

ARCHAOMETALLURGY AND ITS IMPORTANCE IN THE RESEARCH OF THE PREROMAN DACIA MILITARY EQUIPMENT IN THE 1st B.C. – 1st A.C. CENTURIES

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ABSTRACT

Although it appeared in Romania 50 years ago, archaeometallurgy is still treated as a new discipline, despite the fact that it was understood from the beginning that this science, by its methods and by the correct interpretation of the results obtained as a result of modern techniques of characterization of materials generally leads to the obtaining of data that are particularly important for understanding the past. The present study aims to investigate the evolution and the stage in which this field is in terms of modern techniques of characterization of the materials applied to the military equipment of the classical Geto-Dacian period.

KEYWORDS: Dacian armament, archaeometallurgy, characterization of materials

1. Introduction

The present study considers the science of archaeometallurgy and its importance in the research of military equipment from the century I a. Chr. - I p. Chr. in the geographical area of Dacia before the Romans, which today corresponds to the territorial limits of Romania.

The emergence of archaeometallurgy more than a century ago has led to obtaining interesting and complementary data in archaeological research and implicitly in understanding historical realities. Today the contribution of this science, as we will show in the following, has led to the creation of an interdisciplinary connection without which archeology can no longer function in a professional manner.

The analysis of the various artefacts is made especially in the last years due to the emergence of the latest generation equipment, based on archaeometallurgy, with the mention that the latter is only a segment of a much wider interdisciplinary science called archaeometry.

Despite the fact that people have started to discuss more and more about this modern science (which uses natural sciences such as mathematics, physics, chemistry, biology or geology to support archeology or art history), this emerged at the end of the 19th century becoming a self-contained science in the 1950s [1], with the mention that after obtaining

spectacular results from the initial period, the taking over of the techniques of characterization from physics continued with the more refined methods of characterization from chemistry, respectively physics and the mechanics of artifacts properties [2].

Although in Romania one carried out metallographic studies at the end of the 19th century, archaeometry was born after 1970 and culminated in the establishment of the National Society of Archaeometry [1] in 2011.

In order to obtain as much information as possible on the weapons in the Geto-Dacians, archaeometallurgy is used, which aims to describe the conditions of mining and at the same time to try to reconstruct the modified metallurgy processes [3]. In other words, archaeometallurgy studies the whole process, starting from the incipient stage of obtaining the material from the mining, respectively the separation of ores and until the processing of the respective ore by various methods (forging, casting, etc.).

Also, together with the research of metals, it also falls into the sphere of archaeometallurgy research and the investigation of the residues resulting from the production of the respective metals [4].

Of course, in order to obtain the expected information, archaeometallurgy uses various methods of geology, geochronology, sedimentology, mineralogy, petrography, crystallography, as well as

physics, chemistry and metallurgy, in this hazy method of keeping the attention so that it is not lost sight, obtaining the results from the historical and implicit point of view and bringing a new contribution to its writing [3].

Unfortunately, for various artifacts made of iron or bronze, as is the case with weapons or tools, if at the beginning of the 1980s a series of armament pieces were subjected to methods considered at the time to be the most modern (emission spectrometry and absorption spectrophotometry) [5], both archaeologists and physicists or chemists have lately shown interest in performing metallographic analyzes specific to archaeometallurgy, especially on objects belonging to treasures made of precious metals. For example, we mention the situation of the late Dacian Latene treasure from Bucharest-Herastrau on which X-ray fluorescence analyzes were performed [6].

The importance of archaeometallurgy and modern materials characterization techniques must be viewed with at least the same expectations as archaeological research regarding the discovery and interpretation of military equipment at the Geto-Dacians.

Considering the fact that besides a series of armament pieces from the Geto-Dacian world there is another series of related discoveries (metallurgy workshops, ore reduction furnaces, crucibles, slag pieces and even iron ingots) [7], especially since it was established that in the local workshops the craftsmen also used imported iron ingots [7], it is proved that performing the analyzes specific to archaeometallurgy is an indispensable technique in obtaining information. Frequently performing these analyzes would be able to elucidate at any given moment the entire unclear situation regarding the precise origin of an ore, respectively of weapons created from it. Of course, this is possible only to the extent that specialists (both from Romania and from neighboring countries, where two millennia ago the Dacian population lives) would understand that it is absolutely necessary to carry out specific analyzes and to create a common database.

