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Textile Templates for Ceramic Crucibles in Early Islamic Akhsyket, Uzbekistan

Introduction

The FerganaValley, located in the eastern Uzbekistan was an important area of textile production since the beginning of the Common Era. Located on the Silk Road, this area was likely a crossroads of the Central Asia, which absorbed eastern and western influences. The finds of archaeological textiles in Uzbekistan are, however, exceedingly rare. Some of the earliest textiles have been excavated at the Bronze Age site of Sapallitepa in southern Uzbekistan, dated to the 17-14th centuries BCE (Askarov 1977, 173-174). Numerous silk fragments were found in the Karabulak cemetery in southern Fergana and date the last centuries BCE and 1st-2nd centuries CE (Litvinskiy 1972, 133-136). Recently a large number of textiles from the Munchaktepa cemetery near Pap dated to the 5th-8th centuries CE have been published (Matbabaev and Zhao 2010). The vast majority of the surviving textiles are silks but cotton and wool textiles were also present. On the basis of this material, Matbabaev and Zhao (2010, 227) suggest that silk production in the Fergana Valley was already developed at the beginning of the Common Era under the influence of China. Looking at the wider region of Central Asia, most textile scholarship has focused of the often spectacular patterned silk finds (e.g. Schorta 2006 with extensive bibliographies), while little is known about the more mundane and utilitarian textiles made of other materials[1].

An investigation of a large number of crucibles excavated at Akhsyket, a city in the FerganaValley of eastern Uzbekistan dated to the 9-12th century AD, revealed numerous textile impressions. Olga Papakhristu (1985; 1993) was the first scholar to discover that these crucibles must have been made by means of a textile mould. This paper follows up on her research by looking more closely at the textile impressions left on the crucible fabric,advancing our understanding of a highly standardized, industrial scale manufacture of crucible steel. It further brings to focus textiles used for utilitarian purposes in a region where few textiles have been found.

Textile Impressions

Impressions of textiles and basketry have long been investigated for the information they may provide about the perishable materials that left them. Impressions are negatives of the original fabrics, created, for example, when the fabric comes in contact with clay objects or surfaces before they are fired. Some of the earliest evidence for woven fabric, in fact, survives in the shape of such imprints, as in the case of the Upper Paleolithic Czech site of Pavlov I (Adovasio*et al*. 1996; Soffer*et al*. 2000). During the Neolithic period, several ceramic traditions existed, which used cords, baskets and textiles for pottery decoration and entire cultures have been named after this custom, for example the Corded Ware Culture. Recently, results of some archaeological experiments were published, demonstrating the importance of such impressions for our understanding of the past fibre technologies (Grömer and Kern 2010). To our knowledge, textile impressions on metallurgical crucibles have never been investigated before. They open a new field of inquiry into the use of textiles and the economy of their production in the past in contexts where textiles themselves no longer survive.

Methodology and Materials

More than 150 crucible fragments from Akhsyket were investigated in this study, and 30 samples

with fabric impressions were selected for further analysis. Impressions were easily identifiable with a naked eye but could be observed more clearly under a magnifying glass with a raking light. The textile fabric impressions were photographed using a Dino-Lite USB digital microscope. In an attempt to identify the fibre and further microscopic features of the textiles, Vinyl Polysiloxane casts of selected impressions were made for SEM analysis. To our knowledge, this method has not been used before for the study of textile impressions on ceramics. However, unlike other types of textile impressions which in some cases preserve the microstructure of the fibres (Good 2001, 215; Grömer and Kern 2010), the crucible surface vitrified (Fig. 1) when they were heated over to temperatures reaching 1400-1500 ºC (Rehren and Papakhristu 2002, 70), thereby obliterating any more detailed information left by the fibres.

Akhsyket

Akhsyket is located in eastern Uzbekistan, Central Asia (Fig. 2). During the early Islamic period and until the Mongol invasion in the early 13th century AD, it was the political and industrial capital of the FerganaValley (Papakhristu and Rehren 2002, 69; Rehren and Papakhristu 2000, 56; 2003, 395). During the Samanid dynasty (AD 892-998), Fergana became a trade market for steel weaponry and armour (Papachristu 1985, 123). The city structure of Akhsyket is typical for the Sassanid era, comprising three main parts: Quhandizh or Ark, a fortification, which is surrounded by the main city or Shahristan, and then the suburb areas or Rabat which included the industrial quarters. The industrial scale of crucible steel production in Akhsyket is demonstrated by the thousands of crucible fragments excavated at the site, dated from the 9th to 12th century AD (Papachristu and Swertschkow 1993; Papakhristu and Rehren 2002, 69; Rehren and Papachristou 2003, 395). The crucible fragments included in this study come from both stratified and surface contexts. The stratified contexts, however, do not provide a firm chronology, therefore we are unable to discuss the chronological variations of the crucibles.

Crucible Steel and Crucibles

The manufacture of crucible steel is a highly specialised process during which iron is transformed into steel. During this process iron is carburized with a variety of organic materials, *e.g*. wood or charcoal, all of which are placed in a crucible which is then sealed with a lid and heated to very high temperatures in a furnace (Srinivasan 1994, 56; Juleff 1998, 11; Rehren 2000; Craddock, 2003, 242; Rehren 2003, 210). While the metal within the

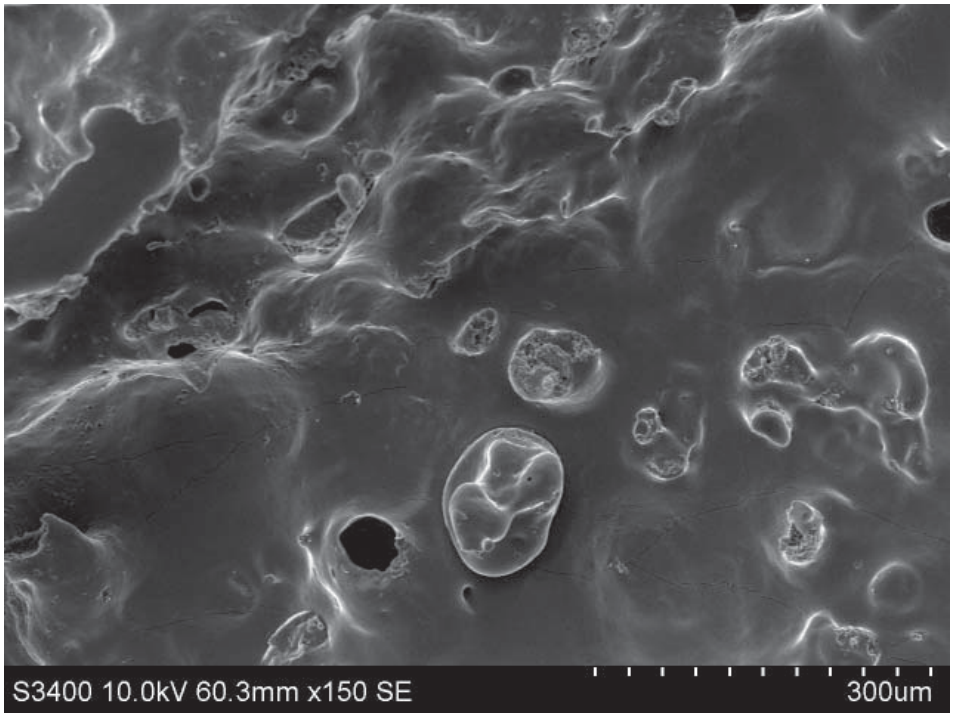

Fig. 1. SEM image showing the vitrification of the inner surface of the crucible fragment No.1.

