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MAIL OF ST. WENCESLAUS – METALLOGRAPHY OF RINGS

Abstract:

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Metallographic examination of three rings from the collar of the St. Wenceslaus mail was performed at the former Institute of Archaeology of the Czechoslovak Academy of Sciences in Prague in 1974. Unfortunately, the rings are those which fell off the mail collar during restoration work and therefore we cannot define more accurately the original location of the rings. The results obtained show that the rings were made of heterogeneous iron, and can be from the perspective of metallurgical quality considered common.

Key words: St. Wenceslaus – mail – metallography – archaeometallurgy – Bohemia

Introduction

In 1974, when St. Wenceslaus mail was subjected to the restoration treatment, an opportunity was taken to examine metallographically three rings coming from the mail collar. As suggested by the recent investigation of the mail (see Bravermanová 2010), the collar might have been composed of two individual parts; the first part (those which bears the golden rings, see Fig.5:a) seems to be the late 10th c. piece, whilst the second (see Fig. 5:b) was most likely associated with the mail later, perhaps sometime in the course of the 13th c. or even later. The mail coat itself, however, might have been contemporary with the St. Wenceslaus. Unfortunately there is no possibility to define more accurately the original location of the rings examined as these rings are those which fell off the collar when it was being handled.

Metallographic examination

The rings were investigated in standard way, i.e. they were mounted in resin, ground, polished and observed in both unetched and etched state. Heyn and Nital reagents were used to determine metallographic structures and distribution of carbon, Jernkontoret standard was used to assess the purity of the metal. Hardness was measured according to Vickers method in all the structures using a Hanemann microhardness device with 30 g and 10 g load. Because the original metallographic report, including all the photodocumentation, was lost during the flood that struck the Institute of Archaeology in Prague in 2002, the metallographic structures of the rings were newly documented in 2007 using an Olympus BX-60 microscope with digital image recording by an Olympus CAMEDIA 5050 digital camera.

Ring No. 491

A well conserved ring without a visible riveted joint; the diameter of the ring is 6 mm and the wire diameter is 0.75 mm. The shape of the ring that remains suggests that a rivet was originally present.

Metallographic description

In the unetched state surface corrosion of the ring can be observed on the specimen, and a few small corroded areas occur also in the metallic core. Elongated silica-based inclusions are arranged into lines in two rows running through the specimen. According to the Jernkontoret standard, the quantity of non-metallic inclusions corresponds to 2-3, in places 3-4, i.e. the metal is of medium to lower purity, in terms of inclusions. The predominant inclusions are elongated and rather coarse, consisting of a dark greyish silica-based single phase, sometimes with blackish areas associated.

In the etched state, a narrow band of ferritic microstructure with coarse grains of grain-size ASTM 6-7 appears in the outer border of the ring. The microstructure that prevails is fine ferrite with partly globularised pearlite scattered within the ferritic grains of grain-size ASTM 11-12. A narrow