It should also be noted that the current level of knowledge in archaeometallurgy and understanding of how iron inventory objects behave when they are brought to the surface by archaeologists may be much more important than even gaining information about the respective objects through modern methods of laboratory investigation. That statement is easily to be proved since, in archaeological research, the lack of specialized personnel with regard to iron objects leads to the situation where properly harvested or unprotected artifacts are destroyed during the sampling, or possibly in the conservation phase of restoration, as it was the case of a Geto-Dacian arrow from Cetățeni, Argeș County, which was destroyed in

the laboratory while it was in the cleaning solution [8].

Handling antique ferrous objects is not always easy. In many cases, they are discovered in a state of advanced degradation due to the physico-chemical interactions that the piece has suffered in contact with the soil, or due to the sudden entry (after the discovery of the object) in contact with oxygen and humidity, all the more so the iron does not need more than 0.05 seconds to enter the corrosion phase [9].

Despite the fact that many weapons were discovered in a so advanced corrosion state that they practically sprayed without leaving behind information that usually accompanies such artifacts, as it is the case with the *umbo* shield from Cetățeni [10], the latest metallographic analyzes having completely saved such situations.

Cases of this kind in which the parts can be completely corroded, today provide valuable information that is preserved between the corrosion layers whose products have replaced the existing metal structures before corrosion [11].

Approaching research with the help of archaeometallurgy and implicitly of modern laboratory techniques can lead to clarification of some aspects down to the smallest details. For example, for more than half a century, certain stages during the forging, including the direction of the hammering force of the hammer used on the material, were found by observing the dark colored stripes showing the maximum concavity where the force to hit it exerts its maximum effect [12].

At the same time, archaeometallurgy can be the answer to those detailed analyzes (other than the archaeological research they have to complete), which archaeologists look for in order to obtain answers regarding the local or external techniques that were used in the workshops when creating various artifacts [13].

Also, if at the beginning of the twentieth century the examination of objects was carried out by destructive methods that often meant destroying the samples, at present these analyzes involve extremely small samples to which non-destructive and non-invasive analyzes are added, which, through various methods, apart by the fact that they can date the objects, they can lead to the identification of false ones [14].

Due to the practical experience and the concrete problems faced by the researchers, archaeometallurgy begins to impose a true "practical guide" that both archaeologists and the personnel with tasks in conservation-restoration must acquire. Specifically, the artifacts (especially the metal ones) must be subjected to the cleaning process, but this excessively applied process as a result of improper restoration

techniques leads not only to the aesthetic deterioration of the object, but also and especially to the impossibility of characterizing the object by studying some essential micro-surfaces [15], which can generate the loss of vital information regarding the techniques used in creating the respective piece or other elementary data.

It should also be noted that, on the one hand, archaeological research for various reasons, but justified primarily by the lack of financial resources, is almost devoid of modern techniques of characterization of materials, and on the other hand, they are not properly turned to account by publication, even if they were carried out, as is the case with military equipment pieces found inside four mounds investigated in Cugir in 1979 and 1981. Although it is stated that besides a series of analyzes on bones, wood and radiocarbon dating were new spectral and microfluorescence analyzes were performed, it seems that the respective studies remained in the manuscript stage [16].

2. Military equipment and research methods

2.1. Study of weapons from Bulbuc locality, Ceru-Băcăini Commune, Alba County

During 2014, on the southern edge of the Bulbuc hamlet, a metal-detecting enthusiast discovered a number of 5 complexes representing possible Dacian burial arrangements, but the analyzes carried out did not identify any traces of burning or other elements that usually appear in the context of the funeral rituals although there is the possibility that they were cenotaphs [17].

In total, the detector would donate to the National Union Museum in Alba Iulia 5 *sica*-type curved daggers, 3 javelins, 5 lace-heads, a spearhead and 3 sheaves, generally the daggers and spears being ritually bent.

