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The invention of trousers and its likely affiliation with horseback riding and mobility: A case study of late 2nd millennium BC finds from Turfan in eastern Central Asia



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ABSTRACT

Here, we present the first report on the design and manufacturing process of trousers excavated at Yanghai cemetery (42°48'–42°49'N, 89°39'–89°40'E) near the Turfan oasis, western China. In tombs M21 and M157 fragments of woollen trousers were discovered which have been radiocarbon dated to the time interval between the 13th and the 10th century BC. Their age corresponds to the spread of mobile pastoralism in eastern Central Asia and predates the widely known Scythian finds. Using methods of fashion design, the cut of both trousers was studied in detail. The trousers were made of three independently woven pieces of fabric, one nearly rectangular for each side spanning the whole length from waistband to hemline at the ankle and one stepped cross-shaped crotch-piece which bridged the gap between the two side-pieces. The tailoring process did not involve cutting the cloth: instead the parts were shaped on the loom, and they were shaped in the correct size to fit a specific person. The yarns of the three fabrics and threads for final sewing match in color and quality, which implies that the weaver and the tailor was the same person or that both cooperated in a highly coordinated way. The design of the trousers from Yanghai with straight-fitting legs and a wide crotch-piece seems to be a predecessor of modern riding trousers. Together with horse gear and weapons as grave goods in both tombs our results specify former assumptions that the invention of bifurcated lower body garments is related to the new epoch of horseback riding, mounted warfare and greater mobility. Trousers are essential part of the tool kit with which humans improve their physical qualities.

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1. Introduction

'Mobility' is one of the most frequently discussed, defined and argued concepts in Bronze and Iron Age archaeology of the Eurasian steppe. It is related to a fundamental socio-economic change which had lasting effects on all the nations of the Eurasian continent, a shift from more sedentary agro-pastoral to more mobile pastoral ways of life (e.g. Hanks and Linduff, 2009; Frachetti, 2012). As Renfrew (2002: p. 7) summarized: "With the Cimmerians, Scythians, Sarmatians and Saka of the first millennium BC, nearly all

authorities agree, we see full nomadic-pastoralism. The horse is now ridden in a manner that is militarily effective, with the use of the bronze bit and harness." In order to exploit the speed of the horse (Dietz, 2003) for far-distance movement and warfare there is a need for some technical means to control the horse, at the minimum, headgear. Therefore archaeological finds of bridles made of bronze or other durable materials play an important role in the discussion (e.g. Anthony, 2007 and references therein). Another way of proving the presence of horse riding at a site is provided by the traces it leaves in skeletal remains. Riding may have caused pathological changes in horses that were ridden (e.g. fractures of the vertebrae; e.g. Benecke et al., 2010 and references therein) and for instance strain and trauma to the adductor muscles of the humans who rode horses (e.g. Wagner et al., 2011 and references therein). But there is yet another archaeological find category

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related to riding. In order to make the human body fit for riding over long distances and fighting on horseback, another precondition is required: a lower body garment which allows the rider to sit astride the horse and which protects the lower abdomen and genitals. Nowadays a pair of trousers would be the garment of choice but until about 3000 years ago only gowns, robes, tunics, togas or a combination of loincloth and leggings were available on the Eurasian continent (e.g. Vogelsang, 2010; Randsborg, 2011; Bergerbrandt et al., 2013). Common dictionaries define trousers as a “garment covering the body from the waist to the ankles, with a separate part for each leg” (http://www.oxforddictionaries.com/us/definition/american_english/trousers). The discrete encasement of each leg is emphasized to stress the difference to the gown and the robe. But tube-shaped leg coverings were in use much earlier as the discovery of the Iceman in the Alps with his leather leggings dated to ca. 3350–3100 cal. BC proved (Fleckinger, 2011). The leggings were tied to a waistband and the abdomen was covered with a loincloth. The onset of trousers as we know them today, however, is marked by the invention of the crotch-piece which joins the leg-pieces together and connects them to the waist part to form a one-piece garment. The construction of a crotch-piece which facilitates even an extreme spreading of the legs at the same time as the trousers protect the pelvis is a ground-breaking achievement in the history of cloth making. It was a precondition for all functional lower body garments of modern times, for all kinds of clothing for specific tasks as well as for sportswear, which have to meet one key-demand: combine maximum freedom of movement with optimal body protection.

The differing assumptions throughout the literature of the history of costume concerning the appearance and dissemination of the first trousers in Asia as well as in Europe show a deficiency in solid knowledge on this subject. A variety of contributions rely entirely on secondary sources, images and descriptions. In most cases accurate technical information about the early trousers is not included (e.g. Alt et al., 2003; Rast-Eicher, 2012). Moreover, the authors reach opposing conclusions. For example, foot-pieces attached to the pair of trousers excavated at Thorsberg (northern Germany) and dated to the first half of the 3rd century AD were interpreted as an indication of a riding costume by some authors, while others argued against this hypothesis (Möller-Wiering and Subbert, 2012 and references therein).

Most of the literature on costumes is outdated and should be revised according to new findings. In this context, the significance of properly dated and documented archaeological artefacts as the primary source for research into clothing and the history of costume is ever increasing (Palmer, 2005; Gleba and Mannering, 2012 and references therein).

A pair of trousers made of fur was discovered in Mebrak (Nepal Himalaya) at ca. 3600 m a.s.l., where one of the caves had been used as a community burial chamber from ca. 400 cal. BC to 50 cal. AD (Alt et al., 2003). Though, no further details of the fur garment are provided in this paper, a rich store of grave goods and the remains of domestic animals point to the importance of sheep, goats and horses for the former population and indicate a (semi-)nomadic life-style of the buried people (Alt et al., 2003).

There is common agreement that nomadic communities in the Eurasian steppes in need of a garment to enhance efficiency and comfort while riding invented the trousers or/and played an important role in their diffusion (Wolter, 1988, 2005; Lillethun, 2010 quoting Good, 1998; Barber, 1999; Vogelsang, 2010; Stauffer, 2012). However, to date there is no well-argued knowledge about the place and time of this revolutionary invention.

The Yanghai site in the Turfan oasis is a recently excavated and partly published burial ground with a number of well-preserved garments (Xinjiang, 2011). In this paper we present the first

direct determinations of age and analyses of the cut, design and sewing made on a pair of trousers excavated from tomb number M21 at the Yanghai site. For comparison we discuss another trouser fragment, this one from tomb number M157 at Yanghai. Our results contribute to the search for the place and time of the invention of bifurcated lower-body garments in Eurasia.

2. Material and methods

2.1. The Yanghai graveyard

The Yanghai graveyard archaeological site (42°48′–42°49′N, 89°39′–89°40′E) is located in a present-day gravel desert (Jiang et al., 2006) in the north-eastern part of the Turfan depression, about 43 km southeast of the modern city Turfan (Turfan, Tulufan) (Fig. 1). The area is rather cold in winter. The mean January temperatures in Turfan are about −9.5 °C (Domrös and Peng, 1988) and minimum temperatures could be as low as −28 °C. The summer in the Turfan depression is extremely hot with a mean July temperature of +32.7 °C. The maximum temperature may reach 50 °C in the desert, although the mountain slopes and valleys of Bogda Shan and Tian Shan (Fig. 1) provide cooler and more comfortable environments for people and their livestock. The annual precipitation is about 16 mm on average (measured at the Turfan meteorological observatory), reflecting an extremely dry climate (Domrös and Peng, 1988). The very dry climate and the high summer temperatures ensure the good preservation of organic materials, including textiles (e.g. Wagner et al., 2009 and references therein), but also of human corpses, rich plant and animal remains, dung, pollen and spores (e.g. Jiang et al., 2006, 2007, 2009; Ghosh et al., 2008; Li et al., 2013).

