

To pleat or not to pleat – an early history of creating three-dimensional linear textile structures

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(with 18 figures)

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Abstract

In this study we present an early history of creating longitudinal three-dimensional textile structures, which might be produced by folding and pressing ready-woven cloth, but also by various spinning and weaving techniques such as spin patterning or barred damasks. They all have ONE thing in common: they result in the visual appearance of a pleated structure, a three-dimensional longitudinal pattern which produces a special effect. In this article we follow the history of pleated structures from 4000 BC to AD 1000. Archaeological textile finds from Central and Western Europe with some glimpse of Egypt are the basis of the different aspects of garments with pleats or a ribbed structure – including some thoughts on body language, visual effects and textile identity. We review well known finds and present new data.

Pleated textiles have been known for centuries, even millennia! Such attempts to produce three-dimensional structures started in prehistory, already during the late Neolithic Period. Linen textiles woven in tabby found in lake-dwellings and dated to the 4th millennium BC show horizontal lines woven in twill. These lines in another pattern than the main weave tend to be higher and three-dimensional. Later in Iron Age pleated garments have been created by experimenting with spin-patterning. Pleated garments are well visible on pictorial sources of that period. During the Early Medieval Period, pleated garments have been made technically in two ways, either by hand-pleating after weaving or creating the pleats in the weave (so-called “*Rippenköper*”, a twill variant). It seems to have been a fashion worn by rich Germanic women (tunic) and men (mantle); the variant with woven pleats have been made only in Alemannic areas (South Germany/Bavaria and North-East Switzerland).

Keywords: Archaeological textiles, pleated structures, Central Europe, Stone Age, Iron Age, Early Medieval Period, fashion.

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Introduction

Textile research is an important task of the Department of Prehistory of the Natural History Museum Vienna. The department houses the collections of Bronze and Iron Age textiles from the salt mines Hallstatt (GRÖMER *et al.* 2013), but also various artefacts mainly from Iron Age and Early Medieval graves, where textiles survived in a mineralised state attached to metal objects (BENDER JØRGENSEN 2005; GRÖMER & SEDLMAYER 2012). Within the framework of international research projects such as CinBA – Creativity in Bronze Age (BENDER JØRGENSEN *et al.* 2018), a re-assessment of textile finds from the Natural History Museum Vienna took place and new methods have been applied to the textile finds stored at the museum (RAST-EICHER 2013). During this effort, interesting details and features have been analysed and described the first time, such as folded and pleated structures. This was set into context with other finds of the same kind (mainly from Austria and Switzerland) that have been analysed by the authors. Here we try to trace back how three-dimensional linear textile structures evolved, also taking already published material and iconographic sources into account.

Woven textiles in general are inventions of early farmer societies; for example, they appear in Europe from the Neolithic Period onwards, 7000 years ago. Right from the beginning, the weavers put some effort in decorating these textiles. Surface and self-patterning structures were used before colour patterns (GRÖMER 2016: pp. 169–205). Linen was not easy to dye, and white or nearly white wool not available until the Bronze Age (RAST-EICHER 2018: pp.125–129.). Here we focus on longitudinal three-dimensional pleated structures – in textile history, they have been produced in many different ways.

Ribbed structures and pleats

Pleats have been used throughout human history to create special garments with highly visible, mostly vertical folds or a ribbed structure. In modern terms, the fullness of a textile is described by the depth of the pleats. “Zero fullness” would be a flat fabric, 100% fullness “*is pleated so that it takes up exactly half as much width as it would if it were not pleated at all*”³. Prehistoric finds show different techniques to achieve three-dimensional structures (Fig. 1): plissé, *i. e.* folding and pressing already woven cloth, but also three-dimensional spin patterning as well as specific weave patterns like barred damasks can create pleat-like structures. In the Medieval Period as well as in (Early) Modern history, pleats have been sewn (*e. g.* early modern smock), or modern textiles were pleated by hand and were fixed by ironing (accordeon pleats) or with a pleating form (steam cupboard). Many materials have been and are used: silk, wool, linen, cotton (cotton drill), and artificial fibres (polyester). If wool is used, the textile should be a crêpe, a tabby woven with very hard spun yarns.

³ WIKI “Pleats”: <https://en.wikipedia.org/wiki/Pleat>. Accessed 24th Nov. 2016

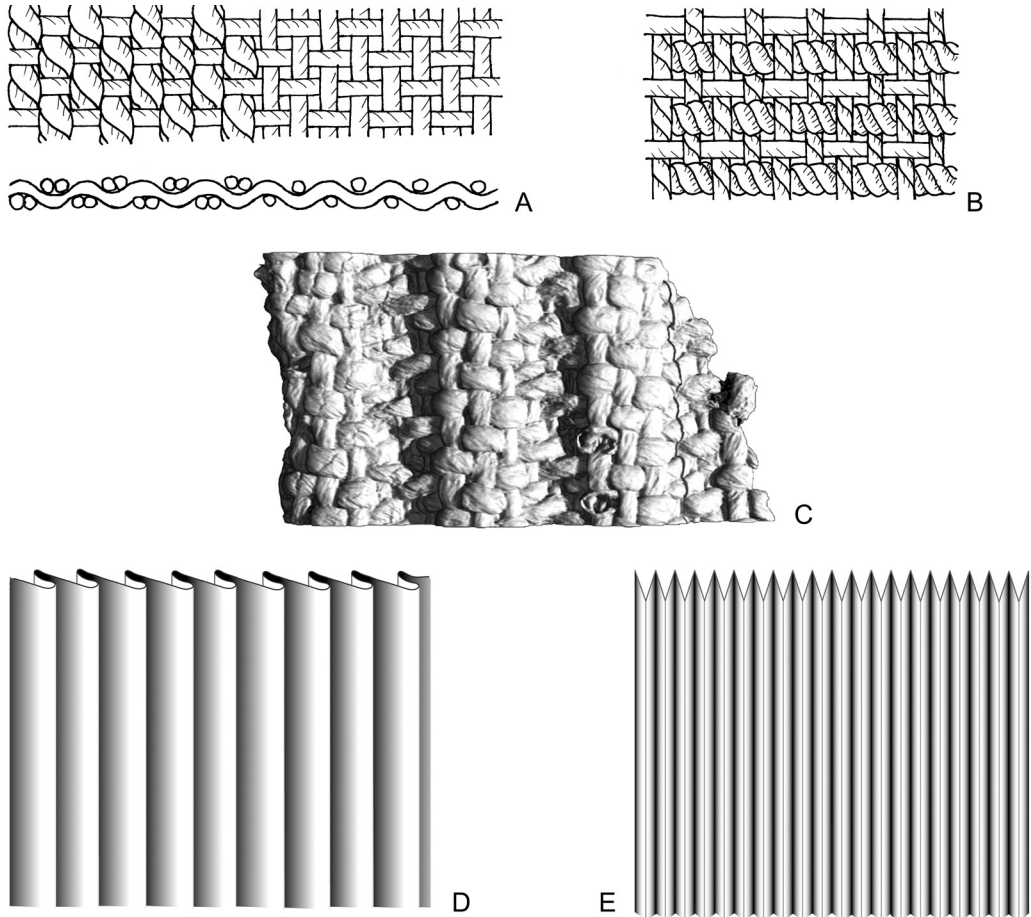


Fig. 1. Textiles with three-dimensional linear structures. A: three-dimensional spin pattern; B: ribbed structure; C: barred damask; D: round pleats; E: knife pleats (sources: K. GRÖMER, B. NOWAK, and B. NUTZ).

In folk costume, pleated textiles have been made all over the world. A technique used in Guizhou (China) still today might serve as an example: A long dark blue textile dyed with indigo and treated with rice paste is fixed with strings around a large wooden water container. Pleats are then made one by one by hand with a long pin. At the end, the pleated textile is coated with rice paste or *bletilia striata* to hold the pleats⁴.

In this study about three-dimensional linear structures before the Middle Ages, we use the terms listed below which are defined as follows:

The term pleats or pleated structure/type is used as the general term for all different three-dimensional linear structures.

⁴ <http://www.narrativemade.com/hand-pleating/3hé093cm0inqbs4lb8sjdxu79gc90fc>

Plissé: Textile pleated after weaving with heat and/or pressure, linen or wool (here tabbies with hard spun yarns). The pleats can be sharp or round.

