Studies on Ancient Metalworking Techniques: Preliminary Report

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Abstract: *This preliminary report focuses on two techniques of jewellery production. The first technique is granulation, and the second is filigree. We know both techniques from different gold jewellery from ancient Thrace. The aim of this study is to gain more knowledge about the use of these techniques, the production steps, and possibly, the technological knowledge of the fine working metalworker. With the help of experimental archaeology, both techniques are examined to draw conclusions about their application, the tools used and the technological knowledge of the craftsmen.*

Keywords: Craftmanship, Granulation, Filigree
Ключови думи: занаятчийски умения, гранулация, филигран

From various Thracian sites, we have jewellery objects with granulation and filigree such as the gold earrings from Mogilanska mogila[1] in the Vratsa Region or some parts of the horse-trapping from Kralevo[2] from the Targovishte Region. Other known jewellery objects with this kind of decoration are from the Malka mogila[3] in the Stara Zagora region or the Arabadzhiyska mogila[4] and Mushovitsa mogila[5], both located in the Plovdiv region. The objects from the Stara Zagora and Plovdiv regions are discussed in more detail below, as the author was able to study them in the original[6].

OBJECTS WITH GRANULATION AND FILIGREE FROM ANCIENT THRACE

Necklaces

From each of the three Mogili (i.e. mounds)[7], comes a necklace with lenticular- and

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[1] *Torbov* 2015: 63, plate XXIV 1a – б.
[2] *Ginev* 1983: fig.26, 27, 30.
[3] *Kitov* 1994: 65.
[4] *Filow* 1934: 132-133, fig.154-155.
[5] *Filow, Welkow* 1930: 306 - 312, fig.31-32; *Filow* 1934: 85-87, fig.108-109.
[6] I would like to thank Momchil Marinov, Director of the Museum of History Iskra Kazanlak and Meglena Parvin, as well as Kostadin Kisiov, Director of the Regional Archaeological Museum in Plovdiv and Ekaterina Ilieva and Lyubomir Merdzhanov for the opportunity to do research on the originals.

biconical beads. At first glance, they look very similar. But with a more detailed view, there are some differences. All three necklaces have a rosette as the central element of the lenticular beads, only on three beads of the necklace from Arabadzhiyska mogila (Inv. Nr. 1646) this element is missing. The rosettes were made with four, five, six or eight leaves. On the necklace from Malka mogila (Inv. Nr. MIK A 1582) the rosettes look a bit like waterlilies, because they are made of three layers (**Fig. 1**). All three show

Figure 1. Detail of the rosettes from the necklace of Malka mogila. (Photo: S. Simon).

a

b

Figure 2. Frontview of the necklace from **(a)** Mushovitsa mogila and **(b)** Arabadzhiyska mogila. (Photo: S. Simon).

that the rosettes are made of a plain filigree wire with a single granule in the centre. These granules have not always the same size. The lenticular beads were made from two halves which are soldered together, and the rim is surrounded by filigree wire, which has different styles, on some beads it's plain (the ones from Arabadzhiyska mogila (Inv. Nr. 1646) (**Fig. 3a**) and on others twisted wire is used (Mushovitsa mogila (Inv. Nr. 1534,1535,1536) and Malka mogila (Inv. Nr. MIK A 1582). On the beads of the necklaces from Arabadzhiyska – and Mushovitsa mogila the granulation is arranged as circle granulation and areal triangle granulation[8] (**Fig. 2**). The backside of the necklace from Mushovitsa mogila shows also circle granulation and areal triangle granulation as well as single granulation (**Fig. 3b**).

a

b

Figure 3. (a) Detailed view of the granulation and filigree from the necklace from Aradadzhiyska mogila (without scale); **(b)** Backside of the necklace from Mushovitsa mogila. (Photo: S. Simon).

Pendants

Two pendants were analysed. Both come from Malka mogila (Stara Zagora region). The first one (Inv. Nr. MIK A 1583), which is made of two hemispheres, shows filigree and granulation work (**Fig. 4**). On both hemispheres plain filigree wire is arranged as beehives[9] with a single granule at the top. Around the centre there is twisted filigree wire. On the bottom of the pendant there is a rosette.

