A SMITING-GOD-FIGURINE FOUND IN THE SANCTUARY OF POSEIDON AT KALAUREIA

BY

BERIT WELLS (†)

Abstract

In 2007 a Reshef figurine was found in a secondary context southeast of the Temple of Poseidon at Kalaureia. This article discusses its origin in the Syro-Palestinian area in the thirteenth century BC and suggests it arrived at Kalaureia towards the end of the Late Bronze Age and was deposited in a sacral context. As Reshef in later history was identified with Apollo in the Greek environment, the author speculates on there being perhaps a kernel of truth in the later myth of Apollo and Poseidon having exchanged dwelling places in the hoary past. The peculiar surface of the piece called for a technical analysis, which was carried out by Andreas Karydas from the Institute of Nuclear Physics, Demokritos, Athens. It clarified that the "pock marks" on the surface stem from the manufacturing process and are not the result of corrosion.

During the 2007 excavations in the Sanctuary of Poseidon at Kalaureia, a bronze figurine (KEP 964, MPo 1449)[1] of the smiting-god type (*Figs. 1–2*) was found in Area H002, Block 25, in an early Hellenistic or early third century BC context.[2] It was discovered in a fill, which had been brought in to level the apparently sloping ground southeast of the temple area *peribolos*. As the author's first impression was that the figure was of Late Bronze Age date, the find context raised a number of questions such as: What was it doing in its Hellenistic find context? What was its origin? Who brought it to our sanctuary and when? Whom does the figurine represent? These questions are concerned with what we today think of as the biography of the object and will be considered in that light. However, first a description of the piece is called for.

The figurine is 15.5 cm tall and solidly cast in one piece with a tang underneath the right foot for insertion into a stand of some kind. Of this foot a small fragment of the heel is missing as is the whole left foot, having been broken off just above the ankle. Missing are also the objects that the figure carried in his hands. The raised right hand has a horizontal piercing pointing away from the figure. The piercing in its left, outstretched hand is diagonal and gives the impression that the figure curled its fingers around a round object. The holes appear to have been drilled after the casting of the piece.

The bronze is wearing the crown of Upper Egypt on its head and a kilt reaching down to its knees; a neckline indicates some kind of shirt, possibly with long sleeves, although no lines at the wrists can be made out. A net pattern decorates the kilt with the overlapping folds of the edge clearly marked with three parallel, diagonal and curving incisions at the front. Over the protruding eyes the eyebrows are distinctly indicated, meeting above the large, fleshy nose. Short, wiry, pin-like objects pierce the large ears standing out on both sides of the face. Like the other facial features the lips have distinct volume.

Most of the figure's surface, including the preserved tang, is covered in bumps. Only the right side of the chest, most of the raised right arm and face and the underside of the foot lack them.

DATE AND IDENTIFICATION OF THE FIGURINE

Bronze figurines in the pose of a smiting god are common in the ancient Greek world from the Late Bronze Age, through the Early Iron Age and into Archaic times. Some exhaustive studies on this type of figurine have been made, and they will form the backdrop for this account.[3] As the type has a very long life it is of importance first to establish where to place the Kalaureia piece chronologically. Its closest parallels are two figurines found in a sacral context at Phylakopi on Melos, where they are clearly datable to the Late Bronze Age.[4] Most other figurines have, like ours, been found in secondary contexts.

As to the question of place of manufacture, the examples found on Greek soil deviate to such a degree from anything indigenous that we can state with confidence that they were produced somewhere else.[5] They resemble nothing Minoan and on the Mycenaean mainland there are no bronze figurines whatsoever datable to the Late Bronze Age. The warring-god type had its origins in the Levant, ultimately in Mesopotamia, and thereafter spread to mainland Greece via Cyprus and

[1] The KEP number is the discrete number assigned to individual objects in the excavation database, the MPo number is the Poros Museum inventory number, see also Penttinen & Wells *et al*., this volume.

[2] For further information on the context, see Penttinen & Wells *et al*., this volume.

[3] Negbi 1976; Byrne 1991.

[4] Renfrew 1985, 303–310 and figs. 8.3–8.4.

[5] Negbi 1976, 29–40.

Fig. 1. Four photographic views of the Reshef figurine (MPo 1449) found in the Poseidon Sanctuary at Kalauriea. By Craig Mauzy.

Crete.[6] In general, two main types of figurines of Bronze Age date are recognized, one Syro-Palestinian[7] and one Anatolian based on their stature and their dress. The latter type is stockier and better modeled than the former, according to J.V. Canby, who has specifically studied Hittite art and ascribes to Anatolia a couple of the Bronze Age figurines found in Greece.[8]

Our figurine is obviously of the Syro-Palestinian type like most of the examples found in present-day Greece. In the

[6] See Negbi 1976, 29–40, for their origin and Byrne 1991, 198–200, for the spread of the type.

