Intl. J. Humanities (2012) Vol. 19 (3): (152-173)

Textiles from Douzlakh Salt Mine at Chehr Abad, Iran: A Technical and Contextual Study of Late pre-Islamic Iranian Textiles

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Received: 2011/10/25 Accepted: 2011/12/26

Abstract

The Douzlakh salt mine at Chehr Abad, Zanjan Province, Iran has provided a rare organic preservation of human remains, and associated cloth and clothing. This textile evidence offers a window into a poorly known but pivotal era of textile history. Moreover, the context is of accidental burial of miners at work, rather than deliberate burial of elites. At least six bodies have been recovered, one of which was very well preserved, being fully clothed and carrying items of personal equipment. This paper is a summary of preliminary findings on the textile assemblage.

Keywords: Archaeological Textiles, Fiber Dyes, Pre-Islamic Salt Mine, Chehr Abad, Iran.

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Introduction

In the northwestern region of Iran where the Elburz and Zagros converge, a geologically remarkable pure halide salt mine exists in the Agh Dagh mountain range near Chehr Abad (Figure 1), where in 1993 the chance discovery of a disarticulated collection of well-preserved human remains soon made international headlines (RCCCR, 1998). This first body (now thought to be a mixed assemblage of at least two individuals) was associated with several textile fragments, with notable weave structure and beautifully dyed threads of yellow, red and blue. The remains were conserved and put on display in the Bastan Museum in Tehran.

Over the next fifteen years, several more ancient bodies were recovered; there are now the remains of at least six, possibly eight individuals (Aali, 2005; Pollard et al., 2008; Ramaroli et al., 2010). They cluster in date to either the later Achaemenid (c. 400 BCE) or to the late Sassanian periods (c. 400-500 CE). In addition, hundreds of textile fragments have been excavated, thereby offering us a vivid picture of weaving technology and of dress, from two pivotal periods in Eurasian textile history. Apart, however, from the clothing and equipment associated with Salt Man #4, few of the textiles do not have direct association with any of the human remains, nor, in general, any secure stratigraphic context.

A Late pre-Islamic Sampler of Wool and Weaves

Textile fragments were catalogued after excavation and brought to the local museum in Zanjan, a branch of the ICHHTO (Iranian Cultural Heritage, Handicraft and Tourism Organzation), for conservation treatment and museum display, due to their significance for Iranian cultural heritage. Technical study of materials and weave structures was undertaken in part at the Zanjan museum and in part in Tehran. Conventional reflected light microscopy with a stereomicroscope was conducted to ascertain weave structures, document thread counts; spin direction and condition of the textiles (see Table 1). High-power magnification under transmission light microscopy was conducted for fibre identification (Figure 2). The textiles from Chehr Abad are composed of primarily of sheep’s wool, with a small percentage of possible goat hair. The textiles may be able to inform us on the variation among late pre-Islamic wools. A detailed study of some of the wools from Chehr Abad is underway, and will be published in a future paper.

Several samples were further collected for detailed dye study and scanning electron microscopy at the Tarbiat Modares University (Figure 3). Dye and mordant analyses were carried out at the Conservation Center in Tehran using standard techniques including high performance liquid chromatography (HPLC), scanning electron microscopy with energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared (FTIR) and Raman Spectroscopy.

Chromatographic study was also carried out at Boston University, USA, using a refined method for extracting complex dye molecules without degradation (Zhang et al. 2008; see below).

A detailed descriptive list of 30 of the textile fragments is given in the appendix of this paper. The majority are structured in a weft-faced tabby weave. This form of cloth is common in woolen textiles of the first centuries BCE/CE West Asia as noted at the contemporaneous Iranian site Shahr-i Qumis in Damghan (Kajitani, *unpublished ms*), and from sites such as Palmyra in central Syria (Schmidt-Colinet et al., 2000).

Techniques of Spinning and Thread-Making

The textiles from Chehr Abad fall into two broad categories - balanced 'open' tabby weave cloth and, more commonly, strongly weft-faced tabbies in which the warp threads are two-plied; but there are several variations on these two main types. The textiles are made of threads that are very consistently and evenly spun. Most single threads are Z-spun. Some warp threads and some weft threads are two-plied (S) of Z-spun singles. Some threads are plied of two different colored thread singles - for example threads associated with textile 10050 (see figure 4). Some weft threads from the textiles at Chehr Abad are more loosely spun, and are extremely fine, ranging between 25-.50mm. Most threads are spun with an angle of twist ranging from 40º to 50º.

The spin of the threads is varied between warp and weft. In the case of the warp, the twist is S and wefts are usually Z spun. In order to apply enough strength to the warp threads they must have been treated with lanolin, or perhaps a wax or other dressing. A great deal of fineness in the textiles - especially wefts, and particularly in the case of specimen number 10128, suggests that they could not have been made just manually and crudely but most probably relied on some form of mechanical aid in the manufacturing process. As shown in Table 1, in most of the samples the thread count is nearly 70 wefts per cm. Such compact fabrics demanded applying considerable force on the wefts to compress them as much as possible. This implies the use of heavy combs or possibly a reed beater in order to compress the wefts so tightly into the textile and avoid fatiguing the hand strength of the weaver.

