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ARCHAEOMETRIC INVESTIGATION OF A HELLENISTIC GOLDEN FUNERARY BELT: A CASE STUDY

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ABSTRACT

Archaeometric analysis based on Optical Microscopy, X-Ray Fluorescence and Ion-Beam analysis were used to study a golden funerary belt with an anthropomorphic and zoomorphic iconography. This complex gold and enamel work shows the portraits of a man and a woman, as well as a libation scene, can be dated to the Early Hellenistic period. The data obtained point to a Near Eastern workshop (Babylon) as the place of manufacture, while comparative typology leads us to the Far East (Afghanistan) as the presumable origin of the morphotype. Elemental analysis results raise anew the old debate on the use of cadmium in the solder alloys.

Finally, from the iconography we suggest to identify the manly figure with one of the few small format portraits of Alexander the Great.

KEYWORDS: Technology, Goldwork, Enamel, OM, XRF, PIXE-PIGE, Near Eastern Hellenism.

1. INTRODUCTION

The history of jewellery research has an early chapter regarding the collecting of the eighteenth and nineteenth centuries (Rudolph 1996; Sopo 2017). The archaeological collection on Siberian Antiquities of Peter the Great (1672-1725) is the earliest of its nature recorded in Russia and probably in Europe. It was kept in his Summer Palace till the death of his wife Catherine I (1727) when it was transferred to the Kunstkamera. The relevant point is not only the high number of items kept in this collection but the documentation associated to them including the origins, time and place of their discovery and Treasury invoices (Korolkova 2017), an exceptional case at the time. Unfortunately a fire partially destroyed these papers in 1747, and finally in 1859 it was taken to a safer place in the Hermitage where it remains. This happy end was not the common fate of other important collections in Russia. For example, the nineteenth century J.A. von Nelidow collection (Minns 1913: 386) was obtained by the Soviet state during the Russian Revolution on behalf of the Hermitage, but finally it was sold in public auction and dispersed in 1931 (Ogden 1992: 11).

With the aim of preserving the information still available and to increase our knowledge on the Hellenistic goldwork technology and iconography we undertook the study of a gold belt from a scarcely known historical collection whose general trajectory is as follows.

The Zar Fyodor I Ivanovich, son of Ivan IV The Terrible, gave this belt to the Orthodox Church as a present in 1588 together with other antiquities. This first nucleus of the collection, known as *Jewels from the Ancient Age*, was increased with further donations by the Empress Catherine II about 1774. In 1915 the Church entrusted the collection to the Great Prince Dolgoruki for security reasons considering the revolutionary instability to be finally deposited out of the country. After some changes in the collection's management it was transferred to the Community (Parish) of St. Dormitory Church of the UOC-MP (Ukrainian Orthodox Church-Moscow Patriarchate) Zhytomir Diocesis in 1993. Unfortunately this collection has not been inventoried or catalogued and it remains unpublished; only very few exceptional objects were analysed or investigated. Basically it is made up of Greek, Greco-Scythian, Scythian, Roman and Byzantine jewellery.

The object of our research is this funerary gold belt made up of a wide strap spaced by five roundels with a figurative ornamentation, and two massive terminals in the form of rams' heads. It is in a good state of conservation and it is actually kept in a Spanish private Collection. The archaeometric study involved the use of a series of analytical techniques in order to solve questions about its technology. The method applied was the combination of optical microscopy (OM), X-Ray Fluorescence (XRF) and Ion Beam Analytical (IBA) techniques, which has proven effective to reveal the expertise of ancient goldsmithery in different civilizations (for example, Perea et al. 2013).

2. THE BELT AND ITS STRUCTURE

The belt is 87 ± 1 cm long; 2,4 ± 0,1 cm wide, and weights 1104,3 gr. The central roundel measures 5,5 ± 0,1 cm in diameter and 0,80 ± 0,01 cm thickness; the other four roundels 4,9 ± 0,1 cm in diameter and 0,66 ± 0,01 cm thickness (Fig. 1).

Figure 1. The gold belt in its complete length of 87 cm.

The complexity of this structure is directly proportional to the number of individual elements that had to be shaped individually and joined together, without losing the flexible nature of the whole. For example, roundels with human faces are made up of at least 55 different elements, without regarding ornamental wires, globules or enamels.

The basis of the structure is a wide strap made up of seven loop-in-loop individual chains cross-linked with a continuous zigzag wire. This particular linkage is rare, with few Hellenistic examples from the East Mediterranean (Ogden 1982: 58). We cannot say if the strap is a continuous piece all along, or if it is divided into six sections separated by the five roundels. The latter hypothesis is more likely, though only an X-ray image could settle this point and we were not allowed. It is worth noting the incalculable meters length of wire necessary to fabricate this strap. Concerning the wire, its gauge is extremely homogenous and relatively thick if we compare it with the ornamental wires used elsewhere; the reason lies in the heavy weight the strap had to support. The helicoidal seam visible on the surface of each loop is an indication of the manufacturing process by twisting a strip of gold (see below). The strap does not show use wear traces so we can infer a short period of use, if any.

Figure 2. Ram's head at one of the terminals. The fine punch pitting of the skin is shown on the snout. Plain wires show a seam line along their surface. The palmette motif was delineated with filigree cords.

At each end of the strap a solid ram's head was attached (Fig. 2). The joining system is not visible as the area was wrapped up in a filigree ornamented gold sheet with a palmette design. At each side of the animal's heads two opposing rings were soldered, possibly being part of the belt attachment (Fig. 3). These heads are very bulky and suppose the main contribution to the overall weight of the belt.

Figure 3. Back side of the ram's head with two opposing soldered rings. We can also see the wrapping sheet union line, and filigree wires with the typical seam line along the surface.

The strap is interrupted by five roundels with different iconographies on them. Their structures are similar, a cylindrical flat box with two opposite openings where the strap comes in, apparently in a continuous way (Fig. 4). The circular sheets of the obverse support an intricate ornamental structure while the reverses are smooth with a very simple filigree palmette in four of the roundels and a double palmette in the central one (Fig. 5).

Figure 4. Side view of the structure of the roundels with the openings where the strap comes in.

The four side roundels repeat two motifs, the frontal faces of a man (Fig. 6) and a woman (Fig. 7). The man has wide eyes without the pupils being marked, while the woman's eyes are complete and lively. They both seem to upsurge from a two-tier rosette with tendrils.