The Yanghai graveyard was discovered by local villagers in the early 1970s. By 2003, more than 500 tombs were excavated by the team of Xinjiang Institute of Archaeology (XIA) and the Bureau of Cultural Relics of the Turfan Prefecture (BCRTP) under the direction of Lü E.G. (Jiang et al., 2009). The archaeological work performed at the Yanghai cemetery revealed its relatively large area (about 54,000 square meters) and a long period of use (i.e. ca. 12th century BC–2nd century AD; Xinjiang, 2011). Excavations of the individual tombs have shed light on the subsistence strategy of the people buried there. However, to date only few results are published internationally.

For example, tomb M90 in area 1 (Jiang et al., 2006) revealed the corpse of a 40 year old man accompanied by the utensils of a horseman and a bow, arrows, musical instruments, wooden cups, a leather basket and a wooden bowl filled with remains of hemp (*Cannabis sativa*). The tomb was AMS-dated using hemp remains to 2475 ± 30 ¹⁴C yr BP (¹⁴C yr BP = radiocarbon years before 1950 AD, conventionally taken as the ‘present’) (Jiang et al., 2006). This radiocarbon date represents a calendar age of 630 ± 95 cal. BC (obtained using the online version of the CalPal radiocarbon calibration program, Danzeglocke et al., 2013).

Another published burial (tomb M213 in area 2) also revealed a male corpse accompanied by numerous arrows and wooden artefacts, a pottery jar filled with millet grains and another one containing the remains of caper and hemp (Jiang et al., 2007). It was dated using the remains of caper to 2620 ± 35 ¹⁴C yr BP (i.e. 805 ± 13 cal. BC; Danzeglocke et al., 2013). Tomb M2069 also belonging to area 2 exposed a piece of grapevine stem AMS-dated to 2245 ± 35 ¹⁴C yr BP (Jiang et al., 2009). This date (i.e. 305 ± 65 cal. BC; Danzeglocke et al., 2013) suggests the existence of viticulture in Turfan almost 2300 years ago.

The Yanghai graveyard is assigned to the Subeixi (Subeshi) culture (e.g. Jiang et al., 2006, 2009), conventionally dated to the first millennium BC (Chen, 2002; Han, 2007; Xinjiang, 2011). The

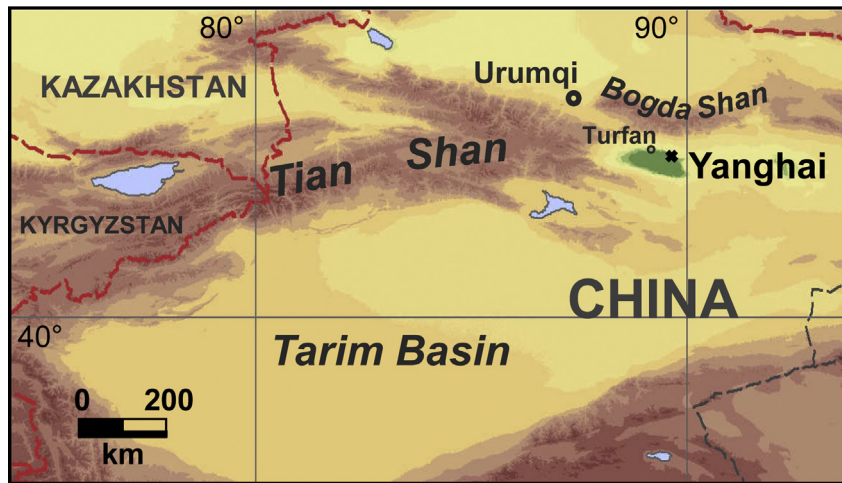


Fig. 1. Map showing the main physiographic features of the Uyghur Autonomous Region Xinjiang in western China and the location of the Yanghai graveyard archaeological site (x) in the northeastern part of the Turfan depression.

culture is associated with the Cheshi (Chū-shih) state known from Chinese historical sources (Sinor, 1990). Archaeological and historical data both confirm a developed agro-pastoral society (e.g. Jiang et al., 2006; Ghosh et al., 2008; Li et al., 2013) and suggest wide-ranging contacts between the Subeixi culture domain and the other regions of Asia (see Li et al., 2013 for details and references).

2.2. Tombs M21 and M157: Setting and archaeological context

Tomb M21, primarily discussed in this study, is located in the southern part of the cemetery. Its even surface consists of gravel and sand. Alternating layers of sand, along with hard, homogenous loess, are found underneath the topsoil. The opening to the grave is below the topsoil, 0.19 m under the surface. It has an elliptic outline (1.63 m long and 1.54 m broad). The grave pit is 1.6 m deep. It also has a 0.14–0.36 m wide ledge at a depth of 1.12 m. The burial has two distinct layers. The upper layer 1 contained two human skeletons. They were buried in flexed positions at a depth of 0.6 m. Body A was a female who was around 25 years of age when she died and was buried here. Her head was pointing to the east, while her bones were badly preserved. Body B was an infant whose head was pointing to the west. This body was well preserved. The infant wore a leather garment and boots, along with golden earrings.

The burial contained a wooden canopy – a lattice-shaped framework of round logs covered with a layer of reed – that was buried at a depth of 1.3 m. The canopy covered the actual burial chamber (layer 2). The elliptically-shaped chamber is 1.31 m long, 0.93 m wide at its opening and 1.6 m deep. The burial chamber was filled with fine sand that must have continually seeped in after the woman and infant were interred on top of it. The chamber contained one mummified body (body C) of a presumably 40 year-old male individual. His head was pointing to the south-east. The mummy's face was turned to the right, while the arms were bent towards the belly and his flexed legs had fallen over to the right. His skin, hair and garments were well preserved. The burial contained altogether 41 artefacts made of bronze, wood, gold, stone, shell, leather, and wool. A leather bridle hung from a wooden stick near the man's head. The bridle was fully decorated with ring-shaped or cowrie-shaped bronze buttons and bronze plaques. A wooden horse-bit was attached to the bridle.

We present here details of the man's trousers based on an examination of the find in Turfan in June 2011. The pair of trousers consists of two straight-cut legs and a stepped cross-shaped crotch-

piece from the centre front to the centre back (Fig. 2). The front part and the left trouser leg were well preserved, whereas the back and the right leg were partially damaged (Fig. 3), thus allowing an insight into the interior of the trousers and the left side of the fabric and the seams.

Tomb M157 revealed another pair of trousers similar to those from tomb M21, though in a not so good state of preservation. The deceased person in tomb M157 has been identified as a male individual of ca. 40 years of age at death (Xinjiang, 2011). Among the grave goods buried with him were a whip, a decorated horse tail, bow sheath and bow.