Notable Textile Fragments

In a few instances the textiles contain some patterns. These patterns were created by several methods: supplementary wefts placement, tapestry bands, and simply changing weft color to form stripes. The supplemental weft (or possibly embroidery mimicking that weaving method) is seen in some samples, all of which are of the same style and geometry. The textiles featuring colored threads can be divided to four weave structures: weft-striped tabby weave, compound twill, tapestry and plain weave.

Some of the Chehr Abad textiles make use of colored threads in weft stripe tabby, tapestry, and even weft-faced 'brocade' or supplemental weft technique. Two textiles in particular are worthy of a more detailed description. Textile 10050 (directly radiocarbon dated to 532 – 617 CE) shows a shift from tabby to basket weave (where single warps shift to paired warps in a given 'shed' and then from tabby/basket weave to twill. The second textile is 10175 (Figure 5). The complex weave of 10050 suggests that a type of loom was used in which the 'sheds' could be changed during weaving in a mechanized way; possibly a harnessed treadle loom, which later developed into the drawloom (Barber, 1991; Geijer, 1979). Textile 10175 appears to be a warp-faced band with complementary warps. It is unclear whether this was created on a tablet-loom, or whether it was made on a narrow band or 'atlas' type of loom.

Both textiles offer distinctive clues about the development of the treadle loom and pattern weaving known as *compound weaving* (Emory, 1966). This question of mechanized loom development remains a nebulous part of textile history (see Granger-Taylor and Thompson, 1996; El-Homossani, 1988; Collingwood, 1982).

There are competing theories on the origins of compound weaving. One idea is that it developed exclusively in China, first with the development of warp-faced –compound tabby silks and then compound twill; then weft-faced compound weaves (Geiger, 1979). Another possibility is that compound weaves first developed in the Near East in Parthian and Sassanian times to accommodate the new medium of silk. Western (weft-faced, wool) compound weaves were an adaptation of Chinese (warp-faced, silk) compound weaves. There is a dearth of weft-faced compound weaves in wool in pre-Islamic Iran; most examples are to be found in Egypt (see Vogelsang-Eastwood, 1988) and Central Asia (Wu Min, 2006); though point of origin is not easily discerned, and most are stylistically associated with Sassanian Iran. The picture at present is therefore unclear, and early looms are only rarely depicted in Western Asia; less so in late pre-Islamic Iran. Although the observations made here are preliminary, it is clear that the Chehr Abad corpus is invaluable in helping to clarify treadle loom technology, due to both the time periods and the location of the finds.

Dyes Analysis

In order to identify organic dyestuffs used in the textiles, 21 colored samples representing the range of different colours were chosen for dye extraction and identification at the Chemistry Laboratory of the Research Center for Conservation in Tehran (Vatandoust, 2005; Hadian n.d.; Figure 6). Dye extraction was performed after washing the threads with distilled water to remove dust by hot acid (HCl) extraction. The following dyestuffs were identified:

Red

After the extraction of dye from the fibers, chemistry was done to identify the dyes. This included converting red pigments to blue in an alkaline environment. In this condition, a purple color appeared which indicates alizarin, most probably from a madder source, possibly *Rubia tinctorum*. All red samples had the same result. From the similarity of the colors in acidic and alkaline environments, we can assume a similar origin for all of them. Prior to this work, dye studies on the textiles from Salt Man no 1 resulted in the red color also being determined as madder. Some of the same samples were also tested in a different laboratory (Department of Chemistry, Boston University) and showed alizarin and also purpurin included in the reds (see Table 2).

Blue

Blue dyestuff was decolorized after extraction. This bleached material was then tested in order to compare blue samples by chemistry. In this test, dyes were placed in ethyl acetate, and the blue color was recovered. This change characterizes indigotin. This examination determined that all blue samples are of an indigoid source. Some samples also tested at the second laboratory also concluded that indigoid dyes were used.

Yellow

Analysis of yellow dye is relatively difficult. The yellow pigment was extracted successfully but it could not be identified by simple chemistry. The most likely source of yellow color is from yellow weed[4] (*Reseda spp*, such as wild mignonette) dye. This color is more common among natural yellow color than others and it is stable.

Study of textiles from Palmyra, Syria in the Damascus Museum, dating from 100-300 A.D, revealed that the blue and red pigments were also indigo and madder (Schmidt-Colinet et al., 2000). The yellow color was determined to be from yellow weed. Based on the synchronism and close relationship in that era and in regard to similarity in hue of the blues and reds, we suggest that the yellow pigment from textiles from Chehr Abad is also yellow weed. This was supported by FT-IR and UV spectrometry.

4. 'Yellow Weed' is from the Farsi to English translation, perhaps was meant to indicate Reseda lutea, or wild mignonette.

Green

Green dye is generally produced by combining the colors yellow and blue without any participation of red. A range of green colors can also be achieved by using different mordents with a yellow dye. The green in the Chehr Abad textiles was obtained by combining yellow and blue dyes. Indeed the Boston University dye study demonstrated that the greens are composed of blue (indigoid) and yellow (flavonoid) dyes.

Mordant Use

Natural pigment sometimes needs an intermediate molecule to establish a stable bond to the fiber. This molecule is the *mordant*. Historically different mineral-based materials such as alum and copper have been used in mordanting. It is in fact the metal ion in these materials, such as aluminum and copper, which acts as the mordant. Another effect of the mordant is the possibility of changing the color associated with the pigment. It is not known precisely when or where mordant were discovered and used in the dyeing process (Hofenk de Graaff, 2004).