The second one (Inv. Nr. MIK A 1581), which is connected to a loop in loop chain, has the form of an amphora (**Figure 5a-b**). This amphora is made from several individual

[7] Malka Mogila, Arabadzhiyska mogila and Mushovitsa mogila.
[8] *Wolters* 1983: 14-17, Fig.3.18, Fig 4.19.
[9] *Wolters* 1987: 1085-1086, Fig.6.2.

parts and shows filigree and granulation, with a rosette as the central front element (**Fig. 5a**). The rosette is made of a gold sheet, filigree wire, with a single granule in the middle. Rosettes can also be found on the tube, which connects the amphora with the loop-in-loop chain and above the acorn. Other elements of the front are twisted wires, which form two palmettes around the rosette (one above and one beneath). Inside the palmette decoration is a line granulation, consisting of eight granules. Overall, the main decoration on the front side is made with filigree. The backside (**Fig. 5b**) of the amphora shows granulation, which is arranged as grape- or pyramidal granulation after Wolter's classification[10].

Omega-shaped ornaments of head dress

From Arabadzhiyska and Mushovitsa mogila we have four omega-shaped ornaments of a head dress. All four ornaments have a pyramid made of granules on their ends, the pyramids on the ones from Arabadzhiyska mogila (Inv. Nr. 1641-1642) end with a small ring made from beaded wire (**Fig. 6a**), while the ones from Mushovitsa mogila (Inv. Nr. 1538) have a granule on top (**Fig. 6b**). The decoration of the four ornaments is different. The ornaments from Arabadzhiyska mogila (**Fig. 6a**) have granulation and filigree also on the wire. The ornaments from Mushovitsa mogila have their decoration only underneath the pyramids. Here different styles are used, on one ornament we see, S-spirals, made of plain wire, and beaded wire with single granulation and beaded filigree wire. The other ornament shows on the one side a decoration with beaded wire and on the other side with plain wire.

Earrings

There are different kinds of earrings from Arabadzhiyska and Mushovitsa mogila.

The basket earrings from Arabadzhiyska mogila (Inv. Nr. 1647) show granulation and filigree on the front side, in form of different styles of granulation and plain filigree wire, which forms a S. Inside this filigree decoration we can see granules arranged as grape granu-

Figure 4. Pendant with granulation and filigree from Malka mogila. (Photo: S. Simon).

Figure 5. Front- and backside of the Amphora shaped pendant from Malka mogila. (Photo: S. Simon).

Figure 6. Omega shaped parts of head dress from **(a)** Arabadzhiyska mogila and **(b)** Mushovitsa mogila. (Photo: S. Simon).

[10] *Wolters* 1983: 18, fig.5.1-2.

lation. The Backside is without decoration. On the edge where the two halves are soldered together, a line granulation is running (**Fig. 7a**).

The ten earrings from Mushovitsa Mogila (Inv. Nr.: 1537) can be divided into three groups. Group 1 (**Fig. 7b**) consists of six earrings. All have traces of wearing and are hardly rubbed, as seen on the decorations. The earrings are made of a sheet of gold, which is rolled into a tube. Due to the damage, it is apparent that the earrings are not made of wire. They are decorated with granulation and filigree wire. The filigree wire is rolled to a cylinder and on top, there is a rosette with four leaves with a granule in the centre. Group 2 (**Fig. 7c**) has three earrings. They are decorated like the ones from group 1, but they are not a damaged. The granules are visible, as well as, the filigree wire, and the rosettes on top. Group 3 (**Fig. 7d**) is a single earring, which is made from plain wire, and is tapered towards the ends. It is decorated with granulation, beaded wire as well as plain wire, and has granulation and filigree (beaded wire) in the centre part. The granules are arranged as triangle area granulation. The ends of the earring show a granule and beaded wire. The earring is made from a forged round wire.

Figure 7. Earrings with granulation from **(a)** Arabadzhiyska moglia and **(b-d)** Mushovitsa mogila. (Photo: S. Simon).

The technique of granulation and filigree

The Techniques of granulation and filigree have their origins in the 3rd millennium BC presumably in Mesopotamia[11] and have since then spread to various regions over the following centuries[12]. Early objects with granulation and filigree are known, for example, from Troy, were different kinds of earrings with granulation and filigree come from[13] or from Kâmid el-Lôz in Lebanon, where two silver discs with granulation were found[14]. Granulation is a technique where small gold beads, so-called granules, are attached to the jewellery object. This is done with diffusion bonding, meaning that the metalworker used a diffusion solder, like copper salt[15]. It is important that the granules and the metal have a high fineness and the same melting point, otherwise the diffusion bonding would not work, and it could be that one part of the object is melting, while the other one hasn't reached the right temperature[16]. Filigree is a technique in which fine wires are applied to the jewellery object to form different patterns and ornaments. These wires come in a variety of styles and can be made from plain wire, beaded wire, or twisted wire[17] and they are also attached to the jewellery with diffusion bonding[18].

