

Morphological Characteristics of the Leather Used in the Shosoin Treasures

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Abstract: The leather products such as harness, shoes, and arms were manufactured 1,250 years ago and have been preserved in the repository named Shosoin in Japan. These products were investigated for the morphological characteristics and animal kind of the leathers with the stereo- and scanning electron microscope.

The saddle is consisted of a wooden seat and four leather pads. The saddle pad on top of the seat was made of deer leather like chamois leather. Two side pads protecting the horse's back were made of bovine or seal leather, while the silk under-pad on the horse's back was hemmed with deer leather. The two sweat pads covering the horse's flanks were made of bear leather. The girth and stirrup straps were made of bovine leather. The tail sack enclosing a horse's tail was made of deer leather. The scanning electron microscope investigation of the tail sack revealed the twist of fibers resulting from heat, suggesting the high probability that the surface was treated with heat such as being smoked or smoothed with a hot iron. There was also a tail suck made of bovine leather.

The sole, upper, and outside of shoes were made of bovine leathers, while the lining was made of deer leather. Many strap leathers of arms such as swords and quivers were made of deer leather. It is recognized as a whole that bovine leathers were used for the parts requiring strength and deer ones were used for the parts requiring softness.

Key words: ancient leather products; bovine and deer leathers; twist of fibers

1 Introduction

There are not many leather remains from the ancient times, because leathers are organic matter which decomposes with the passage of many years. Leathers change in color, softness, and strength with the years. In the case of bad storage, leather products break down.

Various kinds of articles were dedicated to the great Buddha of Todaiji Temple in 756. These objects were most favored by the deceased Emperor Shomu (701-756). There are many leather products, such as harness, shoes, arms, and the like, in the repository named Shosoin in Japan. These leather products were manufactured 1250 years ago. The years are certified by the ancient document entitled Record of the Nation's Rare Treasures.

It is not permitted to investigate the products with damaging, because they are invaluable cultural assets. Therefore, these products were investigated for the morphological characteristics and animal kind of the leathers with the stereo- and scanning electron microscope

2 Experimental

2.1 Materials

Leather products were supplied by Office of the Shosoin treasure house. The products were harness, shoes, and arms.

Deer leathers tanned with formaldehyde were smoked or ironed.

2.2 Stereo- and scanning electron microscope

Samples were observed with a stereo microscope. A part of the leather products was broken after long years and became powder. The powder and the deer leathers at present were observed with a scanning electron microscope without metal coating.

3 Results and discussion

3.1 Observation with stereo microscope

3.1.1 Harness

The Japanese ancient saddle is consisted of a wooden seat and four leather pads (Fig. 1). The seat has designed to give the rider stability and carved to improve riding comfort. The seat is consisted of four planks, pommel, and cantle. These are united by violet leather straps without grain, considered deer one.



Fig. 1 Saddle

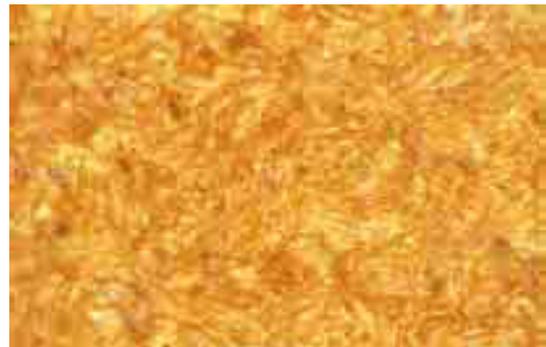


Fig. 2 Stereo micrograph of the surface of inside saddle pad (×20)

The saddle pad spread on top of the planks has a symmetric design of birds holding flowers in their beaks and composite flowers. The surface of the pad was fuzzy and showed that the fine fibers were separated each other, indicating nap deer leather (Fig. 2). The side pads and the under-pad are used to protect the horse's back. There were two kinds of the black and light brown side pads. Former was made of wrinkled leather covered with black lacquer. The parts of the lacquer fell off with grain or papillary layer (Fig. 3). The lacquer-fallen surface without grain showed fine and tight fiber structure, while the surface without a part of papillary layer showed hair roots scattered irregularly. It is concluded that the side pads were made of bovine leathers. The light brown side pads were made of fur, but most of hairs slipped off. However, remaining guard hairs and underfurs were observed in a follicle (Fig. 4A). The fiber bundles were fine relatively to that of bovine (Fig. 4B). These results indicate that the side pads were made of seal skin. The under-pad was made of silk textile and hempen cloth. The surface was hemmed with dyed deer leather.

