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A 5th–6th century Sasanian silk taqueté with simurgh design: new analysis and hypothesis of early patterned weaving transmission in Eurasia

Eric Boudot*
Independent scholar

Abstract

The structural analysis of an exceptional Sasanian unspun silk taqueté (weft-faced compound plain weave) from the Chris Hall collection confirms that a sophisticated loom equipped with a patterning system allowing for a mechanical pattern repeat in the weft direction was present in Central Asia as early as the 5th–6th century CE. In this article, comparisons are made with some important published fragments, and the technical aspects of luxurious silk compound weaving in the Silk Roads in the 5th–6th century CE are discussed, along with the introduction of unspun silk and the gradual spread of sericulture, silk yarn production, and silk weaving from East to West Eurasia. A hypothesis regarding the type of loom mechanism used to produce the taqueté weaving is also presented here, based around a zilu-type loom with a vertical warp; this is placed in the context of the development of patterning systems along the Silk Road region and technological exchanges that may have taken place. This line of technology development may have contributed to the appearance of fully-fledged drawlooms in both China and Central Asia.

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* boudot99@hotmail.com

Introduction

The first millennium CE was a period during which major transfers of weaving technology occurred between the West and the East of Eurasia. This led to a radical transformation of Chinese textile art, which was largely complete by the middle of the Tang Dynasty (618–907 CE). Having excelled for more than a thousand years in weaving warp-patterned compound silks, Chinese weavers of the first millennium made a gradual shift to weft-patterning techniques for the production of new types of polychrome silk textiles, starting with weft-faced compound plain weaves (referred heretofore as taquetés) and culminating with the weft-faced twill weaves (samits) of the Tang and Liao Dynasties.[1]

The complex web of interactions between the weaving cultures of Eurasia, occurring over a multitude of distant workshops, had a considerable impact on the historical evolution of textiles. The overland Silk Road region encompassed many ancient weaving traditions, which pooled together a variety of iconographic styles and weaving structures, and, most importantly, different specialized loom technologies. The interactions amongst these traditions over many centuries sparked totally new, or sometimes convergence and refinement of, woven structures and designs. This gradual phenomenon eventually gave birth to loom patterning systems that enable a mechanical (exact) pattern repeat in both the warp and the weft directions, ultimately resulting in the ancestor of modern complex patterning looms: the drawloom.

In this article I argue that key steps in this assimilation took place in several areas located midway along the Silk Roads, for the most part in the Sasanian world (Persia and Central Asia), but probably also in Xinjiang and Qinghai. These are areas which today are part

of the northwestern provinces of China but which were not sinicized at the time. I will further argue that taqueté played a very important role in this assimilation. Taqueté appeared in East Asia around the 4th century CE and disappeared around the 7th century CE. It is most likely that through this technique a major technological transmission occurred during the mid-first millennium CE.

The origins of taquetés

The earliest known taquetés were made of wool. They have been found in the eastern Mediterranean region, on the site of Masada in Israel,[2] as well as in Berenike, a trading port on the western coast of the Red Sea. They are dated to the 1st century CE.[3] Based on these early fragments most researchers consider that taquetés were first produced in the Mediterranean or North African region.[4] However, there remains future possibility that equally early woollen taquetés could also be discovered in other areas such as Iran, Central Asia, or even northern India. As Tim Williams noted: 'Goods and people did not simply flow from East to West and vice versa. Many of the materials traded emanated in Central or South Asia and many of the ideas that moved along the Silk Roads started in neither the East nor West (e.g. Buddhism).'[5]

By the 3rd to 4th centuries woollen taquetés were traded all the way to the eastern section of the Silk Roads, as shown by the numerous examples excavated in Xinjiang Province, mostly at the archaeological sites of Yingpan, Niya, and Loulan.

The taqueté weave was subsequently adapted for use with silk yarns, presumably first in Central Asia by employing locally produced Z-spun yarn of short discontinuous silk fibers, as opposed to long continuous reeled silk. By the 3rd or the 4th century, silk taquetés were probably already being woven locally in Xinjiang. Numerous examples of these early, Z-spun silk taquetés have been found in eastern Eurasia, mostly in Xinjiang (Zagunluk, Loulan, Yingpan, Astana, Niya), but also in Gansu (Huahai Bijiatan[6] and Uzbekistan,[7] see diagram fig. 1 and map fig. 2). Some silk fragments have also been discovered near the western end of the Silk Roads, notably in Syria on the site of Dura-Europos, a city that was destroyed in 256 CE, providing us with a *terminus ante quem* date for the textiles.[8]

Most scholars agree that Z-spun silk taquetés were woven in Xinjiang (Gaochang, Kudja) with silk floss from locally raised silkworms.[9] Outside of China proper, the practice of using spun silk from broken filaments rather than reeled silk has two probable causes. Firstly, as indicated in the Hanshu 漢書,[10] a text from the second century (111 CE), Chinese authorities only allowed silk exports to outside China in the form of either silk floss from damaged cocoons or finished silk fabrics. This rule, which prohibited export of long continuous silk fibers, lasted until the early 3rd century, probably in order to avoid competition from non-Chinese weavers for the most valuable silk textiles. Secondly, when sericulture developed in Xinjiang around the 3rd–4th century CE (map fig. 2), the local weavers were Buddhist; following the Buddhist code of non-violence, they would have been unwilling to boil the chrysalis alive, whic is the only way to obtain continuous silk fibers. Instead, they would have let the moths escape, thereby breaking the silk fibers that make up the cocoons.

It is only around the 4th or the 5th century that we find unspun silk yarn made of continuous reeled silk fibers (probably of Chinese origin)[11] being woven in taqueté. Most likely, this phenomenon first occurred within the Sasanian cultural sphere,[12] but it is also possible to have it originated in areas closer to China, such as Qinghai or Xinjiang, even Sichuan.

It is logical to assume that weavers already familiar with weaving Z-spun silk taqueté would adopt and switch to using reeled silk yarns as they gradually became available because of their superior quality (smoother, longer, and stronger). This transition was not a simple or 'overnight' change, as taquetés in both yarn types have been found in tomb 170 of Astana cemetery, dating from the mid-6th century (543–562 CE). They are a pair of woman's trousers of Z-spun silk (TAM170:60-1) and two fragments of unspun silk (TAM170:60-4[13] and TAM170:66).[14] These examples tell us that both types of yarns coexisted and perhaps the choice of using one or the other was related to differences in price and availability. It is also possible that different yarns were preferred to make specific products.

Some of the earliest silk taquetés woven with unspun silk wefts have been discovered on archaeological sites extending from Egypt to Northwest China. Judging from their iconography, they were probably woven in workshops located along the central and eastern sections of the Silk Roads, in an area encompassing Iran and Central Asia, as well as Xinjiang Province. In my view, the iconography of these textiles rules out the possibility of a Chinese production, despite the fact that a few Chinese characters appear on some of them (see note 33).

One exceptional example is an early silk taqueté fragment in the Chris Hall collection (referred as CH002, fig. 3). This piece has been carbon 14 dated to the 5th or the 6th century (432–605 CE with 95% probability).[15] It bears a Sasanian-style design, and it is woven using unspun silk weft yarns that were most likely exported from

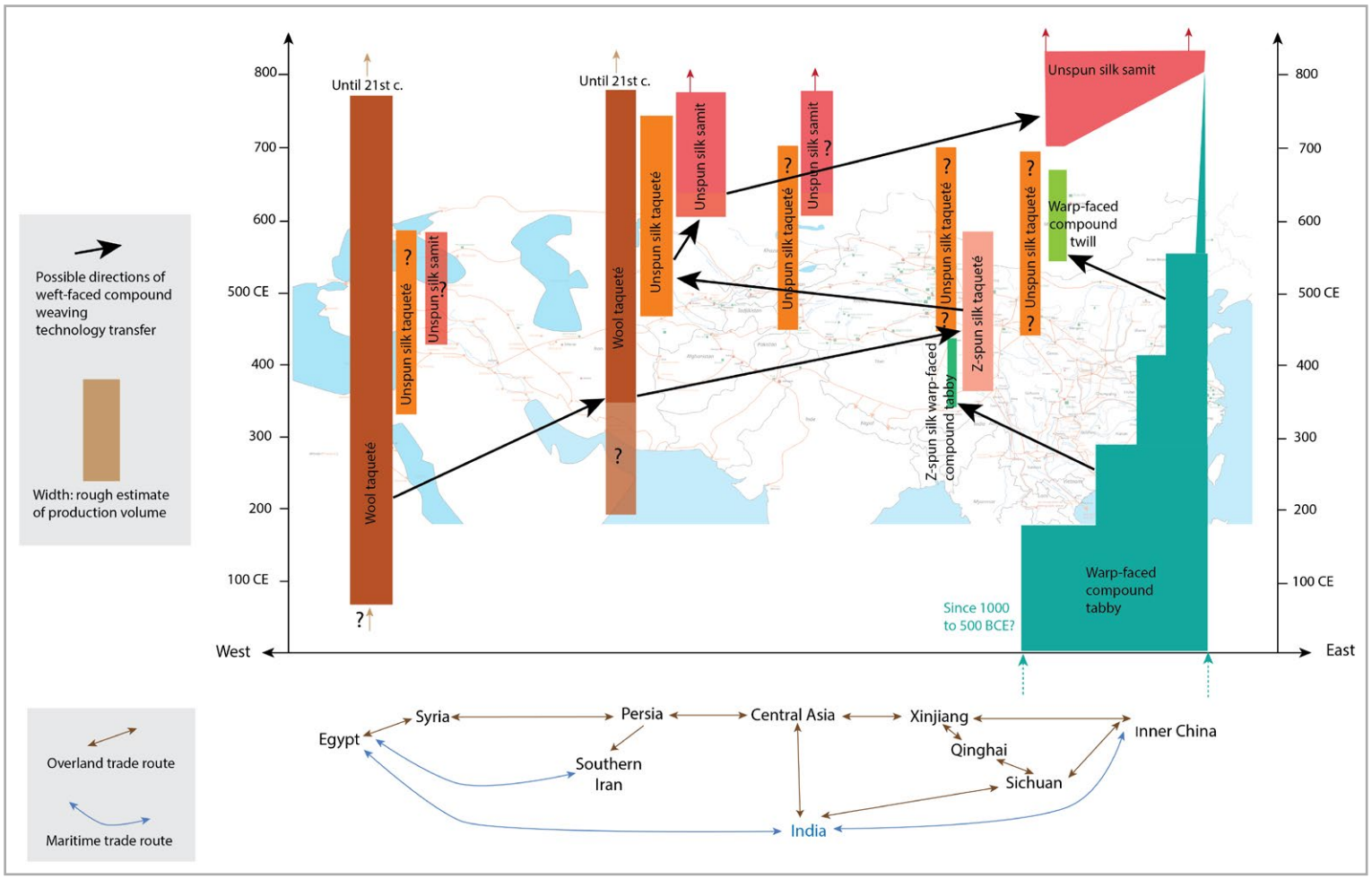


Fig 1. Diagram of the inferred interactions of woven structures across Eurasia in the first millennium CE.

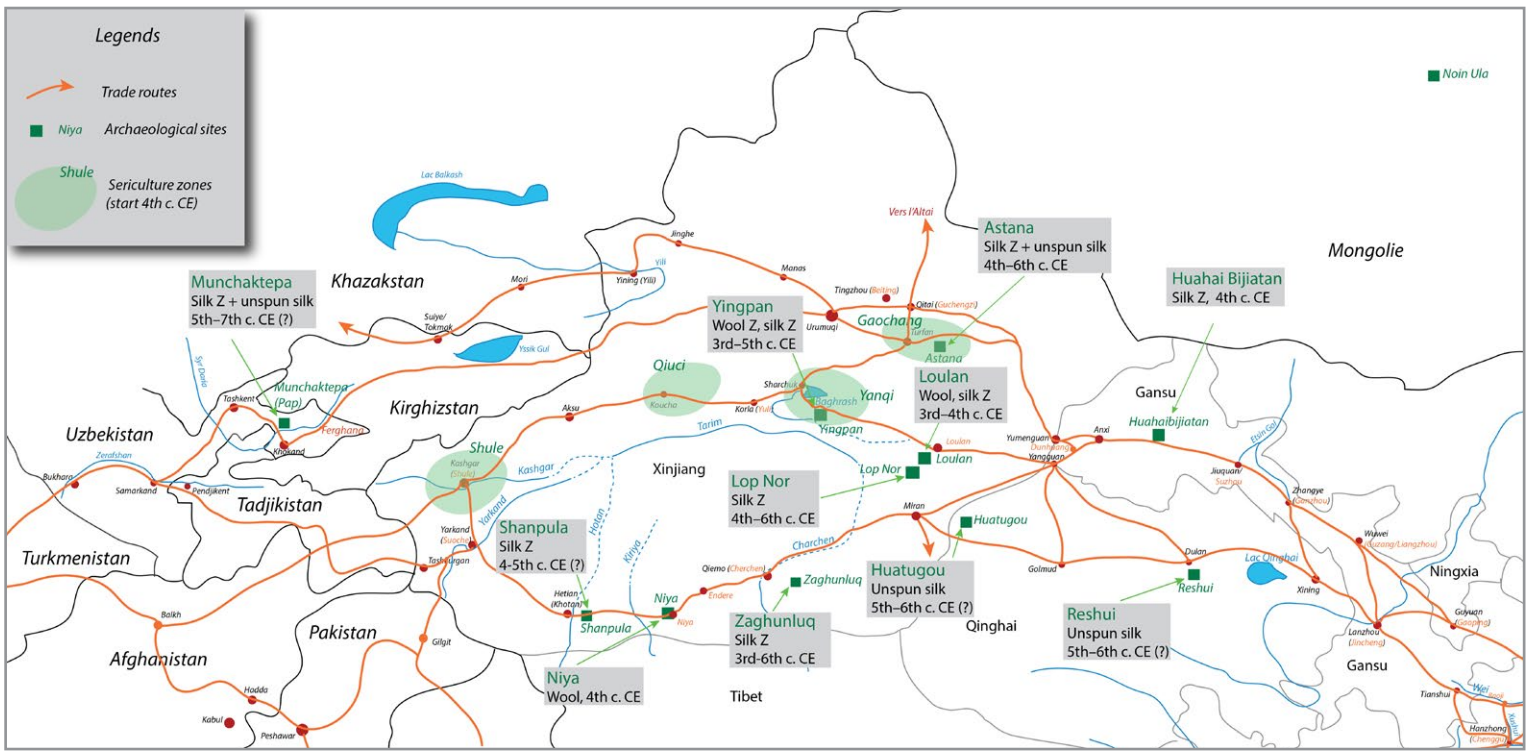


Fig 2. Map of sites where taqueté fragments have been found in northwest China and Uzbekistan.