A barred damask is a 2/1–1/2 (sometimes 3/1–1/3) damask with change after three or five weft threads. This pattern automatically creates pleats. The pattern has been called “*Rippenköper*” – ribbed twill – by Hans Jürgen HUNDT (1966: p. 100), an archaeologist, who discovered them among the Early Medieval graves in Southern Germany in the 1960’s. In 2004 Martin CISZUK introduced the term “barred damask”, a term we will use here (2004: pp. 107–114).

A Three-dimensional spin pattern is created with the use of groups of single and plied yarn, usually of different twist direction. To create a three-dimensional effect, the plied yarn is thicker than the single yarn, also the single yarn is spun quite hard with a twist angle of about 50°. The weave type applied on those textiles is usually tabby.

Structure patterns are understood as types of decoration that are created as three-dimensional woven structures (e.g. barred damask – *Rippenköper* or Three-dimensional spin pattern), in contrast to other pattern types that are woven in a flat way (e.g. two-dimensional colour patterns).

Theoretical background: visual effects and textile identity

The types of cloth with pleated structure are not only an expression of creativity and randomly chosen, but also served as a social expression.

Thus, for our study, concepts of dress and identity from the perspective of psychology, sociology, and semiotics (CALEFATO 2004; SOMMER 2012) are of interest, because throughout history, textiles and clothing were not only used for basic functions like keeping warm. From prehistory on, dress was used to decorate and to express status and it serves as an important non-verbal communication medium. For those who can read it, one can express identity, age, gender, ethnic and religious groups via specific garments, cloth types, colour, and – in combination with this – specific jewellery. All of that is subsumed in the term “visual codes” (CHANDLER 2002).

It also has to be asked, what do those fabrics with pleated structure “do” with the body of the person wearing it – how do they move and interact with the body or not, what are the effects on body movements. Thus, such garments do have specific significance for a certain body language (PEASE & PEASE 2006). Body language is a form of nonverbal communication related to the movement of the body or any part of it – which also comprises of facial expressions, eye movement, and – in relation to clothing – body posture, gestures and use of space.

Visual codes like colours, physical appearance, and also body language are unconsciously read by audiences who then understand them. There are also specialised connotational meanings and ideological codes to reflect particular social, political, moral, and aesthetic values (SØRENSEN 1997; HARRIS 2014: pp. 264–285).

Archaeological finds

Textiles belong to the most fragile finds in archaeology and are preserved in special conditions only: in humid layers, such as stone Age lake dwellings, in salt mines as the ones of Hallstatt (Austria) or thanks to oxidation of metal in graves. Dry conditions for the preservation of textiles are available in deserts. Research in archaeological textiles has become more and more important during recent years; international projects have shown the potential of this subject.

In the following paper, three-dimensional linear textile structures are studied focusing on the archaeological evidence in Central and Western Europe, from the Late Neolithic until the end of Early Medieval Period, that includes a time-span from *c.* 4000 BC to *c.* AD 1000. Within that time, different economic, social as well as technological circumstances formed the basis of daily life in Europe (KRISTIANSEN 2000). Those circumstances influenced the textile techniques available, their production, use, and impact on society. First farmers in Europe (second half of 6th millennium BC) brought flax – linen textiles were the first woven textiles documented in the Neolithic. The Late Neolithic is characterized by a rural way of life with domesticated animals and plants, but without big social differentiation; towards the Bronze Age (2200–850 BC) there are the first hints of a hierarchical society (KRISTIANSEN 1991), if we look at the different level of grave goods accompanying the deceased. From textile technology, Neolithic is the time when tabby weaving was the dominant type and textile technology is based on plant fibres. From the Bronze Age on and especially in the Iron Age wool was used, and twill and dyeing were employed. Especially in Iron Age Europe (*c.* 850–0 BC) we can trace an elite controlling a certain territory and living in central towns or settlements on hills (in Greece the *polis* is emerging), and extraordinarily rich chief's graves, showing their exchange with the Mediterranean (for an overview: CUNLIFFE 1998; KRISTIANSEN 2000). In such graves there are a lot of representative goods – jewellery and luxurious textiles, in many cases trade goods.

In the first half of the 1st millennium AD main parts of Europe were part of the Roman Empire and their advanced technology and trade systems also influenced life there. The areas north of the Roman Empire, north of the river Danube and east of the river Rhine, as well as the area of Scandinavia, were inhabited by Germanic tribes. In the middle of the first millennium AD widespread migrations within Europe started, which led to the fall of the Roman Empire. The Migration Period changed the map of Europe (FRIESINGER & VACHA 1987; HALSALL 2008), as a number of Germanic tribes such as the Alamans, Franks, and Lombards settled in various parts of what had been the Roman Empire; incursions by Asian tribes such as the Huns (5th century AD) and Avars (6th–7th AD century) also left marks. Within that time as well as in the Early Medieval Period, many economic achievements of the Romans were abandoned. The technology used during that time, especially for daily handcraft like building simple wooden houses, pottery, and smithery, often continues the standards of Pre-Roman times. Early Medieval society is based on kinship, and traded luxury goods were available for the higher strata of society.

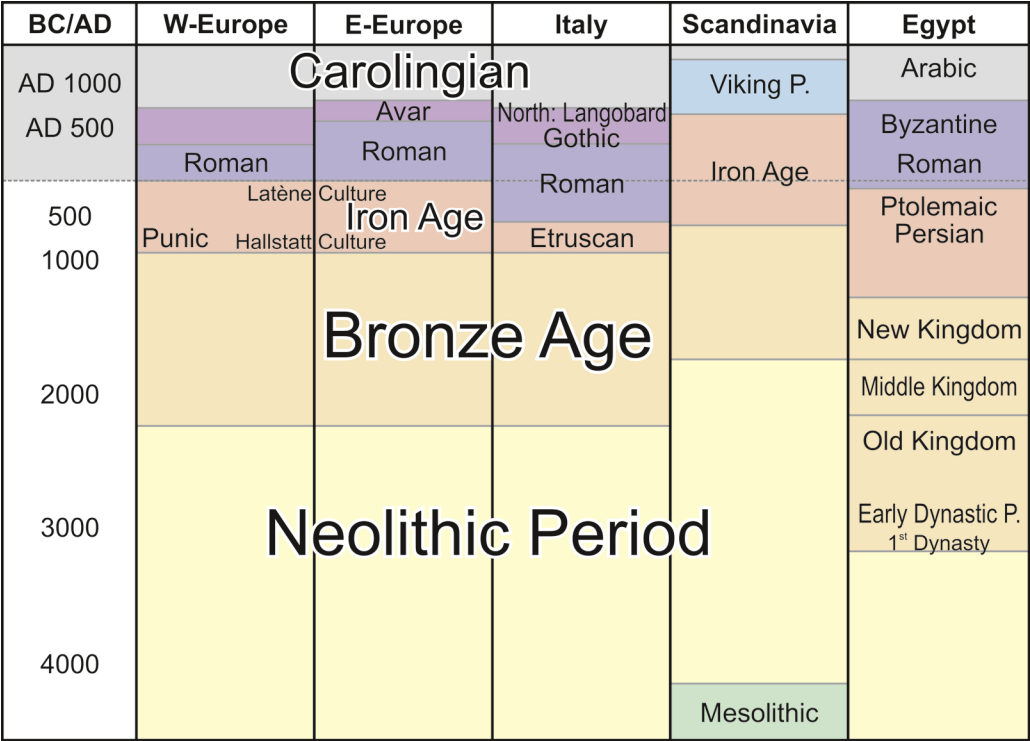


Fig. 2. Cultures and Time periods from 5000 BC till AD 1000 in Europe and Egypt (Drawing: A. RAST-EICHER).

The rich graves of the Merovingian kings family in the Basilica of Saint-Denis in Paris are the best examples for 6th and 7th century AD rich grave goods, including imported silks (FLEURY & FRANCE-LANORD 1998; DESROSIERS & RAST-EICHER 2013; a new publication of all finds is in preparation: PÉRIN, in press; RAST-EICHER, in prep.).

