

Archaeological hair in Paleobiological Research

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KEY WORDS: Hair, Tricocicloforo, SEM, Tricoressi, Mummies.

Abstract

The aim of our research is to define some biological characteristics of ancient populations using hair. Samples of human hair from South American mummies housed in the Museum of Anthropology and Ethnography, Turin University, were studied by light microscopy, "tricocicloforo" measurements and Scanning Electron Microscopy (SEM). Samples were prepared for SEM morphological observation with a Cambridge 360 Stereoscan equipped with an Oxford Instrument X-EDS Pentafet and Inca 200 Microanalysis Suite device for chemical determinations. For some samples, we tried to acquire EDS spectra to obtain qualitative chemical information about the composition of contaminating solid material found during the investigation. The analytical conditions were: 25 mm working distance, 200 pA probe current, 15 kV accelerating voltage, due to the geometric construction of the SEM-EDS chamber. We obtained some qualitative information regarding the presence of high amounts of sulphur (also as a component of hair protein), calcium and potassium. We intend to obtain more precise information in future analyses of carbon-coated samples. Our results underline the importance of SEM in analysing hair for anthropological studies.

Introduction

Hair is a rich and interesting source of information for paleobiological and paleopathological studies, since its structure is sensitive to changes in the internal equilibrium

of the person to whom it belongs. Acute and/or chronic diseases, diet, work habits and environmental conditions can cause morphological and structural alterations, which can be identified by various techniques.

Materials and Methods

Two of the many ancient mummies in the Museum of Anthropology and Ethnography, University of Turin, were chosen for preliminary studies: a female mummy of stated Peruvian origin (M1 - Fig. 1) and a male mummified head of South American origin (M2 - Fig. 2).



Fig. 1 - Mummy 1.

The aims of the preliminary studies were to:

- confirm the ethnic origin of the mummies
- observe the state of preservation and morphological aspects of the hair
- analyse the chemical composition of the surface and inner portion of the hair.

Determination of ethnic origin

The characteristics of hair, particularly the cross-sectional shape, have long been considered useful elements for the



Fig. 2 - Mummy 2.

ethnic classification of human populations.

To confirm the ethnic origin of the two mummies, we analysed cross-sections of their hair with the “tricocicloforo” method. The “tricocicloforo” apparatus, conceived and described by Sergi, allows one to determine the various hair diameters by spinning it around its longitudinal axis and taking measurements with a micrometric eye-piece (Landra, 1935; Canuto, 1948; Sergi, 1957 – 1935-37; Ascenzi, 1959; Correnti, 1964).

To graphically represent the shape of the hair, we measured six diameters spaced at 30° angles in a circle, conforming

to Sergi’s “trichometrogram” drawing: when the centre of the circle is made to coincide with the hair rotation board on the “tricocicloforo”, the combination of different points on the diameters produces a twelve-sided polygonal or “trichometrogram” (Figs. 3, 4), which gives an immediate view of the transverse section of the hair. For each hair, we also calculated the transverse section index (T.S.I.), i.e. the percentage ratio between the minimum and maximum diameters, which gives a rough indication of the shape of the hair. On the basis of the T.S.I. values, the hair is classified as lissotrichous (Tab 1, Tab 2).

State of preservation and morphological aspects

Classic light microscopy allows one to determine some morphological characteristics of the hair, like surface condition and diameter uniformity. Some pathologies can also be highlighted with this methodology. However, further paleobiological information must be obtained by studying the hair with Scanning Electron Microscopy (SEM).

SEM can reveal the condition of the surface structure and deterioration due to contamination by environment agents. It provides a strong three-dimensional view of the specimen, not affected by transparency effects. The high magnification power of the SEM can also be used to investigate single-scale morphology or to reveal parasitoses or fungal infections that are very difficult to detect by light microscopy (Fig. 5).

A few hair samples were prepared for SEM morphological observation and, when possible, EDS analysis of some interesting points. Small pieces of the hairs were glued on a double-adhesive conductive carbon tape and placed on an aluminium stub in optimal orientation to view the cut end. The specimens were gold-coated to ensure adequate conductivity for SEM observation and to avoid artefacts in the scanning image due to electrostatic charging of the object.

The SEM used for the image acquisition was a Cambridge 360 Stereoscan equipped with an Oxford Instrument X-EDS Pentafet and Inca 200 Microanalysis Suite for chemical

Mummy I								
	Hair zone	a	b	c	d	e	f	T.S.I.
		Rotation 0°	Rotation 30°	Rotation 60°	Rotation 90°	Rotation 120°	Rotation 150°	
1	Frontal	52,2	54,1	51,6	45,2	39,7	44,5	73,4
2	Parietal dx	41,8	39,8	40,0	42,4	44,4	43,0	89,6
3	Occipital	43,7	49,7	51,6	51,3	47,5	44,0	84,7
4	Parietal sx	41,4	41,9	41,1	37,9	39,5	40,2	90,5
5	Superior	45,1	46,1	52,7	51,8	49,1	46,3	85,6
	Mean	44,8	46,3	47,4	45,7	44,0	43,6	84,7
	Maximum	52,2	54,1	52,7	51,8	49,1	46,3	90,5
	Minimum	41,4	39,8	40,0	37,9	39,5	40,2	73,4
	Max-Min	10,8	14,3	12,7	13,9	9,6	6,1	17,1

Tab. 1 - Calculation of the transverse section indexes of hair samples from M1.