Fig 3. Fragment CH002, unspun silk taqueté, ^{14}C date of 432–605 CE with 95% probability. Dimension 69.4 x 48 cm (Chris Hall Collection, photo by E. Boudot).

China. My analysis of this fragment shows one of the most impressive accomplishments of the technological and artistic interactions and even 'collaboration' across Eurasia during the middle of the first millennium CE. For this purpose, the analysis concentrates on the technical characteristics of pattern repeats and mirror symmetries, as well as on 'anomalies' observed in structural arrangements at color junctions. Data from the fragment's technical characteristics, comparisons with other known fragments, and observations from present ethnographic practices, inform my hypotheses concerning the loom mechanism and the patterning process that may have been used to produce this early silk taqueté.

Sasanian iconography

While there is unfortunately no record on the exact archaeological site from where fragment CH002 was discovered, we know that it was found in China. We can assume that it came from a site located in the dry regions of Northwest China, most likely Xinjiang, and possibly in the Turfan area (Astana), where closely related specimens have been unearthed in the past (fig. 4). Other possible sites for its provenance are the neighbouring regions of Qinghai, Gansu, Inner Mongolia, or Tibet Provinces.

The textile's iconography suggests that it was produced from within the Sasanian cultural sphere.

Simurgh/ senmurv motif

A row of symmetrical pairs of fantastic animals can be seen decorating this textile. On figure 3 their forelegs are shown stretched downwards and the wings and tails flared up. These animals can be identified as the Sasanian simurgh, or senmurv, a mythological female creature with a hunting dog's head, the claws of a lion, a bird's wings and tail, and a silk ribbon around the neck that associated it with royalty.[16] It was often referred to as a 'bird dog.' Mateo Compareti describes it as 'a winged creature with the face and forelegs of a dog, the paws of a lion and a long tail which resembles that of a peacock

Fig 4. (left) Fragment of unspun silk taqueté, c. 5th–6th century, probably unearthed near Astana in Xinjiang. Dimension 80 x 32 cm. It has technical characteristics similar to fragment CH002, with a two lats weft sequence. Its pattern height (warp direction) is over 80 cm. The iconography is Central Asian but with added Chinese character *ji,* meaning auspicious (Beijing Fashion Institute of Technology, MFB003940).

Fig 5. (above right) Sassanid plate decorated with the simurgh motif, c. 7th–8th century (after https://educalingo.com/fr/dic-en/simurgh).

Fig 6. (below right) Silk samit with simurgh enclosed in a pearled roundel, c. 7th–8th century. Dimension 54.3 x 36.5 cm. This fragment came from the same weaving as two pieces associated with the relics of St Helena at St Leu in Paris, now in the Musée des Arts Décoratifs (Victoria and Albert Museum, London, 8579-1863).

or a fish.'[17] He remarks that some researchers interpret the simurgh as a manifestation of Sasanian royal glory. Some of its distinctive features such as the elongated dog's head, the 'floating' ribbon,[18] pointed ears, a pair of wings, and a curvilinear tail with two or three volutes, can be seen on a Sassanid-style plate dating from the 7th or the 8th century CE (fig. 5). The general straight and 'rigid' shape of the simurgh on the early fragment CH002 suggests that the motif was ultimately inspired by the lithe figure of an Afghan hound, one of the most popular hunting dogs in ancient Persia.

Other published woven examples with simurgh are, to my knowledge, only found on silk samits, dating from about one to three centuries later than CH002 (fig. 6).[19] These later pieces have mostly been found in archaeological sites and other contexts in the western world (Moshchevaya Balka in the Caucasus, as well as several churches in Europe dating from the Carolingian period, such as Rheims, San Salvatore Abbey). Gasparini has published a samit example conserved at the China National Silk Museum in Hangzhou, which possibly came from the Qinghai Province in northwest China.[20] On these samits, the simurghs appear as single, not paired, and are confined within a roundel (most often with a pearled-border). Compared to the simurgh woven in the earlier taqueté fragment CH002, the simurgh in the later samits has changed their body shapes from a rectilinear to a coiled figure, probably to accomodate roundel configuration (fig. 6). Their hind legs have also disappeared and their tail is noticeably different.

The 5th–6th century ^{14}C date of fragment CH002 makes it one of the earliest known woven representations of the simurgh. Depiction of people in costume with simurgh motifs (possibly woven) are found in large numbers, painted on cave walls or carved in stone in *bas-relief*; they appear all the way from Samarkand (present-day Uzbekistan) to Syria and Jordan[21] (which was briefly occupied by the Sassanids). Compareti has noted that one individual wearing a robe with simurgh motif on the 660 CE Sogdian painting of the western wall at Afrasyab (ancient Samarkand)—known as the 'Hall of Ambassadors'—may have been the Sasanian king Yazdigard III (r. 632–651 CE, figs 7, 8).[22] Katsumi Tanabe[23] also identifies Yazdigard III, otherwise known as the 'King of Kings', as the person wearing a robe with simurgh motifs on the stone reliefs depicting a royal boar hunt (figs. 9, 10, 11) at Taq-e Bostan (Iran). The exact date of these reliefs is still debated, but is probably around the 5th–6th century CE. Marshak has made a direct connection between the two depictions: 'The senmurv represented [on Afrasiab paintings] is purely Sasanian. It is like that of Taq-e-Bostan.'[24]

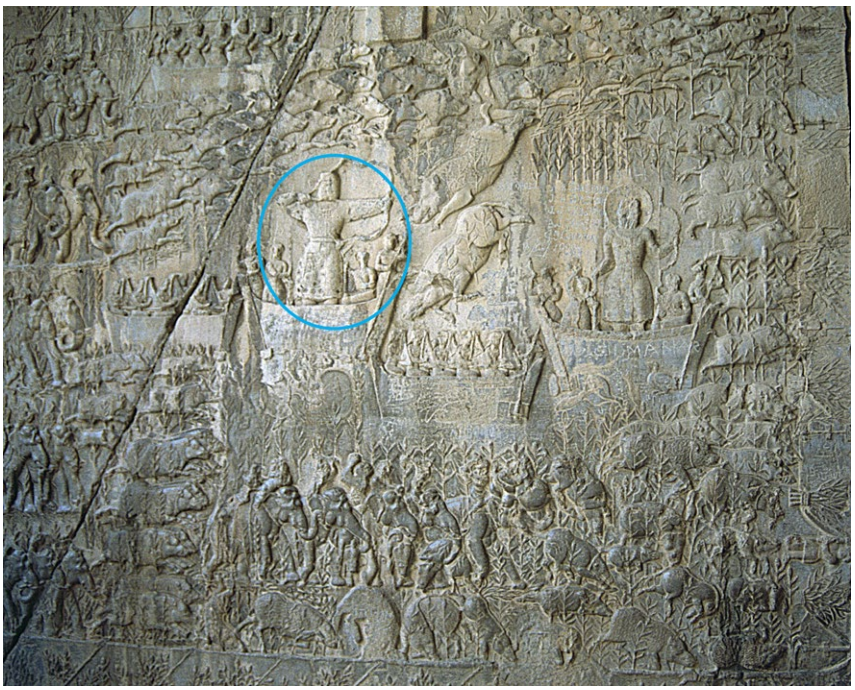
Graphic composition

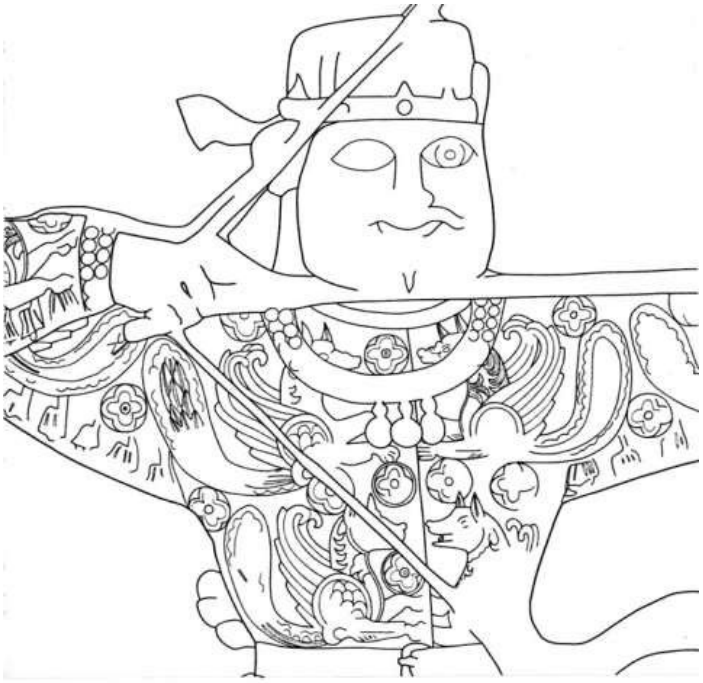
In addition to simurgh, fragment CH002 is decorated with stylized shapes that suggest architectural features. The overall design is composed of relatively narrow (about 9 to 10 cm) repeats in the weft direction with vertical mirror symmetry axes. Presumably, the repeat in the warp direction is much longer, probably more than 48 cm.[25] The same decorative layout can be observed on another taqueté fragment with unspun silk yarn, which was discovered at Antinoë in Egypt and dated to the same period (320–430 CE) (fig. 12). Several fragments with the same decorative style, material and technique have also been unearthed on the site of Astana in Xinjiang.

Another important comparison to fragment CH002 is a silk taqueté (unpublished) that is decorated with very similar stylized architectural composition and colors. But instead of the vertical and rigid simurghs, there are hunting dogs without floating ribbons.[26] Frantz Grenet has noted that Sasanians regarded dog as being at the top of the animal hierarchy.[27] The apparent interchangeability between simurghs and dogs iconographies on this group of taqueté fragments reinforces the argument that fragment CH002 is a product of the Sasanian cultural sphere. A caution, however, was put forward by Schrenk concerning some silk fragments that were discovered at Antinoë and have been attributed to Sasanian culture: 'We postulate a place of production in which, to date, no textiles of this kind have been found in situ.' It is true that no similar silk taqueté has been found in archaeological sites associated with the Sasanian cultural sphere despite the many wall depictions that show such type of textile.[28]

In discussing provenance, we must also take into account the fact that craftspeople are known to have moved or been relocated (willingly or unwillingly) along the Silk Road region. Craftspeople were often spared after conquest, to be enslaved and transported over long distances to work at the court of the victorious power. Female domestic weavers, marrying into or enslaved by a different ethnic group, moved in with their husband's or master's families, adapting their own customs to new weaving traditions, and sometimes vice versa.

To my knowledge, nothing remotely similar to this combination of decorative architecture and fantastic beasts appears on Chinese silk compound weaves of the first millennium CE. To summarize, though this textile may have been found in the remote western regions of what is now China, the weight of evidence suggests that it was woven still further west, probably in the Persian world.

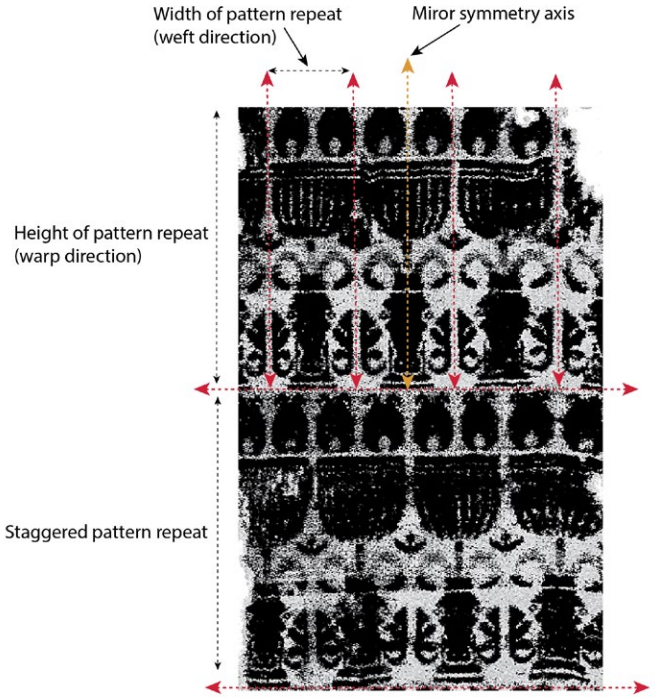




Figs 7, 8. (above left) A Sasanian envoy, possibly king Yazdigard III (r. 632–651 CE) depicted on the 'Hall of the Ambassadors' wall painting (c. 660 CE) in Afrasyab, near Samarkand, Uzbekistan. The garment is decorated with simurgh motifs (after Compareti 2011).