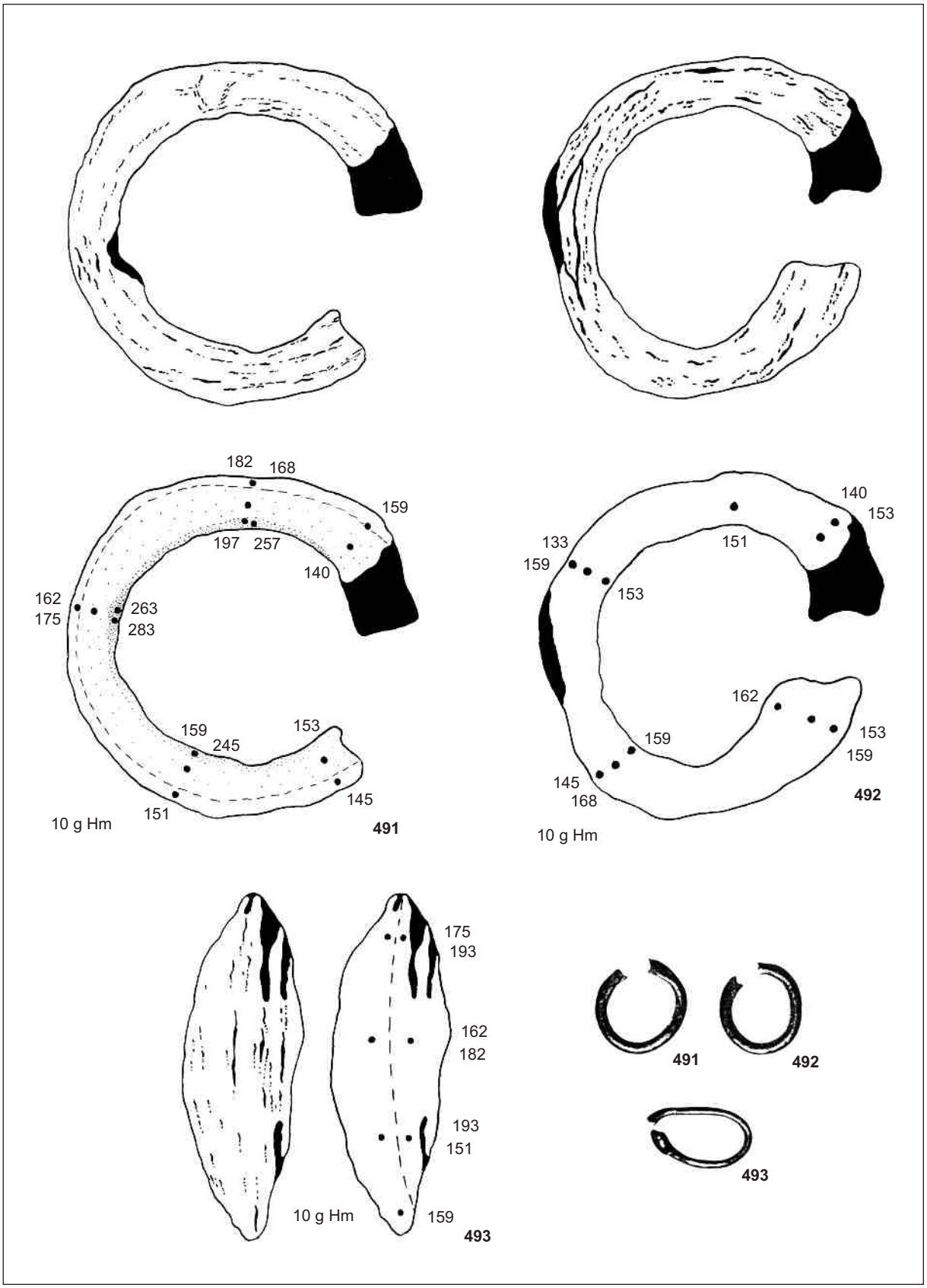

Fig. 1. The so-called mail of St. Wenceslaus. Sketches of metallographic specimens of rings Nos. 491, 492 and 493, in both unetched and etched conditions (etched with Nital, numerical values indicate the microhardness measured). *Drawing by R. Pleiner*.

Ryc. 1. Kolczuga św. Wacława. Szkice metalograficzne ogniw nr 491, 492 i 493 w dwóch stanach – wytrawionym i niewytrawionym (wytrawione nitalem, wartości numeryczne oznaczają pomiar mikrotwardości). *Rys. R. Pleiner.*