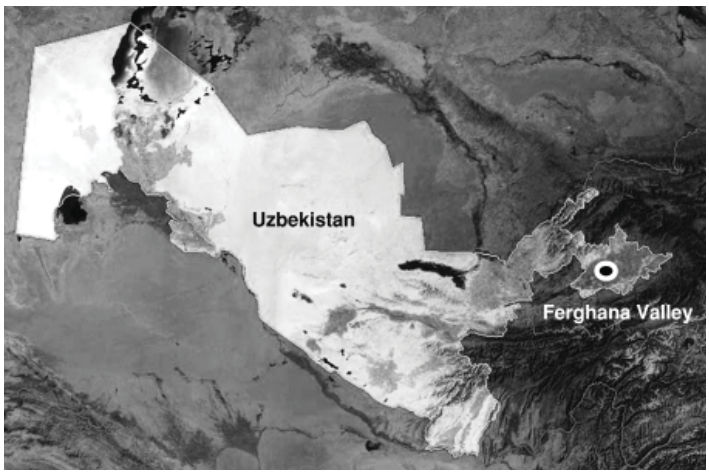

Fig. 2. Satellite view of Uzbekistan and Ferghana Valley (Wikipedia 2010).

crucible absorbs carbon, the melting point of the alloy decreases and it liquefies, allowing the slag and alloy to separate so that a very clean steel ingot solidifies in the crucible (Rehren 2003, 210-211).

The Akhsyket crucibles are tall (28-30 cm) and thin (8 cm diameter) cylindrical vessels with lids (Fig. 3). Their specific characteristics include use of a particular type of clay and the mould-made shape which is atypical for the domestic pottery, the presence of corrugations on the outer surface, and most importantly, textile impressions on the inner and sometimes the outer surface of the crucible. Papachristu (1993) was the first to propose that the crucibles had been made using textile moulds, based on the presence of textile impressions on the inner surface of the crucible walls. The suggested process of making the crucibles started with a textile mould which was most likely filled with sand to give it a cylindrical shape. The crucible was then built around the mould. Once the clay was leather-hard, the sand inside the mould was discarded and the flexible textile mould was retrieved for reuse, leaving the textile impressions on the clay. Subsequently the crucible may have been fired before being used. Thus, the textile impressions on the inner surface of the Akhsyket crucibles are negatives of the original textile moulds impressed onto the clay used to make the crucibles and as such are a result of 'indirect textile trace formation' (Good 2001, 215).

The textile impressions are mostly found on the fragments of upper parts of the crucibles, but rarely if ever in the lower parts. This is due to the fact that during the carburization process the liquid steel and the slag were present in the bottom two-thirds of the crucible, destroying these delicate impressions. Thus, only the upper one-third section of the crucible which

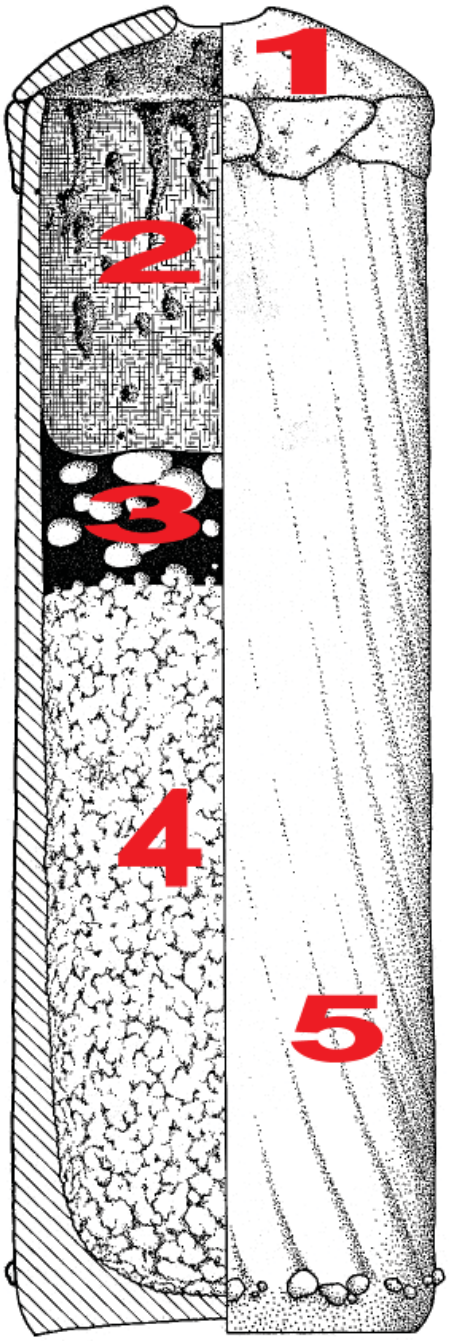

Fig. 3. Reconstruction of the Ferghana Crucible from Akhsiket:
1: Fine Lid
2: The upper crucible wall with remains of textile impression on the inner surface
3: Slag
4: Crucible steel ingot
5: Outer surface of the crucible showing corrugations and textile impressions.

No.	Context	System 1 Thread Count/cm	System 2 Thread Count/cm	Other features	Stitches/ cm
1	23-10a	12	14	seam	2
2	23-10b	18	14	seam	
3	23-Various Layers	16	18	seam	2
4	23-2-9	10	10		
5	23-12	18-20	16		
6	23-19	18	18		
7	23-20	14	14		
8	23-17	12-14	12-14		
9	23-18	14	12		
10	21-3	12	12		
11	23	10-12	10-12		
12	23-21a	12	10		
13	23-21b	12	12		
14	9-3	10	10		
15	Surface	12-14	12	seam	3
16	N5 lower west	10	8		
17	Surface	12	16		
18	WN Lower	16	16		
19	6872-8971	14	16		
20	6070-8158	12	12		
21	Surface	18	18		
22	Surface	12	14-16		
23	Surface	14	12		
24	Surface	16	12		

Fig. 1. SEM image showing the vitrification of the inner surface of the crucible fragment No.1.

was not in contact with the slag and liquid steel retained the impressions. These impressions provide much information about the nature of the textiles used to make the moulds for the crucibles, and it is this information that we present here.