Based on the analogies with other *sica*-type daggers, but especially on the basis of the analogies related to the hooves, it supports the dating of the discoveries towards the 1st century BC.

It should be noted that the weapons, although they had been on the ground for a very long time, were discovered in a very good physical condition that could be considered atypical, in this case the magnetite layer (Fe_3O_4) being preserved very well even if under it, the corrosion affected the metal core, which led to the maintenance of the functional and decorative elements on the blades and handles of daggers [18].

A particularly interesting aspect only valid for the spearhead and two of the lances is the fact that on

these was observed a red-cherry patina that can be attributed to ferric oxide (Fe_2O_3), hematite [18]. This situation is most likely explained by analogy with other types of ferrous materials found at Sarmizegetusa where on a series of iron spikes and targets containing the same red-cherry patina were performed in 1981, respectively 1995 emission spectroscopy analyzes, respectively emission fluorescence, the results of both analyzes being interpreted in the sense that the respective patina represented a primitive enamel used with the role of protecting against corrosion [19]. The analyzes performed by the engineer Gheorghe Topan, the head of the research laboratory at the Armatura factory in Cluj-Napoca and presented in Table 1 determined the chemical elements of an iron pyron provided with glaze (enamel), the chemical composition being expressed in % by weight.

Table 1. Iron pyron with glaze analysis bulletin (enamel) [19]

Elements	Concentration %	
	Polished face (metal)	Unpolished face (glaze)
Fe	Basic Element	Basic Element
C	0.03	-
Si	0.15	2
Al	-	2...3
K	≤ 0.01	0.1...0.6
Ca	≤ 0.01	0.2...0.8
P	≈ 0.05	0.04
Mn	0.04	0.15
Mg	< 0.01	-
Ti	0.01	0.04
V	< 0.004	0.03
Cr	0.02	0.02
Ni	0.03	< 0.01
Cu	0.03	0.04
Sn	0.07	< 0.01
W	0.03	-
Pb	0.02	-
Bi	0.01	-
Mo	< 0.05	0.02
Sb	0.05	-

Considering the excellent state of conservation of the weapons located on the ground, to clarify the whole situation, from the respective pits were collected several soil samples, two of them were analyzed to obtain data on the chemical composition and pH [18], both these and a series of metallographic analyzes being performed at the Research Institute for analytical instrumentation Cluj-Napoca [17].

The results of the soil samples S1 and S2 obtained by the destructive spectrometry method, the

inductive coupled plasma atomic emission spectrometry (ICP-AS) detailed in Table 2, respectively the inductive coupled plasma mass spectrometry (ICP-MS) in Table 3 are presented as follows:

Table 2. Experimental results obtained by the ICP-AS method [18]

Elem. determ.	S-1 mg/kg	S-2 mg/kg
Fe	28693	29540
Ni	31.4	32.4
Cr	26.4	26.3
Co	7.23	7.3
Cu	47.1	48.7
Zn	134	136
Pb	20.5	15.9
Na	-	111
Mg	<4860	5063
K	3427	3500
Ca	31167	37667
Mn	944	1020
Ba	162	172
Al	21037	22193
I	0.31	0.17
Cs	0.53	0.17
La	7.53	5.4

Determination of soil pH according to Table 4 was carried out by instrumental method of serial pH measurement in a 1:5 (V/V) dilute suspension of soil in water (pH in H₂O), in potassium chloride solution concentration 1 mol/L (pH in KCl water) [18].

Based on the soil analyzes, it was found that the very good state of preservation of the military equipment was due not only to the quality of the metal, but especially to the pH of the soil, whose alkaline value allowed the formation of oxide layers with a protective role. Also, the large amounts of calcium carbonates (present due to the decomposition of calcareous rocks in the soil) led to the formation of a protective layer that slowed down the corrosion, this being done randomly depending on the contact of the weapons and the position of the carbonates in the soil, the areas. of the respective contact having a black patina (magnetite) [18].