2.3. Tombs M21 and M157: Dating

For a reliable determination of the age one sample from the trousers and three other samples representing tomb M21 were submitted to the Radiocarbon Laboratory at Poznan (see Kramell et al., 2014 for technical details). The accelerator mass spectrometry (AMS) radiocarbon dates were converted to calendar years using the OxCal v4.1.5 calibration software (Bronk Ramsey, 2008, 2009). The sample of wool from the trousers shows a radiocarbon age of 2855 ± 30 ^{14}C BP (Poz-43695). The calendar age of the trousers falls between 1056 and 940 cal. BC (a 68.2% confidence interval) or between 1122 and 926 cal. BC (a 95.4% confidence interval). The CalPal-based calibration dates the sample to 1028 ± 50 cal. BC (Danzeglocke et al., 2013). Three other dates obtained from wool samples, representing the poncho (2870 ± 30 ^{14}C BP) and plaited bands tied around the right and the left leather boot (2825 ± 35 and 2810 ± 40 ^{14}C BP, respectively) of the man, reveal calendar ages that are similar to the date for the trousers (Kramell et al., 2014). Based on the much better preservation of the plaited bands in comparison to the poorly preserved poncho, we suppose that the bands are younger in age than the poncho and, most likely, than the trousers, as suggested by the ages provided by the radiocarbon dating method. This assumption and the SEQUENCE deposition model help to assign tomb M21 to the interval between 1038 and 926 cal. BC with a 95.4% confidence and the trousers are assigned to the interval between 1074 and 935 cal. BC with a 95.4% confidence (see Kramell et al., 2014 for details and references). Fibres from trousers from tomb M157 have been radiocarbon dated to 2935 ± 30 ^{14}C yr BP, suggesting an even earlier age (i.e. 1261–1041 cal. BC, with a 95.4% confidence interval) for the trousers from M157 (Kramell et al., 2014).

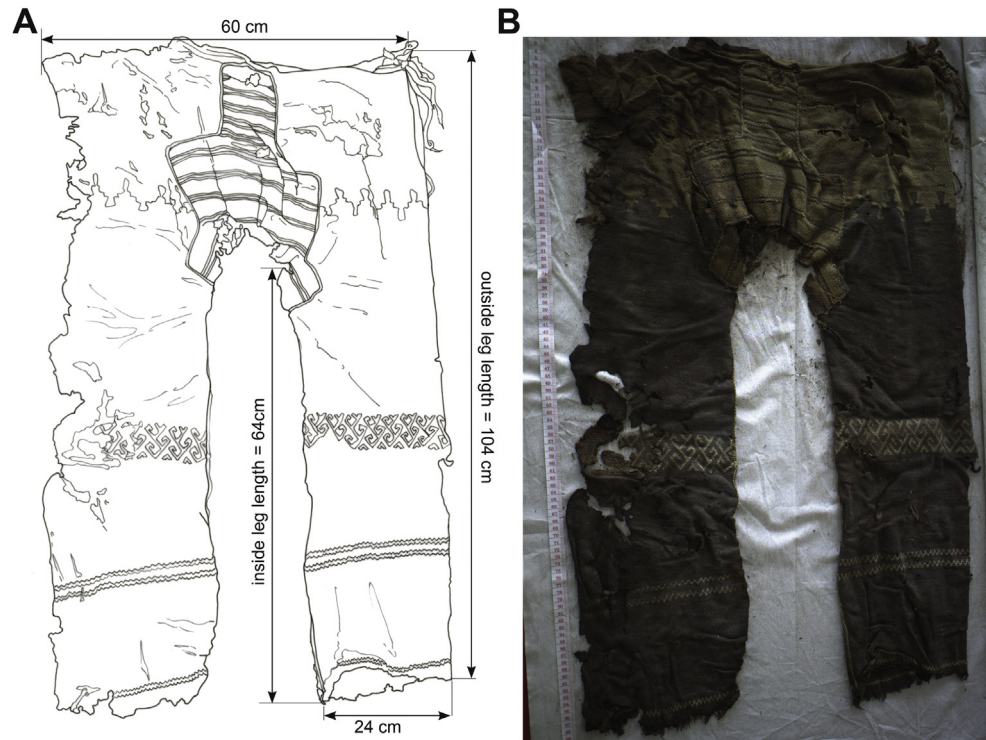


Fig. 2. Front view of the woollen trousers (find number: 2003SYIM21:19, after Xinjiang, 2011) from the Yanghai site, tomb M21; (A) drawing: U. Beck; (B) photograph: M. Wagner.

2.4. Method of reconstructing the design of the trousers

Measurements have been taken at the front and at the right leg, at the few well preserved parts of the trousers at the back and at the left leg (Fig. 4). The precise position of the seams and fabrics in relation to each other has been documented graphically, textually and photographically. Based on the documentation, the cut of the trousers was determined and recorded in a technical pattern drawing in the original size and accompanied by a detailed description (Fig. 5). The reconstruction of the cut includes the accurate measurements but also the method of manufacturing and the different techniques of fashioning. Traces of use have been documented (Fig. 6).

By analysing the superposition of the seams and fabrics, the sequence of the tailoring was reconstructed. The tension on the fabric or seam was tested for information about the positions in which the fabrics were placed during the process of sewing. Some specific characteristics and details of the trousers were recorded and interpreted in terms of function. Based on the inferred pattern, a scientifically accurate and wearable reproduction was manufactured implementing the old fashioning and sewing methods. We asked a model to put on the reproduced pair of trousers to allow the garment to be analysed in its three-dimensionality, movement and function. The conclusions of the wearing test allowed the working hypotheses established before to be checked and corrected. A possibly slight difference in the size of the test person compared to the owner of the garment does not influence the general evaluation of functionality. Infrared (IR) spectroscopy by ATR-FTIR (Attenuated total reflectance – Fourier transform infrared spectroscopy) was applied to samples of warp and weft yarn. For both samples the results showed bands characteristic for protein fibre, allowing us to identify the material as animal wool. The structure of the fibres was not well enough preserved for a more specific identification (see Kramel et al., 2014 for dyestuff and fiber analyses).

3. Results

3.1. Pattern, measurements and sequence of tailoring

The trousers are made from three pieces of cloth, one for each side covering the lower abdomen and the leg and one insert for the crotch (Fig. 4). On both sides the fabric has the same shape. Each piece has a maximum length of 104 cm. It starts at 60 cm wide at the waist but after 6.5 cm begins to narrow symmetrically and diagonally on both sides to a width of 48 cm to continue straight for another 64 cm in length. In the middle of the broad upper part a 21 cm long slit was made. The crotch-piece is shaped like a stepped cross (Fig. 4), 35.5 cm wide and 58 cm high at maximum extension, the width of the three steps either 8.5 cm or 5 cm and the heights either 12 cm or 11 cm (Fig. 4).

After the three separate pieces had been made (Fig. 5A) they were assembled in the following working steps. (1) Each side-piece was folded vertically along the middle axis and the 64 cm straight edges below the diagonal part were sewn together to create tubes (Fig. 5B). The seams were turned towards each other and became the inside of the trouser legs while the fold with the slits became the outside. (2) The side-pieces were sewn together at the centre front and back along the 6.5 cm high straight part of the waist (Fig. 5C). (3) Because the steps of the crotch-piece slant more and more diagonally as it does towards the base of the crotch (Fig. 2A and B) the leg-pieces could not have been parallel to each other when the crotch-piece was sewn in. Instead both leg-pieces were spread apart diagonally to open up a bigger gap at the crotch (Fig. 5D). (4) The crotch-piece was folded horizontally and was inserted and sewn on to the leg-pieces from the centre front to the centre back 6 cm from below the edge (Fig. 5E). The stepped cross-shaped crotch-piece bridges the gap between the leg-pieces and the waistband. When the legs of the finished pair of trousers are laid out parallel to each other, the maximum width of the crotch-piece, that



Fig. 3. Rear view of the woollen trousers (2003SYIM21:19), photograph: M. Wagner.