Analysis and Results

Inner surface impressions

Twenty-four crucible fragments with impressions on their inner surface were available for study. All the impressions are from relatively balanced tabby weaves (Table 1). Since none of the impressions preserve evidence of the edges, the thread system perpendicular to the height dimension of the crucible was designated System 1. The thread system parallel to it, which also had a more distinct and regular visual appearance and was parallel to the seam (where present), was designated system 2. The thread counts range between 8 and 20 threads/cm, with approximately the same number of threads in each system (Table 1).The average thread count for system 1 is 13.5 threads/cm (standard deviation 2.8), and for the system 2 it is 13 threads/cm (standard deviation 2.6). The majority of the samples have thread counts of 12-16 threads/cm (Fig. 4).The thread counts are relative, since we do not know the percentage of clay shrinkage. It was not possible to measure the yarn diameters accurately.

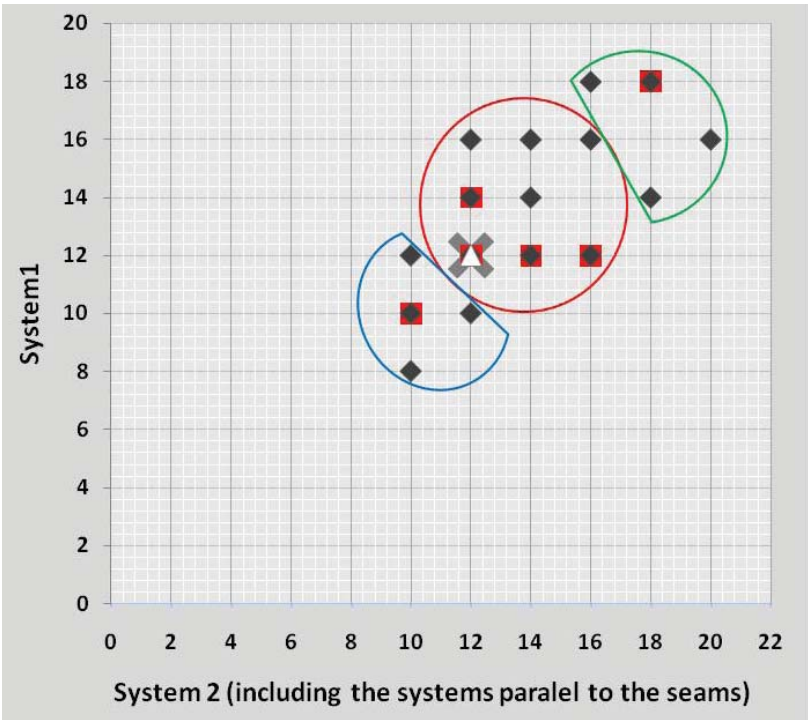

Fig. 4. Thread counts of the inner textile impressions of the crucibles in both systems. (Each diamond corresponds to a single textile impression; note that in several points on the graph (diamonds combined with squares) correspond to 2 or more textiles indicating that 12 threads/cm is the common thread count).

No.	Context	System 1 Thread Count/cm	System 2 Thread Count/cm
16	N5 lower west	16	-
17	Surface	18	-
19	6872-8971	20	-
24	Surface	14	-
25	Surface	10	14
26	Surface	14	-
27	Surface	20	-
28	AxN5	16	-
29	AxN5	14	-
30	Surface	10	16

Table 2. Outer Textile Impressions of the Akhsyket crucible fragments. The thread counts are relative, since we do not know the percentage of clay shrinkage.

Outer surface impressions

A closer examination of the crucible fragments revealed the hitherto unknown presence of textile fabric impressions also on some of the outer surfaces of 10 fragments (some of which also had inner surface impressions; see Table 2). In the majority of the cases a fuel ash glaze has obliterated the impressions, but on some of the crucibles which had light or no fuel ash glaze, the impressions survived. Due to the faint nature of these impressions it was only possible to measure the thread count in System 1, which ranges from 10 to 20 threads/cm, with an average of 15.2 mm. This is slightly higher than in the case of inner surface impressions. Outer surface impressions appeared finer visually as well.

Distinctive weave features

Some of the textile impressions have distinctive features such as unusual weave elements, seams or stitches. One of the impressions is unusual due to the coarseness of the fabric (No. 16 inner side, Fig. 5). The system (system 2) parallel to the seam is more pronounced and has only 8 threads/cm, with yarn diameter measuring over 1 mm; the other system has 10 threads/cm; the yarn diameter could not

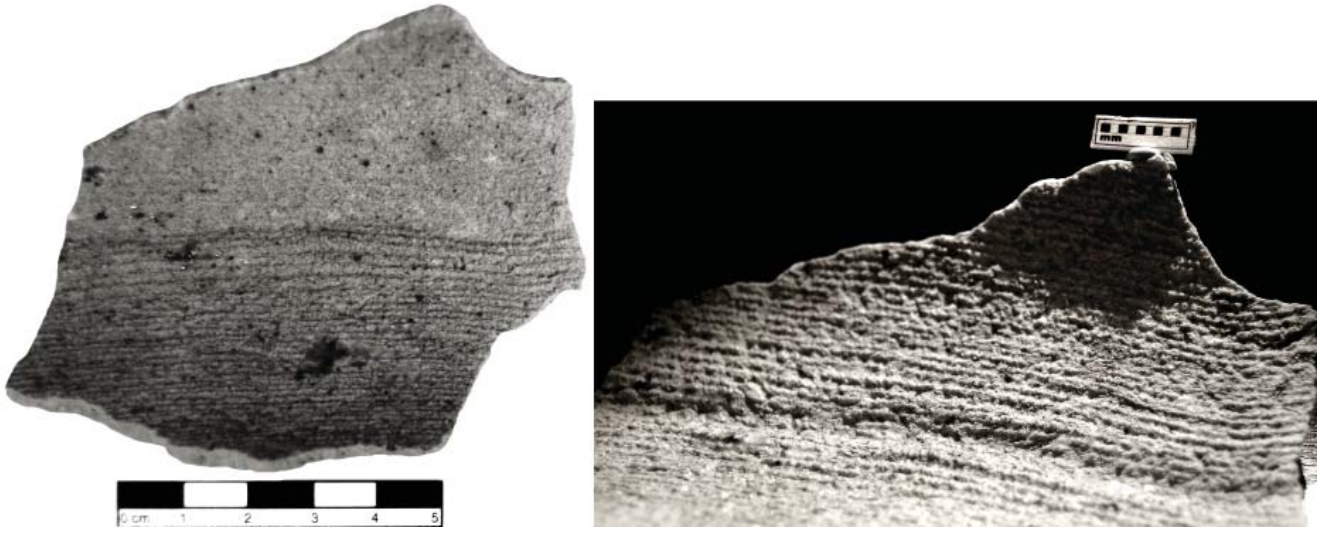

Fig. 5. Crucible-wall fragment No.16 with the coarsest textile fabric impression.