By using X-ray fluorescence in scanning electron microscopy, we can determine the mordant used in dyeing. However, in analyzing archeological textiles it is important to distinguish between metal salts in the fibers that are from the soil matrix and those from possible mordanting. Some of the metals in the fibers are present because of migration from the soil (and there is the concomitant possibility of color change). In each of the fiber samples, the presence of aluminum, iron and copper were investigated as possible mordant. These elements were also investigated in soil samples from the mine (Figures 7-8).

The presence of aluminum, iron and copper in the samples was detected by SEM EDX analysis, which was not surprising given their presence in the soil of the mine. Soil samples collected from the mine indicate that, of these three elements, aluminum has the highest concentration, followed by iron and copper. SEM EDX analysis of the textiles also revealed the same ratios of these elements in the textile fibers.

Fiber samples from green threads were examined in another way. SEM-EDX on yellow samples detected an alum mordant. This mordant is often in association with yellows. The concentration of alum in the green samples is about half of the alum present in the yellow fiber samples, indicating the aluminum was indeed a mordant for yellow, and that the dyers had used a 1:1 solution of blue and yellow to make green.

Conclusion

The textiles discovered at the Chehr Abad salt mine in Zanjan were associated with mummified bodies; the so-called ‘salt men’. Radiocarbon dating clearly associates them within the Achaemenid and Sassanid periods (Pollard et al., 2008). Although the pieces examined so far are limited in number, they provide a wealth of information regarding textile production in late pre-Islamic Iran. There is a growing body of textual, historical and archaeological evidence which attests to the highly developed art of weaving luxury silk fabrics in Sassanid Iran. However, direct evidence of cloth belonging to people associated with mining sheds light on quotidian textile production at that time. Technical details of the textile fragments recovered from Chehr Abad have undergone an array of detailed analyses in order to gather as much as information as possible.

Technical analyses indicate the presence of several types of textile weave structure, with a variety of forms and motifs. The major components of the textiles are sheep’s wool and a small occurrence of goat hair. Generally speaking these fabrics are delicate and at the same time are fairly consistently weft-faced. In some instances embroidery threads as are added onto very delicate fabrics. In some samples weaving is as fine as 70 warps and wefts per cm. Over half of the samples (19 out of 37) represent 30 wefts per cm, indicating a great deal of manual dexterity in the weavers’ hands. As shown in Table 1, thick threads were used as the warp in order to give enough strength to the fabric.

The blue dye found in several samples is indigoid, possibly from indigo (*Indigofera tinctora*) or woad (*Isatis tinctora*). The yellow dye may be from yellow weed (wild mignonette, or *Reseda lutea*). According to preliminary study of the yellows by Zhang and Laursen another yellow may be present. One of the components is a flavonol sulfate, which is quite rare. The main source for the red pigment is most likely madder, probably *Rubia tinctorum*. Microscopic analysis of the green pigment has shown that there were made by combining yellow and blue.

A fineness and sheen in the threads of these textiles is testament to the deft skill of Achaemenid and Sassanian Iranian spinners, weavers and dyers. No trace of extranaeous material such as brushwood was seen in the fibres, which indicates that the wools went through careful processing. That these textiles belonged to miners shows us that non-elite people (although there is some evidence, at least from the finger nails of salt man no. 4, that they might not have been common miners: see Pollard et al. 2008) also had access to a high standard of quality in cloth. The Chehr Abad textiles indicate a sophisticated and consistent quality in both the Achaemenid and the Sassanid periods.

Acknowledgements

This paper is based on a manuscript produced by Manijeh Hadian, translated from Persian into English by Hengameh Ilkhani Mogadam. Thanks are due to Mr. and Mrs. Abolfazl Aali, A. Vatandoust, the Iran Bastan Museum, the Iranian Ministry of Cultural Heritage, Crafts and Tourism, and to the UK Arts and Humanities Research Council.

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Appendix I. A Selection of Textiles from Chehr Abad, Zanjan

For complete textile inventory to date, see
www.saltmen-iran.com

1. Textile Fragment 10007

This textile fragment contains a joined section. The join is created by extra lengths of 3 or 4 weft threads from one cloth (Z-spun singles) being twisted together into a thicker S-plied cord, which is then incorporated into the weave of a second, thicker cloth. These two cloths are similar in that they are both a weft faced repp weave, but they are distinguished by different weave structure. The first is tabby (wefts passing over one warp) and the second is basketweave (wefts passing over two warps). This extended weft set of threads is passed from the tabby side every six warps. It thus makes the join in the form of a column of holes.

2. Textile Fragment 10008

This is a finely woven weft-faced tabby cloth. The warps are Z-spun and S-plied. The wefts are Z-spun singles. They are both composed of unpigmented wool. This sample has an embroidered flower design, with the embroidery thread being the same color as the warp and weft, made of Z-spun and S-plied thread, loosely spun.

3. Textile Fragment 10012

The textile fragment is composed of Z-spun thread of low twist.

4. Textile Fragment 10015

The one system of threads is Z-spun singles, and the opposite system is S-Spun. The weave is a form of basket weave; where one system is trebled (the Z-Spun threads) and the other (S-Spun) are paired. This fragment shows a weaving error, in which one of the warps is not paired.