Table 4. PH values corresponding to the soil matrix [18]

Nr. crt.	Soil sample code	Quantity / volume of distilled water	pH	Temperature	Unit
1	S-1(985)	10.17 g/50 mL	7.90	20.1 °C	pH units
2	S-2(986)	10.16 g/50 mL	7.99	20.2 °C	pH units

For the analysis of the composition was chosen the spearhead from Fig. 1, this one presenting the glove tube with perforation, for fixing the nail found detached from the blade with median rib.



Fig. 1. Spearhead, inventory nr. 4723 [17]

A sample of 0.5 g was taken from the spearhead, which was chosen from the sleeve, indicating that, unfortunately, a strongly corroded area was chosen, which certainly affected the analysis result.

Table 3. Experimental results obtained by destructive methods with ICP-MS [18]

Determ. elem.	S-1 mg/kg	S-2 mg/kg
Li	16.4	6.3
Be	0.61	0.22
Sc	1.6	1.3
V	19.6	12.7
Ga	2.7	1.9
As	21.9	12.3
Rb	11.9	9.1
Sr	11.8	8.7
Y	5.5	3.7
Zr	3.9	2.6
Nb	0.35	0.20
Mo	0.29	0.14
Cd	0.25	0.14
Sn	0.53	0.34
I	0.31	0.17
Cs	0.53	0.40
La	7.5	5.4

The respective sample was subjected to destructive analysis of inductive coupled plasma atomic emission spectrometry (ICP-AES), oxygen

carbon technology (TOC) respectively, according to Table 5.

Table 5. Chemical analysis of the spearhead [18]

Element	Mg/kg	Element	Mg/kg	Element	Mg/kg	Element	Mg/kg	Element	Mg/kg
Li	1.7	Zn	107	Ru	<0.3 2	Nd	<0.3 2	Ta	<0.3 2
Na	486.4	Pb	74.6	Rh	<0.3 2	Sm	<0.3 2	W	<0.3 2
Mg	139.4	Ga	1.04	Pd	<0.3 2	Eu	<0.3 2	Re	<0.3 2
Al	281	Ge	0.45	Ag	2.18	Gd	<0.3 2	Pt	<0.3 2
K	3534	As	20	Sn	6.82	Tb	<0.3 2	Au	<0.3 2
Sc	0.74	Br	2.2	Sb	24.4	Dy	<0.3 2	Hg	<0.3 2
V	18.35	Rb	0.43	I	<0.3 2	Ho	<0.3 2		
Cr	496.1	Sr	6.88	Cs	<0.3 2	Er	<0.3 2		
Mn	126.5	Y	0.4	Ba	17.48	Tm	<0.3 2		
Co	18.3	Zr	0.52	La	0.93	Yb	<0.3 2		
Ni	68.1	Nb	0.53	Ce	0.42	Lu	<0.3 2		
Cu	90.8	Mo	4.28	Pr	<0.3 2	Hf	<0.3 2		

The percentage of 0.80% carbon shows both the long heat treatment and the stopping of this treatment before the weapon becomes brittle, which resulted in obtaining a piece with an optimal ratio between resistance and elasticity [18].

2.2. The study of weapons from the Boeriu Collection, the National History Museum of Romania

Without knowing the place of discovery and without questioning the area of the Geto-Dacians' residence, in the years 2009-2010, Adrian Boeriu donated to the National History Museum of Romania two *sica*-type curved daggers, which he declared he had purchased from London [20].

Of the two daggers, the one with inventory number 334523, represented in Figure 2, had the chance to be analyzed from a metallographic point of view.

This fact was achieved within the project - *Studies of archaeometallurgy on the Dacian Gold and Silver using high-performance X-ray spectrometry methods* [21].



Fig. 2. *Sica*-dagger inv. 334523 [29]

X-ray fluorescence spectrometry (XRF) was performed including X-MET 3000TX portable spectrometer (with detector: Peltier cooled silicon diode, Window detector: Kapton, X-ray tube: RH anode, maximum voltage 30 KV, size spot: 6 mm x5 mm, determination of elements: from potassium to uranium, energy resolution: < 275 eV for K α -Mn). The XRF spectrum is shown in Figure 3.

From the investigations carried out it was found that a series of traces detailed in Fig. 4 that were observed on the blade were composed of a brass alloy remaining from the composition of the teak, a very

important aspect that led to the dating of the dagger in the 1st century a. Chr. Since these alloys appear after the time of Augustus [22].