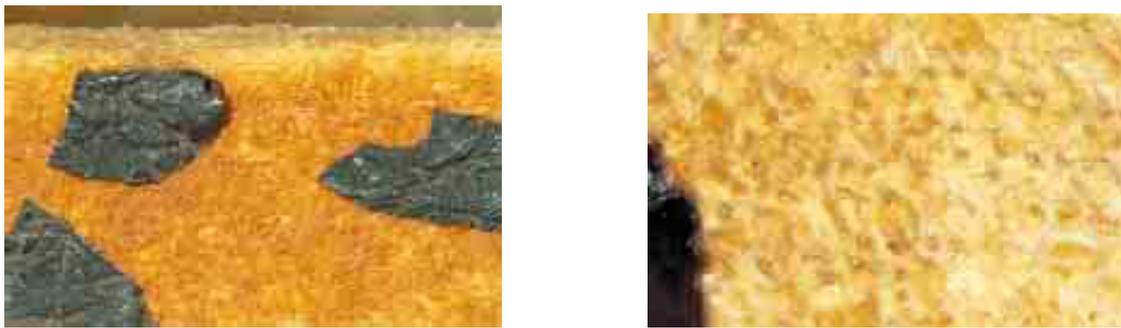


Fig. 3 Stereo micrographs of the outside (A) and inside (B) surfaces of side pads ($\times 8, 20$)



Fig. 4 Stereo micrographs of the surface (A) and cross section (B) of side pads ($\times 25$)

The girth and stirrup straps were made of bovine leather. The sweat pads are placed on each side to cover horse's flanks and protect clothing from getting soiled by horse's sweat or mud splashes (Fig. 5). The hair roots were observed on the back side. It is considered that the pads had furs originally, but most of the hairs slipped off with the lapse of time. The follicle mouths arranged in a regular pattern, two or three mouths in line (Fig. 6). There were several guard hairs and underfurs in a follicle mouth. From the results obtained, it is concluded that the sweat pads were made of bear skin.

Tail sack is a tubular bag and is used to enclose a horse's tail (Fig. 7). The violet leather was buffed and extremely soft, suggesting deer one. The fine fiber bundles got entangled on the surface and in the dermis of the leather (Fig. 8). It is concluded that the tail sack was made of deer leather. There was also a tail sack made of bovine leather.



Fig. 5 Sweat pad



Fig. 6 Stereo micrograph of the surface of sweat pad ($\times 8$)

A

B



Fig. 7 Tail sack

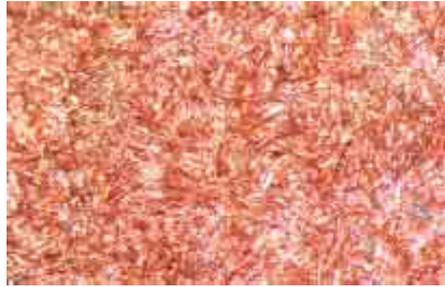


Fig. 8 Stereo micrographs of the surface (A) and cross section (B) of tail sack (×17)

3.1.2 Footwear

Shoes are consisted of sole, upper, outside, sole inner, and lining (Fig. 9 A). They are like footwear worn by Chinese countries and government officials. There were hair roots on the surface of the sole (Fig. 10 A). The fiber bundles were minutely interlaced, indicating bovine leather (Fig. 10 B). The fiber bundles of the side leather were thick like those of sole, indicating bovine leather. While the lining showed fine fiber bundles and interstices among the bundles in the dermis like the tail sack, indicating deer leather. The sole inner was made of hempen cloth and the like. The ceremonial shoes shown in Fig. 9 B also were made of bovine and deer leathers like the shoes described above.