After analysing the jewellery objects, experimental archaeology was used, to examine these techniques.

The analyses of the objects showed that there are different types of granulation and also different types of filigree wire. In these

[11] *Wolters* 1983: 68; *Wolters* 1987: 1095; *Nestler, Formigli* 1993: 11.
[12] *Wolters* 1983: 68.
[13] *Tolstikow, Trejster* 1996: fig.13, fig.66.
[14] *Hachmann* 1983: fig.95.
[15] *Williams, Ogden* 1994: 26-27.
[16] *Williams, Ogden* 1994: 27.
[17] *Wolters* 1987: 1067-1077.
[18] *Wolters* 1987: 1144.

first experiments, granules will be produced for granulation and then applied to a curved surface, also wire will be produced. Which will be later processed into various filigree wires[19].

Experiments

These first experiments on granulation and filigree are carried out with fine silver. Fine silver and fine gold are very similar in their characteristics, except that fine gold is more elastic than fine silver, which is why fine gold can be hammered out into extremely thin layers. Another advantage, working first with silver is, that mistakes in working can exclude in later working with gold.

Before starting with the experiments, the necessary aids and materials must be prepared. Granules, an organic glue and copper salt are required for granulation. The granules and the organic glue were produced by the author, the copper salt, which is used in the form of malachite powder, was purchased from a specialised retailer.

The granulation experiments start with the making of the granules. Small pieces of silver were cut from a fine silver sheet. If possible, they should all have the same size, to ensure the uniformity of the granules. There are two methods to make the granules. The first consists of melting each piece on a piece of charcoal until it forms a ball[20]. The second method involves melting down several granules at the same time in a crucible, where several layers of charcoal powder and metal pieces layered and then the crucible is placed into a kiln[21]. Since no kiln was available, the first method was applied (**Fig. 8a-c**).

After making the granules, the other materials were prepared. Since the soldering required copper salt, malachite powder was used, along with quince seeds and water as an organic glue[22]. The pectin from the seeds reacts with the water and becomes a gluing liquid. This liquid was mixed with the copper salt, and with a small brush, the pattern was painted on the surface. After that, the granules were attached to the surface, with a brush wetted with the organic glue (**Fig. 8d**). After approximately 10 minutes, when the glue had dried down, the silver sheet and the granules were heated with

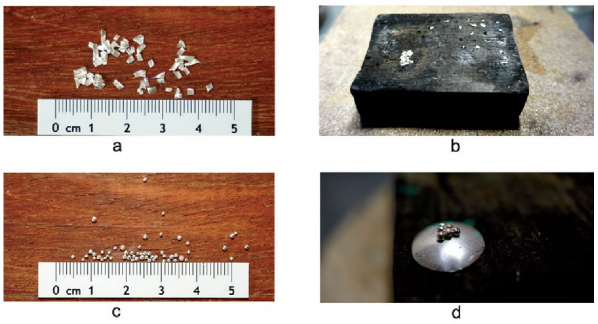

Figure 8. Granulationexperiment: **(a)** small pieces of silver; **(b)** silver pieces on charcoal; **(c)** silver granules; **(d)** silver granules on curved silversheet. (Photos: S. Simon).

a flame low in oxygen, to which more oxygen was gradually added. The surface of the jewellery had to be heated close to the melting point, which could be determined by the colour. As soon as the surface turned shiny, the heat was turned off, and the granules were fixed to the surface. Excess copper salt had to be removed before heating, as it can lead to discolouration and a rough surface (**Fig. 9**).

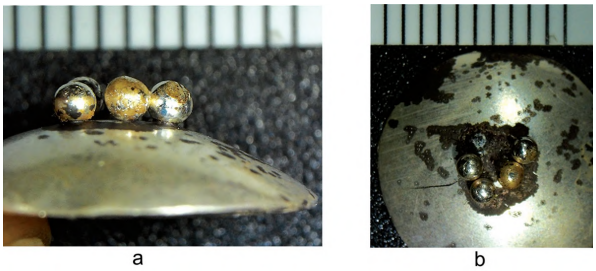

Figure 9. Surface of the granulated object: **(a)** detail of diffusion; **(b)** detail of the rough surface. (Photos: S.Simon).