Fig 9. (above right) Sasanian stone relief depicting a royal boar hunt at Taq-e Bostan, Iran, c. 6th–7th century; the Persian king Yazdirgar III (?) is wearing a garment decorated with simurgh motifs (after Tanabe 2003).

Figs 10, 11. (below left, right) Details of the king's garment decorated with simurgh motifs (after Tanabe 2003).



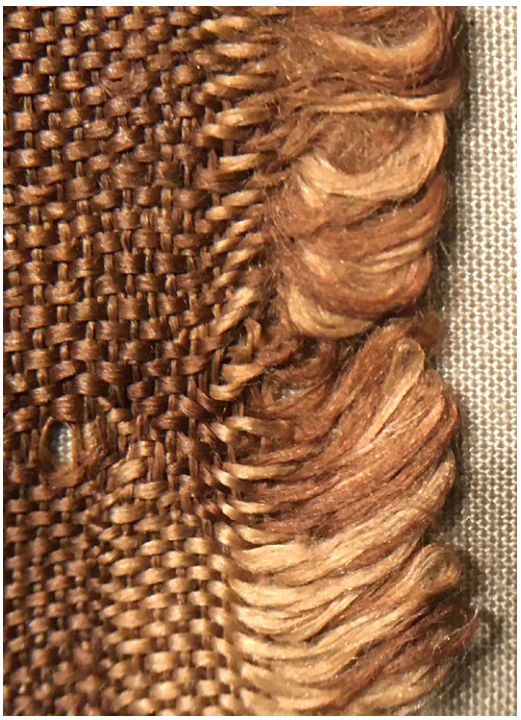


Fig. 12 (above left) Fragment of unspun silk taqueté found at Antinoë (Roman Egypt), 320–430 CE. It is decorated with cantharus motifs in 'architectural' composition. The widht of the pattern repeat in the weft direction is narrow, with a vertical mirror symmetry axis that is offset in the next row, creating staggered horizontal registers of the pattern. The taqueté structure has a three lats weft sequence (Musée du Louvre, Paris, E29180).

Fig. 13 (above right) Selvedge on the right side of fragment CH002, confirming that the textile is a taqueté.

Structural analysis

Technical analysis of fragment CH002

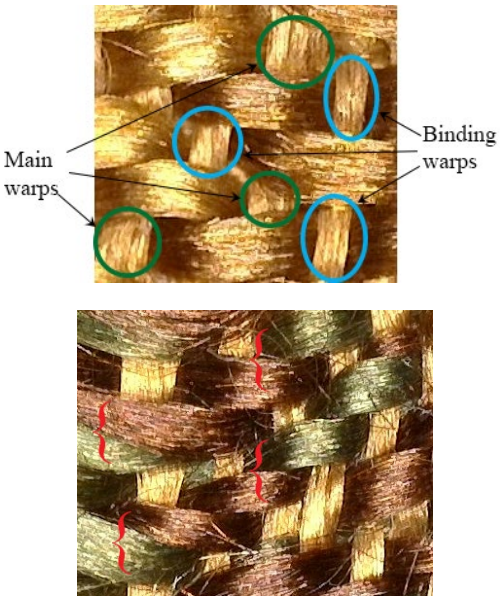
The fragment measures 69.4 cm by 48 cm. Its original width is unknown. Its original purpose is also unknown, though it may have been made for a garment worn by the aristocracy, as indicated by the painted or engraved representations described above. One selvedge is present on the right side of the fragment (fig. 13), confirming that it is a weft-faced compound plain weave structure.

As in any 'classical' taqueté, the woven structure comprises two kinds of warp. The main warps separate the weft sequences, leaving one lat visible on the front face of the textile (floating over three warps) and holding the other lat on the reverse (floating under three warps). The other kind of warp, referred to as binding warps, interlace the basic plain weave structure with alternating weft sequences of two lats belonging to the same pass. (see note[29] for definition of lat)

Thread counts

Fragment CH002[30] has a warp count of 26–28 yarns (13–14 main warps + 13–14 binding warps) per cm. This warp count is finer than that of most woollen taquetés (usually around 10–20 warps per cm), and similar to that of Z-spun silk taquetés (20–30 warps per cm). The thickness ratio of the main warp to binding warp is approximately 1.5:1. One main warp is generally composed of three to four parallel threads, while one binding warp is composed of two to three parallel threads (see fig. 14), but different combinations can be observed in the fragment. The fact that the main warp is generally thicker than the binding warp may be related to the Central Asian tradition of using a double main warp in conjunction with a single binding warp (2:1 ratio).

The patterning weft lats are also made of untwisted silk yarn (with long continuous fibres); passes are formed of two different color wefts. Brown is always present, and combined with another color, which may be golden yellow or indigo blue/green depending on specific horizontal sections. The order of the two color weft are in reversing sequences (1-2, 2-1, 1-2, 2-1) (fig. 15). It is worth noting that this exact sequence was also used for the warp order on earlier Chinese warp-faced compound plain weave. Its use here in this fragment points to a possible Chinese influence—a kind of 90 degree rotation from the warp to the weft technique



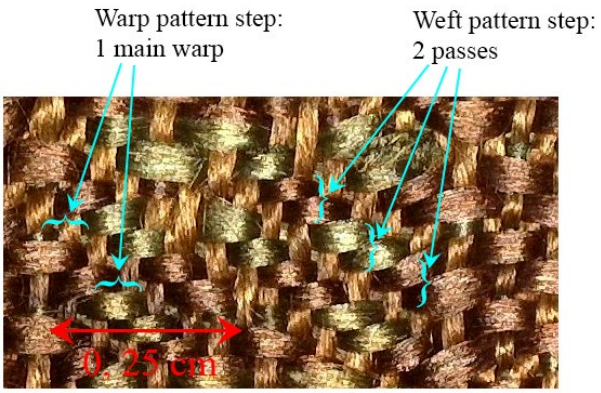


Fig. 14 (above left) Detail of fragment CH002 showing the relative thickness of the main warps versus the binding warps. Normally, main warps are thicker than binding warps, but in this fragment they are inconsistent.

Fig. 15 (below left) Detail of fragment CH002 showing the the two-color weft lats being organized in a reversing sequence: 1-2, 2-1, 1-2, 2-1. Here shown as [blue-brown] - [brown-blue] - [blue-brown] - [brown-blue].

Fig. 16 (right) Detail of fragment CH002 showing pattern steps.

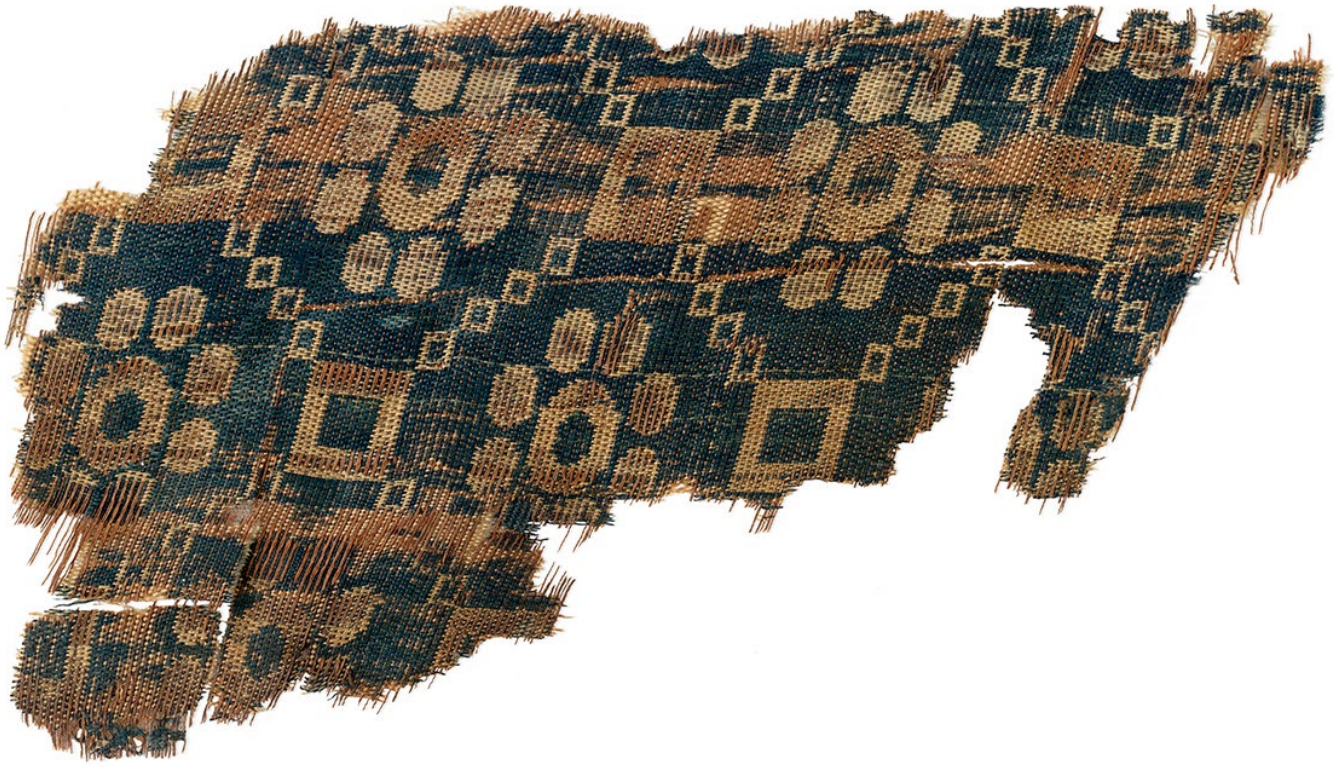


Fig 17. Fragment of unspun silk taqueté, with hexagonal petals flowers and a three lats weft sequence. It was found at Antinoë in a burial dated to 576–664 CE, but was probably imported. Dimension 10 x 9 cm (Lyon Textile Museum, MT28519.2).

The weft count of fragment CH002 has 20 patterning weft sequences (40 lats) per cm, which falls within the average of other taquetés (wool or silk) from the period. This is rather low when compared with the patterning warps thread count of earlier Chinese warp-faced compound plain weave (which usually have between 100 and 200 warp threads by cm). However, this low thread count is here compensated in terms of surface coverage by the remarkable thickness of the weft lats (averaging 413 µ, compared with a thickness of around 150 µ for patterning warps on Chinese warp-face compound plain weave).

Pattern steps (*decoupure*)
A pattern step defines the finest details that can be rendered in the woven design. The warp pattern step is composed of one main warp. The weft pattern step is of two passes, composed of two adjacent lats of the same color, belonging to two adjacent weft sequences that have been inserted in the same patterning shed (fig. 16).

Yarn thicknesses
The warps have an average thickness (*calibre*) of 268 µ, with a range of 196 µ to 352 µ; the wefts lats have a much higher average thickness of 413 µ, with a range between 337 µ and 565 µ.

Comparisons with a corpus of 27 fragments of unspun silk taquetés
I have been able to find 27 comparable examples of unspun silk taquetés, including published examples and fragments that I examined personally. Out of these 27 fragments, 21 were found at the eastern extremity of the Silk Roads, i.e. Northwest China in Xinjiang and Qinghai, and six were found in the West, namely in Egypt or in Europe as part of ecclesiastic treasures. These fragments have been dated to between the early 4th century and the late 6th century. This range of dates indicates that this type of unspun silk taqueté was woven for at least 300 years. By around the 7th century, this technique was apparently abandoned in favor of silk samits.

Comparison with unspun silk taquetés found in the West
Amongst the three documented unspun silk taqueté fragments discovered by Albert Gayet in 1897 on the site of Antinoë (Egypt), two of them appear to belong to the same type as CH002 and to the same weaving tradition.[31] One is in the Louvre Museum in Paris (E29180, fig. 12) and the other is at the Textile Museum in Lyon (MT28519, fig. 17). Technically, they are almost identical (though further analysis are needed regarding the use of structural anomalies to outline some motifs; see further discussion).

The Louvre E29180 (fig. 12) shares iconographic characteristics with CH002, as well as at least eight other examples found in Xinjiang (fig. 4). It also has relatively large pattern repeats in the warp direction (up to 80 cm) and shorter repeats in the weft direction, in units with mirror symmetry.

The second Antinoë fragment, Lyon MT28519 (fig. 17), is too small to permit the entire pattern to be comprehended, but the flower motif composed of hexagonal petals can be found on other examples of the same type of taqueté (see figs. 4, 18). This could indicate that this style of silk fabric enjoyed a wide popularity throughout Eurasia for at least two centuries.

The third unspun silk taqueté fragment discovered at Antinoë (MT26812/E29214) is decorated with an exceptionally fine and naturalistic 'walking lion.' It apparently belongs to a different school of weaving, but it is also considered to have been 'imported' from outside Egypt, possibly from Persia.[32] Further research will be necessary to determine the characteristics of this type of textiles, to establish different subtypes, and to identify their possible geographical sources.

The characteristic of paired-lats weft sequences (two colors forming the polychrome motif) observed in CH002 differs from the three examples found at Antinoë, where the weft sequences are composed of three lats (three colors forming the polychrome motif). This, however, does not necessarily indicate a different weaving tradition, as it should be relatively simple for a master weaver to use three lats instead of two lats per weft sequence.