2.3. Studying the evidence in Cugir locality, Alba County

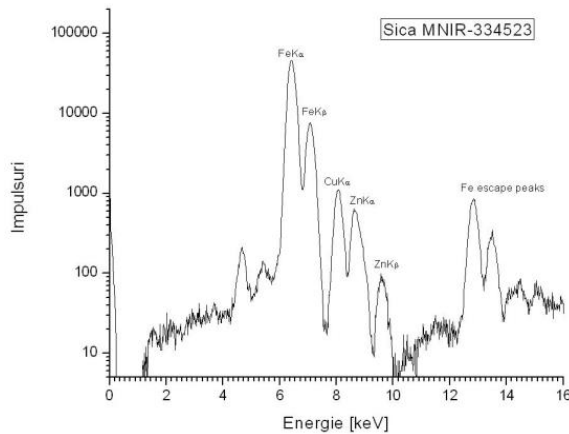


Fig. 3. XRF spectrum [21]



Fig. 4. Upper part with possible brass area from molten sheath [21]

During the excavations in 1979, on the S-V slope of the hill called "Cetate" near the town of Cugir, on which the Dacian fortress Singidava was identified, a number of four tombs containing incineration graves were discovered, the tumulus no. 2 revealing the surprise of the existence within it of a princely tomb [23].

The excavations continued in 1980 by Ioan Horațiu Crișan and Florin Mededeț showed that the four mounds were located in the immediate vicinity of the fortified enclosure, just next to the access road to the Dacian fortress [24].

Basically, the archaeological excavation of the mound with the number 2 revealed that the incineration of the warrior's body equipped with armor from chapels, helmets, Celtic type sword (whose sheath joined with the blade due to the strong burning from the tree), spear, shield with border and *umbo*, the plywood of a bow and a dagger of the *sica* type (all this set being made of iron) was made together with a number of 3 horses (about 100 kg of calcined bones of human and animal origin were harvested), the human body being burned in a ceremonial chariot right at the place where the mound [25] was erected.

Along with these weapons, in the tomb dated in the first half of the century I A.C., besides pieces of gold and silver jewelry from the warrior's clothing, but also from the harness that adorned the horses, one discovered numerous pieces from the chariot, harnesses, hooves, etc. from which samples were collected to establish the material from which they were made [26]. Their analysis is presented in Table 6.

Table 6. Cugir tomb analysis bulletin, raw material samples [19]

Sample nr.				Cu
0	1	2	3	4
I	The bandage of the wheels of the carriage	Steel	Metallography	
II	Bronze element of the carriage (or harness piece)	Bronze	Gravimetric + spectral	91.30
III	Metallic clothing accessory	Silver alloy	- -	4.21
IV	Granule from melting and agglomeration of metal parts (jewelry or clothing)	Silver	- -	0.72
V	Fragment of metal part from the carriage	Bronze	- -	73.70
VI	Rods for fixing the sides of the carriage	Bronze	- -	91.46
VII	Carriage ring	Bronze	- -	78.25
VIII	Bronze vessel (situla)	Bronze	- -	87.72

After establishing the alloy from which the flakes subjected to the analysis were made, one wanted to determine the chemical composition. The result of this analysis according to Table 7 showed that apart from the bronze pieces they contained besides copper and Sn, Pb, Ag, Al, Fe, Si, Mg, P and

Au, and the fact that they were subjected to a final heating on the 850 °C funeral pile, which was followed by a slow cooling due to the preservation of some combinations of chemical elements [19].