A



B



Fig. 9 Shoes (A) and ceremonial shoes (B)

A



B



Fig. 10 Stereo micrographs of the surfaces (A) and cross section (B) of the sole (×15)

3.1.3 Arms

The beautiful ornamental sword is thought to be a ceremonial weapon, probably imported from China (Fig. 11). The leather of the hilt had granular scales and large granules like pearl, suggesting ray

leather. The hanging cords were violet and nappy leather. Fine fiber bundles on the surface and in the dermis were like that of tail sack, indicating deer leather.

Vine quiver is a receptacle for arrows (Fig. 12). The leather straps attached were considered from fiber structure deer leather like the hanging cords of swords.



Fig. 11 Ornamental sword mounting with gilt and silver fittings



Fig. 12 Lacquered vine quiver

3.2 Observation with scanning electron microscope

The scanning electron micrographs of a tail sack and a lining of shoes showed many interstices among the fiber bundles, suggesting deer leathers (Fig. 13 A). The tail sack indicated the left-handed twist of fiber bundles, while the lining did not indicate the twist (Fig. 13 B). In order to clear the difference, the deer leather heated was observed. The fiber bundles of unheated deer leather were not twisted (Fig. 14 A). But the fiber bundles heated were clearly twisted (Fig. 14 B, C). The twist was soft and hard in the case of smoking and ironing, respectively. It is considered that the twist is related to the helix structure of collagen molecule and the shrinkage of fiber bundles by heat, and that its degree is related to the temperature of heating. There is the high probability that the surface of the tail sack was treated with heat such as being smoked or smoothed with a hot iron. In the ancient rules entitled Engisiki, it was provided that the deer skin was ironed and smoked.

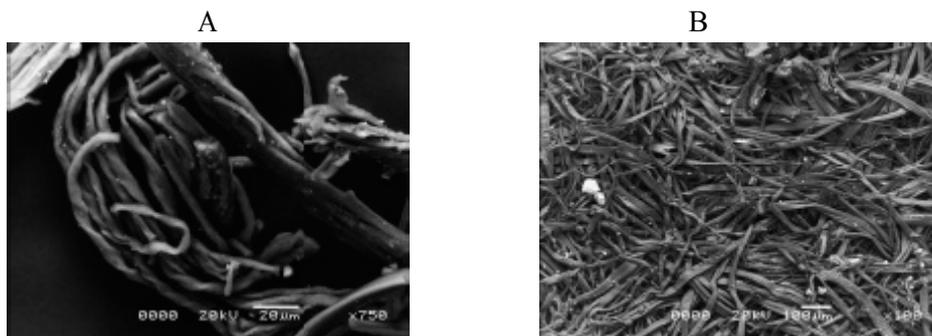


Fig. 13 Scanning electron micrographs of tail sack (A) and lining (B)

A

B

C

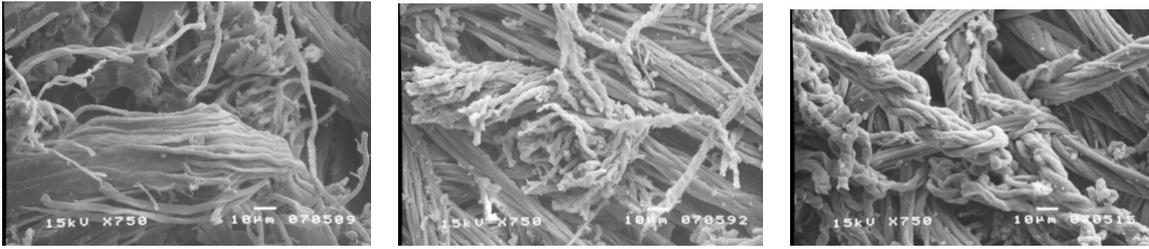


Fig. 14 Scanning electron micrographs of the deer leather unheated (A), smoked (B), and ironed (C)

4 Conclusions

The saddle pad was made of deer leather, while the side pads were made of bovine leather or seal skin. The girth and stirrup straps were made of bovine leathers. The sole, upper, and outside of shoes were made of bovine leathers, while the lining was made of deer leather. The straps of arms were made of deer leather. It is recognized that bovine leathers were used for the parts requiring strength and deer ones were used for the parts requiring softness. The scanning electron micrograph of the tail sack showed the twist of fibers bundles resulting from heat.