# Bronze Age and Recycling of Bronze Items

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Bronze Age is one of the most significant so-called "metal" periods in the human past, and its importance lies in man's discovery, and the ability to create a new material that has irreversibly changed the human past: the bronze. Bronze is an artificially made alloy, made up of 90% copper and 10% tin, used for casting various objects (tools, jewellery, weapons, etc.). Bronze Age lasted approximately from 2200 BC to 800 BC, with the Late Bronze Age period showing a significant rise in the development of production of bronze objects that were cast in moulds. Also, the Late Bronze Age is well known for its large hoards of metal objects, that are differently interpreted as votive or founder's hoards. The latter ones are closely related to the recycling process.

The recycling of objects (including those made of bronze) in the Bronze Age forms part of the "archaeology of production" which consists of different stages of the recycling process, such as the use of objects, their fracture, and recycling (Delfino 2014: 124). Recycled items could be those which were well-made, but eventually got worn out, and went out of use. There are also items that were well cast but did not fulfil the intended purpose in terms of shaping. The second set of items are those that were damaged during casting, and they show traces of casting. The last group consists of items that were never intended for use, and belong to waste.

According to some authors, the amount of copper produced in the Bronze Age is still in discrepancy with the number of archaeological artefacts. Namely, a small amount of deposited bronze material has still been discovered. Recycling of bronze objects probably took place already in the Early Bronze Age, and it is possible that a particular object was recycled several times over time, so in the Late Bronze Age we have bronzes from the Early Bronze Age. This makes it difficult to obtain high-quality archaeometric analysis results (Bradley 2013).

As for the geographic position and the proximity of the raw material deposits after Delfino (2014: 125), it is possible that the communities that were close to the copper deposits practised recycling to enhance their production of bronze items. It is more likely (Bradley 1988: 252) that the communities had certain difficulties in maintaining a continuous supply of raw materials, in this case, copper and tin. The bronze recycling process requires special know-how in order to obtain a good quality alloy. This knowledge has been passed from generation to generation. The best proof of possible recycling are the founder's hoards.

In the so-called founder's hoards, there are broken and unfinished items together with finished items and ingots that can be in the form of plano-convex ingots or hammered or cast ingots. These are usually hoards that are extremely large and heavy, and they can have hundreds of items, some even a thousand. According to A. Harding (2000: 355), it is unlikely that they were transported for longer distances, but were more likely deposited in one place for future use. That place could have been marked, and the smith could come back to what was previously "concealed" or better preserved for further work (Harding 2000: 355) by coming to the village. The problem here lies in the question of why a large number of these hoards has been preserved to this day, without them ever being used in the casting process. Authors offer different explanations, and one of them belongs to Harding (2000: 355). He assumes that a larger number of smiths "disappeared" before they could rediscover their objects. Bradley (2013) also mentions a similar problem, but it leaves an open question. He associated the existence of founder's hoards with the periods of crisis, economic or aesthetic. This is in contradiction with the prevailing hypothesis that for example, Phase II (12th century BC) is a time of well-developed metallurgy (Vinski-Gasparini 1973). For Western Europe, Bradley (1988:253) states that, during the Late Bronze Age, the sources of raw material were being used in Atlantic Europe, while in Central Europe there were fewer sources that were providing large amounts of raw material, concluding that the metal industry might have had some difficulties, especially with the procurement of raw material.

In the hoards, it is possible to find bigger or smaller lumps that consist of fragments of bronze items that were melted together. Sometimes it is one or two pieces, and sometimes there are more. Mozsolics (1985: 24) lists different terminology for these finds, so according to R. Wyss they are "zusammengeschmolzene Altmetallklumpen", and according to J.P. Mohen, they are "bronzes préfondus". English authors use the term "scrap metal" (Bradley 2013). Bended and fragmented objects can also be found in the hoards. Some were additionally put together using a hammer or some similar object ie there are visible traces of forging or hammering (germ. *gehammerte*). They show traces of hammering. As for the so-called Altmetall in the hoards, it is common to find bent pieces of sheet metal, such as the bucket of Kurd type, bronze vessels, belts, etc. (Mozsolics 1985: 25). Similar finds can be found in the hoards in the territory of Drava, Sava and Danube rivers (Vinski-Gasparini 1973), for example, in the hoard Brodski Varoš. In addition to these larger pieces of sheet metal and melted and bended bronzes, there are other objects which are possible results of failed casting, so they had to be melted again to obtain a good quality bronze alloy, and the object cast from it.

From the numerous hoards of the territory of Slavonski Brod, the hoard of Brodski Varoš is worth to mention. It is said (Vinski Gasparini 1973: 90) that it had more than 1000 pieces of bronze items, 90% of which were damaged or preserved only in fragments, and it contained quite a number of amorphous lumps (Fig. 2) and raw materials in the form of "cakes" (plano-convex ingots). It is assumed that this hoard consists of several founder's hoards the were gathered together.

In the inventory of the hoards kept in the Archaeological Museum in Zagreb there are fragments of ingots (Fig. 3), and parts of bronze objects that were later melted, probably because they were no longer in use because of the wear, or because they were not adequately cast (Fig. 4 ). Interestingly, fragments of bronze wire objects (fig. 5) were probably parts of jewellery and clothing. By inspecting the inventory, we came to the conclusion that part of the items belongs to the remains of bronze casting in the moulds (*Gusszapfen)*.

Nesel (2012) wrote about them and their function. Precisely these casting remains, as well as the find of *Punze* (Fig. 7), are proof that this large group of bronze objects was very likely used in one stage of metal production preceded by recycling. Recently some authors have not considered that the so-called "plano-convex" ingots (popularly known as "cakes") have been used

in recycling process because the analyses showed that the ingots were made of copper, and not of copper and tin alloy (Nessel 2014).

Like most of the Late Bronze Age hoards in Europe, the hoards of Urnfield Culture in North Croatia (for example, Brodski Varoš) provided valid evidence on the practice of recycling and production of bronze items. Their connection to the settlements suggests that the whole process of production and recycling could have been taking place within each settlement. Therefore, the recycling process needs to be seen as a part of the everyday activity within a particular Bronze Age community.

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