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Analysis of the Oldest Wool Fabric Found in Europe

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Abstract
The first part of the paper presents the historical development of looms and analyses the oldest preserved fabric samples. Emphasis is given to the analysis of woolen fabrics recently found in Bosnia and Herzegovina in the regions inhabited by Croats. The results show that the fabric is aged from 3550 to 3800 years and is the oldest woolen fabric in Europe. The characteristic of these fabrics is their specific weaving with selvedges on all four edges of the fabric.The fabric was woven from a course wool yarn of various densities in the weft direction using different weaves and weaving techniques, with a border created by weft thread at the beginning and end of weaving. This is the reason why the fabric looks embossed and compact and is easily recognisable amongst the old hand weaving in these regions.

Key words: *oldest wool fabric, vertical frame loom, horizontal frame loom, selvedge weaving.*

Introduction

In prehistoric times man used primitive tools for hunting, the construction of dwellings and the making different things. Basket making and cabin building from twigs required a certain skill of weaving to achieve strength and durability. To obtain better insulation of a space, mud twigs and leaves were used that were intertwined to obtain a solid, durable and watertight dwelling. This weaving of twigs probably preceded fabric making. Manually weaving twigs, leaves and animal hair firstly resulted in a coarse thread, and later in an increasingly thin type which was used in making a surface material for different applications. According to historical drawings, textile gradually took over the functon of fur as a light-weight, airy and comfortable cover of the human body.

Some examples indicate the very beginning of weaving before the Neolithic Age, or the Epipaleolithic Age, about 12,000 years BC. That the skill of weaving existed in the Stone Age is witnessed by archaeological findings, images, frescos, stone monuments, archival documents, bone needles and haberdasheries of stone. One of more valuable archaeological finds were stone weights for attaching warp, originating from Troy 2,500 years BC, which confirms weaving skills at that time [1 - 5].

Historical development of looms

Weaving in Croatia and Bosnia and Herzegovina dates back to the time before Croats settled in that part of the Europe in 7th century, which is supported by archaeological excavated objects used to process textile fibers, yarns and cloths. On the basis of tools found and their estimated age it can be claimed that these are tools which were used by the Illyrians, and from the 7th century the Croats continued to weave with the same raw materials, techniques and tools using their imported skills and the local skills they found [6].

It is assumed that the initial production of fabrics was done on primitive looms using previously prepared warp. On the first looms the warp had a relatively small length but was long enough for a cover or a simply cut garment. These activities were the starting point of making threads and their weaving into fabrics. In Greek mythology the weaver Arahne is mentioned, who was turned into a spider by Athena; Homer describes the decorative veils of the temple of Athena; Strabo describes China as the country of silk, etc. To weave a fabric of a certain area, it was first necessary to prepare a thread system (warp) of the same length stretched between two rollers or on one side suspended and weighted with a weight. Initially passing the weft through warp threads was done by hand and without shed formation, which made weaving more difficult and slowed it down. Shed formation accelerated and facilitated weaving at several stages in history. The first weave was plain requiring two sheds in which odd threads were drawn laterally for one shed, even ones were drawn for the other shed, and the same was further repeated. Pulling a special wooden bar dividing the warp threads in half creates the first shed, and the other is created by pulling a bar with loops through which each second warp thread is pulled; the loops are fixed to the other bar. It is assumed that it was the ancient Egyptians who created a shuttle carrying the weft through the shed, and thus speeded up weaving because a greater thread length could be wound on the bobbin which is placed in the shuttle.

The design of the loom has changed throughout history and it cannot be reliably determined whether the first loom was of the horizontal or vertical type. Horizontal looms were more accessible for working in housing, in a sitting or squatting position, often with two weavers, but they occupied more space. Vertical looms, on the other hand, take up less space and are more appropriate for weaving outside dwellings, but their height required a specific dwelling height, and the weaver usually worked in a sitting position [7 - 10].

