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A 13th-CENTURY KETTLEHAT FROM KODASOO, ESTONIA

UN CASCO DE TIPO KETTLEHAT O CHAPEL-DE-FER DEL S. XIII PROCEDENTE DE KODASOO, ESTONIA

POR

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Abstract - Resumen

The oldest surviving helmet from Estonia is a 13th-century kettlehat found near village of Kodasoo in northern Estonia. Three samples from different parts of the kettlehat were investigated in a metallographic study. The raw material of the Kodasoo kettlehat was a slag-rich iron of heterogeneous carbon content. It was improved by folding and forge-welding it at least three times, resulting in layered structure with more uniformly distributed carbon content.

El casco más antiguo encontrado en Estonia es un *«chapel de fer»* del siglo XIII que proviene de cerca de la aldea de Kodasoo, en el Norte de Estonia. Tres muestras de diversas partes del casco fueron investigadas mediante un estudio metalográfico. El material original del casco de Kodasoo era un hierro de contenido de carbono heterogéneo y con abundantes inclusiones de escoria. Se intentó mejorar su calidad mediante forja, doblándolo y soldándolo a la calda por lo menos tres veces, dando como resultado una estructura estratificada, con el contenido de carbono distribuido más uniformemente.

Keywords - Palabras Clave

Helmet; Mediaeval; Kettlehat; Metallography; EDS analysis.

Casco; Medieval; *Chapel de fer*; Metalografía; EDS análisis.

INTRODUCTION

Archaeological finds of mediaeval armour from Estonia are scarce and among them, there are only few mediaeval helmets. This article focuses on the helmet preserved in Estonian History Museum – a kettlehat of a peculiar construction (fig. 1, Estonian History Museum AM 12628 R 850).

An «old helmet with a brim» was brought to Estonian History Museum (then Museum of Estonian Learned Society) by a local landowner Ferdinand Karl Ernst von Rehbinder in 1869. According to the catalog entry, the helmet was «*auf einem Felde aufgefunden*» – found in the field near the Kodasoo village in the Harjumaa district of Northern Estonia (von Hansen 1875, X-13, Taf. VIII-1). That is regrettably all that is known about the circumstances of this find.

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Figure 1. Kettlehat from Kodasoo, Estonia (Estonian History Museum AM 12628 R 850, photo by V. Lohmus).

DESCRIPTION

The most distinctive and somewhat unusual feature of the Kodasoo kettlehat is the method of its construction – the kettlehat is composed of four pieces, which are joined by riveting. The thickness of the plates varies from 2,2–1,8 mm on the crest and brim to a meager 0,75 mm on the side-plates. The kettlehat weighs in its current state only 870 g, the losses due to the corrosion and mechanical damage should not exceed 15 %, giving the total original weight somewhere near 1 kg.

The brim of the kettlehat is riveted to the bowl and projects at the right angle from the sides of the bowl. The bowl is round, somewhat oval in cross-section. It is assembled from a wide crest-plate and two oval side-plates. Narrow triangular reinforcement-bands descend from the sides of the crest-plate and cover the side-plates (one considerably damaged). On top of the helmet there is a small raised decorative knob in the center of the bowl. On the one side of the helmet, riveted to the underside of the brim, there is a rectangular loop, which seems to have held a chinstrap. The loop on the opposite side of the brim is missing, but its original position is indicated by two corresponding holes on the opposite side of the brim. On both front and the back of the brim, near to the bowl of the kettlehat, there are pairs of smaller holes of 1 mm diameter, which are probably meant for securing the padding. All 26 rivets joining the plates are headless, with the exception of one on the lower part of the bowl, which seems to point to a later repair. The kettlehat is fairly small and taking in account the padding, would fit a head with 54-55 cm circumference.