The central roundel, which is slightly bigger than the others, shows a funerary libation scene in relief (Fig. 8). It represents a nude woman looking at the viewer from the left back; the left hand holds a kylix and the right one holds the end of a very thin cloth whose opposite end rests on a low column. In front of her a shield with a gorgoneion on a stool and a helmet with a crest on the floor. The scene is surrounded by linear frets in filigree, granulation and enamel. Highlights the way in which the artisan fitted an oval form into a circular space without distorting the balanced appearance of the whole.

Figure 5. Double palmette ornamentation at the back of the central roundel. Surface fine pitting is shown on the edges. Filigree wires show a seam line along their surface.

3. METHODS AND RESULTS

The archaeometric study of the belt included the analysis of the metal and enamels (glass) and was undertaken with three main objectives. In view of its good state of conservation firstly we wanted to discard a total/partial fake or any kind of modern intervention, as it was proved (see below). Secondly it was a good chance to characterize materials, procedures and technical abilities of a masterpiece of early Hellenistic goldwork. And thirdly we wanted to investigate the brazing/soldering methods used in the supposed region of origin -Middle East- where there is not much analytical data and compare them with those of a Western European region (Perea, García-Vuelta, Fernández-Freire 2010).

Figure 6. The frontal face of a man with the eyes wide shut. Fine punch pitting is shown to shade the skin.

Figure 7. The frontal face of a woman with lively opened eyes. The punch pitting was used in the same manner as in the man's face.

Methodology consisted firstly in the observation of the metal surfaces by optical microscopy (OM) and then an analytical approach with X-Ray Fluorescence (XRF) as a first attempt to determine the composition of the metal. In this particular case we were not able to use SEM-EDS (Scanning Electron Microscopy with Energy Dispersive Spectroscopy) because of the size of the belt so we used IBA techniques, PIXE (Particle Induced X-ray Emission) for elemental composition, including minor and trace elements of the individual parts of the belt in metal; PIGE (Particle Induced Gamma-ray Emission) to confirm the glass matrix of the enamel; and RBS (Rutherford Backscattering Spectrometry) to assure the belt was not gilded. Other benefits of this technique are the possibility of using an external microbeam (around 150 µm), allowing the analysis of narrow or larger areas, and avoiding the use of vacuum chambers.

Figure 8. The central roundel worked as a cameo with a funerary libation scene surrounded by enamelled filigree and granulation motifs.

3.1 OM

Topographic observation of metal surfaces with optical (OM) or electron microscopy (SEM) -especially gold for its particular nature- has been proven an efficient method in the identification of ancient/modern technical processes, tool marks, finishing work, use wear and deterioration in site/museum conditions (Meeks 1998; Formigli 2009; Perea 2009; Armbruster et al. 2003; Perea and García-Vuelta 2012; Dolfini and Crellin 2016). In our case we had to give up SEM due to the size and shape of the belt that prevented its safe introduction in the vacuum chamber. We finally relied on the observation with binoculars up to 80x and flush lighting which permitted us to identify surface microstructural and working features.

3.2 Technical processes

The belt is a good sample of Hellenistic goldsmithery. We have identified known and other new technical processes performed with great mastery that adds to our knowledge of the craft and the social relations of production. We will summarize the technological study in four general issues, filigree, granulation, plastic deformation and casting.

The filigree wires for ornamental purposes are plain wires with three different gauges combined in diverse forms, mostly two wires twisted together in a cord –we leave out the thread used to weave the strap as it is a structural element. The finest was used in the frets of ova containing enamel and the thickest to top borders and edges. All of them present a seam line on the surface characteristic of the manufacturing process by twisting a strip of gold (Fig. 5). Depending on the strip thickness and the tightness of the coils results could be very different (Oddy 1977; Ogden 1991). Of a different kind is the cord used to delineate the palmettes at the end of the ram's heads; in this case they used a thicker strip of gold twisted more loosely which results in sharp helical ridges (Fig. 2).

There are no worked wires in the belt[1], an important fact which must be taken into account when trying to determine its origin. Worked wires are conspicuously used by Iberian, Etruscan, Greek Classical and Hellenistic jewellery production of the Mediterranean (Cristofani and Martelli 1985; Deppert-Lippitz 1985; Nicolini 1990; Williams and Ogden 1994).

Granulation for its part is used exclusively in the central roundel, around the libation scene (Fig. 8). The outer most ornamental fret is a simple line of granules and the inner one is a line with triangles. Granules are of a relatively large gauge if we compare them with other Western Mediterranean productions of Hellenistic times. Nonetheless the spheres are extremely homogenous and show a very clean brazing procedure.

Plastic deformation by hammering was used to manufacture sheets, the base material of all the hollow elements, roundels and small fittings (Fig. 3). Repoussé work stands out in the shaping of the frontal faces of the man and the woman on the four

[1] Worked or beaded wires show a deformed/segmented surface obtained by rolling a plain wire with the aid of a single or double cutting-edge tool (Ogden 1982: 52-53; Whitfield 1998).

side roundels (Figs. 6, 7). We do not dismiss the use of a die to stamp these faces, which are repeated two to two, but only the examination of the reverses could settle the issue and we had no access. Be as it may, sheets were retouched by hand on the obverse in order to shade the skin appearance; this was achieved by an extremely fine, serried, punch pitting that covers the faces completely. The same technique was used to shade the skin of the ram's heads and in the roundels reverses, but in this last case the pitting covers only the edges (Figs. 2, 5).

Finally, there are three cast elements, the two animal heads of the finials and the outer sheet of the central roundel with a libation scene. The heads are solid cast, most probably by the lost wax method, except the two rings that were subsequently soldered. After cast retouching was observed in the punch pitting of the skin. By its part, the central roundel displays an oval concave gold plate worked as a cameo with a funerary libation scene in relief (Fig. 8). This extremely fine work could only be achieved by a lost wax casting.

Some of these technical processes, mainly filigree and granulation, and the final assembly of the separate elements implies the use of metallurgical joining techniques like soldering/brazing. We will discuss this issue in view of the analytical data below.

3.3 Quantitative elemental analysis: XRF, PIXE and PIGE

The analytical methodology consisted of the combination of portable X-ray Fluorescence (XRF) and ion beam analytical (IBA) techniques. The XRF allowed a first attempt to wide area analysis (X-rays circular beam of 15 mm diameter) of the central roundel, the strap and the two ram's heads. The composition in Table 1 shows the weight percentage in gold, silver and copper, although some very low quantities (<0.3 %) of iron were also found in two spots: the central roundel and the strap. Even though cadmium can be detected by XRF, we have used the PIXE technique because the size of the beam spot allows the accessibility to specific joined elements.