Fig. 3 - Trichometrogram of M1.

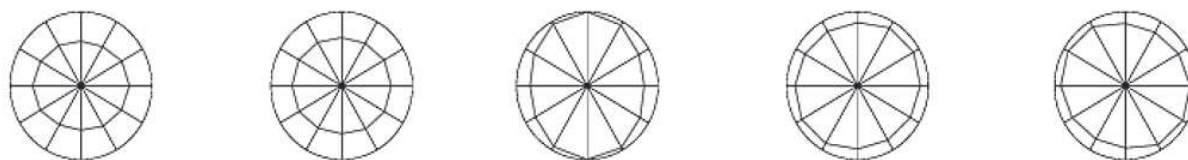
Mummy 2								
	Hair zone	a	b	c	d	e	F	T.S.I.
		Rotation 0°	Rotation 30°	Rotation 60°	Rotation 90°	Rotation 120°	Rotation 150°	
1	Frontal	29,5	30,0	32,6	33,5	32,3	30,9	88,1
2	Parietal dx	31,9	32,5	34,0	34,3	34,2	33,2	93,0
3	Occipital	49,0	46,5	41,4	39,5	42,4	47,3	80,6
4	Parietal sx	41,9	44,2	44,7	43,4	42,2	41,6	93,1
5	Superior	41,3	40,8	42,5	44,8	45,9	45,3	88,9
	Mean	38,7	38,8	39,0	39,1	39,4	39,7	88,7
	Maximum	49,0	46,5	44,7	44,8	45,9	47,3	93,1
	Minimum	29,5	30,0	32,6	33,5	32,3	30,9	80,6
	Max-Min	19,5	16,5	12,1	11,3	13,6	16,4	12,5

Tab. 2: Calculation of the transverse section indexes of hair samples from M2.

determinations. All images were obtained at small working distance and very small probe current to increase the image resolution. For morphological observations, we usually operated at 30kV accelerating voltage, 5-6 mm working distance and 30-100 pA probe current. Each digital image was acquired at 1024 x 768 pixel resolution and 256 grey level colour depth.

Hair surface chemical analysis

For some specimens, we tried to acquire EDS spectra to obtain



Capello Frontale Indice trasversale 88,1 Capello Parietale Dx Indice trasversale 93,0 Capello Occipitale Indice trasversale 80,6 Capello Parietale Sx Indice trasversale 93,1 Capello Superiore Indice trasversale 88,9

Fig. 4: Trichometrogram of M2

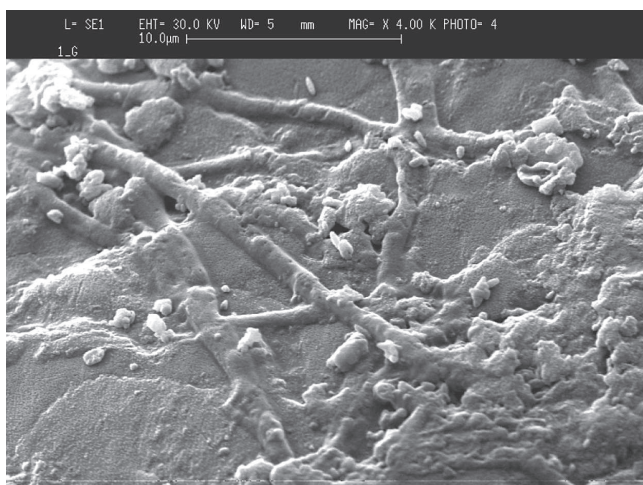
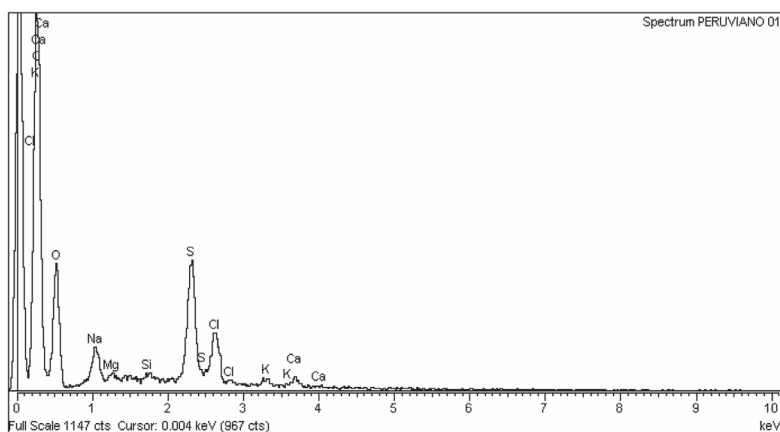