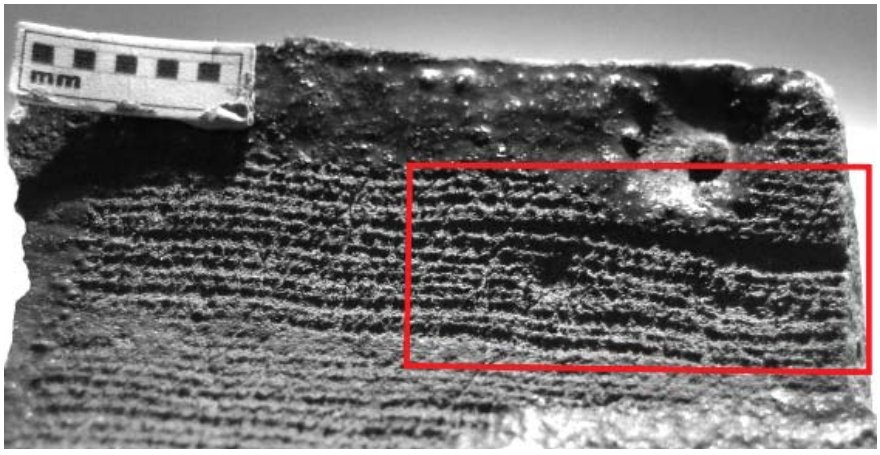

Fig. 6. Crucible-wall fragment No.18 with a weaving fault.

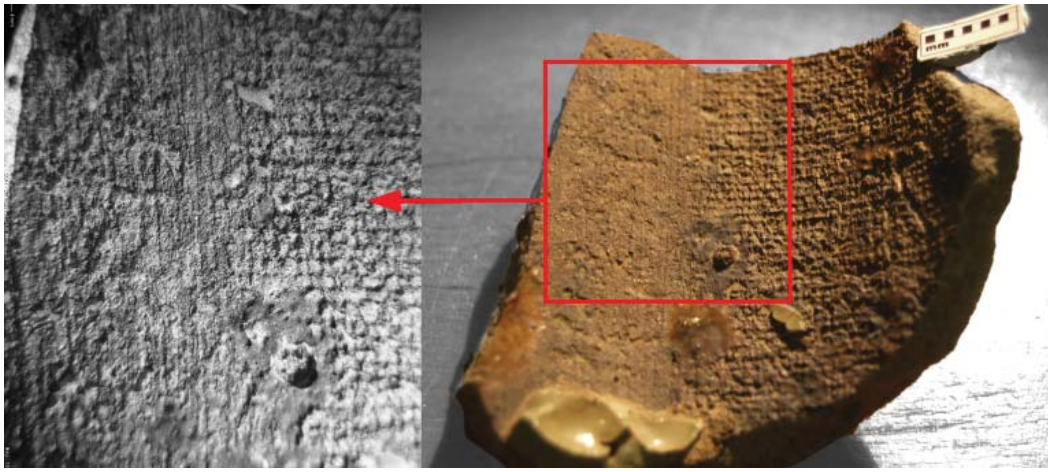

Fig. 7. Left: Photo microscopy of the fragment No.4 with different textile patterns and possible border. Right: Photograph of the fragment.

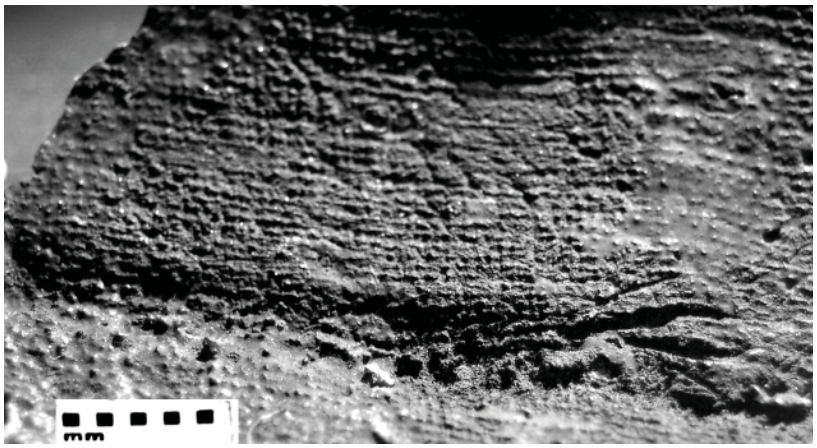

Fig. 8. Fragment No.2 with the seam and textile fabric impressions on the inner side.

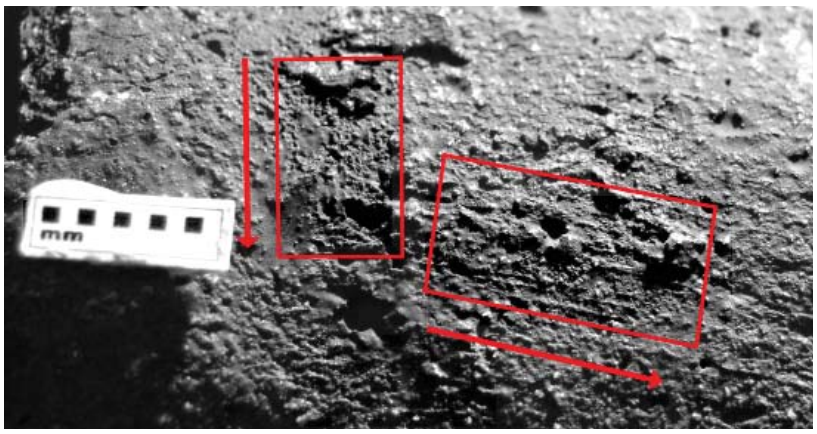

Fig. 9. Fragment No.2, the outer surface bearing textile fabric impressions.

be measured but should be just under 1 mm. The fragment has textile impressions on the outer surface as well. The thread count for the outer impressions is 16 threads/cm, which is clearly different in quality from the inner surface impressions.

Fragment No. 18 has the same thread count of 16 threads/cm in both systems, but one system is more pronounced. In one area the impression has an irregularity in the more pronounced system which may be a weaving fault or a much thicker thread (Fig. 6).