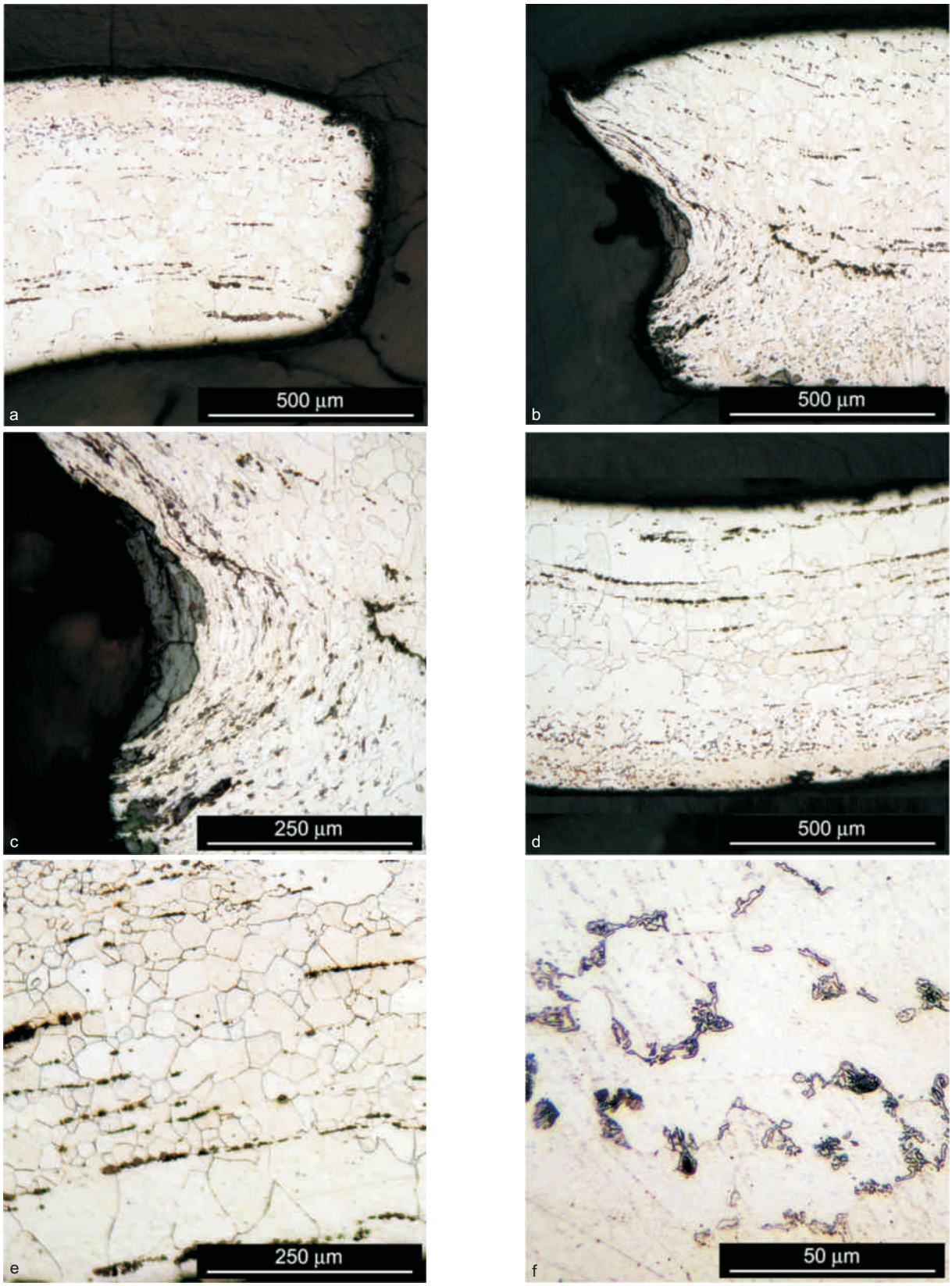

Fig. 2. The so-called mail of St. Wenceslaus. Ring No. 491: a – microstructure at the break in the ring on the left side of the drawing in Fig. 1; b – structure in the right side of the break; c – ditto, detail of the deformed grains of ferrite – the shape suggests that a rivet is missing; d – structure in the central part of the link; e – both fine and coarse grains of ferrite; f – traces of pearlite on boundaries of the ferrite grains. Etched with Nital. *Photomicrographs by J. Hošek.*