[7] A very similar figurine is in the Damascus Museum. See Arnz, Benzel & Evans (eds.) 2008, 246, Exhibit 150 (Metropolitan Museum of Art, New York, Catalogue). I thank Dr Andreas Karydas for drawing my attention to this piece). This Damascus figurine is very well modeled, which would contradict Canby's view below.

[8] Canby 1969, 142–144 (the figurines from Tiryns and Nezero in Tessaly).

Fig. 1. Continued.

curled left hand it could have carried a spear or a dagger and in its raised right hand a mace, an axe or a club as do several examples from the Levant. A well-preserved figurine now in the Louvre carries a shafted axe in his right hand and a dagger in his left.[9]

If we accept that our figurine was manufactured in the Syro-Palestinian area in the Late Bronze Age, how did it end up in a Hellenistic context in the Poseidon Sanctuary at Kalaureia? Two alternate possibilities exist: either the figure arrived at Kalaureia in the Late Bronze Age or it was brought there in Hellenistic times. Whichever alternative we choose, there are many unknowns, but two main scenarios should be considered. For the bronze figurine to have arrived at Kalaureia in Mycenaean times, some kind of community on the is-

[9] Negbi 1976, 30–33; the Louvre piece is AO. 20160 illustrated in pl. 21.

Fig. 2. Drawings of the Reshef figurine found in the Poseidon Sanctuary at Kalaureia. By Anne Hooton.

land is a prerequisite. We know for a fact that the waters of the Saronic Gulf were well-traveled in the Late Bronze Age and only in the last decades, the number of recorded Mycenaean sites has risen drastically on the islands and on the Peloponnesian coast.[10] Against this background it is inconceivable that Kalaureia had no place in the established networks in this seascape. A considerable amount of scattered Mycenaean pottery and a couple of figurines have been found in our excavations in Area H allowing us to conclude that the site was at least visited at the time.[11] A brief survey of the evidence to date is called for in this context.

There have been differing opinions on how to interpret the Mycenaean material found within the temple area in 1894. S. Wide and L. Kjellberg suggested the existence of a cult place already in Mycenaean times, a contention that G. Welter dismissed, proposing burial evidence instead. R. Hägg in 1998 re-examined the evidence against the backdrop offered by the finds at Tiryns, Mycenae but especially at Phylakopi and again voiced the opinion that a Late Bronze Age or LH IIIB–C cult place may have existed at Kalaureia.[12] The two surviving fragmentary vessels from the 1894 excavations, a bowl and a kylix, are very scrappy and abraded, but a date in late IIIC is quite possible. In the 1997 excavations, we partly investigated a house complex west of the temple area, where in the corner of one room a boulder, propped up with smaller stones to create a flat surface, may have served as a focus for ritual acts at the very end of the Late Bronze Age. The sparse pottery from the floor layer of the room consisted of mainly drinking vessels of LH IIIC Middle to Late date.[13] My contention at the time of publication of the context was (and still is) that the boulder was employed in rituals and thus that the building housed a cult place in one of the rooms. Such an interpretation is bolstered by the find of fragments of very large, Late Helladic IIIC Late kraters in three eighth-century cult

[10] A few examples will suffice: Konsolaki-Yannopoulou 2002 (Ayios Konstantinos on Methana); *eadem* 2003 (Magoula, Trizinias); and *eadem* 2007 (Modi).
[11] For Area H, see Penttinen & Wells *et al.*, this volume.
[12] Wide & Kjellberg 1895, 297–302; Welter 1941, 45; Hägg 2003.
[13] Wells, Penttinen & Billot 2003, 41–49; Wells, Penttinen & Hjohlman 2006–2007, 68–71.

deposits in the southwest of our area of investigation (underneath and west of the later Building D).[14] In the light of the recent reappraisal of early cult in the neighboring sanctuaries of Aphaia on Aegina and Poseidon at Isthmia,[15] it would not be surprising if, at Kalaureia, some kind of continuity existed between the activities at the very end of the Late Bronze Age and the ritual activities in the eighth century BC. After all, there is a scatter of pottery from the intervening centuries within our area, both Protogeometric and possibly Early to Middle Geometric as well.[16]

Against this background I submit that the Reshef figurine arrived at Kalaureia and was deposited there probably as a votive in a Late Mycenaean religious context. The question then, of course, is how it ended up in a Hellenistic stratum. A. Penttinen argues that the fill in which the figurine was found originated partly in the area of the Temple. Stratigraphically it is obvious that layers close to the temple enclosure were dug into and leveled out at the time of the construction of a large drainage system in the area early in the Hellenistic period.

The layers contained votive material of various dates, discarded probably from a nearby cult place and our figurine may well have been included here as a damaged piece, perhaps having by then lost its stand and one foot.[17] Thus, its biography could be reconstructed as follows: the Syro-Palestinian Reshef was a primary deposition in a late Mycenaean cult context at Kalaureia; at some unknown point in time it became a discard, which finally, in Hellenistic times, ended up in constructional fill southeast of the temple area.