5. Textile Fragment 10020

A selvedged edge of this textile is present. It is composed of unpigmented warps and wefts with weft stripes of blue dyed thread. Wefts are all Z-Spun. Analysis of the blue dye revealed no presence of any metal mordant. The dye in this sample was identified as indigotin in dye tests.

6. Textile Fragment 10031-1

This textile is a fragment of plain tabby weave, with variable thread thickness both warp and weft in single threads S-spun. On the selvedged edge, warps are doubled twice for an edge border. The dye is alizarin-based (probably madder) according to the report from Zhang and Laursen (see Table 2). It seems to have been dyed after the wool was spun and possibly even after it was woven.

7. Textile Fragment 10031-2

This textile is almost certainly more of the same of sample 10031-1.

8. Textile Fragment 10036

This a textile of weft face made of extremely fine thread with extremely fine wool. The wefts are very loosely spun, yet are very fine and well-integrated, indicating a long staple fiber. It may be of cashmere; as the threads are very soft and have a shining surface.

9. Textile Fragment 10041-1

This textile fragment has very little spin in the weft threads. There is an interesting pattern in one area of the textile, identical to that of fragment 10015 as described above in entry 4; where it becomes a kind of basketweave. The other section is a weft-faced tabby, where the wefts are considerably finer than the warps.

10. Textile Fragment 10041-2

All warps are unpigmented and wefts alternate between pigmented and unpigmented. The result is a striped cream-brown stripe design. Because of the high weft compaction (36 wefts per cm) relative to low warp compaction (6 warps per cm) and a high variation in thickness between warp and weft, the wefts are placed very close to each other to such a degree that the warp is not visible on the surface of the cloth (strongly weft-faced).

11. Textile Fragment 10042.

This sample is comprised of three fragments of cloth. In the main fragment, the weft threads have a very low twist and the cloth is a strongly weft-faced tabby. There is a stripe of red thread. In electron microscopic analysis of this red thread, aluminiumwas clearly indicated. There is a slight possibility of the presence of an iron mordant also, but as noted in the text this may be due to contamination from the mine soil. According to the dye identification, the type of dye in this sample was alizarin. Madder with an alum mordant will produce a red color and with iron mordanting will produce a red – brown. So the possibility of alum mordant is more likely in this sample because it is such a bright red. The amount of iron in this sample can be attributed to minerals in the surrounding soil.

12. Textile Fragment 10041.2

The warps on this textile are Z-spun and S-plied. Wefts are very slightly spun (Z) singles for the coloured stripes' threads; for regular wefts thicker Z spun singles. Among the features of this textile fragment is a thick double cord side selvedge with knotted corner. It is a repp (weft-faced) plain weave with a colored tapestry band comprised of blue stripe outer borders (5 – 6 blue wefts on each face); then yellow (see appendix) and then tapestry lanceolate fields with blue countering, to make a white trefoil. The initial stripe is of 4-5 reds wefts, but of much finer thread, making the stripe thinner.

13. Textile Fragment 10043

This tabby weave textile has threads with low spin.

14. Textile Fragments 10050- 10051

In this sample, there are two pieces of cloth that first piece has colored texture and second sample in fact is a piece of sample of **10043**. 10050 is a multi-colored textile made up of unpigmented, blue, yellow, and red threads. The weave structure is weft-faced 3|4 twill.

Sample 10050- yellow

According to electron microscopic analysis of the yellow thread, alum mordant is present. The type of yellow pigment was not determined, but it is possible that it is from yellow weed (*Reseda alba*). Different natural yellow pigments such as yellow weed, turmeric, *Dorema ammoniacum*, pomegranate bark in addition to an alum mordant will produce a bright yellow color; and a dark yellow with an iron mordant. So regardless of the exact nature of the dyestuff, the existence of aluminum mordant is possible. Tin and chromium mordant are also used in yellow dyeing, but the analyses of the Chehr Abad textile fragments showed no trace of these in the fibers, although they were present in the mine soil. Chromium does not generally appear in dyes until the eighteenth century (Hofenk de Graaff, 2004).

15. Textile Fragments 10052 and 10053

This textile is of plain-woven unpigmented wool with a design made from darkly pigmented threads. They may be embroidered, and may be in fact a supplementary weft weave.

16. Textile Fragment 10069

The weft threads of this textile fragment are highly compacted but with a low twist. They are fine. The warp and weft are of unpigmented wool.

17. Textile Fragment 10073

The weave structure of this sample is also a weft-faced plain weave. Warps are Z-spun and S-plied. Wefts are Z singles. One special feature is a mechanical error in the warp (or possibly a missing warp thread from the sample). It is an evenly striped textile with a stripe of darkly pigmented thread and a red and yellow stripe (in two fragments).

17. Textile Fragment 10088

This textile fragment is of another balanced stripe textile with a stripe of darkly pigmented thread and a red and yellow stripe (in two fragments).

19. Textile Fragment 10093

This textile fragment is a balanced plain weave; with the warp and weft threads nearly the same thickness.

20. Textile Fragment 10127

This textile fragment has a selvedged edge. The fineness of warp and weft is nearly the same, but the textile has a ribbed effect because the warp threads are doubled.

21. Textile Fragment 10128

This textile is quite delicate. The warp and weft threads are each so delicate and fine, and are singles. The wefts are very fine and delicate and also spun with a very low twist, it is a highly compacted weave.