Ryc. 2. Kolczuga św. Wacława. Ogniwo nr 491: a – struktura na lewym złamaniu ogniwa, z lewej strony rysunku na ryc. 1; b – struktura na prawym złamaniu ogniwa; c – j.w., detal zniekształconych ziaren ferrytu – kształt sugeruje brak nita; d – struktura w centralnej części ogniwa; e – drobno i gruboziarniste ziarna ferrytu; f – ślady perlitu na granicach ziaren ferrytu. Wytrawione nitalem. *Mikrofot. J. Hošek.*

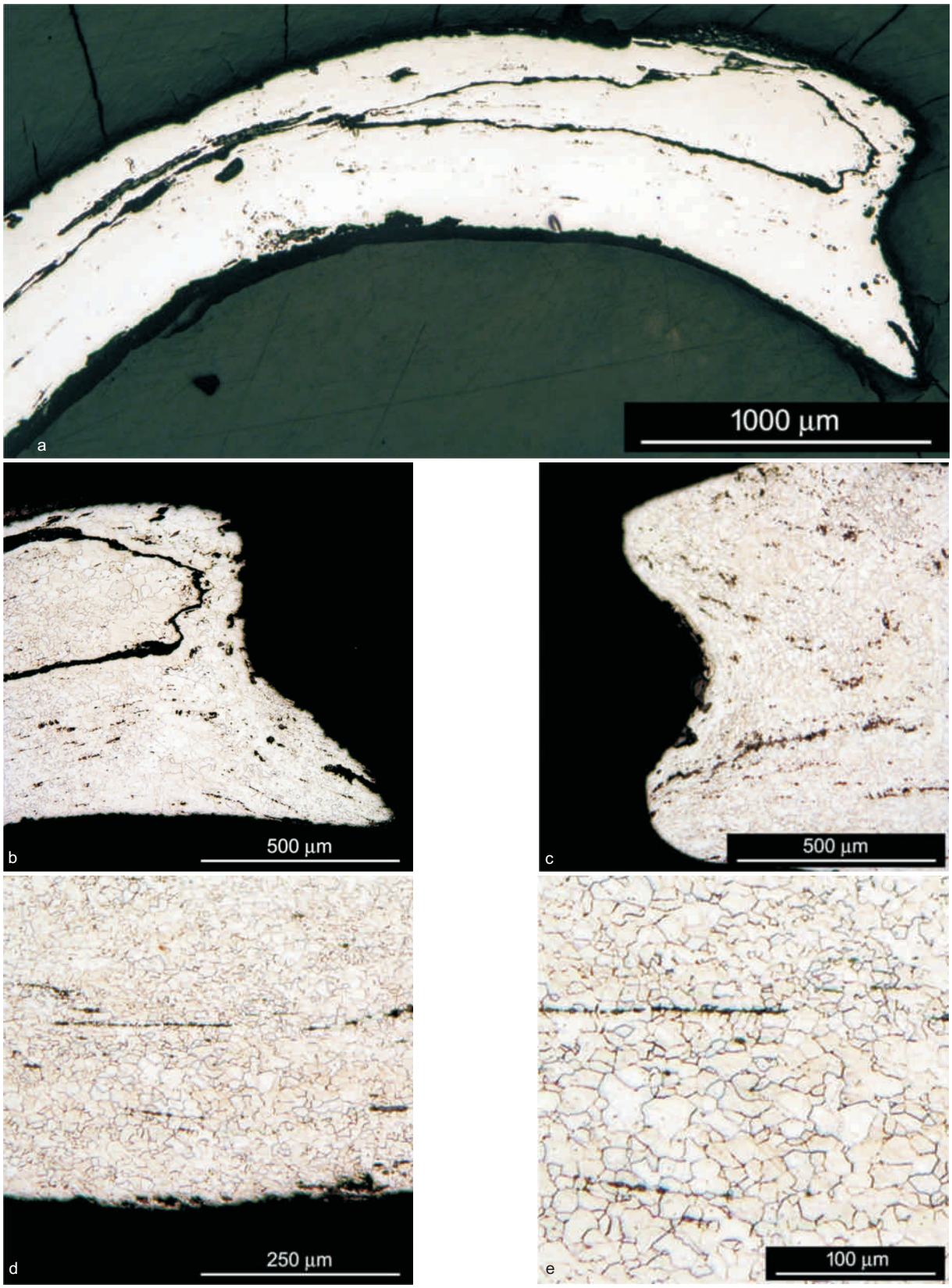

Fig. 3. The so-called mail of St. Wenceslaus. Ring No. 492; a – the left side (according to the drawing in Fig. 1) of the break in the link, in unetched condition; b – the left side of the break with a ferritic microstructure; c – the right side of the break with a ferritic microstructure (the shape of the break in b and c suggests that a rivet is missing); d – ferrite in the central part of the ring; e – ditto. Etched with Nital. *Photomicrographs by J. Hošek.*

Ryc. 3. Kolczuga św. Wacława. Ogniwo nr 492: a – lewa strona (wg rysunku na ryc. 1) na złamaniu ogniwa w niewytrawionym stanie; b – struktura ferrytyczna w lewym złamaniu ogniwa; c – struktura ferrytyczna w prawym złamaniu ogniwa; d – ferryt w centralnej części ogniwa; e – j.w. Wytrawione nitalem. *Mikrofot. J. Hošek.*