The alternative of the figurine having arrived at Kalaureia in Hellenistic times calls for a brief comment. It presupposes the figurine to have resided in a context somewhere else before it was deposited as an exotic piece in the Kalaureian sanctuary in the Hellenistic period. Such a scenario is less likely as we shall soon see. As Negbi has shown, our type of figurine was mainly produced before 1200 BC in the Levant.[18]

The Phylakopi figurines were found in Late Mycenaean contexts giving a *terminus ante quem* for their date.[19] Renfrew accepts a date for their arrival in Melos in either Late Helladic IIIB or IIIC. Broadly this is what we could suggest for the Kalaureia bronze as well. Such a figurine could have played a role in the religious life of the community on Kalaureia. If so, how can we imagine such a role?

Besides the two Phylakopi figurines, a few further examples found on Greek soil have been considered to be prehistoric, one from Mycenae, one from Tiryns, and possibly the ones from Patsos on Crete, from Delos, Thermon, Lindos and Nezero in Thessaly.[20] To dismiss the figures as exotica picked up by perhaps Greek merchants or mariners in the Levant and then deposited in various sanctuaries on Greek soil is not acceptable; rather, we should consider the possibility of their having carried some other meaning or having had a specific function in their new surroundings. M. Byrne has suggested that for such an object to have been accepted in its new environment, those who embraced it should have been able to invest it with meaning associated with their own beliefs or it would not have been accepted into a new context.[21] If we accept this notion, it follows that a warring god existed in the receiving community and the new image was invested with the aspects of the native deity.

There are two Levantine candidates for the smiting-god type: Baal and Reshef. Baal is the weather god and is depicted as such with flames indicating lightning and bull's horns; Reshef is the warring god hurling weapons with his right hand and holding protective armor in his left.[22] The figurines found in Greece have generally been identified as Reshef.[23] His role as an archer, who also afflicts humans with disease, makes him close to Apollo and a fourth-century inscription from Cyprus actually identifies Reshef as this god.[24] We do not know how far back in time this identification was made, neither on Cyprus nor perhaps on the Greek mainland, but it is tantalizing to imagine that maybe it is of some age. Here I will allow myself to speculate on why such a figure as our smiting god could have been accepted into the Bronze Age community on Kalaureia, perhaps at the very end of the period.

If Byrne is right in his supposition that an "imported" god would have had to fit a figure in the receiving community, this community should have been familiar with an Apollo-like deity at the time of receptivity. However, our sanctuary is one to Poseidon (mentioned specifically in *IG* IV 840, 841, 843, 845),[25] although other gods also were the objects of sacrifice. We know of a Zeus Soter (*IG* IV 840) and of an Aphrodite (*IG* IV 844). Undoubtedly other deities had cults in the precinct—and we believe we can tentatively identify one of them as Demeter—but was there an Apollo too?[26] If myth carries at least a kernel of truth, there may have been, at least in the mythical past.

---

[14] Wells *et al*. 2005, 150–159; Wells, Penttinen & Hjohlman 2006–2007; Wells forthcoming.
[15] Morgan 1999 (Isthmia); Pilafidis-Williams 1998 (Aegina).
[16] Wells, Penttinen & Billot 2003, 60–63.
[17] See Penttinen & Wells *et al*., this volume.
[18] Negbi 1982.
[19] Renfrew 1985, 304, 306.
[20] They are catalogued with full bibliographies in Renfrew 1985, 306–307.
[21] Byrne 1991, 201. Petrović 2001, 116–118, comes to much the same conclusion and argues that the smiting-god figurines both in the Levant and in a Mycenaean context were guardians of sacred and liminal areas as were in fact the Mycenaean terracotta figurines.
[22] Byrne 1991, 182–189.
[23] Renfrew 1985, 303.
[24] Byrne 1991, 185.
[25] Wallensten & Pakkanen, this volume.
[26] Wells, Penttinen & Hjohlman 2006–2007, 99.

According to Pausanias (2.33.2) Kalaureia was originally sacred to Apollo and Delphi to Poseidon, but the gods swapped abodes. In Pausanias' days an oracle was quoted as saying that Apollo loved to dwell both in Delos and on Kalaureia. Is there some substance to the myth? We could perhaps imagine Apollo's presence at the very end of the Mycenaean period at Kalaureia. We know that there was some kind of cult place at the time, as mentioned above, and chronologically this is when the figure of Reshef could have been accepted as an image of Apollo. In a new study on Pythian Apollo in the Argolid, Barbara Kowalzig points to the fact that his cult occurs not only around the Bay of Argolis but also all along the *akte* including Troezen and Epidauros, which is where according to myth the Dryopians settled after they had been exiled from the area of the Parnassos.[27] Even though Poseidon is present not only on Kalaureia but also at Hermione and Troezen, Apollo's massive presence in the area is nevertheless striking.