DATING

Kettlehats – simple round helmets with a brim – were used widely by European warriors, both common and knightly, since the early 13th century (Müller 1971, 28–29). As opposed to the abundance of the depictions in contemporary artworks, the preserved examples are few, especially of the type analogous with the Kodasoo kettlehat. Four more or less completely preserved kettlehats and the fragments of one have been found in Norway. An article about Norwegian mediaeval kettlehats was published by Gjutorm Gjessing in 1942, which remains the only study on the topic until today (Gjessing 1942).

The kettlehats found in Ringsaker, Skiptvet and Eiker (fig. 2) present all the same basic construction method also observed on the Kodasoo kettlehat. Gjessing dates those ketTlehats tentatively «*around 1300*», basing the date on depictions in contemporary artworks (Gjessing 1942, 88).

Figure 2. Kettlehats from Norway: Ringsaker, Hedemark county (*left*), Skiptvet, Østfold county (*middle*) and Eiker, Buskerud county (*right*) (Gjessing 1942, Pl. VIII, 2-4).

Gjessing's dating of the Norwegian kettlehats seems a bit too conservative in the light of the illustrations of the widely-known so-called Maciejowski Bible (this iconographical source seems not have been known to Gjessing at the time of the writing). Maciejowski Bible, which is believed to be completed around 1250, depicts among its vivid and detailed battle-scenes numerous warriors, both mounted and on foot, wearing riveted kettlehats (Cockerell et al. 1969, f10r, f27v). Both narrow- and wide-brimmed riveted kettlehats are depicted (fig. 3). Thus, the possibility of the earlier date for both Norwegian and Kodasoo kettlehats should not be excluded – as long as no new information is discovered, a more general date of 13th century would seem preferable.

Figure 3. Footsoldiers wearing kettlehats. Maciejowski Bible, around 1250. (Cockerell et al. 1969, drawing by J. Ratas).

PROVENANCE

As for the question of the provenance of the Kodasoo kettlehat, the possibility of the local, Estonian origin can be most likely to be discarded without much further notice. The fact that the Estonian pagan warriors of the early 13th century lacked armour and helmets more often than not, is repeatedly stressed in the Chronicle of the Henry of Livonia: «*Estones... qui non habent consuetudinem armorum in tantum quantum alie gentes*» (HCL XV:3). Northern Estonia was invaded 1219 by the Danish crusading army and remained in the domain of the Danish King as a Duchy of Estonia until mid-14th century. Thus, the Kodasoo kettlehat might have belonged to a Danish warrior who took part either in the initial invasion, or belonged to the occupation force later. The connection with Norway, indicated by the surviving examples, seems also plausible in the light of recent research: the metallographic study of the medieval iron artifacts found in Denmark indicates that a lion's share of iron, both finished products and raw material, was imported from Norway (Buchwald 2005, 294).

METALLOGRAPHIC EXAMINATION

Metallography has become an extremely important field of study in the research in mediaeval arms and armour, giving astonishing amounts of information of entirely new type: on the quality of the materials used and the production processes involved (for comprehensive overview Williams 2003). The study in this field is still in its primal stages in Estonia – only one suit of late mediaeval armour has been examined by Finnish researcher Lasse Mattila (Mattila 1998).

Three specimens for metallographic study were taken from the kettlehat: from the brim, from the crest-plate and from one of the side-plates (fig. 4).[1]

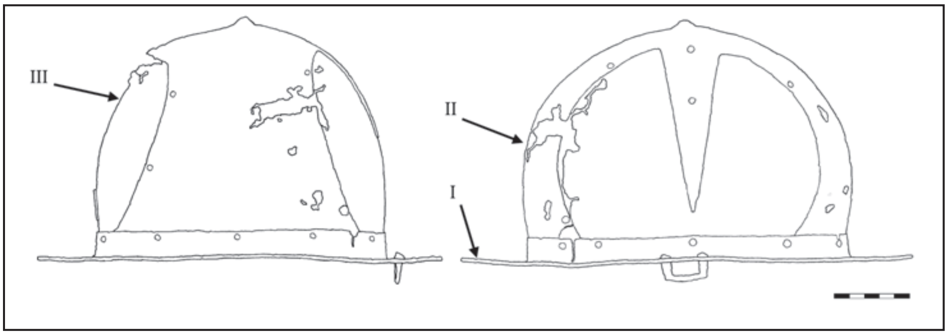

Figure 4. Placement of the metallographic samples taken from Kodasoo kettlehat.

