IDENTIFICATIONS, MICROANALYSIS, EVALUATIONS AND DIAGNOSIS OF AN ETHNOGRAPHICAL LEATHER OBJECT

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ABSTRACT

The aim of this study is the examination, documentation, analysis and diagnosis of a headgear with bit and reins, made of leather and metal, from Abyssinia (the old name of Ethiopia), belonging to Karl F. Jikeli collection of "Franz Binder" Museum, from "ASTRA" National Museum Complex, for the purpose of drawing up the object conservation strategy.

Due to the scarce information regarding the artifact, we started our work by trying to confirm the object origins, and carried out all the available investigations for a good documentation.

After accurate visual and microscopic comparative examinations that revealed the different leather natures and their surface states, we used micro-chemical analysis for identifying various tanning procedures, the presence of fats and copper, etc.

Furthermore, in collaboration with INCDTP – Division Leather & Footwear Research Institute, we have been doing a series of specific and advanced analyses, as the employment of the micro hot table (MHT) technique to obtain relevant results, and measurements/ evaluations on the grain of various leathers.

All investigations not only revealed some interesting and detailed but also necessary information for a proper diagnosis and planning of the various stages of the conservation activity.

INTRODUCTION

Establishing the Context

When the object was taken from the storage place and brought into the Laboratory, there was not much information regarding it. The only registered data on the object were its name and origin.

The object was a **headgear with bit and reins** (registration number: 246 – E) from Abyssinia [1] and it belonged to the Karl F. Jikeli Collection of the "Franz Binder" Museum part of ASTRA National Museum Complex - Sibiu, Romania.

The first step involved assessing the object origin and finding analogies for a better understanding of the artifact (such as: the object use, the traditional manufacturing techniques, materials, etc.).

A raised question was what kind of animal the headgear was made *for*. In that region, people commonly were breeding different types of camels as well as horses and donkeys. A detailed search on Internet provided us with numerous images of camels with various harnesses, some of them quite similar to the one in question. However the resemblance with the camel harnesses wasn't so relevant as to make us stop there with the research.

Therefore, we started to contact some ethnographic museums throughout Europe, hoping to find at least some useful information if not even the same kind of artifact to compare with. Skipping the description of the entire quest, I would like to mention that with the kind help of *Margrit* Reuss – whom we thank - from The National Museum of Ethnology – Leiden, Holland, we came across an important work: *Majesty and Magnificence at the Court of Menilek, Alfred Ilg's Ethiopia around 1900*, by Elisabeth Biasio [2]. The data in this paper not only helped us to confirm the information and suppositions we already had, but also to make up a picture of the context and origins of the object.

Object Description

Horses and mules played an important role as mounts and pack animals in the inaccessible highlands. They were among the Amhara's [3] most prized possessions and the sturdier mules, in particular, were highly valued. In the town as well, a man of repute did not move around on foot, he mounted his steed and rode, escorted by his servants and his soldier who carried his weapons behind him.

Horses and mule equipment included the headgear, a bit with reins, breastband and crupper, a saddle with saddlecloth, girth and stirrups…The bit was a so-called curb or bar bit that often caused bleeding at the mouth. The horseshoe shaped part lay on the tongue and the ring went round the lower jaw. When the animal was reined in these two parts pressed the tongue and lower jaw together… [4]

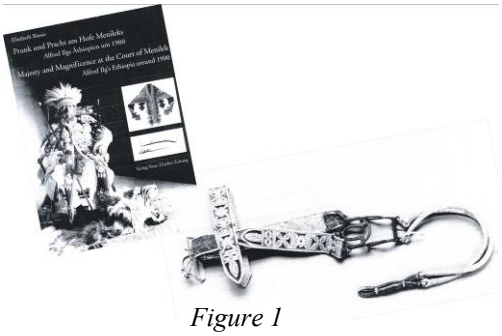


Figure 1

The analog object (briefly presented below) from the mentioned publication (Figure 1) permitted further proper comparisons.