Table 1. XRF results in % weight.

Analyzed Area	Fe	Cu	Ag	Au
Back of central roundel	0,15	7,6	9,29	83
Back of woman`s roundel		7,09	13	80
Back of man`s roundel		6,21	13,2	80,6
Strap	0,26	6,08	7,83	85,8
Wrapping sheet of left ram		7,68	10,1	82,2
Wrapping sheet of right ram		8,48	9,78	81,7

Ion Beam Analyses were performed at the ion accelerator (Climent-Font et al. 2004) of the Centro de Micro Análisis de Materiales (CMAM) Universidad Autónoma de Madrid (UAM). Further information about the external micro-beam line can be found in Enguita et al. 2004. The setup of the analysis and the quantification of the spectra was the one usually used by our group in gold based objects (Perea et al. 2006; Perea et al. 2013; Zucchiatti et al. 2014) but using protons at 2 MeV and with a 75 µm Zn filter on the high X-ray energy detector.

Three gold alloys of known composition and two NIST glass standards 610 and 621 were used as reference materials to assess the reliability of the method. As an example of reproducibility and accuracy we show (Fig 9) PIXE results of the alloy standards (similar reliability was found in the enamels study). However, slightly higher uncertainty can be expected on the analysis on the points of the belt as not all measures were done under perfectly flat surfaces.

The composition determined by PIXE of the main elements, gold, silver and copper, is showed in Table 2 (at the end of the section). Minor or trace quantities of Ti, Mn, Fe and Cd were also found in some analyzed points. RBS shows a bulk spectra matrix, discarding the presence of gilding in the belt.

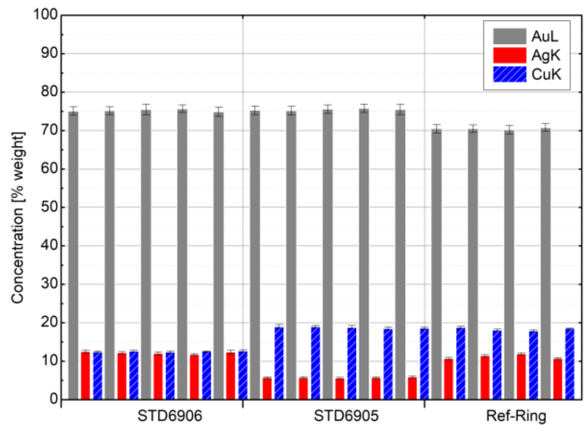

Figure 9. Gold, silver and copper composition of the reference standards obtained by PIXE.

According to the results (Fig. 10), the compositions obtained with p-XRF and PIXE techniques are quite similar, proving that the former gives a proper attempt for performing measurements on objects unable to be carried to a particle accelerator facility. However, due to its advantages as reproducibility, ability to trace detection analysis and work capability with a micro-beam (and therefore accessibility to narrow areas), the later technique was useful for the study of the metal technology of the belt.

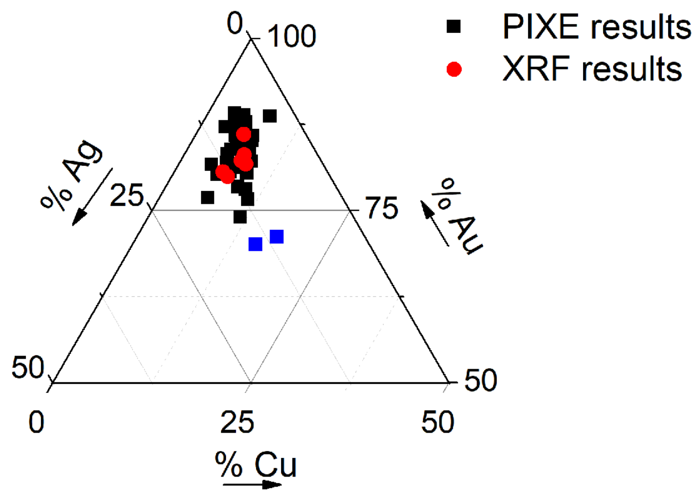

Figure 10. Comparison of the ternary Au, Ag, Cu diagram of the XRF (red circles) and PIXE (black squares) results. Blue squares represent analyzed points by PIXE with high levels of cadmium (>2%w/w).

PIXE results showed that the belt is composed by a relative homogeneous ternary Au-Ag-Cu alloy. With exception of samples with higher contents on Cd (H16, H45) the analyzed points are gold rich with concentrations above 74% in weigh and low levels of Cu (<12%).

Analytical composition of the spots confirms the use of different batches while working the individual parts of the belt. In this sense, the obverses and reverses (in pink on Fig 11) of each roundel have a different composition; and in between them, the one representing the goddess (Aphrodite?) has a higher gold content than the ones with human faces. Furthermore the ram's heads were casted in an alloy with high silver levels similar to the reverse of the man roundel (Table 2 at the end of the section). Finally, the rings and the wire links of the strap have a narrow copper distribution from 4.18% to 7.01%.

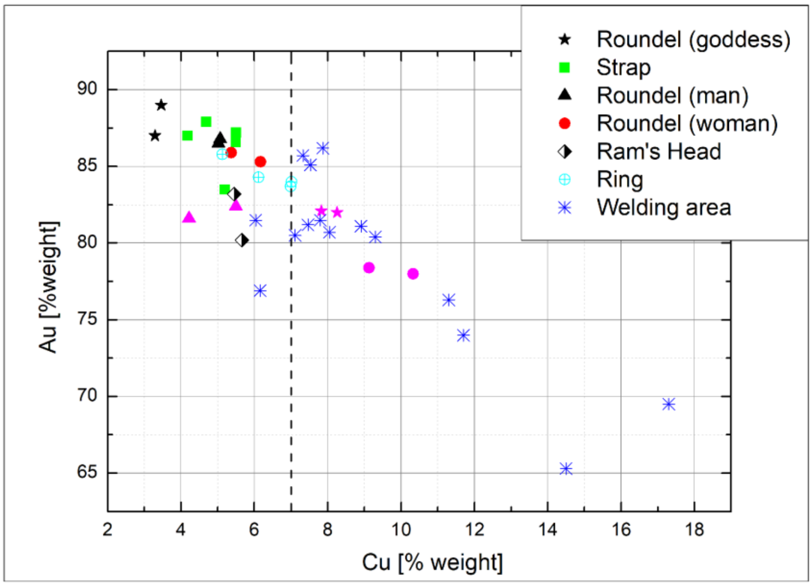

Figure 11. Relationship between Cu and Au contents of the different parts of the belt. Pink data points represent the obverse of each roundel.