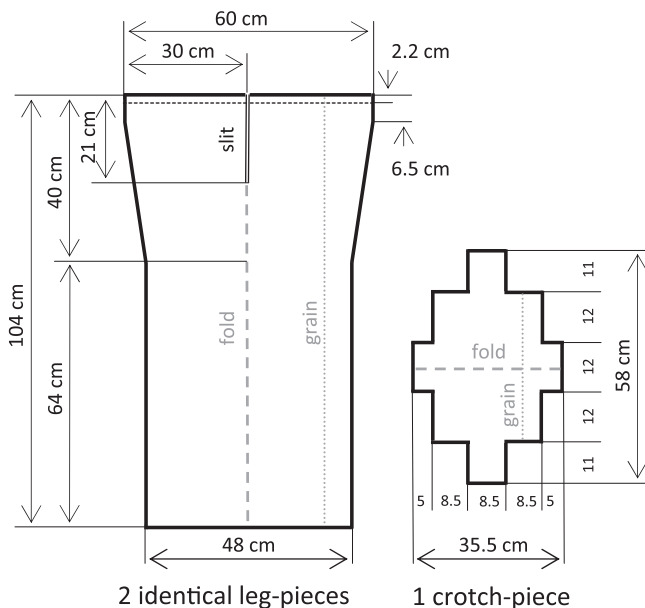


Fig. 4. Parts and measurements of the trousers (2003SYIM21:19), drawing: U. Beck.

is the base of the crotch, is in folds and therefore disguised (Fig. 5F).

3.2. Seams and their concealment

The seams of the inside leg are covered with a decorative bicoloured braid extending the full length and ending in a knot at the crotch (Fig. 7A). The braid was appliquéd with a woollen thread in the same brown as the basic colour of the trouser legs. The edges of the stepped cross-shaped crotch-piece are decorated in a similar manner (Fig. 7B). The braid was sewn on with a woollen thread of the same colour as the crotch-piece and covers all the seams. The cream and brown colour of the braid equals that of the fabrics suggesting that the braids, fabrics and yarns was all made of the same material. A thick sewing thread was used to connect both leg-pieces at the centre front and back. It has the same colour and material as the leg-pieces at the centre front and back below the waistband (Fig. 7C).

3.3. Weave and ornaments

Both leg-pieces were woven from the waistband to the hemline. The 2.2 cm high starting border consists of 0.5 cm brown and 1.7 cm cream-colour weft-yarn and continues as fine twill for most of the remaining length to the hem line. The long sides of the leg-pieces and the sides of the slits feature selvedge (Fig. 8B). The crotch-piece is twill, too. At one place where the braid concealing the edges of the stepped cross crotch-piece at the inside of the left leg near the fold is open a selvedge at a vertical edge is visible.

The warp thread in the leg-pieces is brown but cream-coloured in the crotch-piece, whereas the weft changes between brown and cream and so forms patterns. At the upper part of the trousers, where the fabric covers the abdomen, the ground colour is cream and the ornaments are brown weft. Double lines of brown weft were woven into the fabric decorating the entire crotch-piece at regular intervals. By contrast, the fabric of the leg-pieces is dominated by a shade of brown, on which the ornaments stick out in cream-shaded weft. At the height of the crotch the background colour changes from shades of cream to brown through an interlocking stepped triangle pattern. At the height of the knees a zone of rhombic meandering ornament occurs. At the height of the calves two parallel zigzag lines and a third one just above the hemline are woven around the leg. The ornamental zones feature different weaving techniques which together with the details of the yarns and threads merit a separate study and paper.

3.4. Strings

The remains of strings are visible at the edges of the slits in the waistband. They were probably used as drawstrings to close the trousers on both sides. At the waistband of the left side on the forepart the remains of four pieces of intact twisted strings were found. One of them was still tied to the waistband, the others stuck out loosely from a knot (Fig. 9A). Most likely the knot consisted of strings from the forepart but also of tattered strings from the back. The strings were worked into the fabric carefully. They exhibit the same colour and material as the fabrics of the leg-pieces at the waistband and the upper part; probably they were made of the same threads that were used as weft yarns for the upper part of the trousers. Presumably they were worked into the waistband before the leg-pieces were sewn to each other (Fig. 9B). The original length of the strings cannot be determined. Only one of the loose and tattered strings still seems to have its original ending. There is a small twisted string at the left leg 1 cm below the side slit (Fig. 2). At

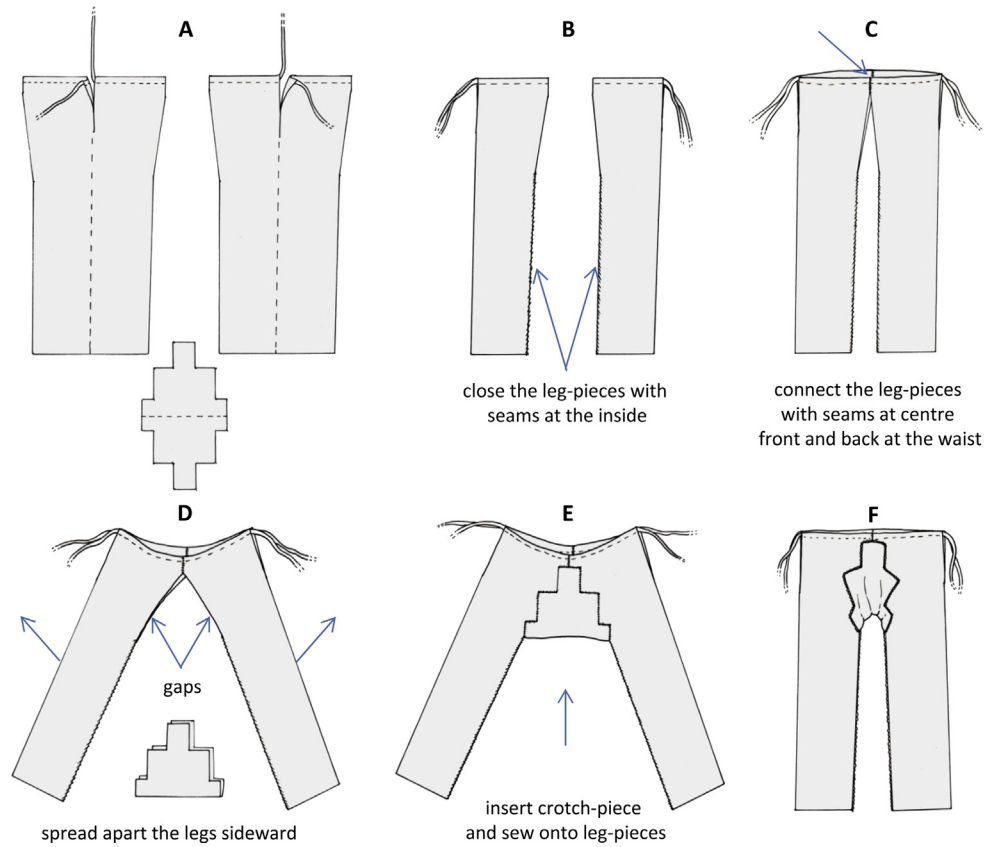


Fig. 5. Sequence of tailoring: (A) starting with three pieces of cloth: two trouser leg-pieces and one crotch-piece; (B) the leg-pieces are folded vertically, the 21 cm long slits with strings are turned outside; the 64 cm straight edges at the inside of each leg are sewn together to create tubes; (C) the leg-pieces are sewn together at the centre front and back along the 6.5 cm high straight part of the waist; (D) both trouser legs are spread out diagonally to open up the gap at the crotch; (E) the folded crotch-piece is inserted and stitched down all around onto the leg-pieces; (F) the finished pair of trousers; drawing: U. Beck.