Bit with headgear and reins. The plaited leather reins are attached to the iron curb and end in a red saffian grip. The headgear is made up of two layers of leather. The under leather is brown natural leather, the upper is a red tanned saffian leather ornamented with openwork green and yellow leather and textile appliqués. Motifs: different kinds of quatrefoils some with diagonals and pointed arcs [5].

Our object was made up of a headgear with bit and reins (Figure 2).

Figure 2

Figure 3

The headgear and the reins were made of leather, while the third element – the bit was made of iron (Figure 3)

The reins were made of plaited thick leather bands of natural brown color (Figure 4), attached through multiple knots to the iron rings that the bit was provided with(Figure 5). At the other side of the bit, the headgear was fixed to it by two other bindings (Figure 3).

Figure 4

Figure 5

In the case of the headgear one could distinguish three different kinds of leather. There was a basic layer (some parts doubled) made of a thick brown natural leather. The decoration is similar to the presented analog object and was made with red saffian leather [6] which has green leather openwork and green leather appliqués from place to place (Figure 6). The overlapped surfaces were fixed together by leather rivets and hand sewed with leather bands and textile line.

Figure 6

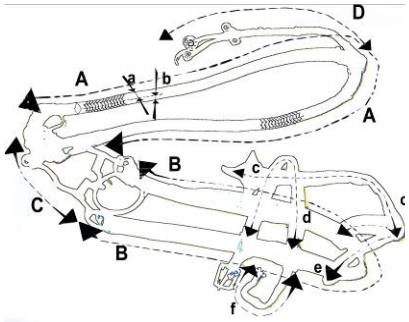


Figure 7

Measurements and various drawings facilitated a better understanding of the object and craft work techniques (Figure 7).

Preservation State

A very careful visual and microscopic analysis has revealed a dusty artifact with adherent greasy dirt on it and in the protein material, and it was worn out some places. A shiny, greasy surface of the reins was visible where it had been usually hung. The brown leather was so worn and torn that the hair holes distribution was not longer visible (Figure 8). The layers of leather used for decoration were poorly hydrated, distorted, inflexible and fragile (Figure 9).

Figure 8

Figure 9

PRELIMINARY INVESTIGATIONS

Identification of Leather

A brief comment upon the following microscopic images has helped in establishing the kind of leather used to manufacture this artifact. The outcome was also confirmed by the data about to the analog harness presented before [2, 4, 5].

The photographed (Figure 10) brown leather surface was so deteriorated that one could hardly observe the hair holes disposal. However the thickness was relevant and expert's eye could identify the cow/calf leather. As some parts of the green decorative leather were covered by the red one (Figure 11), these were so well preserved that the goatskin could be recognized. For a better comparison the Ethiopian sheep *crust* [7] leather sample (Figure 12) was extremely useful. In spite of its deterioration, the red leather could easily be identified as a sheepskin (Figure 13).

Figure 10

Figure 11

Figure 12

Figure 13

Identification of Tanning Agent

For this kind of identification, the so called *spot tests* [8] were used in our Laboratory. The three different pieces of leather were subjected to various tests based on their presumed manufacture procedures. The outcome revealed that the brown (Fig 14) and red leather (Fig 16) had been tanned with vegetable materials. This test is based on the principle that *ferric ions* react with phenol compounds to give dark colored products (Figure 14, 15) [9]. However, the green leather did not respond to the ferric test, so the alizarin test was successfully employed giving positive results (Figure 16). The alizarin test is based on the reaction between bright aluminum compounds and *alizarin* under alkaline conditions to give a bright red lake which is insoluble under acidic conditions [10].

Figure 14

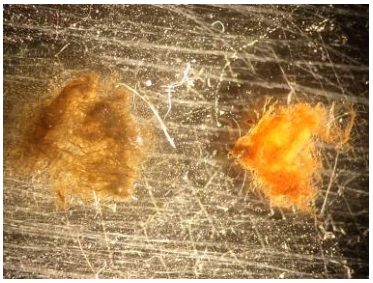


Figure 15

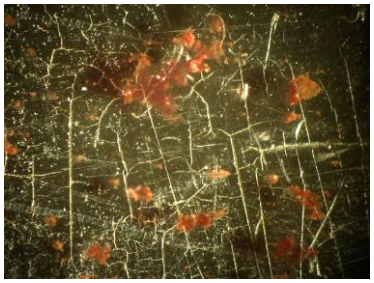


Figure16

Other Analyses
The fatty materials were revealed by a test which uses a drop of ammonium hydroxide and one of hydrogen peroxide producing stabile foam (Figure 17).

