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Research Article

CONTRIBUTION TO THE KNOWLEDGE OF THE TEMPERATURES REACHED DURING THE CREMATION RITES IN THE ROMAN PEOPLES OF THE SECOND IRON AGE IN THE IBERIAN PENINSULA

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ABSTRACT

In this paper studied weapons found in archaeological finds in the Iberian Peninsula of the pre-Roman times, in which have been observed the presence of magnetite patinas and the presence of geometric decoration with silver threads together with them. The novelty of this research is that these pieces are an irrefutable witness to the temperatures reached during the rites incineration of these settlements.

INTRODUCTION

Has always been controversial to say what the range of temperatures reached during the rites of cremation or incineration of corpses in the Roman peoples of the Iberian Peninsula (V centuries B.C. II). we not have clear written records of the details of the rite, which could lead us to propose a more or less successful hypothesis. In this case, archeology, is the tool that can provide real data on the temperatures reached in these rites. Some authors think through testimonials, such as: metallurgical changes of the objects that accompany the body [1-9], color of cremated bones, type of wood used and incineration pyres simulations [10-16]. In this research the results observed in the metal part cremated with the corpse of a warrior are shown, from the necropolis of Hoya (Álava, Spain) the Centuries V - II B.C. (Figure 1). This necropolis has supplied numerous pieces of regalia of warriors as weapons. These weapons of Celtic type, have a patina of magnetite matte black lining and decorated with geometric designs made with silver and bronze. In some parts, especially those composed of two or more elements, presenting the patina is twofold: silver-magnetite or magnetite bronze; leaving the metal film of silver or bronze found with steel workpiece [17-25].

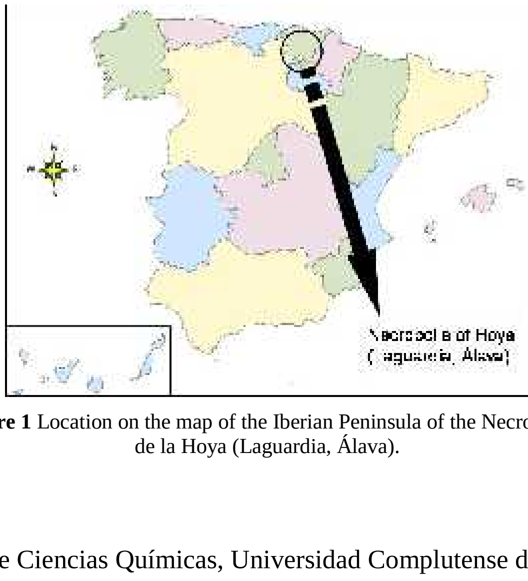

Figure 1 Location on the map of the Iberian Peninsula of the Necropolis de la Hoya (Laguardia, Álava).

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The piece selected for this research (Figure.2) is a sword scabbard Monte Bernorio type [25] of the Armory Museum of Alava, which retains a somewhat precarious state for having undergone the incineration process, and then, severe corrosion. It has a length of 18 cm and is covered with a patina alloy double silver-copper and magnetite, and profuse decoration with geometric designs with silver threads.

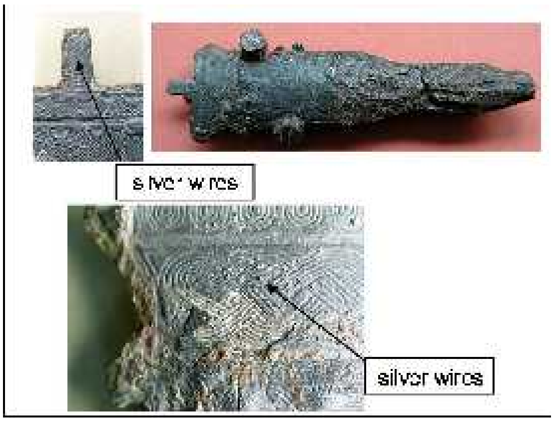


Figure 2 Image of sword scabbard Monte Bernorio typology, with patina silver-magnetite and geometric decoration with silver wires

Research has been carried out by metallography by conventional microscopy (M.O.) and scanning electron microscopy (M.E.B.) using the identification technique and EDS-EDX chemical analysis, incorporated in the scanning electron microscope.

Experimental Technique

Sampling was carried out taking into account the least possible damage of the archaeological piece. a small sample of the area of the tongue (Figure.3) was extracted.