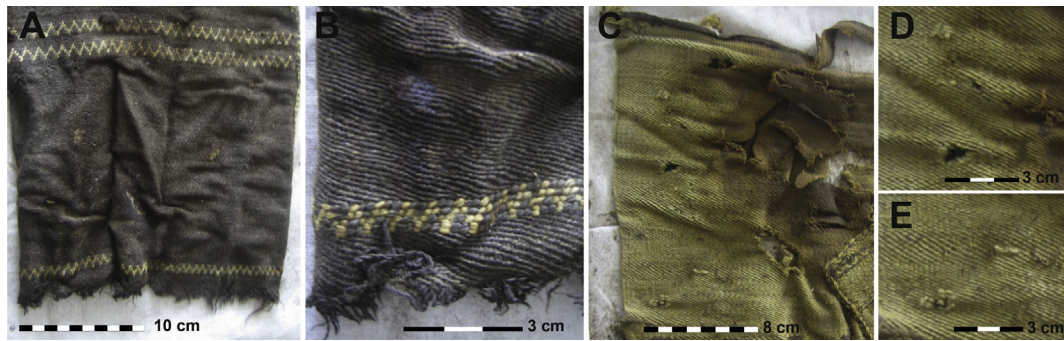


Fig. 6. Deterioration and traces of use: (A) the hemline of the leg; (B) detail of the splayed warp at the hemline; (C) various napped parts below the waistband; (D) and (E) details of the roughened places; photographs: U. Beck.

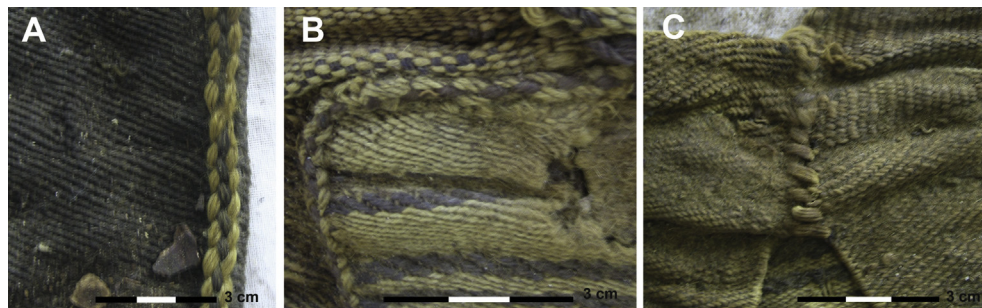


Fig. 7. Details of seams: (A) decorative bicoloured braid covering the seam on the inside leg; (B) a similar braid covers the seams with which the crotch-piece was stitched down onto the leg-pieces; (C) the seam which connects the two leg-pieces at centre back; photographs: U. Beck.

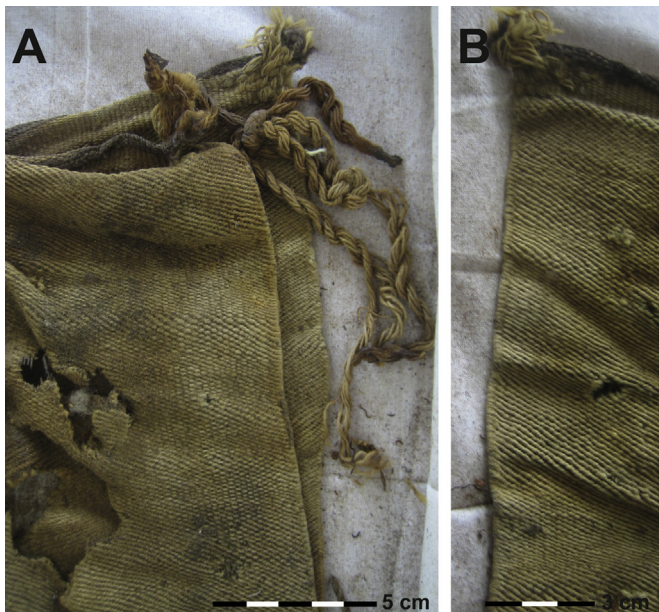


Fig. 8. The side slit (A) at the left side with drawstrings; (B) at the right side; photographs: U. Beck.

the right leg a counterpart is missing. The function of this little string remains uncertain.

3.5. Deterioration and traces of use

The hems of the trouser legs had no trimmed edge. As a result, the fabric has frayed on both legs (Fig. 6A). The loosened threads hanging from both hemlines indicate that the trousers were worn over a longer period. The friction involved in the movement caused the weft yarns ultimately to fall off, while the warp yarns are left hanging loosely (Fig. 6B). Why the hemlines were not tidied up can only be guessed at; maybe it was thought to be unnecessary because when someone was wearing the trousers the hemlines were covered by the boots as in this case. Another option is that the trousers were shortened after being in use for a while. The surface of the fabric shows napping in various places below the waistband (Fig. 6C and D), indicating strain. Those marks might have been caused by rough or sharp items the wearer used or worked with or which were hanging from his belt.

4. Interpretation and discussion

4.1. Overall design of the trousers from tomb M21

The three pieces of fabric of the trousers of tomb M21 match in colour and weave, suggesting they were made from the same wool and woven by the same person or at least in the same workshop. The side slits were already woven into the textiles of the trouser legs during the weaving operation. There is no indication that the cloth was cut. These features prove that the three pieces of fabric were, from the very beginning, planned and manufactured for their later function as parts of one pair of trousers: as the left and right sides and as the piece for the crotch. Small functional features, such as the slits at the sides and the strings, as well as their ornaments, were woven into the fabrics at the correct positions with regard to their later purpose and aesthetic appearance. This requires that the weaver was familiar with the entire sewing process of the trousers and the size of the intended user. In addition, the twisted