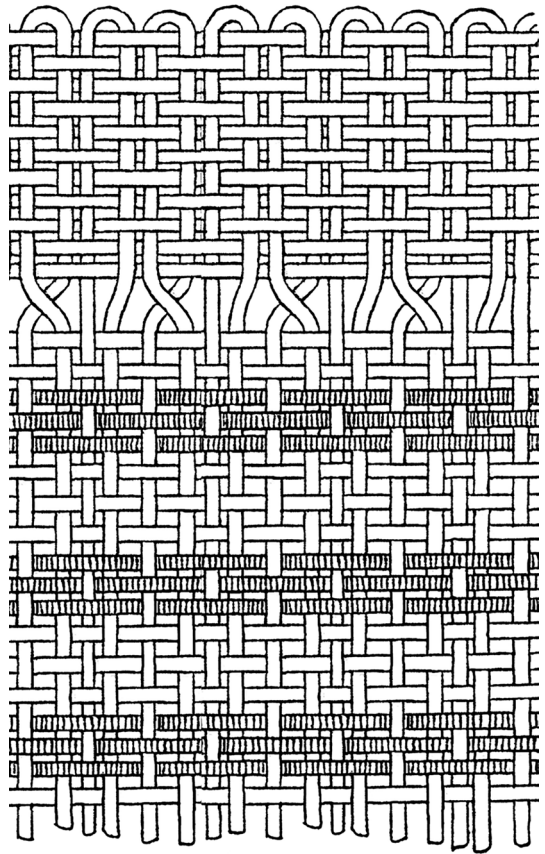
Early evidence of three-dimensional structures: ribbed fabrics, structural stripes, and pleats

The first evidence of woven textiles found in Neolithic Europe derive from the early farming cultures, dated to the first half of the 6th millennium BC: they are imprints on ceramics, like those from Szentés-Kiss Boliszár (Hungary; 1st half 6th mill.; RICHTER 2010) or Luleč in Czech Republic (mid 6th mill BC; GRÖMER 2016: p. 129). Organic preserved woven textiles from the lake dwellings have been found in layers dated to shortly after 4000 BC. Among the finds of the lakes of the canton of Zurich (Switzerland) 70 woven textiles dating to the 4th and 3rd millennium have been documented; they are made of linen with plied yarn and woven in tabby weave (RAST-EICHER & DIETRICH 2015). Few of these finds show a linear decoration – as linen is difficult to dye, it was probably the best way to create structure patterns. One of those patterns has been made with

Fig. 3. Wetzikon-Robenhausen (CH): Linen textile with inserted pattern, c. 3800 BC (after VOGT 1937).

three weft threads in 3/1 twill-structure, which were probably introduced by picking up the correct threads for the pattern by hand (Fig. 3). These stripes are slightly three-dimensional, as the parts with twill tend to rise, if the weft threads are well beaten. Was this the beginning of the concept of pleats?

From the Bronze Age only a single textile with three-dimensional effect has been documented in Europe: in the settlement of Staré Město (Czech Republic) a small textile fragment from c. 1100 BC has been preserved showing a clear ribbed structure (HRUBÝ 1968/69: pp. 51–56). The structure was made by the change of single yarn and triple plied yarn in the weft (Fig. 1b). This type of structure is again found later in the Iron Age as well (see below).



It is important to mention Egypt in this survey of pleated textiles. A nearly complete linen garment with horizontal pleats found in Tarkhan (Egypt) has been preserved, another one from Deshasheh (old Kingdom; RIEFSTAHL & CHAPMAN 1970)⁵. Dated to the 1st dynasty (about 2800 BC), the Tarkhan textile is the oldest well preserved garment, which is nearly complete. It is woven in fine tabby with 22–23/13–14 threads/cm. In the upper part of the linen shirt, knife pleats (*plissé*) lie horizontally. They were made with 1 cm pleats in the damp textiles. The vertically pleated linen textile from Deshasheh (5th dynasty, 2470–2320 BC) has been pleated by weaving parts with loose warps, others with dense warps. The loose warps turn in the sense of the dense warps so that they create pleats (REIFARTH 2013). Another dress dated to the 11th dynasty (c. 2150 BC) is a tunic found in a tomb of Naga-ed-Der in Middle Egypt, now in the Museum of fine Arts in Boston (USA; RIEFSTAHL & CHAPMAN 1970). The sleeves are pleated vertically, the central body area horizontally. As we know from various examples from ancient Egyptian pictorial sources, very fine garments with pleats and draped narrowly around the

⁵ <http://www.ucl.ac.uk/museums/petrie/about/collections/objects/tarkhan-dress;>
<http://www.ucl.ac.uk/museums-static/digitalegypt/deshasheh/uc31182.html>

body seem to have been standard throughout the millennia of pharaonic Egypt (LANDI & HALL 1979). Here it is also worth to mention that pleating plays an important role in textile production and dress in the Ancient Near East and Bronze Age Greece, as we know rich iconography depicting pleated fabrics and garments (*e. g.*, STROMMINGER 1971; JONES 2013, 2015; PETERSON MURRAY 2016).

Iron Age: Early wool textiles with spin patterns and plissé

The European Iron Age knew a great variety of pattern types. Wool added important new venues to the decoration of textiles as it is much more elastic than plant fibres. To understand the impact of wool on the pattern types focused here in this study, we must address the fact that light (not fully white) wool became available in Europe during the Bronze Age. It must have been known for a longer period of time already in the Near or Middle East. White wool is necessary for dyeing; the first dyed wool textiles in Europe appear in the Bronze Age layers of the Hallstatt salt mine in Austria (GRÖMER *et al.* 2013: oldest blue dyed textile HallTex 211, catalogue pp. 269–270). Wool with crimp (known certainly in the Iron Age) is another important factor for the creation of plissé, as such wool is better suited for crêpe-like textiles. In the Central European Iron Age the option of colour had been developed into fancy patterns. This signifies a completely different concept of textile design.

Iron Age art provides us with different kinds of pictorial sources such as incisions or imprints on pottery, anthropomorphic fibulae, figurines, and stone stelae (HUTH 2003). For our research question, the most important is the so called “situlae-art” (LUCKE & FREY 1962; TURK 2005), as it preserved more or less naturalistic images of people and their garments. The situlae art is an artistic style in Late Hallstatt and Early Latène Period (between 700 and 400/300 BC), which is known mainly in alpine Austria, Slovenia, and Northern Italy. It belongs partly to the (South) Eastern Hallstatt Culture as well as to the Este Culture of the Veneti and the (Pre-?)Etruscan Villanova Culture around Bologna. The design is done mostly as a bas-relief with pins, small chisels, and punches. The scenes and figures are very detailed and even the garments of the depicted men and women are well developed. Compared with contemporary textiles, *e. g.* from the salt mine Hallstatt (GRÖMER 2016: fig. 99), we can see that the situla decorations reflect textile and pattern types like stripes and checks which were used in the Hallstatt Period.

One of the most famous items of situlae art is the situla of Vače, Nad Lazam in Slovenia, dated *c.* 500 BC. (LUCKE & FREY 1962: pls 47–51; TURK 2005: cover, figs 2, 90, Kat. No. 48). Here a multi-pronged tool was used to work out the structure pattern of the fabrics. Can we deduce, that those veils and upper garments with the decoration in question had pleated structure? One detail might point to this fact: On the upper garment of the man sitting on a throne (Fig. 4) the pleated structure done with a punch with multiple teeth used in parallel rows follows the natural drape of the garment while sitting.

Contemporary Etruscan statuettes also depict garments with pleats, such as an ivory statuette (dated *c.* 575 BC), kept at the Staatliche Museen zu Berlin (Fig. 5; BONFANTE 2003:

Fig. 4. Vače, SLO: Bronze situla, detail garment with pleated (?) structure, c. 500 BC (Scan: 7reasons; Situla housed at the National Museum of Slovenia, Ljubljana, Inv. No. P581).



pp. 176–177). It is a woman wearing a long dress with regular pleats running over the breasts and the lower body, thus enhancing the slim body silhouette.

Beside colour patterns, structure patterns have been used in European Iron Age. At the beginning of the Iron Age during the Punic Period in Spain (7th century BC), plissé garments seem to have been fashionable as demonstrated by a piece of woollen cloth with very fine pleats found in Carmona in southern Spain. The textile is a weft tabby with single threads (z, hard spun 35–60°, diameter 0.1–0.3 mm, 20–26/38–40 threads/cm; ALFARO GINER & TÉBAR MEGÍAS 2007: fig. 4). We do not know if the Spanish plissé had been influenced by Egyptian fashion. Culturally this could be possible, as many people migrated from the Phoenician towns in North Africa to colonies in Spain from about 1100 BC onwards, following the coasts to the West and crossing to Spain at Gibraltar. There were economic interests as gold, silver, copper, tin, and iron were found in Spain (BOTTO 2016). At the same time, textiles with pleats started to be found in other parts of Europe.