Regarding the study of the enamel decorations in the Ram's head and the goddess's and man's roundels by means of PIXE (Table 3, at the end of the section), remarkable high levels of sulphur and aluminium together with extremely low contents of sodium (checked also by PIGE), evinced a high degree of degradation of the surface. The clear difference between a normal glass matrix as a standard NIST and the analyzed enamels is shown in Fig 12 where the former are represented in red triangles and the degradated samples in black stars, reaching the 66% in sulphur contents (blue stars).

In addition to uncertainties in the quantification of the results due to this degradation issue, PIXE spectra were also contaminated with the underlying alloy peaks (Cu, Ag and Au). Even though silver and gold signals can be ignored (treating them as parasitic elements as no chemical elements of the glass lies in that energetic range), copper could be present also as a chromophore in the enamel.

However, other chromophores as manganese and iron were observed in all the enamels whereas cobalt in very low levels was only found in blue sample L07. Finally, cadmium detected in sample L13 should be associated to the underlying alloy.

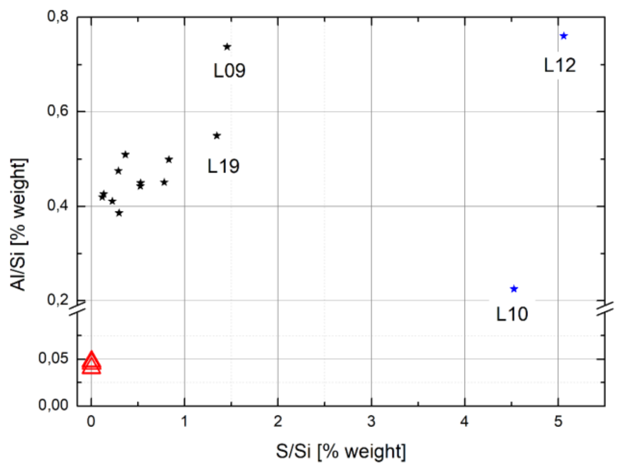

Figure 12. Relation between sulfur and aluminum in the PIGE results of the glass components.

Table 2. PIXE reslts of the metal alloy.

Belt component	Spot analyzed	File	TiK-L	MnK-L	FeK-L	CuK-H	AgK-H	CdK-H	AuL-L
Roundel (goddess)	RG-obverse	H22.dat	-	-	0,123 ± 0,022	3,46 ± 0,06	7,43 ± 0,19	-	88,99 ± 1,13
Roundel (goddess)	RG-obverse	H23.dat	-	-	0,044 ± 0,015	3,29 ± 0,07	9,6 ± 0,3	-	87,04 ± 1,03
Roundel (goddess)	RG-reverse	H30.dat	0,037 ± 0,015	-	0,022 ± 0,015	8,26 ± 0,16	9,6 ± 0,3	-	82,03 ± 1,03
Roundel (goddess)	RG-reverse	H31.dat	-	-	-	7,83 ± 0,19	10,1 ± 0,4	-	82,1 ± 1,4
Ram's head	RH-forehead	H07.dat	-	-	0,034 ± 0,014	5,66 ± 0,09	14,1 ± 0,3	-	80,17 ± 1,05
Ram's head	RH-nose	H06.dat	-	-	-	5,45 ± 0,16	11,3 ± 0,4	-	83,22 ± 2,00
Ram's head	Ring	H10.dat	-	-	-	6,12 ± 0,17	9,6 ± 0,3	-	84,28 ± 1,00
Ram's head	Ring	H15.dat	-	-	-	7,01 ± 0,15	9,0 ± 0,3	-	83,97 ± 1,03
Ram's head	Ring	H44.dat	-	-	-	6,99 ± 0,14	9,3 ± 0,3	-	83,73 ± 1,00
Ram's head-II	Ring	H48.dat	-	-	-	5,13 ± 0,06	9,04 ± 0,23	-	85,84 ± 1,03
Roundel (man)	RM-obverse	H20.dat	-	-	0,075 ± 0,016	5,02 ± 0,06	8,42 ± 0,22	-	86,49 ± 1,00
Roundel (man)	RM-obverse	H21.dat	-	-	0,126 ± 0,018	5,07 ± 0,06	7,97 ± 0,20	-	86,84 ± 1,00
Roundel (man)	RM-reverse	H35.dat	-	-	0,75 ± 0,08	5,5 ± 0,3	10,4 ± 0,6	0,91 ± 0,20	82,4 ± 1,9
Roundel (man)	RM-reverse	H36.dat	-	-	0,08 ± 0,03	4,22 ± 0,16	14,1 ± 0,6	-	81,6 ± 1,6
Roundel (woman)	RW-obverse	H18.dat	0,236 ± 0,025	-	0,050 ± 0,015	6,17 ± 0,12	8,3 ± 0,25	-	85,29 ± 1,08
Roundel (woman)	RW-obverse	H19.dat	-	-	0,072 ± 0,016	5,37 ± 0,06	8,63 ± 0,22	-	85,93 ± 1,00
Roundel (woman)	RW-reverse	H08.dat	-	-	0,078 ± 0,023	9,13 ± 0,18	12,4 ± 0,4	-	78,4 ± 1,3
Roundel (woman)	RW-reverse	H09.dat	-	-	0,059 ± 0,017	10,33 ± 0,17	11,6 ± 0,3	-	77,97 ± 1,09
Ram's head-II	Welding area	H52.dat	-	-	-	7,46 ± 0,18	11,3 ± 0,3	-	81,25 ± 1,05
Ram's head-II	Welding area	H53.dat	-	-	-	7,11 ± 0,19	12,3 ± 0,4	<LOQ	80,47 ± 1,00
Roundel (goddess)	Welding area	H59.dat	0,20 ± 0,03	-	1,70 ± 0,09	7,87 ± 0,22	3,1 ± 0,25	0,86 ± 0,15	86,2 ± 1,6
Ram's head	Welding area	H11.dat	0,112 ± 0,021	-	0,30 ± 0,03	8,91 ± 0,11	8,7 ± 0,3	0,87 ± 0,13	81,11 ± 1,20
Ram's head	Welding area	H16.dat	0,059 ± 0,017	-	-	14,5 ± 0,3	13,4 ± 0,4	6,8 ± 0,3	65,26 ± 1,04
Ram's head	Welding area	H45.dat	-	-	-	17,3 ± 0,3	10,9 ± 0,3	2,37 ± 0,13	69,5 ± 1,3
Ram's head-II	Welding area	H46.dat	-	-	-	11,7 ± 0,3	14,3 ± 0,4	-	74,00 ± 1,00
Ram's head-II	Welding area	H49.dat	-	-	-	6,16 ± 0,13	17,0 ± 0,4	-	76,88 ± 1,02
Ram's head-II	Welding area	H50.dat	-	-	-	7,53 ± 0,07	7,27 ± 0,24	<LOQ	85,08 ± 1,06
Ram's head-II	Welding area	H51.dat	-	-	-	7,33 ± 0,22	6,8 ± 0,3	0,21 ± 0,06	85,67 ± 1,06
Roundel (goddess)	Welding area	H32.dat	0,038 ± 0,020	-	0,069 ± 0,021	9,3 ± 0,3	10,2 ± 0,4	-	80,41 ± 1,24
Roundel (goddess)	Welding area	H33.dat	-	-	-	11,3 ± 0,8	12,0 ± 2,9	-	76,25 ± 3,18
Roundel (goddess)	Welding area	H34.dat	0,08 ± 0,03	-	0,39 ± 0,06	6,04 ± 0,15	12,0 ± 0,9	-	81,5 ± 1,9
Roundel (goddess)	Welding area	H57.dat	0,25 ± 0,03	0,058 ± 0,021	1,93 ± 0,08	8,05 ± 0,22	9,0 ± 0,3	-	80,73 ± 1,23
Roundel (goddess)	Welding area	H58.dat	0,34 ± 0,04	-	2,14 ± 0,10	7,8 ± 0,3	8,1 ± 0,4	<LOQ	81,5 ± 1,6
Strap	Wire	H17.dat	4,39 ± 0,17	-	0,55 ± 0,08	5,19 ± 0,15	6,4 ± 0,3	-	83,5 ± 2,3