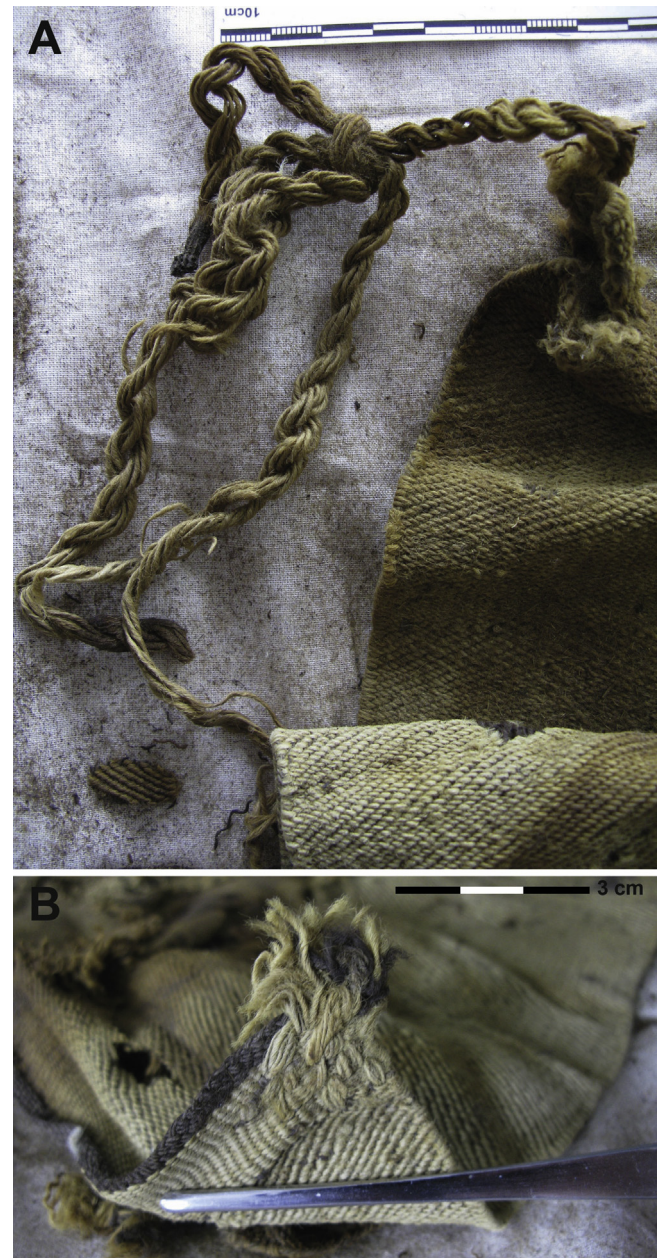


Fig. 9. (A) Twisted drawstrings at the edges of the waistband at the left side; (B) detail of the starting border with tattered strings at the right side slit; photographs: U. Beck.

drawstrings at the waistband as well as the threads and the braids which were used to sew and decorate the trousers display the same colours and quality as the fabric yarns. In conclusion, the sewer must have had access to the same basic material as the weaver. Weaver and tailor either cooperated closely or were one and the same person.

4.2. Comparison with a pair of trousers from Yanghai, tomb M157

The remains of another trousers in tomb M157 with similar design features to those identified in the find from tomb M21 proves that it was not a solitary find at the Yanghai site. Fig. 10 shows the remnants of an unfolded horizontally striped trouser leg from Yanghai tomb M157. The examination of the fragments of the garment yielded three pieces: two trouser leg-pieces and one crotch-piece. With a width of 55 cm it was possible to reconstruct a

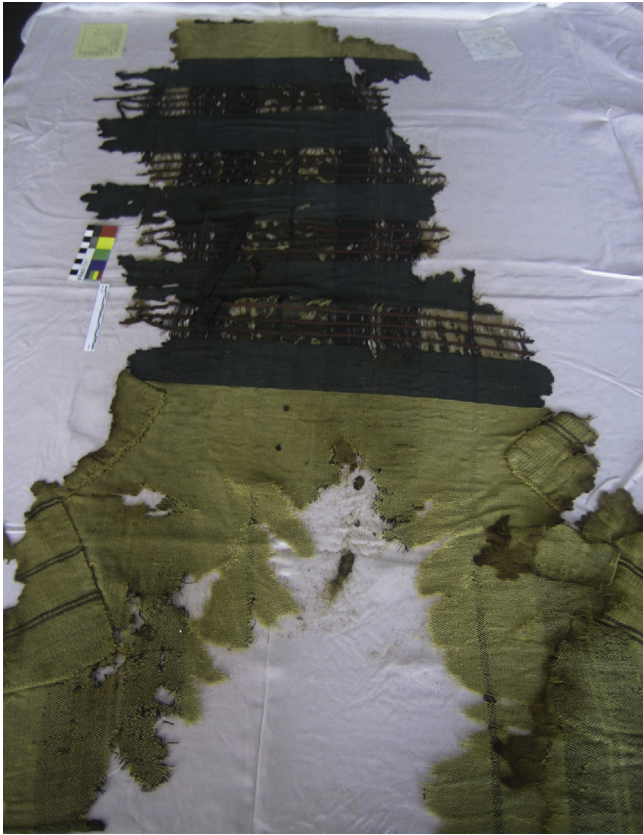


Fig. 10. A fragment of a pair of trousers from the Yanghai site tomb M157 (find number: 2003SYIM157:14, after Xinjiang, 2011); photograph: U. Beck.

waistband similar to the size of the waist of the trousers from tomb M21. The exact length of the trousers could not be established, but the length of the fragment is 123 cm and therefore about 20 cm longer than that of the trousers from M21. Whether this pair of

trousers also had side slits or closing strings could not be ascertained. There were remnants of the waistband at the top edge of the fabric (Fig. 11). At the upper left part of the piece of textile the vertical selvage of the trouser leg was clearly recognisable. A part of the second trouser leg was still connected to this edge. Folded inwards, this fragment lay on top of the other (Fig. 11A). The seam which connects both leg-parts once formed its centre front or back. Fragments of the stepped cross-shaped crotch-piece were attached about 12 cm below the waistband on both sides of the trouser leg. The fabric of both fragments was identical as well as that of the threads with which they were attached. Most likely both fragments belonged to the very same crotch-piece (Fig. 11A and B) which was comparable in shape, and position – extending from the centre front to the centre back just below the waistband – to the piece from tomb M21. Dark-coloured horizontal stripes were woven into this crotch-piece as well. Here, the edges of the crotch were partly turned inwards and the seams remained uncovered (Fig. 12). Both fragments of the crotch-piece were sewn diagonally onto the leg-piece. Especially at the left side of the leg the diagonal position of the crotch-piece fragment relative to the vertical seam at the centre front or back can be clearly seen (Fig. 13). The diagonal position of both fragments indicates that the crotch-piece was sewn onto the legs when they were spread sideward as described above. Although the fold is not preserved we can conclude that this crotch-piece must have been very wide at the fold as well. Most likely it had only two steps towards the fold (Fig. 14). Obviously the trousers of tomb M157 and those of tomb M21 were designed in the same way suggesting that this was a well-known procedure.

It has not been possible to fully reconstruct the size of the steps of the cross-shaped crotch-piece of M157. Only the first step was well enough preserved for measurement. With 20 cm in width and 18 cm in height it was more than double as wide and two thirds higher than the first step of the crotch-piece of M21 (8.5 cm wide, 11 cm high, compare Fig. 4). For the second step of the crotch-piece of M157 it is possible to reconstruct a width of 15 cm and height of 12 cm. Taking all the remaining fragments and traces of stitching into account we calculated the entire width of the crotch-piece as

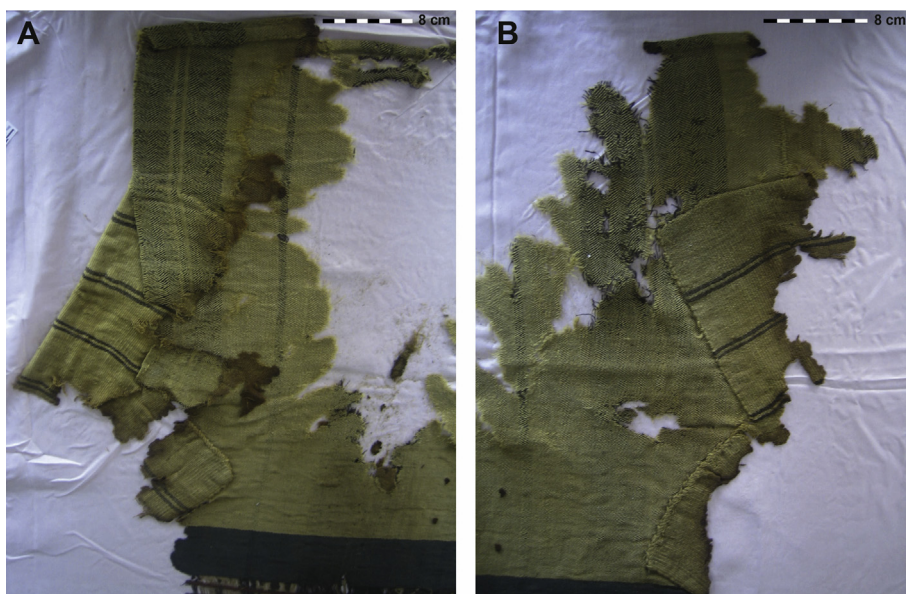


Fig. 11. The upper part of a fragment of trousers (2003SYIM157:14): (A) the left side of the trouser leg with remnants of the waistband, an inwardly-folded fragment of the second trouser leg on top and fragments of a stepped cross-shaped crotch-piece; (B) the right side of the trouser leg with remnants of the waistband and another fragment of the stepped cross-shaped crotch-piece; photographs: U. Beck.