One of the first well-dated Early Iron Age wool textiles with plissé has been excavated in Verucchio (Italy; 725–650 BC; STAUFFER 2012: figs 10.10 and 10.11, pleated pattern). A ceremonial garment in the shape of a long sleeveless tunic with open sides and curved lower edges (Object A), made of balanced wool twill, possesses such a structure. On the surface of the garment, a regular system of folds in both directions could be detected under a strong lateral light by STAUFFER. The folds form small rectangles of about 4 by 3 cm and have been deliberately made. As the pleats run over the tablet-woven borders, it seems certain that the pleating was done after the garment had been finished. When pleated, the garment must have looked quite different than it did directly after weaving. Its shape was optically minimised and it would have looked more like a *chiton* than a wide fitting sleeveless tunic. *Chiton* is a generic term for a Greek tunic, more fitted to the body than the Roman *tunica* (CLELAND *et al.* 2007: pp. 32, 200–201).

In Central and Western Europe, the Hallstatt Period (c. 800–400 BC) is one of the first heydays of various pattern types: we find colour pattern such as stripes and checks, and complex designs made with tablet weaving such as meanders, lozenges, or swastikas (GRÖMER 2016: figs 99, 102–105, 107). Such patterns appear on textiles as well as on other types of objects (*e.g.* pottery, metals). The most famous structure pattern type is the spin pattern, which could be detected in more than 50% of the textiles found in the salt-mine of Hallstatt. For a spin pattern, the difference of spinning direction was exploited to provide decoration, for otherwise identical S- and Z-spun threads laid side

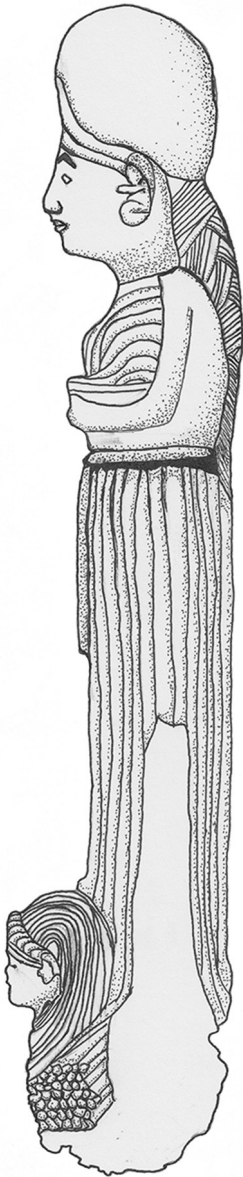


Fig. 5. Etruscan statuette with pleated dress, provenience unknown, c. 575 BC (Drawing: A. NARDINI and K. GRÖMER, after BONFANTE 2003: fig. 64).

by side will catch the light differently and give a subtle tonal pattern. Usually spin patterns were made using more or less regular groups of s- and z-twisted yarn in warp and/or weft; it creates a three-dimensional effect. As the textiles from the Hallstatt salt-mine, Austria, are preserved in their original organic composition and in very good condition the structural effects can still be seen very well. Recent microscopic and visual analysis of the spin patterned fabric with three-dimensional effect explained the phenomenon; the prehistoric weavers used groups of thicker plied and thinner single yarn of different twist direction to create a structure effect – thicker and thinner stripes in the fabric which look like pleating. This deliberately chosen effect is additionally highlighted when combined with hard or light spinning. The tightness of twist is defined by the angle of the fibres in the vertical axis of the yarn. *“A twist so tight that the yarn is inclined to retwist on itself when not under tension generally referred to as a crepe twist since such yarns tends to produce a creped or crepe effect.”* (EMERY 2009: pp. 11–12).

Textile HallTex 63 from the salt-mine Hallstatt is a large yellowish tabby, woven by alternating 8 S-plyed yarns (0.4 mm thread diameter) and 8 z-single yarns (0.2 mm thread diameter; Fig. 6; GRÖMER *et al.* 2013: catalogue pp. 383–384).

Textiles from Iron Age graves did usually not survive in an organic state, but are mineralized and hardened; in the worst case, the former textile can be preserved only in form of mineralized remains attached to a metal artefact. Although colour information is usually lost, details of the thread and weave structures are commonly still visible and such single or plied yarn as well as the spin direction can be analysed on grave finds. Thus, the Hallstatt Period graves also offer some information about the pleated structure effects.

From Berg/Attergau in Austria, dated to c. 600 BC (GRÖMER 2014: catalogue p. 195 [No. HaZ-12]) we know of a woollen twill fabric with alternating groups of 5 Z-plyed yarns (0.7 mm thread diameter) and z-single yarns (0.5 mm thread diameter). In this case, the fragment is too small to see the effect, but with the technical details, it is comparable to the three-dimensional spin pattern of HallTex 63 from Hallstatt (see Fig. 4).

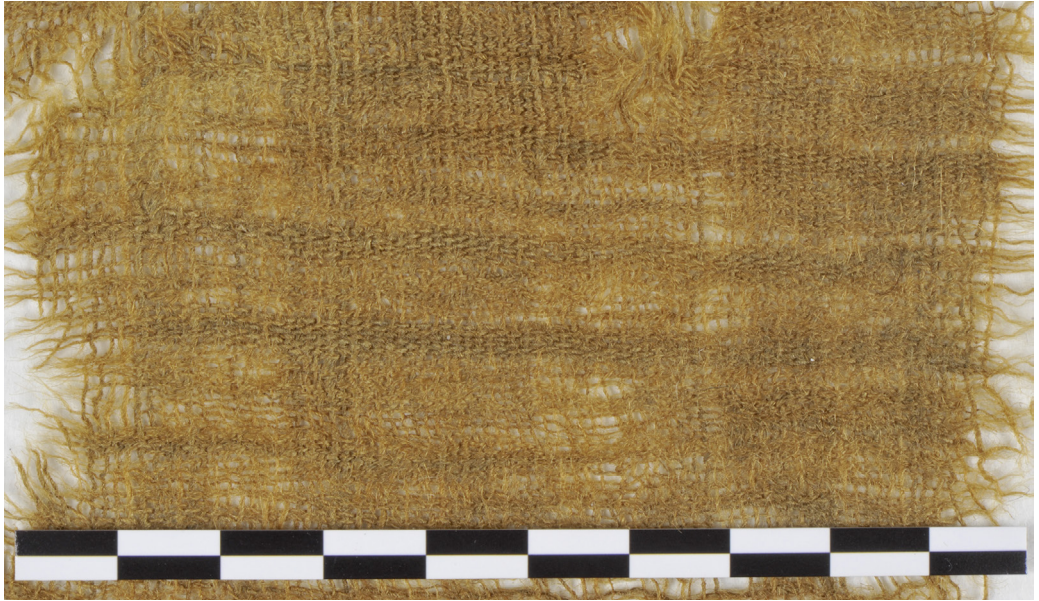


Fig. 6. Hallstatt (A): HallTex 63 with spin pattern in three-dimensional structure effect, 800–400 BC (© Natural History Museum Vienna, Photo: A. RAUSCH).

A pleated structure was also visible in fragments from the later Iron Age in Giubiasco, Southern Switzerland (canton Ticino), similar to the techniques found in Hallstatt: by combining a fine warp thread (hard spun) to a thick weft (soft spun) a ribbed structure was achieved (Fig. 7) on a 2/2 twill fabric (Tomba 10, reperto 2; RAST-EICHER 2016a).

Plissé is sometimes visible even in small fragments from graves. One example is a well-dated early Iron Age linen textile of



Fig 7. Giubiasco (CH): 2/2 twill mineralized on an iron fibula, late Iron Age, the finer warp is combined with a soft spun weft (Photo: A. RAST-EICHER).

Bulle-Teraillet (Canton of Fribourg; CH; Bulle-Teraillet 2015, Inv. 205; Hallstatt C, c. 750 BC) woven in tabby. The fragments show regular small folds which were made intentionally (RAST-EICHER 2016b).

Roman and Early Medieval Period: plissé and barred damask

Based on archaeological textile material, the evidence for pleated structures is scarce during the first half of the 1st millennium AD in Europe. In the North East European Wielbark Culture (Poland) dated to the AD 1st–5th century AD, no textiles with pleats have been found so far (MAIK 2012).

