surface).69 The Egyptians were fully conversant with the baking of gypsum. Oven baked gypsum was used as mortar (in Karnak for instance). The coatings of gypsum-plaster on walls as backings for decorations were plaster in the modern sense of the term.70

In ancient times, large quantities of gypsum minerals were quarried in Egypt in two conditions, one a rock-like formation, which is found in the Mariut region to the west of Ismialia and Suez, in the Faym, and near the Red Sea coast. The other in scattered masses of loosely aggregated crystals, which merely have to be dug up from just below the surface of the limestone desert, and it is this latter that was, and still is, used largely for making plaster. As found gypsum is never pure, but contains varying proportions of calcium carbonate and quartz sand, together with small amounts of other ingredients.71 Furthermore it was found in Phoenicia in present Libanon72, and in ancient Greece in Epeiros near the Tympha Mountains, where it was quarried by opencast mining.73 In Roman times it was quarried in Italy in several places, such as Thurii or Volterra. The latter was celebrated for its gypsum alabaster, a tinted variety that resembles marble.74 The properties of plaster make it a particularly suitable material for making moulded figurines and decorations like festoons on buildings, were already known in classical

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68. For technical details of all kinds of different applications of plaster see: Bonhagen 1914, 2ff.
69. Lucas 1962, 76ff.
71. The fact that it was not pure makes it sometimes difficult to distinguish if objects made from this are to be called stucco or plaster. See: Ponger (1942, 80) who did research on antique Egyptian, Greek and Roman plaster and stucco objects in the collection of the Allard Pierson Museum in Amsterdam. For a general introduction on the use of stucco and plaster in ancient Egypt see: Godin 2000.
antiquity. In antiquity the moulds were usually made from clay, in contrary to modern times when they were also made of plaster. When purified this heavy white powder is mixed with water, which then forms a thick paste that sets quickly into a hard crystalline material. Due to the slight expansion of the plaster paste while setting and thus filling the slightest cavities of the mould, a perfect cast is the result. Obviously the quality of the cast depends on the purity of the plaster. In the production of a cast the first stage is taking a plaster mould from the original, using a separating agent to prevent the plaster sticking to the surface. A traditional mould is made of several plaster pieces which together are called a ‘piece mould’. Because all sculpture, other than that executed in very low relief, has projections and undercutting, these moulds were invariably made in many pieces forming a kind of interlocking three-dimensional jigsaw. Such was done to allow the mould to be removed from the original sculpture. The piece mould would then be enclosed in an outer casing, the interior coated with a separating agent (in modern times shellac lacquer, but in antiquity oil or grease) and the wet plaster is poured in. The divisions between the different sections of the piece mould produce a network of casting lines on the completed plaster cast. From the number of these lines on all the plaster statues manufactured this way, it is clear that this casting process demands specialist skills. A large cast takes a considerable amount of time to make, but can be re-used many times, some ‘modern’ cast have been in use for over a hundred and fifty years.

Plaster is also a suitable material for carving, the casts were sometimes carved over which makes them useful as preliminary studies for sculptors. But also free modelled pieces are known to exist. (ill.28a+b)

7. The application of plaster for moulds and casts

Pliny the Elder mentions Lysistratus of Sicyon as the first to model a likeness in plaster of a human being from the face of a living person, and established the method for pouring wax into a plaster mould to produce a life like cast on which corrections could be made. Excavations have shown that this technique was older and that the Egyptians were familiar with it.

Several plaster heads dating from about 1340 B.C. were found in Tell al-Amarna (18th Dynasty) in the workshop of a sculptor thought to be Thutmosis. (ill.29a+b; 30a, b, c) These masks were taken from sculptures as well as from real faces, some of which are believed to have been of the dead. (ill.31) Others were taken from unfinished sculptures. They all served as mo-

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75. Plin. *HN*, XXXVI, 183; also see Theophr., 67; Paus., XXII, 6-9: ‘In Stymphalus there is also an old sanctuary of Stymphalian Artemis, the image being of wood, for the most part gilded. Near the roof of the temple have been carved, among other things, the Stymphalian birds. Now it was difficult to discern clearly whether the carving was in wood or in gypsum, but such evidence as I had led me to conclude that it was not of gypsum but of wood (…)’. The fact that Pausanias doubts whether the decorations on the temple were of plaster or not proves that plaster was not an uncommon material used for this purpose.