Comparison with unspun silk taquetés found in the East
Most unspun silk taquetés documented in Chinese publications or displayed in Chinese museums belong to the same group as CH002. They were discovered on the site of Astana in the Turfan district of Xinjiang Province, though one of them may have been found in Qinghai Province. They are characterized by having thick weft yarns (ranging between 300 and 500 µ), decorated with pattern units of an exceptionally large size in the warp direction (from 17 cm up to more than 80 cm), and vertically oriented ('debout' meaning that they are 'aesthetically readable' with the warp placed vertically). In addition, their patterns share the characteristics of fragment CH002: narrow vertical motifs repeated in mirror symmetry in the weft direction. And, like CH002, the majority of fragments found in Northwest China have weft sequences composed of two lats of different colors (mostly golden-yellow and brown, occasionally blue-green indigo) forming the polychrome motif.

Fig 18. (left) Detail of a fragment of unspun silk taqueté decorated with six hexagonal petals flowers and the Chinese character *wang* 王 ('king'), dated to 5th–6th century, found on the site of Astana, Xinjiang Province (after Museum of Xinjiang Uighur Autonomous Region 1973, pl. 31).

Fig 19. (right) Detail of a fragment of unspun silk taqueté decorated with confronting pairs of ibex, dated to 5th–6th century, found in tomb 170 at Astana, Xinjiang Province (Museum of Xinjiang Uighur Autonomous Region, TAM170-66).

Amongst the most common motifs are flowers with six or eight hexagonal petals (figs. 4, 17, 18, 30), often referred to as 'tortoise shell', 龟甲 *guijia* in Chinese texts, and woven Chinese characters. Two simple characters that are found on this type of textile are either *wang* 王 meaning 'king' (figs. 18, 30) or *ji* 吉 meaning 'auspicious',[33] (fig. 4). Also commonly found are pairs of facing animals from the Sasanian decorative vocabulary, such as cranes seen on the Abegg fragments (fig. 31) or ibexes on a fragment from Astana (fig. 19). Several examples are on display at the China National Silk Museum in Hangzhou while other fragments appear in Chinese publications. Wu Min shows two similar textiles found in tomb 507 in Astana, decorated with flowers composed of six hexagonal petals.[34] Li Wenying illustrates another piece decorated with the same floral motif, also discovered in Astana, from tomb 170.[35]

The combination of floral motif and the character *wang* 王 appear on yet another example found in tomb 44 of Astana cemetery, illustrated in the 1973 publication of the Museum of the Xinjiang and Uighur Autonomous Region, Urumqi (fig. 18). This fragment has also been described in detail in other Chinese publications.[36]

One of the most beautiful examples of this type of weave (Museum of the Xinjiang and Uighur Autonomous Region, TAM170-66) is decorated with pairs of ibex (fig. 19). This piece was also unearthed in Astana and has been described by several Chinese authors including Wu Zhefu[37], Wang Le,[38] and Bao Mingxin.[39] The discovery in tomb 170, dated 543 to 562 CE, is particularly significant as this unspun silk taqueté was found alongside contemporaneous fragments of Z-spun silk taquetés, showing that the production of these two types of silk taquetés overlapped during the 6th century at least.

A tree motif is also frequently depicted on unspun silk taquetés of this type. The tree has seven pairs of leaves along the trunk and two pairs of 'double wings' (*shuangyi* 雙翼) at the top. Wang Le describes it as the 'tree of life' pattern and considers it a typical Persian design.[40]

Many Chinese scholars concur in the attribution of this group of unspun silk taquetés to Persian workshops. While the weaving may have been done in Sasanian Iran, however, Zhao Feng and Long Bo believe that the

Fig 20. Four study areas in red rectangles (labelled motifs 1, 2, 3 and 4). Motifs 1 and 2 belong to one pattern unit, motifs 3 and 4 to a second pattern unit. Each pattern unit is formed by two comber units replicated by a mirror symmetry with a single point (fig. 23) along the symmetry axis. The motifs have been selected in order to illustrate the widest variety of color junctions (photo by E. Boudot, © Chris Hall).

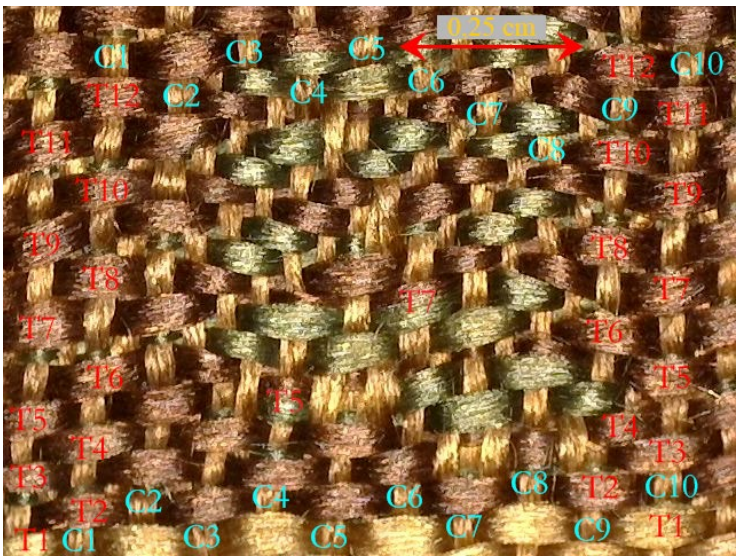


Fig 21. Motif 1 seen from the front of textile. Each motif is produced by the interlacing of 12 weft sequences (24 complementary lats) with 10 warp sequences (10 binding warps and 10 main warps). Each element is given a number: T is for wefts, C is for warps (photo by E. Boudot, © Chris Hall).

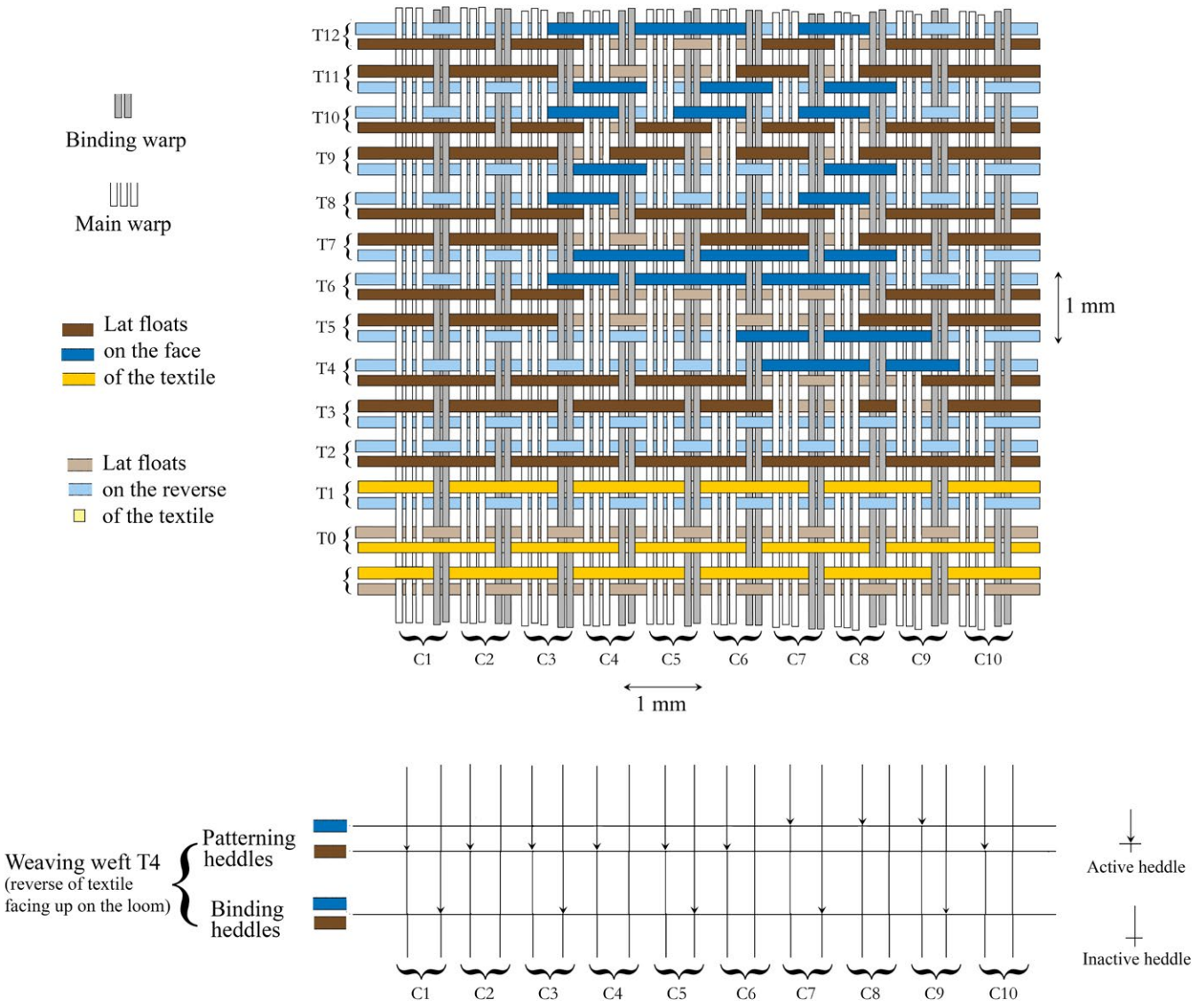


Fig 22. Technical diagram of of motif 1: (above) woven structure, drawn from the face of textile; (below) heddle arrangement.

unspun silk yarns used for the patterning wefts lats were imported from central China.[41] This would imply that by the 5th century CE at the latest, Chinese unspun silk yarns made of long continuous silk fibres were already exported abroad.[42] As mentioned above, the prohibition of silk yarn export seems to have been in place until the 3rd century. I consider that this change in rules may have been triggered by the occupation of some silk-producing regions in China's northern half by non-Han political entities, such as the Northern Wei (386–534 CE), for whom the protection of China domestic monopoly of the production of fine silk textiles was not a priority.

A note on main warps-binding warps ratio

While scholars often mention a difference in the ratio of the main warp-binding warp for woollen taquetés that were made in the West versus those in the East (1:1 in the West, 2:1 in the East), this difference is not so clear-cut for silk taquetés. For Z-spun silk taquetés, 19 fragments were found with a 2:1 ratio and 9 fragments with a 1:1 ratio, independent of their geographical location. Unspun silk taquetés are even more variable as warps are often made of several parallel threads in irregular numbers (untwisted groups of two, three, or four threads) (fig. 14), though the groups forming the main warps are usually thicker that those forming the binding warps.

Weaving process and looms

To determine whether the weaving process of repeating polychrome patterns was executed manually or with the help of mechanisation, we need to understand and com-

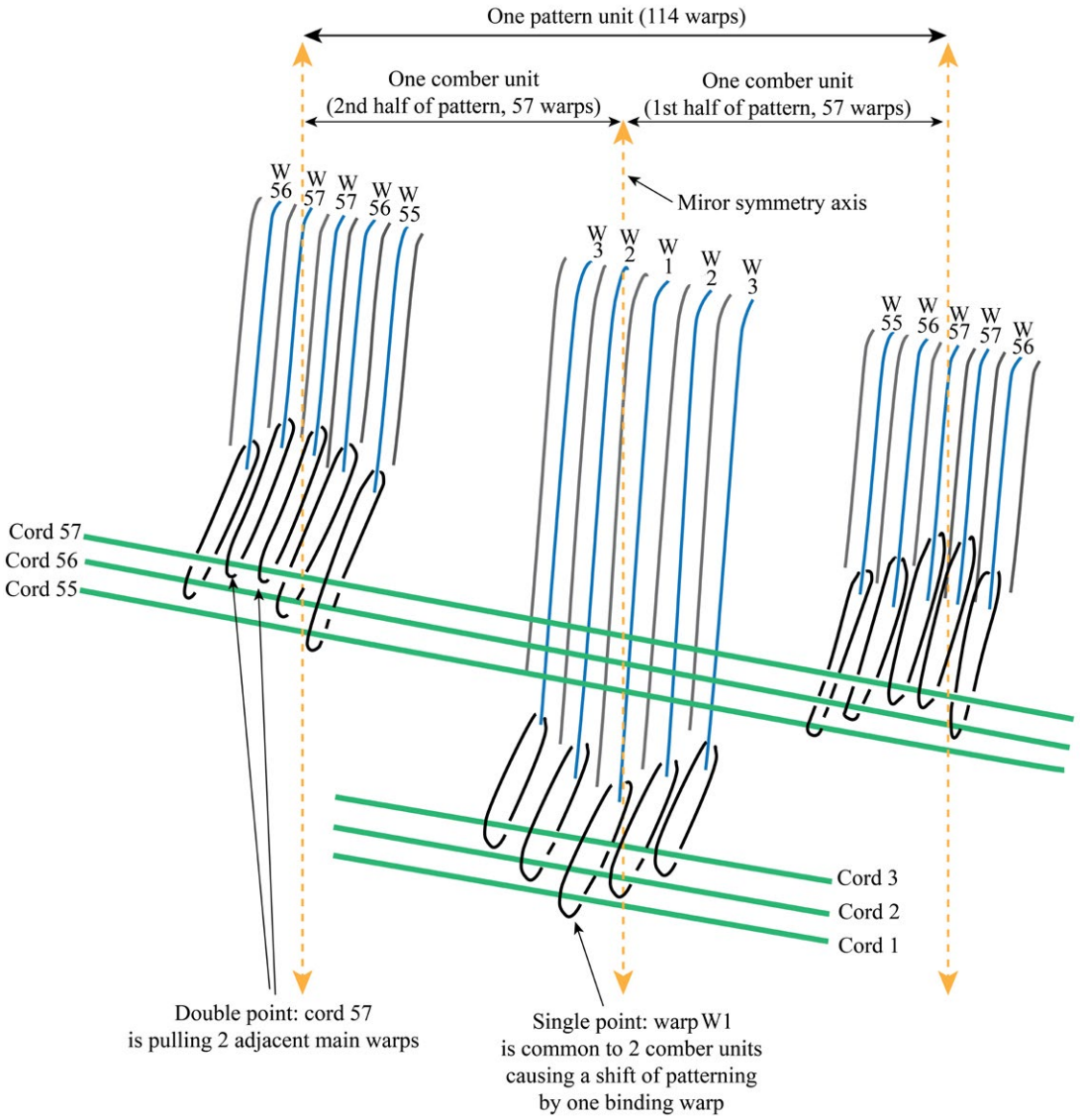


Fig 23. Hypothesis for the patterning system used to weave fragment CH002 (note that the warp numbers refer to the whole comber unit (W), a different numbering (C) is used on the motif section analysis).

pare the precise interlaces of wefts and warps on several sections along repeated motifs. If the interlaces show an exact reproduction for a sufficient number of warps and wefts over several motifs, we can conclude that the repeat was produced by a 'mechanical' system, not by manual selection of warps. It is only when a mechanical repeat of the motifs can be identified that the researcher would be able to hypothesise what type of loom mechanism was used. In the case of fragment CH002, it only contains part of one pattern in the vertical warp direction, so I have only been able to examine the question of pattern repeats in the weft direction.