Strap	Wire	H37.dat	0,14 ± 0,06	-	0,95 ± 0,14	4,69 ± 0,11	6,4 ± 0,4	-	87,88 ± 3,17
Strap	Wire	H38.dat	0,097 ± 0,023	0,055 ± 0,019	0,85 ± 0,05	4,18 ± 0,12	7,8 ± 0,3	-	86,98 ± 1,18
Strap	Wire	H39.dat	0,093 ± 0,018	-	0,114 ± 0,021	5,49 ± 0,05	7,74 ± 0,20	-	86,56 ± 1,10
Strap	Wire	H40.dat	0,113 ± 0,022	0,039 ± 0,017	0,064 ± 0,020	5,50 ± 0,09	7,06 ± 0,19	-	87,22 ± 1,21
		LOD	0,024	0,023	0,03	0,04	0,21	0,11	0,3

Table 3. Oxide composition in % weight of the enamels determined by means of PIXE

Sample	Ram's head ova					Goddess roundel ova					Man roundel ova		Goddess roundel ova	
Filename	L07	L08	L09	L10	L12	L13*	L14	L15	L16	L17	L18	L19	L20	L21
Enamel	Blue	Blue	Green	Blue	Green	Blue	Green	Green	Blue	Blue	Green	Blue	N/D	N/D
Na_2O	0,55	0,55	1,77	2,59	2,56	5,36	4,01	3,78	1,91	2,20	1,49	2,03	2,50	3,96
MgO	2,97	3,02	0,80	3,76	-	3,76	3,46	3,42	3,25	8,60	3,45	2,74	5,67	2,82
Al_2O_3	21,40	19,84	20,43	3,30	9,82	17,24	21,65	22,12	17,64	17,77	16,29	15,09	18,37	17,66
SiO_2	50,99	46,58	27,70	14,69	12,90	41,97	45,57	43,43	39,23	46,04	36,13	27,48	41,49	35,41
SO_3	6,06	6,20	40,31	66,49	65,29	9,50	13,24	15,88	20,70	13,72	28,24	36,95	21,85	29,46
Cl	0,070	0,035	1,268	1,594	1,755	-	0,080	0,147	0,065	0,047	0,510	0,332	0,132	0,223
K_2O	3,13	3,06	1,79	0,97	1,41	2,78	2,58	2,20	2,50	2,05	2,33	1,83	1,69	1,99
CaO	9,50	14,79	0,91	0,98	0,45	6,61	4,57	4,70	9,62	3,98	7,07	8,19	5,02	4,60
TiO_2	0,74	0,68	3,82	1,95	2,28	1,10	1,51	1,44	0,71	1,26	0,59	3,35	0,81	1,87
V_2O_3	0,011	0,013	-	0,034	-	-	-	-	-	0,023	-	-	-	-
Cr_2O_3	-	-	0,049		0,003	0,015	0,005		0,008	0,012	0,005	-	-	0,005
MnO	0,45	0,53	0,17	0,05	0,06	1,80	0,96	0,97	0,93	0,61	1,09	0,86	0,64	0,44
Fe_2O_3	3,62	4,01	0,48	1,82	0,32	5,50	1,86	1,41	2,76	2,70	2,35	1,00	1,50	1,27
CoO	0,065	-	-	-	-	-	-	-	-	-	-	-	-	-
NiO	0,0047	0,0066	-	-	-	0,0049	-	-	0,0043	0,0040	0,0027	-	-	-
CuO	0,31	0,44	0,42	0,87	2,78	2,86	0,42	0,41	0,26	0,39	0,34	0,11	0,19	0,23
ZnO	0,12	0,12	0,08	0,57	0,37	0,72	0,08	0,08	0,25	0,56	0,12	0,02	0,12	0,05
SrO	0,008	0,008	-	-	-	0,010	-	-	0,007	0,017	0,005	0,007	0,009	-
BaO	-	0,114	-	0,325	-	0,641	-	-	0,142	-	-	-	-	-

3.4 The cadmium debate and authenticity

In the early nineties of the last century an argument arose concerning the ancient use of cadmium or cadmium compounds in solders (Demortier 1987 *vs* Meeks and Craddock 1991). It was thought that the element appeared only in modern restorations and its absence became a proof of authenticity whereas its detection condemned the object as a fake (for a comprehensive view see Demortier 2004). The discussion soon changed to the accuracy of the different analytical techniques and equipments (PIXE, SEM-EDX, XRF) that each team and laboratory were using in the early stages of Archaeometry practice. It seems clear today that the relation cadmium/authenticity is not univocal, furthermore the criteria for authentication and our knowledge of the ancient metallurgists' technological achievements have widened considerably (for example Guerra and Rehren 2009).