Besides the natural brown leather, the other two seemed dyed. In addition, the green leather was dyed probably only on one side. The other side is lighter and the green color penetrated it due to the reduced thickness. On this leather piece, copper was identified by giving a gelatinous, rusty copper ferro-cyanide precipitation in the presence of potassium ferro-cyanide (Figure 18).

pH measurements with high quality pH paper applied on a moistened spot on the reverse side of the headgear have revealed proper values between 5.5 and 7 (Figure 19).

Figure 17

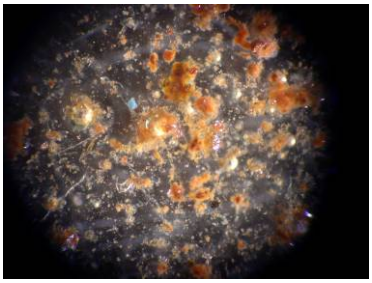


Figure 18

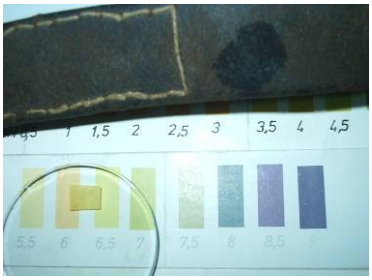


Figure 19

ADVANCED INVESTIGATIONS, ANALYSES AND EVALUATIONS
We would like to mention our collaboration with INCDTP – Division Leather & Footwear Research Institute [11], both parts aiming at establishing a strategy and perhaps a routine in the investigation of leather heritage objects. This institute is able to perform specific analyses on leather and skin using advanced devices and technologies, which museum laboratories can not afford and sustain.

Sampling has been made as follows (Figure 20):
S I – Green leather (very small fallen piece)
S II - Thick brown natural leather (left knot between bit and reins)
S III – Red leather (left interior knot between bit and headgear)
S IV - Thick brown natural leather (top of the reins)
S V - Thick brown natural leather (left side under-head band)
S VI - Thick brown natural leather (right side under head band))
S VII- Thick brown natural leather (left side star decoration).

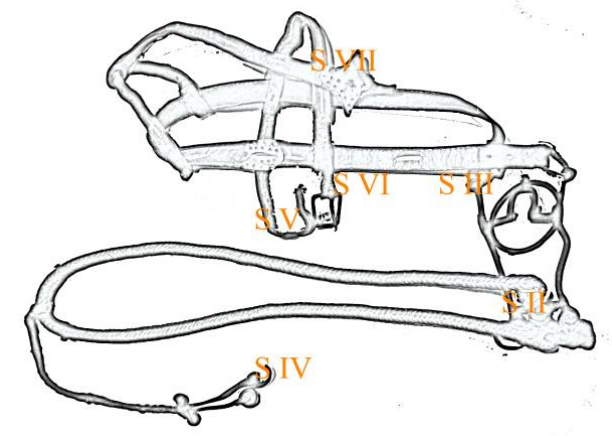


Figure 20

Analysis of Shrinkage Temperature of Collagen Fibers

These samples were used for the analysis of shrinkage temperature (hydrothermal stability) of collagen fibers. The results of such measurement can give an estimative overview of the leather condition. Shrinkage temperature also depends on the skin processing method, and the results can also be used for identifying the tanning agent. Sykes, 1991[12], in his evaluation (Table 1) gives some ranges corresponding to the different tanning methods applied. However, on Reed's opinion [13], the values obtained according to the employed tannin agent and the tanning levels should only be taken into consideration as a general feature. [14]

Oil tanned	50 – 63 ^{0}C
Formaldehyde tanned	63 – 73 ^{0}C
Vegetable tanned	75 – 85 ^{0}C
Hydrolysable	75 – 80 ^{0}C
Condensed	80 – 85 ^{0}C
Alum tawed	50 – 63 ^{0}C
Basic aluminium	81 – 90 ^{0}C
Basic chromium	95 – 105 ^{0}C