Method of comparing the structures of pattern repeats in the weft direction

First, I selected a motif that includes several color changes in order to compare the interlaces of patterning wefts floats and to observe the details of the color junctions. I analysed four motifs sections repeated in the weft direction (fig. 20) and compared them by microscopic observation. Each motif section consists of 10 warps sequences (10 main warps and 10 binding warps) interwoven with 12 weft sequences (12 blue lats and 12 brown lats) (fig. 21). The number of interlacing points, a total of 680, is sufficient to draw conclusion on the nature (manual or mechanical) of the repeats in the weft direction.

Mirror symmetry in the pattern unit

The two halves of each pattern unit (motifs 1 & 2, motifs 3 & 4, figs. 20, 23), are symmetrical about a single point (in other words, both symmetric halves of the pattern unit share a common warp at the center). This means that the appearance of the reverse half-motif

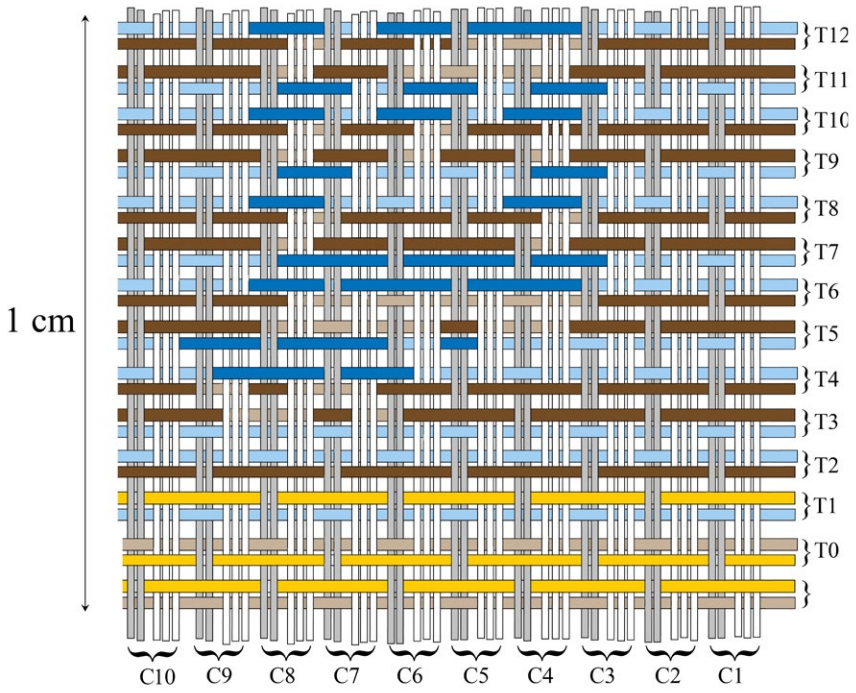


Fig 24. Structure of motif 2, drawn from the face of textile. Motif 2 is the exact reverse of motif 1 in the weft direction (mirror symmetry), even though the appearance is slightly different, as the plain weave ground warps have shifted by one binding warp (single point on mirror symmetry axis in fig. 23). Two lats of the same color, belonging to two adjacent passes (reverse sequences) are always inserted in the same patterning shed (a labor-saving process for the weaver).

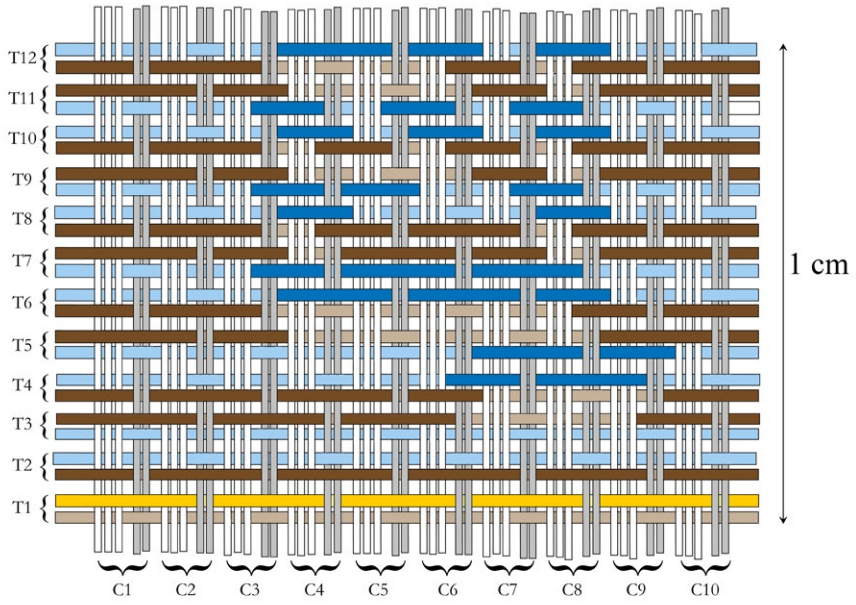


Fig 25. Structure of motif 3, drawn from the face of textile. Motif 3 is the exact repeat of motif 1 (repeat of the same comb unit), even though the appearance is slightly different, as the plain weave ground warps have shifted by 1 binding warp (single point on mirror symmetry axis) in the pattern unit of motif 1 (fig. 23). On motif 3, weft T1 has a second yellow lat, while this lat is blue on motif 1, this is caused by a defect in the indigo dyeing of the thread.

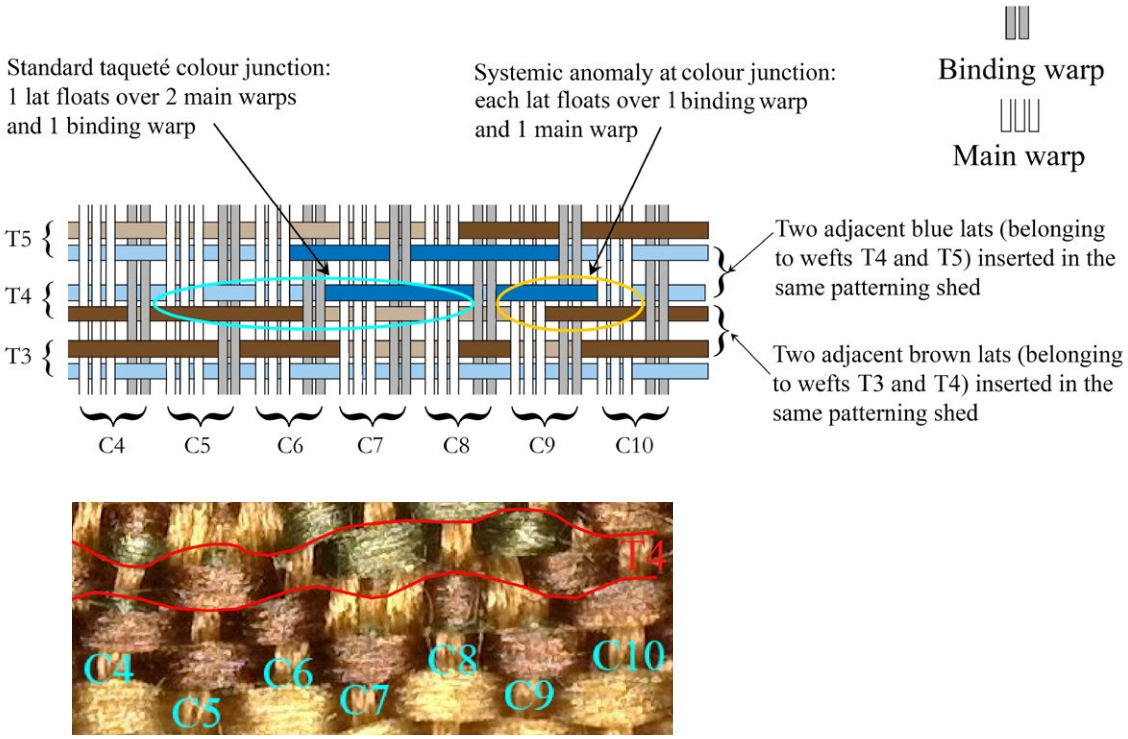


Fig 26. (above) Diagram of standard float and 'systemic anomaly' color junctions. The 'systemic' junctions result from the insertion of two adjacent lats of the same color, belonging to two different adjacent weft sequences, in the same patterning shed (pattern step: two weft passes).

Fig. 27 (below) Macrophotograph corresponding to fig. 26.

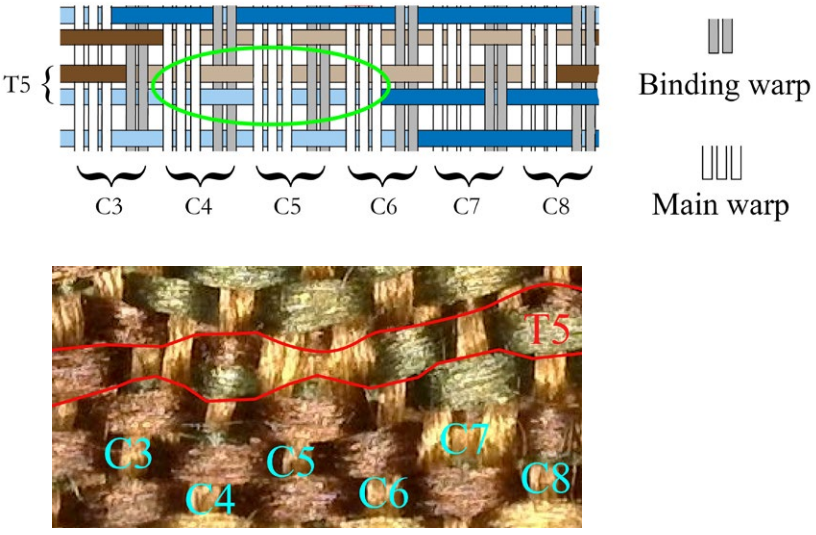


Fig 28. (above) Diagram showing complex anomalies on weft T5 interlaces with main warps C4, C5 and C6 on motif 2.

Fig 29. (below) Macrophotograph corresponding to fig. 28.

is slightly different from that of its counterpart, as the binding points are shifted by one warp. Nonetheless, the interlacing of the main warps with the patterning wefts is the exact reverse of that in the weft direction.

Pattern repeat
Two adjacent pattern-units are divided by a double-point. In other words, two adjacent pattern units do not share a common warp sequence at their line of division, as the first warp sequence is repeated for each of motif, see fig. 23), therefore motif 1 (figs. 21, 22) is the exact reverse of motif 4, and motif 2 (fig. 24) is the exact reverse of motif 3 (fig. 25), as the two single-points of the mirror symmetry in each pattern unit 'cancel' the one warp shifting observed in the mirror symmetry. Based on the exact repeat of the interlace, established on a motif section made of 680 interlacing points, and observed on four horizontally aligned repeats, I conclude that a mechanical system for controlling repeats in the weft direction is present (discussed further below).

Treatment of color junctions
As the weft sequence is systematically reversed (*passée paire à retour*, fig. 15), a change in color on the surface of the textile implies some unavoidable arrangements involving some variations from the 'standard' taqueté structure (1 weft lat floating successively over 1 main warp, 1 binding warp and 1 main warp). For the purpose of this article, I call these arrangement 'systemic anomalies.' Other arrangements at color junction are not a systemic consequence of the reverse sequence of the wefts, and I will show that they are also not errors, but most likely deliberate choices by the weaver to refine the definition of a motif outline. I call these 'complex anomalies'. The following analysis of these anomalies assumes that the weaver wove with the reverse of the textile facing her.