The issue in question stemmed from a group of gold objects of Iranian and Syrian origin, dated from the 1st to the 11th century, coming from different European Museums and private Collections, where cadmium was detected at low concentrations in the soldering areas while the copper content increased proportionally at those spots (Demortier 1991; Mathot and Demortier 2004). The hypothesis was that the Iranian goldsmiths smelted greenockite - cadmium sulfide- with copper ores and gold to obtain a solder of low melting point (Demortier 2004: 29).

While analyzing the two types of welding areas that we could appreciate on the ram's head, that is, the union of the ring (H11, H16, H45 on Table 2) and the joining area of the wrapping sheet with a palmette design (H50, H51, H53), and the filigree on the reverse of the roundel we detected cadmium with concentrations from 0.21 to 6.8 %. In a different analyzed point we also detected this element but under the limit of quantification (marked as <LOQ in Table 2). Copper and gold contents of the different parts of the belt in Fig 11 show a wide range of levels of copper, from 6.04 to 17.3%, where highest values of copper seem to be related with cadmium contents greater than 2%.

There is no trace of a modern restauration in the belt, which should have been necessarily conspicuous, so that the detection of cadmium should be explained otherwise.

The analytical data we are handling are very scarce, but if we take into account that the most probable origin of the belt is somewhere in the Middle East, as we are trying to argue, the cadmium debate is raised again. Future research should be directed to discriminating between random contents of cadmium, as it is in the case that concerns us, and a deliberate use in the alloys.

4. ICONOGRAPHY

Most of the structural elements referred to above show a symbolic iconography that includes anthropomorphic and zoomorphic images.

The central roundel depicts an apparent explicit funerary rite scene of a dead warrior. Cultural and chronological indicators are the helmet with high plume and the shield with the gorgoneion (Snodgrass 1967), plus the perfectly defined kylix in the hand of the nude lady –most probably Aphrodite as the wife of Ephaestus, the blacksmith who forged the gods' armours- and the wet drapery technique, finally the ornamental frets of *ova* and the palmettes at the back. All these point to the Greek imagery of a late Classical or Early Hellenistic date. Another detail hinting to the same period is the lady's hairstyle and her backwards position, looking to the spectator, as in the Callipygian Venus sculpture type -*Venus of the beautiful buttocks*- (Boardman 1986, 1991; Ridgway 1990, 1997; Rolley 1999; Säflund 1963). It is not a farewell scene as we are used to see in the funerary stone Greek stelae (Grossman 2001), but rather a ceremony of a heroic or divine character.

The four side roundels repeat twice the front face portrait of a man and a woman. The most astounding feature is the absence of pupils in the man's eyes but not in those of the woman. Greek literature, as we know by the Iliad, is generous describing bloody deaths of warriors in battle always using the metaphor of the loss of sight, the darkness or a mist impeding vision (for example Il. XVI 315-316, 323-325, 344, 502-503, 606-607). We would suggest that the roundel depicts a dead warrior's portrait. The same warrior whose arms are displayed in the scene of the central roundel? Who could he be? The deep-set eyes, the finely modelled mouth with the typical M-shaped pattern of the upper lip, the leonine hair and the clean shaven face, all hint at a portrait of Alexander the Great as conceived by the artists who settled the artistic standard in the portraits that circulated, during and after life, either in sculpture, coinage or paintings, like Lisypos, Apelles and Pyrgoteles (Bieber 1965; Kiilerich 1988).

Some of this marble portraits were probably gilded (Bianchi 2010), but there are very few examples of small scale gold portraits except in coins –most if not all in profile. One of these is an intaglio gold ring with a three quarter portrait of Alexander as Herakles wearing the lion's skin of the late 4th or early 3rd century B.C. (Metropolitan Museum 10.132.1). The second example comes from Grave 3 of Tyllia tepe princely necropolis in Afghanistan dated to the 1st century B.C. and it is the highly debated figure of an armored warrior stamped on the twin buckles of a funerary belt (Abdullaev 2017). We will return to this site when discussing typology below.

Last but not least are the ram's heads at each end. They stand out for their size, weight and fine modeling. We could even say that they are clue elements in the story telling of the belt which could not be understood without them. Given the iconographical context of the central roundel just mentioned and the identification of the two side roundels with Alexander's funerary portrait, it follows that the ram makes reference to Ammon, the Egyptian divinity assimilated to Zeus, and his divine reference, together with Herakles (Bosworth 1996: 167-168). This looks like a circular argument, but rather we are trying to fit pieces in a puzzle.

Greek and Latin biographers tell us how Alexander went to the Siwah oasis in Egypt to consult Ammon's oracle before the campaign against the Achaemenid Empire (for example in Arrian III, 3-4; Curtius IV, 7; Diodorus 17, 49-51. For a comprehensive reference on sources see Fredricksmeyer 1991). He wanted to know about his own nature, either human or divine, an act of propaganda and self-assertion typical of the character.

We don't have any iconographic hint to find out whose the woman's matching face could be. Following the classical sources the Bactrian princess Roxane, Alexander's favorite wife, accompanied him during his fatal illness in Babylon and played an important role as the child bearer of his heir –if it were to be a boy as it was. Naturally this is only a working hypothesis which however seems to fit in the general picture.

5. CONCLUSIONS

The belt under study meets all the characteristics of a Hellenistic masterly goldwork of the late 4th or early 3rd century BC with some technological peculiarities and iconographic traits that are indicators of its origin in a deeply Hellenized region of the Middle East. Although we know that Near Eastern jewellers were extremely skillful, as attested by ancient sources and representations in reliefs and sculpture, there are very few archaeological gold finds (Amandry 1958; Rehm 1992; Curtis 2005; Dalton 2010). Nevertheless the general heraldic style and the extreme symmetry of the ornamental elements outline are very distinctive. To what has already been said we must add some archaeological facts.