Table 7. Bulletin of the Cugir tomb analysis, chemical elements and sample components [19]

Content in chemical elements %												
Ag	Sn	Pb	Al	Fe	Si	Mg	Mn	P	Au	Bi	Ni	C
5	6	7	8	9	10	11	12	13	14	15	16	17
				≈0.90								≈0.05
≈0.1	5.50	1.86	0.1... 0.5	≈0.1	≈1	≈5.10 ⁻²	10 ⁻³ ... 5.10 ⁻³	0.5...1.0	≈10 ⁻³	≈10 ⁻²	5.10 ⁻³ ... 10 ⁻²	
92.0	0.5... 1.0	≈1	≈0.1	≈0.1	0.5...1	10 ⁻² ...5.10 ⁻²	≈10 ⁻³ ...	5.10 ⁻²	≈0.1	0.5... 1.0	5.10 ⁻³	
84.61	13.94	0.1... 0.5	10 ⁻³ ... 5.10 ⁻³	10 ⁻² ... 5.10 ⁻²	10.5... 1	≈5.10 ⁻²	10 ⁻³ ... 5.10 ⁻³	≤5.10 ⁻²	≈1	≈1	≤5.10 ⁻³	
2.78	6.55	0.1... 0.5	5.10 ⁻² ...10 ⁻¹	0.1... 0.5	10.5... 1	10 ⁻³ ... 5.10 ⁻²	10 ⁻³ ... 5.10 ⁻³	5.10 ⁻² ... 10 ⁻¹	≈5.10 ⁻³	5.10 ⁻³ ... 10 ⁻²	5.10 ⁻² ... 10 ⁻¹	
0.1... 0.5	0.52	≈0.1	≤10 ⁻³	0.1... 0.5	10 ⁻² ... 5.10	5.10 ⁻³	≤10 ⁻³	≤5.10 ⁻²	<10 ⁻³	<10 ⁻³	≈10 ⁻²	
≈0.1	6.90	1.55	5.10 ⁻² ... 10 ⁻¹	0.1... 0.5	0.5...1	10 ⁻² ... 5.10 ⁻²	10 ⁻³ ... 5.10 ⁻³	5.10 ⁻² ... 10 ⁻¹	≤10 ⁻³	0.1... 0.5	≈10 ⁻²	
≈0.1	7.60	≈0.1	10 ⁻² ... 5.10 ⁻²	0.1... 0.5	0.1... 0.5	10 ⁻² ... 5.10 ⁻²	≤10 ⁻³	≈0.1	≤10 ⁻³	<10 ⁻³	≈10 ⁻²	

2.4. Studying the evidence in Orodel place, Dolj County

In 1917, on the right side of Orodel Valley, in the area of the old church and the cemetery, a cremation tomb was discovered (although no traces of the cremation were found, the patina of the weapons proved that they were passed through the fire) at that time, a Celtic sword, jagged, a spearhead and a *sica*-type dagger [27], detailed in Fig. 5.



Fig. 5. Sica dagger from Orodel place [29]

Quite rightly, the respective *sica* due to the accidental discovery and without a clear context was challenged as to whether it belonged to the same eventual grave in which the other weapons were discovered [28], especially since it is a weapon specific to the Geto-Dacian population.



Fig. 6. Sica blade detail with copper-lead alloy ornaments, possibly from the sheath [21]

2.5. Studying the evidence in place. Piatra Roșie, Lunca Village, Hunedoara County

A spectacular warehouse of Dacian pieces that included besides several dozen tools, some three pieces of military equipment consisting of a spearhead and two lance-heads, shown in fig. 8, one of which was unfinished, being processed, was donated to the museum of the Castle of Corvinești approximately between the years 1995-1996 by an unknown person, without knowing the context of the discovery, but only that it took place in the proximity of the fortress Piatra Roșie [30].

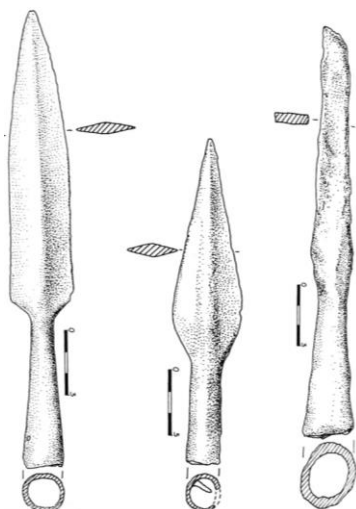


Fig. 7. lance-head, spearhead, unfinished lance-head [30]

On the respective pieces, in the laboratories of the Iron and Steel company Hunedoara, later turned into Mittal Steel, chemical analyzes were performed with the help of a spectral analyzer, respectively metallographic ones carried out under a microscope [30], which revealed, in addition to a series of characteristics related to the metallurgical processes to which they have been subject to the respective objects also the chemical elements in their composition according to Table 8.