Sample I was taken from the brim of the kettlehat. The material was heterogeneous, with a layered structure. Although admittedly with some difficulty, somewhere around 8 or more layers could be distinguished, mainly judging by the «bands» of slightly different carbon content, grain size and elongated slag incursions between layers. The carbon content of the sample was low (0-0,01 % C) and the material was identified as layered iron (ferrite) with very low carbon content (fig. 5, above).

Sample II was taken from the crest-plate of the helmet. The material was heterogeneous, with a layered structure, and seemed also to be consisting of at least 8 layers. Elongated slag incursions were observed. The carbon content of the layers varied: on the inner side of the helmet the layers had 0,5–0,7 % C content, in the middle part 0,3–0,5 % and on the outer side 0,1 % C. The material was identified as a layered composite structure, consisting of the layers of low to medium carbon steel and iron (fig. 5, middle).

Sample III was taken from the side-plate of the bowl and presented a so-called banded structure, which is encountered fairly often in the metallographic samples taken from the mediaeval armour (Williams 2003, 375, 385, 393, 476, 488, 618). Probably due to the higher deformation level compared to the other details (thickness of the side-plates 0,75 mm as opposed to 2,1–2,2 mm on crest and brim) no boundaries between different layers and no slag incursions were visible at the same level of the magnification. Three bands or «zones» were identified, differentiated according to the carbon content: the layer on the inner side of the helmet consisted of ferrite with 0–0,1 % C, the layer in the middle part consisted of ferrite-pearlite mix of 0,2–0,5 % C and the layer on the outer part again ferrite with 0–0,1 % C. The material was identified as a layered or banded structure consisting of a layer of low to medium carbon steel sandwiched between two layers of soft iron, where due to the high level of deformation, the boundaries between layers had welded completely (fig. 5, below).

General observation of the microstructures indicated, that the areas showing higher carbon content presented only pearlite. No martensite was found, indicating, that the final heat treatment of the kettlehat was not quenching but some form of slow cooling.

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[1] Samples were prepared and analyzed at the Institute of the Materials of the Tallinn University of Technology. Samples were etched with a 3% HNO_3 solution (Nital) and examined with the microscope Axiovert 25 (Zeiss).