Fig. 12. Detail of the crotch-piece with vertical selvedge and the horizontal edge partly turned inwards at the corner; photograph: U. Beck.

50 cm and the full height as 60 cm. Therewith the crotch-piece of the M157 trousers appears to have been substantially wider than that of M21 (M21: 35.5 cm wide) but similar in height (M21: 58 cm). The greater width of the crotch-piece corresponds to the length of the trousers suggesting that the garment from M157 was made for a taller build person than that of M21.

The cream and brown colour of the stepped cross-shaped crotch-piece and the upper parts of the side pieces covering the abdomen and onto which the crotch-piece was sewn make a perfect match visually. The tube-shaped leg-parts however were manufactured in bright turquoise and red colour (see [Kramell et al., 2014](#); for the analyses of the chemical dyes).

4.3. Design and effect of the crotch-piece

As could be observed from both examples of the crotch-piece, the vertical sides of the stepped cross are selvedged, the horizontal sides show plain edges and therefore allow us to deduce that the pieces were woven in the required shape and not cut. The crotch-piece connects both trouser legs, bridges the gap at the crotch and covers the lower abdomen. Thus the crotch-piece is the decisive part in the process of making the trousers as it transforms two separate hip-plus-leg wraps into a functional one-piece pair of trousers. Both the shape and processing of the crotch-piece are of crucial importance. The crotch-piece was made substantially wider than needed for a normal stride and forward movement of the legs. Instead it was made to allow sideward movement of the legs in a wide arc. This sideward movement was imitated in the tailoring process by spreading out the leg fabrics before the crotch-piece was inserted. As the wearing test confirmed, the crotch can easily be expanded to full width to allow the wearer maximum freedom to take big strides forward as well to mount and straddle a horse. The crotch-piece extends far beyond the abdomen to the centre back



Fig. 13. Detail of the diagonal position of the fragment of the crotch-piece in comparison to the vertical selvedge at the folded centre of the trousers; photograph: U. Beck.

and front just below the waistband so that the area around the lower abdomen is kept seamless. No seam means less friction and sores during extended periods of riding. So we conclude that the Yanghai design of trousers was not just suitable for riding but rather that it was deliberately created for this purpose. The width of the crotch-insert as well as the position of the seams reveals a design resembling the functionality of modern riding trousers. Like those, the legs of the Yanghai trousers are form-fitting.

4.4. Trousers in costume history

Publications on costume history and research often trace the origin of trousers by means of indirect sources, i.e. images of trouser-wearing persons (e.g. [Gleba and Krupa, 2012](#)). Some older books still refer to sketchy cave paintings of southern France dated to about 12,000 years ago ([Thiel, 1968](#); [Loschek, 1991](#)) which are not regarded as reliable evidence ([Wolter, 1988](#)). The adoption of trousers as a part of northern European dress traditions is assumed to have been a relatively late process ([Andersson et al., 2010](#)). [Thiel \(2010\)](#), referring to Roman and Greek art and literature, describes Celts as the first Europeans who adopted trousers from Scythians in about the 6th century BC. [Wolter \(2005\)](#) presumes that Sarmatians, Dacians, and Lydians might have adopted them after 700 BC from the Persians. [Lillethun \(2010\)](#) and [Vogelsang \(2010\)](#) assume that the Romans adopted the trousers for their cavalry during the first century BC. [Wolter \(1988\)](#) and [Thiel \(2010\)](#) believe that Germanic tribes got to know trousers from the Celts; however both authors describe them in a very contrasting way.

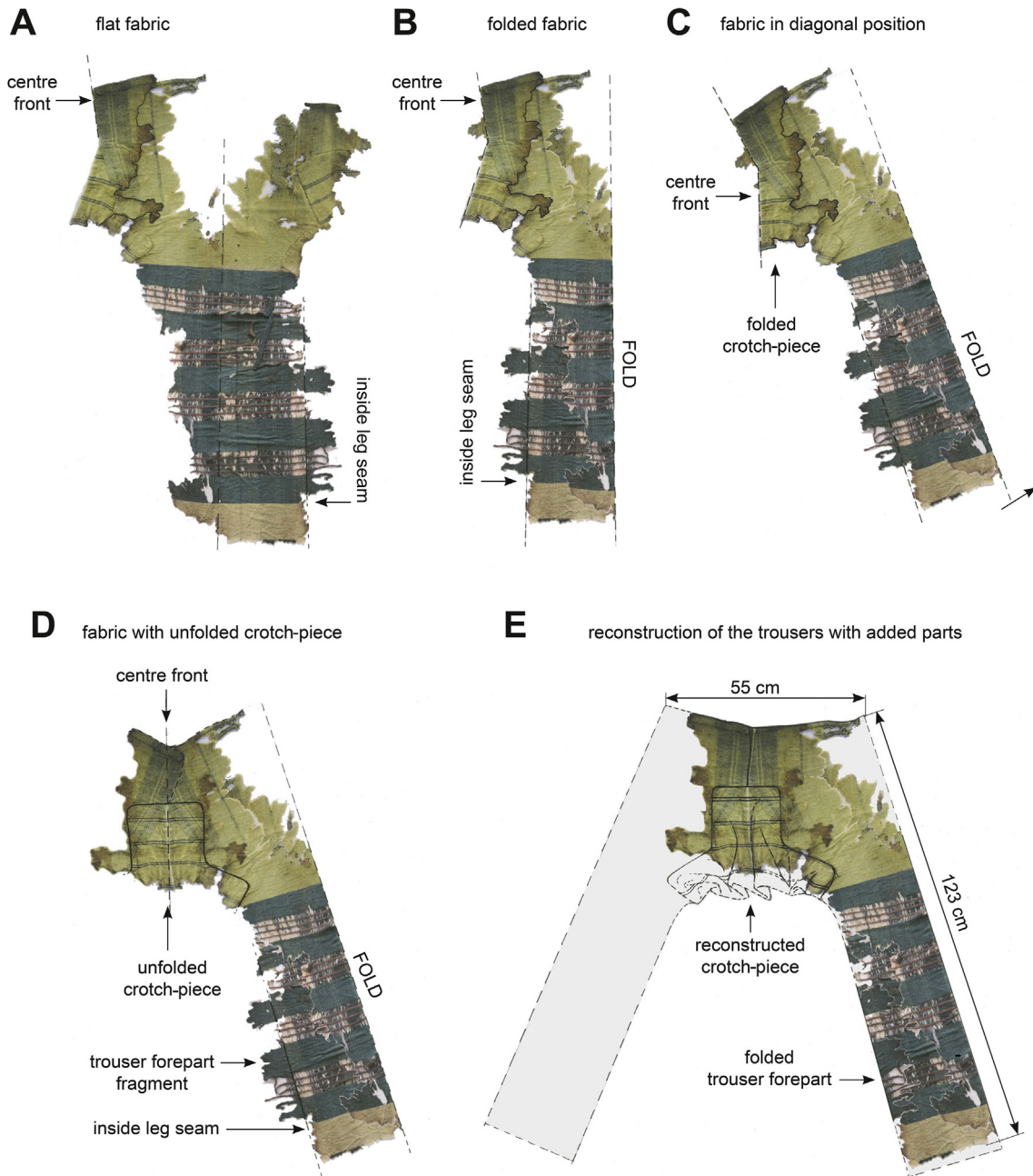


Fig. 14. Step by step reconstruction of the trousers from the Yanghai site, tomb 157 (2003SYIM157:14); drawings: U. Beck.