Regarding the component parts of the warehouse, based on their characteristics, but also on the basis of analogies with different pieces from the Dacian environment, the authors of the study proposed as a chronological landmark the period between the years 101-105 p. Chr. [30].

Table 8. Chemical elements in the composition of the armament pieces, Piatra Roşie [30]

Nr. sample	%	C	Mn	Si	S	P	Cr	Ni	Cu	Al
8	Spear head	0.41	0.01	0.03	0.018	0.100	<0.01	<0.01	<0.01	0.009
12	Spear head	0.21	-	-	-	0.012	-	-	0.03	0.005

2.6. Weapons study in Rastu Commune, Dolj County

In the respective locality, in Griful Şifarului point, systematic archaeological investigations were carried out in 1950, which led, among others, to the discovery of cremation graves and pieces of military equipment consisting of *sica*-type knives, lances and sheaf fragments [31].

The respective pieces currently owned by the National Museum of History of Romania were classified in the 2nd-1st centuries BC, following analogies from Oltenia, Histria or northern Bulgaria [32].

Of the total weapons discovered, only two of the *sica*-type daggers were investigated. The microstructure analyzes performed on the *sica* with inventory number III 5962 from Fig. 8 (left), reveals that the weapon had been ritually bent with its burial, although it had probably been tempered, this being subjected to a warming above the critical point after which the descent took place [32].

Regarding the other weapon with inventory number III 5963 from Fig. 8 (right), it was subjected to a metallographic analysis that revealed that it was made of 0.7-0.8% carbon steel, was uncoated and had been made by forging [32].

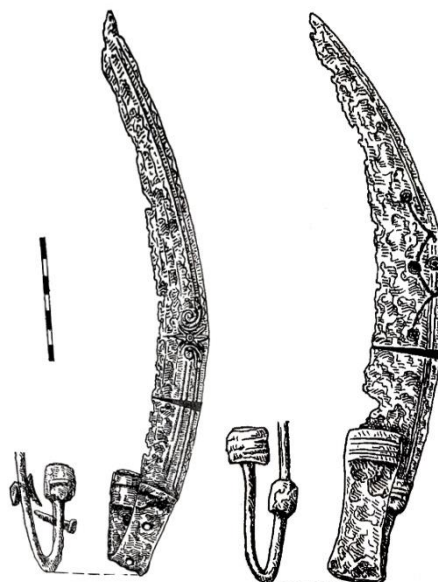


Fig. 8. *Sica* inv. 5962 (left) and *Sica* inv. 5963 (right) [32]

As with the other curved dagger, it was also found that it must have been initially hardened, especially due to its functionality, and the heating above the critical transformation point that led to the decay was accounted for by the ritual burning of at

the funeral parade, an explanation that is perfectly logical.

3. Conclusions and perspectives

As for the answers offered by the archaeometallurgy, they come as a result of the requests received from archaeologists as a rule, specifying that these analyzes are performed according to the questions to which the archaeologists expect answers, and the methods of characterization of the materials are influenced by the existing facilities.

At the same time, the remaining scraps from the metallurgical process, respectively the slag, should be treated with the same importance as the finished parts under analysis. The detailed study of these slags can bring a number of relevant data including the metallurgical processes through which the slag has passed.

In the situation of these remains, one must understand that only scientific research can link the piece of slag to the piece of metal that was created [4].

The stake of the proper research of these slags is a special one. Practically, the careful archaeological research in the workshop areas, respectively of the ore reduction furnaces, followed by the collection and transmission to the laboratory of these remains can finally lead to the clarification of the eternal disputes in the specialized bibliography regarding the local origin or the origin of the import of certain military equipment.

In general, it should be borne in mind that the process of physical-chemical characterization of some archaeological finds led to the knowledge of technologies and materials used in the past and at the same time contributed to obtaining new information on trade, human migration, as well as the penetration of various cultures, which led to data that can be used in dating objects [14].

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