Table 1

According to Larsen, the shrinkage of collagen fibers is a thorough issue and one has to take into consideration not only the condition of collagen fibers, the tanning and the possible conservation methods applied, but also the structure of the collagen molecule. Therefore, the result interpretation is a complex task and takes into account several factors [14]. The hydrothermal reaction involving water, heat, and collagen fibers brings about the brake down of hydrogen bonds in the collagen structure – an irreversible deformation known as *shrinkage,* [15].

The micro hot table method (MHT) for measuring the shrinkage activity of micro samples of fibrous collagenous materials has been used in the study of historic/ethnographic vegetable tanned leathers [16].

The shrinkage sequence, according to Larsen is divided into five intervals (A1→B1→ C→B2→A2), from *no activity* to *complete shrinkage*. This can be described in three temperature intervals with the following characteristics [17]:
Interval A1: Individual fibers shrink sporadically and not continuously
Interval B1: Individual fibers shrink continuously
Interval C: Two or more fibers shrink at the same time and continuously
Interval B2: As for interval B1
Interval A2: As for interval A1.
The start temperature for interval C, the main shrinkage interval, is called T_s. This value is registered as the fiber shrinkage temperature. The length of the main interval is called ΔT (B2 - C) and illustrates the interval where the major part of the shrinkage activity occurs. Interval B2 and A2 are not always observed. The start of A1 is called T_{first} and the last shrinkage activity observed in the A2 interval is called T_{last}. The total shrinkage range from T_{first} to T_{last} is called ΔT_{total} [15].

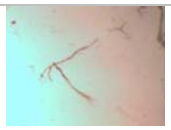
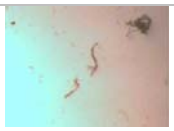
Equipment employed: *Micro Hot Table (MHT) method with CALORIS equipment and F.L.T.K. 1.1.X Soft*

Devices:
1. Stereomicroscope Wild Heergbrugg/ Hot Table Caloris/ webcam/ computer
2. Soft F.L.T.K. 1.1.X for reaching the temperature in the imagine place.

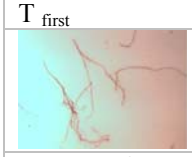
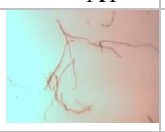
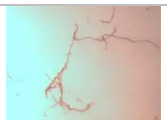
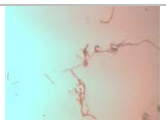
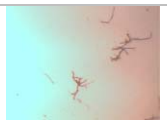
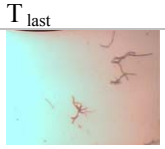
Experimental procedures: A sample of about 0.1 mg fibers taken from the corium part (flesh side) of the leather was wetted with demineralized water from 10 to 20 minutes on a concave microscope slide. The measurements are performed only on a few fibers. The slide was places on the hot table (Caloris) and heated at a rate of 2ºC/min. The highest controlled level of temperature used was 100 degree for leathers and the image was magnified about 40 times its size.

Sample I could not be analyzed due to its bad preservation state, the small piece of green leather being fragile and brittle.

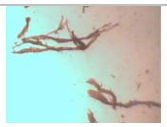
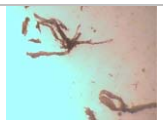
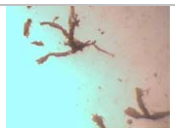
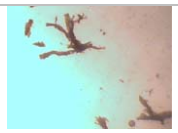
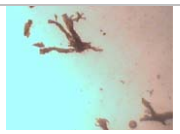
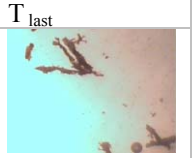
Sample II