Fragment No.4 with textile impression on the inner surface has two different patterns. It is likely that one part of the impression is the textile border with either a denser thread system or different yarns, while the rest of the impression is the ground weave in simple balanced tabby with 10 threads/cm in both systems (Fig. 7). Visually, the diameter of the yarn of the ground weave appears thicker than the yarn of the border. In fact, the yarn in the border part appears thinner than the yarn of the ground weave. The yarn of the perpendicular system, which could not be measured and differentiated in either part of the imprint, appears to have the same diameter in both parts. This fragment also has textile impressions on the outer surface, which are finer in terms of thread diameter than those on the inner surface.

Fragment No.2 has distinctive impressions both on the inner and outer surfaces. The inner textile fabric is tabby with a seam running along the fragment. The thread count for the system parallel to the seam line is 14 threads/cm, while the other system has 18 threads/cm. Thus, while the yarn diameter is the same, one of the systems is woven more closely. The outside surface textile impression is again finer than the inner, with an average thread count of 20 threads/cm (Figs 8-9).

Fragment No.17 also has textile impressions on both sides. The textile on the inner surface has 12 and 16 threads/cm in the two systems. The outer surface impression appears finer and has18 threads/cm. Furthermore, the binding might not be a tabby, as one system is completely indiscernible (Fig.10).

Apart from all the crucible wall fragments with textile impressions, one lid fragment (No.21) was found to have textile impressions with thread count

of 18 threads/cm in both systems. It may suggest that textile moulds were also used to manufacture a particular type of crucible lid (fine lid) (Fig. 11).

Seams

Crucible fragment No.15, preserved impression of a seam with regular stitching and 3 stitches/cm. It has two parallel ridges along the stitches creating an area lower than the surface of the other parts of the crucible, suggesting the presence of an open seam (Fig. 12). Another seam, with 2 stitches/cm, is present on the fragment No.3. The surface at both sides of the seam line is uneven and one side of the seam appears to be raised and more pronounced than the other one, suggesting a raised seam (Figs 13-14).Fragment No.1 has a seam similar to an open seam but both wings of the excess fabric were stitched to the body of the mould with diagonal hem stitches which are visible in the crucible impression (Fig. 15).

Discussion

Textile fabric impressions on the crucibles are evidence of the functional and technical processes of crucible making. Their investigation allows us to retrieve information about technology and organization of not only the steel industry but also textile production in the Fergana region during the Early Islamic period. The use of a mould is indicative of a highly standardized craft and is a response to a demanding, specialized and sophisticated production process.

The clay for making crucibles contains a high amount of quartz temper, which would have been abrasive on the hands of the potter. This factor and the very narrow tubular shape of the crucible would have made it almost impossible to produce the vessels by hand and on a wheel. In fact, none of the crucibles preserve any wheel marks. A solution to make such crucibles would have been to prepare a mould of a sand-filled textile to manufacture large quantities of standardised crucibles. At the same time, the clay is relatively fine, so a relatively dense and smooth textile template was required in order for the clay to be shaped around it without filling the empty spaces between the threads of the textile. Analysis of the textile impressions indicates that fabrics used for making the moulds are well woven, without any obvious mistakes and with very even yarns. They are all relatively balanced tabbies in a relatively narrow range of qualities. The thread counts of the impressions lead to the categorization of the textiles into three qualities (Fig. 4), also discernible visually:

- Medium (8-10 Threads/cm): 5 fragments (Nos 4, 11, 12, 14, 16).
- Medium fine (12-16 Threads/cm): 14 fragments (Nos1, 7, 8, 9, 10, 15, 17, 19, 20, 22, 23, 24, 27, 28)
- Fine (18-20 Threads/cm): 5 fragments (Nos 2, 3, 5, 6, 21)

The relatively narrow range of the thread counts in both systems might suggest that the textiles were made or at least selected for the purpose. Furthermore, the outer surface are generally finer than the textile impressions of the inner surface of the

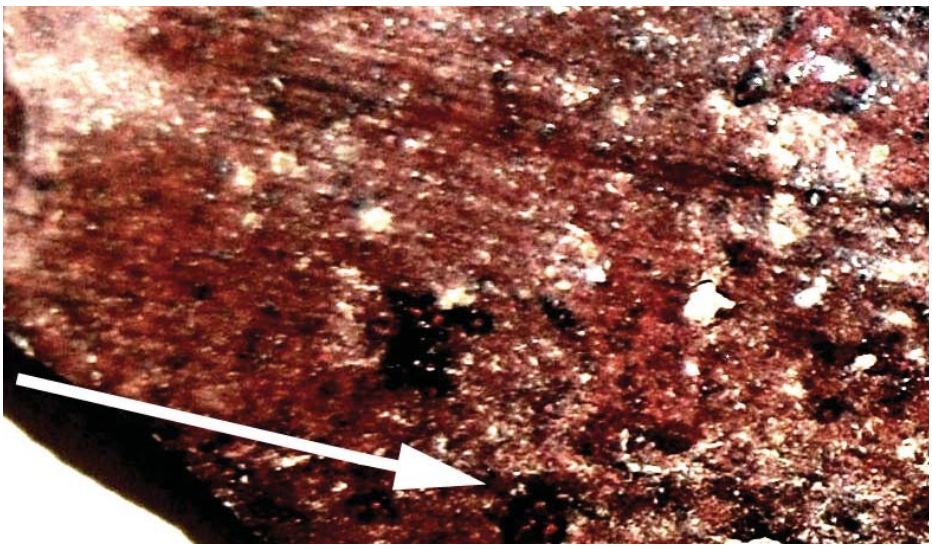

Fig. 10. The outer surface of a crucible-wall fragment No.17 with unusual fabric impressions.

Fig. 11. Lid fragment No.21 with textile impressions of tabby weave.

crucibles, indicating that the textiles which left traces on the outer surfaces were different from those used for the moulds.
The textiles on the inner surface of the crucibles are all tabbies but they have subtle visual differences. Hammarlund (2005) has classified different tabby textiles based on their visual characteristics. Three of these visual classes could be matched to the textile impressions on the inner surface of the crucibles:

- Tabby-'Character' (Fig. 16): both systems are straight and balanced (Hammarlund 2005, 92-93). The majority of textile impressions investigated can be classified under this category.
- Tabby-'Movable'(Fig. 17): in this visual category one or both systems are moving two-dimensionally and there are noticeable spaces between the yarns (Hammarlund 2005, 94-95).
- Tabby-'Flat'(Fig. 18): in this type, the binding is not very obvious since one system is loosely spun (Hammarlund 2005, 100-101).