Systemic anomalies (figs. 26, 27)
The most common systemic anomaly involves floats of a complementary lat over only one main warp instead of two. Gabriel Vial and Donald King observed a similar phenomenon, but rotated 90 degrees, for complementary patterning warps on Chinese Han period warp-faced compound plain weave.[43] These anomalies are a logical consequence of the inversion of the sequence (*passée paire à retour*) of the patterning elements (e.g. [blue-brown] – [brown-blue] – [blue-brown], etc.). As the weft pattern step is of two passes, two contiguous lats of the same color (but belonging to two different adjacent weft sequences) are inserted through the same patterning shed, but through a different plain weave ground shed. Therefore one patterning lat floats over three warps (one main warp, one binding warp and one main warp), while the next one only floats over two warps (one main warp and one binding warp).

Complex anomalies (figs. 28, 29, 30)
The most common among complex anomalies at color junctions is seen when weft floats are absent over three successive main warps. In other words, three successive main warps do not separate the two complementary lats of a weft sequence (as is normally the case in a taqueté structure) but hold both lats on the reverse of the textile, so that no colour appears on the face of the textile. This corresponds to main warps that have not been lifted for the insertion of both complementary lats of a weft sequence (with the reverse of the textile facing the weaver). As the weft pattern step consists of two passes and the weft sequences are disposed in reverse sequences, this means that there are four vertically adjacent lats (for example one brown lat, two blue lats and one brown lat) that do not float over the main warps, thereby accentuating the visual effect. Assuming the presence of a correctly functioning patterning system consisting of some arrangement of warps attached to lashes that are further linked together in some way (observation shows no mistakes in pattern repeats), these 'complex anomalies' can only result from the deliberate choices in the configuration of the lashes. This type of anomaly is also found in another unspun silk taqueté found in Astana tomb 44 (figs. 18, 30), where these anomalies are clearly aligned to outline the horizontal bars of the Chinese character *wang* 王.[44] Its presence in multiple examples indicates that these 'complex anomalies' were probably intentional, devised for a visual effect to strengthen some motif outlines.

One question is to determine on which side of the textile, the 'outlining' effect was intended for: face or reverse? As there are only two complementary lats forming the weft sequence, the pattern is equally visible (in reversing colors) on both sides of the fabric. I propose that these intentional complex anomalies (absence of weft float on one or several main warps) appear on the face of the fabric, in order to give a more distinct outline to the motif. This observation helps with distinguishing the face and the reverse of a 2-lats taqueté. It also helps avoid the potential mistake of considering the best preserved side as the face, when in fact the face is most likely to be worn and in poorer condition than the reverse. The presence of these complex color junction structures could also be helpful, when sufficient data has been collected, to identify the distinctive characteristics of different workshops and perhaps determine the areas of production of silk taquetés and the places they were exported to. In the next section, I will show how this effect could have been produced on the loom.

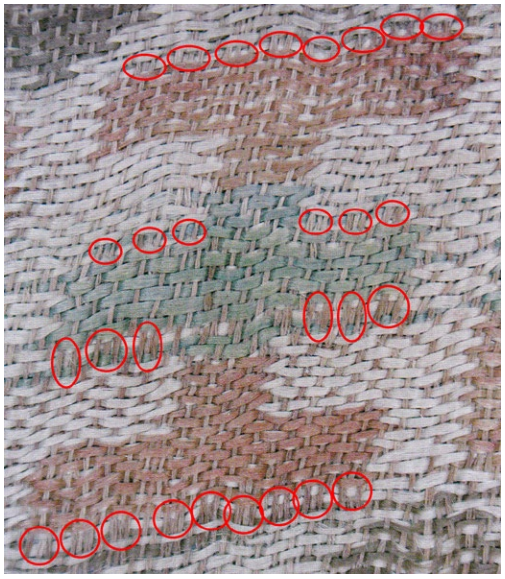


Fig 30 (left) detail of silk taqueté (fig. 18) showing complex anomalies at color junctions (main warps not separating 2 lats of a weft sequence); these anomalies have clearly been placed deliberately along the horizontal bars forming the Chinese character *wang*, in order to strengthen its outline.

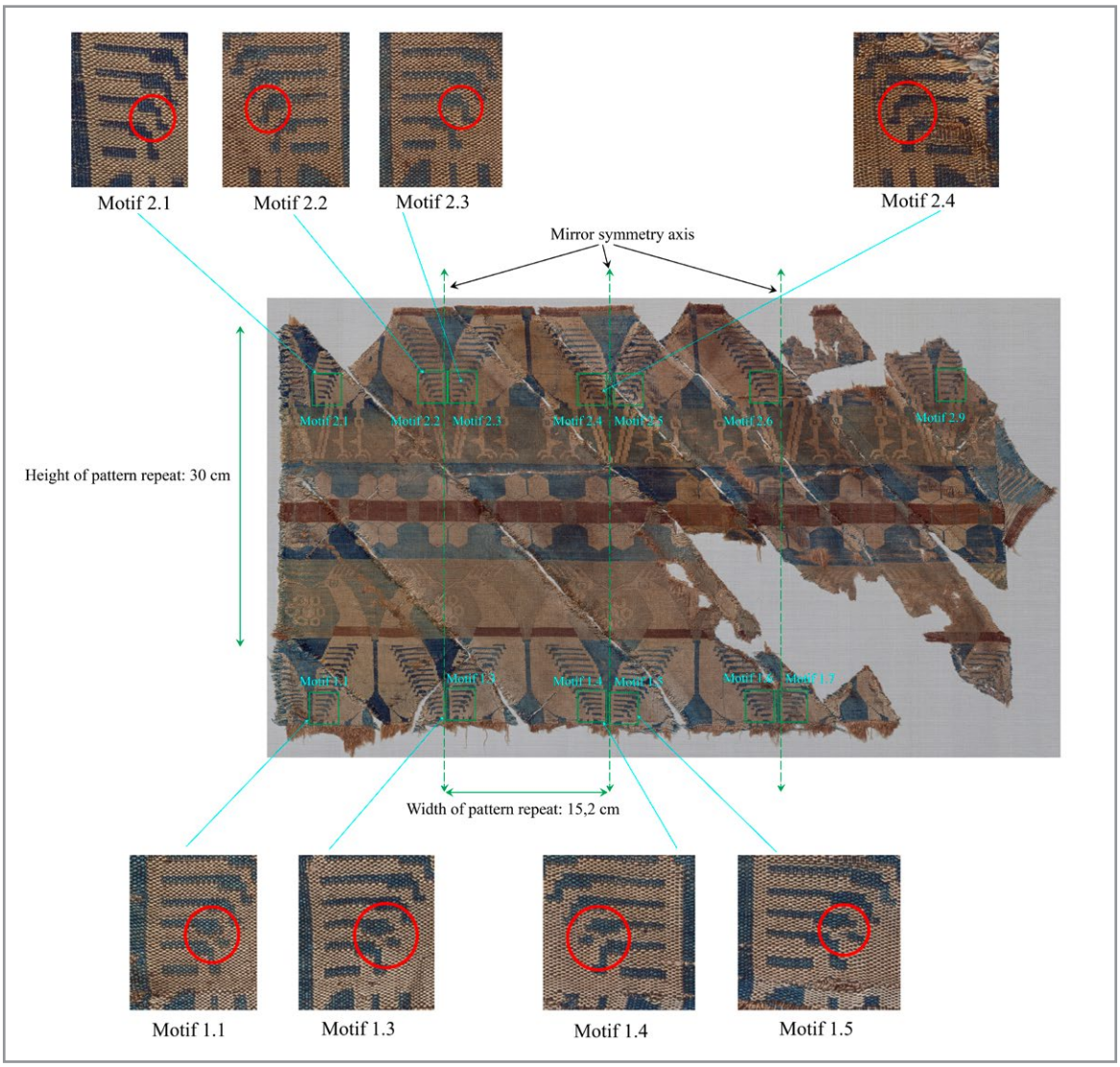


Fig 31. The size of this fragment of unspun silk taqueté, probably of the same type and period as CH002, allows the comparison of some details of the pattern repeat in the warp direction. Differences appear clearly to the naked eye, demonstrating that the pattern repeat was not woven with a mechanical patterning system (Abegg-Stiftung, 5273a; superimposed drawings by E. Boudot)

Loom and mechanism: hypotheses

The exact reproduction of structure on motifs 1, 2, 3 and 4, (figs. 22, 24, 25) without a single error in 680 interlacing points per section, attests to long experience with this weaving technique and to the maturity of the loom and patterning system involved. The precision of the structure repetition in the weft direction provides further evidence of the presence of a sophisticated and reliable 'mechanical' pattern repeat system in the weft direction on certain looms in this region by 5th century.

As noted, the question of a mechanical pattern repeat in the warp direction cannot be answered by the study of this fragment. But if such a feature existed, it would have required more than 1000 pairs of lashes [50 (cm) x 20 (20 weft passes per cm) = 1000 pairs of lashes], which could have been rather cumbersome to manipulate. Comparing with another fragment (Abegg-Stiftung, 5273a) with the same type of weave, from the same period, and most likely the same weaving tradition, showing the same kind of complex anomalies at some color junctions (figs. 31, 32), it seems likely that the repetition of the pattern in the warp direction was not mechanized. Possibly, the full height of the pattern unit in the warp direction, because of the excessive number of required lashes, would have been divided in several sections of the pattern, involving several corresponding sets of lashes. To start a new section, the already used set of lashes would have to be removed from the loom; and a new set of lashes, corresponding to the next section of the pattern, would have had to be mounted on the loom. Errors, such as those outlined in figure 31 are most likely to have occurred during the manual reconnection between the patterning system (sets of lashes) and the warps.

The loom

Following Martin Ciszuk's suggestion[45] and Zhao Feng's work,[46] I propose that the fragment CH002 was most likely woven on a vertical Central Asian loom. My hypothetical reconstruction is based on the observation of traditional weavers demonstrating their work on an Iranian *zilu* loom (fig. 33) and on an Indian *jaala* loom (figs. 34, 35, 36, 37).

The proposal of a vertical loom, similar in type to the *zilu* loom still used today in the Iranian region of Meybod, fits the probable size of the original textile: silk taquetés woven in Central Asia are described in a text found in tomb 88 at Halahezhuo (Karakoja), near Turfan, dated to 447 CE, as having a length (height) of 9 *chi* 5 *cun* (218 cm) and a width of 4 *chi* 5 *cun* (103 cm).[47] The textile could also have been woven on a horizontal loom similar to the Indian *jaala* type. However, from a patterning standpoint it does not matter if the loom was vertical or horizontal.

Wulff mentions the existence of a *zilu*-type loom with a patterning system in Iran in the 1960s, but it is not described in detail.[48] We do not know if it existed in the 5th–6th centuries CE, but it is very possible that a loom almost identical to the *zilu* loom existed in Persia in the 5th–6th centuries CE. Thompson and Granger-Taylor,[49] citing Gillian Vogelsang-Eastwood, pointed out that textiles with the same structure and character as the *zilu* have been found in Shahr-e Qumis in Iran, dating from the Sassanid period (6th century).

My ethnographic experience amongst weaving traditions in southwest China also shows that looms can survive almost unchanged for centuries or millennia, and the existence of a *zilu*-type loom in the 5th century CE is certainly possible. Until recently Iranian weavers also used a horizontal drawloom (described by Wulff in some detail) that was essentially identical to the Indian *jaala* loom in the operation of its patterning system. The *jaala* loom is said to have been imported in northern India by artisans linked to the court of Sultan Ghiasuddin Tughluq in the early 14th century CE. According to Moroccan explorer Ibn Battuta (1304–1368), Tughluq was believed to be of Turkic origin and to have come from a 'region between Turkestan and Sindh'. Other accounts say that he came from Khorasan (northeast Iran). Whichever account is correct, it seems very likely that both the Indian *jaala* loom and its Iranian predecessor are ultimately the result of the evolution and sophistication of the Persian *zilu* loom, equipped with a similar patterning system (cross-cord figure harness), rotated by 90 degrees to become horizontal.[50]

Loom setup (fig. 38)

The reverse side of the textile faces the weaver during the weaving process. The binding heddles (plain weave ground heddles) only 'lift' the binding warps. The patterning system (leashes-cords-simple-lashes = figure harness) only 'lifts' the main warps.

Dimensions of pattern repeat

The width of the pattern repeat (in the weft direction) measures between 9 cm and 9.5 cm on fragment CH002. The height of the pattern repeat (in the warp direction) is unknown, but it can be no less than 49 cm.

Patterning system (figure harness) set up hypothesis

Each main warp is attached to a leash linked to one cross-cord, each cross-cord can be pulled by one pull-cord; a lash (corresponding to the opening a pattern shed for the insertion of one colored complementary lat) is composed of several loops, each loop pulling one pull-cord (figs. 38, 41). So that one lash is pulling several main warps to create the patterning shed. A pair

Fig 32. Detail of fig. 31, showing 'complex anomalies' at color junctions, similar to those observed on fragment CH002 (figs. 27, 28).

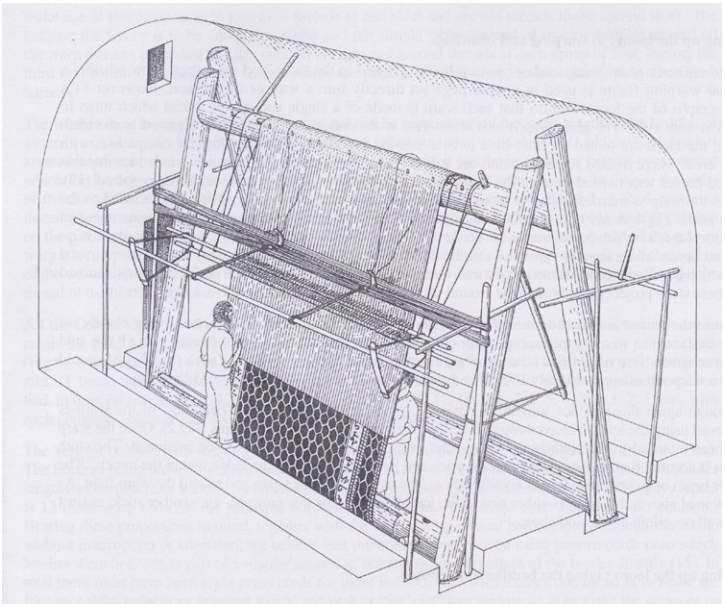


Fig 33. The Iranian *zilu* loom in Meibod, Khorassan, northeast Iran (after Thompson and Granger-Taylor 1995, p. 31). This loom is equipped only with hand-operated pull cords: there is no pattern recording system.