22. Textile Fragment 10141

This sample has a selvedged edge. A section of weft forms a tapestry band, with a trefoil design made of colored threads. This cloth has a patch in one part. The weft threads are delicate and with low twist, so that a ribbed effect is apparent from the delicate contrast to warp. Microscopic analysis of green thread from this sample suggests the existence of iron and alum mordant in the fibers, but this cannot be verified confidently. It is possible that the sample contains purely alum mordant. The green dye is a combination of blue and yellow dyes; the blue being indigotin and yellow is a flavanoid, possibly from *Reseda*. So, it is possible that half of the dye used was indigo with an oxidation reaction and without any mordant; and the other part is yellow weed with an alum mordant. It was determined by microscopic analysis of the yellow in the sample that an alum mordant was indeed used. So, not only the dye, but also the dyeing method (adding materials in yellow) must be the same. An olive green can be produced on the wool by using another mordant such as copper or chromium with yellow weed. However the current sample wasn't olive green and it was closer to blue. Furthermore, the amount of copper in this sample was very low and chromium was imperceptible.

23. Textile Fragment 10142

The weft threads of this cloth are very delicate and with such low twist; the subtle thread count difference between warp and weft creates a ribbed affect in the cloth.

24. Textile Fragment 10144

This textile has the appearance of twill (serge) but in fact the diagonal effect is brought about by having an oblique form due to a doubled warp that is comprised of three plied thread; the warp is three-plied with low twist.

25. Textile Fragment 10148

This textile contains four pieces that are sewn together. The first part contains two sections of the same cloth facing opposing direction from the outside and second part contains two different sections of cloth placed in the inside. The exterior section is more delicate and the interior one is coarser. On the interior part, 2-plyed wefts with an almost open twist almost appear as two wefts.

26. Textile Fragment 10149

This textile fragment consists of a two-toned cord in cream and brown. This textile is probably made of goat hair. It has a selvedge of 0.5 cm, like modern cloth. In contrast to previous samples, it has a different type of selvedged edge. The color is brown and cream with striped texture but we can see a four – part design. This pattern is the result of a difference in warp density that is regular. The weaver used two distinct warp thread counts-including 6 warps per cm and 4 warps per cm. These two distinct thread counts are repeated regularly and alternatively. The weft density is consistently stable. So, some weaving areas with 6 warps per cm are evenly spaced, thus it creates a striped figure. The combination of a vertical striped figure with a horizontal striped plan by using two colors creamy and brown, it has a four-part design with warp threads doubled. A brown thread is used as weft and it is the combination of thick brown and creamy wool with higher percent of brown pigmented fibers.

27. Textile Fragment 10175

This textile is associated directly with salt man no. 3. New (as yet unpublished) work on these remains have shown that two individuals are represented in this mixed deposit, with eight radiocarbon dates on bone and human tissue centering around 400 BCE (the previously-published age of salt man no. 3), but one date on a human mandible suggesting a date of c. 500 CE. It is not clear which (if any) of these two humans is associated with the textile. It is the most technically advanced textile in this collection. It is a very complex weave structure, possibly tablet woven, made with complementary warps and was probably originally made as a starting band for weaving another cloth. According to electron microscopic analysis of the blue thread, none of the mordant types known were recognized in this fiber sample. The quantity of metals such as aluminum, iron, and copper (other than the presence of sulfur from the wool of fibers) was very low. According to dye tests, this pigment was indigotin. So it is not surprising that there wasn't any mordant in these fibers, because indigotin dyes fibers through oxidation. In dyeing blue through the use of indigoid dyes, there is no need for mordanting.

26. Textile 10176

It is almost identical to samples 10042, 10053-10052, with dark brown embroidery (possibly made of goat hair) and in one section of it, we can see a part of embroidery with light like golden color. The warp of it is doubled.

27. Textile 10179

It is tabby woven from red dyed threads. This cloth is open-weave (i.e. has low compaction). Based on the lack of copper, iron and aluminum we can assert that no mordant was used in the orange sample from this textile. According to the dye analysis, this textile was dyed with alizarin (probably madder). Madder is a dye giving an orange – red color when used alone and it can range in tone between red, orange, pink and brown through the use of different mordant. To make an orange hue, for example, one can add a yellow dye such as *Reseda* in addition to madder, or use a mordant such as tin. The dye in sample 10179 had not penetrated evenly into this textile. It may be that in this case madder was used without any mordant. Energy dispersive scanning electron microscopy (SEM EDX) also determined an absence of any mineral material in the red dye used in textile 10179. It was determined through chromatography (HPLC) that alizarin was present in this textile and this produced an orange color. The heterogeneity of color in textile 10179 reveals information about the method of dyeing.

28. Textile 10180

This textile is a serge weave, a 3|4 twill, strongly weft-faced.

29. Textile 10181

This textile fragment is actually made up of two similar weave cloth layers that are sewn to each other by red and cream threads. It has one seam, forming part of a pocket or possibly a small bag. The thread of non-pigmented thread is S-spun and Z-plied.

30. Textile 10183

This textile fragment is made up of two parts – two cloths made of the same color, but made with different fineness and design, which are sewn together. The first part is more delicate, with threads of a low angle of twist, and there is some embroidery or basting stitches with thick threads making short lines. The warp of this cloth is two-plied and very fine. The twist of warp and weft is nearly imperceptible. The embroidery thread is S-spun. The weave structure of the second part is has plied threads. It is interesting to note that both cloths are facing each other in grain making a positive effect on elastic properties and tolerance of tension in varying humidity conditions.