The careful and regular stitching of the seams also indicates a careful and possibly specialised production of moulds. The mould would have required a high quality textile with sufficient strength and density to keep the sand. It is likely, thus, that the textiles were either produced for the purpose, or

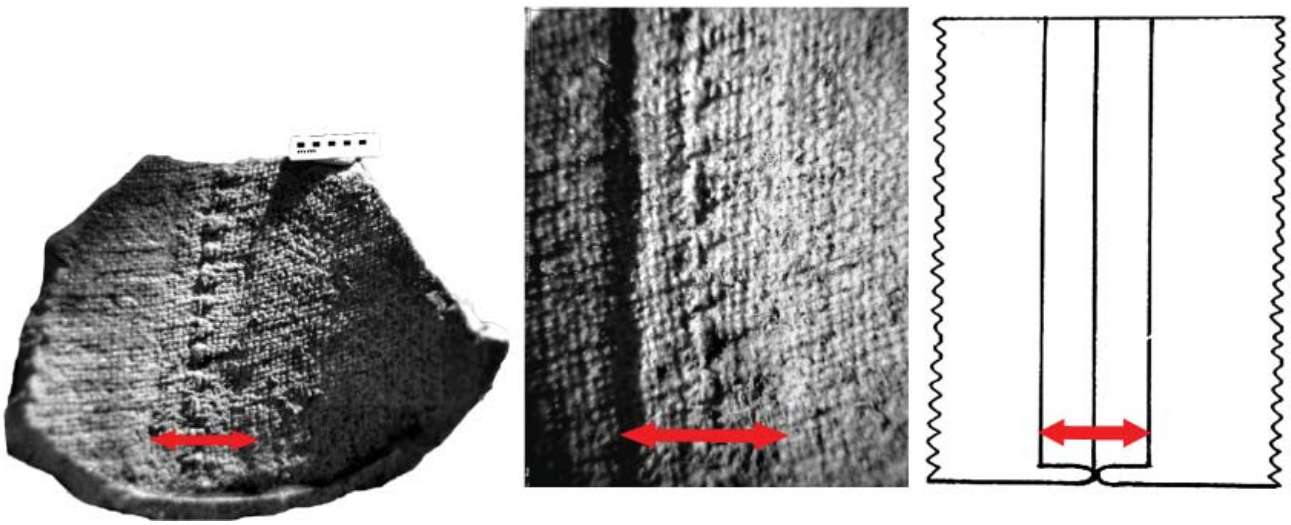

Fig. 12. Left: Crucible-wall fragment No.15 with an open seam. Middle: Photo microscopy of the seam. Right: drawing of an open seam. (After Morell n.d. 15).

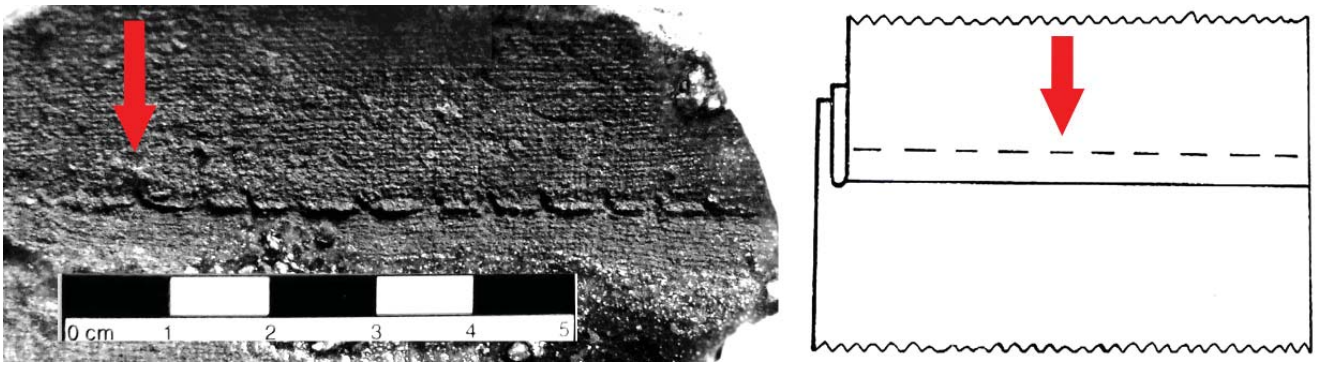

Fig. 13. Left: Fragment No.3 with a raised seam. Right: drawing of raised seam (After Morell n.d., 15).

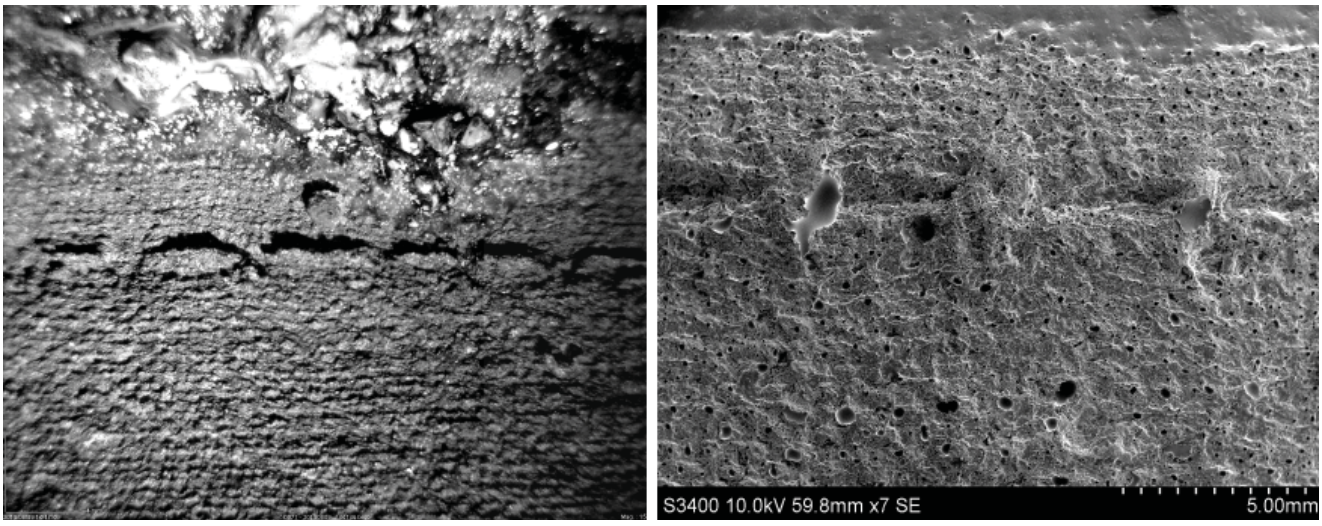

Fig. 14. Left: Photo microscopy of the raised seam of the fragment No.3. Right: SEM picture of the raised seam.