Coming back to the forementioned site of Tyllia tepe in northern Afghanistan, a soviet expedition excavated a princely necropolis in 1978 with extremely rich grave goods, mainly gold jewellery, dated to between the 1st century BC and the 1st century AC by the numismatic finds, although others –glyptic and toreutics- can be dated earlier. Sarianidi (1985) assumed that the tombs belonged to the Yüeh-chih tribes that invaded the Graeco-Bactrian Kingdom at the time, and in particular to the family who founded the Kushan Empire [2]. Nevertheless other authors defend that they are better related to the nomadic Saka-Parthian (Scythians) groups in which the Hellenistic substrate remained strong (Puganchekova and Rempel 1991). Be as it may, Grave 4 contained the remains of a man -the other five burials were of women- wearing a gold belt of the same typology as the belt we are studying (Sarianidi 1985: 247). It is made up of a wide loop-in-loop chain strap interrupted by nine roundels ornamented with a Parthian version of the Hellenic Mistress of the Animals (a picture of the belt can be seen in the following links https://en.wikipedia.org/wiki/Tillya_Tepe; https://www.cemml.colostate.edu/cultural/09476/afgh05-207.html). It has no finial pieces but the roundels themselves. This is the unique parallel we have found typologically matching with our object of study. A second belt of a different typology was found in Grave 3, mentioned above, (Sarianidi 1985: 236); it was probably made in an organic material with twin gold belt buckles that bear the portrait of a warrior that has been identified as the deified portrait of Alexander the Great (Abdullaev 2017).

As we know special morphotypes could be very persistent when it comes to highly symbolic or ritualized objects. For example, the known gold bands/diadems with triangular ends of the Orientalizing Period in Iberia (7th century BC) continued to be manufactured in the same way -with iconographic changes only- till the 3rd century BC (Perea 1996). The belt from Tyllia tepe could be a similar case of a persisting tradition -and we should add ritualized- of funerary belts in which only imagery transmits the passage of time and social change. All this data add coherence to the iconographical lecture we have proposed.

Concerning technological and stylistic features, as the ornamental palmettes at the rams' necks and on the back of the roundels, the punch pitting of skins and faces, plus the absence of worked/beaded wires, all point to an Eastern workshop as the place of origin. Analytical data confirmed that the different belt pieces were worked independently and with slightly different alloys. This cannot be explained appealing to functional or technological reasons but more likely in symbolic terms. The use of cadmium -intentionally or not- as a welding element in the

[2] For a general view of the political events after Alexander in Central Asia see Cribb and Herrmann 2007.

soldering alloys can be taken as another eastern trait, considering its absence in western European goldwork.

If the story telling of the belt is true we should think on Babylon as the most probable place of manufacture, the city where Alexander died and where his embalmed corpse remained for two years till the construction of the hearse was ready for the last journey of the controversial King of Asia. During that lapse of time it was claimed by anyone who thought to have any right to be the heir of the Empire, but it was Ptolemy who finally took it to Alexandria with the argument that he should rest with his father Ammon.

This is not to say that the belt manufacture necessarily took place immediately after the death of Alexander, it could have taken place some years later but not many. We know that in his final resting place he received visits, and with them presents, of important people. This was the much later case of Augustus who, after his victory at Actium in 31 BC, placed a golden crown on the body as an homage of respect (Erskine 2002).

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REFERENCES

Abdullaev, K. (2017) The image of Alexander the Great in small-form Art in Bactria (an identification of the depiction of a warrior on the gold clasp from Tyllia Tepe). *Ancient West and East*, Vol. 16, pp. 155-175.

Amandry, P. (1958) Orfèvrerie achéménide. *Antike Kunst*, vol. 1, pp. 9-23.

Armbruster, B., Comendador, B., Montero, I., Perea, A., Pernot, M., (2003) Tools and tool marks. Gold and bronze metallurgy in Western Europe during the Bronze and Early Iron ages. In *Archaeometallurgy in Europe*. Proceedings, Vol. I, Milan, pp. 255-266.

Bianchi, R.S. (2010) The Princeton Portrait of Alexander the Great. *Record of the Art Museum, Princeton University*, Vol. 69, pp. 22-29.

Bieber, M. (1965) The portraits of Alexander. *Greece and Rome*, Vol. 12 (2), pp. 183-188.

Boardman, J. (ed.) (1986) *Greece and the Hellenistic World*. Oxford University Press, Oxford.

Boardman, J. (1991) (2nd) *Greek Sculpture. The Classical Period*. Thames & Hudson, London.

Bosworth, A.B. (1996) *Alexander and the East. The Tragedy of Triumph*. Clarendon Press, Oxford.

Climent-Font, A., Pászti, F., García, G., Fernández-Jiménez, M.T., Agulló, F. (2004) First Measurements with the Madrid 5MV Tandem Accelerator. *Nuclear Instruments and Methods in Physics Research- B*, Vols. 219–220, pp. 400–404.

Cribb, J., Herrmann, G. (eds.) (2007) *After Alexander. Central Asia before Islam*. The British Academy, Oxford University Press.

Cristofani, M. and Martelli, M. (1985) *L'Oro degli Etruschi*. Instituto Geografico de Agostini, Novara.

Curtis, J. (2005) Jewellery and personal ornaments. In *Forgotten Empire. The World of Ancient Persia*, J. Curtis, N. Tallis (eds.). The British Museum Press, London, pp. 132-149.

Dalton, O.M. (2010) *The Treasure of the Oxus with other Examples of Early Oriental Metalwork (1905)*. Kessinger Publishing.

Demortier, G. (1987) La chrysocolle des orfèvres est-elle jaune? *Archaeometry*, Vol. 29 (2), pp. 275-288. http//doi.org/ 10.1111/j.1475-4754.1987.tb00418.x

Demortier, G. (1991) Étude de soudures sur quelques bijoux de l'Iran ancien par la technique PIXE. In *Découverte du Métal*, Mohen, J.P., Eluère, Ch. (eds.). Millénaires, dossier 2. Picard. Paris, pp. 425-438.

Demortier, G. (2004) Ion Beam study of ancient gold solders. In *Tecnología del Oro Antiguo: Europa y América. Ancient Gold Technology: America and Europe*, Perea, A., Montero, I., García-Vuelta, O. (eds.). Anejos de AespA XXXII, CSIC, Madrid, pp. 27-40.

Deppert-Lippitz, B. (1985) *Grieschischer Goldschmuck*. Verlag Philipp von Zabern, Mainz am Rhein.

Dolfini, A., Crellin, R.J. (2016) Metalwork wear analysis: the loss of innocence. *Journal of Archaeological Science*, Vol. 66, pp. 78-87. http://dx.doi.org/10.1016/j.jas.2015.12.005

Enguita, O., Fernández-Jiménez, M.T., García, G., Climent-Font, A., Calderón, T., Grime, G.W. (2004) The new external microbeam facility at the 5 MV Tandetron accelerator laboratory in Madrid: beam characterisation and first results. *Nuclear Instruments and Methods in Physics Research-B*, Vols. 219–220, pp. 384–388. https://doi.org/10.1016/j.nimb.2004.01.087

Erskine, A. (2002) Life after Death: Alexandria and the body of Alexander. *Greece and Rome*, Vol. 49 (2), pp. 163-179.