Figure 1. Map of Zanjan with location of Douzlakh salt mine

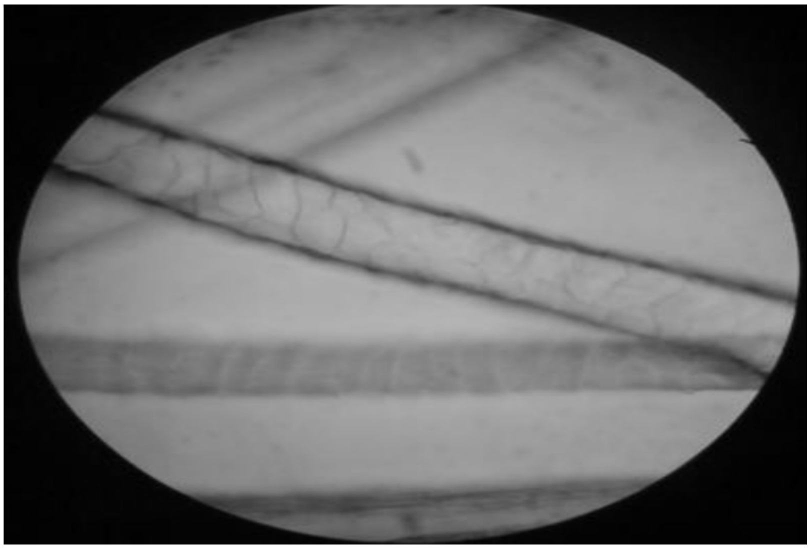

Figure 2. Transmission light microscopy of fibers

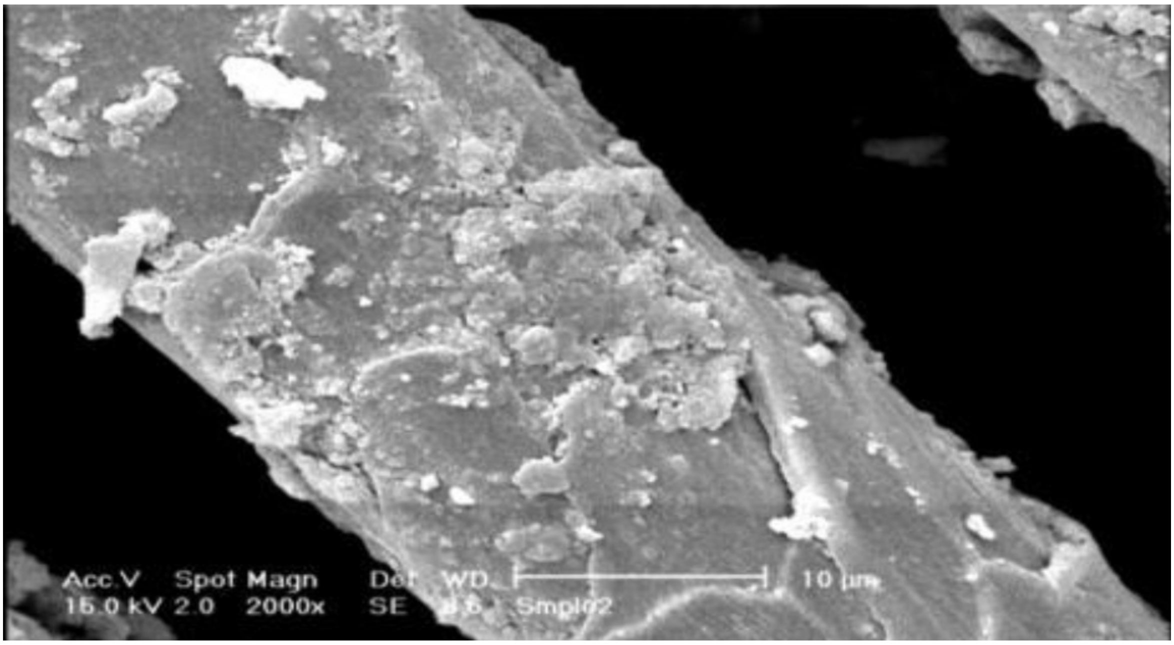

Figure 3. Scanning Electron Microscopy of fibers

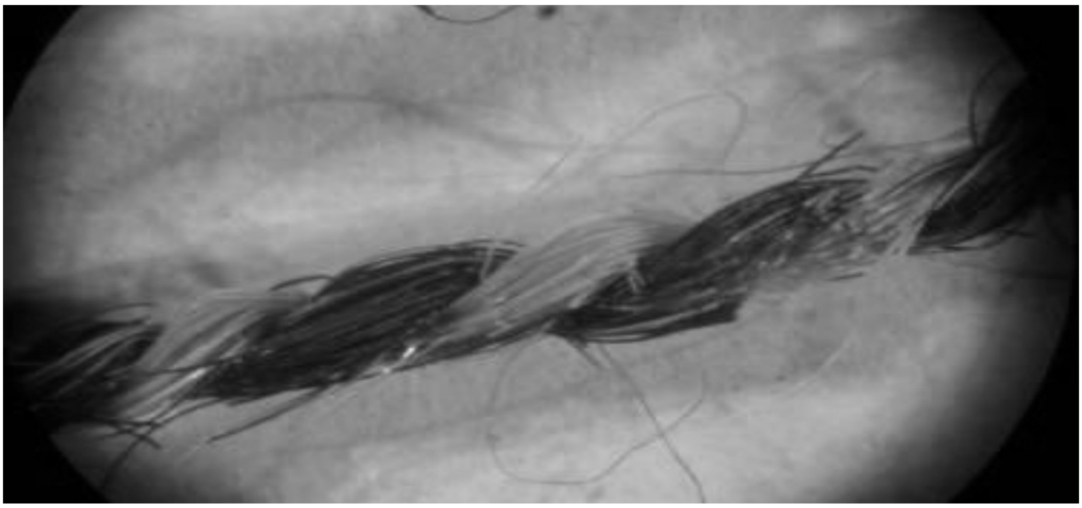

Figure 4. Bi-colored thread from sample 10050

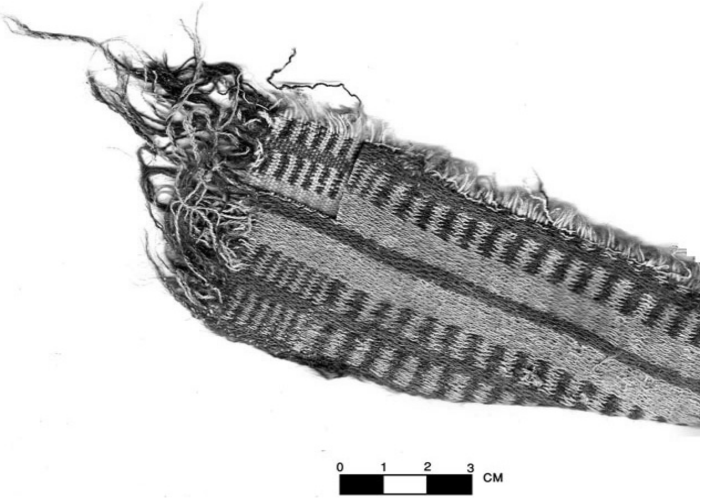

Figure 5. Textile sample 10050

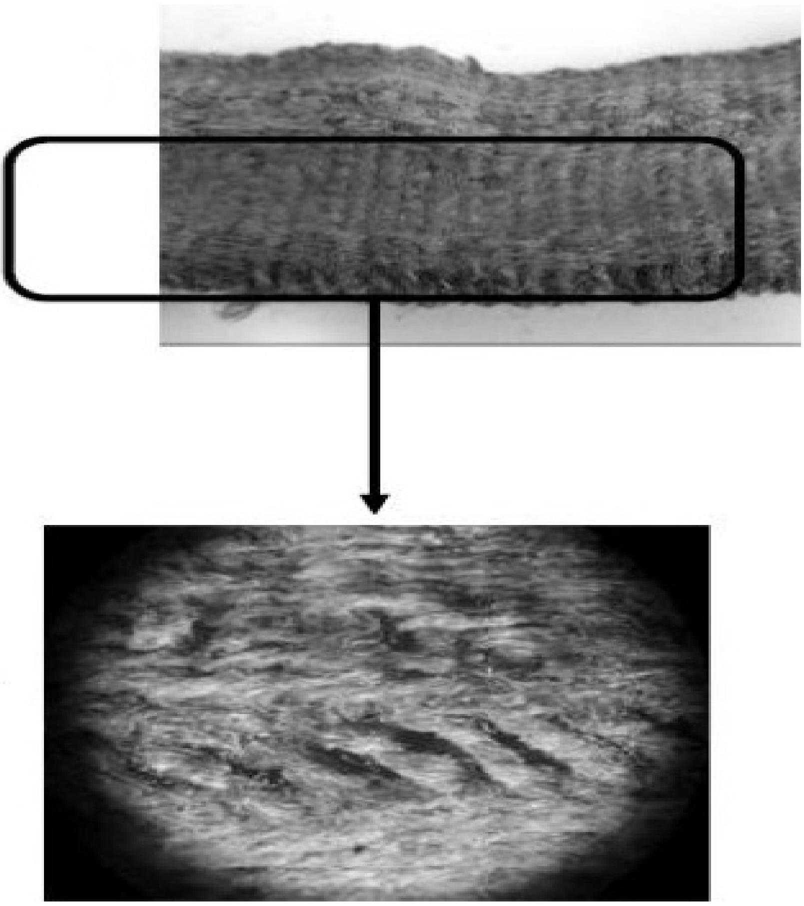

Figure 6. Textile sample 10175

Figure 7. Textile sample 10175

Table 1. Technical features of selected textile fragments from Chehr Abad

Sample	Dye Present ?	Structure	Thread count per cm. Warp . Weft	Direction of Twist Warp Weft
10007 – 1	_	Tabby	7 . 34	S Z
1007 – 2	_	Tabby	12 . 48	S Z
10008	_	Tabby	9 . 48	S Z
10012	_	Tabby	12 . 42	S Z
10015	Yes	three – plied weft and two – plied warp	22 . 24	S Z
10020	Yes	Tabby	7 . 20	S Z
10031 – 1	Yes	Tabby	9 . 16	S S
10031 – 2	Yes	Tabby	7 . 11	Z Z
10036	_	Tabby	20 . 7	S Z
10041 – 1	_	Twisted – three plied weft	13 . 50	S Z
10041 -2	Yes	Tabby	6 . 26	S Z
10042 – 1	Yes	Tabby	10 . 40	S Z
10042 - 1	Yes	Tabby	10 . 40	S Z
10042 – 2	_	Weft repp	12.48	Z S
10042 – 3	_	Tabby	6 .30	S Z
10052-10053	Yes	Tabby	11. 36	S Z
10069	_	Tabby	10 . 50	S Z
10050-10051 - 1	_	Tabby	16 . 24	Z S
10050 -10051- 2	_	Tabby	14 . 60	S Z
10093	Yes	Two – plied warp	5 . 10	Z Z
10128	_	Tabby	14 . 66	S Z
10127	_	Tabby	12 . 18	S Z
10128	_	Tabby	14 . 66	S Z
10141	_	Tabby	10 . 40	S Z
10142	Yes	Tabby	8 . 32	S Z
10144	_	Warp repp	10.16	Z S
10148 – 1	_	Tabby	15 .66	Z S
10148 – 2	_	Warp repp	6. 24	Z S