First preserved fabrics

It is assumed that the first fabrics were made of animal fibres, such as the wool, silk and hair of domestic and wild animals, as well as seed fibres, while stem fibres (flax, hemp) came later into use. This is supported by the fact that wool,

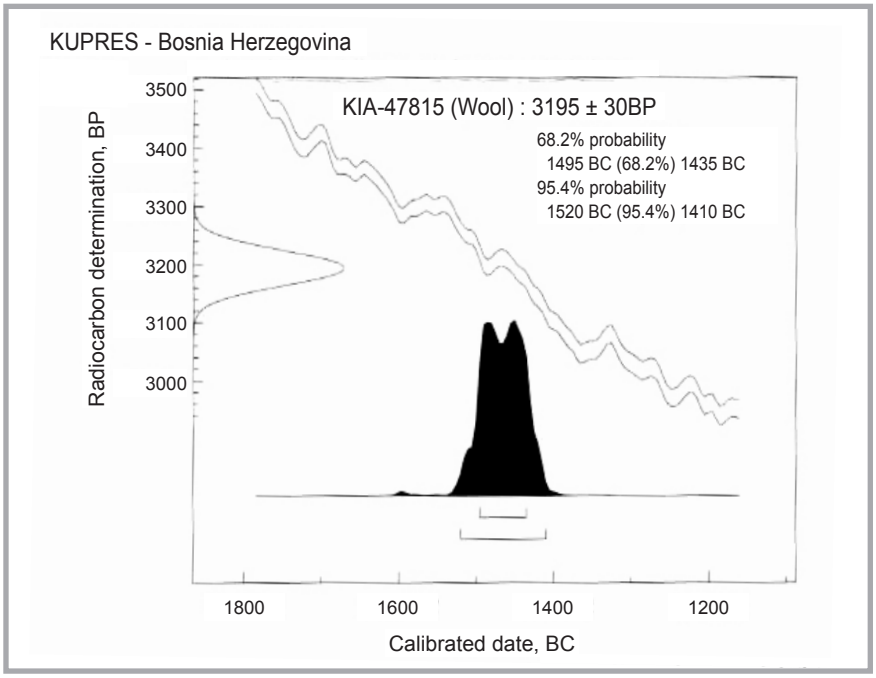

Figure 1. *Graphical presentation of the radiocarbon age determination of the fabric; Researched at the Royal Institute for Cultural Heritage (KIK-IRPA), Brussels, Belgium.*

silk and cotton fibres are more readily available than fibres obtained from flax or hemp stems. Animals such as sheep, goats, camels, horses and others, which are completely or partially covered with hair, were used, except for fibre, as well as for meat, milk and carrying loads.

However, the oldest fabric samples preserved are not made of wool according to the earliest records in which wool treatment is mentioned. The Egyptians wrapped their mummies mainly in linen, which did not disintegrate. In addition, the religion of that time did not allow to place animal fibres into tombs, hence it is probably also one of the reasons why the preserved woolen fabric samples from there are not the oldest. The oldest preserved sample of linen cloth was taken off a mummy and dates back to 6,000 years BC, from Catal Huyuk, Turkey, which was carbonised in a fire [7]. According to the present findings, it can be confirmed that woolen cloth was also used for wrapping the dead, and that the problem is very likely its faster decomposition in comparison to flax. Other influential parameters must not be omitted, such as the depth of buried mummies, soil type, changes in soil conditions, quality of mummification, etc.

One of the most dominant raw materials for making fabrics in our country was certainly wool obained from domestic Tsigai and Pramenka sheep, which was widely available (requiring only collecting, pulling or shearing and scouring).

Making single fabric samples was kept strictly within family circles, which probably resulted in some rare technique of weaving and unknown sources of old fabric patterns.

Remnants clearly indicate that in prehistoric times fabrics were made on a loom in the form of a frame that could be used as a vertical or horizontal loom (archeological site in Kupreško polje about 3,500 years old). Characteristic geometric motifs on fabrics connected people who lived in this area. Fabrics with characteristic geometric patterns were made by a special technique which is only possible with domestic coarse wool, further proof that wool has been used in this region from prehistory until today. The Catholic Church has made the greatest contribution to the preservation of textile items and the rich heritage of Croatia and Bosnia and Herzegovina. However, the oldest items and records have been found in archeological excavations [11 - 14].

The aim of this paper was to analyse historical fragments of the oldest wool fabric found in Europe in the territory of Bosnia and Herzegovina where Croats live. This will make a valuable contribution to the preservation of cultural heritage at a world level.