76. Nothing is known about the technical aspects of the production of plaster in Classical antiquity, although charcoal marks on ancient plaster casts found in Baiae, Italy (2nd century A.D.) could be an indication of the burning of gypsum on charcoal fires. Cf. Landwehr 1985, 14; Pliny states that plaster is obtained by burning mineral stone (*HN*, XXXVI, 182).


78. In 1912 the Deutsche Orient-Gesellschaft discovered several plaster heads at Tell el-Amarna, in a building familiarly known as the studio of the chief sculptor Thutmosis. These casts are now at the Ägyptisches Museum SMPK in Berlin.

79. Sir Flinders Petrie, who excavated the plaster masks in 1891, believed that one of the casts was the death mask of King Amenophis III. Other scholars, like Lange (1951) 87, doubted this and pointed out that the features of the cast mask in question do not resemble the features of the face of a dead person. That some of the casts were taken from real faces is evident from the head cloth clearly visible
delts for the production of stone statuary. The faces are slightly worked over but have very realistic features, representing the king and members of the court. It illustrates a short-lived period of a naturalistic art style after which Egypt returned to older and more conventional art forms. Plaster continued to be used by sculptors for models as is evident from plaster casts from the Ptolemaic period (342-30 B.C.).

Both in the Greek and the Roman period the use of plaster as material for large freestanding sculptures is rare but not unknown. There are also cases in which it was used as a surrogate when there was not enough material available. Pausanias relates that Theokosmos got the assignment from Megara to make a statue for the local Zeus temple out of gold and ivory. This coincided with the moment the Peloponnesian War had broken out. When the head of the statue was finished, lack of money forced the artist to make the rest from clay and plaster. It is likely that this perishable material was painted and gilded. Examples of such statues, which have survived, are few.

The plaster worker in the Roman period was called *gypsarius*, as inscriptions testify. Plaster cast ornaments and moulding stamps were also used by the stucco worker (*tector*) for the decorations of stucco ceilings. In the first century B.C., the Roman architect Vitruvius recommends the use of stucco for decorated flat and vaulted ceilings. He also describes the manufacturing process for the application of stucco on walls. When the stucco surface was still moist, marble powder was applied and rubbed down in several stages. Finally it was highly polished until it had the reflection of a mirror. Vitruvius advises against the mixing of gypsum with stucco, for this sets too quickly which hampers the stucco-worker in making decorations. Moreover it prevents the work to dry uniformly, which may cause cracks. Stucco ceilings were quite common in Rome, Pompeii and Ostia. Ceilings as described by Vitruvius are found in Pompeii and Ostia where some of them have survived until today. Pompeii is the best place of the ancient world where these ceilings can be studied in a variety of specimens and in a good state of preservation (ill.32). Earlier excavations in Pompeii neglected the, often fragmented, remains of stucco ceilings. When they were uncovered they were destroyed or allowed to perish. Remaining cornice ceiling mouldings, the *coronae* of Vitruvius, especially the ones that were slovenly made, clearly show the use of a moulding stamp (ill.33a, b, c). These stamps were made of wood and pushed into a raised strip of moist stucco and then applied to successive sections along the line. The stucco decorations were usually adorned with painting. It is also possible that some ornaments or mouldings were cast separately and at a later stage attached onto the ceiling. Evidence of the use of moulding stamps and casts was found during excavations in Pompeii in the 19th-century. In a house called *La Casa delle forme di creta*, several casts of around the woman's face (ill. 29a) which had to protect the hair while the cast of the face was made. On some of them there were clearly marks that they were cast from a mould and filled in from the top, see: Roeder 1941, 153. Günther Roeder, who wrote the most comprehensive article on the plaster masks, was also convinced that some of the heads were casts from life, see: Roeder 1941, 170, n.1.

Several plaster impressions and casts from the Ptolemaic period were found in Mit Rahîneh near Memphis and in Bagram in Afghanistan. See: Möbius 1964, 12; Lunsingh Scheurleer 1967, 1984; Reinsberg 1980; also see: Kyrieleis 1975, he mentions two plaster casts, one is a double portrait of Ptolemaeus Soter and Berenice (Taf.6.3), the other a cast taken from metal relief ware (Taf.7.3). Because his main aim is to give a typology of Ptolemaic portraits he does not address the plaster issue.

Van Buren 1924, 116. Van Buren sums up a list of stucco ceilings of houses in Pompeii that showed mouldings made with the use of a moulding stamp. Also see: Riemenschneider 1986.