10149	_	Tabby	13 . 20	S Z
10173	Yes	Tabby	9 .22	S Z
10175	Yes	Tabby	_	_
10176	Yes	Tabby	13 . 36	S Z
10179	Yes	Two – plied weft repp	14 . 6	S S
10180	Yes	Special texture	7 . 32	S S
10181 – 1	-	Tabby	14 . 10	S Z
10181-2	-	Tabby	10 . 8	S Z
10183 – 1	_	Tabby	11 . 42	S Z
10183 – 2	_	Coarse texture	14 . 14	S S

Table 2. Dye analyses from X. Zhang and R. Laursen

Preliminary Analysis of Zanjan Salt Mine Textile Dyes

Xian Zhang
Williamstown Art Conservation Center
Richard Laursen
Department of Chemistry, Boston University
December 10, 2007

Zanjan Sample No.	Color of yarn	Color found	Type of dye	Common name of plant	Botanical name
10050	Red	Red	Alizarin & Purpurin (a little)	Madder	*Rubia* sp.
	Blue (Green?)	Blue & Yellow	Indigotin Flavonoid	Indigoid ?	Indigoid ?
	Yellow	Yellow	Flavonoid	?	?
	White	none	---	---	---
10141	Red	Red	Alizarin & Purpurin (a little)	Madder	*Rubia* sp.
	Green*	Blue & Yellow	Indigotin Flavonoid	Indigoid ?	Indigoid ?
	Yellow*	Yellow	Flavonoid	?	?
	White	none	---	---	---

*The samples used in these cases were too small. The analyses need to be repeated.

Notes:

Blue--The only blue seen in textiles throughout the world is indigo which can be derived fr several species of plant. Because the indigo (generally seen as indigotin and/or indirubin) i same, regardless of source, it is impossible to determine what plant it cam from.