Experimental part

The experimental part of the paper analysed the oldest preserved woolen fabric in Europe, found in a grave at Pustopolje Kupres, Bosnia and Herzegovina (exhibited at the Franciscan Museum and Gorica Gallery in Livno, Inv. No. FM 66-6974) in the form of a cryptic mantle from a prehistoric tumulus and is the oldest sample of woolen fabric in Europe. In 1980 the tomb of the mummy, which was wrapped in a mantle, was found by Alojz Benacn while digging the foundation for a hotel. The fabric was used for wrapping the deceased, and the estimated age of the fabric ranges from 1550 to 1880 B.C. (***Figure 1***) [15, 16].

The relatively poor condition of the fabric during its separation from the deceased caused its destruction. The final appearance of the fabric consists of about 600 fragments. When putting the fragments together in positions according to the estimation of the original fabric, the estimated dimension is about 300 cm (length, warp direction) × 170 cm (width, weft direction). The fabric is characterised by selvedges woven on all four sides. At the Croatian Conservation Institute a sample of wool fabric was made on a frame with selvedges on all four sides [17]. Thus it can be concluded that it was woven on a frame loom, either with a horizontally or vertically disposed warp that was wound around two rollers, or stretched between two rollers. In the first case the length or height of the loom was half the size of the warp length, while in the other case, the distance between the rollers was the same as the fabric length. The warp was warped with a little more length than the fabric length (about 10% longer than the fabric). Interlacing warp and weft threads caused weaving in the warp. One roller, over which the warp passed, was able to shift and thus to loosen the warp. The width of the disposed warp was also somewhat greater than the fabric width (about 15%). Since the warp threads rested on only two rollers, which stretched them, it was difficult to keep the same fabric width. However, this problem is not visible to a greater extent because the fabric sample was woven from a coarse wool yarn which with its rigidity, uneven surface and roughness did not allow different weaving in the weft direction. In addition, it was woven with maximum density in the warp direction, or as much as was made possible by the thread thickness, so that the threads

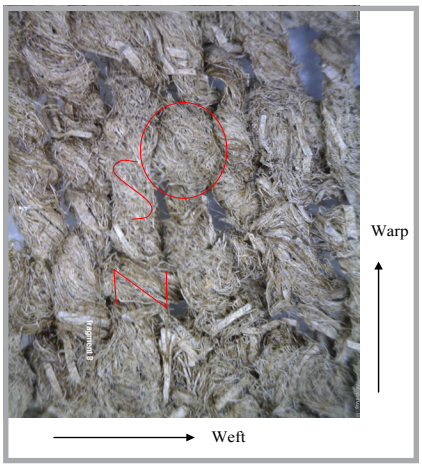

Figure 2. *Direction of warp and weft twisting.*

Figure 3. *Plied threads in the warp.*

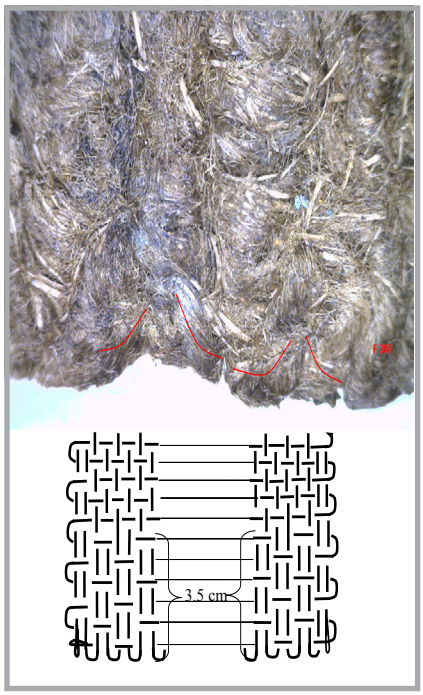

Figure 4. *Beginning of weaving; a) fabric selvedge at the beginning of weaving in the selvedge, b) scheme of the beginning of weaving.*

were warped next to each other without any gaps among them. Warp tension during weaving increased, and an occasional shift of one roller to a smaller distance decreased the excessive warp tension. During this procedure the woolen fabric was squeezed in the wet process, which resulted in extracting fibres covering the fabric surface, and a stabilised fabric dimension was obtained. The total number of warp threads can be obtained as an orientation across the fabric width and density of warp threads (fabric width 170 × 4 to 5 threads/1 cm 680 to 850). The number of weft threads is more difficult to determine because the weft density deviates in the fabric length, especially at the beginning and end of weaving, where changes in the weave are observable (orientation number of weft threads: fabric length 300 cm × 10 to 12/1 cm = 3,000 to 3,600 threads). In spite of a maximum weft beating up, the weft density is twice as low because the maximum warp density and plain weave in the central fabric area did not allow higher density, while at the beginning and especially after finishing, when weaving in rep weave, the weft density is higher than in the central area of fabric woven in plain weave. Therefore greater fabric thickness is observable when the rep weave was applied, and the fabric border at the beginning and end of the fabric is marked.