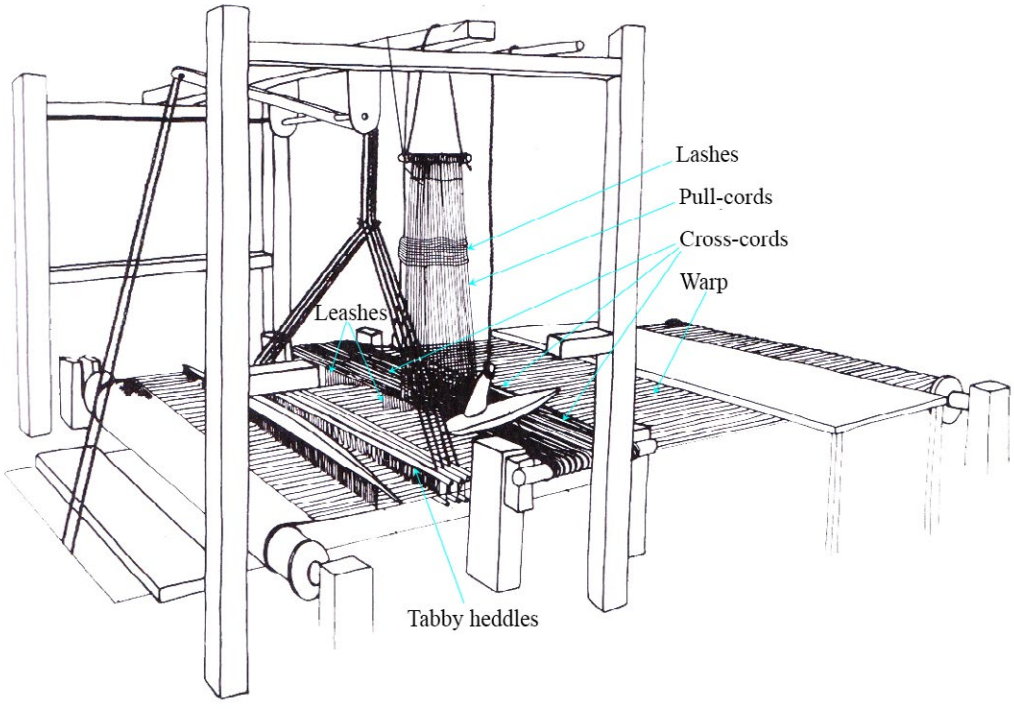
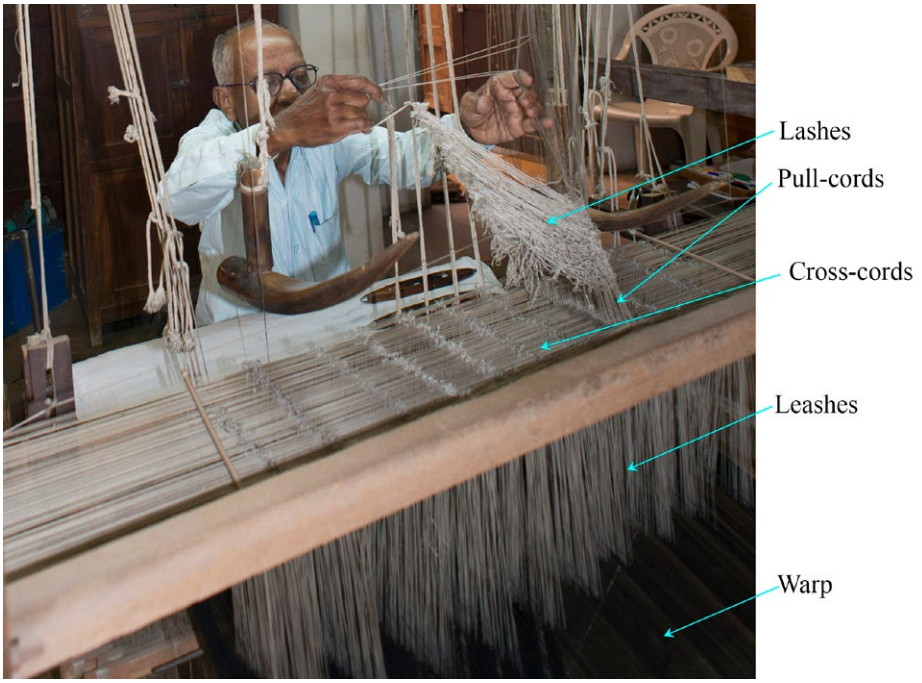


Fig 34. The Indian *jaala* loom; the simple cords (or 'pull-cords') are directly attached to the cross-cords (after Varadarajan and Amin-Patel 2008, p. 99).



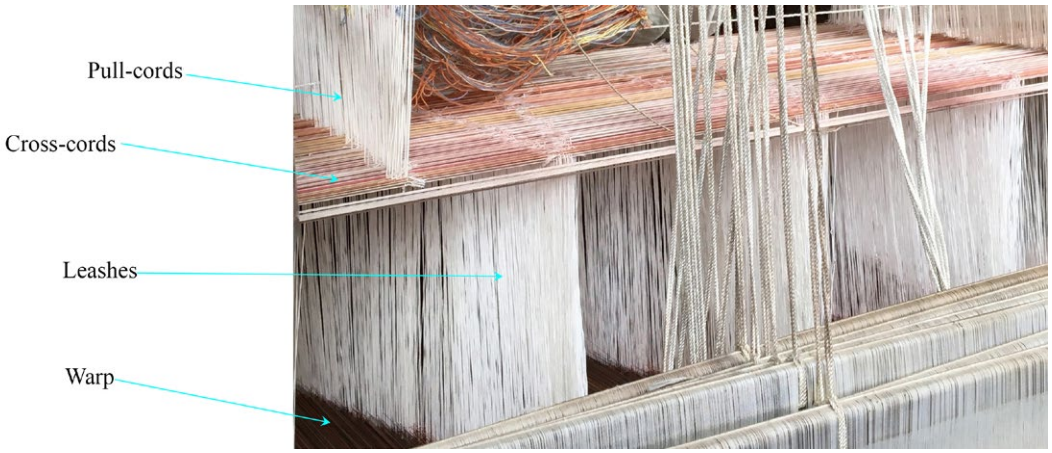


Fig 35. (above) Indian weaver working on a *jaala* loom in Aurangabad (photo courtesy of Christopher Buckley)

Fig 36. (middle) Leashes attached to the cords forming a reverse symmetry pattern on a *jaala* loom (seen from the back of the loom), Cholapur, Varanasi area, India (photo courtesy of Christopher Buckley)

Fig 37. (below) Patterning system on a *jaala* loom, idem as fig. 36 (seen from the front of the loom), Cholapur, Varanasi area, India (photo courtesy of Christopher Buckley)

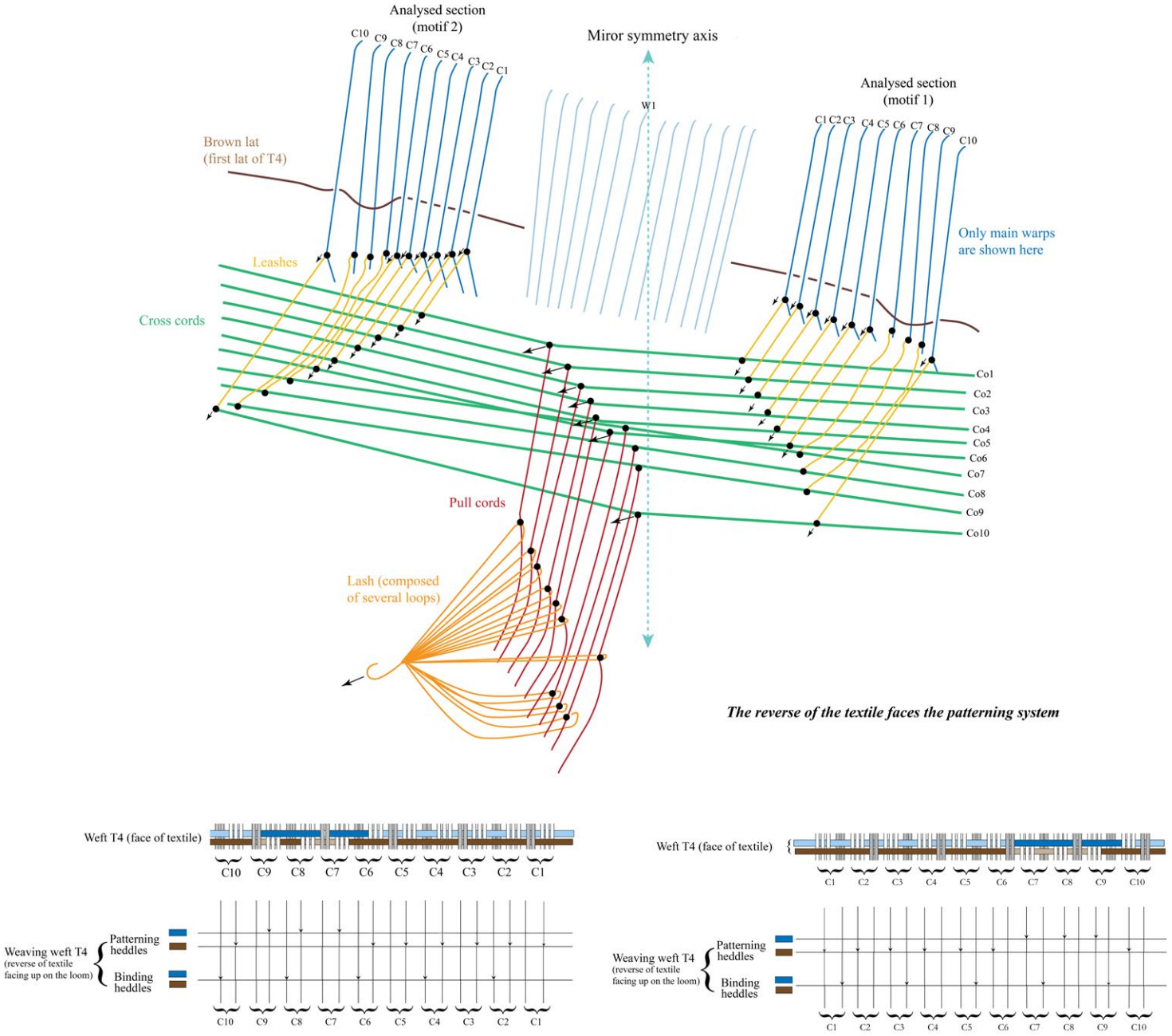


Fig 38. Diagram showing the process involved in opening the patterning shed where the brown lat is inserted, the first lat of weft sequence T4 in motif 1 (right) and motif 2 (left) (note that the reverse of the textile faces the weaver). Seven main warps (C1 to C6, and C10) are pulled by the action of the seven loops forming the first lash, while three main warps stay in their original position; warp W1 corresponds to the 'single point' symmetry axis.

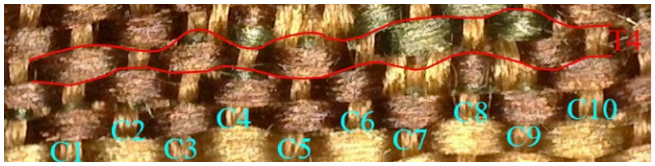


Fig 39. (above) Weft T4 seen on the front of the textile, as woven according to diagram on figs. 38, 41.

Fig 40. (below) Weft T4 seen on the reverse of the textile, as woven according to diagram on figs. 39, 41.