TECHNOLOGICAL ANOMALIES

In the description of the figurine above, I pointed out that most of its surface is covered with small bumps as if the bronze had chicken pox. Further, our conservator Maria Tziotziou came to the conclusion while cleaning it that the bumps are not the result of regular bronze disease.[28] So what are they? What first comes to mind is that the figure had been covered with some material which, when the bronze corroded, combined with it and formed the bumps. However, if this were the case, it must have been applied after the figure lost its stand, or the surface of the tang would not have had the bumps. Negbi states that sheet gold and silver could be used to coat figurines like ours and, in fact, one of the Phylakopi bronzes is such an example.[29]

In early December 2008 we had the Reshef figurine analyzed by Dr Andreas Karydas from the Institute for Nuclear Physics at the NCSR "Demokritos" in Athens.[30] The investigation was carried out in the Poros Museum and the technological report by Karydas is appended. It establishes unequivocally that the bumps on the surface of the object neither result from any material the figurine was covered with or wrapped into, nor were created through environmental factors such as acidic soil. It also underscored that the bumps cannot be attributed to bronze disease (see above), although, as will be seen in the technological report, some remnants of it is left on top of the bumps; thus, the bumps curiously seem to be part of the original piece, which may seem surprising. A mishap in the manufacturing process seems a more likely explanation for the bumpy surface and could even be attributed to the casting process, as Karydas informs me. Still, the figurine nonetheless attracted "buyers".

Below the right foot of the Kalaureia bronze figure the casting tang is preserved for insertion into a stand. The Phylakopi bronzes have similar tangs as do the other prehistoric examples mentioned above.[31] In some cases the tangs have obviously been broken off, but this is not necessarily always the case, which leaves the question open whether the stands came with the figure or the figure could be inserted into whatever stand suited the recipient. A figure very similar to ours in the Pomerance Collection in New York stands on a lion, which in its turn has a tang for insertion into another object.[32] The legs of the male figure appear not to be inserted into the lion with tangs, which leaves us with yet another possibility of attaching the figure to an object. If the figure generally came with a stand, this was probably of perishable material, as most of the smiting-god figurines now lack stands.[33]

In summary, the Kalaureia Reshef figurine turns out to be an anomalous piece. No other such figurine with bumps on the surface has been illustrated in the literature. The distribution of these bumps on the figurine does not indicate intent as I see it, and therefore, my contention is that the artisan made some mistake while producing the figurine. The piece is so far unique at Kalaureia but is a substantial addition to our corpus of Late Bronze Age material at the site and can be used as a further argument for cult as early as this period.

Berit Wells (†)

BIBLIOGRAPHY

Arnz, Benzel & Evans (eds.) 2008 — *Beyond Babylon. Art, Trade, and Diplomacy in the Second Millennium B.C. held at the Metropolitan Museum of Art, New York, November 18, 2008–March 15, 2009* (Exhibition Catalogue), eds. J. Arnz, K. Benzel & J.M. Evans, New York 2008.

Byrne 1991 — M. Byrne, *The Greek Geometric warrior figurine. Interpretation and origin* (Archaeologica Transatlantica, X), Louvain-La-Neuve 1991.

[27] Kowalzig 2008, 149. Kowalzig points out that what she calls "Apollo's catchment area is strikingly similar to that of the so-called Kalaureian amphictyony."

[28] I also thank Maria Tziotziou for her assistance and for discussions on the technological aspects of the figurine.

[29] Negbi 1991, 2; Renfrew 1985, 305.

[30] I gratefully acknowledge the permit to do so by the Greek Ministry of Culture, The Department of Conservation via the 26th Ephorate of Prehistoric and Classical Antiquities.

[31] Renfrew 1985, figs. 8.3–8.4; Negbi 1991, pl. 1.

[32] Collon 1972, 111–113.

[33] See e.g., Collon 1972, which illustrates figures from all areas where they have been found.

Canby 1969 — J.V. Canby, 'Some Hittite figurines in the Aegean', *Hesperia* 38, 1969, 141–149.

Collon 1972 — D. Collon, 'The smiting god: a study of a bronze in the Pomerance Collection in New York', *Levant* 4, 1972, 111–134.

Hägg 2003 — R. Hägg, 'Some reflections on the sanctuary of Poseidon at Kalaureia in the Bronze Age', in Konsolaki-Yannopoulou 2003a, 333–336.

Konsolaki 2002 — E. Konsolaki, 'A Mycenaean sanctuary on Methana', in *Peloponnesian Sanctuaries and Cults. Proceedings of the Ninth International Symposium at the Swedish Institute at Athens, 11–13 June 1994*, ed. R. Hägg, Stockholm 2002, 25–36.

Konsolaki-Yannopoulou 2003 — E. Konsolaki-Yannopoulou, 'Η Μαγούλα στο Γαλατά της Τροιζηνίας: ενα νεο ΜΕ–ΥΕ κέντρο στον Σαρωνικό', in Konsolaki-Yannopoulou 2003a, 159–228.

Konsolaki Yannopoulou 2003a — *ΑΡΓΟΣΑΡΩΝΙΚΟΣ. Πρακτικά 1ου Διεθνούς Συνεδρίου Ιστορίας και Αρχαιολογίας του Αργοσαρωνικού, Πόρος, 26–29 Ιουνίου 1998*, ed. E Konsolaki-Yannopoulou, Athens 2003.