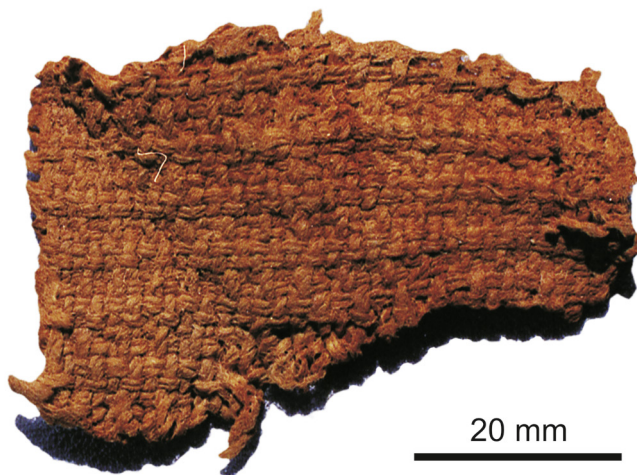
In the areas of the Roman Empire during the 1st/2nd century AD cremation graves are dominant, during the Late Antique Period (3rd to 5th century AD) in the Central and Western European Provinces inhumation graves were preferred. In Scandinavia, cremation and inhumations were practiced, so that textiles of that period are more numerous. Among these graves one is especially interesting, because a single pleated textile has been found; dated to the 5th century AD, it is a 2/1 barred damask otherwise not found in this region (Hjemsted Grave 1409; BENDER JØRGENSEN 1986: fig. 100c).

Textiles of the Roman Period graves (*e. g.* Germania, Danube provinces, Noricum/Pannonia) have been a research focus in the last years. Among the hundreds of textiles recorded, tabbies clearly dominate (GRÖMER 2014: fig. 17 and tab. 4); pleated textiles are rare and only plissé, no other textile type creating three-dimensional linear structures could be identified so far. Two of the rare examples of plissé textiles in Late Roman context have been found in the Late Antique cemetery of St. Maximin in Trier (D), graves 287 and 304 (REIFARTH 2013: figs 287/7 and 304/3).

Roman Period textiles in Italy would be very important, but have not been documented in sufficient quantity to judge the question of patterns. This is why we have to look at material in Roman Egypt, where they also used a pattern variant creating a pleated structure; in the sites of Mons Claudianus and Krokodilô, sites dated to the 1st/2nd century AD (CARDON 1999; CISZUK 2004: pp. 107–113), two types of barred damask types have been found – the barred damask 1/2–2/1 and 1/3–3/1. Another 2/1 barred damask has been discovered in the late Roman fort of ‘Abu Sha’ar (1st half of 4th century AD) (Fig. 8). They are all made of wool. The first variant then became very important in the Early Medieval Period in Europe from the 6th century AD onwards, and was made of linen.

During the Early Medieval Period, in the second half of the 1st millenium AD, pleats seem to be common. Two types of pleated structures have been known: the first is a textile woven in tabby and pleated after weaving (plissé) and made of wool or linen, the second the barred damask (or “*Rippenköper*” by H. J. HUNDT) and made of linen. In the Early Middle Age the plissé has been produced with round or sharp pleats of about 7 mm depth. The sharp pleats were probably made as knife pleats (see Fig. 12), as for

Fig. 8. ‘Abu Sha’ar (Egypt):
Barred damask (no. 309), 300–
350 AD (Photo: L. BENDER
JØRGENSEN).



the round ones Agnes GEIJER proposed warm iron sticks to form the pleats (GEIJER 1938: p. 17, pl. 1; HÄGG 1991: pp. 209–210). Technically, the plissé is made of a textile with hard spun threads, and spun in warp and weft in the same direction, in Europe mostly z/z. The hard spinning creates a crêpe-like surface which is ideal to make the later pleating hold (Fig. 9).

The second pleated structure type has been woven as 2/1–1/2 barred damask with changes after three or five weft threads. This pattern creates durable pleat-structures, even surviving washing.

In a few cases, barred damask 2/1–1/2 has been combined with a second pattern, a herringbone twill: four examples are known: from Niederstotzingen (D; HUNDT 1967), Elgg (Canton of Zürich, CH; WINDLER 1999), and Fehraltorf (Canton of Zürich, CH; RAST-EICHER, 2017), all of them dated to the 7th century AD (Fig. 10). Combinations of patterns have been known in the Iron Age already (RAST-EICHER & TIDOW 2002; GRÖMER *et al.* 2013: pp. 163–178;). The pattern with twill barred damask combined with herringbone twill seems to be an Alamannic speciality, as the few textiles known so far have all been found in Southern Germany and Eastern Switzerland, the probable geographical expansion of this Germanic tribe which was ruled by the Merovingian dynasty.

For the 6th and 7th century AD in Central and Western Europe all examples of the plissé of the 6th century AD are located in France, Germany, and Switzerland, with two exceptions, one in England and one in Italy, but both in Germanic context. The pleated textile found in the ship burial of Sutton Hoo (GB) was wound around a mailcoat (CROWFOOT 1983). The pleats visible on fig. 319 of Crowfoot’s article are broken and look similar to the mineralized ones attached to a brooch from Flaach (Canton of Zürich, CH; Fig. 11; RAST-EICHER 2012) or from a Lombard grave of Maria Ponsee (A; Fig. 12). However, this type appears later in Scandinavia, for example in Birka in Sweden, and there the textiles were held by tortoise pins (GEIJER 1938).

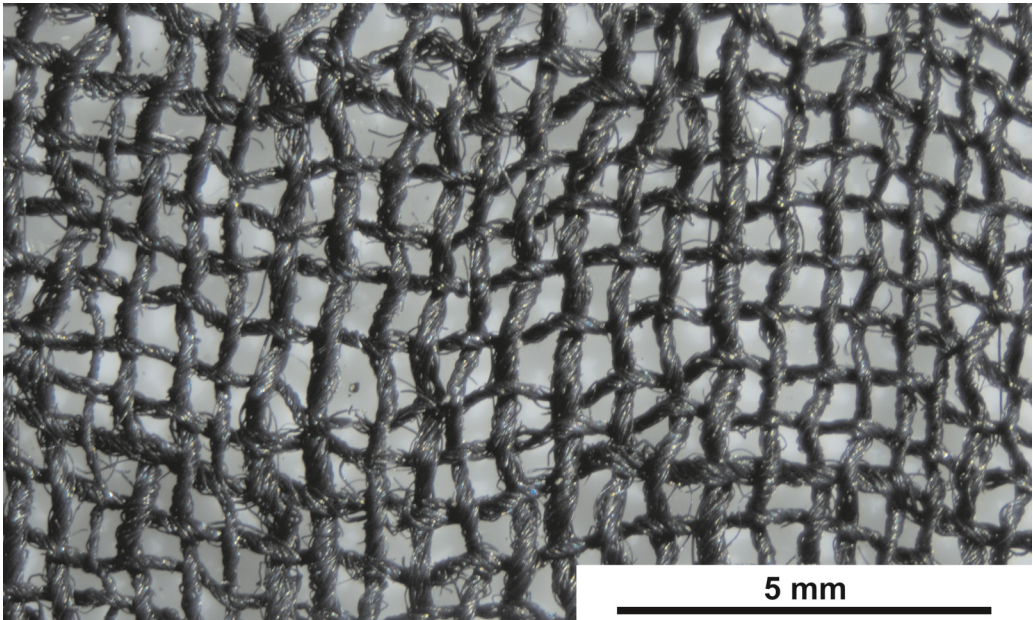


Fig. 9. Saint-Denis/Paris (F): Detail of pleated textile of grave 48, 6th century AD (Photo: A. RAST-EICHER).

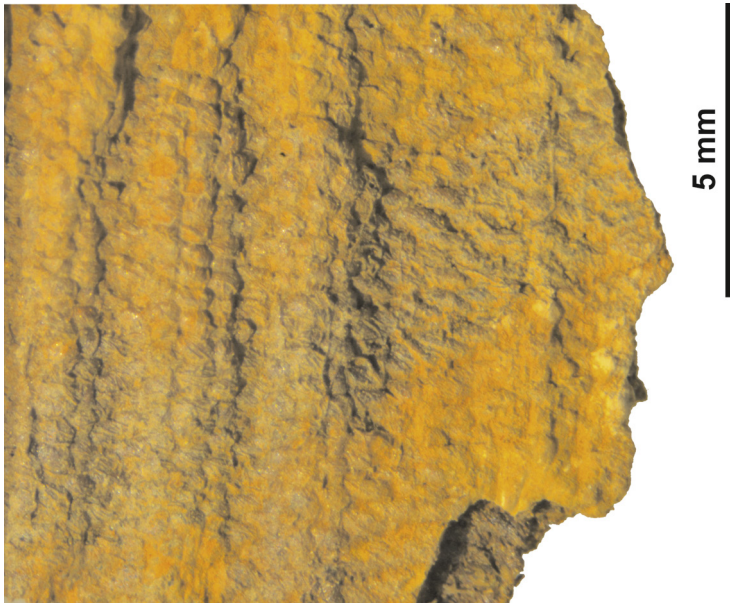


Fig. 10. Fehraltdorf (CH): Barred damask with herringbone twill, grave 53, 7th century AD (Photo: A. RAST-EICHER).