It is known that in hand-spinning yarn, which is done with three fingers of the right hand using a spinning wheel or drop spindle or any other more primitive method of twisting fibres into yarn, the twisting direction is always the Z-direction. By twisting the thread between the thumb and two next fingers it is much easier in the clockwise direction in contrast to the opposite one. Therefore during hand-spinning, the twisting direction is in that of the central or slanted line of the letter Z. These two yarns are plied in the opposite direction, i.e. in the S-direction, in which the yarn is doubled and wound into a ball. The doubled thread is fixed to the spindle before twisting. The spindle is held in the right hand and the thread is held in the left. The thread length between the spindle and left hand is twisted by the rotating spindle. The spindle is rotated in the hand using all five fingers, and only twisting in the S-direction is possible. By analysis of fabric samples by fragments it can be noticed that one twisting direction is S and the other Z (***Figure 2***). According to the shrinkage, density and rule of the direction of twist-

Figure 5. *Double warp threads.*

Figure 6. *Left selvedge of the fabric.*

Figure 7. *Right selvedge of the fabric.*

ing yarn, it can be claimed that the weft is a single yarn twisted in the Z-direction and the warp is a plied yarn twisted in the S-direction. Since the warp is under tension during weaving and by interlacing with the weft it is additionally stressed, it is mostly a plied yarn in order to obtain appropriate strength and evenness. In this case this rule is also applied. Since it was

Figure 8. *Fabric fragment with visible weaving in of double weft threads in four sheds, and the weave characteristic of tapestry.*

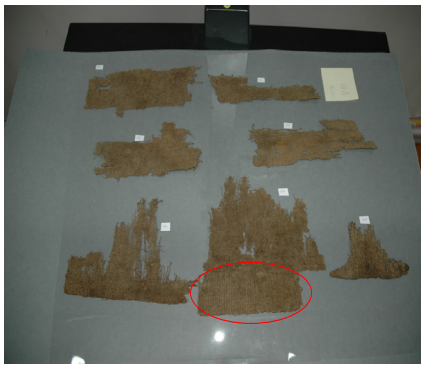

Figure 9. *Fabric fragments with visible border after finishing the weaving.*

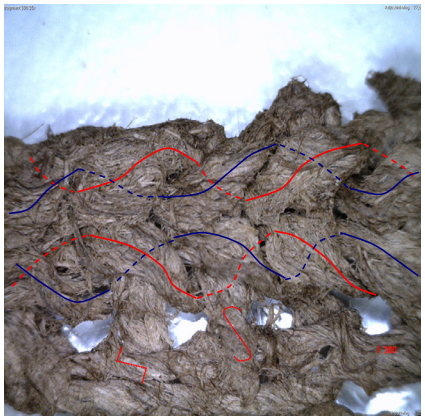

Figure 10. *Mutual twisting of weft threads in pairs and interlacing with the warp.*

planned to felt this fabric after weaving, the number of twists is almost minimal so that the effect of felting should be as great as possible. Due to a small number of twists it is very difficult to notice on the fabric fragments that the warp is plied and composed of two twisted threads; however, it can be noticed somewhere (***Figure 2***, a prominent circle, ***Figure 3*** arrows). By felting the fabric, not only were smoothness and impermeability to water and wind achieved, where it was very common in this region that wool blankets were felted for protection from strong winds and cold in winter, but it was also soft and comfortable to the touch. The visibility of woven warp and weft threads decreases by felting, and as a consequence it is very difficult to detect the interlacing of warp and weft threads in most preserved fragments. In view of the deterioration of many fragments, where only the central part of the thread remains and fibres were pulled out by felting and disintegrated, it is possible to determine the method of weaving the fabric in the selvedges and central part very accurately.

The weave type changed during weaving. At the beginning of weaving a longitudinal rep weave  as high as 3.5 cm was used (***Figure 4***). Then it was further woven in plain weave, and the selvedges were reinforced with the first and last double warp thread (***Figures 4*** to ***7***).