Red—Alizarin, with varying amounts of purpurin, is typical of madder (*Rubia* sp.), which i found throughout Eurasia. It is not possible to pinpoint the species of *Rubia* used because t plants are so widespread, but it probably is not Indian madder (*Rubia cordifolia*), which co more purpurin. On the other hand, it is clear that the red is not of insect origin, e.g., kermes found in and around Armenia.

Yellow—The yellow dye (possibly two dyes) is interesting because one of the components flavonol sulfate, which is quite rare. Possibly this dye was derived from a plant that grows grew) in the vicinity of Zanjan. It is not in our database of some 200 yellow dyestuffs.

پارچه‌های معدن نمک دوزلاخ در چهرآباد، ایران

منیژه هادیان[۱]، آیرین گوود[۲]، مارک پولارد[۲]
همراه با مطالعات تکمیلی رنگ توسط ژانگ[۳] و لارسن[۳]

تاریخ دریافت: ۱۳۹۱/۸/٤ تاریخ پذیرش: ۱۳۹۱/۱۰/٦

معدن نمک دوزلاخ واقع در چهرآباد استان زنجان در ایران دارای یکی از منحصر به فردترین و خوب حفظ شده‌ترین مجموعه‌های بقایای انسانی همراه با قطعات تن‌پوش و پارچه است. این شواهد پارچه‌ای بازکننده دریچه‌ای به سوی یکی از کمتر شناخته‌شده‌ترین و در عین حال مهمترین دوره‌های تاریخ پارچه است. افزون بر این، شواهد به دست آمده برخلاف دیگر داده‌ها که بیشتر منتسب به تدفین‌های عامدانه افراد سرشناس در جامعه بودند، مربوط به افراد عادی جامعه است که تصادفاً در معدن کشته شده و زیر آوار مدفون گردیده‌اند. حداقل شش فرد تا کنون در معدن نمک شناسایی شده‌اند که یکی از آنان در شرایط حفاظتی مطلوبی بوده و سرتاسر بدنش با لباس پوشیده شده و همرا با برخی ملزومات شخصی است. این نوشتار خلاصه از نتایج مقدماتی یافته‌ها در خصوص مطالعات بر روی پارچه این افراد را ارائه می‌نماید.

واژگان کلیدی: پارچه، الیاف، رنگ، پیش از اسلام، معدن نمک.

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