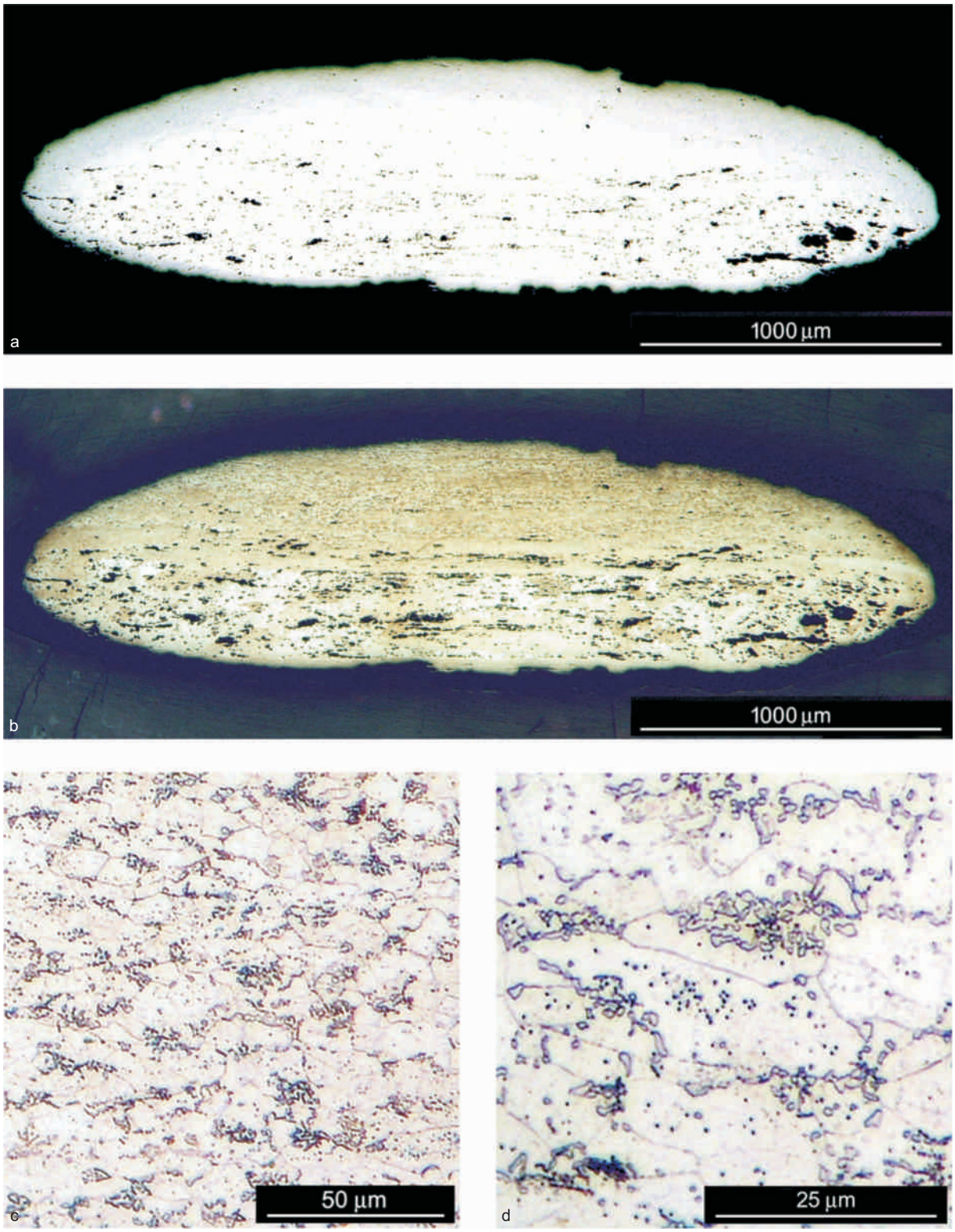

Fig. 4. The so-called mail of St. Wenceslaus. Ring No. 493 after repolishing in 2004: a – unetched condition; b – after etching by Oberhoffer reagent, c-d – ferritic-pearlitic structure that occur on one of the sides of the specimen (on the upper side according to a and b). Etched with Nital. *Photomicrographs by J. Hošek*.

Ryc. 4. Kolczuga św. Wacława. Ogniwo nr 493 po polerowaniu w 2004 r.: a – w stanie niewytrawionym; b – po wytrawieniu reagentem Oberhoffera; c-d – ferrytyczno-perlityczna struktura występująca na jednej stronie okazu (wg a i b na górnej stronie). Wytrawione nitalem. *Mikrofot. J. Hošek.*