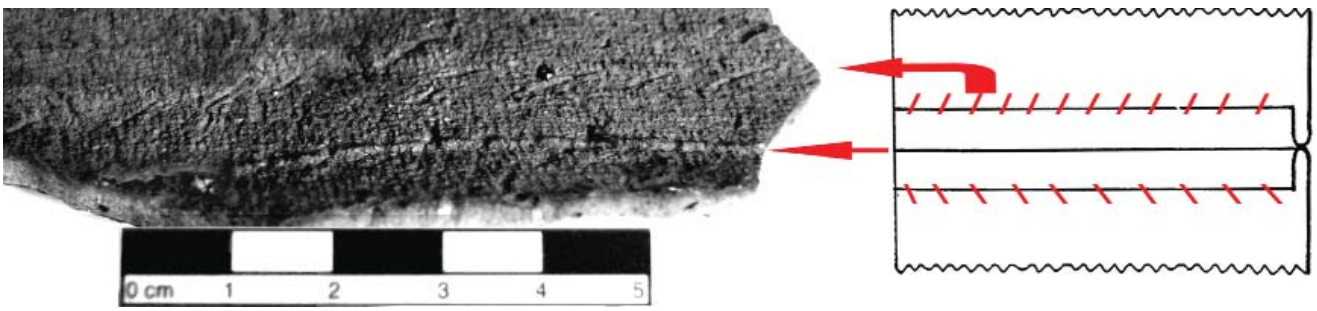

Fig. 15. Left: The crucible wall fragment No.1 with an open seam and hem stitches on both excess wings (After Morell n.d., 6).

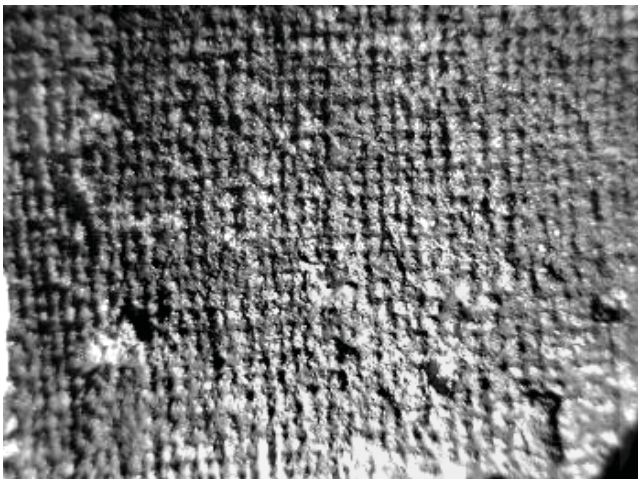

Fig. 16. Photo microscopy of an example of tabby - character impression, No.13.

Fig. 17. Photo microscopy of a tabby - movable impression, No.22.

selected from new or used textiles of specific quality. The later possibility seems more likely. Since the workshops involved in the manufacture of crucible steel were probably only few(2 or 3) at any one time or period, and the moulds used to make the crucibles were likely to be reused and lasted for some time, it is unlikely that the textiles used to make them were produced for the purpose. As and when textiles for moulds were needed, buying a suitable piece of cloth was probably more practicable than producing a small amount of textile especially for this purpose; however more information is needed regarding the organisation of production in order to make further conclusions. The differences in the thread counts of the textiles indicate that they do not belong to the same production, although individual preferences of the craftspeople and chronological differences also must be kept in mind.

The small differences in the textile qualities are probably due to random variation in the textiles chosen, rather than evidence for different workshops for making textiles for crucible manufacture. These slight deviations have no functional effect for the moulds and are in line with fabric variability overall. However, the differences in seams could suggest either a chronological deviation in practice or that each crucible-making specialist was making/stitching each mould personally.

As noted above, due to heavy vitrification of the crucible surfaces, fibre identification is no longer possible. However, some possibilities may be suggested. Akhsyket was a centre for silk production, and one possibility is that textiles used for steel crucible production were made of silk. Silk fabric is very strong, elastic and does not tear easily – all

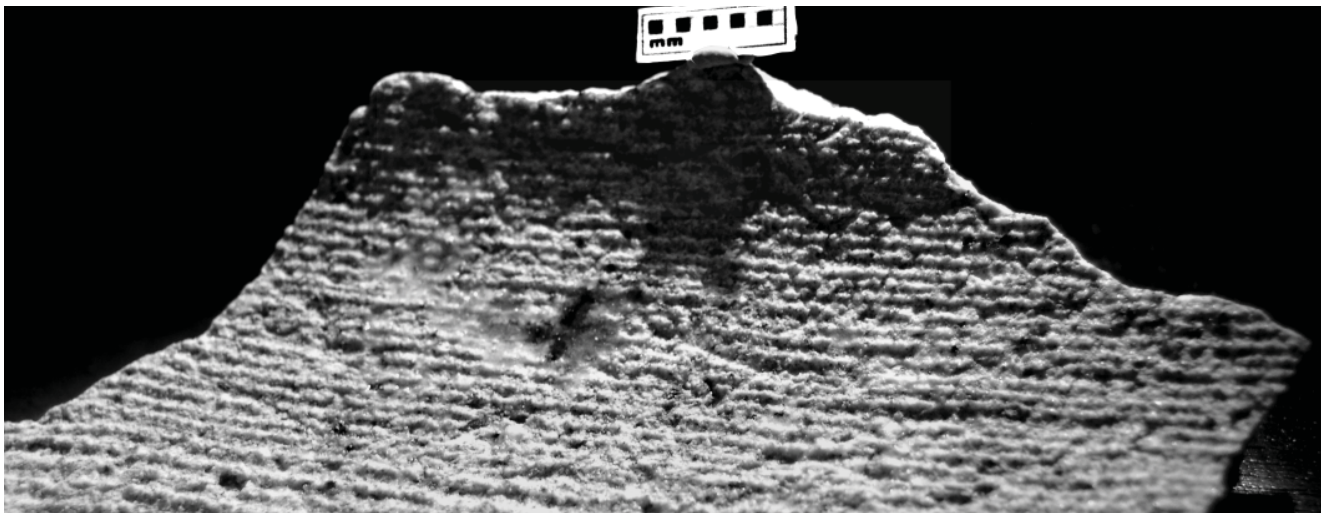

Fig. 18. Photo microscopy of a tabby - flat style impression, No.16.

qualities which would have made it perfect for the purpose. Another possible fibre is cotton. While not as strong as silk, it is less elastic which may have been an advantage in this case. Cotton was used in Uzbekistan since prehistoric times and is the most likely material used for the crucible templates. Only very few comparisons could be found. The cotton fabrics from Munchaktepa, dated 5th-8th century BCE and supposedly produced in the Fergana Valley were tabbies with12 threads/cm in warp and weft (Matbabaev and Zhao 2010, 217), which are comparable to the ones presented here.

Conclusions

The textile impressions on the inner and outer surfaces of crucible fragments have not been analysed before. This survey gives a new direction both for textile and crucible studies. Investigating these textile impressions is important because, even in the absence of surviving textiles, much can be learned not only about the textile characteristics used in a specific industry but also about the economy, organization of crucible production, the skills and preferences of the craftspeople involved in crucible making.