Fig. 5 - SEM, condition of the surface.

qualitative chemical information on the composition of contaminating solid material found during the investigation. Gold-coating is not ideal for microchemical analysis, due to its strong absorption of x-rays emitted from the specimen's surface. Despite this, we obtained some qualitative information on the presence of high amounts of chlorine, sodium, sulphur (also as a component of hair protein), calcium and potassium. These preliminary results suggests some differences due to surface impurities or contamination by sodium chloride (human sweat) and atmospheric particulate matter (Fig. 6) (Tab. 3). No other information could be derived with certainty from the EDS spectrum analysis due to the presence of gold, which results in high background and absorption. We intend to obtain more precise information in future analyses of carbon-coated specimens. The spectra were obtained with 25 mm working distance, 2 nA probe current and 15 kV accelerating voltage, due to the geometric construction of the SEM-EDS chamber and analytical specifications.



Conclusions

“Tricocicloforo” investigation can confirm the attribution of hair to a specific ethnic group. We have shown that the method is a simple,

Fig. 6 - Hair surface chemical analysis.

Mummy I								
Element	Line	App. Conc	k ratio	Intensity corr.	Weight%	Weight% sigma	Atomic%	Standard
O	K_SERIES	6,76	0,03012	0,765	8,83	0,3	68,23	sio2 19-Sep-2002 04:16 PM
Na	K_SERIES	0,98	0,0053	0,8839	1,11	0,09	5,95	albite 20-Sep-2002 10:39 AM
Mg	K_SERIES	0,17	0,00127	0,7819	0,22	0,06	1,1	mgo 19-Sep-2002 04:21 PM
Si	K_SERIES	0,14	0,00115	0,9469	0,14	0,04	0,63	sio2 27-Sep-2002 03:11 PM
S	K_SERIES	3,58	0,03263	0,98	3,65	0,12	14,09	anhydrite 20-Sep-2002 10:18 AM
Cl	K_SERIES	1,7	0,01708	0,7733	2,19	0,11	7,66	KCl 1-Jun-1999 12:00 AM
K	K_SERIES	0,29	0,00246	0,9637	0,3	0,06	0,96	sanidine 20-Sep-2002 11:05 AM
Ca	K_SERIES	0,42	0,0038	0,9313	0,45	0,07	1,38	wollast 19-Sep-2002 04:28 PM
Totals					16,89			
<i>Processing option: All elements analyzed</i>								
<i>Number of iterations 3</i>								
<i>Sample is unpolished X-ray corrections may be approximate.</i>								
<i>Sample is coated with Carbon</i>								
<i>Thresholding has been selected : All quantitative results below 2 sigma have been set to zero</i>								

Tab. 3 - Hair surface chemical analysis.

economical and rapid investigation tool for quantitative measurements, index determination and attribution of ethnic origin. Light microscopy gave us further information on hair surface alterations and some aspects of hair metabolism. Electron microscopy is a powerful tool for morphological investigation at very high magnification. SEM allowed us to perform detailed investigations of hair morphology, parasitosis, fungal infection, hair integrity and structure. The use of combined analysis techniques (EDS) greatly increases the amount of data, even from a single hair. This confirms that SEM-EDS is a powerful instrumental combination requiring a very small amount of hair, which is very important when dealing with valuable archaeological specimens.

Literature Cited

- Ascenzi A, Sergi M. 1959. Ricerche ed osservazioni sui caratteri morfometrici ed istologici dei capelli e del cuoio capelluto di una serie di Daiacchi dell'isola di Borneo. Riv. di Antr. 46, 37-64.
- Canuto G. 1948. La diametria del pelo come elemento di identificazione individuale. Riv. di Antr. 36, 151-158.
- Correnti V, Margiotta G. 1964. Saggio metodologico per lo studio della variabilità dei diametri dei capelli. Riv. di Antr. 51, 99-122.
- Landra G. 1935-37. Sulla morfologia del capello presso alcune popolazioni africane (Acioli Dell'Uganda, Dauada, Tebu e Tuaregh della Libia). Riv. di Antr. 31, 299-338.
- Sergi S. 1935-37. Tricocicloforo. Riv. di Antr. 31, 409-410.
- Sergi S. 1957. Capelli di Tasmaniano e di Boscimano: saggio tricometrico di tecnica applicata alla misurazione dei capelli mediante il tricocicloforo. Riv. di Antr. 44, 285-316.