This house is located in Regio VII, nr.4, 62.
plaster ornaments were found which were made with moulds or moulding stamps. This led to the assumption that this must have been the house of a stucco worker.  

8. The evolution of a Roman copy industry

The practise of imitating statues or portrait busts was known in pre-Roman times. But the technique of making exact copies of existing sculpture was introduced by the Romans in the first century B.C and soon became an industry by itself. This phenomenon has its roots in cultural and historic, as well as in economic developments.

During the late Republic, the Mediterranea...
As I resolved to pay my respects to Nigrinus the Platonic philosopher (...) I went to his house (...) On entering I found him with a book in his hands and many busts of ancient philosophers standing round about'.

Plaster statues also had an ephemeral function e.g. for decorative purposes at certain occasions. As is recorded in the *Historiae Augustae*:

(....) Again on the day of the circus games, when three plaster figures of Victory were set up the customary way, with palms in their hands (....) struck by a gust of wind, fell down from the balcony (this was the podium: a platform close to the arena, occupied by members of the imperial family).

9. Athena Parthenos and Harmodius and Aristogiton

Some renowned examples of Hellenistic copies and casts, are those of Athena Parthenos and the Tyranicides Harmodius and Aristogiton. In the 2nd century B.C. the rulers of Pergamon, in admiration of the Attic coast, had a copy made of the statue of Athena Parthenos which was more than ten meters high, a work of the famous sculptor Phidias (ill.34). The smaller copy was three feet high and can now be found in the National Archaeological Museum in Athens, though many other copies were made, ancient and modern.

The Tyranicides Harmodius and Aristogiton (ill.35) were the symbol of Athenian freedom and democracy; their statues were erected on the Agora of Athens. The popularity of these statues is confirmed by the discovery of the plaster copies in the Roan copyworkshop in Baiae, Italy, that date from the 2nd century A.D. Among them were the head of Aristogiton and several body parts, also of Harmodius, like feet and arms. In 514 B.C. these two young aristocrats tried to assassinate the tyrants Hippias and Hipparchus. The slaying of tyrants was not punishable by law, neither in Greek nor Roman antiquity. They failed though, not only Hipparchus was killed but so was Harmodius. Aristogiton was taken into custody and sentenced to death. The fame of the two Tyranicides was increased by the false legend that they had ‘liberated’ Athens. Their names also appear in drinking songs (*skolia*) of the time, it was also a popular theme to be depicted on vases. Before the Persians were finally defeated in 480 B.C. at Salamis, they had ransacked large parts of Greece. They also looted Athens, confiscated the statue of the tyrant slayers and took it to Persia. The Athenians did not want to lose their symbol of liberty, and in 477 B.C. a copy in bronze was placed on the agora where previously the original statue had been. After 150 years of exile the original statue was returned to Athens and put next to the replica on the agora.

Despite the large number of memorial statues for private individuals in the sanctuaries and public squares of Greek cities, especially during the late Hellenistic period, no mass production of statues occurred. An exception to this are the ruler portraits from the Hellenistic period, like the Alexander the Great portraits or Ptolemaic portraits. Strictly speaking they cannot even be considered as copies but imitations, since they were often copied from vase paintings or drawings and they only imitate the original.

93. Lucian, *Nigr.*, II. The best example of portrait-copies in a private context were found in the Villa of the Papyri in Herculaneum. Also see: Mattusch 2005.
95. Landwehr 1985, Taf. 4, 6, 8, 9, 10, 11.
96. Simon., *Anath.*, 131, recorded in Bergk 1867, 1162.
The first archaeologist who studied copies from the Hellenistic period was Adolf Furtwängler (1853-1907). The main scope of his studies was the then recently recovered sculptures from Pergamon, which gave proof for the existence of real copies (Wirkliche Kopien). Furtwängler's criterion was the likeness of the copy to the original. He regarded the Pergamon copies as a ‘Preliminary phase (..) of simple and true copying’.\(^99\) But after taking this as an accomplished fact he does not consider this subject any further.\(^100\)

Since Furtwängler all literature on this subject adheres to the theory that Hellenistic copies are the forerunners of the copies of the Roman Principate. According to this theory there is a development from freely made copies to exact and correct copies.\(^101\) A comprehensive dissertation on the subject was written by Jörg Niemeier (1985). He puts the subject in a wider context and explains that the Hellenistic attitude towards copies is more complicated and cannot be viewed as merely a preliminary phase of the Roman copy techniques.