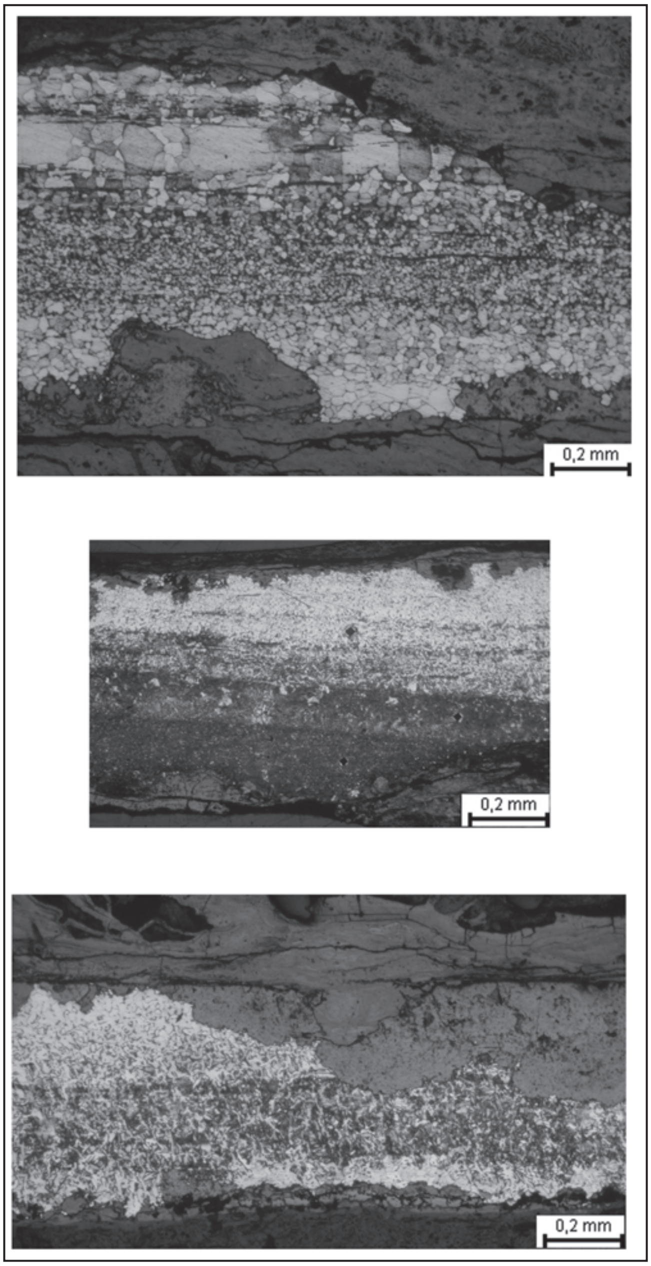

Figure. 5 Microstructures of the metallographic samples from the Kodasoo kettlehat: Sample I – layered ferrite (*above*), Sample II – layered structure consisting of pearlite and ferrite (*middle*) and Sample III – banded structure, band of pearlite and ferrite mix sandwiched between two layers of ferrite (*below*). Arrows indicate possible boundaries of layers resulted from repeated folding and welding.

Measured hardness of the ferritic areas (iron) gave as a result 120-180 VPH (*Vickers Pyramid Hardness*) and pearlitic areas (steel) 180-240 VPH.[2] The measurements were consistent with the visual examination of the samples, confirming the material being in annealed state (not hardened by quenching).

Also, no signs of extensive cold-working – cold-shuts, elongated grains and cracks – were discovered in the samples. As in case of the higher degree of deformation in Sample III, the formation of the banded structure was believed to be the result of the complete welding of the homogeneous layered structure. Therefore, it was concluded that the hot-work on the kettlehat was performed in the completely austenitized state – at least 730-900º C and higher – and that the amount of the cold-work was either insignificant or that the effects of it were negated by regular annealing.

SLAG INCURSIONS

Examination with a scanning electron microscope (EDS) revealed, that the slag incursions in the samples contained traces of aluminium (Al), potassium (K), calcium (Ca) and manganese (Mn), last being the most prominent (fig. 6).[3] High manganese levels indicate Scandinavia as a possible origin for the iron used in making the kettlehat (Buchwald 2005, 302-330) and seem to exclude Estonia,

2 Hardness-testing was performed at the Institute of the Materials of the Tallinn University of Technology with the Mikromet 2000 (Buhler) microhardness-meter using loads from 0,1 to 0,3 kg.

3 EDS-analysis was performed at the Institute of the Materials of the Tallinn University of Technology with the scanning electron microscope JSM-840A (JEOL) and EDS chemical analysis device AN10000 (Link Analytical).

as the local limonite ores and analyzed slags from archaeological sites show only microscopic traces of manganese (Peets 2003, 34, 45).

TECHNOLOGICAL PROCESS

The data obtained from the metallographical study of the samples allowed forming some hypotheses about the technologies used in making of the kettlehat from Kodasoo.