T_{first}	A1	B1	C	B2	A2	T_{last}
						
29,5 ºC	51,7 ºC	53,2 ºC	56,2 ºC	60,2 ºC	63,4 ºC	66,5 ºC

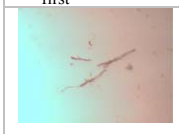
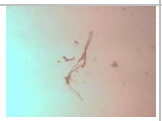
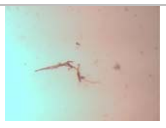
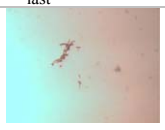
Sample III

T_{first}	A1	B1	C	B2	A2	T_{last}
						
30,0 ºC	56,4 ºC	59,5 ºC	61,9 ºC	63,0 ºC	66,3 ºC	68,5 ºC

Sample IV

T_{first}	A1	B1	C	B2	A2	T_{last}
						
27,2 ºC	37,0 ºC	46,2 ºC	50,4ºC	57,9 ºC	62,7 ºC	71,3 ºC

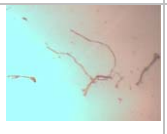
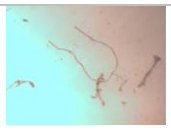
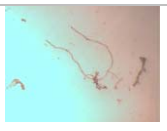
Sample V

T_{first}	A1	B1	C	B2	A2	T_{last}
						
26,5 ºC	51,2 ºC	53,4 ºC	55,9 ºC	56,7 ºC	59,2 ºC	64,3 ºC

Sample VI

T_{first}	A1	B1	C	B2	A2	T_{last}
						
26,5 ºC	51,2 ºC	53,4 ºC	55,9 ºC	56,7 ºC	59,2 ºC	64,3 ºC

Sample VII

T_{first}	A1	B1	C	B2	A2	T_{last}
						
27,0 ºC	65,4 ºC	66,6 ºC	67,5 ºC	70,6 ºC	73,7 ºC	77,3 ºC

The shrinkage temperatures observed in the sample material, based on the information obtained from specialists and from the technical literature is expected to be 80-85^{o}C as in skin tanned with condensed plant polyphenols.

A well tanned skin sample which is considered to be in a good condition, and which is tanned with condensed tannins, would typically have a high T_{first} (A1) in the vicinity of 75-80^{o}C. T_s would lie between 80-85^{o}C and the main shrinkage interval would be short, in the vicinity of 5-6^{o}C. The main shrinkage interval ΔT, and ΔT_{total}, would also be short, approximately 5-10 ^{o}C and 15-20^{o}C, respectively [14].

According to the results included in the chart below (Chart 1), the values obtained for S II, S IV, S VI, S VII have revealed the worse preservation state among the six samples. Putting aside other factors, these samples were representative for some of the most worn and torn parts of the object (see placement in Figure 20). Furthermore, S IV and S VI had a large ΔT_{total}, over 30^{o}C for S IV and around 20^{o}C for S VI, confirming the large interval shrinkage activity value T_s as a bad conservation state indicator. S III – red leather has revealed a good preservation state.

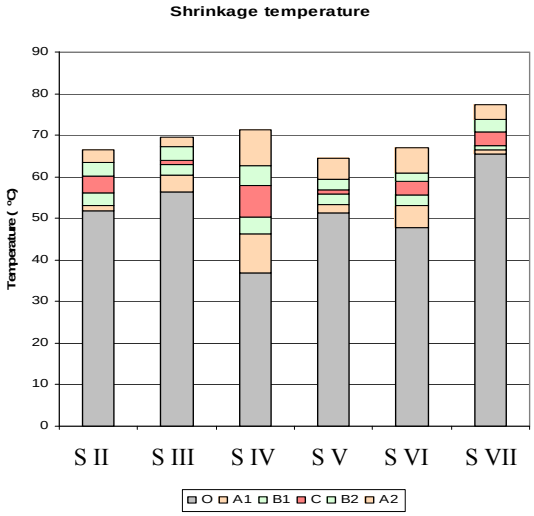


Chart 1

In the end, we would say that we still need a lot of practice and experience in the interpretation of such evaluations, considering the recentness (in our country) of this application in the heritage conservation field.