The next experiment aimed to recreate the filigree wire. Since there is little evidence for the use of a drawing plate in antiquity[23], the wire for the experiments was rolled from a thin strip of metal[24]. Thus, a strip of fine silver

[19] As the experiments have not yet been completed, only the production of a wire will be described.
[20] *Wolters* 1983: 46; *Nestler, Formigli* 1993: 41-43.
[21] *Wolters* 1983: 46-47; *Roth* 1986: 56-57, fig.26; *Nestler, Formigli* 1993: 50-54.
[22] *Moesta* 1983: 126.
[23] For more detailed information about the use of drawing plates see for example *Ogden* 1991; *Özşen* 2021.
[24] *Nestler, Formigli* 1993: 47; *Williams; Ogden* 1994: 23.

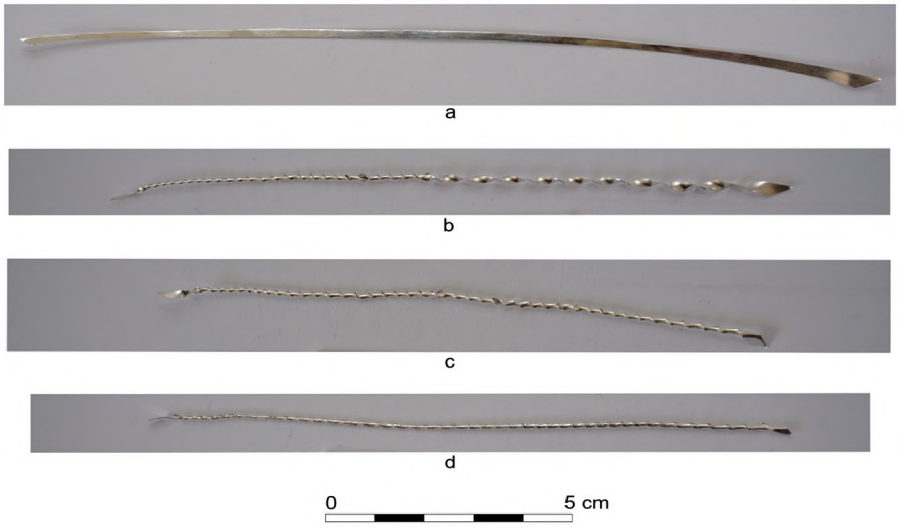

Figure 10. Different steps of making wire from a small sheet of silver. (Photos: S.Simon).

was used. The fact that it was common practice in antiquity to make metal in this manner can be seen on some of the objects discussed above, such as the necklace from Arabadzhiyska mogila (Inv. Nr.1646). Here the edges of the sheet that was rolled into a plain wire are still visible (**Fig. 3a**).

For the experiment, the strip was twisted manually as far as possible. Then, it was placed between two pieces of metal, and with a slight pressure, rolled into a plain wire. The technique of rolling wire, is more challenging than it may seem at first sight. The method must be mastered; otherwise, the wire will either not be rolled correctly or break from uneven pressure distribution during rolling (**Fig. 10**).

Conclusion

This preliminary report was intended to show impressions and results of a series of further experiments that are being carried out as part of a study on ancient Thracian jewellery. The experiments showed that several factors need to be considered in the making of jewellery. The results of the experiments serve as a first basis for answering the question of which soldering techniques were used for granulation and filigree. It should be investigated whether a reaction solder, i.e., a copper salt, or a metallic solder, an alloy with a lower melting point than the starting alloy, was used. The craftsman needs to have extensive knowledge about the qualities of the material, such as gold and silver, while also being aware of diffusion solder like copper salt or the use of organic adhesives like pectin found in the quince seeds.

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Проучвания на античните техники на металообработка: Предварителни наблюдения

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Статията анализира древни техники за обработка на метал с фокус върху техниките на гранулация и филигран. Разгледани са различни бижута от Старозагорско и Пловдивско, за да се установят приликите и разликите. Изследванията показват, че телта, използвана за украса на бижутата, не е произведена чрез изтеглянето на метала, а чрез валцуване на метална лента. Въз основа на резултатите от изследването бяха проведени експериментални тестове за получаване на гранулация и филигран. Тези експерименти показаха, че много различни фактори трябва да се вземат предвид при производството на бижута. Резултатите от експериментите служат като основа за отговор на въпроса кои техники за запояване са използвани в древността или как е произведена нишката и какви знания са необходими за работа с техниките.