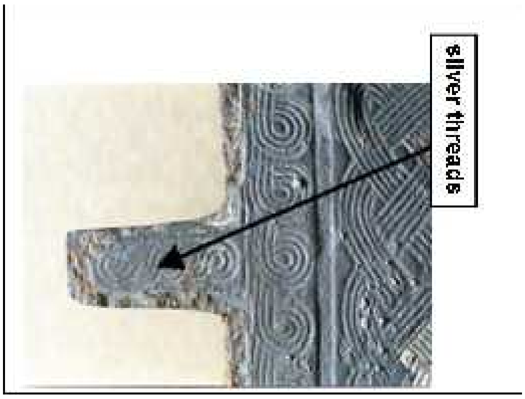


Figure.3 Image, at higher magnification, the area of the tongue from which the sample was took.

The sample, of just 4 millimeters in length, taken from the piece was embedded in resin Mecaprex KM-U. Roughed by abrasive discs of Buehler grain 240, 320, 600 and 2000 in water; and subsequent polishing α alumina (0.3 microns) and alumina γ (0.03 microns) in Buehler polishing cloth. Chemical etching for metallographic observation by FEG should be very careful and free from residues of attack deposited on the target surface. The high quality of the microscopic observation of this instrument may be affected with a defective metallographic preparation and chemical attack. The etching was performed with 4% Nital, and washed with distilled water in an ultrasonic bath. For the observation of the samples in scanning electron microscopy, after preparation roughing, polishing and chemical etching, they were metallized with gold for 30 seconds with a current of 20 mA, and thickness of 3 nm gold. (Figure.4). The scanning electron microscope with thermionic cathode of tungsten filament (FEG) used is JEOL model JSM 6400 that provides images and physic-chemical data of the sample surface. It has three sensors: secondary electron detector, the image resolution is 35 KV, detector to work at 8 mm distance with an image resolution of 3,5nm and detector to work to 39 mm with an image resolution 10nm. It provides backscattered electron images with an image resolution of 10 nm, a 8 mm working distance. In addition, you can perform qualitative elemental analysis (EDS) with a resolution of 133eV.

Figure 4 Image of the sample embedded in resin and covered with gold sputtering

RESULTS AND DISCUSSION

The piece of the sample, show amazing technological knowledge. One is the use of an alloy of silver as silver patina composed of magnetite instead of the bronze-patina magnetite detected in numerous pieces of this time (V centuries B.C. II) so far. This means that silver alloys were also used as brazing for composite pieces of iron or steel: doorknobs and sword sheaths, compounds sconces, etc. Therefore, there is no exclusivity in brazing; also formed in an easy manner and by the same mechanism the skid magnetite layer on the silver film used in brazing [17, 18, 22-24]. In Figure 5a can be seen an image of the patina of silver alloy.

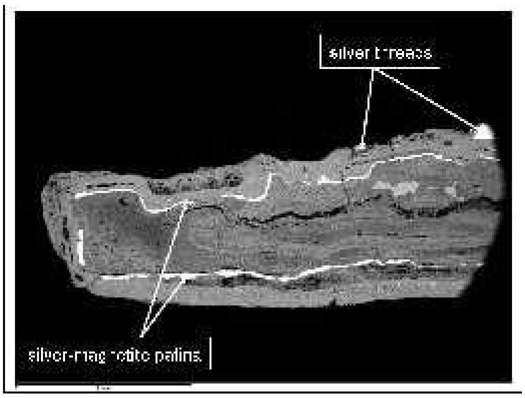


Figure.5a Image of the sample, obtained by M.E.B. using ackscattered electrons. In white is observed metallic patina nveloping the sample

The patina of magnetite created at the time of obtaining the metal film is observed only in some sections; as the piece suffered incineration with the corpse of the warrior and subsequent severe and prolonged corrosion (Figures. 5b and 5c).

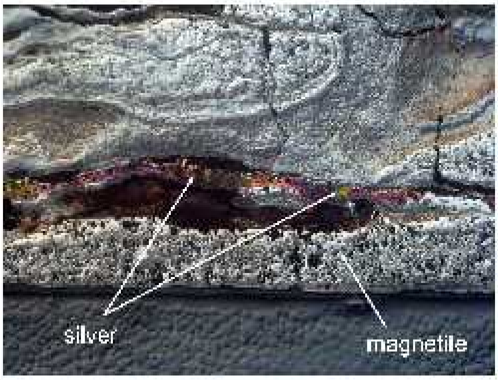


Figure.5b Image of the sample, obtained by M. O., of the patina composed of silver-magnetite alloy

Figure.5c Detail, at higher magnification, of figure.5b showing the structure of the patina silver-magnetite and the eutectic structure of the silver-copper alloy

The threads of silver inlaid geometric decoration on the patina of magnetite, were dispersed by magnetite layer formed during incineration stage and subsequent corrosion (Figures.5a and 6).