Microscopic Observations and Measurements

Measurements for hair holes and row distances were performed when the sizes of some of these samples allowed these. At INCDTP – Division Leather & Footwear Research Institute a data base is being built up for identification of leather types according to hair holes diameter and row distances. The following table is illustrating the values obtained to be used for confirming other visual determinations (Table 2), but this is still under construction. It is important to take into account that measurements have revealed different values according to the tanning agent/procedure, too.

Leather type and tanning agent	Largest hair hole diameter (µm)	Smallest hair hole diameter (µm)	Longest hair holes row distance (µm)	Shortest hair holes row distance (µm)
Calf-Mimosa	110,98	33,41	220,07	13,58
Calf-Chestnut	101,95	54,31	306,50	18,19
Calf -Valex	112,77	65,28	340,59	28,23
Calf -Oak	97,36	43,28	313,04	12,43
Calf -Chestnut and Quebracho	123,59	42,09	280,39	
Calf -Valonee	113,94	52,80	240,53	
Cattle-Chestnut and Quebracho	224,47	103,91	423,19	70,81
Cattle-Valonee and Chestnut	133,37	74,25	296,62	21,80
Kid-Chestnut	110,45	64,56	786,53	31,62
Goat-Quebracho_1	271,39	161,05	1.144,20	68,41
Goat-Quebracho_2	144,84	95,08	979,73	93,51
Goat-Chestnut	172,26	106,47	760,45	44,18
Pig - Cr			2.079,47	
Pig-Quebracho		460,84	1.725,76	
Horse	240,07	93,89	351,63	89,31

Table 2

Fortunately we could employ three of the samples (Figure 21 – S I – green leather, Figure 22 – S II – brown leather, Figure 23, 24 – S III – red leather) corresponding to the three different kinds of leather which were used to make the artifact. Photos were taken for the samples at a magnified size which allowed establishing/measuring the dimensions of the factors taken into account for the wanted identification.

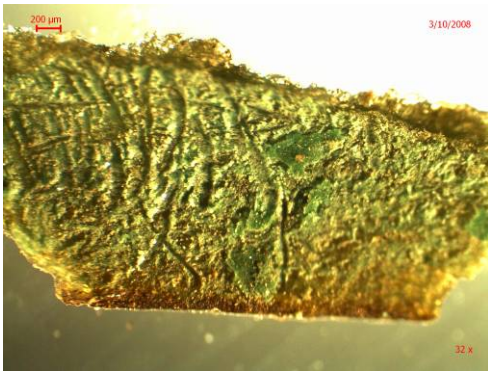


Figure 21

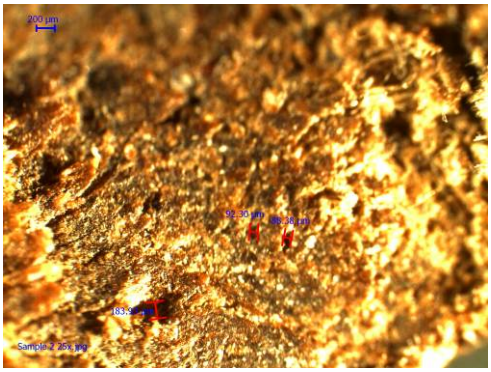


Figure 22

Figure 23

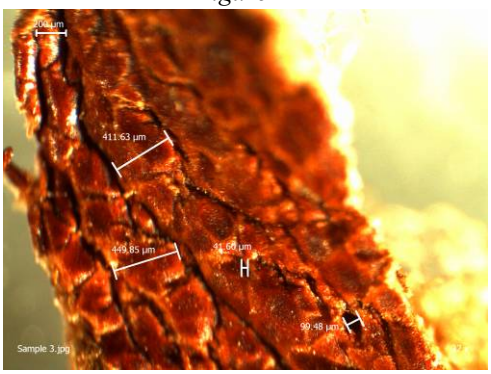


Figure 24

The measurements visible in the photos have to be compared with the/other references that the institute is still working on.

CONCLUSION

For the sake of a thorough documentation, it is very important and useful to gather all the information by any possible and available investigation method.

Sometimes in the case of ethnographic/historic objects the results obtained in the museum investigation laboratory are few and/or uncertain. Besides specific analysis that only a research institute is able to carry out, corroborating several specialists' opinions, investigation methods and procedures assures a major certainty in the evaluation of an artifact.