RAW MATERIAL

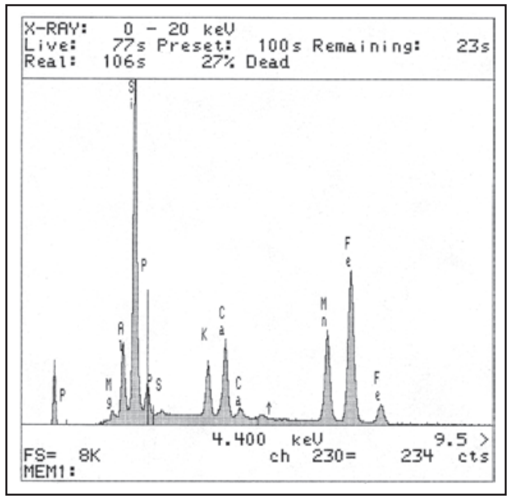

Figure. 6 EDS-analysis of the slag incursion in Sample II.

The iron used in making the kettlehat was probably produced by the method of the direct reduction in the bloomery furnace – a standard method for iron production in medieval period (Tylecote 1992, 75-76). Although the date of the kettlehat and probable Scandinavian origin (see above) allows also for some probability, that the iron may have been produced by indirect reduction in primitive finery, the almost overall accepted date for the introduction of the blast furnace in Sweden being late 12th century (Buchwald 2005, 336; Tylecote 1992, 76), a reliable method for differentiating between bloomery and finery product is yet to be discovered (Williams 2003, 891; Buchwald 2005, 338-339).

It is commonly acknowledged, that both in bloomery furnace and finery there was very little chance of producing iron or steel of homogeneous carbon content. Due to this, the iron from bloomeries and fineries was subjugated to repeated forging, folding and forge-welding. The process attempted to achieve more uniform hardness in metal by mechanical mixing and also breaking up the slag particles. The practice was common until the invention of the method of producing homogeneous steel and iron by Henry Bessemer in mid-19th century (Tylecote 1992, 164-165). Following passage from the early 19th century knifesmith's handbook describes the practice quite well:

> *«All described methods (of steel production) are imperfect and unreliable. Very seldom a steel of uniform composition and elasticity is obtained. Therefore, it must be refined before use, by which it will obtain more uniform consistence of the body. The raw iron is forged to square bars of 20-24 inches in length and 15-18 lines of thickness, thrown into cold water while red-hot and afterwards tied into bundles. Great care is exercised in composing the bundles and usually harder bar alternates with the softer one, and experienced smiths can tell the grade of hardness by observing the surface of the break alone... The bundles will be heated to the white glow, covered in powdered clay and brought to the anvil between great tongs. The powdered clay will protect the bundle from the atmospheric air, lest the carbon contained in steel will burn out. The bundles will be hammer-welded or rolled to bars of 18-20 lines of thickness, cut into pieces, welded again and stretched out again. This operation will be performed two, three and sometimes four times, but the better the quality of the original steel, the less is needed.» (translated by author, Landrin 1836, 51-52)*

Thus, the layered structures presenting wildly different carbon content (0,01–0,7 %, from soft iron to medium-carbon steel), observed in the metallographic samples are most probably the result of above-described process – a piece of iron of heterogeneous carbon content was stretched by forging, then folded and hammer-welded repeatedly. As there were at least 8 different layers visible in Samples I and II, the process must have been repeated at least 3 times. Such «banded» structures seem to occur quite often in samples taken from medieval armour (Williams 2003, 375, 385, 393, 476, 488, 618).

FORGING: HOT AND COLD WORK

The microstructures of the samples taken from the different parts of the kettlehat demonstrated uniformly distributed layers running almost parallel to the surfaces. This seemed to indicate, that the details of the kettlehat have been not forged from bars or lumps of iron, which would have caused at least some shifting and irregular distribution of the layers, but that the supposed «refined» iron was first worked into sheet not much thicker than the thickest parts of the kettlehat (2–2,5 mm). The blanks for the details of the kettlehat would have been then cut from the sheet metal with the help of patterns, and then shaped by forging, demanding less skill from the workmen and giving also probably some economy in fuel, compared to the forging from the piece of iron. This method would also explain the surprisingly uniform style of construction of the extant kettlehats (figs. 1 and 2). The unavoidable sheet metal scrap produced this way would not have been lost, but could have been, for example, easily used for making coats of plates.

