

EARLY IRON AGE WEAPONS – METALLOGRAPHY AND SEM ANALYSIS

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Abstract

One of the positive trends, clearly visible in the last decade is the broader application of interdisciplinary methods in the analysis of archaeological artefacts. There is a great level of interest in the research of metals and their role in the development of ancient societies. Unfortunately, until now very little focus has been put on the iron artefacts. The current research is mainly related to precious metals, copper and copper alloys.

Key words: archaeology, radiography, flaw detection, SEM

Introduction. The review of BUYUKLIEV [1] states that the majority of known artefacts made of iron were arrowheads and swords, as the main offensive weapons during the early Iron Age.

More than 20 iron swords and parts of bronze swords with iron handles were found in the southern territory of today's Republic of Bulgaria. Several regions with a leading role in their use can be distinguished – the Rhodopes, Central, Northern and Southeastern Thrace. Most of the iron swords are accidental finds. This situation greatly complicates the attempt to date them accurately. There are objective obstacles to this. First of all is their condition when they are discovered. The strong corrosion of most swords does not allow us to see the individual characteristics of the sword, and they are important for the typology and, accordingly, for their dating. For example, such fine elements as the centre edge is damaged. In other cases, the main dating and type-determining element of the sword, namely

its handle, is often damaged or completely missing. A region with a strong presence of iron swords is Southeastern Thrace, where four iron swords have been found – those from Omarchevo and Zagortsi, Nova Zagora, Popovo, Yambol, and one from Haskovo with an unknown location. The line of distribution can be continued to the north with the sword from the village of Topchii, Razgrad region. The sword from Omarchevo was found in a settlement with many ceramic finds and, according to CHICHIKOVA [2], it can also be dated to the beginning of the Early Iron Age.

Researched artefacts. Two samples, No. 1 and No. 2, were examined from a Nenzingen-type sword (Fig. 1).

Section No. 1 is taken from the area of the sword handle, and No. 2 from the cutting part of the sword.

The sword has an elongated blade and a rhomboid cross-section. Only the diamond-shaped plate of the transition between the blade and the handle has been preserved. There are traces of three rivets on it for attaching the sheathing.

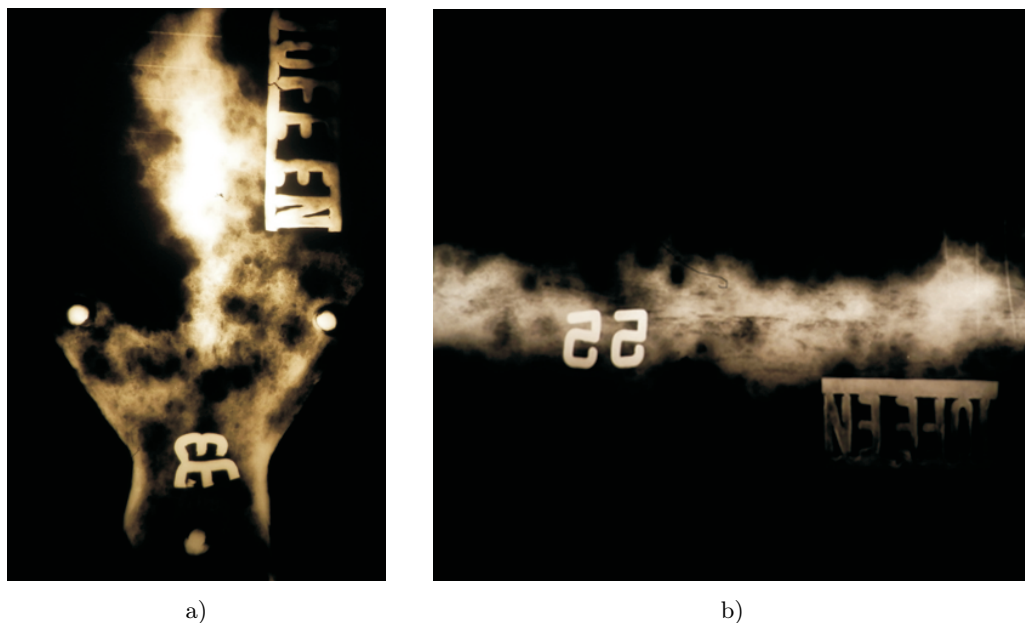


Fig. 1. X-ray photographs of a) the hilt, and b) the blade of the sword

Metallographic analysis. Section No. 1 – Slag inclusions are observed, gray in colour, of different shape, size and orientation (Fig. 2), [3].

In the middle of the section, several very coarse slag inclusions are observed, which are visible even with the naked eye. Some of them have impaired integrity (micro cracks are observed in them (Fig. 2) and it cannot be said whether they were in the inclusions and were obtained during the manufacture of the sword, or during the preparation of the section). The total contamination of section No. 1

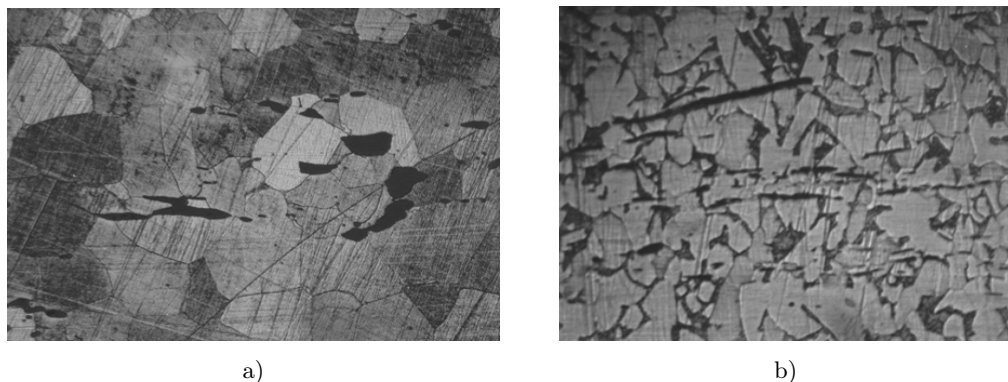


Fig. 2. a) Grouped slag inclusions $\times 100$, b) Widmanstätten structure $\times 100$

with point-shaped oxides is up to 3.0 points, oxides in rows – 1.0 points on scale A and 1.0 points on scale B. The determination of the structure is based on BDS EN 3326:1975/Amendment 1:1985 Steel – Metallographic method for determining non-metallic inclusions.