10. Roman copying techniques: puntelli and bitumen

The Romans developed a system to make exact copies of existing sculpture.\(^102\) A common technique, well documented for sculptors from the Italian Renaissance and used until the 20th century, is creating copies with a copy cage.\(^103\) (ill.36a+b) It is very likely that this technique was also applied in Roman times. For the faithful imitation of works of art the artists worked from a plaster or clay model equal in scale. That the technique was very accurate becomes clear when one compares some of the surviving copies (not with the originals they are all lost). Despite the high level of resemblance of the copy versus the original, there were variations, especially in the faces, hairs and clothes.\(^104\)

The system that was generally applied for copying was called the pointing technique. For this the original piece of sculpture is placed into a copy cage. With the aid of a number of horizontal and vertical measuring rods and pins, the position on the surface of the statue that has to be copied is ascertained. The position of the measuring pins is then transferred onto another identical cage that holds the copy. This system was also used with a square frame that was hung...

\(^99\) Furtwängler 1896, 538. The original text reads: Vorstufe (..) zum einfachen treuen Kopieren.

\(^100\) An important contribution after Furtwängler was Georg Lippold's book (1923). He aimed to give a complete survey of the phenomenon of copies and also attempted to establish more uniformity in the terminology. Whereas he, like Furtwängler, was aware of deviations in Hellenistic copies, his main criterion was still the exactness of the copy versus the original. His definition of a copy is: ‘the imitation of a work of art (of any period) which has to reproduce the original as a whole, as in every detail, regardless whether this intention has to be deemed successful or not’ (Nachbildung eines Werkes - gleich welcher Zeit- die im ganzen und in den Einzelzügen das Vorbild reproduzieren soll, einerlei ob diese Absicht als wirklich gelungen betrachtet werden darf [p.3]).

\(^101\) Niemeier 1985, 10. or Miranda Marvine (1989).

\(^102\) Although there are no written sources, which testify to this, nor was it ever depicted in any way. For an attempted reconstruction of Roman copy techniques, see: Pfanner 1989, 157ff. For two early studies on copies and imitations, see: Furtwängler 1896, and Lippold 1923.

\(^103\) Pfanner 1989, 157ff. Pfanner gives a review of the copying of existing sculpture by using the pointing-technique and a copy cage. On such copies measuring points or puntelli were found. For practical aspects of the pointing technique see Hermann Schittenhelm (1920) who wrote an illustrated manual for sculptors on this subject. For economical reasons such copied heads were often herm portrait copies of which many survived time, this type of sculpture decorated many urban horti and garden villa’s.

\(^104\) For the importance of dress styles in judging Roman copies see: Bieber 1977, 20ff. Although it is almost impossible to state with certainty which of the numerous variations, for instance among statue heads, can be attributed exclusively to one Greek original.
over the statue which had to be copied. From the frame, plummets with measuring pins were hung that could be transferred onto an identical square frame above the copy. Both these systems could have been applied by the Romans, but there is no evidence of this. What is certain is that the Romans applied the copy system, because of sculpture that has been found with measuring points or puntelli (ill.37). These elevations belonged to pieces of unfinished sculpture and served as affixtures for the compasses or other measuring instruments to transfer the different proportions.  

Pieces of sculpture executed in bronze and marble were precious and could easily be damaged; it is therefore likely that for the purpose of copying a plaster cast was used to work from. Ancient literature provides us with clues. Evidence of making cast copies of existing sculpture is found in a passage of Lucian's *Theon dialogoi* (2nd-century A.D.), a satire in which traditional Greek mythology is mocked. He describes a Hermes statue on the Agora of Athens, which was very dirty, because every day sculptors were taking casts of it:

Zeu:  ‘(..) Oh yes, it is your brother, Hermes, the one of the public square, beside the Painted Porch. At any rate he is all covered with pitch from being cast every day by the sculptors (..)

Hermagorus:  (..) It fell just now that they who work in bronze had smeared me o'er with pitch on breast and back.  
A funny corslet round my body hung,  
conformed by imitative cleverness.  
To take the full impression of the bronze (..)  