Formigli, E. (2009) Micro rayures et signes d'usure: authentification d'orfèvrerie archéologique. *Archeosciences. Revue d'Archéométrie*, Vol. 33, pp. 335-339.

Fredricksmeyer, E.A. (1991) Alexander, Zeus Ammon, and the conquest of Asia. *Transactions of the American Philological Association*, Vol. 121, pp. 199-214.

Grossman, J.B. (2001) *Greek Funerary Sculpture. Catalogue of the collections at the Getty Villa*. The J.P. Getty Museum, Los Angeles.

Guerra, M.F., Rehren, T. (2009) AURUM: Archaeometry and authenticity of gold. *Archeosciences, Revue d'Archéométrie*, Vol. 33, pp. 13-18.

Kiilerich, B. (1988) Physiognomics and the iconography of Alexander. *Symbolae Osloenses*, Vol. LXIII, pp. 51-66.

Korolkova, E.F. (2017) The Siberian Collection of Peter the Great. In *Scythians, warriors of ancient Siberia*, Simpson, St J., Pankova, S. (eds.). The British Museum, Thames and Hudson, London, pp. 34-40.

Mathot, S., Demortier, G. (2004) Diffusion bonding from Antiquity to present times. *Nuclear Instruments and Methods in Physics Research-B*, Vol. 226, pp. 222-230. http://doi.org/10.1016/j.nimb.2004.06.039

Meeks, N.D. (1998) A Greek gold necklace: a case of dual identity. In *The Art of the Greek Goldsmith*, Williams, D. (ed.). British Museum Press, London, pp. 127-138.

Meeks, N.D., Craddock, P.T. (1991) The detection of cadmium in gold/silver alloys and its alleged occurrence in ancient gold solders. *Archaeometry*, Vol. 33 (1), pp. 95-107. https://doi.org/10.1111/j.1475-4754.1991.tb00688.x

Minns, E.H. (1913) *Scythians and Greeks. A survey of Ancient History and Archaeology on the North coast of the Euxine from the Danube to the Caucasus*. University Press, Cambridge.

Nicolini, G. (1990) *Techniques des Ors Antiques. La bijouterie Ibérique du VIIe au IVe siècle*. Picard, Paris.

Oddy, W.A. (1977) The production of gold wire in Antiquity. Hand-making methods before the introduction of the draw plate. *Gold Bulletin*, Vol. 10 (3), pp. 79-87.

Ogden, J. (1982) *Jewellery of the Ancient World*. Trefoil Books, London.

Ogden, J. (1991) Classical gold wire: some aspects of its manufacture and use. *Jewellery Studies*, Vol. 5, pp. 95-105.

Ogden, J. (1992) *Ancient Jewellery*. University of California Press. The British Museum, London.

Perea, A. (1996) La orfebrería peninsular en el marco del arcaismo mediterráneo: dos perspectivas. In *Formes Archaïques et Arts Ibériques*, Olmos, R., Rouillard, P. (eds.). Collection Casa de Velázquez vol. 59, Madrid, pp. 95-109.

Perea, A. (2009) Wands in the hand! Or Potter's powers. *Archeosciences, Revue d'Archéométrie*, Vol. 33, pp. 21-28.

Perea, A., Climent-Font, A., Fernández-Jiménez, M., Enguita, O., Gutiérrez, P. C., Calusi, S., Migliori, A., Montero, I. (2006) The visigothic treasure of Torredonjimeno (Jaén, Spain): A study with IBA techniques. *Nuclear Instruments and Methods in Physics Research-B*, Vol. 249, pp. 638-641. https://doi.org/10.1016/j.nimb.2006.03.071

Perea, A., García-Vuelta, O., (2012) Gold usage. Wear marks and/or deterioration in site conditions. In *Historical Technology, Materials and Conservation: SEM and Microanalysis*, Meeks, N., Cartwright, C., Meek, A., Mongiatti, A. (eds.). Archetype. London, pp. 86-92.

Perea, A., García-Vuelta, O., Fernández-Freire, C. (2010) *El Proyecto Au. Estudio arqueométrico de la producción de oro en la Península Ibérica*. BPH XXVII, CSIC, Madrid.

Perea, A., Gutiérrez-Neira, P.C., Climent-Font, A., Fernández-Esquivel, P., Rovira-Llorens, S., Ruvalcaba-Sil, J. L., Verde, A., Zucchiatti, A. (2013) Pre-hispanic goldwork technology. The Quimbaya Tresure, Colombia. *Journal of Archaeological Science*, Vol. 40, pp. 2326-2334. https://doi.org/10.1016/j.jas.2012.12.033

Puganchekova, G.A., Rempel, L.I. (1991) Gold from Tillia-tepe. *Bulletin of the Asia Institute*, New Series, Vol. 5, pp. 11-25.

Rehm, E. (1992) *Der Schmuck der Achämeniden*. Ugarit Verlag, Munster.
Ridgway, B.S. (1990) *Hellenistic Sculpture I. The Styles of ca. 331-200 B.C.* The University of Wisconsin Press.
Ridgway, B.S. (1997) *Fourth-Century Styles in Greek Sculpture*. The University of Wisconsin Press.
Rudolph, W. (1996) Toward a historiography of jewelry research. In *Ancient Jewelry and Archaeology*, Calinescu, A. (ed.). Indiana University Press, pp. 17-25.
Rolley, C. (1999) *La Sculpture Grecque vol. 2. La période Classique*. Picard, Paris.
Säflund, G. (1963) *Aphrodite Kallipygos*. Acta Unversitatis Stockholmiensis. Studies in Classical Archaeology 3, Stockholm.
Sarianidi, V. (1985) *L'Or de la Bactriane. Fouilles de la nécropole de Tillia-Tépé en Afghanistan Septentrional*. Editions d'art Aurora. Leningrad.
Snodgrass, A.M (1967) *Arms and Armour of the Greeks*. Ithaca, New York.
Sopo, E. (2017) The periodization and typology of the history of collecting as a methodological approach to collecting in the Russian Empire. *Journal of the History of Collections*, Vol. 29 (1), pp. 33-43. https://doi.org/10.1093/jhc/fhw007
Williams, D., Ogden, J. (1994) *Greek Gold. Jewellery of the Classical World*. British Museum Press, London.
Whitfield, N. (1998) The manufacture of ancient beaded wire: experiments and observations. *Jewellery Studies*, Vol. 8, pp. 57-86.