Konsolaki-Yannopoulou 2007 — E. Konsolaki-Yannopoulou, 'Η Υστερομυκηναϊκη εγκαταστάση στην Ερημονησίδα Μόδι του Σαρωνικού', in *ΕΠΑΘΛΟΝ. Αρχαιολογικό Συνέδριο προς Τιμήν Αδώνιδος Κ. Κίρου Πόρος. 7–9 Ιουνίου 2002*, Athens 2007, 171–198.

Kowalzig 2008 — B. Kowalzig, *Singing for the gods. Performance of myth and ritual in Archaic and Classical Greece*, Oxford 2008.

Morgan 1999 — C. Morgan, *Isthmia* VIII. *The Late Bronze Age settlement and Early Iron Age sanctuary*, Princeton 1999.

Negbi 1976 — O. Negbi, *Canaanite gods in metal. An archaeological study of ancient Syro-Palestinian figurines*, Tel Aviv 1976.

Negbi 1982 — O. Negbi, 'Evidence for early Phoenician communities on the eastern Mediterranean islands', *Levant* 14, 1982, 179–182.

Penttinen & Wells *et al*. 2009 — A. Penttinen & B. Wells, with contributions by D. Mylona, P. Pakkanen, J. Pakkanen, A. Karivieri, A. Hooton & E. Savini and with an appendix by T. Theodoropoulou, 'Report on the excavations in the years 2007 and 2008 southeast of the Temple of Poseidon at Kalaureia', *Opuscula* 2, 2009, 89–134.

Petrović 2001 — N. Petrović, 'The 'smiting god' and religious syncretism in the Late Bronze Age Aegean', in *The Archaeology of cult and religion* (= *Archaeolingua* 13), eds. P. Biehl & F. Bertemes, Budapest 2001, 107–120.

Pilafidis-Williams 1998 — K. Pilafidis-Williams, *The Sanctuary of Aphaia on Aigina in the Bronze Age*, München 1998.

Renfrew 1985 — C. Renfrew, *The archaeology of cult. The sanctuary at Phylakopi* (BSA, Suppl. 18), Oxford 1985.

Wallensten & Pakkanen 2009 — J. Wallensten & J. Pakkanen, 'A new inscribed statue base from the Sanctuary of Poseidon at Kalaureia', *Opuscula* 2, 2009, 155–165.

Wells 2003 — B. Wells, 'The sanctuary of Poseidon at Kalaureia. The investigations of 1997', in Konsolaki-Yannopoulou 2003a, vol. 1, 337–347.

Wells forthcoming — B. Wells, 'Kalaureia in the Early Iron Age: Evidence of early cult', in *Acts of the "Dark Ages" revisited. An International Conference in Memory of William D.E. Coulson. Department of History, Archaeology and Social Anthropology, University of Thessaly, Volos, Greece. 14–17 June 2007*, forthcoming.

Wells, Penttinen & Billot 2003 — B. Wells, A. Penttinen & M.-F. Billot, 'Investigations in the sanctuary of Poseidon on Kalaureia, 1997–2001', *OpAth* 28, 2003, 29–87.

Wells, Penttinen & Hjohlman 2006–2007 — B. Wells, A. Penttinen & J. Hjohlman, 'The Kalaureia Excavation Project: The 2004 and 2005 seasons', *OpAth* 31–32, 2006–2007, 31–129.

Welter 1941 — G. Welter, *Troizen und Kalaureia*, Berlin 1941.

Wide & Kjellberg 1895 — S. Wide & L. Kjellberg, 'Ausggrabungen auf Kalaureia', *AM* 20, 1895, 267–282.

APPENDIX: *IN SITU* XRF ANALYSIS OF A BRONZE FIGURINE IN THE POROS ARCHAEOLOGICAL MUSEUM

BY

ANDREAS KARYDAS

INTRODUCTION

The portable X-ray Fluorescence (XRF) spectrometer of the Institute of Nuclear Physics at NCSR "Demokritos", Athens, was transported to the Poros Archaeological Museum for the *in situ* and non-destructive examination of a unique bronze figurine. The XRF technique provides elemental surface analysis (to a depth of up to some very few tens of micrometers) with very poor depth resolution. The aim of the investigation was to identify the composition of the raw metal, quantitatively if possible, and further, to identify elements associated with corrosion or alteration products distributed on its surface. Eventually, the investigation aimed to provide hints about the nature of green-colored, spot-like bumps that dot the figurine's surface rather randomly.