From the lack of cold-shuts and delaminations in the metallographic samples was concluded, that at least the rough forming of the details of the kettlehat has been done in hot work. In addition to this, the areas of higher carbon content in the material of the kettlehat (up to 0,7%) would probably have not withstood extensive cold-working. Still, as some cold-work in finishing and assembling would have been necessary, it was assumed, that it was interrupted with frequent annealing.

HEAT TREATMENT

The reason for the medieval armourer who made the Kodasoo kettlehat, to avoid hardening by quenching may lay in the heterogeneous composition of the metal used. In quenching, steel tends to increase in volume and soft iron does not. So, quench-hardening of the Kodasoo kettlehat would probably have resulted in added structural stress, causing deformations and cracks. The danger of such failure was much greater as compared to modern homogeneous steels, if we consider the slag incursions present in the metal – mainly silicon oxide (SiO2), which is glass-like and brittle substance. This problem seems have been occurred often enough in pre-Bessemer era:

> *«As experienced and knowledgeable a bladesmith is, accidents and mistakes can not be avoided... Often also the most skilled smith, who is known to be able to quench 20 blades one after another with no mishap, is on other occasion not able to take even 1 blade of 20 out of the water whole or undeformed.» (translated by author, Landrin 1836; 205).*

CONCLUSION

The metallographic study of the oldest surviving helmet from Estonia allowed the following reconstruction of the technological process: the raw material used for the Kodasoo kettlehat was slag-rich iron of heterogeneous carbon content produced either in direct reduction furnace or in a primitive finery. It was additionally stretched, folded and forge-welded at least three times, resulting in a layered structure with the more uniformly distributed carbon content. The resulting piece was then forged into a sheet and the details of the kettlehat cut from it. The main shaping of the details of the kettlehat was probably done in hot work: no cold shuts or laminations typical for cold working were observed in samples. Although cold work in some extent, probably in finishing stages, can also not be ruled out. After the assembly the kettlehat was annealed, probably to relieve the stresses caused by cold working of the details in finishing stage. Also the fear of possible deformations during quench-hardening may have been the reason, why annealing was preferred to the hardening.

BIBLIOGRAPHY

Buchwald, V. F. (2005): *Iron and steel in ancient times*. The Royal Danish Academy of Sciences and Letters. Historisk-filosofiske Skrifter 29. Copenhagen.

Cockerell, S. C. *et al.* (1969): *Old Testament miniatures.* New York.

Gjessing, G. (1942): *Stålhuene fra Bejarn og andre norske stålhuer framellomalderen*. Viking VI. Oslo. 75-108.

HCL : *Heinrici Chronicon Livoniae – Henriku Liivimaa Kroonika*. Tallinn 1980.

Hansen, G. von (1875): *Die Sammlungen inländischer Alterthümer und anderer auf die baltischen Provinzen bezüglichen Gegenstände des Estländischen Provinzial-Museums*. Reval.

Landrin, M. H. (1836) Die Kunst des Messerschmiedes. Übersetzt von H. Leng und C. H Schmidt. Weimar. Reprint 2000.

Mattila, L. (1998): *Komposiittihaarniska 1500-luvulta*. Muinasaja teadus 5. Tallinn. 308–320.

Müller, H. (1971): *Europäische Helme aus der Sammlungen des Museums für Deutsche Geschichte*. Militärverlag DDR.

Peets, J. (2003): *The Power of Iron*. Iron Production and Blacksmithing in Estonia and Neighbouring Areas in Prehistoric Period and the Middle Ages. – Research into Ancient Times 12. Tallinn.

Tylecote, R. F. (1992) *A History of Metallurgy*. 2nd edition. The Institute of Materials.

Williams, A. (2003) *The Knight and the Blast Furnace.* A History of the Metallurgy of Armour in the Middle Ages & the Early Modern Period. – History of Warfare 12. Leiden & Boston.

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