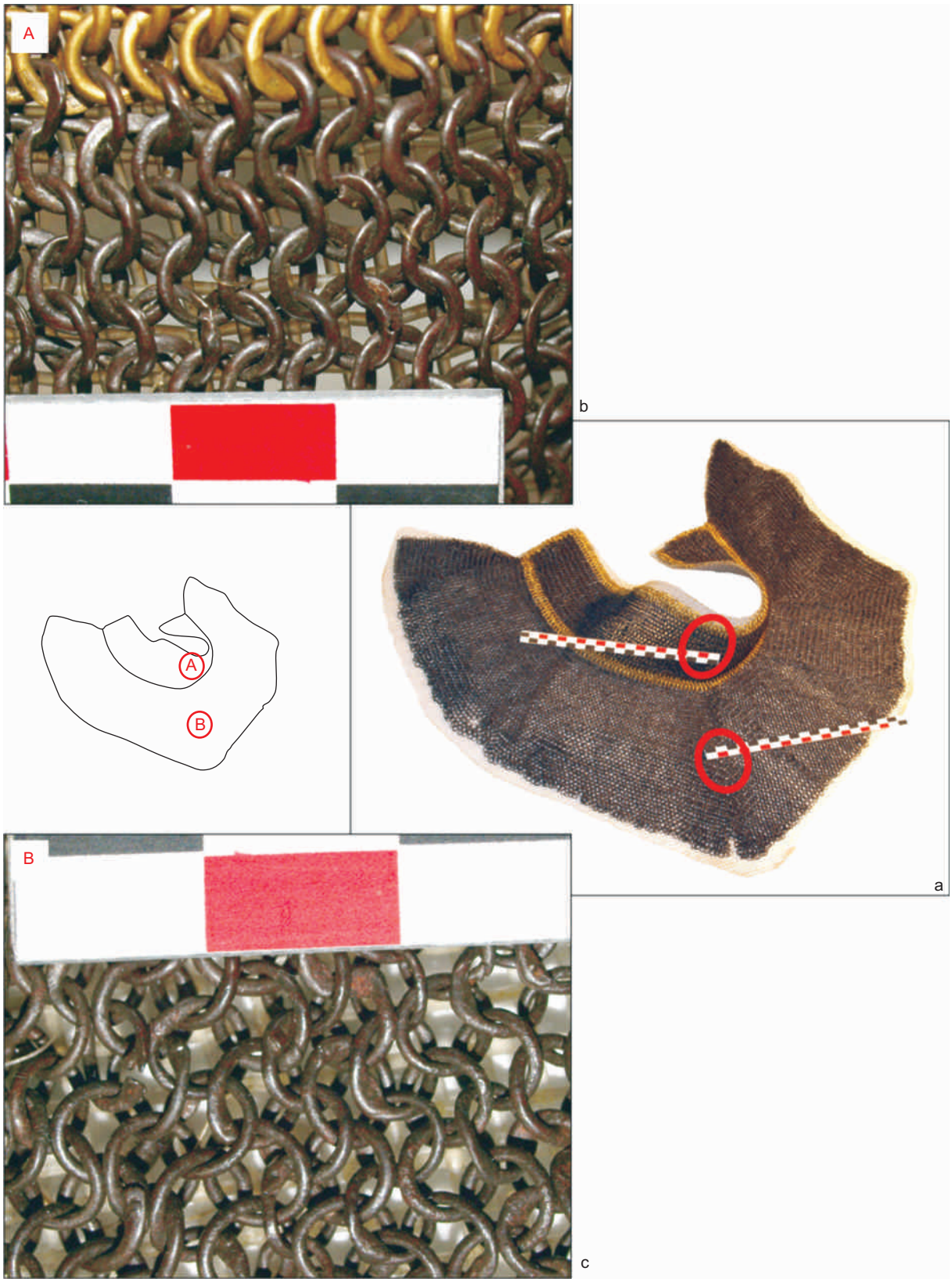

Fig. 5. The so-called mail of St. Wenceslaus: a – the mail collar indicating the positions of documented areas; b-c – examples of the mail where rings having an outer diameter of 7 mm and without riveted joints occur (rings of the same size and construction were examined metallographically). *Photo by J. Hošek.*

Ryc. 5. Kolczuga św. Wacława: a – kołnierz kolczy z lokalizacją zadokumentowanych miejsc; b-c – przykłady lamówki kolczugi, gdzie ogniwa mają średnicę zewnętrzną powyżej 7 mm i nie posiadają nitów. Ogniwa o tym samym rozmiarze i konstrukcji zostały przebadane metalograficznie. *Fot. J. Hošek.*

band of globularised pearlite is located by the inner border of the ring.

The hardness of the ferrite is 159±13 HV0.03 and the hardness of the pearlite is 249±32 HV0.03.

Ring No. 492

A well conserved ring without a visible riveted joint; the diameter of the ring is 6 mm and the wire diameter is 0.75 mm. The shape of the ring that remains suggests that a rivet was originally present.

Metallographic description

In the unetched state the specimen is characterised by a layer of surface corrosion in the ring. In several places, the corrosion has propagated into the metallic core and filled cracks. The quantity of non-metallic inclusions corresponds to 2-3 on the Jernkontoret standard; hence the metal is of medium purity. Silica-based inclusions are elongated and are both coarse and fine. Single-phase inclusions are of dark colour. Multiphase inclusions contain lighter crystalline phases.