THE PORTABLE XRF SPECTROMETER

The portable XRF spectrometer used consists of an Rh-anode side-window, low-power X-ray tube (50 Watt, 50 kV, 75 μm Be window), a PIN X-ray detector with nominal 165 eV FWHM at MnK_{α} and 500-μm nominal crystal thickness controlled by a digital signal processor. The analytical range of this portable XRF spectrometer extends through almost the whole periodic table starting from the atomic number Z=13 (Aluminum), under two operational modes, the "unfiltered" with the high voltage set at 15 kV ("low-energy" mode) and the "filtered" one with the high voltage set at 40 kV ("high-energy" mode). The measuring time per spot was set equal to 200s. It should be noted, however, that the detection limits vary for different elements in a rather extended range, from the ppm (μg/g) level to percentage values for the less "sensitive" elements. In the "filtered" mode, the primary tube spectral distribution is modified to an exciting tube spectrum having the low-energy continuum up to about 13–14 keV practically eliminated. This is achieved by the insertion of a composite filter in the exciting beam's path. Two laser pointers are mounted in the spectrometer head in such a way so that the intersection point of their beams coincide with the cross-point of the incident X-ray beam axis and the detector axis, ensuring reproducibility of the measurements. The beam spot at the sample position has a diameter close to about 3 mm.

RESULTS

The object is a bronze figurine consisting mainly of copper and tin (bronze). Minor amounts of lead and iron are also present. The bronze figurine was analyzed in 11 positions (*Fig. 1*). *Table 1* gives a description of the spot areas measured as well as reports the elements detected, arranged from the left to the right according to their relative abundance, estimated on a semi-quantitative basis. Elements exhibiting strong evidence of preferential surface enrichment or contamination have been designated in bold, whereas the underlined designations are the less enriched ones.

In position #8, at the bottom of the left leg, due to its macroscopic appearance the surface was considered representative of the raw metal, i.e., free from any corrosion or alteration layer. Of course, such an assumption cannot be accepted without proof. However, certain experimental parameters were compared between the bronze figurine and a standard reference copper alloy (BCR-A, tin content equal to about 7%). More specifically, both the intensity ratio of Sn and Cu, characteristic X-rays at the high- to low-energy condition, show comparative values between the bronze figurine (#8) and the BCR-A. This reflects the fact that to a certain degree the two elements are rather homogeneously distributed in the surface layer up to about a few tens of 10 micrometers. In addition, by performing compositional analysis at both the low- and high-energy condition, the results are in very good agreement. *Table 2* shows the compositional analysis of the bronze figurine at position #8 (results present an average of two measurements at adjacent spot areas).

The analyzed spot areas on the bronze figurine can be classified according to their macroscopic appearance and texture as the ones with a black-dark green color with a smooth surface and those belonging to the reliefs in a green color. A red-colored spot area (#9) on the back of the figurine was also analyzed. By incorporating the copper-to-tin-characteristic

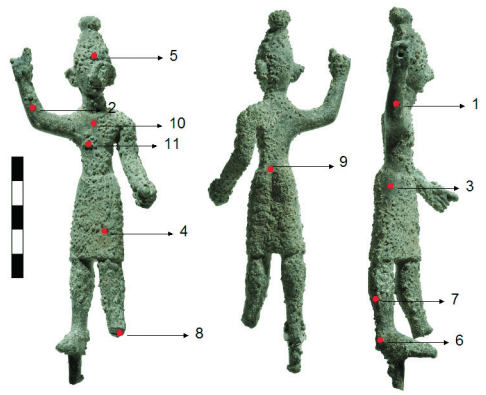

Fig. 1. Spot areas of the bronze figurine analyzed, numbered from 1 to 11.

X-ray intensities at the low-energy condition, we can observe a clear pattern that differentiates the black-dark green areas from the green ones (*Fig. 2*); in the first ones (low values of Cu/Sn #1, 2, 3, 10) there is a tin surface enrichment, probably in the form of cassiterite together with copper oxide (cuprite), whereas in the last ones (#4, 5, 6, 7, 11) tin has been depleted from the surface and green-colored copper compounds are more abundant. The fact that no chlorine or sulfur was detected at the green spot areas indicates that the copper compound present is malachite. At spot area #9, increased amounts of iron were detected in addition to copper. A slightly different but complementary angle is provided by *Figure 3*, where the ratio of tin intensities measured at high- and low-energy condition, respectively, is plotted. Although the difference between the two major groups of spot areas (black and green) is less pronounced, it is still evident. More specifically, in spot #1, the tin layer seems to be thinner than at the remaining ones (#2, 3, 10), whereas in spot #7 the malachite layer is much richer or/and thicker than that in spots #4, 5, 6 and 11. In all the analyzed spot areas, a relative enhancement of iron and lead intensities is observed without excluding the possibility of an external burial contamination. On the other hand, the detection of silicon and calcium is certainly associated with the burial environment indicating the presence of quartz and calcium salts on the surface. The detection of very minor amounts of chlorine in one spot (#4) may further indicate the very selective and local presence of a copper-chlorine compound.