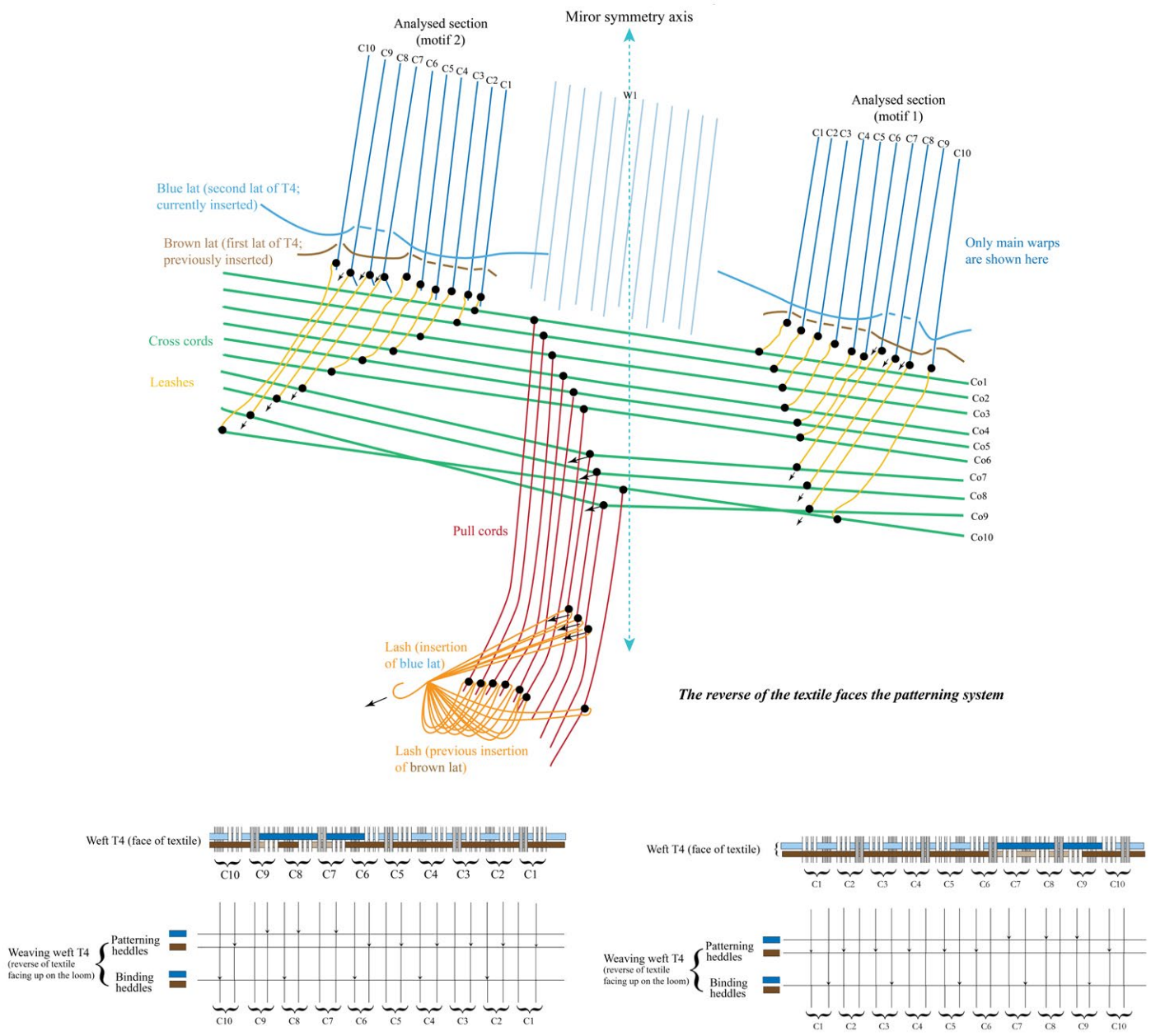


Fig 41. Diagram showing the process involved to open the patterning shed where the blue lat is inserted, the second lat of weft sequence T4 in motif 1 (right) and motif 2 (left). Three main warps (C7, C8, C9) are pulled by the action of the three loops forming the second lash, while seven main warps stay in their original position; warp W1 corresponds to the 'single point' symmetry axis.

of lashes commands the successive insertions of the two complementary lats forming a weft sequence.

Execution of pattern repeats

The width of the pattern unit, 9 cm to 10 cm (containing two affronted simurgh), corresponds to two comber units, of a width of approximately 4.5 cm, reproduced by mirror symmetry (figs. 20, 23). We counted 13.5 (average) main warps per cm, 13.5 x 4.25 = 57 main warps (on average); as the warp pattern step is one main warp, the patterning system requires 57 cords to weave one comber unit.[51]

Execution of complex color junctions

In a standard taqueté weaving, on a pair of lashes (corresponding to one weft sequence), the first lash should normally pull the main warps that are not pulled by the second lash. In order to produce complex anomalies voluntarily, and to reproduce them on each pattern repeat (as can be seen above on figs. 22, 24, 25), the weaver had to plan them when preparing the patterning system. This result was probably achieved by omitting one or several pairs of loops in a pair of lashes, so that both lats of one weft sequence did not float over one or several main warps (the main warps that were not pulled) (fig. 42).

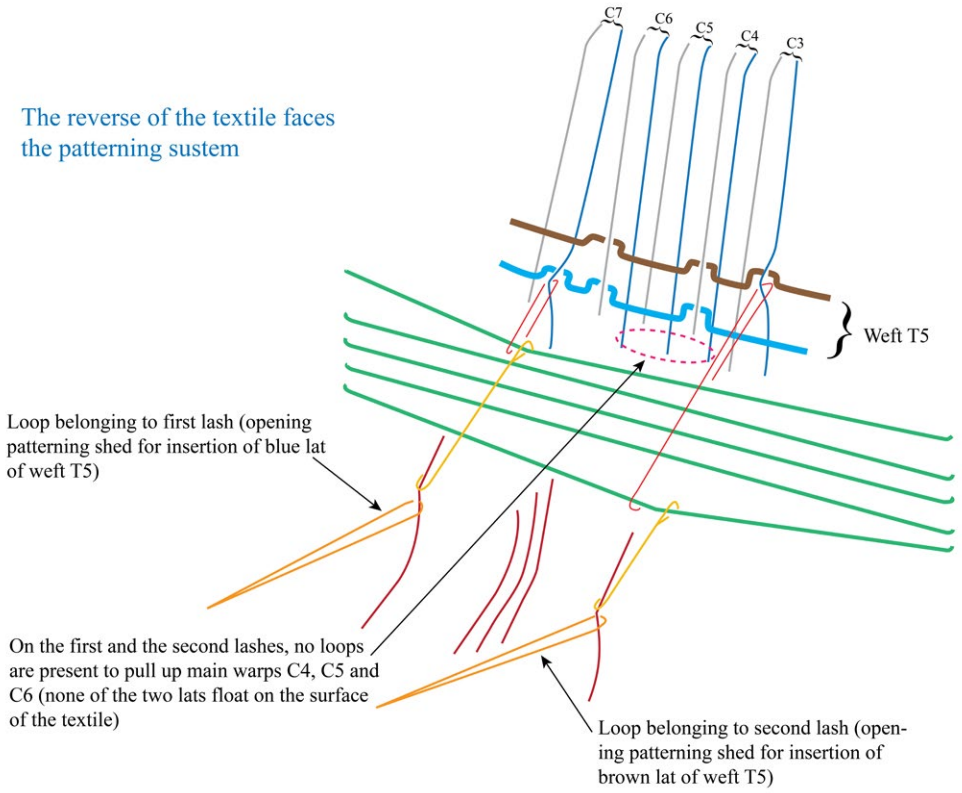


Fig 42. Hypothetical setup of the patterning system for the weaving of a color junction with complex anomalies illustrated on figs. 28, 29.

Conclusions

The quality, precision in the planning, and execution of this textile imply long experience, which points more toward Sasanian Persia, where a solidly established weaving tradition has been witnessed some few centuries later in Muslim times, than to Sogdiana, an area which is mostly mentioned in the context of cotton weaving.

To my knowledge, the fragment analysed here shows one of the earliest examples of the representation of a simurgh on a silk taqueté, and the only case where the simurgh motif is seen in a straight and 'rigid' depiction. On later silk samits found mostly in the Caucasus and in European church treasuries, but possibly also in Northwest China, the simurgh is represented as a coiled shape, usually enclosed in a pearled roundel.

The analysis of this fragment provides clues that textiles patterns could have been reproduced mechanically in the weft direction as early as the mid-first millennium CE in Central Asia. The quality of the workmanship also shows that sophisticated silk weaving centers existed in the Sassanian world and that their weaving tradition most likely already developed centuries earlier to attain such a maturity by the 5th century CE. Considerable archaeological research will be needed in order to determine the location of these workshops at the time.

In a subsequent article I will discuss the possibility, based on the observation of another type of unspun silk taqueté, that a loom with the functionality of a drawloom, enabling the mechanical repeat in both weft and warp direction, had been invented during the same period.

Drawings and photographs are by the author, unless otherwise stated. The author would like to thank Chris Hall for allowing him to study textiles in his collection.

Notes

1. See Sheng 1998, 117–158; Marshak 2006, 49–60; Raspopova 2006, 61–73; Wu Min 2006, 211–242; Zhao Feng 2006, 189–210; Li Wenying 2012, 115–166 ; Luo Qun 2012, 112–118; Zhao Feng 2015.

2. Verhecken-Lammens 2006, 203.

3. Barbara Thomas, personal communication, January 2021.

4. Martin Ciszuk (2004, 112) considers that "aqueté was invented and produced in Egypt."

5. Williams 2014, 8.

6. Zhao Feng 2015, 115–116.

7. Matbabaev and Zhao 2010, 48–49, 70–71.

8. Riboud 1974, 154–160.

9. Zhao Feng 2015, 27 and 115–116.

10. Juan 94b, 3803, quoted in Loewe 1986, 396–397.

11. It is also likely, that, as sericulture expanded westward along the middle section of the Silk Roads, local weavers acquired the art of unreeling long silk fibres at some point in the second half of the first millennium.

12. 'Sasanian cultural sphere': following the doubts regarding the validity of the 'Sogdian-Zandaniji' hypothesis (see Marshak 2006, Raspopova 2006, Dode 2016), and the absence of solid evidence about the location of silk weaving centers in this area, this paper refers globally to a 'Sasanian cultural sphere' (or Sasanian world) that includes Khorezm, Fergana, Soghd, Bactria and Khorasan.

13. Wang Le 2007.

14. Wu Zhefu 1988, 92–93.

15. 1528 +/- 35 uncal BP, calibrated using the OxCal 2020 curve.

16. According to Frantz Grenet, Conference at the Collège de France; February 2021.

17. Compareti 2011, 29–32.

18. See Sheng 1998, 148; '… royal ribbons around the neck', and note 80: 'All representations of Sasanid royalty show similar head-dress of a diadem with long, flying ribbons."

19. See Mancinella 1975, 120–126; Bier 2004, 146; Sheng 1998, 150; Tanabe 2006, 583–601; Gagetti 2012, 95–108; Gasparini 2014, 119–126; Comparetti 2015, 36–45; Gasparini 2016, 84–96.

20. Gasparini 2016, 91.

21. Compareti (2011, 32) stated that 'Single representations of so-called simurgh within circular frames (often pearled) were recovered at Qasr al Hayr al Gharbi (Syria, first half of 8th century), at Qasr al Hallabat (Jordan, first half of 8th century) and at Khirbat al-Mafjar (Palestine, second quarter of 8th century).'

22. See figures 7 and 8 in Compareti 2011, 30.

23. Tanabe 2006, 583–601.

24. Marshak 2006, 54.

25. As Becker (1986, 104) explains: 'Chinese weavers developed their patterns to still more sophistication all over the width. Weavers in Western Asia made use of an increasing number of pattern heddle rods or shafts for repeated pattern units in the width.'

26. The photograph of this fragment was kindly shown to me by Dr. Zvezdana Dode, (Senior Researcher at the Heritage Institute), but the material has yet to be published. It could have been found in the Caucasus or Central Asia but there is no confirmation of provenance as yet.

27. At the Conference *Les thèmes royaux* at the Collège de France; February 2021.

28. Schrenk 2006, 33

29. A lat is a colored complementary weft; a minimum of two lats is required to form one patterning weft sequence..

30. This fragment has been described by Zhao Feng and Qi Dongfang (2011, 52–55).

31. Calament and Durand 2013, 62–64, 393–394.

32. Calament and Durand 2013, 57.

33. The presence of two Chinese characters on this type of textile does not necessarily imply Chinese production; their presence is more an indication that the textiles were meant to be sold on the Chinese market. The same phenomenon is observed on Z-spun silk taquetés produced in Xinjiang (*qiucijin* 丘慈錦 or *mianjing mianwei* 綿經綿緯), where the two simple characters *tian* 田 and *mu* 目(and only those) are often present. By contrast, Chinese-woven warp-faced silk compound tabbies, mostly made during the Eastern Han period, exhibit more numerous Chinese characters which vary from one textile to another and form meaningful aphorisms.

34. See figure 158 in Wu Min 2006, 221.

35. Li Wenying 2012, 175.

36. Zhao Feng 2015, 173; Wang Le 2018, 40.

37. Wu Zhefu 1988, 92–93 and 136.

38. Wang Le 2013, 207.

39. Bao Mingxin 2017, 23.

40. Wang Le 2018, 40.

41. Personal communication, January 2019.

42. Angela Sheng (1998, 132) writes: 'Sericulture began in Gaochang [near Turfan in Xinjiang Province] sometimes after ethnic Han people settled as military colonists there during the first c. CE… Excavated documents from Turfan show that by the 5th c. it was already well established.'

43. Gabriel Vial and Donald King 1968, 10.

44. Museum of Xinjiang Uighur Autonomous Region 1973, pl. 31; Zhao Feng 2005, pl. 2.
45. Ciszuk 2004, 107.
46. Zhao Feng 2006.
47. Nie Xiaohong 2003, 2.
48. Wulff 1966, 211.
49. Thompson and Granger-Taylor 1995, 27.
50. I am indebted to Christopher Buckley and Sandra Sardjono for sharing their 2019 field research on the Indian *jaala* loom in Aurangabad, Gujarat and Varanasi with me. Buckley observes that: 'The *naqsha* [system of lashes] cords are grouped into pairs: each pair corresponds to the insertion of a weft of each colour.' (Christopher Buckley, personal communication, September 2019).
51. For comparison, see Becker (1986, 76) description of an early wool taqueté requiring 76 to 78 'main warp end' to form the hunting scene pattern on a fragment woven with S-spun yarn, dated to the early 3rd century CE; its origin is debated: Egypt or Syria?

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