The etched specimen consists of inhomogeneous, ferritic, slightly banded microstructure of grain-size ASTM 10-12. Ferrite with nearly invisible grain-boundaries also appears in some places.

Hardness of the metal is 151±12 HV0.01.

Ring No. 493

A well conserved ring with a riveted joint as shown on the drawing (Fig. 1); the diameter of the ring is 6 mm and the wire diameter is 0.75 mm.

Metallographic description

The unetched specimen reveals a thin layer of surface corrosion and corrosion cracks which have propagated into the metallic core. Lines of elongated inclusions occur in several rows. The quantity of inclusions corresponds to 2-3, in places 3-4, on the Jernkontoret standard; hence the metal is of medium purity. The inclusions are elongated silica-based and mostly multi phase. They are of grey colour with lighter crystalline phases and sometimes with blackish areas associated.

The etched specimen may be divided into two halves longitudinally. The right half consists of a ferritic microstructure of grain size ASTM 7-8. The left half of the specimen reveals very fine grained ferritic microstructure with traces of pearlite at the grain boundaries; the grain size is ASTM 11-12.

Hardness of the pearlite is 170±16 HV0.01.

Conclusion

As evidenced by metallographic examination, the rings from the St Wenceslaus mail collar were made of rather heterogeneous iron wire. The prevailing microstructure is ferrite, with scattered particles locally of globularized cementite. The average hardness of the ferrite in all the three rings is 159±15 mHV. The hardness of the globularized pearlite in the ring No.491 is 249±32 HV0.03. The average hardness measured across the ferrite and pearlite is 177 ± 42 mHV. The measured hardness of the ferrite differs somewhat between rings Nos.492 and 493; otherwise the hardness of ferrite is similar.

We can conclude that within our current state of knowledge about the production techniques of medieval mail, the metallographic investigation shows a commonplace material, i.e. both wire and rings were made by those methods usual in the Middle Ages (see Ustohal, Stránský 1988; Půpala et al. 1998; Edge 2001; Pleiner 2002; Hošek 2003, 174-184; Ustohal 2003).

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KOLCZUGA ŚW. WACŁAWA – BADANIA METALOGRAFICZNE OGNIW

Streszczenie

W 1974 r., kiedy kolczuga św. Wacława (należąca do skarbu przechowywanego w Katedrze św. Wita w Pradze) poddawana była zabiegom konserwatorskim, nadarzyła się okazja do przeprowadzenia badań metalograficznych trzech ogniw pochodzących z kołnierza. Jak zostało zasugerowane w najnowszych publikacjach (por. Bravermanová 2010), mógł się on składać z dwóch osobnych części: pierwsza, zawierająca złote ogniwa (ryc. 5:A), wydaje się pochodzić ze schyłku X w., ale druga (ryc. 5:B) została prawdopodobnie dołączona do kolczugi w późniejszym czasie, możliwe że w XIII w. lub nawet później. Sama kolczuga jednakże może pochodzić z czasów św. Wacława (urodzony najprawdopodobniej w 907 r. i zamordowany w 935 r.). Niestety, nie ma możliwości, by dokładniej określić miejsce pobrania ogniw do badań, jako że są to pierścienie, które wypadły w trakcie zabiegów konserwatorskich.

Badania metalograficzne dowiodły, że ogniwa z kołnierza kolczugi św. Wacława wykonano raczej z heterogenicznego drutu żelaznego. Dominującą mikrostrukturą jest ferryt z lokalnie rozrzuconymi cząsteczkami sferoidalnego cementytu. Wywnioskować można, biorąc pod uwagę dzisiejszy stan naszej wiedzy na temat technik produkcji średniowiecznych pancerzy kolczych, że badania metalograficzne ukazują nam pospolity materiał – tzn. zarówno drut, jak i pierścienie wykonano metodami powszechnymi w okresie średniowiecza.

Tłumaczenie: Arkadiusz Michalak