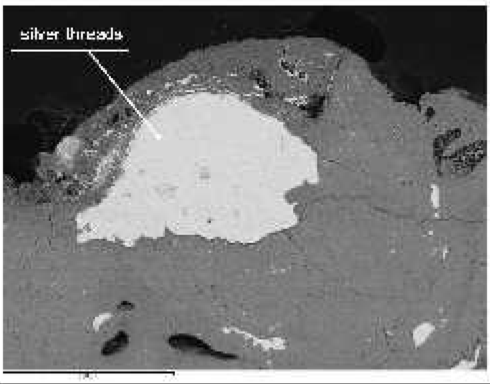
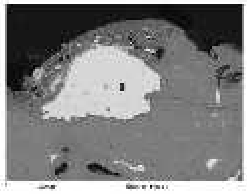


Figure 6 Image obtained by M.E.B. with backscattered electrons, the silver thread section of the geometric decoration shown. The thread is drifting in the mass of iron oxide, production of the corrosion of steel sheath.

EDS-EDX analysis confirms that thread is silver with a slight copper content, about 5 mass% (Figure.7).



Spectrum	Cu	Ag	Total
3	5.61	94.39	100.00
Mean	5.61	94.39	100.00

All results in weight%

Figure.7 Analysis of silver thread by EDS-EDX technique. It is silver with a low copper content.

The copper alloy of the silver-copper patina has a composition close to the eutectic: silver ≈ 70% and copper ≈ 30% by mass; achieving a melting during the brazing operation, slightly above 780° C; significantly lower than when they used bronze (Cu-Sn). The patina appears very clear eutectic solidification structure, from which it follows that during the incineration of the weapons with the corpse of the warrior reached at least 800° C temperatures (Figures.8-11).

In Figure 8, it is clear, the eutectic structure with a higher proportion of light areas, some correspond to dendrites silver rich phase (Figure.9).

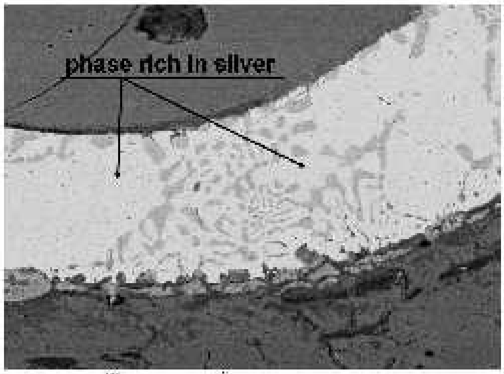
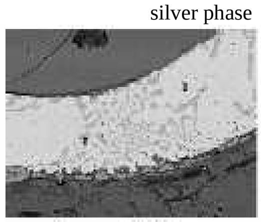


Figure 8 Image obtained by M.E.B. using backscattered electron, in which the eutectic structure of the silver- copper alloy patina is observed. It is, clearly, that the amount of light phase (rich in silver) exceeds the dark phase. These areas are rich dendrites of primary silver phase



Spectrum	Cu	Ag	Sn	Total
1	11.22	88.78		100.00
2	90.17	5.77	4.06	100.00

All results in weight%

Figure 9 Identification by EDS-EDX, of the patina of copper-silver alloy. The silver-rich phase is light in color, and rich in copper, dark color

While in figura.10, the excess is of dark areas, some of them are dendrites of the copper rich phase (Figure.11). The identification of the phases can be seen in the figura.10, where the EDS-EDX that observed in the analysis is shown figura.9. The end result is that the melting temperature of the patina was higher than the eutectic (780 ° C) because primary dendritic structures appear of rich phase silver and copper rich phase.

Inside the base steel sheath we have been able to observe some colonies of steel not corroded. In this mass of corrosion they have survived those colonies which have a very revealing metallographic structure.