DISCUSSION–CONCLUSIONS

In *Table 3* compositional data for Greek statuettes belonging to different periods are presented.[1] Unfortunately, data are missing for statuettes of any earlier period than the Greek Late Bronze Age and from different provenances. Nevertheless, we can deduce some useful information in comparison with the compositional data of the Poros bronze figurine. The average tin content is between 4–8% but concentrations of up to about 16.5% have been recorded. Therefore the value of about 16.7% for the Poros bronze figurine seems to be an extreme one, but within the expected range. Lead appears in generally large variations and certainly for the earlier periods is not an intentional addition. Values below 1% are common from the early to the Geometric and Archaic periods.

In the framework of the FP6 project PROMET, two gilded copper alloys with typological characteristics similar to the Poros bronze figurine were analyzed. Among the various positions examined on their surfaces, a few could be considered almost free of corrosion products. In these cases, the XRF results indicate that the raw metal (for both Syrian figurines) is bronze with a tin content of about 6–7%. Arsenical impurities are also present.

Concerning the nature of the corrosion/alteration products

[1] Craddock 1976; *idem* 1977.

Table 1. Description of the spot-areas analyzed and of the elements detected by the portable XRF spectrometer.

No.	Description	Elements*
1	Smooth surface, right hand, black-dark green color	*Cu*, **Sn**, **Si**, **Ca**, *Fe*, *Pb,* As
2	Smooth surface, right hand, black-dark green color	*Cu*, **Sn**, **Si**, **Ca**, *Fe*, *Pb,* As
3	Smooth surface, body, black-dark green color	*Cu*, *Sn*, **Si**, **Ca**, *Fe*, *Pb,* As
4	Bump/relief, front side, dress, green color	**Cu**, *Sn*, **Si**, Ca, *Cl,* Fe, Pb, As
5	Bump/relief, head in the center, green color	**Cu**, *Sn*, **Si**, Ca, Fe, Pb, As
6	Bump/relief, right leg at the ankle, green color	**Cu**, *Sn*, **Si**, Ca, Fe, Pb, As
7	Bump/relief at the right leg-side, pale green color	**Cu**, *Sn*, **Si**, Ca, Fe, Pb, As
8	Clean metal at the bottom of the left leg	Cu, Sn, **Si**, Ca, Fe, Pb, As
9	Red area, back side	**Cu**, Sn, **Si**, Ca, Fe, Pb, As
10	Smooth surface at the chest, black-dark green color	*Cu*, *Sn*, **Si**, **Ca**, *Fe*, *Pb,* As
11	Bump/relief at the chest, green color	**Cu**, *Sn*, **Si**, Ca, Fe, Pb, As

* The elements have been arranged from the left to the right according their relative abundance, estimated on a semi-quantitative basis. Elements exhibiting strong evidence of preferential surface enrichment or contamination have been designated in bold, whereas the underlined elements are the less enriched ones.

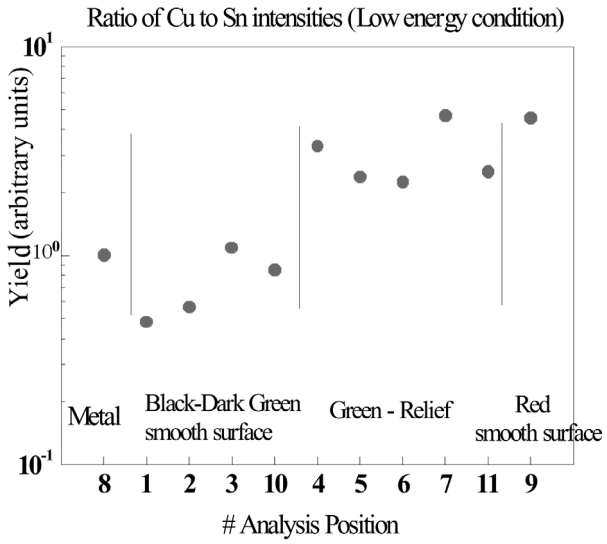

Fig. 2. Variation of the ratio of copper-to-tin-characteristic X-ray intensities at the various spot areas of the bronze figurine analyzed.

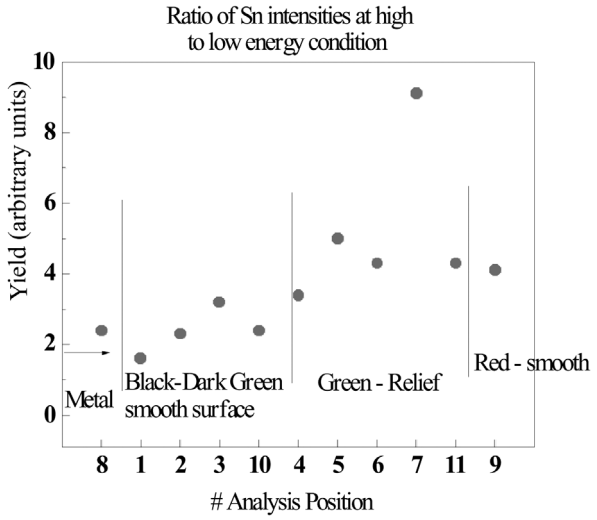

Fig. 3. Variation of the ratio of the tin-characteristic X-ray intensities (high (SnKα) to low (SnLα) energy condition), at the various spot areas analyzed on the bronze figurine.

on the surface of the Poros bronze figurine, the following pattern has been observed: 1) Black–dark green areas contain a tin-rich compound (cassiterite) together probably with copper oxide (tenorite) and carbonate (malachite); 2) The bump reliefs with green color are composed mainly of copper carbonate (malachite); 3) One red area in the back seems abundant in copper (cuprite) and iron (iron oxides due to burial environment). Calcium salts and quartz are detected in all the spot areas examined originating from the burial environment.