The examined structure is ferrite-pearlitic with a uniform distribution of ferrite and pearlite, without pronounced striation. In some areas of the surface, a ferrite structure with a larger pearlite grain size (2.3 points according to BDS 11174:1982/BDS EN ISO 2624:1997/Methods for determining grain size) shown in Fig. 3 is often observed, while in the middle of the section the ferrite grain is smaller.

In a small area of the surface, a Widmanstätten structure up to 2.0 points according to scale A of the above-mentioned standard is also observed, shown in Fig. 2b.

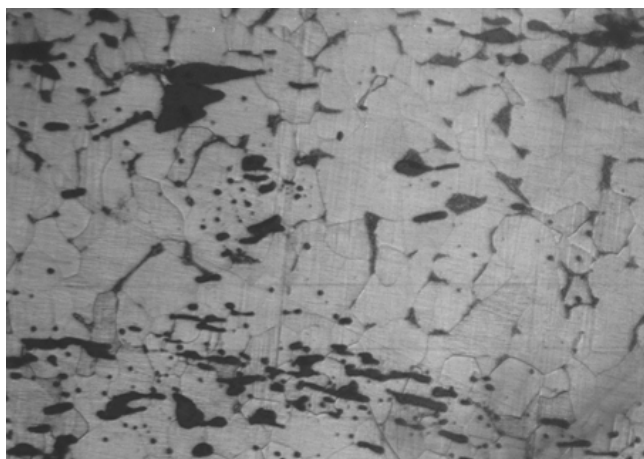


Fig. 3. Longitudinal drawn non-metallic inclusions $\times 100$

This type of structure is like that of meteorites, for which there are numerous analyses and publications.

Section No 2 – Non-metallic inclusions and slag inclusions of the same nature are present, but here the rows of strongly elongated slag and other inclusions are in greater quantity and smaller, which is evidence of the presence of deformations (Fig. 3) [3].

Dotted oxides are observed – 4.0 points in volume and 3.0 points in rows on scale A and 2.0 points on scale B in total.

SEM analysis – micrograph 1 – Fig. 4a, and SEM analysis – Fig. 4b.

The Widmanstätten structure is clearly outlined.

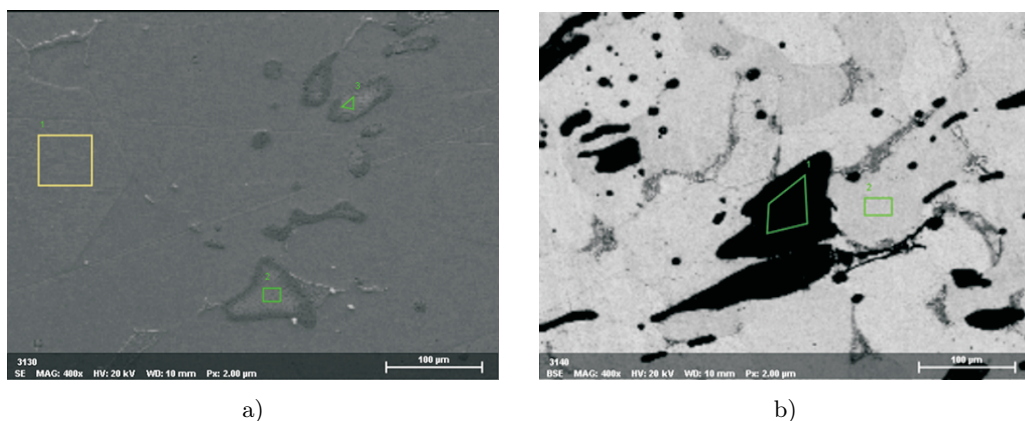


Fig. 4. a) 1 – Area with ferrite – about 90%; 2 – Probable ferrosilicates Fe-Si-Ca and traces of Al and K; 3 – Area with predominant Si; b) In zone 1, silicate lichen is definitely established, while in zone 2 almost pure Fe predominates

Conclusions.

1. In the area of the sword handle, coarse slag inclusions are observed, as well as microcracks. The slag inclusions are parallel to the forging direction.

2. The total contamination of section No. 1 with point oxides is up to 3.0 points on scale B (BDS ISO 3326:1975 Steel. Metallographic method for determining non-metallic inclusions/Amendment 1:1985).

3. The structure of section 1 is ferrite-pearlitic with a uniform distribution of ferrite and pearlite, without pronounced striation.

4. In small areas of the surface, a Widmanstätten structure is also observed up to 2.0 points on scale A of the above-mentioned standard.

5. For section No. 2, the non-metallic and slag inclusions present are of the same nature as for section No. 1, but the rows are strongly elongated in the longitudinal direction, which is evidence of the presence of deformations.

6. In both sections, a larger ferrite grain is observed on the surface compared to the middle of the specimen.

7. In section No. 2, a clearly expressed ferrite structure is observed in the area of the blade.

8. For section No. 3, there is granular pearlite on the surface, and in the middle, granular lamellar pearlite, with the granular one having a smaller grain than that on the surface.

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