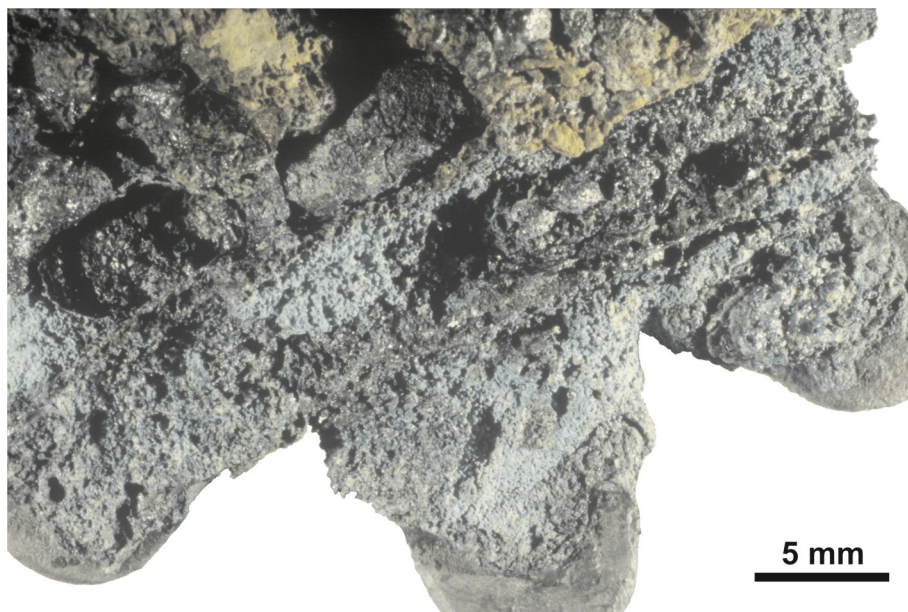
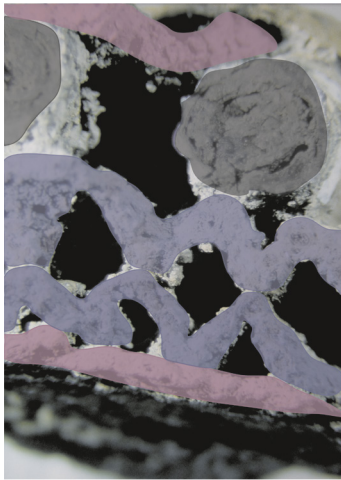


Fig. 11. Flaach (CH): Pleated textile mineralized on a girdle plate, beginning of the 6th century AD (Photo: A. RAST-EICHER).



Fig. 12. Maria Pöschel (A): Pleated textile on a knife, grave find, 6th century AD (Photo: A. SCHUMACHER, NHMW).

The function of these textiles with pleated structure seems quite clear: in women's graves the pleated textiles have been found under the girdle or pinned with a brooch, in men's graves those textile types were identified over the girdles. We have interpreted the women's garment as a tunic or over-tunic with a front opening, the men's garment as a cloak. In several graves, the textile could be documented in connection with more than one object. In the 6th century AD graves pleated garments have been found attached on certain fibulae (bow brooches) or found on buckles, also in the graves of Flaach (canton of Zürich, CH) dated to the beginning of the 6th century AD. This cemetery is especially interesting, as it is the oldest Germanic graveyard south of the Rhine, documenting the expansion of Germanic tribes towards the South at that time (WINDLER 2012: pp. 56–77). In the 7th century AD women's graves, the position of dress fasteners (such as brooches)






-  Linen textile
-  Plissé (wool)
-  Metal girdle

Fig. 13. Schleithelm (CH): cut through two layers of pleated textile under a chain from grave 504, 7th century AD (Photo: A. RAST-EICHER).

differ to those of the 6th century AD. We might interpret the evidence as such that even the type of garments fastened with them are different. Maybe the over-tunic with front opening from the 6th century AD, closed with two fibulae, was eventually replaced by a cloak closed by a single large fibula on the chest. In Schleithelm (Canton of Schaffhausen, CH) grave 504 (7th century AD), the woman wore a long pleated garment (fine knife pleats of about 7 mm), which has been documented all along the chain hanging from the girdle, delimiting this way the length of the garment (RAST-EICHER 2002a: pp. 211–228) (Fig. 13). Similar to this is grave 189 from Baar-Früeburgstrasse (Canton of Zug, CH; 7th century AD); the pleated textile (here the barred damask type) has been found under the girdle (buckle), and under the objects hanging from the girdle. The reconstruction has been drawn according to the organic material found on the different objects (MÜLLER 2010: pp. 458–461) (Fig. 14).

In a man's grave from Meikirch (Canton of Bern, CH, dated to the end of the 7th century AD; BOSCHETTI 2004: pp. 183–200, fig. 201) a pleated textile was attached on top of the large girdle plate. The pleated garment was identified as a coat, because the textile formed the upper layer on the girdle. Iconography supports this interpretation; on a grave plate found in Zenica (BIH; CREMOŠNIK 1958: pp. 150–151), one woman and three men are depicted, each wearing a pleated garment (Fig. 15). The women's garment shows a sleeve and is therefore a tunic, while the men wear a garment fixed on the shoulder by a large late antique fibula (crossbow fibula) and hiding their arm – a coat. Later depictions of the 7th century AD in the church of Cividale, the “tempietto Langobardo” (especially to the right of the arch), confirms the Early Medieval use of pleated garments among the Lombards. North of the Alps, *phalerae*, like the one found in Hüfingen (D), are depicting Mary in a pleated garment (FINGERLIN 2012: pp. 7–26).

In the Early Medieval Period, written sources also mention pleated garments. Bishop Isidorus of Seville (AD 560–636) enumerates the garments in his *Ethymologies*, which



Fig. 14. Baar-Früebergstrasse (CH): reconstruction of Grave 189, 7th century AD (Drawing: Amt für Denkmalpflege und Archäologie Zug, Eva KLÄUI).

were probably worn in Visigothic Spain in the 6th century AD. Among the women's coats (Isidor Ethym. 19, 25, *De palliis feminarum*) he wrote about a pleated coat which “sways its ripples in fluttering folds”; “...quod rugis vibrantibus sinuata crispetur”. This is the only text of the period mentioning such pleated textiles. On later depiction of Isidor (AD 800, Monastery of Corbie), sister Florentina is wearing a coat with many folds (Fig.16).

During the Carolingian Period a written source from AD 899 informs us about pleated textiles: *phaltena* or *phalta*, *paltena* (the Old High German word *phalt* = *Falt* means “pleat”!). It is a textile for which the Franks of the East and the Slavic People have to pay taxes to the bishop of Würzburg (Germany); this means that this textile was of a local tradition and probably quite expensive (MÜLLER 2003: p. 90, footnote 144).

Discussion

As the survey on archaeological textile finds up to AD 1000 has demonstrated, during European history different textile types have been used to create three-dimensional



Fig. 15. Zenica (BIH): grave plate with persons wearing pleated garments, late Antique (Photo: National-museum Bosnien und Herzegovina, Sarajevo).

linear structures – some of them by the use of specific spinning and weaving techniques, some of them with the post-processing of a flat textile, *i. e.* plissé.

Chronological issues

The first attempts to create decorative structures on a woven textile can be traced back as far as European Neolithic and Bronze Ages, working with lines in twill structure on tabby weave for creating ribbed structures. Looking at early civilisations, pleated linens were common in Egypt from at least 2800 BC and onwards. Pictorial sources from the Ancient Near East and Bronze Age Greece also point to the use of pleated textiles; albeit there are no actual textile finds, we do not know which technique was applied to produce that structures. In Central Europe, pleated textiles appear from the Iron Age on, which is more or less the 1st millenium BC. At the same time, in Europe we find three-dimensional linear structures made with spinning and weaving techniques, as is demonstrated by three-dimensional spin patterns (combination of thinner, hard spun single yarn and thicker soft plied yarn) from the Hallstatt Culture. The specific effect of such textiles is also depicted in contemporary iconography.

The pleated and three-dimensional effects with wool are chronologically later than the production of such structures with linen textiles. The Egyptians had developed plissé



Fig. 16. Isidor presenting the work to sister Florentina, c. AD 800, Abbey of Corbie (Bibliothèque Nationale de France, Latin 13396 fol. 1v; © Bibliothèque Nationale de France).

textiles with fine linen, technically resembling the early wool patterns. This might have gone hand in hand with developments in sheep breeding, namely the appearance of wool with fine crimp, which can be identified from the Hallstatt Period onwards (RAST-EICHER 2013). Wool is more elastic than plant fibres and is therefore better suited for pleat structure creations. Wool with crimp, together with hard spinning, supports a crepe effect and, therefore, three-dimensional structures.