The casting process was started by covering an original sculpture with a thin layer of moist clay, which has the same thickness that the mould should have. Around this mantle a second one of gypsum-plaster is applied which completely covers the clay mantle. When the plaster has hardened the two mantles are taken off and the still soft clay is removed, as well from the statue as the plaster. Subsequently the original is surrounded with the plaster mantle and in the space in between the two a warm liquid casting material is poured. After the plaster is removed the mantle of plastic material that now completely surrounds the original can be cut open and be removed. When the material is cold it is hard and solid, but when it is still warm it has great plasticity. Several plastic materials were used for casting this way, such as resin and gelatine. The advantage of such materials is that they provide the possibility to make a mould in one piece. This in contrast to plaster casting which, due to the rigidity of the material, always has to be done in segments in order to be able to take the mould off the piece of sculpture that has to be copied. Plaster casts can be taken from marble as well as bronze originals. Before casting the original has to be prepared first by applying a separation material, before the plaster mould segments can be

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105 Due to the very few examples that were ever retrieved, it is impossible to reconstruct exactly how the Romans applied their copying techniques.

106 Landwehr 1990, 149.

107 Lucian, *Iup. trag.*, 33 (tr.) A.M. Harmon. Also see: Plin., XXXV, 153. Christa Landwehr (1985, 17), points out that the pitch that is mentioned here is probably bitumen. This material was found near the Red Sea and was the trade product of the Nabataeans, an Arab tribe of greater Syria.

108 Although it is most likely that a mould was made to produce a bronze cast, it is also possible that the process that Lucian describes was applied for plaster casting. The Greeks did not have a name for a plaster worker, who is called a *gypsarius* in Latin. Harmon translated it therefore as ‘They who work in bronze, see: Landwehr 1985, 17, n.98-99.
made. With bronze statues it is more complicated, because there are more openings and roundings than with statues made of marble. The opening folds in draperies first had to be filled with clay, eyelashes were covered with small metal caps, and if possible hair locks were taken off to facilitate the removal of the plaster moulds. Finally the gypsarius removed the ridged seams that were left after casting and applied a mixture of oil and wax on the surface of the plaster copy to give it greater resistance.

As said what greatly enhanced the insight in copies and copying practises was the find in 1952 of the debris of a copy-workshop in Baiae, a luxurious bathing resort at the Bay of Naples in the 2nd-century A.D. From the hundreds of fragments of plaster casts taken from renowned sculptures that were recovered it was clear that they were an intricate part of a copy process. It was the first time that plaster casts of monumental sculptures were ever found. All the plaster casts from Baiae were taken from both marble as well as bronze originals. Deviations in the casting technique permitted to detect this. Some of them were made in Greece and taken to Rome. There are indications that the negative moulds, from which the plaster fragments were cast, were also made of plaster. The durability of this material allowed to re-use the negative moulds. Plaster statues were reinforced with lead, bone, iron or reed. Metal or bronze pins that stuck out of the cast segments were an indication that they were used to connect them together. Of all the fragments finally sixty-seven were identified and ascribed to twelve Roman copies of well known statues which originated in Greece during the 5th- and 4th-century B.C. One of the fragments was identified as a cast from the head of Aristogiton of the Tyranicides. Copies of the Korai of the Erechteion at the Acropolis in Athens were found in Corinth, the Forum of Augustus in Rome (dedicated in 2 B.C.) and in Hadrian’s villa near Tivoli (117-138 A.D.). Although the casts were taken from Greek originals, the way in which they were executed makes them into datable Roman works of art. Despite of the level of perfection of casting techniques, no cast bronze from the Roman period of any Greek sculpture was ever found. With their advanced casting techniques the Romans could, if they wanted to, have made numerous bronze replicas of Greek statues. Also marble copies should have been reproduced on a much higher level of perfection than they actually were.

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109. For a detailed account of the problems related to plaster casting from bronze originals, see: Landwehr 1990, 150ff.
110. For examples see: Landwehr 1990, 160.
111. For details see: Landwehr 1985, 15ff.
113. Landwehr 1990, 152.
114. Pieces of bone and very small fragments of lead, but no iron, were found in the recovered plaster fragments in Baiae. The lead and iron were probably taken out and re-used.
116. Richter 1970, 296, fig.74. Landwehr points out that the Roman copies of the Tyranicides were most probably made after the imitation group made by Kritios and Nesiotes and not after the original by Antenor. For further discussion see: Landwehr 1985, 29.
117. Although examples of a Greek original that can be linked to a Roman copy are rare, see: Landwehr 1990, 150.
119. Landwehr 1990, 161. It is not quite clear why this is the case.