However, we need to establish and then place emphasis on the non-destructive analysis that offers truly useful results for the documentation and *conservation* purposes. In addition, we need to find the balance between sampling (even micro-samples) and the significance and relevance of the results for the preservation of the heritage in the future.

ENDNOTES

1. Abyssinia is the historic name of Ethiopia - situated quite centre of Africa's Eastern Cost
2. Elisabeth Biasio, 2004, *Majesty and Magnificence at the Court of Menilek, Alfred Ilg's Ethiopia around 1900,* ed. Neue Zürcher Zeitung, Zürich, Horse and Mule Equipment
3. A major ethnic group in the central highlands of Ethiopia
4. Excerpt from *Majesty and Magnificence at the Court of Menilek, Alfred Ilg's Ethiopia around 1900,* 163-164 pp.
5. Excerpt from *Majesty and Magnificence at the Court of Menilek, Alfred Ilg's Ethiopia around 1900,* 165 p.
6. Fine, thin goat or sheep leather, obtained through a complex tanning process and variously colored
7. The name crust is coming from the fact the skin is very hard at the time having only had a basic tannage and minimal oiling - http://www.hewit.com/sd5-leat.htm
8. ***, 2004, Leather/Skin and Its Conservation for Museums and Archaeologists, Dept. Conservation of Antiquities and Works of Art, T.E.I. of Athens (Greece), Leather Conservation Center (Great Britain), Conservation Dept. of Hungarian National Museum (Hungary) CD
9. ***, 2004, *Leather/Skin and Its Conservation for Museums and Archaeologists*, 7 Documentation and examination of leather objects, Spot Tests – *Ferric Test*
10. ***, 2004, *Leather/Skin and Its Conservation for Museums and Archaeologists*, 7 Documentation and examination of leather objects, Spot Tests – *Alizarin Test*
11. INCDTP – Division Leather & Footwear Research Institute (Institutul de Cercetare Pielarie-Incaltaminte-ICPI), 93 Ion Minulescu Str., Tel (4021) 323.50.60, 0723 619238, Fax (4021) 323.52.80, http://www.icpi.ro/
12. Sykes, R. L., 1991, "The principles of tanning". In: *Leather, Its composition and changes with time.* Eds.C.Calnan & Haines, B, The leather conservation centre. Northampton, 10-11 pp., in Torunn Klokkernes, 2007, PhD thesis
13. Reed, R., 1972, Ancient *skins parchments and leathers*. Seminar Press, London, NewYork 331 p., in Torunn Klokkernes, 2007, PhD thesis
14. Torunn Klokkernes, 2007, PhD thesis: *Skin Processing Technology in Eurasian Reindeer Cultures* - A comparative study in material science of Sami and Evenk methods – perspectives on deterioration and preservation of museum artifacts, Published by LANgELANDSMuSEuM, ISBN 978-87-88509-33-5, 162-164 pp.
15. Larsen, R., Vest, M., Nielsen, K., 1993, *Determination of hydrothermal stability (shrinkage temperature) of historical leathers by the micro hot table technique*, Journal of the Society of Leather Technologists and Chemists 77, 151 p.
16. Larsen, R, 1933. 151-156 pp.

Larsen, R., Vest, M., Nielsen, K., 1994 b, *Determination of hydrothermal stability (shrinkage temperature)* in: STEP Leather Project: Evaluation of the correlation between natural and artificial ageing of vegetable tanned leather and determination of parameters for standardization of an artificial ageing method. Ed. R. Larsen, The Royal Danish Academy of Fin Arts, School of Conservation, Copenhagen, 151-164 pp.

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Larsen, R., 2000, *Experiments and Observations in the study of environmental impact on historical vegetable tanned leathers*, Thermochimica Acta 365, 85-99 pp.

17. Larsen, R., Poulsen, D. V., Vest, M., 2002a., *The hydrothermal stability (shrinkage activity) of parchment measured by the micro hot table method (MHT),* in: *Micro analysis of parchment.* Ed. R. Larsen, Archetype Publications, London, 55-62 pp.

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