Before finishing weaving (with the rest of the warp about 10 cm long), it was continued in reverse, i.e. from the other end of the warp with beating up the weft upwards. It was woven in plain weave using four-fold weft or longitudinal rep weave (***Figure 8***), which was used as end border (***Figure 9***). The weft density was doubled in relation to the density in the central fabric segment, which thickens and emphasises this edge section. An increase in weft density produced a weave in which the weft thread passes over 4 warp threads on the fabric face, passing to the reverse side under 4 weft threads and running back to the fabric face over the whole fabric width; this enables the easier beating up of weft threads and greater density in relation to that when it was woven in plain weave.

Thus it is assumed that the last selvedge of the fabric was formed by inserting weft threads before finishing weaving because of the easier drawing through of a long needle and inserting of the last weft threads (***Figures 10*** and ***11***); however, this study did not confirm it, although several experts were involved in various projects at different institutions in Croatia, Bosnia and Herzegovina, Norway and Austria [18].

By taking the fabric off the loom, one part of the warp shrank, and the last interwoven weft threds moved into the free part of the warp. However, if the warp length without the weft is longer than that covered by the weft, loops fixed by the felting remain in the fabric and are noticeable (***Figure 12***).

Conclusion

According to archaeological excavations it can be noted that a long time ago fabrics were woven with a predetermined length and width with selvedges on all four fabric sides in the Herzegovinian and South-Dalmatian regions of Croatia. To weave such fabrics, relatively simple and practical frame looms, but very strong and solid, were necessary. According to the construction vertical looms were more used than horizontal ones. Vertical looms were more practicable as the weaver could sit and the loom did not occupy much space in relation to the ground-plan. On a horizontal loom two weavers wove in a squatting position, and they occupied more space.

According to the age of the fabric found, it can be determined that it was woven by the Illyrians or the peoples who lived in the region of Herzegovina before the arrival of the Croats in the 7th century. One of the main raw materials for the production of fabrics in this region was the wool of domestic sheep (today: Tsigai and Premenka), which was mostly used for making carpets, tapestries, coarser winter clothes, rugs, blankets, socks, bags, etc. Since this material was easily spinnable and within reach (collection, pulling, shearing and washing), preparation for weaving was very quick and easy. By felting wool fabrics, a soft, supple, strong and impermeable surface material was made which provided good protection from cold and windy winters in the form of clothes and blankets. After death, great people were wrapped in such a fabric, which was a symbol of protection.

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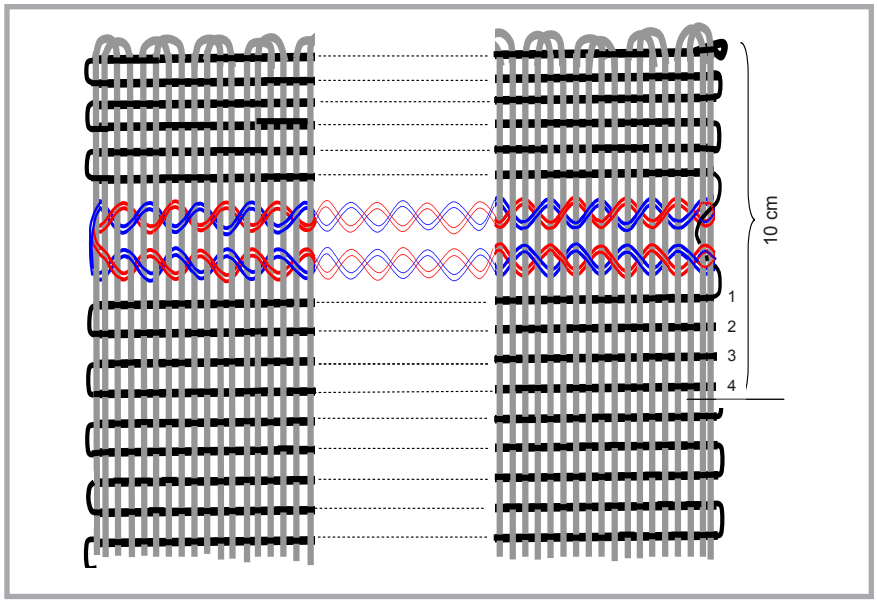

Figure 11. *Fabric weaves after finishing the weaving.*

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Figure 12. *Remaining loops of warp threads left free without inserted weft threads.*

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