Interestingly, during the Roman Period this kind of pleated textile structure does not seem to be important in Central and Western Europe – the Roman textile industry is based on different design-principles. The plissé textile from a late antique grave in Trier might be of Germanic influence, but s-spun threads in warp and weft tend to come from regions south of the Alps – Italy and/or Spain – or Egypt. Plissé textiles and textiles with such pleated structures reappear in the Early Medieval Period, and then also a new textile structure, the barred damask type, was introduced.

The chronology of the barred damask type demonstrates that this weave type expanded from south to north (RAST-EICHER 2002b). The barred damask has been found at Roman sites in Egypt (1st–2nd century AD, see above), even as a variant of the 3/1 twill barred damask, which has not been found in Europe; however, a variant of this is known as block damask woven in silk (WILD 1970; BENDER JØRGENSEN 1991: pp. 83–96; CISZUK 2004; REIFARTH 2013: p. 264). Block damask does not have a three-dimensional effect like barred damask. Nevertheless, it is interesting that block damask has not been found in the elite graves of the 6th/7th century AD in Saint-Denis/Paris – it seems to have been a typical Roman textile.

If we look at the chronological development in Europe, we can see that the barred damask appears in the late 6th and 7th century AD in Southern Germany and Eastern Switzerland. However, it is not present in Western Switzerland and France except the textile from Meikirch near Bern (Fig. 17). In these regions, the (Gallo)-Roman textile types such as the weft-faced wool tabby for tunics (found under the girdles) are present, but not in Germanic territories such as Germany, Northern France, and Eastern Switzerland. This data is important, especially because in Northern and North-Western France, among the many textiles seen in large and rich grave yards such as the royal tombs of Saint-Denis/Paris, barred damask is not present (CARRÉ *et al.* 2015). This type, furthermore, is not present east of Central Austria, a territory inhabited by the Avars (Fig. 18).

Geographically, there are interesting differences in the Early Medieval Period. Plissé textiles can be found usually in France, Germany, and Switzerland; the exceptions concern one textile from Southern England and one from a Lombard (Germanic!) grave in Maria Ponsee in Austria (see Fig. 12). The latter is especially important, because the tribe of the Lombards migrated from the North of Europe towards the Danube region in Austria, and then finally after 568 towards Northern Italy (Lombardy!) where they founded a kingship (MENGHIN 1985). Also, a single find from Sutton Hoo in England underlines the Germanic tradition of pleated textiles (CROWFOOT 1983: pp. 404–479, especially fig. 319). The 6th/7th century AD barred damasks are

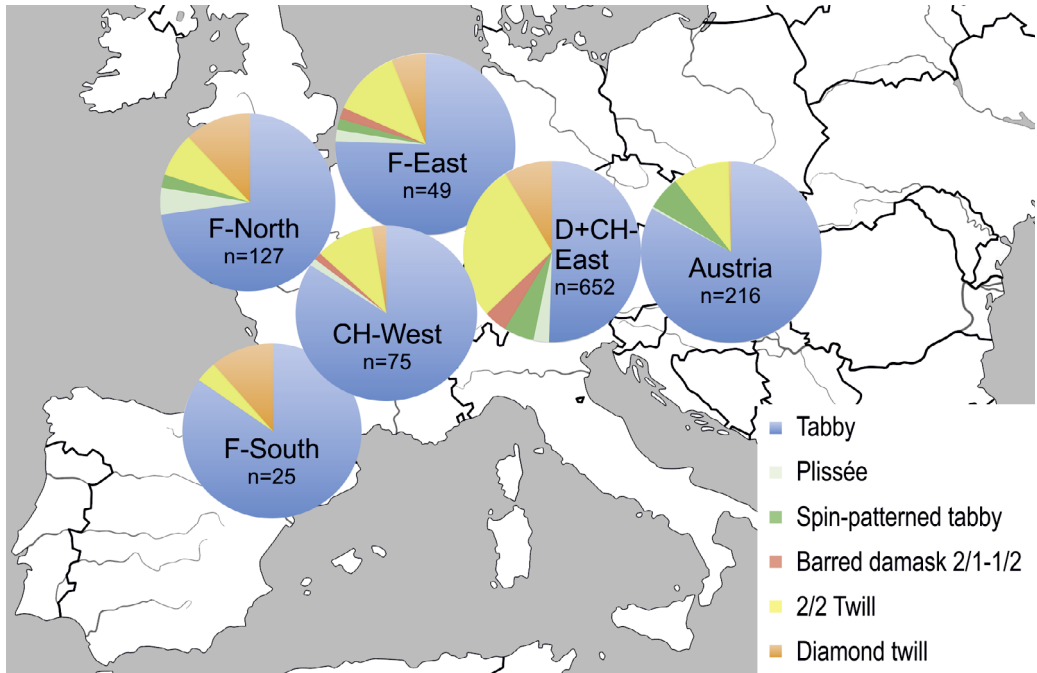


Fig. 17. Main textile types in Europe, 6th and 7th century AD (Drawing: A. RAST-EICHER).

restricted within the Germanic traditions geographically to Southern Germany and North-Eastern Switzerland.

In the later Early Medieval Period, after AD 700, textiles are not present in the graves in Western Europe; however, in the rising Viking towns such as Birka in Sweden fine pleated textiles (plissée, no barred damask) have been found in the back of large tortoise pins, fastening an upper tunic (GEIJER 1938).

Pleating had become, during later periods up to modern time, an important part in textile design, especially for costume and fashion. A quick overview through European fashion history (see *e. g.*, BÖNSCH 2001) informs us that, for example, pleated textiles were used in the Renaissance as well as in the 1920ies. This cloth type is also periodically reappearing in modern fashion design since the 1960ies, most recently in the winter season of 2017/18.

Visual coding – textile identities

Visual effects in woven textiles seem to be very old. Men and women tried to embellish the textiles used especially for garments. As we have seen, different techniques were introduced to transform a flat woven cloth into a three-dimensional one, or even to imitate such a structure by weaving. The effect of all of that – to apply the modern term

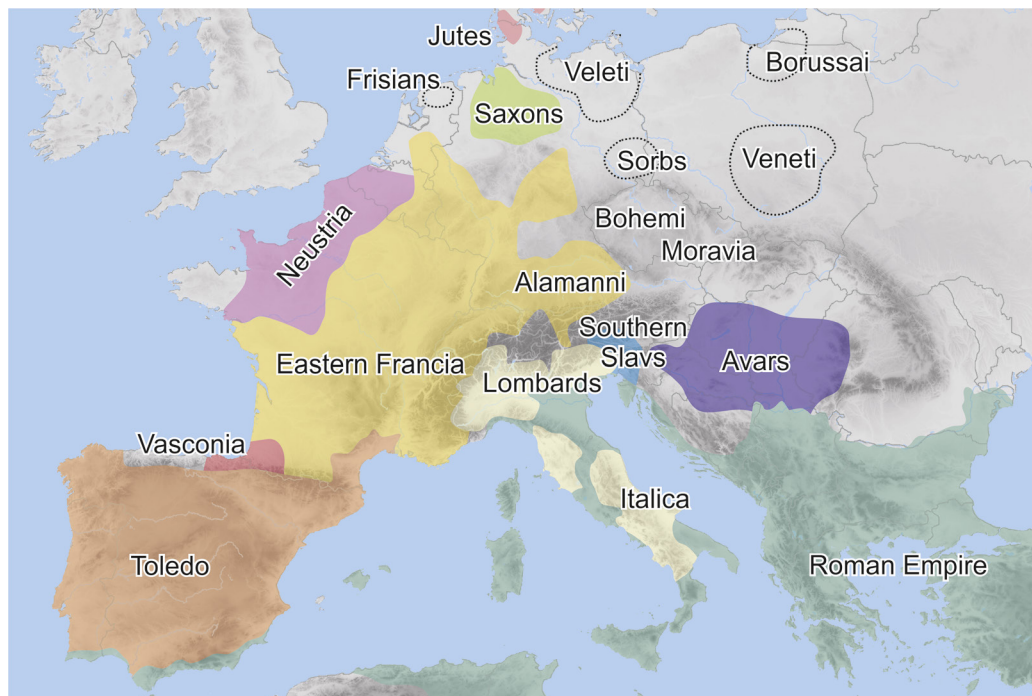


Fig. 18. Europe in the early Medieval Period, beginning 7th century AD.