It is noteworthy that along with metalwork, textiles were important commercial goods for Uzbeks, and the Fergana valley had very active textile workshops during Early Islamic times, typically located in a 'Tim', a bazaar, which was a centre of a highly specialized and intense production area of the city (Knorr and Lindahl 1975, 50). The textile impressions on crucibles possibly provide a glimpse of these local products. They also document utilitarian fabrics, as opposed to the better investigated luxury silks.

This study suggests that the fabric used in making the moulds is relatively fine, typically a balanced tabby weave with around 13 to 14 threads/cm in both warp and weft. Systematic differences in thread counts between inner and outer impressions suggest a conscious selection of textile quality, matching divergent requirements for the two. The largest variability was seen in the stitching of the moulds, suggesting that this was not done by a standardised procedure or professional tailor, but probably *ad hoc* by the mould makers.

Although the actual fibres did not survive, applying the visual analysis of the impressions led to the visual categorization and specification of textiles used in the manufacture of moulds. The methodology used for this study can be used in the similar cases for other industries.

Acknowledgements

The authors wish to thank Dr.Olga Papakhristu as the first scholar to identify the textile fabric impressions on the crucibles. We are also grateful of Xiuzhen Janice Li for making the vinyl polysiloxane casts of the impressions.

Notes

1. Several cotton fragments are known from the 11th century AD settlement of Bazardara, located in the south-eastern Pamir, in the neighbouring Tajikistan. One simple tabby fragment has 15.5 threads/cm in both systems; numerous others, mostly reps, vary in thread count and patterning and represent clothing remains (Bubnova 1985).

Bibliography

Adovasio, J. M., Soffer, O., and Klima, R. B. (1996) Upper Palaeolithic fibre technology: interlaced woven finds from Pavlov I, Czech Republic, c. 26,000 years ago. *Antiquity* 70, 526-534.

Askarov, A. (1972) *Sapallitepa*. Tashkent.

Bayley, J. and Rehren, Th. (2007) Towards a functional and typological classification of crucibles. In S. La Niece, D. Hook and P. Craddock (eds),*Metals and Mines - Studies in Archaeometallurgy*, 46-55. London.

Bosworth, C.E. (1975) The Tahirids and Saffarids. In*The Cambridge History of Iran.Vol.4, The Period from the Arab Invasion to the Saljuqs*, 99-135Cambridge.

Bubnova, M. A. (1985) Поселение Базардара (Восточный Памир. XI в.) In*Древности Таджикистана* [*Antiquities of Tajikistan. Exhibition Catalogue*].Dushanbe.

Craddock, P.T. (2003) Cast Iron, Fined Iron, Crucible Steel: Liquid Iron in the Ancient World. In P.T. Craddock and J. Lang (eds),*Mining and Metal Production through the Ages*, 231-257. London.

Eastwood, G. and Walton, P. (1983) *A brief guide to the Cataloguing of Archaeological Textiles*. York.

Feuerbach, A., Griffiths, D. and Merkel, J.F. (1995) Analytical Investigation of Crucible Steel Production at Merv, Turkmenistan. *Newsletter of the Institute for Archaeo-Metallurgical Studies*19, 12-14.

Feuerbach, A.M., Griffiths, D.R. and Merkel, J.F. (1998) An examination of crucible steel in the

manufacture of Damascus steel, including evidence from Merv, Turkmenistan.In Th. Rehren, A. Hauptmann and J. Muhly (eds),*Metallurgica Antiqua* (=Der Anschnitt, Beiheft 8), 37-44.

Feuerbach, A.M., Griffiths, D.R., and Merkel, J.F. (2003) Early Islamic Crucible Steel Production at Merv, Turkmenistan. In P.T. Craddock and J. Lang (eds),*Mining and Metal Production through the Ages*, 258-266. London.

Frye, R.N. (1964) *The heritage of Persia*. London.

Good, I. (2001) Archaeological Textiles: A Review of Current Research. *Annual Review of Anthropology* 30, 209-226.

Grömer, K. and Kern, D. (2010) Technical data and experiments on corded ware.*Journal of Archaeological Science*37, 3136-3145.

Hammarlund, L. (2005) Handicraft Knowledge Applied to Archaeological Textiles. *The Nordic Textile Journal*, 87-119.

Henshaw, C. M. (2010) *Early Islamic Ceramics and Glazes of Akhsyket, Uzbekistan.*PhDthesis.University College London, London.

Knorr, T., and Lindahl, D. (1975) *Uzbek:the textiles and life of the nomadic and sedentary Uzbek tribes of Central-Asia*. Basel.

Litvinskiy, B. A. (1972) *КурганыикурумыЗападнойФерганы[Kurgans and kurums of Western Fergana]*. Moskva.

Matbaev, B., and Zhao, F. (2010) *Early Medieval Textiles and Garments of Ferghana Valley*. Shanghai.

Papakhristu, O. (1985) Black metallurgy of Northern Fergana.Materials of archaeological investigations at the ancient fort Akhsyket of the 9-early13 cc. A.D. Abstracts of the Candidate of History Dissertations, Moscow.

Papachristou, O. and Swertschkow, L. (1993) Eisen ausUstruschana und Tiegelstahl aus dem Fergana-Becken.*Der Anschnitt* 45, 122-131.

Papakhristu, O. and Rehren, Th. (2002) Techniques and technology of the manufacture of ceramic vessels- crucibles for smelting wootz in Central Asia. InV.Kilikoglou, A. Hein and Y. Maniatis (eds), *Modern Trends in Scientific Studies on Ancient Ceramics*, 69-74. BAR International series 1011.Oxford.

Rehren, Th. and Papakhristu, O. (2000) Cutting Edge Technology- the Ferghana Process of medieval crucible steel smelting. *Metalla* 7, 55-69.

Rehren, Th. and Papachristu, O. (2003) Similar like White and Black: a Comparison of Steel-making Crucibles from Central Asia and the Indian subcontinent. In Th. Stöllner*et al*. (eds), *Man and Mining: Mensch und Bergbau: Studies in Honour of Gerd Weisgerber* (= Der Anschnitt, Beiheft 16), 393-404. Bochum.

Ranganathan, S. and Srinivasan, Sh. (2004) *India's Legendary Wootz steel, an advanced material of the ancient world*. Bangalore.

Schorta, R., ed. (2006) *Central Asian Textiles and Their Contexts in the Early Middle Ages*. RiggisbergerBerichte 9. Riggisberg.

Soffer, O., Adovasio, J. M., Illingworth, J. M., Amirkhanov, H. A., Praslo, N. D., and Stre, V. M. (2000) Palaeolithic perishables made permanent. *Antiquity* 74, 812-821.

Srinivasan, Sh. (1994) *Wootz crucible steel: a newly discovered production site in south Indi*a. *Papers of the Institute of Archaeology*5, 49-61.