Authors taking archaeological and historical information into account discuss the trousers-and-coat dress of Scythians as shown on Greek metal art and in depictions of Sakas on stone panels of stairway to the Apadana palace in Persepolis, the ceremonial capital of the Achaemenid Empire (i.e. Cernenko, 1983; Parzinger, 2006; Harlow and Llewellyn-Jones, 2010; Vogelsang, 2010 and references therein). The images to which all these authors refer, however, only show the lower legwear. The thigh and abdomen are covered with either a coat or weapons so that the design of the garment at that part cannot be verified.

Zhao and Kuang (2010) identify as the oldest known trousers found in China a pair of hemp trousers excavated from a royal tomb of the Guo state of the Western Zhou dynasty (1046–771 BC), in modern Henan province in central China. However, the authors do not further specify the find.

In the southern part of the autonomous region of Uyghur Xinjiang garments of the first millennium BC are well preserved in the archaeological records due to the extremely arid climate conditions (Barber, 1998, 1999; Good, 1998; Xinjiang, 2010, 2011). Vogelsang (2010) identified as the oldest trousers the garments of the “Cherchen Man” on exhibit in the museum in Urumqi (Urumchi), China. He indicated a date of about 1000 BC but did not explain how it was obtained. For this he quoted Barber (1999). E.J.W. Barber and I. Good were the first non-Chinese textile specialists who travelled to Urumqi in 1995 after V. Mair started to make the stunningly well-preserved mummies famous in the English-speaking world (e.g. Mair, 1998; Wang, 1999 translated by V. Mair). They examined several textile pieces from the Zaghunluq site near the county capital Cherchen (Chinese: Qiemo) and provided first observations, drawings, photographs and interpretations in their publications

(Barber, 1998; Good, 1998). Barber (1999: p. 37) reports that the pants of the famous man “were not in a position to be studied”. This was perhaps related to the fact that he was wearing them as he still did when we saw him in the museum in 2013. Instead, Barber and Good examined another pair of trousers and provided a very simple drawing showing a diamond-shaped crotch-piece which appears triangular when viewed from the front because it was folded on the base (Barber, 1999: p. 39, Fig. 2.11). For the age of the finds they relied on information given by local archaeologists. The round number of 1000 BC already indicates that it is a rough age estimate and rather hypothetical. Wang (1999) gives one single radiocarbon date 2840 ± 80 ^{14}C yr BP (i.e. 1010 ± 115 cal. BC) obtained from poplar wood at the bottom of the tomb of the “Cherchen Man” but without further details about the laboratory and the sample. Compared with dates obtained from samples collected during the excavation campaign in 1996 the date published by Wang (1999) can be regarded as too old (Xinjiang, 2003). Currently the majority of the burials in the Zaghunluq cemetery, including the tomb of “Cherchen Man”, are assumed to belong to the time interval of ca. 800–300 BC (Xinjiang, 2003, 2010). However, none of the several known Zaghunluq trousers has been sampled for dating.

Up to the present, the oldest known Scythian trousers have been excavated from tombs in the Altai Mountains and dated by the archaeological context to the Pazyryk culture, i.e. ca. 5th to 3rd centuries BC (Molodin and Polos'mak, 2007). Polos'mak and Barkova (2005) published the woollen trousers from the Ak-Alakha-1 site and the Verkh-Kal'djin-2 site kurgan 1 and 3 which show triangular (diamond-shaped) crotch-pieces comparable to those from Zaghunluq described by Barber. They are dated from the end of the 5th to the first half of the 4th century BC (Parzinger, 2006 and references therein). Although none of the trousers preserved in ice kurgans in the Altai Mountains have been dated directly, all of examples presently known seem to be younger than the trousers from the Yanghai site reported in the current study. Even younger dates were obtained for the trousers excavated in the Nepal Himalaya, i.e. fur and leather trousers dated to ca. 400 cal. BC to 50 cal. AD (Alt et al., 2003) and in Germany, i.e. the Damendorf Man trousers dated to 135–335 cal. AD and the knee-long trousers from Marx-Etzel tailored from one piece of cloth dated to 45–125 cal. AD (Möller-Wiering and Subbert, 2012 and references therein).

We can not say for sure whether the Yanghai trousers described in this study are among the earliest fashioned trousers in garment history. It is possible that earlier examples may not have survived or are not found yet. Though, as a matter of fact, the so far earliest known Xinjiang mummies from the Xiaohe burial site ($40^{\circ}20'11''\text{N}$, $88^{\circ}40'20.3''\text{E}$) predating the Yanghai finds by three to six centuries (Xinjiang, 2007) were dressed in string skirts, leather boots and felt hats, but not in trousers (e.g. Mair, 2010). The Xiaohe bodies were wrapped in large rectangular wool cloth pieces (e.g. length of 225 cm and width of 130 cm) resembling a blanket or cloak (Mair, 2010). Similar clothing, including string skirts and rectangular cloaks has been excavated in Denmark and dated to the Early Bronze Age, ca. 14th to 12th century BC (Mannering et al., 2012).

5. Conclusions

In tomb M21 and M157 of the burial field Yanghai, Turfan, two pairs of woollen trousers were discovered which date to the time interval between the 13th and the 10th century BC. Their age correspond to the onset of mobile pastoralism in eastern Central Asia and predates the widely known Scythian finds. The horse gear placed as burial goods in tomb M21 and a decorated horse tail and a whip in tomb M157 put the deceased men who were clad in those trousers in a connection with horseback riding. A battle axe and a leather bracer in M21 together with a bow and a bow sheath in

M157 add attributes of warriors. Detailed studies of the design and tailoring process of both trousers revealed the following particularities. (i) The trousers were made of three independently woven pieces of fabric, one nearly rectangular for each side (in the more completely preserved example of M21 spanning the whole length from the waistband to the hemline at the ankle) and one stepped cross-shaped crotch-piece which bridged the gap between the two hip-plus-leg-pieces. (ii) The three pieces were woven for the very purpose of being assembled into one pair of trousers, they match in colour and weaving technique and incorporate side slits and strings for fastening at the waist; consequently the weaving was aimed at a particular final product and the weaver was either also the tailor or both of them cooperated in a highly coordinated way. (iii) The tailoring process did not involve cutting the cloth, instead the parts were shaped so on the loom. (iv) They were shaped in a specific size to fit a specific person. (v) The design of the Yanghai trousers with straight-fitting legs and a wide crotch-piece is a predecessor of modern riding trousers (e.g. breeches).

A pair of trousers is one of the most suitable items for studying human creativity focused on making the human body fit for new challenges, in this case to speed up movement, to enhance efficiency of transportation and warfare, and to widen the range of mobility. Furthermore, striking similarities between the oldest preserved garments found in Xinjiang and northern Europe (i.e. Denmark and Germany) certainly deserve more attention in future research.

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