“fullness” from the introduction again – had a specific variety. Three-dimensional spin pattern has less fullness than barred damask; the best technique to create 100% fullness is plissé. There, pleats are created by post-processing of a flat textile by folding (pleating) and subsequent pressing, or the like, to make the folds durable. Early Medieval folds are of about 7 mm depth, carried out as round or sharp pleats.

Especially plissé and also barred damask is highly visible from a certain distance and shows the person in a very distinct style, as the longitudinal linear structure enhances the body silhouette when worn as a fitted garment. As explained in the introduction, textile structures as well as colours and patterns are part of a visual effect and thus a visual code within a specific society. Those visual codes transport non-verbal information about the wearer.

For the Neolithic and the Bronze Age Central Europe, our knowledge is too poor to make statements about who was wearing textiles with such pleated structures. On the Iron Age *situlae* we can identify a man in a tunic with pleated structure as well as a woman wearing a veil with the same structure. At the Iron Age sites of Giubiasco and Bulle, textiles with pleated structure appear in both male and a female graves. The plissé textile from Verucchio has been found in a rich man’s grave. These few Iron Age examples show that men and women were using textiles with pleated structure in Europe at this time.

For the Early Medieval Period, we have much more evidence of garments with pleated structure such as plisse and barred damask. This offers a wider basis for a discussion

about the social status and the gender of the persons wearing them. It is obvious that this type of textile was linked to the richer part of a community. In Schleithelm (canton of Schaffhausen, Switzerland) and in Baar-Früeburgstrasse (canton of Zug, Switzerland) the richest women of the 7th century AD found in these graveyards wore pleated tunics (one plissé, the other barred damask). In these graveyards no men with pleated garments have been found, but in a late 7th century AD men's grave in Meikirch (canton of Bern, Switzerland), a pleated garment has been found on top of a girdle plate. The placement on the girdle suggests a coat instead of a tunic as in women's graves. The two women's graves (38 and 48) in the Basilica of Saint-Denis (Paris, France) with plissé textiles demonstrate that this type of garment was worn in the highest classes of the society, even by the royal family (RAST-EICHER in prep.). Early Medieval plissés have been used by men, women, and children. Such garments, plissé or barred damask, might have had a specific visual effect that surely was recognized by contemporary people.

In those cases it can be stated that barred damask is a weave type that is more time-consuming in production than simple tabbies or even simple coarse twills. Furthermore, to create 100 % fullness, plissé (pleated tabby), needed much more cloth than for a similar garment made of simple tabby – the amount is about three times higher than for a simple tunic (for each depth of the folds). Therefore, maybe the amount of cloth, as well as a type of cloth woven in a time-consuming technique, might be a hint for higher strata of society. Such mechanisms can also be detected in other cultures (*cf.* CORDWELL & SCHWARTZ 1979; FEEST & JANATA 1989: pp. 161–163, 225–226; LEVENTON 2008: pp. 184–223, 256–275). Different fabric types and qualities, as well as the amount of material used, can be an important tool for the differentiation of social ranks, even if the cut pattern of the garments remains the same in broad terms within a culture. In Early Modern India for instance, only the high castes and the nobles were allowed silk fabrics, sometimes pleated, whilst the lower classes were only allowed simple cotton and wool tabbies.

Additionally, the fact that in Early Medieval Europe barred damask as well as plissé fabrics can mostly be found in a well-defined geographical area (despite of very rare finds in England or Denmark) which was then inhabited by the Bajuvarians and Alamannic, could lead to the interpretation of a specific visual code. Are we able to trace the higher social classes of Bajuvarians and Merovingians? Future research with more data from graves will enable us to come to more conclusions for that question.

Effect with body movement and body language

As stated in the introduction, clothing, body movements, and body language are all part of a performance, communicating a message. It is an interesting challenge to look at pleated structures from a movement and performance perspective. Textiles with different kinds of three-dimensional linear structures have a great variant in how they interact with the body, especially in their use of space. Generally, it has to be stated that

plissé with 100% fullness has two different effects on body language – depending on the specific use. If worn as a wide swinging garment – a wide skirt, dress or the like – it supports movement, expands the shape of the garment, swinging wide. On movement, such a garment takes up space, and enlarges the body size of the wearer. The same type of cloth, worn as a fitted garment (or even as a narrow draped garment), behaves in a different way; it moves along together with the body, forming a distinct body silhouette, enhancing natural forms. Furthermore, such a garment must have been very comfortable. Pregnant women did not need another garment – a pleated garment is very elastic and provides enough room for the baby as well. And last but not least, as the textile is elastic, it looks quite erotic, taking up all the curves of the body.

Those effects described for plisse textiles can also be stated for other cloth types with pleated structure. It has to be taken into account that for barred damask, and especially on three-dimensional spin pattern, the effect is weaker than for sharp knife pleats.

It has to be asked, which of those effects – the wide flaring one or the enhancement of the body silhouette, was intended in prehistoric and Early Medieval societies. For Ancient Egypt it seems as if the accentuation of the natural body silhouette is an important design principle. That can be seen in various works of art, and also the plissé garments fit well into this context. The Iron Age evidence in Central and Southern Europe, especially the Verucchio garment and the Etruscan statuette, also point to the enhancement of a slim body silhouette. Situla art, like the example from Vače, is not that simple to explain. On the one hand, the depiction of pleated structure on the garment of the man sitting on the throne follows the lines of his body. On the other hand, the veil of the woman, decorated in the same way, covers and more or less encloses her.

For the Early Medieval Period, the use of cloth types with pleated structures involves fitted and flaring garments. The women's pleated garment – the tunic or over-tunic can have a narrow cut or can even be wide. The men's cloaks are usually wide flaring, as suggested by various depictions in contemporary art (Ivory of the CARRAND collection, Florence, SANGIORGI 1895: fig. 50).

To end with a modern example: Accordion pleats or knife pleats are a form of tight pleating which allows the garment to expand its shape when moving. Accordion pleating is also used for some dress sleeves, such as pleating the end of the elbow, with the fullness of the pleat gathered closely at the cuff. This form of pleating inspired the “skirt dancing” of Loie FULLER⁶, a famous artist of the beginning of the 20th century AD.

Conclusion

Different techniques to create pleated textiles have been documented since prehistoric periods. There are surface patterns with lines of twill structures in linen textiles and lines with thick multiple plied yarns. An important step was taken when people discovered

⁶ https://en.wikipedia.org/wiki/Loie_Fuller. 6/12/2016

that textiles with hard spun threads were especially well suited to create folds. This has been the case with the textile from Hallstatt, using in combination single yarns and plied yarns. Depictions of this period prove the use and desired effects of plissé. According to our current state of knowledge, the Verucchio (I) and Carmona (E) examples are the first plissés in Europe. The Hallstatt (A) textile shows a structure very similar to plissé; the technique is a bit different than pleating after weaving (plissé), but the intention of creating pleats might be the same. It is interesting that all three pleated fabrics of Hallstatt have been made with hard spun yarn, the same as the later plissé in the Early Medieval Period (see Fig. 9). It was obviously clear in early times, that wool textiles needed to be crêpe-like, so that folds would hold. The spinning of the Verucchio textile is not specified in the technical description, but Fig. 10.11 in STAUFFER (2012) shows a crêpe textile.

In spite of the rare finds during the Roman Period for the plissé technique, the tradition goes on at least until the Viking Period. One of the scarce plissé textiles in Europe dated to the Roman Period is woven with s/s-spun yarn – a spin-direction which is traditionally south European or Mediterranean. The special barred damask, which is more demanding in weaving technique (twill instead of simple tabby) arrived in the Roman Period and was probably taken up in the Alamannic and Bajuvarian regions of South Germany/Switzerland. However, in these regions it was mostly produced in linen and not in wool, as in the Roman finds. The linen barred damask, therefore, seems a development of the Roman wool barred damask.

The study presented also highlights that the pleated structure had a specific impact on the visual appearance of the garments made with such a cloth. Besides this, body language and body movement, together with expression of identity, were linked to such textiles. Compared to other textile types, more effort was put into making them (more time and know-how of the weaver for barred damask was needed). Especially for Early Medieval Europe, there is a link between pleated textiles and the richer strata of society – maybe serving as a specific connotational code for particular social and aesthetic values.

Even today, pleated structures are used in fashion design – sometimes for enhancing body silhouettes, and sometimes for flaring skirts, as seen at the 2017/2018 winter season fashion shows.

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