A final comment should be added concerning the tin content. It should be noted that a tin concentration of about 7% results in a soft matrix of α-kind crystals in the copper metal, i.e., a solid solution of tin in copper with the structure of copper. Such an alloy can be processed by hammering. How-

Table 2. Compositional analysis of the bronze figurine at the position #8.

Element	Concentration (%)
Cu	81.9 ± 1.0
Sn	16.7 ± 1.0
Pb	0.79 ± 0.09
Fe	0.35 ± 0.05

Table 3. Compositional data for Greek statuettes belonging to the Department of Greek and Roman Antiquities of the British Museum and from the Department of the Antiquities of the Ashmolean Museum.

No.	Period	Tin–Sn		Lead–Pb	
		Concentration Range (%)	Concentration Average (%)	Concentration Range (%)	Concentration Average (%)
1	Greek Late Bronze Age	1–13.8 (13) <1 (9)	5.6 (13)	1–27.1 (9) <1 (13)	7.3 ± 8.0
2	Sub-Minoan Bronze	1–7.8 (6) < 1 (7)	4.1 (6)	> 1 (3) <1 (10)	–
3	Greek Geom. Bronze	1–13.7 (68) < 1 (5)	6.6 (68)	1–17 (33) <1 (40)	3.8 ± 4.8
4	Archaic Greek	1–16.5 (62)	7.4 (62)	1–21.6 (48) <1 (14)	6.8 ± 5.4
5	Classical Greek	2.35–12.8 (27) < 1 (1)	7.9 (27)	1–21.6 (23) <1 (5)	5.9 ± 4.3
6	Hellenistic Greek	2.0–13.8 (29) < 1 (2)	7.6 (29)	1–30.5 (28) <1 (3)	14.8 ± 9.1

ever, as the tin content is increased, another crystal phase dominates, the so-called α+δ (eutectic constituent that appears around the originally formed α-phase) that is very brittle and cannot be processed by hammering. In cases where a tin content of about 11% has been measured in bronzes whose function required hardness (like the Dendra cuirass) J. Papadimitriou[2] suggests a two-stage process to overcome this problem: firstly, the heating of the bronze metal to relatively high temperature obliterates the eutectic phase. Next, with a sudden cooling in room temperature the soft (α-phase) remains and manifests the microstructure of the alloy. The measured tin concentration of 16.7% in the Poros bronze figurine might suggest that it was manufactured under "uncontrolled" conditions and may be of even earlier date than the Syrian bronze figurines. The small range of variation of the average content of tin in statuettes from the Bronze Age to Hellenistic times further supports this argument.

Andreas Karydas
Institute of Nuclear Physics
N.C.S.R. "Demokritos"
PO Box 60228
GR-153 10 Agia Paraskevi, Athens
E-mail: karydas@inp.demokritos.gr

BIBLIOGRAPHY

Craddock 1976 — P.T. Craddock, 'The Composition of copper alloys used by the Greek, Etruscan and Roman civilizations. 1. The Greeks before the Archaic period', *JAS* 3, 93–113.

Craddock 1977 — P.T. Craddock, 'The Composition of copper alloys used by the Greek, Etruscan and Roman civilizations. 2. The Archaic, Classic and Hellenistic Greeks', *JAS* 4, 103–123.

Papadimitriou 2001a — G.D. Papadimitriou, 'Η εξέλιξη των κραμάτων χαλκού στον Ελλαδικό χώρο μέχρι το τέλος της γεωμετρικής περιοχής. Κραματικές προσμείξεις και τεχνολογική εξέλιξη', in *Αρχαιομετρικές μελέτες για την Ελληνική Προιστορία και Αρχαιότητα,* Επ. Επιμέλεια, Ι. Μπασιάκος, Ε Αλούπη & Γ. Φακορέλλης, Athens 2001, 587–608.

Papadimitriou 2001b — G.D. Papadimitriou, 'Μελέτη προσομοίωσης αρχαίων ορείχαλκων: Οι μηχανικές και μεταλλοτεχνικές τους ιδιότητες', in *Αρχαιομετρικές μελέτες για την Ελληνική Προιστορία και Αρχαιότητα,* Επ. Επιμέλεια, Ι. Μπασιάκος, Ε. Αλούπη & Γ. Φακορέλλης, Athens 2001, 713–733.

[2] Papadimitriou 2001a; *idem* 2001b.