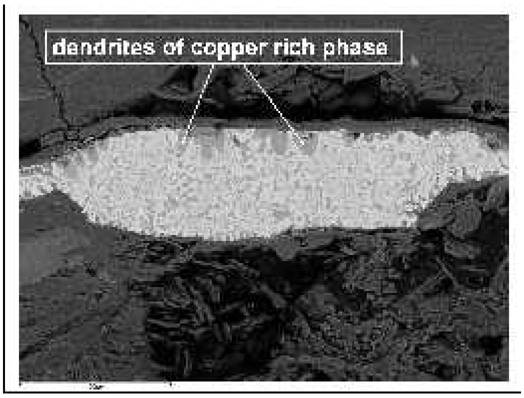
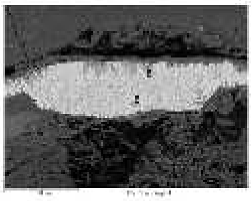


Figure.10 Image obtained by M.E.B. using backscattered electrons, in which the eutectic structure of the patina is observed on a different image area of the figure.8. Dendrites of copper rich phase in dark color



Spectrum	Cu	Ag	Sn	Total
7	92.99	7.01		100.00
6	8.15	85.60	6.24	100.00

All results in weight%

Figure 11 Identification by EDS-EDX, of the patina of copper-silver alloy

Figure12 Imagen en la que se observan gotitas de plata fundida, pertenecientes a los hilos de la decoración geométrica. Se hallan en la superficie de la vaina, junto a los surcos en la pátina de magnetita pertenecientes a la decoración incisa.

On the outside of the sheath are observed small droplets of molten silver on insertion channels geometric decoration with silver threads. This provides evidence that the temperature reached during the incineration was, at least, the point of silver spheroidization (962ºC) (Figure.12).

Another noteworthy information about this piece is that within the base steel sheath, have been observed colonies of corroded steel. In this mass of oxides, corrosion product, have survived those colonies, which have a very revealing metallographic structure (Figures.13, 14, 15 and 16). The microstructure observed shown iron carbides in a ferritic matrix Widmanstätten [4,8,26]. In addition, conventional pearlitic colonies (Figure.16) are observed.

Figure 13 Image obtained by M. O. that show steel colonies that have survived severe corrosion observed.

Figure.14 Detail, at higher magnification, of the image of figure.13, showing a detail of steel colonies

Figure.15 Image obtained by M.E.B. with secondary electrons of the structure observed in figura.14

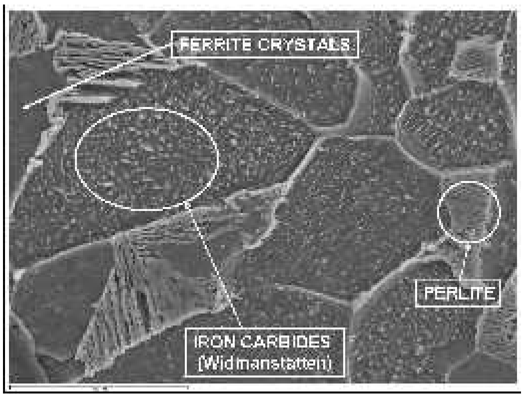


Figure 16 Image obtained by M.E.B. with backscattered electron in which colonies of pearlite, ferrite crystals and iron carbide type Widmanstätten were observed in ferritic matrix

This information is very valuable because it reveals that incineration temperatures could overpass in many cases of 1000ºC. The appearance of these type iron carbides Widmanstätten are interacting with very rapid cooling from high temperatures [4,8,26]; what has been demonstrated with this part of the necropolis of the Hoya (Álava, Spain) that appear structures have melted during the incineration process, both eutectic silver-copper patina as own silver the threads of surface geometric decoration.

CONCLUSIONS

In this part of the necropolis archaeological de la Hoya (Álava, Spain), we have observed that the patina composite metal-magnetite instead of bronze-magnetite is an alloy of silver and copper-magnetite. It has been seen how patina silver-copper alloy exhibited a typical microstructure of eutectic solidification. In some areas the composition was slightly hypereutectic and in others, hypoeutectic. Therefore, the temperature reached during the rite of incineration must rise above the eutectic isotherm at 780°C.

The information supplied by the silver threads of geometric surface decoration is, that coalesced in some areas, showing that the temperature reached during the rite of incineration should exceed 962ºC (melting point of silver). The formation of small spheres or droplets of silver, shows that the fluidity of the molten silver must be high enough that this phenomenon occurs. This would show that the temperature at which the piece was subjected under study would exceed 1000ºC. This shows that proposed by some authors [4,8,26], in recent years, about the emergence of iron carbides of Widmanstätten type in steel parts cremated, only rapid cooling from high temperatures, can cause appearance of these structures. This has been corroborated with small colonies steel found in the mass of iron oxide corrosion of the sample studied.

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